# Measuring Code Compliance Effectiveness for Fire-Related Portions of Codes

***Final Report***

Prepared by:

*National Fire Protection Association*
and
*Fire Protection Research Foundation*

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THE FIRE PROTECTION RESEARCH FOUNDATION
Research in support of the NFPA mission

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## FOREWORD

The portions of codes, standards and regulations intended to improve fire safety start by defining the level of safety or risk we collectively consider acceptable. As a jurisdiction enforces their respective codes and regulations, how do they know if their compliance efforts are effective? How do they measure their code compliance effectiveness? Effectiveness measurement is a long-established tool to assist managers of any activity in making sure that their choices and level of effort are sufficient to achieve the goals of their activity.

The state of the art in inspection effectiveness measurement is still reflected in a now 30-year-old study by the NFPA and the Urban Institute (i.e., the 1976 NFPA/UI Study). Similar measures have been developed for all types of local government services and published periodically by the International City Management Association, and similar measures have also been picked up for use in so-called performance audits by public-sector accountants.

This project addresses code compliance effectiveness for fire-related portions of codes through a twofold approach that (1) refines the effectiveness measurement methods developed in the 1976 NFPA/UI study, and (2) enhances the detail and usefulness of the effectiveness measurement methodology. The goal of the project has been to develop a tool to measure how fire prevention activities of fire safety enforcement organizations can reduce fire risk in communities, where both *prevention* and *enforcement organization* are interpreted broadly. In addition, the project includes a component on Leadership in Life Safety Design (LLSD), which is a potential management tool directly related to the measurement of code compliance effectiveness. Unlike the measures presented and discussed in other parts of this study (i.e. Volume II), LLSD-type measures focus on success in exceeding code requirements rather than success in complying with code requirements.

The Research Foundation expresses gratitude to the report authors Jennifer Flynn, Casey Grant and John Hall, the Project Technical Panelists, and all others who contributed to this research effort. Special thanks are expressed to the U.S. Department of Homeland Security for providing the funding for this project.

The content, opinions and conclusions contained in this report are solely those of the author.

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## PROJECT SPONSOR

U.S. Department of Homeland Security

# PROJECT ON
# MEASURING CODE COMPLIANCE EFFECTIVENESS FOR FIRE-RELATED PORTIONS OF CODES

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# Preface

In 2007, the NFPA Fire Analysis & Research Division began a project, under the auspices and with the active participation of the Fire Protection Research Foundation (FPRF), to develop new approaches to *effectiveness measurement* as applied to *code compliance* activities, particularly *inspections*. The project goals as originally stated are:

- Develop tools to measure how *fire prevention* activities of fire safety *enforcement* organizations can reduce *fire risk* in communities.

- Develop a *refined methodology* to measure *fire prevention inspection effectiveness*, to meet the needs of today's state and local *fire prevention* personnel.

This project is one element of a research grant from the U.S. Department of Homeland Security to FPRF.

The work of this project is intended first and foremost for fire marshals and other fire prevention managers and fire inspection managers in municipal fire departments. It may also be of value to other managers whose responsibilities include fire-related inspections and code compliance activities, including fire department chiefs, building departments, inspection departments, and safety managers of buildings in the private sector. In addition, Volume III on "Concepts Addressing the Measurement of Leadership in Life Safety Design" will be of interest to others in the design community, including architects & engineers, building owners/managers, consumers, first responders, and insurers.

# Acknowledgements

The authors express gratitude to the U.S. Department of Homeland Security for sponsoring and funding this project. Special thanks also go to the International Fire Marshals Association (IFMA) for their strongly voiced interest and input in the project, sustained over literally years of discussions, without which this project would never have been launched.

We are extremely grateful and appreciative to the many individuals who provided candid answers and cooperation in our research and interviews. Although space limits our abilities to name all those individuals who have helped, acknowledgements and thanks go to the following persons, who served as principal contacts in our work with their communities, as well as their staffs and superiors:

- Arlington (TX) Chief Stephen Lea
- Austin (TX) Battalion Chief Don Smith
- Charlotte (NC) Deputy Chief Robert Kinniburgh
- Colorado Springs (CO) Fire Marshal Brett Lacey
- Nashville (TN) Fire Marshal Danny Hunt
- Phoenix (AZ) Fire Marshal Barbara Koffron
- Providence (RI) Fire Marshal Anthony DiGiulio
- Reedy Creek Improvement District (FL) Fire Chief Ray Colburn
- Tualatin Valley Fire and Rescue (OR) Assistant Fire Marshal Steve Forster.

Our project technical panel helped shape the course of our research and provided many useful suggestions and feedback. We express our appreciation to these individuals:

**Project Technical Panel**

- Kristen Collette, NFPA staff, Quincy MA –*LLSD Sub-Component*
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We also acknowledge and thank the project workshop attendees who contributed to the report, which includes members of the project technical panel along with the following individuals:

- IAFF- Sean DeCrane, Cleveland OH FD
- IAFC- Alan Purdue, F&LS Section
- ICC- Jim Tidwell
- IFCC- Brian Maltby, Ontario
- IFMA- Scott Adams, Park City UT FD
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- Interviewee Kelvin Bartee Phoenix AZ FD
- Interviewee  Mike Dalton, Colorado Springs CO FD
- Interviewee Richard Lepere, Reedy Creek Improvement District FL
- Jefferson Parish- Sam Vanover, LA FD
- NASFM- Bill Degnan, NH SFM
- NASFM- John Mueller, NY Office of Fire Prevention and Control
- PARADE- Ron Farr, Kalamazoo Township FD
- PARADE- David Kerr, Metro National
- USFA- Ken Farmer, National Fire Academy

The authors have received much help with this study, but they accept sole responsibility for the content, opinions and conclusions contained in this report.

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# Executive Summary

## Project overview

The work of the project is collected in three Volumes.

Volume I contains the results of the literature review. Based on the literature review findings and the advice of the project's technical advisory panel, nine communities were selected for the on-site visits and informal interviews:

- Arlington, TX
- Austin, TX
- Charlotte, NC
- Colorado Springs, CO
- Nashville, TN
- Phoenix, AZ
- Providence, RI
- Reedy Creek Improvement District, FL
- Tualatin Valley Fire District, OR

The interviews have not been written up as a separate deliverable for the project, but they contributed a number of ideas, examples, and lines of argument cited in this report, and those connections are noted.

In Volume II in the literature review, the community interviews, the ideas of the project technical panel, and additional discussions were assembled into a proposed approach to measuring effectiveness for inspections and code compliance activities.

Volume III is a conceptual analysis and summary addressing a comprehensive building evaluation protocol used to measure enhanced safety features in a structure referred to as Leadership in Life Safety Design (LLSD).

## Refining the project goals

The project goals are:

- Develop tools to measure how *fire prevention* activities of fire safety *enforcement* organizations can reduce *fire risk* in communities.

- Develop a refined methodology to measure *fire prevention inspection effectiveness*, to meet the needs of today's state and local *fire prevention* personnel.

"Code compliance" is understood to include *inspections* and any other activities intended to achieve compliance. "Inspections" include inspections of new construction (including major rehabilitation projects) as well as existing construction, regardless of who performs those inspections. It includes follow-up inspections.

"Fire inspection" means an inspection in support of *any fire-related requirements* appearing in a code, law or other formal and binding requirement. It is meant to include fire-related provisions in a building code or other code that may not have "fire" in the title of the code, regardless of whether the fire department is involved in those inspections.

"Fire prevention" is understood broadly to include not only reductions in the likelihood of fire ignition but also reductions in the severity of fires that do occur. The latter is often distinguished using the label "mitigation". Together, prevention (defined narrowly) and mitigation correspond to the two parts of "fire risk" – likelihood and consequence – whose reduction is the intended result of code compliance and fire prevention (defined broadly).

This broad definition of "fire prevention" also means that the project is concerned with impact on intentional and unintentional fires. Even if intentional fires cannot be fully prevented through inspections and other code compliance activities, any fire can be mitigated, reducing its loss to a much lower level than would otherwise be the case.

## Literature review (Volume I)

The goal of this literature review was to review previously published literature about inspections and what effectiveness measures are being used in the field. To do this, literature was examined regarding the purpose and importance of inspections, how we know inspections are accomplishing this, what is being done in the field and how might fire departments measure effectiveness.

In the 1970's the National Fire Protection Association (NFPA) and Urban Institute (UI) published a series of three reports about fire inspections and effectiveness. Now, 30 years later, these documents are still cited as the leading resource for measuring inspection effectiveness.

1974: *Measuring Fire Protection Productivity in Local Government*
1976: *Improving the Measurement of Local Fire Protection Effectiveness*
1978: *Fire Code Inspections and Fire Prevention: What Methods Lead to Success?*

In 2002-2005, an estimated annual average of 519,000 structure fires were reported to municipal fire departments. These fires resulted in an average of 3,140 civilian fire deaths, 15,520 civilian fire injuries and an estimated $8.7 billion in direct property loss, annually. Approximately 10-25% of these structure fires, less than 5% of deaths, less than 10% of injuries, and 20-30% of property damage occurred in areas in buildings subject to fire-code inspections.

Fire inspections can be categorized into three types, (1) inspections of newly constructed buildings, (2) inspections of existing buildings undergoing renovations, and (3) inspections of existing buildings for routine safety checks.

The main purpose of a fire related portions of code compliance inspection program is to discover and correct conditions that pose a threat to life and property, based on legally adopted code requirements, and to motivate owners and building managers to prevent future hazards by educating them as to the hazards and proper methods of prevention.

Regularly inspecting every inspectable property, maintaining a complete and accurate list of properties considered inspectable, and using fire-suppression companies for a large share of regular fire related portions of fire-code inspections are all characteristics of inspections that are associated with effectiveness and success.

Fire risk estimates can be used to prioritize occupancy inspections. There are many different approaches to evaluating the associated fire risk, and assumptions must be made as to what variables increase or decrease the chance of fire or the life-hazard that can take place when a fire occurs. St. Paul (MN), Boulder (CO), and Austin (TX) are a few examples of departments that use, or have used, some method of calculating fire risk.

If a department allocates inspection efforts based on risk ratings, they will need to have an estimate of the time and other resources required, on average, per inspection so that they know when they have exhausted their resources as they allocate inspections on a priority basis. There are different ways of estimating how many inspectors are needed. One method includes estimating the number of hours an inspector has available to inspect compared to the estimated amount of time each inspection will take. Another method uses estimates on the number of inspections an inspector can conduct per day, week, or year based on observations of other inspectors. TriData has estimated that a full-time inspector can conduct at least four to six inspections on average per day using manual reporting systems, based on previous audits of various fire departments. This is an average of between 800 to 1,000 inspections per year.

Some departments have instituted self inspection programs to both meet the suggested goal of annually inspecting all occupancies and as a method of educating business owners about hazards and the proper methods of prevention. The self inspection program requires that business owners be responsible for checking their own occupancies for fire hazards and code compliance. Gwinnett County (GA) and Phoenix (AZ) are two examples of departments that utilize, or have utilized, a self inspection program.

In 2006, a needs assessment of the U.S. fire service found that 25.2% of responding fire departments reported that no one conducts fire-code inspections within their communities. As a result, an estimated 20.3 million people, or 7% of the population, live in communities where no one conducts fire-code inspections.

Lack of inspection or negligent inspection practices can result in casualties and fire loss. When a fire occurs and inspection practices are found to be negligent, the fire or building inspector, department, fire marshal, and municipality can be held liable. Tracking and abating violations is necessary to protect against claims of negligence.

An inspector's enforcement style or persuasion techniques can impact compliance and the mitigation of hazards. *At the Regulatory Front Lines: Inspectors' Enforcement Styles and Regulatory Compliance*, a study about the interactions between fire inspectors and homebuilders, suggests that a consultant-like approach with strict guidelines and follow-through associated with the self inspection program may be an effective way of gaining compliance. It may also reduce similar violations in future inspections of the same properties due to educating them on the reason for the violation.

*Regulatory Styles, Motivational Postures and Nursing Home Compliance*, a study about nursing home regulations and inspections, came to similar conclusions as the 1978 NFPA/UI study. This study failed to find that certain kinds of regulatory strategies, i.e. deterrence versus education, work better than others. However, answers to the question "Do regulators associate different enforcement strategies with different perceptions of the nursing home director?" the findings were interesting. Giving management advice and educating nursing home directors in what standards meant were the most commonly recommended strategies by inspection teams, while persuading that the standards are in the best interests of residents and getting tough were considered less necessary.

There are wide variations in inspection practices across the country. Codes and standards are adopted into law, typically with state or local amendments not provided in the model code. It is up to the fire department, or anyone under any auspices in support of a defined set of fire related requirements, to establish procedures for inspecting property. Departments can decide what type of inspections will be performed (e.g., inspections on new construction, inspections of existing buildings), who performs inspections (e.g., fire-suppression personnel, fire inspectors), how inspections are conducted (e.g., checklists, handheld electronic devices, self inspections), the frequency of inspections (e.g., staggering inspections, prioritizing inspections based on fire risk), and enforcement styles (e.g., deterrence, consultant-like approach) to name a few areas.

In the United Kingdom, quality is essentially a measure of effectiveness, in terms of final outcomes. The UK Centre for the Measurement of Government Activity notes that the quality of the fire prevention program can be measured by the amount of awareness raised, changes in behavior, and reduction in the number of fires started.

Regardless of the variations or the methods chosen by the fire department for conducting fire inspections, ultimately, the intended outcomes remain the same: corrected conditions of hazards that posed a threat to life and property, based on legally adopted code requirements, and motivated owners and building managers that are educated as to hazards and proper methods for prevention. All of which result in a reduction in the number of fires within the community.

## Proposed code compliance effectiveness measurement approach (Volume II)

The results were organized into a proposed structure for effectiveness measurement tailored to the three stages of program evaluation, excluding the initial stage of formative evaluation:

- Process evaluation type measures – Measures of the quantity and quality of inspection service or related program activity delivered to the target population;

- Impact evaluation type measures – Measures of the presence of hazards in the target population; and

- Outcome evaluation type measures – Measures of fire loss within the target population.

As is commonplace for effectiveness measures, the process evaluation type measures tend to be the most responsive measures, that is, the ones that will respond most directly, most quickly, and with greatest confidence to changes in the management of the program. On the other hand, process evaluation type measures provide the lowest degree of confidence that hazards have been removed and fire losses have been reduced. The best process evaluation measures address both quantity and quality in terms that have been or can be shown to have a high degree of influence on the presence of hazards and the level of fire loss.

Similarly, the outcome measures provide information in terms of goal achievement and are therefore most clearly evidence of success. However, management will be less clear on how to improve measures through changes in a program for outcome measures than for any other type of measure.

Impact evaluation type measures fall in between. The implications for management will be clearer than for outcome measures but not so clear as for process evaluation type measures. The evidence of success will be clearer than for process evaluation type measures but not so clear as for outcome measures.

The best approach is to use all three types of measures. The process evaluation type measures will provide the most actionable information, and it is expected that proposals to change the program to improve effectiveness will primarily draw on insights gained from these measures. Once those changes are made, it will be interesting to see whether the three types of measures all move in the same direction or not. If the process evaluation type measures improve, but the other measures do not, then there may be a time lag at work (which should become more clear with the passage of time) or there may be a disconnect between the program elements changed and the principal drivers of impact and outcome effectiveness.

Inspections achieve success partly through the direct removal of hazards and partly through indirect *educational* and *motivational* effects on the people responsible for a property. Effective education and motivation may reduce the time required (and resistance involved) in having hazards removed. More importantly, effective education and motivation may sharply reduce the recurrence of violations and induce safer behaviors that will reduce fire loss and fire risk even in scenarios where no physical hazards are clearly involved. One way to add quality to inspections is to design the program to maximize these educational and motivational effects.

No matter how a community or other fire safety enforcement organization (authority) sets its goals, it is possible to measure inspection effectiveness against those goals. However, any comparison of effectiveness over time or between communities (or other entities) needs to be done against common goals.

The simplest way to assure common goals for any comparison is to assess effectiveness against an ideal program, one that includes every type of hazard, every type of property, and every type of effect (including educational and motivational effects). However, such a consistent evaluation against the ideal, conducted in an era of widespread limited resources, is likely to generate results framed as bad versus worse news.

It is important that the effectiveness measures be useful for communities of all sizes and not be tailored solely to the practices of larger communities. Smaller communities are less likely to have fire department inspectors or any department inspection program using department personnel of any kind. Every effort has been made to set the proposed measures and methodologies in a generic form suitable for use by any department.

A total of 11 core measures have been identified. Many important issues are not addressed by these core measures, most notably, measures related to the educational and motivational effects of fire inspections. The reason for that particular omission is the large quantity of work needed to produce detailed guidance for a program with enough specifics to warrant measurement. For the other measures identified and discussed but not included in the core, the reasons are priorities, problems with obtaining enough data for meaningful analysis, and readiness for practical use in management and decision-making.

Here are the core measures:

| Measure | Comments on Measure |
|---|---|
| 1. **Structure fire rate** per 1,000 inspectable properties (**Existing buildings**) | Use five-year averages to compensate for small numbers of fires per year. May exclude intentional fires. Designed for **routine inspections**.<br><br>Use instead of structure fire death rate, which will not have enough incidents per year for meaningful statistical results. However, calculate measures #5-7 separately for fatal fires and/or develop matrix for fatal fires showing points addressed in measures #5-7, in order to obtain information targeted on fatal fires. |
| 2. **List** inspectable-property structure fires with **at least $25,000 in loss**; show **matrix** with presence and importance to fire severity of standard list of **major hazards**. (**New construction** and **existing buildings**) | Work with insurance companies to get best loss estimates. Consider including indirect loss, such as business interruption costs.<br><br>Link to measure #4, which identifies major classes of hazards to be tracked separately. Distinguish hazards associated with new construction versus routine inspections. |
| 3. Estimated monetary **value per additional inspection**, by major property use group. (**Existing buildings**) | Calculate using the formula: Value of one annual inspection = (Fire loss per year) x (% loss preventable by inspection) / (# occupancies)<br><br>Link to measure #5, which sets up formula for what is preventable. |

| Measure | Comments on Measure |
|---|---|
| 4. Number of **violations** found per inspection, overall and separately for (a) sprinkler-related and (b) safe evacuation related.<br><br>For new construction, also identify number of **conditions** that could not be inspected because they were **not inspected while still exposed**.<br><br>(**New construction** and **existing buildings**) | The focus on sprinkler status and evacuation-related violations is one way of singling out problems that are frequently cited as major reasons for multiple-death fires in inspectable properties. Hazardous-material-related violations, compartmentation-related violations, and detection/alarm-related violations are other major groups that could be given their own focus.<br><br>Link to measure #2, which can use the same major-hazard groups selected for focus here. |
| 5. Percentage of fires that were **preventable** or could have been **mitigated** by **inspection** or by the **educational** and motivational elements of inspection. (**Existing buildings**) | Link to measure #3 on estimated value of an additional inspection, which will use the same framework for judging fires preventable or amenable to mitigation. |
| 6. Percentage of fires where there were **pending, uncorrected violations** present at the time of the fire. (**Existing buildings**) | Designed primarily to focus on problems post-inspection in achieving removal of hazards and code compliance. |
| 7. Percentage of **fires** in properties subject to inspection that were **not listed in inspection files**. (**Existing buildings**) | Code by reason not listed. |
| 8. Percentage of **inspections** for which **time since last inspection** is greater than the department's target cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |
| 9. Number of **building systems and features**, from defined list, for which **inspection** and approval were **not completed**, per new construction project. (**New construction**) | A building system or feature would go on this list if no **timely** inspection had occurred. |

| Measure | Comments on Measure |
|---|---|
| 10. Percentage of **inspections** conducted by **inspectors** with **all necessary certifications** for their assignment. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups. It may be appropriate to analyze initial inspections and follow-up inspections separately or to separate assignments in other ways that relate to differences in required certifications. A list of necessary certifications needs to be developed to support the measure. |
| 11. Percentage of **inspections** conducted by **full-time inspectors**. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |

## Leadership in Life Safety Design (LLSD) evaluation protocol (Volume III)

LLSD is a potential management tool directly related to the measurement of code compliance effectiveness. Unlike the other measures presented and discussed in Volume II and developed in Task 4, LLSD-type measures focus on success in exceeding code requirements rather than success in complying with code requirements.

Among its attributes, LLSD provides a comprehensive fire safety evaluation of an eligible building or structure. As a fire risk indexing tool it provides a publicly visible evaluation of a building's fire safety characteristics, including use of non-required systems or features. LLSD has the potential for promoting formal, public recognition of features which may contribute to higher levels of societal safety and protection than are required by traditional building and fire safety codes and regulations.

LLSD is envisioned to provide a method for categorizing and quantifying the performance levels of specific building parameters for application to the design of a building. This would provide a simple rating system easily understood by individuals other than fire protection professionals (i.e. the general public), and indicate the extent to which a building exceeds the required minimum code.

LLSD has some similarities to other risk indexing methods. One example, and perhaps most noteworthy because of its increasing popularity in recent years, is the "Leadership in Energy & Environmental Design" (LEED) concept administered by the U.S. Green Building Council. Despite certain inherent differences, LEED is a building risk indexing method with certain characteristics that parallel LLSD.

Part of the background motivation for this particular study can be traced back to the NFPA High-Rise Building Safety Advisory Committee, which proposed at a joint meeting with the NFPA Standards Council in March 2006 that this concept be considered by NFPA in the NFPA codes and standards process. After a review of the information available at the time, further action on LLSD was tabled pending a more detailed evaluation and analysis of the concept.

This task produced a review of the available literature and compared LLSD to other risk indexing methods. Potentially affected stakeholder groups were identified, and likely perceived positive and negative characteristics of the concept as a tool for use by the code enforcement and building community were summarized by major stakeholder group. It is intended that this study will provide sufficient supporting information to allow fire protection professionals interested in LLSD to establish their own independent judgment of the proposed methodology.

# PROJECT ON
# MEASURING CODE COMPLIANCE EFFECTIVENESS

# VOLUME I

# LITERATURE REVIEW

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# Volume I Table of Contents

# 1. What Do Inspections and Other Code Compliance Activities Do, and How Do They Reduce Fires and Fire Losses?

## 1.1 Purpose of Fire Related Portions of Code Inspection Programs

The main purpose of a fire related portions of code compliance inspection program is to discover and correct conditions that pose threat to life and property, and motivate owners and building managers to prevent future hazards.

## 1.2 Inspections Change Conditions that in Turn Reduce Risk

Before receiving an inspection, specifically for fire related portions of a code, a property can be thought of as having a particular level of fire risk such as the probability of having a fire, a fire death, a fire injury, or a dollar of fire loss during the course of the year. This pre-existing risk may be better estimated as a function of various characteristics, such as the type of occupancy, the size of the property, the number of people or value of property on site, or the fire protection systems or features in place. An estimate of the risk therefore might be made by dividing a loss measure (e.g. number of fires, involving similar properties) by a measure of exposure (e.g. number of similar properties).

If an inspection produces a change in targeted conditions and/or behaviors of owners, managers, or employees, then that should lead to a reduction in risk. This points to several approaches to using data in the design or evaluation of inspections and related code compliance activity:

(1) Develop refined estimates of community risk to focus on fires and losses when better or timelier inspections could have made a difference. This approach leads to measure of the "rate of fires preventable by inspection" type.
(2) Distinguish pre-existing risk by type of occupancy or other characteristic, and use that information when allocating inspection resources to get the most "bang for the buck."
(3) Identify characteristics of inspections that are credibly believed to produce positive results, and measure success in delivering those characteristics.
(4) Identify characteristics of properties that are credibly believed to respond to well-executed inspections, and measure success in achieving those characteristics.

## 1.3 Which Fires Are Preventable by Inspection?

In 1978, the National Fire Protection Association and Urban Institute conducted a study, *Fire Code Inspections and Fire Prevention: What Methods Lead to Success?* The authors held the assumption that fire prevention and fire inspections are intended to protect against unintentional fires, or those fires that are not purposely set. They found that unintentional fires can be divided into two classes: those that involve relatively visible hazards easily remedied by direct action and those that involve behavioral errors or electrical or mechanical failures not easily visible before ignition. In properties that are required by code to be inspected in all the communities examined, the fires from the latter circumstances greatly outnumbered fires due to visible hazards that inspectors are likely to order corrected.  Also, most of the fire incidents that resulted in ten or more civilian deaths involved preventable circumstances. (Hall, et al. 1978)

Even if intentional fires cannot be fully prevented through inspections and other code compliance activities, any fire can be mitigated, reducing its loss to a much lower level than would otherwise be the case.

## 2. How Much of the U.S. Structure Fire Problem is Targeted By Fire Related Code Compliance Inspections?

In 2002-2005, an estimated average of 519,000 structure fires were reported to municipal fire departments, annually. These fires resulted in an average of 3,140 civilian fire deaths, 15,520 civilian fire injuries and an estimated $8.7 billion in direct property loss, annually. Table 1 shows a breakdown of fires by occupancy type.

**Table 1.**
**Structure Fires by Occupancy Type, 2002-2005 Annual Average**

| **Occupancy Type** | **Fires** | | **Civilian Deaths** | | **Civilian Injuries** | | **Direct Property Damage (in Millions)** | |
|---|---|---|---|---|---|---|---|---|
| Homes[1] | 377,100 | (73%) | 2,870 | (91%) | 13,370 | (86%) | $5,918 | (68%) |
| *One- or two-family dwellings, including manufactured homes* | *271,300* | *(53%)* | *2,430* | *(77%)* | *9,590* | *(62%)* | *$4,839* | *(55%)* |
| *Apartment, tenement or flat* | *105,800* | *(20%)* | *440* | *(14%)* | *3,780* | *(24%)* | *$1,079* | *(12%)* |
| Other Residential[2] | 26,300 | (5%) | 170 | (5%) | 660 | (4%) | $316 | (4%) |
| Storage | 25,300 | (5%) | 40 | (1%) | 300 | (2%) | $525 | (6%) |
| Mercantile and Office | 21,100 | (4%) | 10 | (0%) | 270 | (2%) | $690 | (8%) |
| Outside or Special Property | 20,100 | (4%) | 10 | (0%) | 70 | (0%) | $109 | (1%) |
| Public Assembly | 15,700 | (3%) | 10 | (0%) | 160 | (1%) | $376 | (4%) |
| Manufacturing and Processing | 7,700 | (1%) | 10 | (0%) | 280 | (2%) | $475 | (5%) |
| Health Care, Detention, and Correction | 7,400 | (1%) | 20 | (1%) | 230 | (1%) | $37 | (0%) |
| Educational | 6,600 | (1%) | 0 | (0%) | 100 | (1%) | $99 | (1%) |
| Industrial, Utility, Defense, Agriculture, and Mining | 3,300 | (1%) | 0 | (0%) | 50 | (0%) | $123 | (1%) |
| Unclassified or undetermined, not reported, or none listed | 8,400 | (2%) | 10 | (0%) | 60 | (0%) | $64 | (1%) |
| Total | 519,000 | (100%) | 3,140 | (100%) | 15,520 | (100%) | $8,732 | (100%) |

Source: NFIRS and NFPA Survey

The majority of structure fires and civilian fire deaths occurred in one- and two-family dwellings during 2002-2005, which is consistent with historical trends. Typically, dwellings are not included in inspection programs, unless they are undergoing construction, during major renovations, for some specific exceptions or when refinancing. Requirements vary from state to state and town to town.

Removing dwellings from the total leaves 47% of fires, 23% of deaths, 38% of injuries, and 45% of property damage. However, fire related code inspections of multi-family homes such as apartments are normally limited to common areas outside individual

[1] Homes are dwellings, duplexes, manufactured homes, apartments, townhouses, rowhouses, and condominiums.

[2] Other Residential properties are boarding/rooming houses, hotels, motels, residential board and care, dormitory-type residence, sorority house, fraternity house, barracks, and unclassified residential occupancies.

housing units. These areas account for a small fraction of areas of fire origin and an only slightly larger fraction of fires which spread beyond the room of origin. Fire related code inspections are also typically limited to common areas in all other residential properties. The storage category includes a large share of dwelling garages, sheds, and barns on the grounds of dwellings, which will not be subject to fire related code inspections. Outside or special properties are principally structures other than buildings.

It appears that areas in buildings subject to fire related portions of code inspections are involved in about 10-25% of structure fires, less than 5% of deaths, less than 10% of injuries, and 20-30% of property damage. In any single community, even a large city, there will not be enough deaths or injuries in properties that are required by code to be inspected to support statistically meaningful loss rates for use as inspection effectiveness measures.

## 3. What are the Activities Conducted During Inspections?

Fire inspections can be categorized into three types, (1) inspections of newly constructed buildings, (2) inspections of existing buildings undergoing renovations, and (3) inspections of existing buildings for routine safety checks. Jurisdictions may be conducting only one type of inspection or all three. This creates a wide variation in inspection practices across the country. Also, the actual inspection process can vary greatly between departments, depending on how they choose to construct their program.

According to the *Building Construction and Safety Code Handbook NFPA 5000,* "[Authorities having jurisdictions] who enforce building code rules conduct seven main tasks, as follows:

1. Receive information
2. Review the information against a legal standard
3. Issue a written approval or correction list
4. Conduct inspections in the field for compliance with the approved documents
5. Issue a written approval or correction list for that inspection
6. Make a final inspection and final review of the file to assure that all inspections have been passed and all required documentation is in the file
7. Retain the records for review and inspection by the public on demand" (Building Construction and Safety Code Handbook 2003)

These duties were established to ensure the safety of occupants and the building. By carrying out these duties, the inspector is both a customer service representative and technical coordinator, tasked to make sure minimum provisions of the *Code* are being met. (Building Construction and Safety Code Handbook 2003)

The frequency with which occupancies are inspected, how life-risk associated with an occupancy is assigned, the priority of the inspection, how inspectors are prepared, trained, or supported, how the inspector obtains compliance, and fines and penalties associated with non-compliance can vary between jurisdictions.

With so many different combinations in the choices that can be made in the inspection process, the effectiveness of each variable needs to be measured and each variable in itself must be effective to contribute to a fully effective fire inspection program.

# 4. How Can the Department Measure Risk and Inspection Workload to Support Allocation of Inspection Resources?

## 4.1. Determining Fire Risk

Fire risk estimates can be used to prioritize occupancy inspections. Fire risk indexing, also known as rating schedules, are models of fire safety that constitute various processes of analyzing and scoring hazard to produce an estimate of fire risk. This model uses professional judgment and past experience to assign values to variables representing fire safety features. (Watts 2002)

There are many different approaches to evaluating the associated fire risk, and assumptions must be made as to what variables increase or decrease the chance of fire or the life-hazard that can take place when a fire occurs. In the case of fire risk indexing for occupancies, variables might include occupant capacity; a very packed night club, for example, has the potential for multiple casualties. Occupant mobility might be a variable that is considered. For example, nursing homes or hospitals could have a higher fire risk index rating because occupants may need additional assistance escaping due to reduced mobility.

### *4.1.1 Example of Defining Fire Life Risk*

The Austin, Texas Fire Department uses a statistical model of risk to evaluate occupancy types. In an article by the Department, published in the *NFPA Journal*, the author discusses how risk is calculated, and uses one- and two-family dwellings for an example to calculate risk. The total number of fires in these properties in a given year is multiplied by the number of fatalities in the same property type as a percent of overall fire fatalities in all property types, plus the total dollar loss in that property type as a percent of total fire-related dollar loss in all properties. (Baum 2002) A risk assignment can be made for each occupancy, and an inspection hierarchy can be created.

The Department now follows the results from their relative risk formula to see if the target occupancies' risk over time is improving. If relative risk has dropped, then this suggests a positive influence from fire inspections. The Austin Fire Department developed another formula that would take into account the population of the City. In this formula, risk is determined by the frequency of fires times the number of casualties, plus the frequency of fires times dollar loss in millions (adjusted for inflation) divided by population of occupancies in that category in thousands. By factoring in population, the Department accounts for increases or decreases in at-risk occupancies and occupants. (Baum 2002) Formulas are included in Appendix A.

### *4.1.2 Example of Staggered Building Inspection Frequency Schedule*

To compensate for not being able to annually inspect all occupancies, some Departments choose to stagger building inspections based on risk prioritization. One example of this comes from the Saint Paul Department of Fire & Safety Services.

In 2007, TriData, a Division of System Planning Corporation, conducted a Comprehensive Management Study of the Saint Paul Department of Fire & Safety Services the St. Paul, MN. This study examined the inspection program for the city. In the TriData findings, the author states that the management process that is used by the City to determine the frequency of inspections is impressive because the City uses actual fire data to determine risk rather than basing frequencies on a perceived theoretical risk.

Those properties deemed to be of highest life risk are labeled High Hazard occupancies and are inspected annually. The second highest-life risk is in assembly occupancies, factories, institutional occupancies, residential occupancies that are required by code to be inspected, such as apartment complexes, and storage facilities, and is inspected every two years. Those occupancies that pose the lowest-life risk are inspected every three years. Over the course of three years, the city inspects 7,881 occupancies. (TriData 2007)

To determine the frequency of inspections, the St. Paul Department of Fire and Safety Services uses actual fire data rather than using a theoretical risk assignment. While the theoretical risk for fire in hospitals or schools is great, few fires occur in these institutions and most are protected by automatic sprinkler systems. St. Paul puts more emphasis on residential inspections in properties such as multi-family homes. (TriData 2007)

### *4.1.3 Example of Prioritizing Inspections*

In 1997, seven fire suppression companies were responsible for protecting over 95,000 people in Boulder, Colorado. The City devised a system for prioritizing the 3,000 properties that are required by code to be inspected in Boulder. The prioritization was based on calculating a life safety hazard value for every business in Boulder. Under this prioritization, fire companies are able to do inspections on high life-safety hazards every year. The less hazardous occupancies were inspected every two to three years. (Donner 1997)

Building use, occupancy, ease of escape for occupants, ease of access for fire crews, and built-in fire protection are examined to calculate a life safety hazard value. Each factor is weighted based on its overall importance to life safety. Occupant load and building use are weighted more heavily than other factors. The occupants' ability to evacuate quickly - level or height of the occupancy, time of normal occupancy and impairment potential - is important in determining the life safety hazard rating. The fire department's vehicular access is the next factor examined. Buildings that are accessible from two directions with access to a two-story roof or a third-story window from three sides are given the best score. Windowless buildings are automatically assessed 50 points as are buildings with no built-in fire detection or protection, such as sprinklers. Occupancies with more points are deemed high life safety hazard occupancies and are inspected annually. Occupancies with points closer to zero are deemed lower life safety hazard occupancies and are inspected every two or three years, depending on rating. (Donner 1997)

Fire prevention personnel trained line firefighters to use the evaluation form. Engine companies filled out the form while conducting inspections. Fire prevention personnel assisted as necessary. All information was then computerized. New businesses operating in existing buildings are evaluated and added to the system as they are discovered. Closed businesses are moved to an inactive file and newly constructed occupancies are added when they receive a Certificate of Occupancy. Company officers review inspection priorities on an annual basis to ensure the accuracy of the life safety hazard rating. (Donner 1997)

To prioritize the risk assigned to a specific occupancy in a community, historical data about fire rates in the community should be examined. Where do fires occur most and what are the losses at these properties? What properties have had the greatest fire losses in the past?

*Update: The City of Boulder no longer uses this prioritization method due to complications of incorporating the system into their new computer program.*

## 4.2 Inspector Workload

The 1978 NFPA/UI study recommended that cities consider using fire-suppression companies for a large share of their regular fire-code inspections because using this approach appears to be necessary to achieve annual inspections. (Hall, et al. 1978)

Also, if a department allocates inspection effort based on risk ratings, they will need to have an estimate of the time and other resources required, on average, per inspection so that they will know when they have exhausted their total of inspection time as they allocate inspection on a priority basis.

Based on past fire audits and inspector observation, TriData estimates that a full-time inspector can conduct at least four to six inspections on average per day using manual reporting systems. This is an average of between 800 to 1,000 inspections per year. (TriData 2007)

A standard way of assessing the Department's workload potential for inspections is to calculate the number of workable days or hours in a year.

To calculate workable days in a year for a full-time inspector, multiply the number of days in one week the inspector works times 52 weeks in a year. Then subtract this total by the number of vacation days, holidays, training days, sick time, and other days allocated to other than inspection duties, for that inspector for that year.

To calculate workable hours in a year for a full-time inspector, first find the number of hours the employee works in one day, this number is typically eight hours minus time for lunch and breaks. Multiply this number by the number of workable days in a year (as calculated above). This number is the number of workable hours in a year for a full-time inspector.

Assuming that TriData is accurate in estimating an inspector can conduct 4-6 inspections per day, the workable days formula can be taken one step further to calculate the number of inspections one inspector can conduct in a year. To find a range for the potential number of inspections for a year, multiply the low end daily estimate of 4 inspections per day by the number of workable days in a year. Next multiply the high end estimate of 6 inspections per day by the number of workable days in a year. These two numbers will provide a range for potential inspections.

NFPA 1201: *Standard for Providing Emergency Services to the Public* provides a process for analyzing the personnel needed to achieve the level of service(s) determined by the ESO or by the authority having jurisdiction.

The standard outlines five steps for analyzing personnel needs, which include:

(1) Identify scope services, duties, and desired outputs
(2) Determine total time demand
(3) Determine required personnel hours
(4) Calculate personnel availability
(5) Calculate total personnel required

This method of personnel analysis combines identified services and duties that should be performed by the individual with historical performance data, taking in consideration for personnel availability and time adjustments such as vacation, to identify the number of personnel positions needed. Formulas are included in Appendix A.

The following are some examples of how fire departments measure inspector workload or divide workload between personnel.

### *4.2.1 Example of Workload Measurements*

Chief John Fowler examined the annual workload of company-level personnel in Sumner, Washington in terms of average annual hours. He identified eight tasks that must be managed over the course of a year. They include emergency response workload, annual training hours, annual maintenance hours, annual hose and hydrant testing, special assignment hours, and annual inspection activities. (Fowler 1998)

Fowler assumes regular or initial inspections take one hour (1.0), while re-inspections take three-quarters of an hour (.75). He then multiplied the number of inspections conducted in a year by the corresponding assumed time needed to complete the inspection. He added the totals for regular inspections and re-inspections to get a figure that would show how many work hours are needed to perform inspections in a year. (Fowler 1998)

### *4.2.2 Example of Fire Department Resource Allocation*

In the City of New Orleans, prior to Hurricane Katrina, Chief Mark Jee analyzed the inability of the New Orleans Fire Prevention Division to perform annual fire inspections of every facility within the scope of jurisdiction, by only using full-time inspectors. (Jee 1999)

At the time, the City of New Orleans had 17,000 structures that fell under the classification of property that is required by code to be inspected. The Fire Prevention Division of New Orleans consisted of nine people. Inspections occurred only between the hours of 8 a.m. and 5 p.m., Monday through Friday. Under this system only 44% of these buildings were inspected annually. (Jee 1999)

Chief Jee made reference to the 1978 NFPA/UI study findings and methodology to calculate the work potential needed to inspect all 17,000 occupancies annually. It was recommended that the City of New Orleans use the nine full-time fire prevention inspectors and supplement that with 44 company officers, who would each make two inspections per day in order to complete all inspections each year. (Jee 1999)

In this case, Chief Jee assumes that there are 111 days in a year for each company officer to perform inspections. This number takes into account 10 days of vacation time and fire suppression's use of the platoon system. Chief Jee then assumes each company officer can perform two inspections per day for the 111 days. This total is then multiplied by the number of company officers and added to the workload capability of the nine full-time fire prevention inspectors.

### *4.2.3 Example of Inspection Program Administration*

Stephen Bradley described several changes to the Indianapolis, Indiana fire inspection program in a 2003 EFO paper. The fire inspection program, which was instituted in the late 1970's, utilized firefighters assigned to the Administrative Office and was an administrative function until 1990, at which time personnel assigned to fire apparatus and ambulances were trained to conduct fire inspections. In 1993, the administrative positions that had been established in the 1970's were eliminated and fire inspections of buildings with high-life hazards and administrative functions became the responsibility of the Fire Marshal and Assistant Fire Marshal. The remaining inspections were completed by company personnel when they were not responding to emergency runs or training detail. At this time, inspection totals were high yet less than 100% of occupancies were inspected. (Bradley 2003)

In 1995, the program was changed again to ensure that all buildings that are required by code to be inspected were inspected each year. Firefighters were given additional in-house training in fire inspections and company personnel visited more businesses and buildings. (Bradley 2003)

In 2003, the fire inspection program underwent another change. Company personnel would make fewer inspections. However, they would return to re-inspect businesses cited for violations. Also, the Fire Marshal would inspect hospitals, the large public high school, the two largest high-rise buildings, and all new construction. Company personnel would examine the remaining high-life risk occupancies, while businesses with a history of no hazards or lower-life hazards were each inspected over a three year period. (Bradley 2003)

# 5. What Characteristics of Inspections are Associated With Effectiveness/Success?

## 5.1 Inspection Frequency

The 1978 NFPA/UI study team recommended that departments make it a policy to annually inspect all or nearly all public buildings, as fire rates are lower when inspection rates were higher. (Hall, et. al 1978)

Although it would be ideal for every property that is required by code to be inspected, to be inspected annually, this is not routine practice. The code enforcement process usually involves an inventory and prioritization of the properties. Typically, inspections are prioritized based on the statistical history of fire problems or on a list of potential problem occupancies where risk of death or loss is great, if infrequent. (Crawford 2002)

Throughout the literature, there was one common issue with this recommendation. Fire departments and inspectors agree that annual inspections of all public properties would reduce fire losses within the community. With population growth not being matched by fire department growth, especially in fire prevention, and with lack of financial support in budgets, many fire departments are unable to achieve inspections of all or nearly all public buildings within one year.

Inspections that occur more frequently would yield a safer community. Documenting the number of hazards noted and abated through the inspection process is a good way to track hazards and by comparing this to the fire rates, effectiveness can be measured. This would provide some evidence that risk was being reduced. However, no definitive studies have outlined what inspection frequency is best. (Crawford 2002)

To measure the frequency of a Department's inspections, an accurate record of occupancies that fall under the jurisdiction of inspections is needed. It is also necessary to keep accurate records for when inspections are completed, and when the next inspection needs to be conducted. Records should also be kept on the type of inspection performed, such as license, regular, new construction or renovation, or re-inspection.

In the 1978 NFPA/UI study, inspection frequencies were estimated by using a procedure developed in a 1976 NFPA/UI study, *Procedures for Improving the Measurement of Local Fire Protection Effectiveness*. For each property that had fires, the time since last inspection was defined as the number of months between the fire and the last inspection of the property prior to the fire. To measure the time-since-last-inspection, count the number of months from the latest inspection prior to the fire, to the month of the fire. (Hall, et al. 1978)

## 5.2 Completeness of Coverage of Inspections

To ensure that all occupancies that legally require inspections are considered, the 1978 NFPA/UI study recommended that fire departments use geographic areas of responsibility to assign inspections. The findings from this study showed that when inspectors covered the city block by block or street by street, there tended to be fewer problems with missed coverage. (Hall, et al. 1978)

Tracking permits for new construction and renovation projects is a way of ensuring that new properties that are required by code to be inspected are added to the list of occupancies to inspect within the community. This information can also be used to measure effectiveness.

## 5.3 Inspection Quality as a Function of Who Conducts Inspections

Full-time inspectors typically receive more training than firefighters who perform in-service inspections. The quality of a self inspection program depends on who performs the inspections, the property owner or someone with expertise hired to perform the inspection by the owner. There is also the question of how much and what kind of training inspectors need. See Appendix B for an overview of the requirements in NFPA 1031.

In 2006, the U.S. Fire Administration and NFPA performed a needs assessment of the U.S. Fire Service. One aspect of the assessment looked at who conducts fire-code inspections in the community. The study found that 25.2% of fire departments reported that no one conducts fire-code inspections within their communities. As a result, an estimated 20.3 million people, or 7% of the population, live in communities where no one conducts fire-code inspections. (Hall, et al. 2006)

**Table 2.**
**Who Conducts Fire Inspections in the Community?**
**By Community Size (2006)**

| Population of Community | Full-Time Fire Department Inspectors | In-Service Firefighters | Building Department | Separate Inspection Department | Other | No One |
|---|---|---|---|---|---|---|
| 1,000,000 or more | 100.0% | 70.0% | 10.0% | 0.0% | 0.0% | 0.0% |
| 500,000 to 999,999 | 92.9% | 64.3% | 3.6% | 3.6% | 0.0% | 0.0% |
| 250,000 to 499,999 | 100.0% | 54.3% | 10.9% | 0.0% | 2.2% | 0.0% |
| 100,000 to 249,999 | 97.0% | 49.7% | 12.4% | 2.4% | 1.2% | 0.0% |
| 50,000 to 99,999 | 91.0% | 51.8% | 14.7% | 4.0% | 4.0% | 1.0% |
| 25,000 to 49,00 | 74.0% | 46.0% | 19.3% | 3.4% | 13.6% | 1.6% |
| 10,000 to 24,999 | 47.6% | 37.9% | 22.3% | 7.9% | 19.5% | 4.3% |
| 5,000 to 9,999 | 20.4% | 22.8% | 24.6% | 10.3% | 28.7% | 13.8% |
| 2,500 to 4,999 | 9.6% | 17.3% | 19.7% | 14.3% | 28.3% | 23.7% |
| Under 2,500 | 4.0% | 11.6% | 13.0% | 14.5% | 25.2% | 36.6% |
| Total | 17.3% | 19.5% | 17.1% | 12.4% | 24.5% | 25.2% |

Source: Dr. John R. Hall, Jr., *A Second Needs Assessment of the U.S. Fire Service,* U.S. Fire Administration, October 2006

Percents in Table 2 are based on a survey response of 4,610 fire departments. Departments were asked to circle all that apply, so departments could select multiple responses. Percents may not add to totals due to rounding. (Hall, et al. 2006)

The table indicates which of several groups conduct fire-code inspections in the community. For communities of 50,000 population or more, at least 91% report the use of full-time fire department inspectors. The percentage drops to 74% for communities of 25,000 to 49,999 population. (Hall, et al. 2006)

The next most commonly cited resource for conducting fire-code inspections was in-service firefighters. About 70% of departments protecting communities of 1 million or more population cited the use of in-service firefighters. Then, 64% of communities of 500,000 to 999,999 population cited their use, falling to 46-54% for communities of 25,000 to 499,999. (Hall, et al. 2006)

Building department inspectors were cited by 4-25% of departments, and separate inspection departments were cited by 0-15%. “Other” inspectors – such as those from a state fire marshal’s office – were cited mostly by smaller communities and were the principal inspection resource for communities with less than 10,000 population. (Hall, et al. 2006)

Of greatest concern were the roughly 25.2% of respondents, which represents 6,900 fire departments and 20.3 million people, that reported no one conducted fire-code inspections in their community. Thirty-seven percent of the fire departments that reported no one conducted fire inspection in their community are departments that serve in rural communities (less than 2,500 population). (Hall, et al. 2006)

The 1978 NFPA/UI study found that cities which used fire-suppression companies for a large share of their regular fire-code inspections appeared to have substantially lower fire rates than cities that used full-time fire prevention bureau inspectors exclusively. This is most probably due to the fact that cities using full-time inspectors exclusively often did not have sufficient personnel to make annual inspections of all properties that are required by code to be inspected. Cities that used fire suppression companies usually had the needed personnel resources. (Hall, et al. 1978)

### *5.3.1 Self Inspection Programs*

Some Departments have instituted self inspection programs to meet the suggested goal of annually inspecting all occupancies. The self inspection program requires business-owner involvement in the inspection process. Business owners are responsible for checking their own occupancies for fire hazards and code compliance. It is hoped that by utilizing this method, compliance is met and business owners will be more educated in safety and have a greater incentive to maintain compliance in the future.

To measure the effectiveness of the self inspection program, the Department will need to keep an accurate and up to date record of those occupancies which qualify to be part of the self inspection program, when self inspection reports are sent out and returned, how many and who is sent reminder mailings and how many occupancies return their inspection compliance forms and checklists. To determine the number of occupancies that are in the self inspection program but not participating, subtract the number of responses from the number of mailings. These occupancies must be inspected by fire inspection personnel.

Also, quality controls should be set in place to ensure that business owners are actually complying with standards. A random sample of self inspecting occupancies should be selected and inspected by inspectors.

If the self inspection program is effective, Departments should have a 100% return rate for compliance forms and checklists. Also, all returned self inspection reports and checklists should be in compliance and inspectors should find no violations in the random sample of occupancies. It is important that inspectors follow up on violations or hazards noted on the self inspection forms.

### *5.3.2 Examples of Self Inspection Programs*

In 1979, Gwinnett County Georgia instituted a self inspection program in response to a cost effectiveness analysis of Department programs and complaints from business owners wanting minimal government supervision. New construction and places of public assembly were not included in the self inspection program and were inspected regularly by fire inspectors. At the time, Gwinnett County had 188 firefighters and 3,000 businesses operating within 440 square miles and a population of 150,000. (Self Fire Inspection 1980)

When the program was implemented, businesses were sent an open letter about the program, a one-page fire inspection checklist, and a two-page explanation sheet. Businesses had 30 days to complete and return the form and were warned that any falsification could result in a higher insurance classification for the business. If a fire occurred and was deemed attributable to bad housekeeping, business owners could be fined and sentenced to jail time. Fire departments performed a random sample quality control check of 85 self inspected businesses. They found about a dozen discrepancies which they deemed to be minor and mostly unintentional. For example, a business owner did not realize he needed a permit or that certain material was a fire hazard. (Self Fire Inspection 1980)

In 2007, Gwinnett County has grown to a population of 800,000 and still utilizes a self inspection program to ensure fire and life safety in businesses and local schools. In addition to this, a Community Risk Reduction Partnerships program was instituted to build partnerships within the business community and promote safety and self inspection programs. The Compliance Assistance Program which provides fire and emergency preparedness information to businesses. The Office of the Fire Marshal inspects all new construction and remodel construction, in compliance with laws and regulations that require specific fire inspections at various stages of construction. Each month the Office of the Fire Marshal conducts an average of over 700 new construction inspections. (OFM Gwinnett County 2007)

By implementing the self inspection program, Gwinnett County improved their ISO rating from class 5 to class 4. (Self-fire Inspection 1980) In 2007, Gwinnett County retains the class 4 ISO rating. (OFM Gwinnett County 2007)

Sumner Fire Department in Washington is a more recent example of a fire department with a self inspection program. In 1995, a self inspection program was implemented by the Department. The program targeted low hazard occupancies, or those occupancies which were deemed to have a lower life risk than other public occupancies. In 1998, approximately 700 occupancies that are required by code to be inspected. Of these 700 occupancies, 360 were part of a regular inspection program with inspections conducted by company-level inspectors. The remaining 340 occupancies were part of the self inspection program and therefore inspections were the responsibility of the business owner. To ensure the quality of self inspections, one quarter of these occupancies were also inspected by inspectors annually. All inspections occur between the hours of 8:00 a.m. and 5:00 p.m., Monday through Friday. (Fowler 1998)

Phoenix, Arizona is another example of a city that has an innovative approach to inspections by using public education seminars for local industry groups and a self inspection program for small business owners. According to a 1997 article in the *NFPA Journal*, the city of Phoenix utilizes fire company inspections along with a self inspection program for small businesses. The Phoenix Fire Prevention office goes by the name Urban Survival for Business and sponsors day-long seminars called Community Partnership. The goal of the partnership is to develop a working relationship between the fire department and business owners. (Scott 1997)

The Phoenix Fire Department's self inspection program for small businesses has a goal of reaching 25 businesses a week, or 1,300 a year. Fire prevention specialists deliver information packets, self inspection checklists, and "responsible party cards" to business owners and managers. (Scott 1997)

An effective self inspection program requires all participating business owners to be invested in code compliance. They must understand the need for compliance and what needs to be done to achieve compliance. Business owners must participate in the program if selected; those business owners that do not voluntarily participate must be removed from the self inspection program and be inspected by fire inspectors or company personnel. Quality controls should be set in place to ensure that business owners understand what constitutes compliance. Fire departments can check the quality of fire inspections by randomly selecting occupancies in the self inspection program that have submitted compliance reports, and re-inspecting the business to ensure compliance is being met. If the self inspection program is effective, all business owners will participate and there will be no violations or failures to comply in businesses that report full compliance.

*Update: The self inspection program in the City of Phoenix was discontinued due to the time and monetary costs of the program. It was found that Inspections could have been taking place in the time it was taking to distribute information to businesses and inspections were being conducted anyway, for those businesses that did not mail in their compliance forms.*

### *5.3.3 Examples of the Need for Quality Control. What's Being Missed in Inspections and How Can These Omissions Be Discovered?*

A random review of the 2003 inspection program was conducted in Indianapolis. The author visited 400 occupancies for inspection follow-up and found that 170 violations were originally found by and documented by inspectors. However, this number should have been 190 because 20 failures to comply were missed. Those categories missed the most were: emergency lights must be in working condition and directed to exit corridors and fire extinguishers must be annually inspected and properly displayed. (Bradley 2003)

In Boca Raton, the Assistant Chief is assigned to review all inspections performed by the division. Each new occupant is issued a list of inspection criteria, prior to an inspection. The author of the paper noted that even with prior notice, the same problems are repeated. Fire extinguishers not being the proper size or in the proper location or having expired inspection tags was the example cited as a recurring issue. The use of extension cords and improper use of electric devices is a major problem as well. (Johnson 2001)

## 5.4 Inspection Deficiencies Associated With Liability

Lack of inspection or negligent inspection practices can result in casualties and fire loss. When a fire occurs and inspection practices are found to be negligent, the fire or building inspector, Department, Fire Marshal, and municipality can be held liable. Tracking and abating violations is necessary to protect against claims of negligence. (Crawford 2002)

The Department, State, or municipality can be held accountable when a fire occurs as a result of conditions that would have been alleviated with appropriate inspection practices, failure to inspect, failure to seek correction for noncompliance, or failure to re-inspect.

### *5.4.1 Significant Court Cases*

In a 2001 Executive Leadership paper, Kenneth Wood outlined several important court cases cited in the IFSTA Manual *Fire Inspection and Code Enforcement*, which illustrates how courts waver on public agency immunity.

<u>Adams v. State, 555 P. 2nd 235 (1976)</u>

"A suit against the state was filed following a fire in a motel in which five people died. The State of Alaska had inspected the motel eight months before the fire and had failed to issue a letter to the owner citing the violations of the State Fire Safety Code, despite the fact that the inspector had indicated to his superior that the motel presented an "extreme life hazard." The Supreme Court of Alaska reversed and remanded for trial a lower court's granting of the state's motion for judgment on the pleading. The court ruled that the statute that immunized the state from tort claims arising out of failure to perform discretionary functions did not immunize the state from negligent failure to alleviate known fire hazards." (Wood 2001)

The Inspector failed to issue a letter regarding a violation. The State of Alaska was found at fault.

Coffey v. City of Milwaukee, 74 Wis. 2d526, 247 N.W. 2d 132 (1976)

"A tenant in an office building brought suit against the City of Milwaukee following a fire that damaged his tenant space. Despite arrival of the fire department in time to control and extinguish the fire, a defective standpipe was unable to furnish the necessary water to fight the fire. The building had been inspected, but the inspector had failed to either detect, or order the replacement of, the defective standpipe. The Supreme Court of Wisconsin affirmed a lower court ruling that overruled the city's and inspector's demurrers. It stated that the building inspections do not involve a "quasi-judicial" function within the meaning of governmental tort immunity statute and that the city could not claim it was merely performing a "public duty," because there was no distinction drawn between "public duty" and "special duty" owed to the tenant under the circumstances." (Wood 2001)

The Inspector failed to detect or order a replacement for defective standpipe. The City was found at fault.

Halvorsen v. Dahl, 89 Wash., 2d 673, 574 P. 2d. 1190 (1978)

"The Supreme Court of the State of Washington revised and remanded for trial a superior court dismissal charging liability against the City of Seattle following a hotel fire in which a man was killed. The court ruled that the Seattle housing code did impose special duty to those individuals who reside in buildings covered by the code, and that the city had long-term knowledge of violations of that code in the building and had undertaken to force compliance on several occasions but had not followed through." (Wood 2001)

A violation letter was sent, but there was no follow through taken to ensure correction. The City was found at fault.

Wilson v. Nepstad, 282 N.W., 2d, 664 (1979)

"Following an apartment fire in Des Moines, Iowa that involved deaths and injuries, a district court dismissed a municipal court tort claim action. The Supreme Court of Iowa reversed and remanded the case on the basis that certain statutes were intended to impose municipal tort liability for negligence based on a breach of statutory duty, in this case inspection of the property in a negligent manner and issuing an "inspection certificate" which by implication warranted the premises to be safe for the purposes of human habitation." (Wood 2001)

The issuance of an inspection certificate implied a safe habitat, which was not the case.

Thompson v. Waters 267PA99 NC (2000)

The Supreme Court of the State of North Carolina revised a ruling that Lee County, NC was protected under the Public Duty Doctrine, which says a public entity cannot be held liable for negligent performance. The Thompson Family's newly constructed home suffered cracks and stress factors due to structural defects. The family sued the home builder and Lee County for negligent inspections. The North Carolina Supreme Court held that the family could sue the County and that the North Carolina Public Duty Doctrine does not bar a homeowner's claim against a public entity for construction defects negligently overlooked by government inspectors. (Thelen, et. al 2001)

The government inspector is not immune to liability under the Public Duty Doctrine when construction defects are negligently overlooked.

Inspectors must correctly inspect a facility, issue a correction or cite a violation when one is found, follow through to ensure the violation is corrected by the building owner, and maintain records of when inspections were conducted, what violations were found, how this was dealt with by the owner and inspector, when and how the violations were corrected, what follow-through actions were taken and when, and when does the next inspection need to occur, for each occupancy.

## 5.5 Enforcement Styles and Persuasion Techniques

The 1978 NFPA/UI study found that there was no evidence that differences in fire rates are sensitive to other differences in inspection practices examined, such as preparation, assurance persuasion, and enforcement techniques. However, it recommended that Departments develop policies on the approach that inspectors should take in trying to educate and motivate property managers. (Hall, et al. 1978)

The following are findings from studies about the relationship between the Regulator and the Regulated/Regulatees.

### *5.5.1 A Study on the Attitudes and Behaviors of Municipal Fire Protection Personnel In Relation To Prevention Effectiveness*

Philip Coulter performed an analysis on the organizational effectiveness of municipal fire protection and found that attitudes and behaviors of an organization's members and the internal processes of the organization may contribute to effectiveness but should not be confused with it. Organizational effectiveness refers to effectiveness in terms of goal achievement, or the extent to which the fire service avoids or reduces property loss, death, and injury due to fire.  Coulter measures prevention effectiveness by number of fires per 1,000 population. (Coulter 1979)

Data was analyzed for 324 municipalities with populations of 25,000 or greater.  Cities were scored on each measure and grouped into four quartiles, to eliminate the instability of the extreme variability in fire incidents and fire loss that can occur year to year. Coulter found that the most effective cities are low-hazard cities that have relatively large land area and high social class, better trained inspectors and fewer full-time, paid fire fighters. (Coulter 1979)

Coulter's analysis does not take into account that fire prevention and code compliance is intended to protect against unintentional fires, those fires that are not purposely set, or reduce fire spread.  Also, fire code inspections do not take place in one- and two-family dwellings.  Including these fires in the inspection effectiveness calculations is inappropriate.  Still, it is possible that Coulter's findings would still be applicable if effectiveness measures were re-calculated in his study.

### *5.5.2 Constituent Interaction Case Study: Inspectors and Homebuilders*

The interactions between inspectors and homebuilders and inspectors' enforcement styles are examined in a study by May and Wood.  The authors define enforcement style as the character of the day-to-day interactions of inspectors when dealing with representatives of regulated entities.  Enforcement styles can be facilitative, or consultant-like, by using a friendly approach or they can be formalistic, using a more strict, reserved or legalistic approach. (May and Wood 2003)

From their survey of homebuilders and observations of inspectors in the field, the authors found that both homebuilders and inspectors view compliance as a means for quality control and 84% of homebuilders viewed their relationship with inspectors as somewhat or very cooperative.  There was no effect found for inspection style on compliance, which the authors noted as puzzling, but suspect that this is due to inconsistency of homebuilders' interactions with inspectors. (May and Wood 2003)

Homebuilders prefer to have a single inspector for the duration of the project (May and Wood 2003).  May and Wood also found that repeated interactions and consistent signals are needed to ensure shared expectations about compliance.  This may have implications for fire inspection programs, suggesting the building owners might prefer to have the same inspector that has cited violations to conduct re-inspections.  This could encourage uniform enforcement and future compliance.

Homebuilders' awareness and knowledge of code requirements has a positive impact on voluntary compliance.  Home builders' compliance is highest when cooperation and knowledge are high, and lowest when cooperation is high, but knowledge is low (May and Wood 2003).  This may suggest that the education programs implemented by fire departments are more effective at meeting compliance than fire prevention programs without an educational component.  In the homebuilders' study, builders that reported high levels of code knowledge and reported inspectors were cooperative had the fewest code deficiencies. (May and Wood 2003)

Homebuilders' knowledge of the rules was positively influenced by a formal enforcement style, yet it has its limits. The authors found that those inspectors with high scores of formalism had a statistically indeterminate effect on the homebuilders' knowledge. A Facilitative style was not found to have an influence on the homebuilders' knowledge of the rules; however it does have a positive influence in fostering cooperation. The formal inspection style has a negative influence on fostering cooperation (May and Wood 2003). In other words, homebuilders' are more likely to cooperate with an inspector that uses a consultant-like, friendly approach to inspections, yet appear to learn more when the inspector uses a formal, more legal approach.

This may imply that the consultant-like approach with strict guidelines and follow-through associated with the self inspection program may be an effective way of gaining compliance. It may also reduce similar violations in future inspections of the same individuals due to educating them on the reason for the violation.

### *5.5.3 Occupancy Interaction Case Study: American Regulation in Nursing Homes*

Braithwaite, Makkai, and Braithwaite examined nursing home inspections and regulation in the U.S. in their book, *Regulating Aged Care: Ritualism and the New Pyramid*. Through their research, the authors found that the U.S. regulatory strategy is greatly diverse, or as they term it, "a regulatory mosaic." (Braithwaite, et al. 2007)

Previous studies of the nursing home regulation in the U.S. concluded that there was a dichotomy of deterrence regulation versus compliance regulation. Braithwaite, et al. confirmed this finding in their own research. They expanded the conclusions to say that the dichotomy would be better explained as deterrence regulation versus consultancy. (Braithwaite, et al. 2007)

The authors pointed out that praise, by the inspectors, for success or strengths is the most important communication and that they did not see a U.S. inspection where at some point some informal praise was not expressed. (Braithwaite et. al. 2007)

In *Regulatory Styles, Motivational Postures and Nursing Home Compliance*, by Braithwaite, Braithwaite, Gibson, and Makkai, Australian directors of nursing homes and inspection teams were surveyed to examine perceptions of regulators and of regulatees and to predict compliance with nursing home quality of care standards. (Braithwaite, et al. 1994)

Similarly to the 1978 NFPA/UI findings, this study failed to find that certain kinds of regulatory strategies, i.e. deterrence versus education, work better than others. However, answers to the question "Do regulators associate different enforcement strategies with different perceptions of the nursing home director?" the findings were interesting.

Giving management advice and educating nursing home directors in what standards meant were the most commonly recommended strategies by inspection teams, while persuading that the standards are in the best interests of residents and getting tough were considered less necessary. (Braithwaite, et al. 1994)

## 6. What Characteristics of Properties Can Be Measured as Evidence of Inspection Effectiveness?

In the UK, quality is essentially a measure of effectiveness, in terms of final outcomes. The UK Centre for the Measurement of Government Activity recommends that the quality of the fire prevention program can be measured by the amount of awareness raised, changes in behavior, and reduction in the number of fires started. (National Statistics 2007)

There is a wide variation in inspection practices across the country. The town adopts codes and standards into law. It is up to the fire department to establish procedures for inspecting property. Departments can decide what type of inspections will be performed (e.g., inspections on new construction, inspections of existing buildings), who performs inspections (e.g., fire-suppression personnel, fire inspectors), how inspections are conducted (e.g., checklists, handheld palm pilots, self inspections), the frequency of inspections (e.g., staggering inspections, prioritizing inspections based on fire risk), and enforcement styles (e.g., deterrence, consultant-like approach) to name a few areas.

Regardless of the variations or the methods chosen by the fire department for conducting fire inspections, ultimately, the intended outcomes remain the same: corrected conditions of hazards that posed a threat to life and property, based on legally adopted code requirements, and motivated owners and building managers that are educated as to hazards and proper methods for prevention. All of which result in a reduction in the number of fires within the community.

## 7. Inspection Variables Matrix

The following matrix identifies important variables related to inspections. The purpose of this matrix is to identify gaps in the literature and research. A score has been assigned to each variable in order to rate both the availability of literature about the variable and the relevance of the variable to this project.

Literature availability was measured by the quantity of appropriate literature and research on the inspection variable. Inspection variable relevance was measured by the appropriateness of the variable to the goals and questions of the research project. Literature and research was collected from the National Fire Protection Association's Charles S. Morgan Library catalog, the U.S. Fire Administration's Learning Resource Center catalog, the Journal of Public Administration Research and Theory website, Journal Storage (JSTOR), Gale Infotrac, Google, and Google Scholar.

Literature and research is sparse in those variables with a rating of "medium" or "low or no." Further research is recommended for those variables with a low or no rating in literature availability, such as the best practices for conducting inspections or guidelines for conducting effective inspections.

**Table 3. Inspection Variables Matrix**

| | Definitions and subtopics | Availability in literature | Relevant to project |
|---|---|---|---|
| **Prevention** | | | |
| Codes and standards | Literature about fire codes and what the code says | High | Very |
| | Literature about building codes and what the code says | High | Somewhat |
| | Analysis of the code's effectiveness in prevention or inspection effectiveness by type of code used | Low or No | Mostly |
| Fire safety culture | Literature about attitudes towards fire prevention | Medium | Somewhat |
| **Inspections** | | | |
| Definition of inspectable properties | Literature about the types of properties that require inspection under the code | High | Very |
| Inspection type | Literature about inspection requirements and procedures in new construction, routine inspection, renovations, and complaint response | Medium | Very |

**Table 3. Inspection Variables Matrix**
**(Continued)**

| | | | |
|---|---|---|---|
| Inspection procedures/protocol | Literature about standard inspection procedures in codes and standards | High | Somewhat |
| | Literature on the best practices for conducting inspections | Low or No | Very |
| | Literature on guidelines for conducting an effective inspection | Low or No | Very |
| Training | Literature on inspector training and qualifications in codes and standards | High | Somewhat |
| | Literature on training techniques that result in effective inspections | Low or No | Very |
| Inspection philosophy | Literature on enforcement styles used by inspectors | Low or No | Mostly |
| | Literature on enforcement techniques that promote effective inspections | Low or No | Very |

**Table 3. Inspection Variables Matrix**
**(Continued)**

| | | | |
|---|---|---|---|
| Psychology involved in inspections | Literature about the relationship between the regulator and regulated | Low or No | Somewhat |
| | Literature about attitudes and behaviors of inspectors and business owners as they relate to inspection effectiveness | Low or No | Very |
| Communication/public education | Literature on education techniques used by fire prevention departments | Medium | Somewhat |
| | Literature on education techniques and correlation to effective inspections | Low or No | Very |
| Liability | Literature on legal cases and rulings relating to inspections and inspectors | High | Mostly |
| | Literature on fire experience or major fires and the aftermath of such events | High | Mostly |

**Table 3. Inspection Variables Matrix
(Continued)**

| | | | |
|---|---|---|---|
| Software/technology | Literature about the products or software available to fire prevention departments | Medium | Somewhat |
| | Literature about the products or software used by fire prevention departments | Low or No | Mostly |
| | Literature about products and software use and its correlation to inspection effectiveness | Low or No | Very |
| **Measures** | | | |
| Efficiency | Literature about efficiency measures related to fire inspections | Medium | Mostly |
| Productivity | Literature about productivity measures related to fire inspections | Medium | Mostly |
| Workload | Literature about workload measures related to fire inspections | Medium | Mostly |
| Effectiveness | Literature about effectiveness measures | Medium | Somewhat |
| | Literature about effectiveness measures related to fire inspections | Low or No | Very |

## Summary of Literature Review

The main purpose of a fire related portions of code compliance inspection program is to discover and correct conditions that pose a threat to life and property, based on legally adopted code requirements, and to motivate owners and building managers to prevent future hazards by educating them as to the hazards and proper methods of prevention.

In 2002-2005, an estimated annual average of 519,000 structure fires were reported to municipal fire departments. These fires resulted in an average of 3,140 civilian fire deaths, 15,520 civilian fire injuries and an estimated $8.7 billion in direct property loss, annually. Approximately 10-25% of these structure fires, less than 5% of deaths, less than 10% of injuries, and 20-30% of property damage occurred in areas in buildings subject to fire-code inspections.

Fire inspections can be categorized into three types, (1) inspections of newly constructed buildings, (2) inspections of existing buildings undergoing renovations, and (3) inspections of existing buildings for routine safety checks.

Regularly inspecting every inspectable property, maintaining a complete and accurate list of properties considered inspectable, and using fire-suppression companies for a large share of regular fire related portions of fire-code inspections are all characteristics of inspections that are associated with effectiveness and success.

Fire risk estimates can be used to prioritize occupancy inspections. There are many different approaches to evaluating the associated fire risk, and assumptions must be made as to what variables increase or decrease the chance of fire or the life-hazard that can take place when a fire occurs. St. Paul, Boulder, and Austin are a few examples of Departments that use, or have used, some method of calculating fire risk.

If a department allocates inspection efforts based on risk ratings, they will need to have an estimate of the time and other resources required, on average, per inspection so that they know when they have exhausted their resources as they allocate inspections on a priority basis. There are different ways of estimating how many inspectors are needed. One method includes estimating the number of hours an inspector has available to inspect compared to the estimated amount of time each inspection will take. Another method uses estimates on the number of inspections an inspector can conduct per day, week, or year based on observations of other inspectors. TriData has estimated that a full-time inspector can conduct at least four to six inspections on average per day using manual reporting systems, based on previous audits of various fire departments. This is an average of between 800 to 1,000 inspections per year.

Some departments have instituted self inspection programs to both meet the recommendation of annually inspecting all occupancies and as a method of educating business owners about hazards and the proper methods of prevention. The self inspection program requires that business owners be responsible for checking their own occupancies for fire hazards and code compliance.  Gwinnett County (GA) and Phoenix (AZ) are two examples of departments that utilize, or have utilized a self inspection program.

In 2006, a needs assessment of the U.S. Fire Service found that 25.2% responding fire departments reported that no one conducts fire-code inspections within their communities.  As a result, an estimated 20.3 million people, or 7% of the population, live in communities where no one conducts fire-code inspections.

Lack of inspection or negligent inspection practices can result in casualties and fire loss. When a fire occurs and inspection practices are found to be negligent, the fire or building inspector, department, fire marshal, and municipality can be held liable.  Tracking and abating violations is necessary to protect against claims of negligence.

An Inspector's enforcement style or persuasion techniques can impact compliance and the mitigation of hazards. *At the Regulatory Front Lines: Inspectors' Enforcement Styles and Regulatory Compliance*, a study about the interactions between fire inspectors and homebuilders, suggests that a consultant-like approach with strict guidelines and follow-through associated with the self inspection program may be an effective way of gaining compliance.  It may also reduce similar violations in future inspections of the same properties due to educating them on the reason for the violation.

*Regulatory Styles, Motivational Postures and Nursing Home Compliance,* a study about nursing home regulations and inspections, came to similar conclusions as the 1978 NFPA/UI study.  This study failed to find that certain kinds of regulatory strategies, i.e. deterrence versus education, work better than others.  However, answers to the question "Do regulators associate different enforcement strategies with different perceptions of the nursing home director?" the findings were interesting.  Giving management advice and educating nursing home directors in what standards meant were the most commonly recommended strategies by inspection teams, while persuading that the standards are in the best interests of residents and getting tough were considered less necessary.

There is wide variation in inspection practices across the country.  The codes and standards are adopted into law, typically with state or local amendments not provided in the model code.  It is up to the fire department, or anyone under any auspices in support of a defined set of fire related requirements, to establish procedures for inspecting property.  Departments can decide what type of inspections will be performed (e.g., inspections on new construction, inspections of existing buildings), who performs inspections (e.g., fire-suppression personnel, fire inspectors), how inspections are conducted (e.g., checklists, handheld electronic devices, self inspections), the frequency of inspections (e.g., staggering inspections, prioritizing inspections based on fire risk), and enforcement styles (e.g., deterrence, consultant-like approach) to name a few areas.

In the UK, quality is essentially a measure of effectiveness, in terms of final outcomes. The UK Centre for the Measurement of Government Activity notes that the quality of the fire prevention program can be measured by the amount of awareness raised, changes in behavior, and reduction in the number of fires started.

Regardless of the variations or the methods chosen by the fire department for conducting fire inspections, ultimately, the intended outcomes remain the same: corrected conditions of hazards that posed a threat to life and property, based on legally adopted code requirements, and motivated owners and building managers that are educated as to hazards and proper methods for prevention. All of which result in a reduction in the number of fires within the community.

# Appendix A: Formulas and Calculations

## Austin, Texas-Risk Calculation

*The following is an excerpt from the article "Formula for Success" by Kevin Baum. This article was originally published in NFPA Journal November/December 2002. Formulas are discussed in section 4.1.1 of the literature review.*

### Understanding risk

As we dug into the problem, we noted that our approach to choosing the structures for which we'd conduct in-service inspections was inconsistent, emphasizing quantity rather than quality. This led us to reevaluate our occupancy types, focusing on them in a logical fashion so we could coherently justify our choices and measure our results statistically.

To evaluate occupancy types, we first had to define their risk levels. To do this, we had to develop a consistent model of risk we could apply to historical incident data and sort using NFIRS coding. This would provide a relative-risk indicator by multiplied by the number of casualties these fires caused, plus the amount of dollar loss they generated. As a mathematical formula, this concept of relative risk looks like this:

$$R=F*C$$

Where "R" is the risk of fire; "F" is the frequency, or number, of fires; times "C," the consequence of the fires, or the number of casualties plus the dollar loss.

Each time we ran the model, we calculated the consequences by property use. For example, the total number of fires in one- and two-family residences for the reporting period--usually a year—was multiplied by the number of fatalities in that property type as a percent of overall fire fatalities in all property types, plus the total dollar loss in that property type as a percent of total fire-related dollar loss in all properties.

This model produced some interesting results. We've known for years, based on national studies, that more people die in fires in their one- and two-family homes than in any other type of occupancy. The occupancy in Austin. Here was a clear a road map for our inspection efforts.

Based on these data, we redirected the entire focus of the in-service inspection program to multifamily occupancies. Today, the AFD inspects more than 10,000 apartment buildings each year, and we inspect every such occupancy within the city limits over the course of two years.

### Measuring inspection effectiveness

In 2000, we realized that, if our relative risk formula provided a risk value for each property type, we could follow that value over time for our target occupancies and **see** whether it dropped, thus suggesting a positive influence. After careful consideration, we developed the following formula:

$$R=F(C)+F(D)/P$$

# Appendix A: Formulas and Calculations (Continued)

Where "R" is risk, "F(C)" is frequency of fires times the number of casualties, "F (D)" is the frequency of fires times dollar loss in millions divided by "P," is population in thousands.

Frequency in this model is the number of fires in a specific property class for a specific period. Consequence is the same as it is in the relative-risk formula, but we don't calculate percentage of consequence as a value of the overall fire experience in the city. We simply calculate the specific number of casualties and the specific amount of dollar loss, adjusted for inflation, in the population of occupancies in that category.

We further enhanced our previous model by normalizing the data with a population divisor. Austin has experienced incredible economic growth in the last 10 years, and the population has increased in lockstep with the booming economy. By normalizing the data with a population divisor, we effectively account for increases or decreases in at-risk occupancies and occupants.

There are three ways to infer inspection success from these data. Does the risk value decrease over time while the number of fires remains constant or increases? Does the risk value remain constant while the number of fires increases? Or do the risk value and the fire frequency decrease, while the population increases?

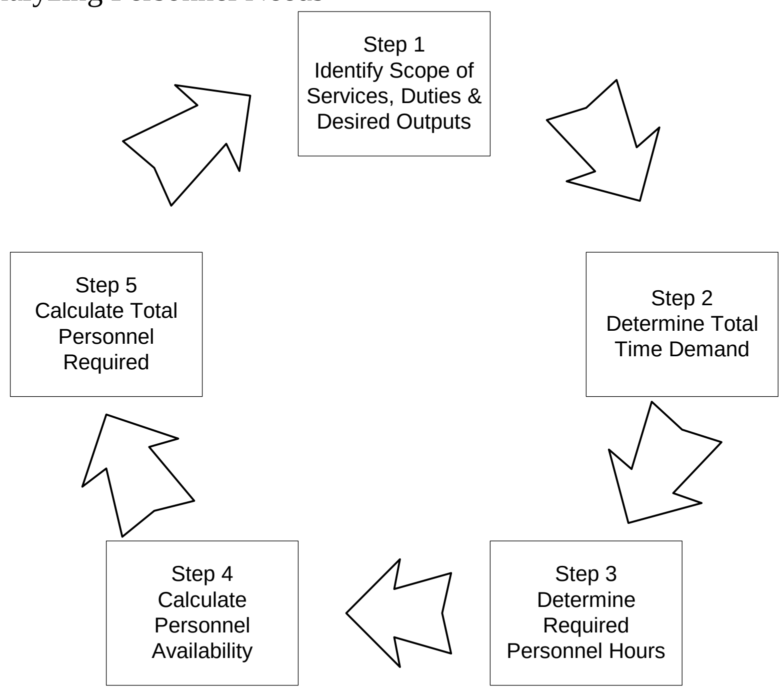
As you can see, these data don't penalize based on fire ignitions. Rather, the data propose to measure the magnitude, in terms of casualties and dollar loss, of hostile fires over time in at-risk occupancies, based on our assumption that hostile fires will occur and that effective inspection efforts will produce a decrease in the magnitude of damage they cause over time, as represented by the risk value.

# Appendix A: Formulas and Calculations (Continued)

## NFPA 1201: Standard for Providing Emergency Services to the Public

*This model has been extracted from NFPA 1201 to show the process for analyzing personnel needs. It is discussed in Section 4.2 of this literature review.*

Process for Analyzing Personnel Needs




*Step 1. Scope of Services, Duties and Desired Outputs.* Identify the services and duties that are performed within the scope of the organization. Outputs should be specific, measurable, reproducible and time limited. Among the elements may be:

- Administration
- Data collection, analysis
- Delivery
- Authority/responsibility
- Roles/responsibilities
- Local variables
- Budgetary considerations
- Impact of risk assessment

*Step 2. Time Demand.* Quantify the time necessary to develop, deliver and evaluate various services and duties identified in Step 1.

- Local nuances
- Resources that impact personnel needs

# Appendix A: Formulas and Calculations (Continued)

| Task | Time per task | Total time required |
|---|---|---|
| | | |

*Step 3. Required Personnel Hours.* Based on Step 2 and historical performance data, convert the demand for services to annual personnel hours required for each program. Add any necessary and identifiable time not already included in the total performance data.

- Development/preparation
- Service
- Evaluation
- Commute
- Prioritization

| Task | # Task | Time per task[1] | Task commute time | Other[2] | Total |
|---|---|---|---|---|---|
| | | | | | |

[1] includes preparation/site/research/follow-up/report
[2] includes personnel functions/admin functions/interruption time/prioritization

*Step 4. Personnel Availability and Adjustment Factor.* Average personnel availability shall be calculated.

- Holiday
- Jury duty
- Military leave
- Annual leave/vacation
- Training
- Sick leave
- Fatigue/delays/other

Example - Average personnel availability is calculated for holiday, annual and sick leave per personnel member:

— Annual hours at 100% availability (__ hr/wk x 52 wk/yr)
(hrs per year per person) ______

— Less annual leave and holiday (__ days per yr at _ hrs per day) ______

— Less estimated sick leave (average _ days per yr at _ hrs per day) ______

— Less annual training (__ days per yr at _ hrs per day) ______

# Appendix A: Formulas and Calculations (Continued)

Personnel Hours Subtotal (hrs per year per person) ______

— Times uncertainty factor at __% x __ = ______

Total available hours (hrs per year per person) ______

*Step 5. Calculate Total Personnel Required.* Division of the unassigned personnel hours by the adjustment factor will determine the amount of personnel (persons/yr) required. Any fractional values may be rounded up or down to the next integer value. Rounding up provides potential reserve capacity; rounding down means potential overtime or assignment of additional services conducted by personnel. (Personnel may include personnel from other agencies within the entity, community, private companies or volunteer organizations.)

Correct calculations based on

- Budgetary validation
- Rounding up/down
- Determining reserve capacity
- Non-personnel resources impact on personnel (materials, equipment, vehicles)

$$\frac{\text{Total demand hours}}{\text{Adjustment Factor}} = \text{Personnel positions}$$

# Appendix B: Training and Certification

## Training and Certification

Each model code organization offers some type of training or certification programs for code enforcement personnel for code familiarity and criteria for inspection experience. (Crawford 2002)

## NFPA 1031: Standard for Professional Qualifications for Fire Inspector and Plan Examiner, 2003 Edition

The 2003 edition of NFPA 1031, *Standard for Professional Qualifications for Fire Inspector and Plan Examine*, was prepared by the NFPA Technical Committee on Fire Inspector Professional Qualifications.

This standard identifies the professional levels of performance required for fire inspectors and plan examiners, specifically identifying the job performance requirements necessary to perform as a fire inspector or a plan examiner.  NFPA 1031 defines three levels of progression for fire inspectors and two levels of progression for plan examiners.  The following job performance requirements have been taken directly from the NFPA 1031 Codebook.

### *Fire Inspector I*

The Fire Inspector I should prepare correspondence and inspection reports, handle complaints and maintenance of records, as well as participate in legal proceedings and maintenance of open dialogue with the plan examiner and emergency response personnel according to the following job performance requirements. (NFPA 1031)

- Prepare inspection reports, given observations from field inspection, so that report is clear and concise and accurately reflects the findings of the inspection in accordance with applicable codes and standards.

- Recognize the need for a permit, given a situation or condition, so that requirements for permits are communicated in accordance with the policies of the jurisdiction.

- Recognize the need for plan review, given a situation or condition, so that requirements for plan reviews are communicated in accordance with the policies of the jurisdiction.

- Investigate common complaints, given a reported situation or condition, so that complaint information is recorded, the AHJ-approved process is initiated, and the complaint is resolved.

## Appendix B: Training and Certification (Continued)

- Identify the applicable code or standard, given a fire protection, fire prevention, or life safety issue, so that the applicable document, edition, and section are referenced.

- Participate in legal proceedings, given the findings of a field inspection or a complaint and consultation with legal counsel, so that all information is presented accurately and the inspector's demeanor is professional.

- Perform field inspections of new and existing structures and properties for construction, occupancy, fire protection, and exposures.

- Identify the occupancy classification of a single-use occupancy, given a description of the occupancy and its use, so that an accurate classification is made according to the applicable codes and standards.

- Compute the allowable occupant load of a single-use occupancy or portion thereof, given a detailed description of the occupancy, so that the calculated allowable occupant load is established in accordance with applicable codes and standards.

- Inspect means of egress elements, given observations made during a field inspection of an existing building, so that means of egress elements are maintained in compliance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Verify the type of construction for an addition or remodeling project, given field observations or a description of the project and the materials being used, so that the construction type is classified and recorded in accordance with the applicable codes and standards and the policies of the jurisdiction.

- Determine the operational readiness of existing fire detection and alarm systems, given test documentation and field observations, so that the systems are in an operational state, maintenance is documented, and all deficiencies are identified, documented and reported in accordance with the policies of the jurisdiction.

- Recognize hazardous conditions involving equipment, processes, and operations, given field observations, so that the equipment, processes, or operations are conducted and maintained in accordance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

## Appendix B: Training and Certification (Continued)

- Compare an approved plan to an existing fire protection system, given approved plans and field observations, so that any modifications to the system are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Verify that emergency planning and preparedness measures are in place and have been practiced, given field observations, copies of emergency plans, and records of exercises, so that plans are prepared and exercises have been performed in accordance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Inspect emergency access for an existing site, given field observations, so that the required access for emergency responders is maintained or so that deficiencies are identified, documented, and corrected in accordance with the applicable codes, standards, and policies of the jurisdiction.

- Verify code compliance for incidental storage, handling, and use of flammable and combustible liquids and gases, given field observations and inspection guidelines from the authority having jurisdiction, so that applicable codes and standards are addressed and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Verify code compliance for incidental storage, handling and use of hazardous materials, given field observations, so that applicable codes and standards for each hazardous material encountered are addressed and all deficiencies are identified, and reported in accordance with the policies of the jurisdiction.

- Recognize a hazardous fire growth potential in a building or space, given field observations, so that the hazardous conditions are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Determine code compliance, given the codes, standards, and policies of the jurisdiction and a fire protection issue, so that the applicable codes, standards, and policies are identified and compliance determined.

- Verify fire flows for a site, given fire flow test results and water supply data, so that required fire flows are in accordance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- There are no plan review job performance requirements for Fire Inspector I.

# Appendix B: Training and Certification (Continued)

## *Fire Inspector II*

The Fire Inspector II should perform the duties of a Fire Inspector I in addition to the following job performance requirements. (NFPA 1031)

- Conduct research, interpret codes, implement policy, testify at legal proceedings, and create forms and job aids.

- Process a permit application, given a specific request, so that the application is evaluated and a permit is issued or denied in accordance with the applicable codes, standards, policies, and procedures or the jurisdiction.

- Process a plan review application, given a specific request, so that the application is evaluated and processed in accordance with the applicable policies and procedures of the jurisdiction.

- Investigate complex complaints, given a reported situation or condition, so that complaint information is recorded, the investigation process is initiated, and the complaint is resolved.

- Recommend modifications to codes and standards of the jurisdiction, given a fire safety issue, so that the proposed codes and standards are correctly written and address the problem, need, or deficiency.

- Recommend policies an procedures for the delivery of inspection services, given management objectives, so that inspection are conducted in accordance with the policies of the jurisdiction and due process of the law is followed.

- Perform field inspections. This duty involves code enforcement inspections and analyses of new and existing structures and properties for construction, occupancy, fire protection, and exposures.

- Compute the maximum allowable occupant load of a multi-use building, given field observations or a description of its uses, so that the maximum allowable occupant load calculation is in accordance with applicable codes and standards.

- Identify the occupancy classifications of a mixed-use building given a description of the uses, so that each area is classified in accordance with applicable codes and standards.

# Appendix B: Training and Certification
# (Continued)

- Determine the building's area, height, occupancy classification, and construction type, given an approved plan, a description of a building, or observations of construction features, so that they are in accordance with the applicable codes and standards.

- Evaluate fire protection systems and equipment provided for the protection of life safety, a building, or a facility and documentation, the hazards protected, and the system specifications, so that the fire protection systems provided are approved for the occupancy or hazard being protected. Evaluate installation for compliance with applicable codes and standards so that deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Analyze the egress elements of a building or portion of a building, given observations made during a field inspection, so that means of egress elements are provided and located in accordance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Evaluate hazardous conditions involving equipment, processes, and operations, given field observations and documentation, so that the equipment, processes, or operations are installed in accordance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Evaluate code compliance for the storage, handling, and use of hazardous materials, given field observations, so that applicable codes and standards for each hazardous material encountered are properly addressed and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Determine fire growth potential in a building or space, given field observations or plans, so that he contents, interior finish, and construction elements can be evaluated for compliance with applicable codes and standards and all deficiencies are identified, documented, and corrected in accordance with the policies of the jurisdiction.

- Inspect emergency access for a site, given field observations, so that the required access for emergency responders is provided, approvals are issued, or deficiencies are identified, documented, and corrected in accordance with the applicable codes, standards, and policies of the jurisdiction.

- Verify compliance with construction documents, given a performance-based design, so that life safety systems and building services equipment are installed, inspected, and tested to perform as described in the engineering documents and the operations and maintenance manual that accompanies the design, so that all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Conduct plans review. This duty involves field verification of shop drawings, plans, and construction documents to ensure that they meet the intent of applicable codes and standards for fire and life safety.

- Classify the occupancy type, given a set of plans, specifications, and a description of a building, so that the classification is made according to applicable codes and standards.

- Compute the maximum allowable occupant load, given a floor plan of a building or portion of the building, so that the calculated occupant load is in accordance with applicable codes and standards.

- Review the proposed installation of fire protection systems, given shop drawings and system specifications for a process or operation, so that the system is reviewed for code compliance and stalled in accordance with the approved drawings and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Verify that means of egress elements are provided, given a floor plan of a building or portion of a building, so that all elements are identified and checked against applicable codes and standards and any deficiencies are discovered and communicated in accordance with the policies of the jurisdiction.

- Verify the construction type of a building or portion thereof, given a set of approved plans and specifications, so that the construction type complies with the approved plans and applicable codes and standards.

## *Fire Inspector III*

The Fire Inspector III should perform the duties of a Fire Inspector II in addition to the following job performance requirements. (NFPA 1031)

- Make recommendation, create, and evaluate policies and procedures for fire safety inspections and code enforcement activities.

# Appendix B: Training and Certification (Continued)

- Generate written correspondence related to the issuance of appeals, given a request for an appeal, so that the resulting document clearly addresses the issue and is appropriate for the intended audience.

- Facilitate code adoption and modification processes, given fire loss data and a demonstrated need or deficiency, so that the code is correctly written and precisely addresses the identified need or deficiency.

- Assess the impact of proposed codes, ordinances, and other legislation, given draft documents, so that the impact of the proposal on fire safety and code enforcement activities is documented.

- Develop policies and procedures for the administration of inspection functions, given management objectives, so that the policies are clearly defined and concise and in accordance with the legal obligations of the jurisdiction.

- Suggest technical reference material acquisition, given a scope of responsibility, budget limitations, and specific code related issues, so that resources matching specific needs are acquired within budget limitation.

- Enforce permit regulations, given a report of a violation, so that enforcement actions are in accordance with the policies of the jurisdiction and applicable codes and standards.

- Initiate legal action related to a fire code violation, given a description of a violation and a legal opinion, so that the action taken is in accordance with the policies of the jurisdiction and due process of law is followed.

- Recommend a program budget, given organizational goals, budget guidelines, and organizational needs, so that overall program needs are addressed within budget guidelines.

- Evaluate the completion and correctness of inspection reports and completed forms and checklists, given applicable codes, standards, policies, and procedures of the jurisdiction, so that the information contained in the reports, forms, and checklists is correct, clear, and concise and key issues are addressed in compliance with applicable codes, standards, and policies.

- Perform field inspection. This duty involves analysis of code compliance alternatives; evaluation of construction occupancy fire protection and exposures; and emergency planning.

## Appendix B: Training and Certification (Continued)

- Assess alternative methods to adjust occupant loads, given a description of an area, building, or portion of a building and its intended use, so that the occupant load is in accordance with applicable codes and standards.

- Evaluate corrective measures, given a list of means of egress deficiencies in a building and the proposed correction, so that each deficiency and its proposed correction are evaluated for compliance with applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Evaluate the construction type required for an addition or remodeling project, given a description of the building and its use, so that the construction type is evaluated based on applicable codes and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

- Evaluate alternative protection measures of equipment, operations, and processes, given deficiencies noted during a field inspection of a facility and proposed alternative methods, so that the equipment, process, or operation is provided with a level of protection that is in compliance with the intent of applicable codes and standards.

- Evaluate fire protection plans and practices, given a field report describing a facility housing a complex process or operation, so that the fire growth potential for all areas is determined, the level of protection is appropriate to the hazard, and applicable codes and standards are met.

- Recommend criteria for the development of emergency planning and procedures, given a description of a building and its use, so that plans and procedures are in compliance with applicable codes and standards.

- Evaluate alternative compliance measures for the storage, handling, and use of hazardous materials, given field inspection reports and proposed alternative compliance measures, so that he hazardous materials are provided with a level of safety that is in compliance with the intent of applicable codes and standards.

- Evaluate alternative compliance measures for the storage, handling, and use of flammable or combustible liquids and gases, given field inspection reports and proposed alternative compliance measures, so that the storage, handling, and use is provided with a level of safety that is in compliance with the intent of applicable codes and standards.

# Appendix B: Training and Certification (Continued)

- Verify code compliance of heating, ventilation, air conditioning, and other building service equipment and operations, given field observations, so that the systems and other equipment are maintained in accordance with applicable cods and standards and all deficiencies are identified, documented, and reported in accordance with the policies of the jurisdiction.

## Volume I References

Baum, Kevin, Formula for Success, *NFPA Journal*, November/December 2002, pg 66

Bradley, Stephen, *Efficiency of Fire Inspections Conducted by Fire Companies,* EFO Paper, June 2003

Braithwaite, V., Braithwaite, J, Gibson, D, & Makkai, T, Regulatory Styles, Motivational Postures and Nursing Home Compliance, *Law & Policy*, Vol. 16, No. 4, October 1994

Braithwaite, Makkai, and Braithwaite, *Regulating Aged Care: Ritualism and the New Pyramid*, 2007

Building Construction and Safety Code Handbook NFPA 5000, Robert E. Solomon P.E. & Gregory Harrington, P.E. 2003 edition, pp 11-12

Cote, Arthur, *Fundamentals of Fire Protection*, Quincy, MA 2004

Coulter, Philip, Organizational Effectiveness in the Public Sector: The Example of Municipal Fire Protection, *Administrative Science Quarterly*, Vol. 24, No. 1 (March 1979), pp. 65-81

Crawford, Jim, *Fire Prevention a Comprehensive Approach,* Prentice Hall, NJ 2002

Donner, L.D., (1997, April). A Better Way to Manage Company Functions. *Fire Chief*, 100-104.

Fowler, John F., June 1998, *Sumner Fire Department: The Efficiency and Effectiveness of a Company-level Inspection Program*, Strategic Management of Change

Hall, et al., *Fire Code Inspections and Fire Prevention: What Methods Lead to Success?,* National Fire Protection Association & Urban Institute (NFPA/UI), 1978

Hall, et al., *Four Years Later-A Second Needs Assessment of the U.S. Fire Service*, USFA and NFPA, October 2006

Jee, J. Mark, *Use of Fire Suppression Personnel In Conduction Fire Code Enforcement Inspections: An Effective Approach*, EFO paper, November 1999.

Johnson, J.A., *Evaluating the Boca Raton Fire Rescue Services Standard for Fire Safety Inspections of Commercial Occupancies*, EFO paper, November 2001.

May, Peter J., Regulatory Regimes and Accountability, *Regulation & Governance* (2007) 1, pp 8-26

## Volume I References
## (Continued)


May, Peter J. & Wood, Robert S., At the Regulatory Front Lines: Inspectors' Enforcement Styles and Regulatory Compliance, *Journal of Public Administration Research and Theory,* Vol. 13, no. 2, pp. 117-139

National Statistics, UK Centre for the Measurement of Government Activity, *Measuring Quality as Part of Public Service Output*, July 2007

NFPA 1031-Standard for Professional Qualifications for Fire Inspector and Plan Examiner, 2003 Edition

Office of the Fire Marshal: Gwinnett County Department of Fire and Emergency Services Newsletter, Spring 2007 Lawrenceville, GA Vol. 1 Number 1

Self-fire inspection: A new concept in fire safety (1980, May). Fire Chief Magazine, 24, 34-35.

Scott, David, The New Inspector: Everywhere at Once, *NFPA Journal*, January/February 1997

Thelen, Reid, Brown, Raysman, & Steiner, *North Carolina Supreme Court Allows Homeowners to Sue for Negligent Building Inspection*, September 2001, http://www.constructionweblinks.com/Resources/Industry_Reports__Newsletters/Sept_24_2001/north_carolina_supreme_court.htm

TriData, *Comprehensive Management Study of the Saint Paul Department of Fire and Safety Services Final Report*, TriData A Division of System Planning Corporation, March 2007

Watts, John M. Jr, *Fire Risk Indexing*, The SFPE Handbook: Fire Protection Engineering, Third Edition, Chapter 10 pp. 5-125, 2002

Wood, Kenneth P.E. *A Quality Control Program for the Office of the Illinois State Fire Marshal* EFO Paper, National Fire Academy, September 2001

# PROJECT ON MEASURING CODE COMPLIANCE EFFECTIVENESS FOR FIRE-RELATED PORTIONS OF CODES

# VOLUME II

# FINAL PROPOSED MEASUREMENT METHODOLOGY

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# Volume II Table of Contents

# Chapter 1. Introduction

In 2007, the NFPA Fire Analysis & Research Division began a project, under the auspices and with the active participation of the Fire Protection Research Foundation (FPRF), to develop new approaches to *effectiveness measurement* as applied to *code compliance* activities, particularly *inspections*. The project goals as originally stated are:

- Develop tools to measure how *fire prevention* activities of fire safety *enforcement* organizations can reduce *fire risk* in communities.

- Develop a *refined methodology* to measure *fire prevention inspection effectiveness,* to meet the needs of today's state and local *fire prevention* personnel.

This project is one element of a research grant from the U.S. Department of Homeland Security to FPRF.

The work of this project is intended first and foremost for fire marshals and other fire prevention managers and fire inspection managers in municipal fire departments. It may also be of value to other managers whose responsibilities include fire-related inspections and code compliance activities, including fire department chiefs, building departments, inspection departments, and safety managers of buildings in the private sector.

## Refining the Statement of Project Goals

"Code compliance" is understood to include *inspections* and any other activities intended to serve the goal that all properties within a community should be completely in compliance with all applicable codes and standards, including relevant laws and regulations, bearing on fire safety.

Code compliance is the stated goal of the activities, but the ultimate, intended result is reduction in "fire risk".

Because codes are legal requirements, "enforcement" of those laws is considered to be another term for compliance.

"Inspections" include inspections of new construction (including major rehabilitation projects and any other situations where the building code and other new construction requirements would be binding) as well as existing buildings under provisions of the fire prevention code. It includes inspections designed to achieve code compliance regardless of who performs those inspections. It includes follow-up inspections.

"Inspections" does not include court hearings or other non-inspection activities that may be involved in achieving correction of violations. However, these latter activities may be important to the effectiveness of inspections and so may be relevant to analysis and interpretation of the inspection effectiveness measurement data.

“Fire inspection” means an inspection in support of *any fire-related requirements* appearing in a code, law or other formal and binding requirement. It is meant to include fire-related provisions in a building code or other code that may not have “fire” in the title of the code, regardless of whether the fire department is involved in those inspections.

“Fire prevention” is understood broadly to include not only reductions in the likelihood of fire ignition but also reductions in the severity of fires that do occur. The latter is often distinguished using the label “mitigation”. Together, prevention (defined narrowly) and mitigation correspond to the two parts of “fire risk” – likelihood and consequence – whose reduction is the intended result of code compliance and fire prevention (defined broadly).

This broad definition of “fire prevention” also means that the project is concerned with impact on intentional and unintentional fires. Even if intentional fires cannot be fully prevented through inspections and other code compliance activities, any fire can be mitigated, reducing its loss to a much lower level than would otherwise be the case.

“Refined methodology” is a reference to the inspection effectiveness measurement methodology developed three decades ago in the principal methodological research project prior to the current project. In the mid-1970s, the Urban Institute and NFPA collaborated on a series of projects to develop, test and apply a set of effectiveness measures for use by fire departments. The last of these three projects used the fire-code inspection measures to examine practices that could be linked to high vs. low performance on the measures. The set of measures has been revisited and republished over the years by the International City/County Management Association, most recently in the Fire Protection chapter of the third edition of *How Effective Are Your Community Services?*, published in 2006. In addition, TriData, the analysis and consulting firm founded by Philip S. Schaenman, who led the first two projects in the earlier series of three projects, has used the previously developed measurement techniques in scores of studies and assessments of individual fire departments and communities.

## Tasks 1-3 of the Project

Task 1 was a primarily administrative task.

Task 2 was the literature review task, whose results are described in detail in Volume 1 of this final report.

Based on the literature review findings and the advice of the project’s technical advisory panel, nine communities were selected for the on-site visits and unstructured interviews that constituted Task 3:

- Arlington, TX
- Austin, TX

- Charlotte, NC
- Colorado Springs, CO
- Nashville, TN
- Phoenix, AZ
- Providence, RI
- Reedy Creek Improvement District, FL
- Tualatin Valley Fire District, OR

The interviews have not been written up as a separate deliverable for the project, but they contributed a number of ideas, examples, and lines of argument cited in this report, and those connections are noted.

## Effectiveness Measurement and Program Evaluation

Program evaluation is often divided into four stages:

- Formative evaluation – The process of testing program plans and elements for feasibility, appropriateness, acceptability, and applicability;

- Process evaluation – The mechanism of testing whether a program is reaching the target population;

- Impact evaluation – The mechanism of measuring changes in the target population of the sort the program is intended to produce; and

- Outcome evaluation – The mechanism of determining how well a program achieves its goals of reducing fire loss.

(Adapted from Table 5.8.1, *Fire Protection Handbook*, 20th edition, NFPA, 2008)

The first stage is appropriate before a program is launched, whereas the other three stages can provide useful information for any program that is up and running. Consider the following as an application of the three later stages of program evaluation to the subject of fire-related inspections:

- Process evaluation – Evaluation of how well the *specific goals of the inspection activity* have been met.

- Impact evaluation – Evaluation of how well the overarching *goal of achieving code compliance* has been met.

- Outcome evaluation – Evaluation of how well the intended result of *reducing fire loss* has been met.

Here is a proposed structure for effectiveness measurement tailored to the three later stages of program evaluation as applied to inspections and other code compliance activities:

- Process evaluation type measures – Measures of the quantity and quality of inspection service or related program activity delivered to the target population;

- Impact evaluation type measures – Measures of the presence of hazards in the target population; and

- Outcome evaluation type measures – Measures of fire loss within the target population.

As is commonplace for effectiveness measures, the process evaluation type measures tend to be the most responsive measures, that is, the ones that will respond most directly, most quickly, and with greatest confidence to changes in the management of the program. On the other hand, process evaluation type measures provide the lowest degree of confidence that hazards have been removed and fire losses have been reduced. The best process evaluation measures address both quantity and quality in terms that have been or can be shown to have a high degree of influence on the presence of hazards and the level of fire loss.

Similarly, the outcome measures provide information in terms of goal achievement and are therefore most clearly evidence of success. However, management will be less clear on how to improve measures through changes in a program for outcome measures than for any other type of measure.

Impact evaluation type measures fall in between. The implications for management will be clearer than for outcome measures but not so clear as for process evaluation type measures. The evidence of success will be clearer than for process evaluation type measures but not so clear as for outcome measures.

The best approach is to use all three types of measures. The process evaluation type measures will provide the most actionable information, and it is expected that proposals to change the program to improve effectiveness will primarily draw on insights gained from these measures. Once those changes are made, it will be interesting to see whether the three types of measures all move in the same direction or not. If the process evaluation type measures improve, but the other measures do not, then there may be a time lag at work (which should become more clear with the passage of time) or there may be a disconnect between the program elements changed and the principal drivers of impact and outcome effectiveness.

## Litigation, Limited Resources, and Other Constraints

Fire departments and fire-related code compliance programs generally must live with limited resources. In many instances, the limited resources are considered to be a principal reason why the program cannot be more effective in achieving its goals.

Resource limitations are not an element of effectiveness and they are not an appropriate subject for effectiveness measurement.  Rather, they are a *constraint* on the program that may be an important part of the context in explaining why programs are conducted as they are and why they are not more effective than they are.

Liability considerations were identified in the literature review and the informal interviews as important constraints much more so than three decades ago when the original NFPA/Urban Institute studies were conducted.  The court cases on this subject have been taken to mean that an inspector is more legally vulnerable for conducting an imperfect inspection than for conducting no inspection at all.  If the department knew or should have known of a hazard but did not have that hazard corrected, then it is more exposed to litigation than if it did not know and could not have been expected to know about that hazard.  The incentives created by this legal framework are somewhat perverse and may lead to less effective programs and less safety, exactly the opposite of the intentions of the legislators, jurists, and lawyers who created the framework. Nevertheless, where such constraints exist or are perceived to exist, they will have an effect on the programs, limiting the range of choices.

Other examples of legal constraints on the design of an inspection and code compliance program might be collective bargaining agreements or state certification requirements that reduce the flexibility of the department to increase the role of suppression-company firefighters in inspections.  Here again, these arrangements often arise as a result of legitimate concerns and may even be motivated by a desire to improve inspection effectiveness, but the specific form of the constraints may not always have the intended effect.

Some departments are bound by a state-mandated minimum period for owners to appeal a violation.  This is an unavoidable built-in delay in removing hazards.  It also is a constraint that needs to be acknowledged when analyzing and interpreting inspection and code compliance effectiveness data.

## Direct and Indirect Inspection Impacts

Inspections achieve success partly through the direct removal of hazards and partly indirectly through *educational* and *motivational* effects on the people responsible for a property.  Effective education and motivation may reduce the time required (and resistance involved) in having hazards removed.  More importantly, effective education and motivation may sharply reduce the recurrence of violations and induce safer behaviors that will reduce fire loss and fire risk even in scenarios where no physical hazards are clearly involved.

One way to add quality to inspections is to design the program to maximize these educational and motivational effects.  If education and motivation are regarded as an essential part of inspections, then the program’s effectiveness measurement needs to reflect this activity and its intended impact.  Fires whose causes and reasons for severity would not be affected by the hazard removal of an inspection may still be prevented or mitigated by changes in occupant behavior achieved through a well-designed educational, motivational inspection program.

## Effectiveness Relative to What?

No matter how a community or other fire safety enforcement organization (authority) sets its goals, it is possible to measure inspection effectiveness against those goals. However, any comparison of effectiveness over time or between communities (or other entities) needs to be done against common goals. Suppose community A is showing high effectiveness relative to some not very ambitious goals. Suppose they set more ambitious goals. It would be quite possible for their absolute performance to improve modestly while their performance relative to goals worsens, because they are doing better but are further away from their new goals than they were from their less-demanding old goals.

In any comparison, it is important that a difference in goals not be misreported as a difference in effectiveness.

The simplest way to assure common goals for any comparison is to assess effectiveness against an ideal program, one that includes every type of hazard, every type of property, and every type of effect (including educational and motivational effects). However, such a consistent evaluation against the ideal, conducted in an era of widespread limited resources, is likely to generate results framed as bad versus worse news. That is, no one will appear to be doing very well, and so the shine may be taken off the fact that some are doing less badly than others (or today's department is doing less badly than yesterday's).

Effectiveness measurement relative to goals inherently deals in the measurement of shortfalls. The very best you can hope to do is to perform the entire job acceptably. There are other ways of measuring performance, and they are also discussed in this report.

One approach is to measure code exceedance. That is, for a group of buildings (or communities) screened as being fully or reasonably code compliant, the measurement focuses on how much more safety they have adopted – in their systems, features, and behaviors – than is required by the code. Such approaches are the subject of Volume 3 and Task 5 of this project, which examines Level of Life Safety Design (LLSD) concepts of measurement.

Another approach is to measure the value of inspections against a baseline of less or no inspection activity. This is difficult because it may be difficult to find a baseline community that is exactly like your community with the sole exception being the level of inspection activity, and it will probably be impossible to find a baseline community that is the same except for having no inspection activity. Nevertheless, this report will include some discussion of options for this kind of measurement, as well as for analysis and interpretation of results in this type of context.

## New Construction versus Existing Buildings

Inspection timing takes a very different form in new construction versus existing buildings. In existing buildings, inspections cover the same hazards each time, and the effect of timing is well reflected by the frequency of inspections, which is to say, the time between inspections. In new construction, there are no recurring inspections of the same hazards; each inspection is examining different features or examining them against different criteria, reflecting the requirements of a different stage in the construction process. The key issue of timing is whether the inspection occurs late enough for a particular hazard to have had a chance to occur but early enough that that hazard be detected without removing later construction and corrected without redoing later construction. (Although a community may have a provision that allows construction to be opened up if it was closed before inspection and approval of the now-concealed features, it would not be surprising if authorities were reluctant to use this authority because of the cost to the project.) These differences in timing need to be reflected in the design of the effectiveness measures.

Also, when hazards are detected after the building has been up and running for a while, it may not be possible to determine whether those hazards were introduced during construction or during the subsequent operation of the building. This fact also needs to be reflected in the design of the effectiveness measures.

## Effectiveness versus Efficiency

Much of the interest in performance measurement for fire inspections arises from an interest in obtaining more value per dollar spent. Benchmarking measures that define how much of what kind of inspection work can be done per hour or per day are efficiency measures, not effectiveness measures, and they are outside the scope of this project.

An important caution needs to be stated about efficiency measures. If efficiency measures are used without effectiveness measures, decisions are likely to be tailored to what is being measured. It can be all too easy to assume high quality rather than confirm it and to assume that cost savings and efficiencies can be achieved with no sacrifice in quality. It is important that any trade-off of quality versus quantity be done explicitly with full awareness of the implications of the decisions taken.

## Large Communities versus Small Communities

It is important that the effectiveness measures be useful for communities of all sizes and not be tailored solely to the practices of larger communities. Smaller communities are less likely to have fire department inspectors or any department inspection program using department personnel of any kind. The project interviews all involved larger communities, but every effort has been made to set the proposed measures and methodologies in a generic form suitable for use by any department.

## Fire Departments versus Other Agencies and Other Entities

While the project goals specifically identified "fire safety enforcement organizations" and included other references normally associated with fire departments, the emphasis has been on measures of the effectiveness of inspections by anyone under any auspices in support of a defined set of fire-related requirements.

In many communities, especially smaller communities, these activities are located in a building department or a separate inspection agency, and the proposed measures should be as useful for these entities as for a fire department.

There also are private organizations where fire safety managers are responsible for enforcing rules on one or more buildings on behalf of the owners of the building or complex.  Again, the proposed measures should be useful, possibly with some adaptation, for such private entities as well.

## Structure of the Report

In the rest of the report, we will work backward from outcome measures to impact measures and finally to process-evaluation type measures, where most of the detail will be provided.

Then, some additional ideas and guidance will be provided on miscellaneous topics related to the project's goals and scope.

Finally, this volume will conclude with a proposed starter set of measures, abstracted from the larger set presented in the report.

# Chapter 2. Outcome Evaluation Type Effectiveness Measures

In our on-site interviews, the one constant was the answer to the question of how the fire department knows that its fire inspection program is effective. The answer was that fire loss was low. The specifics might vary.

"Low" might mean declining over time or lower than in comparable communities or simply perceived as low by the management and the community.

"Loss" might mean fires or deaths or property damage or large-loss fires or rates relative to population or relative to property values.

Injuries are not included as a candidate measure because they tend to be harder to measure consistently than the other measures, account for a smaller share of the total loss than deaths and property loss, and are less clearly responsive to prevention programs than the other measures.

Loss is defined here only as direct loss. Various measures of indirect loss – particularly business interruption costs – could be included if a good source of data (such as insurance company figures) were identified.

The following table has an overview of components of candidate outcome-type measures for fire-code inspections of existing buildings. Each measure is defined as a numerator, giving the magnitude of fire experience or fire loss, divided by a denominator, giving some measure of exposure, such as number of people or number of buildings. For each measure, it may be useful to track trends over time, compare results with similar communities, and look at results separately by major property use group.

**Table 1. Fire Loss Measures as Candidate Outcome Measures for Code Compliance Effectiveness**

| Numerator – Type of Loss | Denominator – Type of Exposure | Comments on Measure (Pros, Cons) |
|---|---|---|
| (Building) fires | Per 1,000 population<br>Per 1,000 buildings | CON: Will only capture fires reported to fire department.<br>CON: Tends to measure prevention success but not mitigation success. |
| Civilian fire deaths | Per 1,000 population | CON: Number of deaths in inspectable areas of inspectable properties are so low that statistically meaningful results are unlikely, even in the largest cities. |

**Table 1. Fire Loss Measures as Candidate Outcome Measures for Code Compliance Effectiveness (continued)**

| Numerator – Type of Loss | Denominator – Type of Exposure | Comments on Measure (Pros, Cons) |
|---|---|---|
| Property loss<br><br>(Incorporate insurance figures for best results.) | Per 1,000 population<br>Per 1,000 buildings<br>Per $1,000 of property protected (Use tax records as basis for dollars of property protected.) | CON: Loss estimates can vary greatly from one person to another.<br>CON: Property values can also vary greatly over time, affecting the rates.<br>CON: Sensitive to effects of a single fire with large loss.<br>PRO: Impact on property loss is easier to compare to costs of code compliance programs, to show cost-effectiveness. |
| Fires with loss over $X<br><br>(Incorporate insurance figures for best results.) | Per 1,000 population<br>Per 1,000 buildings | CON: Loss estimates can vary considerably from one person to another.<br>PRO: Not sensitive to effects of a single fire with large loss.<br>PRO: Focus on more severe fires to focus on code provisions that are designed more to mitigate fires than to prevent fires. |
| Fires with flame beyond room of origin | Per 1,000 buildings | PRO: Isolates severe fires in order to focus on code provisions that are designed more to mitigate fires than to prevent fires.<br>CON: For some points of origin (e.g., concealed spaces, exterior), the interpretation of "room of origin" is problematic. |

## Measures for New Construction

Any fire loss reflects on the effectiveness of inspections done on the building when it qualified as new construction and any inspections done while the building was operating. Most hazards involve conditions that could have been introduced at any stage.

One could track fires in which contributing factors to ignition or severity included conditions that are of the type that should have been caught and corrected before issuance of a certificate of occupancy.

An analogy might be drawn with the situation in Florida some years ago. In the aftermath of widespread hurricane damage to homes with inadequately secured roofs, some news account and lawsuits alleged that some inspectors would drive by a construction site and conduct only those observations that could be made without leaving the car, sometimes dubbed "windshield" inspections. The absence of the features required to properly secure a roof constitute an example of building deficiencies that could be readily identified as primarily responsible for significant damage and that could and should have been identified and addressed through a proper new-construction inspection.

Here are some characteristics of hazards that are more likely to have been introduced at the new-construction stage than at a later stage when the property is operating:

- The hazard involves the presence or absence of something as opposed to the status of something. Decisions on what type of sprinkler system to install, if any, are made prior to or during new construction and are not casually modified later, while the maintenance-related problems of system status (e.g., valve turned off) are more likely to arise during the operation of the property.

- The hazard is concealed, posing a danger of fire origin or spread through concealed combustibles or spaces or involving ignition due to concealed heat sources, such as wiring. Not only are such hazards very likely to be introduced at the new construction stage; they also will be almost impossible to detect after they are covered up.

- The hazard affects the severity of fire rather than the ignition of fire. Relatively few fires begin with heat sources or combustibles that are introduced during new construction and not modified later. However, effectiveness in compartmentation, avoidance of rapid initial fire growth, early detection, early suppression, and safe evacuation depends primarily on building features and systems that are set during construction. This argues for a measure of loss that focuses on larger fires.

## Which Property Use Groups Should Be Included?

The table shown below provides numbers and percents of reported structure fires and associated civilian fire deaths and direct property damage for the U.S. for 2002-2005 (taken from the NFPA Quick Look-Up Book, an internal reference document containing NFPA national estimates based on NFIRS and NFPA survey data).

Also shown are thousands of buildings and billions of square feet for the same property classes.

The building and square footage statistics are taken from the three different periodic surveys of the U.S. Energy Information Administration – the Residential Energy Consumption Survey, the Commercial Buildings Energy Consumption Survey, and the Manufacturing Energy Consumption Survey. Statistics for homes are from 2005, for industrial and manufacturing properties from 2002, for non-dwelling parking garages from 1992 (the latest year for which the survey included this property type), and for all other property classes from 2003.

Note also that the cited data sources do not provide numbers of buildings for apartment buildings. Instead, the number of housing units is given for buildings with 2-4 units and for buildings with 5 or more units. For estimation purposes, it has been arbitrarily assumed that the average building with 2-4 apartment units has 3 units and the average building with 5 or more apartment units has 6 units. This results in an estimate of 5.5% of buildings being apartment buildings. Based on a wide sensitivity range, the true value probably lies in the range of 3.5-7.5%.

Note also that two-unit buildings are included with single family dwellings for fire incidence purposes but with apartment buildings for building characteristics purposes.

In Table 2, the first group shows properties that will be excluded by most if not all fire inspection programs. Few if any fire departments or communities include existing dwellings within the scope of their codes, at least in general. There may be requirements for smoke alarm inspections at point of sale and for permitting of electrical system work, for example, but for the most part, dwellings are not under the jurisdiction of fire prevention codes or associated routine inspections. Dwelling garages and other small, non-commercial storage properties (e.g., sheds) are similarly excluded.

The second group is just apartments, where inspections tend to stop with the common areas. The third group has all the other properties.

The definitions of property classes may not match completely for fires and for building characteristics, and there are other limitations to some of the data, but they provide a reasonable snapshot of the different properties. A few points are worth making about the individual property groups.

Nursing homes and some board and care homes (assisted living facilities) are included in health care for fire experience but in other residential for building characteristics. Fatal store fires are disproportionately located at service stations.

Stores and offices account for large combined shares of fires in inspectable properties and of buildings and square footage in inspectable properties. Based on our interviews with communities, stores and offices are the properties most likely to be given low inspection frequencies or to be excluded completely from periodic inspections of existing buildings (with exceptions, to be noted later).

Some properties – such as ordinary stores and offices – may be covered by the code for new and existing buildings but may be excluded from most inspection activity, either explicitly or as a side-effect of the allocation of resources. Many of these inclusions, exclusions and areas of greater and lesser emphasis are dictated by state or local law or other requirements. However, to the extent that local discretion comes into play, it can be useful to make those choices based on relative risk.

**Table 2. Fire Experience, Floor Space, and Number of Buildings, by Major Property Use**

| Property Use Group | 2002-2005 average structure fires | 2002-2005 average fire deaths | 2002-2005 average property damage ($M) | Floor space (billions of square feet) | Buildings (thousands) |
|---|---|---|---|---|---|
| **Properties that are generally not considered subject to inspection** | | | | | |
| (One or two family) dwellings | 271,350 (52.3%) | 2,426 (77.2%) | $4,839 (55.4%) | 233.4 (68.6%) | 86,600 (89.1%) |
| Special property (e.g., non-building structure) | 20,090 (3.9%) | 7 (0.2%) | $108 (1.2%) | 0.0 (0.0%) | 0 (0.0%) |

## Table 2. Fire Experience, Floor Space, and Number of Buildings, by Major Property Use (continued)

| Property Use Group | 2002-2005 average structure fires | 2002-2005 average fire deaths | 2002-2005 average property damage ($M) | Floor space (billions of square feet) | Buildings (thousands) |
|---|---|---|---|---|---|
| **Properties that are generally not considered subject to inspection** | | | | | |
| Outbuilding, shed or unknown storage | 14,480 (2.8%) | 13 (0.4%) | $187 (2.1%) | No data located | No data located |
| **Properties that are generally not considered subject to inspection** | | | | | |
| Unknown or unclassified residential | 14,230 (2.7%) | 128 (4.1%) | $180 (2.1%) | No data located | No data located |
| Unknown property use | 8,380 (1.6%) | 11 (0.4%) | $64 (0.7%) | 4.3 (1.3%) | 261 (0.3%) |
| Dwelling garage | 5,290 (1.0%) | 12 (0.4%) | $74 (0.8%) | No data located | No data located |
| **Properties where most but not all areas are not considered subject to inspection** | | | | | |
| Apartment | 105,760 (20.4%) | 443 (14.1%) | $1,079 (12.4%) | 23.1 (6.8%) | 5,383 (5.5%) |
| **Properties where all areas and all properties are generally considered subject to inspection** | | | | | |
| Mercantile (including services) | 17,150 (3.3%) | 10 (0.3%) | $591 (6.8%) | 16.5 (4.8%) | 1,505 (1.5%) |
| Hotel, motel, dorm, or other residential | 12,120 (2.3%) | 44 (1.4%) | $136 (1.6%) | 5.1 (1.5%) | 142 (0.1%) |
| Industrial (including agriculture) | 11,030 (2.1%) | 11 (0.4%) | $596 (6.8%) | 10.6 (3.1%) | 368 (0.4%) |
| Eating or drinking establishment | 8,370 (1.6%) | 3 (0.1%) | $170 (1.9%) | 1.7 (0.5%) | 297 (0.3%) |
| Health care or correctional, including some board and care | 7,390 (1.4%) | 17 (0.5%) | $37 (0.4%) | 4.3 (1.2%) | 200 (0.2%) |
| Educational | 6,560 (1.3%) | 0 (0.0%) | $99 (1.1%) | 9.9 (2.9%) | 386 (0.4%) |
| Public assembly excl. eating or drinking and place of worship | 5,400 (1.0%) | 2 (0.1%) | $107 (1.2%) | 3.9 (1.2%) | 277 (0.3%) |
| Office | 3,920 (0.8%) | 0 (0.0%) | $99 (1.1%) | 12.2 (3.6%) | 824 (0.8%) |
| Storage building, excl. outbuilding, vehicle | 3,570 (0.7%) | 10 (0.3%) | $205 (2.3%) | 10.1 (3.0%) | 597 (0.6%) |
| Non-dwelling parking garage | 1,980 (0.4%) | 2 (0.1%) | $59 (0.7%) | 1.7 (0.5%) | 24 (0.0%) |
| Place of worship | 1,910 (0.4%) | 2 (0.1%) | $100 (1.1%) | 3.8 (1.1%) | 370 (0.4%) |
| | | | | | |
| Total | 518,960 (100.0%) | 3,143 (100.0%) | $8,732 (100.0%) | 340.5 (100.0%) | 97,234 (100.0%) |

Source: Energy Information Administration; NFPA national estimates from NFIRS and NFPA survey data; see notes in text.

Table 3 provides additional information on the 11 property use groups above, excluding those where either the entire property or most of the areas on the property are normally not subject to inspection for existing buildings.

**Table 3. Severe Fires and Measures of Fire Risk, by Major Property Use**

| | | | | Life loss risk – estimated or statistical | | | |
|---|---|---|---|---|---|---|---|
| Property Use Group | Fires with flame beyond room of origin | Percent of fires with flame beyond room of origin | Suggested threshold (in thousands) when flame beyond room of origin | Potential based on number of occupants | Potential based on occupant limitations | Deaths per million buildings | Deaths per billion square feet |
| Mercantile | 4,010 | 23% | $35 | Depends on size | Normal | Low (7) | Low (<1) |
| Hotel, dorm, othr. residential | 560 | 6% | $20 | High | Normal | Very High (>300) | Very High (~9) |
| Industrial | 3,450 | 25% | $45 | Depends on size | Normal | High (~30) | Medium (~1) |
| Eating or drinking | 1,410 | 14% | $25 | Depends on size | Normal | Medium (10) | High (~2) |
| Health care/ correctional | 330 | 4% | $25 | High | High | High (>80) | High (~4) |
| Educational | 470 | 7% | $30 | High | High | Low (0) | Low (0) |
| Public assembly excl. eating or drinking and place of worship | 480 | 12% | $45 | Depends on size | Normal | Low (7) | Low (<1) |
| Office | 870 | 18% | $45 | Depends on size | Normal | Low (0) | Low (0) |
| Storage building | 4,810 | 51% | $25 | Low | Normal | Medium (16) | Medium (~1) |
| Non-dwelling parking garage | 1,090 | 47% | $10 | Low | Normal | High (>80) | Medium (~1) |
| Place of worship | 400 | 23% | $35 | High | Normal | Low (5) | Low (<1) |

Source: Table 2; additional NFPA analysis of data from NFIRS and NFPA survey.

The first three columns provide estimates of the annual average of 2002-2005 structure fires with flame spread beyond the room of origin, the percentage of the total represented by such fires, and a suggested threshold for dollar loss in a fire with flame spread beyond the room of origin in such a property.*

* The threshold is estimated as the geometric mean in thousands of dollars (more appropriate than the arithmetic mean because fire grows exponentially), rounded to the nearest five, of the average loss per fire for (a) fires with flame beyond object of origin but not beyond room of origin and (b) fires with flame beyond room of origin but not beyond floor of origin.

The last four columns provide different approaches to the estimated, potential, or perceived life loss risk, any of which could be used as the basis for risk prioritization. The first two are based on potential life loss in terms of the number of occupants in the facility or the occupant characteristics that may reduce their ability to escape if fire occurs. The last two are rates of 2002-2005 structure fire deaths per million establishments or per billion square feet.

The thresholds are offered as a basis for setting X in the Table 1 measures that are rates of fires above a certain property damage minimum. Most of these thresholds fall in a range of $25-$50 thousand. This suggests that a threshold of $25,000 could be used across the board for the sake of simplicity.

At this point, it is useful to take a reality check on the size of the fire problem a community is likely to be tracking. If you focus on only the 11 property use groups in Table 3, then the combined rate of such fires relative to the U.S. population was 5 total reported fires (from Table 2) including 1 fire with flame spread beyond room of origin for every 16,000 people. A city of 100,000 population could expect to report about 30 such fires a year including about 6 with flame spread beyond room of origin. These numbers are not large enough to support strong conclusions in statistical analyses of trends or statistical comparisons of different communities. Only metro-size cities can expect to have enough fires to justify extensive statistical analysis of their own fire problem. If the community does not routinely inspect stores, offices, restaurants, and warehouses, then the numbers of fires for properties within the scope of the inspection program will be even smaller. Instead, these outcome type measures may be better used in alternative formats such as the following:

- Track statistics using rolling multi-year averages, in order to smooth out the kinds of large year-to-year variations one may expect with small numbers.

- Pool statistics with a number of other nearby communities with similar characteristics and similar inspection programs.

- Emphasize supporting lists, in which each of the fires included in the statistics is described in brief detail, with summary implications for types of hazards and property uses to be sure to include and focus on in the inspection program. This is a localized generalization of the way in which the Station nightclub fire led to increased emphasis on nightclubs in fire inspections across the country.

Table 3 shows that there is far from perfect agreement between measures or perceptions of potential life loss from fire and measures of actual life loss adjusted for exposure. The most striking example is educational properties, where properties with large populations having special vulnerabilities by virtue of age have collectively gone a half a century without a multiple-death fire. At the other extreme, warehouses and other storage properties are generally assumed to have low life loss potential because of assumed low occupancy, but their death rates have been medium.

The value of the last four columns of Table 3 is not so much as a basis for designing fire inspection effectiveness measures as it is a basis for revisiting the rules for informal risk prioritization that many communities use.

## Can You Estimate the Value of Inspections?

If it were possible to translate outcome-type inspection effectiveness measures into estimates of the dollar value of inspections, then that would be a powerful tool in fire department discussions with community managers regarding budgets for the department in general and the inspection activity in particular. Such calculations could be used on their own or in combination with cost-recovery fees for inspections, which many departments are revisiting.

Ideally, one would estimate annual property loss due to fire relative to numbers of inspectable properties with the inspection program and compare that estimate to a reference baseline case involving a different frequency or quality of inspections. The difference would be an estimate of the monetary value of inspections on a per building basis.

One might experiment with different choices for the measure of exposure, such as square feet or community population instead of inspectable buildings. One might experiment with different choices for loss, factoring in indirect loss (e.g., business interruption costs) or savings (e.g., property that would have burned if more or bigger fires had occurred).

### *Value Estimated Using the NFPA/Urban Institute Study*

In the last of the 1970s NFPA/Urban Institute studies, such comparisons were made. The study separated nine cities into six that were achieving at least annual inspection frequencies for at least 65% of inspectable properties involved in fires and another three cities that were achieving at least annual inspection frequencies for at most 53% of inspectable properties involved in fires. The six cities had a median percentage of 80% with inspection within the past year for inspectable properties involved in fires, compared to the three cities, which had a median percentage of less than 40% with inspection within the past year for inspectable properties involved in fires.

After excluding fires with incendiary, suspicious, or natural causes, the three cities were found to have fire rates per 1,000 inspectable properties that were higher than those in the six cities. When all fires were included, the fire rate averaged across the three cities was 59 compared to a fire rate averaged across the six cities of 38, or 57% higher. (Putting it another way, the rate of 38 for the six cities was 36% lower than the rate of 59 for the three cities.) When only fires with losses of at least $5,000 (roughly $19,000 today) were included, the three-city average was 3.9, or 136% higher than the six-city average of 1.6. (Or, the six-city average was 59% lower than the three-city average.) When only fires with losses of at least $25,000 (roughly $93,000 today) were included, the three-city average was 1.8, or 156% higher than the six-city average of 0.7. (Or, the six-city average was 61% lower than the three-city average.)

Because such a small percentage of fires, then and now, involve losses as high as the non-zero thresholds used then, the highest estimate of loss reduction comes from using the comparison involving fires of all magnitudes of loss. For example, the NFPA/Urban Institute study can be used to estimate the value of raising inspection coverage and frequencies from just under 40% of inspectable properties receiving annual inspection to roughly 80% of inspectable properties receiving annual inspection. That value is a 36% reduction in dollar loss in fires of all sizes, excluding fires with incendiary, suspicious or natural causes. The latter causes accounted for about 32% of direct property damage in non-home structure fires in 2002-2005, so the 36% reduction in the other 68% translates into a roughly 24% reduction in total loss, or about $800 million per year nationwide.

This estimate is very rough, involves a number of major simplifications, and is based on data from only nine cities. Nevertheless, there is little if anything in the way of a competing analysis from any other study to put against it.

Even this very crude estimate is far beyond anything that can be implemented at the local level, for the simple reason that it depends on a comparison of communities with different inspection frequencies. Therefore, it is not clear how this approach can be built into an ongoing local inspection effectiveness measurement program.

### *Value Estimated Based on Fires Deemed Preventable by Inspection*

Tualatin Valley has implemented a highly specific and formal procedure of categorizing fires in properties subject to inspection by the assessed likelihood that prevention programs could have prevented or mitigated the fire. Their program was adapted from a program in Orange County, CA. Tualatin Valley has also taken this approach a step further in attempting to estimate the monetary value of adding inspections. The formula they use is equivalent to the following:

Value of one additional inspection per year in a defined property use =

(Fires per occupancy per year) x (Loss per fire) x (% fires preventable by inspection).

In their approach, the estimates of fires preventable by inspection tend to fall in a narrow range across nearly all property use categories. Therefore, the variations in value per inspection are driven by the other two terms. Assembly, industry, and storage properties rank high because of a high average loss per fire, while education ranks high because of a high rate of fires per 1,000 occupancies. Business (offices) rank low because of a low rate of fires per 1,000 occupancies, while health care/correctional and non-home residential properties (primarily hotels and motels) rank low because of a low average loss per fire. Mercantile properties rank in the middle because a somewhat higher than average loss per fire is offset by a lower than average rate of fires per 1,000 occupancies.

The approach could be refined by attaching the judgment of preventable or not preventable by inspection directly to the dollar loss for each fire. Then, one could calculate directly the percentage of dollar loss in fire preventable by inspection, and in so doing automatically compensate for the possibility that the average loss per fire is different in fires preventable by inspection than in fires not preventable by inspection.

There are other weaknesses of the approach that are not so easily addressed. The judgment of fires as preventable by inspection needs a stronger foundation (and this will be discussed further in the next section). More importantly, it is unrealistic to assume, as this formula implicitly does, that inspections will completely eliminate all the types of fires they target. The value estimates are inflated by this assumption of perfect prevention effectiveness.

On the other hand, this formula takes no credit for the value of inspections in making big fires smaller through mitigation, and there is reason to believe that the primary purpose of inspections – removal of hazards – is more likely to reduce loss by mitigating fires than by preventing them. The next section of this chapter discusses approaches to estimating the value of mitigation.

Notwithstanding these weaknesses, this formula provides a basis for thinking about the ways in which inspections deliver value in quantitative terms. The pros and cons of this kind of measure complement the pros and cons of other measures. It is worth considering as part of a portfolio of inspection effectiveness measures.

### *Value of Savings From Mitigation – Avoiding the Larger Fire Through Inspection and Code Compliance*

There are a couple of methods for estimating savings from a fire mitigation program that do not rely on the comparison of losses with and without the program.

Philip Schaenman ("Actual savings," *Fire Chief*, March 2008, pp. 50-56) described an approach developed by the U.S. Navy Fire and Emergency Services program and modeled by them after the degree-of-impact scale used by pilots to measure their effectiveness in shooting down enemy aircraft. Simply put, the Navy devised a four-value scale for estimates of what fraction of property at risk (minus the loss in the fire) would have been destroyed by fire if the program in question (in this case, the Navy's fire suppression forces) had not stopped the fire where they did:

- 90% if fire spread was deemed highly probable,
- 60% if fire spread was deemed probable,
- 25% if fire spread was deemed possible, and
- 10% if fire spread was deemed unlikely or low.

Using fire incident narratives to assign these "discount factors", the Navy is then able to apply weights to the value of the undamaged property and use that figure as a "save" number for the property.

One can imagine a refinement of this approach. For example, suppose the incident narrative supported an estimate that, without the effective action that occurred, fire would have spread farther, but even then, it would not have spread beyond the fire-rated compartment of origin. In that case, one could use the same discount factors for likelihood of spread but apply them only to the portion of the building's value contained within the fire-rated compartment, and not to the value of the entire building.

In the same article, Schaenman cited the long-established NFPA program of documenting saves of people in fires, based on an assessment of incident narratives without a quantitative structure or discount factors.

Another approach to estimating people saves would be to assign discount factors, similar to those described above, to the saves matrix developed in one of the old Urban Institute/NFPA projects. (See Chapter 2 of Philip S. Schaenman, John R. Hall, Jr., et al., *Procedures for Improving the Measurement of Local Fire Protection Effectiveness,* Urban Institute and National Fire Protection Association, 1977.)

The matrix is a template in which people can be categorized as saves relative to *need* (how mobile was the person, or how much help did the person need to escape?) and *risk/hazard* (how close was the person to the fire, or how quickly might the fire have caused injury to the person?). The need scale includes a second line that indicates the magnitude of the fire department action that was needed and provided to achieve a save. For purposes of inspection effectiveness evaluation, that fire department action scale would need to be replaced with an appropriate scale showing the building systems and features that were in place and performed as designed, in whole or in part because of effective inspections.

When the matrix is used for its original purpose, it quickly becomes clear that any major fire may have a small number of people who were in imminent danger of injury and needed some significant help to avoid injury, while there are far more people who were not in imminent danger and/or were able to escape injury on their own if they were aware of the fire. A redesigned matrix tailored to inspection effectiveness would probably show the same pattern.

One can imagine assigning discount factors like those above to the cells of the matrix, then using them to calculate a weighted sum of saved people for any fire. Combining this approach with a modified version of the Navy system would provide estimates of saves of people and money through the mitigation effects of inspections and code compliance activities.

Because so much additional thinking and work would be required even to propose an adapted version of these scales, they are not included in the list of candidate measures below, but they could well be the basis of further research to develop additional useful measures of effectiveness.

## Summary of Proposed Outcome-Type Inspection Effectiveness Measures

Table 4 summarizes a recommended core group of measures.

**Table 4. Core Outcome-Type Measures for Code Compliance Effectiveness**

| Measure | Comments on Measure |
|---|---|
| 1. **Structure fire rate** per 1,000 inspectable properties | Use five-year averages to compensate for small numbers of fires per year. May exclude intentional fires. Designed for **routine inspections**.<br><br>Use instead of structure fire death rate, which will not have enough incidents per year for meaningful statistical results. |
| 2. **List** inspectable-property structure fires with **at least $25,000 in loss**; show **matrix** with presence and importance to fire severity of standard list of **major hazards**. | Work with insurance companies to get best loss estimates. Consider including indirect loss, such as business interruption costs.<br><br>Link to measure #4 in Table 7, which identifies major classes of hazards to be tracked separately. Distinguish hazards associated with **new construction** versus **routine inspections**. |
| 3. Estimated monetary **value per additional inspection**, by major property use group. | Calculate using the formula: Value of one annual inspection = (Fire loss per year) x (% loss preventable by inspection) / (# occupancies)<br><br>Link to measure #5 in Table 7, which sets up formula for what is preventable. For **routine inspections**. |

# Chapter 3. Impact Evaluation Type Effectiveness Measures

Impact evaluation type measures involve some measurement of the presence of uncorrected hazards that could become factors contributing to fire likelihood or severity. When hazards are discovered in an inspection and are determined to be in conflict with applicable requirements, they are recorded as violations. Not all hazards will qualify as violations.

Hazards can be installed or other relatively permanent conditions (e.g., improper interior finish, inadequate electrical service, absence of required sprinklers) or they can relatively transitory conditions, which can be created or removed quickly and easily, often in a single action (e.g., sprinkler valve turned off, combustibles located too close to heat sources, exit paths blocked). Transitory hazards are less likely to be observed by an inspector, because they come and go, while installed hazards are more likely to stay in place and visible once they exist.

Therefore, the keys to keeping a property free of installed hazards are effective identification of the hazards and effectiveness in having them corrected in a timely manner. The keys to keeping a property free of transitory hazards will tend to rely more on the educational and motivational impact of code compliance activities.

With uncorrected hazards, one is concerned with the importance of the hazard and the duration of the hazard.

"Importance" means some measure of how much more likely a fire is because of the hazard or how much more serious a fire, once ignited, will be because of the hazard. For example, a broken exit sign and a locked exit door are both hazards that affect the ability of occupants to escape safely and in time, but the latter is much more likely to cause significant delay, resulting in harm to occupants.

The duration of the hazard is critical because every day with an uncorrected hazard in place is another day when a fire could start or become more severe because of that hazard.

There are several opportunities to identify and record the presence of hazards or other factors contributing to fire likelihood or severity.

- Violations can be identified and recorded during an inspection;
- Overlooked violations can be identified and recorded during a re-inspection by a supervisor or other, more senior inspector, which serves as an audit of the original inspection, and incorrectly recorded violations can be removed from records in the same manner; and
- During or in conjunction with investigation of a fire, violations can be identified by fire investigators or fire inspectors as having been present at the time of fire ignition.

The first two opportunities can support measures on a per inspection basis. The last opportunity can support measures on a per fire basis.

Measures based on fires have some advantages. The duration question is addressed implicitly (the hazard was present long enough to contribute to fire loss) and the importance question can be addressed more substantively (the hazard was or was not a contributing factor to actual fire loss). Such measures also have disadvantages. Serious fires in properties subject to inspection and involving hazards that inspections address will be relatively rare in most communities. One would like to be able to evaluate an inspection program by more than the community's ability to avoid a statistically high level of actual fire loss. The degree of assurance of safety involves a safety margin that the community would like to have verified through effectiveness measurement, but that cannot be measured solely by factors in reported fires.

Measures based on inspections have compensating advantages and disadvantages. There will typically be far more inspections per year than fires in even smaller communities, and if so, the chances of having enough data for meaningful statistics are greatly improved. By focusing upstream of any fires, a department is not so likely to wait for serious fires to recognize and correct gaps or problems in the inspection program. However, the duration of a hazard cannot be readily estimated when inspections are usually at least a year apart.

As noted in the previous chapter, Tualatin Valley, OR, has implemented a highly specific and formal procedure of categorizing fires in properties subject to inspection by the assessed likelihood that prevention programs could have prevented or mitigated the fire. Specifically, each fire is coded yes or no on:

- ✓ Could have been prevented by inspection
- ✓ Could have been prevented by education
- ✓ Could have been made less severe by inspection
- ✓ Could have been made less severe by education

For an approach like this to work, there needs to be guidance on how to make these judgments. Tualatin Valley uses a conservative approach that is also more closely tied to their local program design. They assess fires relative to inspection and education programs and points of emphasis in the district. At the other extreme, it is difficult to think of any type of fire that could not be prevented or made less severe by some kind of education.

This points to the value of a national project to develop and agree on a standard grading schedule, tying the four judgments above to both specific model code provisions and specific fire incident coding choices. Such a system could be automated and made thoroughly consistent, removing the subjectivity entirely.

The disadvantage is that such an approach would require simplifications, some of them probably hard to justify, so that inconsistency would be replaced with consistent error. Even then, it would be possible to develop analysis protocols that would extract valid, actionable information from the data, as well as pointing to useful improvements in later editions.

Table 5 presents a starting point for such a framework.

These are the Factor Contributing to Ignition code groups cited in the third column of Table 5:

- Factor Contributing to Ignition 10-19: Misuse of material or product, including Factor Contributing to Ignition 13, which is cutting or welding too close to combustibles
- Factor Contributing to Ignition 20-29: Mechanical failure or malfunction
- Factor Contributing to Ignition 30-39: Electrical failure or malfunction
- Factor Contributing to Ignition 40-49: Design, manufacturing, or installation deficiency
- Factor Contributing to Ignition 50-59: Operational deficiency

These are the Factor Contributing to Ignition code groups that are not cited anywhere in Table 5:

- Factor Contributing to Ignition 60-69: Natural condition
- Factor Contributing to Ignition 70-79: Exposure to other fire, rekindle, or other fire spread or fire control factor

## Table 5. A Framework for Determining Potential for Prevention or Mitigation by Inspection, Linked to Types of Inspectable Code Requirements and Fire Incident Coding

| Element of Fire Safety and Related Code Requirements | Preventable by Inspection? | Relevant Fire Incident Coding |
|---|---|---|
| Prevention<br>✓ Electrical system (Equipment Involved in Ignition 200-299)<br><br>Permit-related inspections when changes are made to system. | New construction – can check on capacity, workmanship<br>Routine inspection – can check on observable statuses, including fuse or circuit breaker panels<br>Education via inspection – look for transitory hazards, like extension cords | Factor Contributing to Ignition 40-49<br>Factor Contributing to Ignition 20-39<br>Heat Source 13 (electrical arcing)<br>Equipment Involved in Ignition 263 (extension cord) |
| Prevention<br>✓ HVAC equipment (Equipment Involved in Ignition 100-199)<br><br>Possible link to routine annual inspections and maintenance by fuel or power supply company. | New construction – can check on installation of fixed equipment, including furnaces, fireplaces<br>Routine inspection – can check on observable statuses, use of prohibited equipment<br>Education via inspection – look for combustibles too close to equipment, evidence of fueling errors, creosote buildup. | Factor Contributing to Ignition 40-49<br><br>Factor Contributing to Ignition 20-39<br><br>Factor Contributing to Ignition 10-19, 50-59 |
| Prevention<br>✓ Hot work (Torches, burners, and soldering irons are Equipment Involved in Ignition 331-334)<br><br>Permit-related inspections | New construction – not applicable?<br>Routine inspection – check practices against requirements<br>Education via inspection – safe behaviors and practices | Factor Contributing to Ignition 13 especially but also all of Factor Contributing to Ignition 10-19, 50-59 |
| Prevention<br>✓ Hazardous processes and materials (Some or all of Equipment Involved in Ignition 300-599; Type of Material First Ignited 10-39)<br><br>Permit-related inspections | New construction – equipment design and installation, materials storage and handling arrangements<br>Routine inspection – check practices against requirements<br>Education via inspection – safe behaviors and transitory hazards | Factor Contributing to Ignition 20-49<br><br>Factor Contributing to Ignition 10-19, 50-59 |
| Mitigation<br>✓ Prevent rapid fire growth through control of materials<br><br>Focus on hazardous materials is same as in previous row and is not further discussed here. | New construction – construction materials, concealed combustibles, interior finish<br>Routine inspection – check any changes to interior finish or other materials noted above<br>Education via inspection – explain impact of changes to interior finish, etc. | Fire incident coding does not do well in identifying second items ignited and paths of flame spread. Fire Suppression Factor field is available but rarely used. These will need to be identified and coded separately from the normal fire incident coding. |
| Mitigation<br>✓ Compartmentation | New construction – heights and areas, fire doors and other doors, openings in construction<br>Routine inspection – check status of fire doors, new holes in walls<br>Education via inspection – explain impact of hazards found | Fire incident coding does not do well in identifying role of compartmentation features. The Fire Suppression Factor field is rarely used. These will need to be identified separately from the normal fire incident coding. |

**Table 5. A Framework for Determining Potential for Prevention or Mitigation by Inspection, Linked to Types of Inspectable Code Requirements and Fire Incident Coding (Continued)**

| Element of Fire Safety and Related Code Requirements | Preventable by Inspection? | Relevant Fire Incident Coding |
|---|---|---|
| Mitigation<br>✓ Early detection<br><br>Link to routine inspections or supervisory contracts by system contractors | New construction – check on required equipment and system type and coverage<br>Routine inspection – check on observable statuses, including placement and operationality<br>Education via inspection – exit planning and drills, dealing with nuisance alarms | Detector Presence<br>Detector Type<br>Detector Power Supply<br>Detector Operation 3 (Failed to operate, excluding fire too small)<br>Detector Effectiveness 2,4 (Failed to alert occupants or alerted occupants who did not respond)<br>Detector Failure Reasons |
| Mitigation<br>✓ Early suppression<br><br>Link to routine inspections or supervisory contracts by system contractors | New construction – check on required equipment and system type and coverage<br>Routine inspection – check on observable statuses, including appropriateness given changes in hazard below, operationality, obstructions<br>Education via inspection – transitory problems such as valve turned off, contents blocking sprinkler flow | Automatic Extinguishing System (AES)<br>Presence<br>Type<br>Operation 2,4 (Operated but not effectively or failed to operate)<br>Failure Reasons |
| Mitigation<br>✓ Safe and timely evacuation | New construction – check on adequacy of exits, including number and capacity<br>Routine inspection – check on exit status, including locked, blocked<br>Education via inspection – escape planning and drill practice; transitory problems | Factor Contributing to Injury<br>10-19 (Egress problem)<br>20-29 (Blocked or trapped by flame or smoke)<br>30-39 (Escape error or problem)<br>The Fire Suppression Factor field is rarely used but the 600-699 range for the field covers egress and exit problems. |

The structure of column 1 is based on a general framework of designs and programs for fire safety which has been used to organize the NFPA *Fire Protection Handbook* for two decades, combined with the structure of the NFPA *Inspection Manual*. Many details vary across the variety of technically complex property uses, and this framework would need to be elaborated and reviewed carefully before being used in practice. Also, the entries regarding areas of focus for the educational component of inspections, which would then form the basis for identifying fire circumstances that should have been preventable by education as part of inspections, are very sketchy and would especially need to be fleshed out.

Table 6 describes a number of impact-type inspection effectiveness measures that could be built around the common concept of identifying and tallying violations found in inspections or in fires in inspectable properties.

## Table 6. Violations-Found Measures as Candidate Impact Measures for Code Compliance Effectiveness

| Measure | Comments on Measure |
|---|---|
| Number of violations found per inspection, by type of violation and specific major violation (New construction and routine inspections) | This measure can be calculated relatively easily from a database of computerized inspection reports. It should be analyzed separately for different major property use groups. In interpreting results, note that some violations are more important than others. Table 5 may be useful in creating a structure of violation types. |
| Average change in number of violations per inspection, based on results of audits and/or follow-up inspections, by type of violation and specific major violation (New construction and routine inspections) | This measure will work only in a department where there are audits and/ or follow-up inspections to check for corrected violations that are done by someone other than original inspector. Audits are sometimes done only for new inspectors during training. The form of the measure anticipates the possibility that an audit will add or subtract violations, relative to the original finding. It should be analyzed separately for different major property use groups. Table 5 may be useful in creating a structure of violation types.<br><br>Because this measure can so easily reflect on the performance of individual inspectors – and that potential may make supervisors reluctant to use it honestly – it is important that the measure not be used externally when results can be attributed to individual inspectors. |
| Percentage of fires that were preventable or could have been mitigated by inspection or by the educational and motivational elements of inspection (Based on Tualatin or Table 5 type judgments; new construction and routine inspections) | This measure requires guidelines for making judgments on what could be prevented and what could be mitigated.<br><br>Consider whether judgment should be relative to department programs (including any limitations on which inspectable properties are being inspected) or relative to an ideal inspection program, or both.<br><br>It should be analyzed separately for different major property use groups.<br><br>The system should be designed to "drill down," e.g., to identify specific factors in fire and specific inspection steps that could have prevented or mitigated the fire. A Table 5 type approach would make this possible. |
| Percentage of fires where there were pending, uncorrected violations present at the time of the fire (Routine inspections only) | This measure should distinguish violations involving conditions that contributed to ignition or fire severity, and it should be analyzed separately for different major property use groups.<br><br>This measure can be viewed as a special case of the previous measure, because any property having a fire and having pending, uncorrected violations is likely (though not certain) to have had a fire that could have been prevented or mitigated by inspection or education.<br><br>The intent is to focus on the violations that are the clearest evidence of serious gaps in the effectiveness of the inspection program. |

The first two measures address gaps in the identification of hazards and violations, when and where inspections occur.

The third measure can be used to combine gaps in hazard identification with gaps in coverage of inspectable properties, either gaps due to deliberate exclusions (e.g., only high-priority properties and complaints are inspected) or gaps due to individual errors (e.g., a particular property did not receive the inspection it was scheduled to receive).

The last measure is the measure best designed to isolate problems arising because corrective actions were allowed to take too long or were derailed somewhere along the line (e.g., court refuses to enforce findings and require correction of violations).

## Summary of Proposed Impact-Type Inspection Effectiveness Measures

Table 7 summarizes a recommended core group of measures, with numbering of measures continuing from Table 4.

**Table 7. Core Impact-Type Measures for Code Compliance Effectiveness**

| Measure | Comments on Measure |
|---|---|
| 4. Number of **violations** found per inspection, overall and separately for (a) sprinkler-related and (b) safe evacuation related.<br><br>For new construction, also identify number of **conditions** that could not be inspected because they were **not inspected while still exposed**. | The focus on sprinkler status and evacuation-related violations is one way of singling out problems that are frequently cited as major reasons for multiple-death fires in inspectable properties. Hazardous-material-related violations, compartmentation-related violations, and detection/alarm-related violations are other major groups that could be given their own focus.<br><br>Link to measure #2 in Table 4, which can use the same major-hazard groups selected for focus here.<br><br>Designed for **new construction** and **routine inspections**. |
| 5. Percentage of fires that were **preventable** or could have been **mitigated** by **inspection** or by the **educational** and motivational elements of inspection. | Link to measure #3 in Table 4 on estimated value of an additional inspection, which will use the same framework for judging fires preventable or amenable to mitigation.<br><br>Designed for **routine inspections**. |
| 6. Percentage of fires where there were **pending, uncorrected violations** present at the time of the fire. | Designed for **routine inspections** and designed primarily to focus on problems post-inspection in achieving removal of hazards and code compliance. |

Remember that impact-type measures are best to determine whether program goals are being achieved but not to determine whether risk and loss are being reduced and not to determine what program elements need to be changed if goals are not being achieved. Analyze the drivers of the outcome measures using the impact measures to assess which program goals are most important to the ultimate purpose of reducing loss and risk. Analyze the drivers of the impact measures using the process measures to assess which program elements are most important to achieve more impact.

# Chapter 4. Process Evaluation Type Effectiveness Measures

Process-evaluation type measures track success in the delivery of the program. If the program is an effective program when used, then the only thing needed for it to be effective in the community is for it to reach its intended population. Program effectiveness may also be known or suspected to be dependent on the quantity and/or quality of service delivered. Quantity would mean frequency of inspection and also scope of coverage, because some property use groups may not be scheduled for regular inspections on any schedule. Quality would mean how well each inspection succeeds in identifying hazards, initiating a process to have those hazards quickly corrected, achieving timely hazard correction through effective follow-up, and possibly, educating and motivating the occupants and managers to operate safely in general.

The primary inspection effectiveness measure emphasized by the Urban Institute/NFPA projects was *percentage of fires in which the affected property was inspected within the 12 months prior to the fire*. This is a process evaluation type measure focusing on quantity. As Chapter 1 discussed at more length, the study of factors contributing to effective fire-code inspections had found that complete coverage and at least annual frequency contributed greatly to statistical success (measured by rate of fires with property loss over a defined threshold).

Based on the argument that relatively few fires started because of the kinds of installed hazards that regular inspections can realistically expect to observe and remove, the study concluded that quantity of inspection was more important to effectiveness than any quality measure considered at the time.

A separate analysis in the earlier study showed that installed conditions – including the absence of sprinklers and the presence of open stairway – were often cited as major factors in severity for the deadliest building fires. This observation did not alter the conclusion of the statistical analysis, because (a) these very deadly fires account for only a small fraction of total fire deaths and (b) these critical features were not required by applicable codes at the time, and so their absence or presence could not have prevented by better or more frequent inspections.

Quantity means something different for new construction, where frequency of inspection over time as a means of maintenance of safety does not make sense. Instead, quantity may be better understood as *timeliness*. Specifically, there are a series of time windows associated with inspectable systems, features, and conditions. Each time window begins when work begins on the system, feature, or condition, and ends when it is no longer practical or timely to modify the work. For example, if the walls have been closed up, so one can no longer observe or test the structural elements, the insulation, or the wiring, without the costs of opening up the building, then it is no longer practical to inspect those now-concealed elements of the construction if the only reason is to make sure everything is in good order.

The remainder of this chapter will address the elements of quality listed below, the variety of inspection practices that bear on the level of quality for each element, and proposed measures of effectiveness for each.

- Quantity – *Completeness of coverage* (for new construction and existing buildings): Measurement of gaps in coverage, either individual properties or whole property use groups that are not provided any inspection, for new construction or for routine inspections of existing buildings. Measured for properties in the community's property inventory and for properties that have fires and are subject to inspection.

- Quantity – *Frequency* (for existing buildings) and *timeliness* (for new construction): Measurement of time since last inspection for routine inspections of existing buildings. For existing buildings, measurement of whether or not each needed inspection, by building system or feature, was completed, with associated approval, before inspection or modification of that system or feature was no longer possible. Measured per inspection or per fire, in property subject to inspection.

- Quality – *Inspector quality as proxy* for inspection quality (for new construction and existing buildings). Can be measured directly based on whether inspector has certifications, training, experience, and resources (e.g., access to building plans, results of sprinkler contractor inspection results, results of tests on materials used in building) deemed necessary to perform a quality inspection for a particular property type. Can also be measured indirectly using type of inspector as a proxy for level of quality of inspector, typically when full-time fire inspectors are treated as having high quality and in-service suppression company inspectors are treated as having lesser quality. Can be measured as coverage and time since last inspection limited to inspections conducted with a defined level of quality or more. "Defined level of quality" can be defined by characteristics of inspector. Can also be measured in terms of coverage and results of audits of inspections.

- Quality – *Inclusion of specific educational/motivational elements* by inspectors as proxy for inspection quality with respect to educational/motivational impact (for existing buildings). Can be measured directly based on whether inspector has certifications, training, experience, and resources (e.g., access to prepared script elements for educational contacts with building managers) deemed necessary to perform a quality inspection for a particular property type.

- Quality and Quantity – Measures that combine quality and quantity can be constructed as variations on quantity measures. For example, a measure of time since last inspection can be modified to a measure of time since last inspection by an inspector with sufficient quality, where sufficient quality is defined based on one of the quality measures.

## Completeness of coverage

The UI/NFPA studies assumed that every fire-code inspection program should – and would attempt to – cover every property in the community that was subject to inspection. Our interviews revealed a much more complex picture:

- In the mid-1970s, Charlotte (NC) was one of the first communities in the country to have sufficient computerization of fire inspection files to permit computerized matching as a basis for identifying properties that should be inspected but were not known to the inspectors. At that time, they used matching to tax records, utility bills, and other property files within the city's jurisdiction to identify businesses that needed to be added to the system. However, the early study found that some fires still occurred at businesses previously unknown to the department. That study found that Seattle (WA), a city that inspected by block rather than from a list of properties, achieved a higher degree of comprehensive coverage.

Our 2008 interview found that the Charlotte practice was discontinued some time ago. Instead, Charlotte adds to their records based on issuance of certificate of occupancy or based on happenstance, such as noticing a new business in a complex while inspecting previously known properties in that location. Charlotte checks whether properties having fires were in the system and interviewees could not recall any examples (excluding data entry problems) of missing properties being discovered in this way.

Arlington (TX) uses a similar process for adding properties.

Austin (TX) updates its files using certificates of occupancy, permits, and licenses. Sometimes, insurance companies ask about the inspection history of a property filing a claim.

Providence (RI) updates its files using licenses and discovery of new properties in the field during routine inspections of other, nearby properties. By emphasizing licensed businesses as the primary targets for inspection, Providence puts itself in a stronger position if enforcement is necessary, because the non-compliant owner can be threatened with loss of that license.

- Reedy Creek Improvement District (FL) serves a district where a large share of properties are owned by Disney, and that company's emphasis on safety sets the tone for the district. Reedy Creek was very confident that their list was complete with respect to Disney properties. For others, they do not use any systematic methods like the old Charlotte system or the old Seattle system, but they will add businesses based on discovery by happenstance, as in Charlotte.

- Colorado Springs (CO) estimates they have about 18,000 businesses in the city and can afford to inspect about 600 to 900 occupancies per year (or about 2-5% of the total). The city does not design to cover all properties, but officials are reasonably confident that they capture all the high-priority types of properties they must or can cover. They also inspect based on complaints and other referrals.

  Colorado Springs is experimenting with the use of in-service firefighter inspections to cover the Business and Mercantile occupancies that represent all or nearly all of the uncovered properties. The pilot uses some of the geographic-based route principles seen in Seattle in the earlier project. As they begin to examine properties that have not been inspected in many years, they are finding lots of violations, many of them major.

Nashville (TN) similarly estimated that their own files had about 11,000 entries compared to about 60,000 properties listed on the tax rolls. Like Colorado Springs, they are most concerned about priority occupancies, which they believe they are able to identify through permit and license records. They also capture some properties through discovery by happenstance or through complaints.

- Phoenix (AZ) uses certificate of occupancy and business license records to update its files. Phoenix does not use tax rolls or utilities or any other file mining of that sort. Complaints or fires will also lead to the addition of a file, but as with the other communities interviewed, complaints or fires do not trigger a broader review of missing properties of a certain type. Only the specific property that had the fire or was the subject of the complaint will be added to the files.

  Phoenix has a constant problem with owners converting their property to other uses, whether temporary or not, without appropriate approvals. The Building Department has a well-established fast-track procedure to take such cases to court on an accelerated timeline. The procedure is not as well established in the Fire Department. Civil procedures are used much more than criminal.

  Phoenix officials would like to have a broader business licensing program, which would allow them to have more complete records. Officials in Austin, where they also do not have a broad business licensing program, said they thought that business licenses, with associated fees, may be viewed by area businesses as a way to charge for inspections.

- Tualatin Valley (OR) is a district that includes 9 cities, each with its own separate database. They hope to improve network interoperability in the future. They had done a block-based check for completeness and found they were very complete on properties but often not current regarding the name of the business. Tualatin Valley says they obtain 70-80% of new certificates of occupancy and have found that the business license database misses a lot.

Putting all this together, most communities do not attempt to maintain a complete database on inspectable properties, using either updates from a wide range of linked databases or updates from a systematic geographic pass through the community. Instead, they update using databases that are directly tied to a need for inspections (e.g., certificate of occupancy, permit, license) supplemented by properties identified through happenstance (e.g., because they had a fire, because they are next to another property scheduled for inspection). Even with these limited sources of update information, system limitations can result in additional gaps (e.g., a district that encompasses multiple jurisdictions with multiple databases and so misses some certificates of occupancy).

Notwithstanding the bare-bones nature of the updating and capture processes in most communities, most fire officials appear to believe that their files are complete with respect to the high-priority core of properties that they are required or expected to inspect, including all new construction.

To be useful, an effectiveness measure on completeness probably needs to have some coding on the circumstances explaining how the property was missed.

Table 8 presents completeness measures of inspection effectiveness. These measures are not numbered because numbering is done for the reduced, core group of measures, shown in Table 16 and on the summary table for the report, Table 17.

**Table 8. Completeness Measures as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness (for Existing Buildings Only)**

| Measure | Comments on Measure |
|---|---|
| Number and percentage of fires in properties subject to inspection that were not listed in the inspection files. | This measure will be more useful for action if it includes coding on the circumstances. Here is a proposal for consideration and revision for coding of reasons why properties were not listed:<br>1. Certificate of occupancy not received by department; property listed in other data bases (e.g., tax rolls, utility customers) not forwarded to department.<br>2. Certificate of occupancy not received by department; property not listed in other known data bases.<br>3. Property opened without certificate of occupancy.<br>4. Property's occupancy use group has no required or target frequency of inspection, and department does not require file completeness.<br>5. Property not listed because of data entry or data network error.<br>This measure should be analyzed separately by major property use group. |

## Frequency

The UI/NFPA studies assumed that every fire-code inspection program should – and would attempt to – cover every property in the community at least once a year. (Some communities interviewed in these earlier studies were attempting *more* frequent inspections for some or all properties, but no one was planning for less.)

Our interviews revealed a much more complex picture today:

- Charlotte (NC) reported that their state rules would not allow the fire department to inspect more frequently than the state-mandated frequencies, which were every 3 years for most properties, every 2 years for industrial properties, annual for high rise or high hazard properties including health care, and twice annual for schools.

- Reedy Creek Improvement District (FL) was the only department to report that they were attempting and achieving annual inspection for all properties. In addition, they offer optional inspections every two months, which their principal client (Disney) accepts and other properties have declined.

- Arlington (TX) reported a target of annual inspection, but they know they don't achieve this frequency, and they are not using it as a hard standard but as more of an aspirational target for most properties. However, Arlington's advanced computerized records have allowed them to develop time since last inspection profiles, and they have begun using that information to do better on target frequencies for their high-priority occupancies.

- Providence (RI) reported that licensed properties are to be inspected annually while all other properties are to be inspected every 3 years. They also noted that they maintain flexibility to shift priorities in response to complaints or concerns raised by major fire incidents (e.g., nightclubs after the Station nightclub fire).

- Phoenix (AZ) reported they had no mandated or externally dictated inspection frequencies. Their hazard unit has some target frequencies for their priority categories, but these targets tend to be for 2 to 5 years, and they are unable to meet those targets with their resources.

- Austin (TX) reported that the state mandates annual inspection of schools, nursing homes, day cares, and anything licensed. They aim for inspections every 3 years for warehouses. There is no target schedule for small stores and restaurants.

  Nashville (TN) somewhat similarly inspects schools and day cares annually and aim for inspections every 3 years for hotels, motels, and large assembly or mercantile properties. There is no target schedule for small stores, and there will be none until or unless they add in-service firefighter inspections.

- Tualatin Valley (OR) has annual and every 2 year frequency targets, based on the priority of the occupancy type. When listing properties they cover, officials did not list ordinary mercantile and business occupancies. Such properties were included in the district's in-service firefighter inspection program, which had been discontinued about 5 years ago.

Unlike the situation in the mid-1970s, when every participating community professed to be seeking at least annual inspection of all inspectable properties, the situation today suggests most communities have less ambitious goals.

To be useful, an effectiveness measurement program needs to distinguish low frequencies that fall short of targets and requirements from low frequencies that are fully in line with local targets and requirements.

Also, effectiveness measurement can be done using each inspection as a case or each fire as a case. Each approach has advantages and disadvantages, and they are described in Table 9. These measures are not numbered, which is reserved for Table 16, with the reduced list of core measures for this chapter, and the report' summary table, Table 17.

## Table 9. Frequency and Timeliness Measures as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness (for Existing Buildings and New Construction, Respectively)

| Measure | Comments on Measure |
|---|---|
| Percentage of *inspections* for which time since last inspection is greater than the department's target cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |
| Percentage of *inspections* for which time since last inspection is greater than one year. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |
| Number of building systems and features, from defined list, for which inspection and approval were not completed, per new construction project. (**New construction**) | A building system or feature would go on this list if no **timely** inspection had occurred, for example:<br>➢ No inspection was ever conducted<br>➢ Approval was given before work on the system or feature was completed<br>➢ Approval was given even though it was no longer possible to examine the system or feature because it had been covered up by subsequent work on the building<br>➢ The certificate of occupancy was issued before identified violations had been confirmed as cleared |
| Percentage of *fires* for which time since last inspection is greater than the department's target cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. Analyzing fires rather than inspections is more practical in the absence of a sufficiently computerized inspection file and involves a much smaller number of cases per year. Analyzing fires will capture gaps in inspection frequency but also gaps in inspection coverage. |
| Percentage of *fires* for which time since last inspection is greater than one year. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |

**Table 9. Frequency and Timeliness Measures as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness (continued) (for Existing Buildings and New Construction, Respectively)**

| Measure | Comments on Measure |
|---|---|
| Percentage of *fires* for which ignition or severity involved building systems and features, from defined list, for which inspection and approval were not completed, per new construction project. (**New construction**) | The percentage should be based only on buildings constructed after the implementation of this measure. |

## Inspector quality

While inspector quality is more directly measured by certification, training, experience, and supporting materials of inspectors, all conversations begin with an examination of who conducts inspections, because the type of inspector is widely regarded as a strong proxy for the quality of his or her inspections.

Table 10 provides an overview of what types of inspectors are involved in conducting fire-code inspections, by size of community. Nearly all communities of at least 50,000 population use full-time fire department inspectors, but most also use in-service firefighters. In rural communities, only 4% have full-time fire department inspectors, only 12% use in-service firefighters, and 37% of these small communities have no one conducting fire-code inspections. The "other" inspectors, which are also common only for smaller communities, may refer to state inspectors.

**Table 6. Types of Inspectors Conducting Fire-Code Inspections, by Size of Community**

| Population of Community | Full-Time Fire Dept. Inspectors | In-Service Firefighters | Building Department | Separate Inspection Department | Other | No One |
|---|---|---|---|---|---|---|
| 1,000,000 or more | 100% | 70% | 10% | 0% | 0% | 0% |
| 500,000 to 999,999 | 93% | 64% | 4% | 4% | 0% | 0% |
| 250,000 to 499,999 | 100% | 54% | 11% | 0% | 2% | 0% |
| 100,000 to 249,999 | 97% | 50% | 12% | 2% | 1% | 0% |
| 50,000 to 99,999 | 91% | 52% | 15% | 4% | 4% | 1% |
| 25,000 to 49,999 | 74% | 46% | 19% | 3% | 14% | 2% |
| 10,000 to 24,999 | 48% | 38% | 22% | 8% | 20% | 4% |
| 5,000 to 9,999 | 20% | 23% | 25% | 10% | 29% | 14% |
| 2,500 to 4,999 | 10% | 17% | 20% | 14% | 28% | 24% |
| Under 2,500 | 4% | 12% | 13% | 15% | 25% | 37% |

Source: *Four Years Later – A Second Needs Assessment of the U.S. Fire Service*, Department of Homeland Security and NFPA, FA-303, October 2006, Table 25.

In the mid-1970s UI/NFPA study, the only inspectors considered were full-time fire department inspectors and in-service firefighters as inspectors.

That study found that the use of in-service firefighters was necessary to provide reasonably complete coverage of a community's inspectable properties.

Therefore, the issue of who conducts inspections in a community will have a significant impact on the ability of the community to achieve complete coverage and to achieve at least annual inspection frequency.

However, the use of in-service firefighters also has a bearing on inspector quality.

Table 11 summarizes the points made about the inspector quality advantages of full-time fire department inspectors and the characteristics (primarily perceived disadvantages) of every other group considered.

**Table 11. Inspector Quality Issues by Type of Inspector**

| Type of Inspector | Comments on Quality Issues |
|---|---|
| Full-time inspectors | Inspectors are certified, and their certification levels often, but not always, are factors in the properties and types of inspections assigned to them. Certification also includes requirements for continuing education.<br><br>If certification is done to a recognized NFPA standard or equivalent, it can be reasonable to infer that the code knowledge of the inspectors will be greater – broader and deeper – than for other inspectors without such certification.<br><br>Training also should result in more consistently high quality in inspection practices.<br><br>Apprentice-style training with senior partners and spot auditing by supervisors can be used to achieve and maintain consistent high quality inspections. Same techniques would be impractical or prohibitively time-consuming for inspectors who are not full-time inspectors.<br><br>Easier to implement quality assurance through Standard Operating Procedures and manuals than with other inspectors. Same problems of applying training to too large a group or from a position without supervisory authority. |
| In-service suppression companies | Can be used to provide coverage of large numbers of business and mercantile properties that are not complex or challenging and are beyond the resources of the full-time inspectors to cover otherwise. Nashville uses a partial program in which only some captains are certified and deployed to cover some smaller stores and like properties.<br><br>The NFPA/Urban Institute study found that in the three cities with high fire rates and low percentages of buildings receiving at least annual fire inspection, 0-10% of inspections were reported to be conducted by suppression companies. In the six cities with lower fire rates and higher percentages of buildings receiving at least annual fire inspection, 30-85% of inspections were reported to be conducted by suppression companies. |

## Table 11. Inspector Quality Issues by Type of Inspector (continued)

| Type of Inspector | Comments on Quality Issues |
|---|---|
| In-service suppression companies (continued) | Generates work for full-time inspectors in terms of supervision, training, and possibly follow-up inspections (to check whether violations corrected) and audits or quality assurance reviews of reports (to check whether inspections are being done well). Several communities said there are not enough resources to handle existing workload plus the workload generated by an in-service program. However, Arlington uses a program where follow-up inspections are only conducted by full-time inspectors, which allows them to also do audits on original inspections.<br><br>Lack relevant certification and training. Regulations or state or department policies may prohibit use of uncertified personnel. Too expensive to provide certification to all fire suppression forces.<br><br>Difficult to achieve consistency.<br><br>Size and complexity of workload for firefighters keeps growing – including emergency medical response and all kinds of training – and this leaves less time to devote to inspections. Also, firefighter culture remains resistant to fire prevention as a priority. Need to schedule inspections when time is available and to interrupt inspections if an emergency call comes in both make it likely that managers of inspected properties will be inconvenienced and their attitude toward inspectors and inspections will suffer.<br><br>Possible conflict of interest, if firefighters have second jobs in trades or as contractors. May violate state laws prohibiting inspections done by contractors.<br><br>Possible heightened liability exposure, not so much because firefighters will miss hazards but because lack of resources to properly follow-up all in-service referrals will lead to fires occurring due to hazards the department knew about but hadn't been able to correct.<br><br>Reno union sued to block in-service inspection task unless terms were negotiated. |
| Self-inspections | Arlington reported participation dropped from 75% to 22% over the 4 years of their now-discontinued program, and a 10% quality audit found poor inspection quality.<br><br>Training, explaining, supervising, conducting follow-up inspections and inspections of businesses that fail to submit inspection reports, and other related fire department workload can be more time-consuming than the inspections had been.<br><br>Limits to program – such as requiring fire department inspection if hazardous materials are present – can be difficult to enforce. It is attractive to businesses to use self-inspection in all situations, not just where it is appropriate.<br><br>Some businesses may attempt to use participation in self-inspection as a reason to block fire department fire inspectors, again overlooking or trying to override program limits.<br><br>At least one community among those interviewed was considering using self-inspections for sprinkler inspections in condominium apartment units, because both the fire department and the sprinkler maintenance contractors were having trouble gaining access to these properties. |

## Table 11. Inspector Quality Issues by Type of Inspector (continued)

| Type of Inspector | Comments on Quality Issues |
|---|---|
| Self-inspections (continued) | Phil Schaenman reported to the authors that France and New Zealand use a modified form of self-inspections, in which the government requires that the building hire a certified inspector to conduct inspections but provides no oversight or quality assurance beyond the initial requirement. The only quality control is after the fact, if a fire occurs in a building where the required inspections were not being conducted; penalties are much more severe. It may be relevant to note that most criminal justice system research has found that increased penalties do little to deter crime but a higher likelihood of being apprehended will significantly deter crime. If this research is relevant in this other context, then one would expect the higher penalties following fire to be a weak quality assurance approach. |
| Insurance inspectors | State law may prohibit use of insurance inspections in lieu of department's own. At least one of the communities interviewed indicated that was their situation.<br><br>No tradition of formal sharing of reports, although there may be extensive informal sharing of information. Insurance companies typically are not interested in providing information and proprietary or confidentiality concerns may be a barrier. Tualatin Valley was the only department to indicate some use of insurance company inspections to cover some aspects of inspections for selected large facilities. |
| State or federal inspectors | State and federal agencies often delegate inspections to local inspectors in larger communities. In the smallest communities, state inspectors may be the only inspectors, with no local counterparts to share findings.<br><br>No tradition of state or federal agencies sharing reports with their local counterparts. |
| Inspectors from other agencies | Fire departments question whether inspectors from other agencies – such as building departments or inspection departments – are as likely to have the relevant expertise, certification and training.<br><br>Typically problems in inter-agency cooperation, data sharing. |
| System maintenance and supervision contractors | In many communities, reports are shared and are considered valuable and reliable on issues addressed.<br><br>System inspections cannot be used as substitute for a fire department inspection that covers other issues but often are used for system issues. Usual approach is to require sprinkler inspection reports to be kept available on site and require any violations found to be reported directly to fire department by contractor. |
| Other private inspectors | While this subject was not raised during the informal interviews, later discussions have identified other types of private inspectors – such as the staff from fuel or power companies who provide annual inspection and maintenance of central heating and air conditioning equipment under contract for many customers – as other potential sources of inspections whose findings could be useful if connected to the local government's fire-related inspection programs and databases. |

Table 12 describes measures based on inspection quality, using inspector type as one proxy for inspector quality and a more direct list of desirable characteristics of inspectors and inspections as an alternative proxy. These measures are not numbered, because numbering is reserved for the reduced list of core measures, shown in Table 16, and the summary table of core measures for the report, which is Table 17.

**Table 12. Inspector Quality Measures as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness**

| Measure | Comments on Measure |
|---|---|
| Percentage of *inspections* conducted by inspectors with all necessary *certifications* for their assignment. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups. It may be appropriate to analyze initial inspections and follow-up inspections separately or to separate assignments in other ways that relate to differences in required certifications. A list of necessary certifications needs to be developed to support the measure. |
| Percentage of *inspections* conducted by *full-time* inspectors. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |
| Percentage of *fires* for which last inspection was conducted by an inspector with all necessary *certification* for the assignment. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. It may be appropriate to analyze initial inspections and follow-up inspections separately or to separate assignments in other ways that relate to differences in required certifications. A list of necessary certifications needs to be developed to support the measure. |
| Percentage of *fires* for which last inspection was conducted by a *full-time* inspector. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |

Table 13 describes measures based on both inspector quality and inspection quantity. These measures are not numbered, because numbering is reserved for the reduced list of core measures, shown in Table 16, and the summary table of core measures for the report, which is Table 17.

**Table 13. Measures Combining Inspector Quality and Inspection Quantity as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness**

| Measure | Comments on Measure |
|---|---|
| Percentage of *inspections* for which time since last inspection by an inspector with certification appropriate to the assignment is (a) greater than one year or (b) greater than the department's cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |

**Table 13. Measures Combining Inspector Quality and Inspection Quantity as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness (continued)**

| Measure | Comments on Measure |
|---|---|
| Percentage of *inspections* for which time since last inspection by a full-time inspector is (a) greater than one year or (b) greater than the department's cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |
| Percentage of *fires* for which time since last inspection by an inspector with certification appropriate to the assignment is (a) greater than one year or (b) greater than the department's cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |
| Percentage of *fires* for which time since last inspection by a full-time inspector is (a) greater than one year or (b) greater than the department's cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. The use of a one-year threshold reflects the results of the mid-1980s UI/NFPA study and the absence of any other research to indicate that a different cycle time better represents the tipping point between too frequent and not frequent enough. |

## Educational/motivational elements

The earlier UI/NFPA studies promoted the importance of the educational and motivational aspects of inspections based on a couple of arguments:

- Most importantly, it was difficult to square the large percentage reduction in fire rates in communities with strong inspection programs with small percentage of fires involving the kinds of hazards inspections are designed to identify and remove. Educational and motivational effects that last long after the inspector departs seemed the most likely factor to close that gap.

- Inspectors in all communities routinely identified educational and motivational effects as a major part of what they tried to do.

All of the communities interviewed for the current project agreed with the importance of educational and motivational aspects, but few had done anything about them other than hiring and training inspectors in general people skills.

Therefore, effectiveness measurement of inspector quality with respect to educational and motivational aspects of inspections must begin with work not yet conducted, let alone standardized, to define and agree on the program elements that constitute quality in this regard.

Only then will it be possible to define effectiveness measurements that refer to those program elements.

**Table 14. Possible Elements for an Approach to Strengthen and Systematize the Educational and Motivation Aspects of Inspections**

| Concept for Element | Brief Description of What Would Be Involved in the Element |
|---|---|
| Having a plan and a philosophy | Inspection managers would develop a plan that presents, explains, and translates into action their philosophy for how inspections work best to create behavior change in the managers of properties subject to inspection.<br><br>This could extend even to details in the form of scripted ways to introduce certain topics or to set a tone.<br><br>It should extend to the identification of key elements of inspector training, which can then also be incorporated into effectiveness measurement. |
| Explaining why violations matter | Inspectors would be trained to explain the science and engineering behind the requirements. They would be able to explain how a particular type of hazard can lead to a fire ignition or a more severe fire.<br><br>Ideally, this would be a model procedure developed by experts in codes, inspection procedures, and relevant elements fire protection engineering, behavioral science, and life safety education.<br><br>Explanatory materials can be made more effective if well-designed text is supported by well-chosen photographs. Providence (RI) photographs violations to aid in discussions with facility managers and to use in their own records. Photographs also help when follow-up inspections are done by different inspectors than those who performed the original inspections. This established technique could be broadened to show inspectors and property owners or managers what hazards look like and, in other photographs, how such hazards lead to ignitions or more severe fires. |
| Making it real | Inspectors would be provided with concise, accurate descriptions of real fires that illustrate the potentially severe consequences of particular types of hazards.<br><br>Relevant fires could include both well-publicized major national or international fires and possibly unpublicized local fires that locals can relate to through personal familiarity with the affected properties.<br><br>Ideally, this would be a model procedure including a stock of national fires ready for use, as well as steps to take to develop local fires in a similar format.<br><br>Providence has held occupancy-specific education sessions that they consider very effective. This is a different approach – tying education to a special session rather than to an individual inspection – but the intent is the same. |

## Table 14. Possible Elements for an Approach to Strengthen and Systematize the Educational and Motivation Aspects of Inspections

| Concept for Element | Brief Description of What Would Be Involved in the Element |
|---|---|
| Tap the inner caregiver | Many people will treat risks to themselves and their property as personal choices, which they should be able to accept as tolerable even if the laws and the rules say otherwise. Many of those same people, however, will accept an obligation – moral and legal – to protect others from risks that they themselves might consider acceptable. By framing the consequences of hazards and violations in terms of threats to others, the inspector will be even more persuasive.<br><br>This should be folded into the model procedure for how to communicate and how to frame messages, as referenced above. |
| Relate to constituents | One community referred to salesmanship rather than a "heavy badge." Another referred to "recovering disgruntled guests." A third referred to moving away from "gotcha" inspections.<br><br>There is wide agreement that most property managers will respond to persuasion and do not need threats to do the right thing.<br><br>One department provides mailings on common violations in advance of inspection, making it easy for a manager to earn a clean rating. Then they follow up with a customer satisfaction survey.<br><br>There will be exceptions, and the program needs to be carefully designed. For example, certain types of hazards are so likely to emerge from the normal course of business – for example, overcrowding and blocking of exits at nightclubs – that they require unannounced inspections. The key is to treat those cases as exceptions rather than the rule.<br><br>Most of the larger communities and many smaller ones encompass multiple languages and multiple cultures. The more the department can do to train inspectors and adapt materials to suit the needs of special constituencies, the better the chances that the inspection event will be fully successful. |

Once the program elements defining quality have been specified, one can define inspection effectiveness measures based on them. These measures are not numbered because numbering is reserved for the reduced list of core measures for the chapter, shown in Table 16, as well as the report's summary list of core measures, in Table 17.

## Table 15. Inspector Quality Measures Related to Educational and Motivational Aspects as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness

| Measure | Comments on Measure |
|---|---|
| Percentage of inspectors who have received specified training in communication and educational techniques. (**New construction** and **existing buildings**) | These can be general techniques or special techniques targeted on special constituencies but should be clearly defined, suitable for formal training and possibly certification. |

### Table 15. Inspector Quality Measures Related to Educational and Motivational Aspects as Candidate Process Evaluation Type Measures for Code Compliance Effectiveness (continued)

| Measure | Comments on Measure |
| --- | --- |
| Percentage of inspectors who have received formal training on why violations matter. (**New construction** and **existing buildings**) | This includes the ability to provide lay-friendly concise descriptions of relevant science and engineering. This measure assumes that the complementary training on how to effectively communicate this technical information is addressed by the previous measure in Table 15. |
| Percentage of inspectors who have been trained on fires relevant to their inspection assignments and on their implications for the importance of hazards and violations (**New construction** and **existing buildings**) | This includes national and local fires, set up as short cases. |

## Summary of Proposed Process-Type Inspection Effectiveness Measures

Table 16 summarizes a recommended core group of measures from this chapter. The numbering resumes from Table 7.

### Table 16. Core Process-Type Measures for Code Compliance Effectiveness

| Measure | Comments on Measure |
| --- | --- |
| 7. Percentage of **fires** in properties subject to inspection that were **not listed in inspection files**. (**Existing buildings**) | Classify by reason not listed. |
| 8. Percentage of **inspections** for which **time since last inspection** is greater than the department's target cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |
| 9. Number of **building systems and features**, from defined list, for which **inspection** and approval were **not completed**, per new construction project. (**New construction**) | A building system or feature would go on this list if no **timely** inspection had occurred. |

## Table 16. Core Process-Type Measures for Code Compliance Effectiveness (continued)

| Measure | Comments on Measure |
|---|---|
| 10. Percentage of **inspections** conducted by **inspectors** with **all necessary certifications** for their assignment. | This measure should be analyzed separately for different major occupancy groups. It may be appropriate to analyze initial inspections and follow-up inspections separately or to separate assignments in other ways that relate to differences in required certifications. A list of necessary certifications needs to be developed to support the measure. |
| 11. Percentage of **inspections** conducted by **full-time inspectors**. | This measure should be analyzed separately for different major occupancy groups. |

## <u>Chapter 5. Other Ideas and Issues</u>

### Software for Inspection Management and Effectiveness Measurement

When the mid-1970s UI/NFPA projects were conducted, computerization of anything was still new and far from universal. There was nothing like NFIRS to provide standardized coding. Today, the situation could not be more different. Where there are not official standards, like NFIRS, there are often default standards associated with the products offered by major vendors. And the vendors exist because there is a large enough volume of demand for software and database systems in the fire service.

Some of the features that are now in wide use but still far from universal include the following:

- <u>Networked notebook computers</u>. These provide support for inspectors on site and in the field. Many can be linked to the network to upload and download files from the inspector's car, and some can be linked to printers in the car to generate forms to be left at the inspected property. (The term "notebook computer" is often used to refer to a particular size of portable computer. Here, it should be understood more broadly to include any type of portable computer, including a personal data assistant.)

  It is important to make sure that this technology provides a real enhancement of inspector work. Tualatin Valley found that their first set of notebook computers actually added 20 minutes per inspection to the service time. Interacting with the network in real time involves some additional time, and that time may be greater in the beginning as people become familiar with the system. The test is whether there are even greater savings in time at some other stage in the system.

- <u>Individual files for each property</u>, geo-coded by address. Geo-coding allows the inspection files to be easily linked to other local government databases organized by property or address, including computer-aided dispatch systems, fire incident databases, and tax rolls. Each property's file shows each contact by date, findings of each contact, and pending violations with due dates.

- <u>Document generation ability</u>. Increasingly, fire inspection management systems can take a short entry from the inspector regarding a violation finding and translate it into a complete notice to the property manager, including precise language from the regulations.

Our interviews suggested a number of other features that could be useful in future editions of this kind of software:

- Because vendors of fire inspection management systems operate nationally, they initialize a customer's system using national model codes. Every community has local variations – amendments, codes they do not adopt, special regulations – and every community faces a long, time-consuming process of **customizing to reflect local**

**differences**. Some software is better set up to facilitate this local customization process than others, but it is a laborious process with even the best systems. There is room for development of a national or state-level resource that could be linked to by any locality in the state as a means of customizing and updating the referenced codes.

- None of the interviewed departments had anything good to say about checklists, and their reasons were usually the same. They were concerned that inspectors with checklists will tend to work to the checklists, omitting important parts of the code that are not cited often enough to be included in a traditionally short checklist.

  A checklist will reduce the chances that something on the checklist will be missed, while increasing the chances that something not on the checklist will be overlooked. With advanced computerization, it should be possible to create a **menu-driven inspection protocol** that would operate like a checklist but would literally miss nothing. Such a protocol could not only provide a comprehensive set of prompts for everything to check but could identify the tests and sources of data (e.g., sprinkler maintenance contractor reports on site) for everything on the menu.

- It would be useful to set up report **software macros to generate** any and all of the **effectiveness measures** identified in this report.

- It would be useful to set up **script reminders, concise hazard impact descriptions,** and **national and local fire synopses**, all accessible for use in a more systematized and detailed approach to the educational and motivational aspects of inspections.

- It would be useful to embed **route-making programs** that could cluster inspections for efficiency in assignments. This will apply less to departments that use specialization for all or nearly all of their inspectors.

- It would be useful to develop **work scheduling programs** that could organize assignments each day based on which inspections were due, who was on duty, and what constraints applied to assignments. Short of this, it would be useful to generate **tickler files**, reminders of which inspections are due.

## Fees

Many departments reported struggling with the conflict between a public service philosophy for fire inspections and code compliance programs versus increasing pressure from local government management to recover more costs through fees. There was considerable diversity in fee structures. Most departments reported fees associated with permits, licenses, and certificates of occupancy, and some reported differing fee amounts, for different property use groups, reflecting the considerable variations in size and complexity of different kinds of properties.

Some departments reported charging fees for follow-up inspections but not for initial inspections. Some of those departments reported waiving the follow-up inspection fees so long as promised progress was being made. They referred to the unwaived fees as fees for wasting the department's time.

This suggests the possibility of instituting nominal fees for all initial inspections but waiving those fees for any inspection with no violations (or no major violations). In combination with a precedent of waiving follow-up inspection fees when work is done and the program used in one department of mailing out a checklist of common violations in advance of an inspection, there are the elements of a program with multiple incentives and multiple aids for well-meaning property managers to improve safety and avoid costs in the process.

## Rotation of assignments

Some departments were committed to keeping the same individual on the same property, from initial inspection to any follow-up, from one inspection to the next. They stressed the value of continuity in building specific knowledge about a property with an inspector and building a productive, collaborative relationship between the inspector and the property managers.

Other departments were just as committed to regular rotation of assignments. Part of the rationale for rotation was greater opportunity to equalize workload and cluster assignments to reduce total travel time and improve efficiency. Another rationale was the development of broad familiarity with all kinds of properties among all the inspectors. Still another rationale was the downside of familiarity and close relationships. A new inspector serves as an implicit peer check on the old inspector.

The suggested effectiveness measures should work equally well no matter which approach to rotation is favored in a community. But there remains an interesting research question on whether the advantages of rotation or the disadvantages of rotation tend to be more significant in practice. Both sides make a good case for their approach, but there is little or no hard data on either side.

## Efficiency measurement

The informal interviews asked a few questions about workload measures and analysis for efficiency, but the project did not place much emphasis on the subject, and there was not much information received in the interviews or the literature review to point toward favored approaches to efficiency measurement.

An exception was Austin, which has built up tracking reports around measures like average time per inspection, by type of inspection and type of property use; and inspections per month per inspector, again designed to allow for predictable, legitimate differences in assignments.

# Chapter 6. Summary of Proposed Core Effectiveness Measures

A total of 11 core measures have been identified in the report in Tables 4, 7 and 16. Many important issues are not addressed by these core measures, most notably, measures related to the educational and motivational effects of fire inspections. The reason for that particular omission is the large quantity of work needed to produce detailed guidance for a program with enough specifics to warrant measurement. For the other measures identified and discussed but not included in the core, the reasons are priorities, problems with obtaining enough data for meaningful analysis, and readiness for practical use in management and decision-making.

Here are the core measures in one place:

**Table 17. Proposed Core Measures of Code Compliance Effectiveness**

| Measure | Comments on Measure |
|---|---|
| 1. **Structure fire rate** per 1,000 inspectable properties (**Existing buildings**) | Use five-year averages to compensate for small numbers of fires per year. May exclude intentional fires. Designed for **routine inspections**.<br><br>Use instead of structure fire death rate, which will not have enough incidents per year for meaningful statistical results. However, calculate measures #5-7 separately for fatal fires and/or develop matrix for fatal fires showing points addressed in measures #5-7, in order to obtain information targeted on fatal fires. |
| 2. **List** inspectable-property structure fires with **at least $25,000 in loss**; show **matrix** with presence and importance to fire severity of standard list of **major hazards**. (**New construction** and **existing buildings**) | Work with insurance companies to get best loss estimates. Consider including indirect loss, such as business interruption costs.<br><br>Link to measure #4, which identifies major classes of hazards to be tracked separately. Distinguish hazards associated with new construction versus routine inspections. |
| 3. Estimated monetary **value per additional inspection**, by major property use group. (**Existing buildings**) | Calculate using the formula: Value of one annual inspection = (Fire loss per year) x (% loss preventable by inspection) / (# occupancies)<br><br>Link to measure #5, which sets up formula for what is preventable. |

## Table 17. Proposed Core Measures of Code Compliance Effectiveness (Continued)

| Measure | Comments on Measure |
|---|---|
| 4. Number of **violations** found per inspection, overall and separately for (a) sprinkler-related and (b) safe evacuation related.<br><br>For new construction, also identify number of **conditions** that could not be inspected because they were **not inspected while still exposed**.<br><br>(**New construction** and **existing buildings**) | The focus on sprinkler status and evacuation-related violations is one way of singling out problems that are frequently cited as major reasons for multiple-death fires in inspectable properties. Hazardous-material-related violations, compartmentation-related violations, and detection/alarm-related violations are other major groups that could be given their own focus.<br><br>Link to measure #2, which can use the same major-hazard groups selected for focus here. |
| 5. Percentage of fires that were **preventable** or could have been **mitigated** by **inspection** or by the **educational** and motivational elements of inspection. (**Existing buildings**) | Link to measure #3 on estimated value of an additional inspection, which will use the same framework for judging fires preventable or amenable to mitigation. |
| 6. Percentage of fires where there were **pending, uncorrected violations** present at the time of the fire. (**Existing buildings**) | Designed primarily to focus on problems post-inspection in achieving removal of hazards and code compliance. |
| 7. Percentage of **fires** in properties subject to inspection that were **not listed in inspection files**. (**Existing buildings**) | Code by reason not listed. |
| 8. Percentage of **inspections** for which **time since last inspection** is greater than the department's target cycle time. (**Existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |
| 9. Number of **building systems and features**, from defined list, for which **inspection** and approval were **not completed**, per new construction project. (**New construction**) | A building system or feature would go on this list if no **timely** inspection had occurred. |

## Table 17.  Proposed Core Measures of Code Compliance Effectiveness (Continued)

| Measure | Comments on Measure |
|---|---|
| 10. Percentage of **inspections** conducted by **inspectors** with **all necessary certifications** for their assignment. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups.  It may be appropriate to analyze initial inspections and follow-up inspections separately or to separate assignments in other ways that relate to differences in required certifications.  A list of necessary certifications needs to be developed to support the measure. |
| 11. Percentage of **inspections** conducted by **full-time inspectors**. (**New construction** and **existing buildings**) | This measure should be analyzed separately for different major occupancy groups. |

# PROJECT ON
# MEASURING CODE COMPLIANCE EFFECTIVENESS FOR FIRE RELATED PORTIONS OF CODES

## VOLUME III

## CONCEPTS ADDRESSING THE MEASUREMENT OF LEADERSHIP IN LIFE SAFETY DESIGN

Casey Grant
Fire Protection Research Foundation

# Volume III Table of Contents

# Volume III Executive Summary

This study provides a conceptual analysis and summary addressing a comprehensive building evaluation protocol used to measure enhanced safety features in a structure referred to as Leadership in Life Safety Design (LLSD).

LLSD is a potential management tool directly related to the measurement of code compliance effectiveness. As such, this study is companion to another research project on "Measuring Code Compliance Effectiveness", which is a study under the auspices of the Fire Protection Research Foundation.

Among its attributes, LLSD provides a comprehensive fire safety evaluation of an eligible building or structure. As a fire risk indexing tool it provides a publicly visible evaluation of a building's fire safety characteristics, including use of non-required systems or features. LLSD has the potential for promoting formal, public recognition of features which may contribute to higher levels of societal safety and protection than are required by traditional building and fire safety codes and regulations.

LLSD is envisioned to provide a method for categorizing and quantifying the performance levels of specific building parameters for application to the design of a building. This would provide a simple rating system easily understood by individuals other than fire protection professionals (i.e. the general public), and indicate the extent to which a building exceeds the required minimum code.

LLSD has some similarities to other risk indexing methods. One example, and perhaps most noteworthy because of its increasing popularity in recent years, is the "Leadership in Energy & Environmental Design" (LEED) concept administered by the U.S. Green Building Council. Despite certain inherent differences, LEED is a building risk indexing method with certain characteristics that parallel LLSD.

Part of the background motivation for this particular study can be traced back to the NFPA High-Rise Building Safety Advisory Committee, which proposed at a joint meeting with the NFPA Standards Council in March 2006 that this concept be considered by NFPA in the NFPA Codes and Standards process. After a review of the information available at the time, further action on LLSD was tabled pending a more detailed evaluation and analysis of the concept.

This study includes a review of the available literature and compares LLSD to other risk indexing methods. As a project deliverable, the study provides a summary of those stakeholder groups who potentially would be affected by implementation of LLSD, and addresses the perceived positive and negative characteristics of the concept as a tool for use by the code enforcement and building community. It is intended that this study will provide sufficient supporting information to allow fire protection professionals interested in LLSD to establish their own independent judgment of the proposed methodology.

# 1. Introduction

## 1.1 Background

This study provides a conceptual analysis and summary addressing a comprehensive building evaluation protocol used to measure enhanced safety features in a structure referred to as Leadership in Life Safety Design (LLSD).

Among its attributes, LLSD provides a comprehensive fire safety evaluation of a candidate building or structure. As a risk indexing tool it provides a publicly visible evaluation of a building's fire safety characteristics. LLSD has the potential for promoting formal, public recognition of those buildings, which could result in achieving higher levels of societal safety and protection than are required by traditional building and fire safety codes and regulations.

LLSD is a potential management tool directly relating to the measurement of code compliance effectiveness. As such, this study is companion to another research project on "Measuring Code Compliance Effectiveness", which is a study under the auspices of the Fire Protection Research Foundation.

## 1.2 Purpose and Scope

The purpose of this study is to analyze and evaluate LLSD and its implementation options. This will be done through the following:

- Review of work done to date on the concept;
- Summarization of applicable literature;
- Discussion and comparison to similar related concepts and programs;
- Definition and description of the various building attributes and related parameters that make-up the proposed evaluation process;
- Clarification of the point scoring system in the proposed evaluation process;
- Identification of stakeholder groups who would have a direct relationship to LLSD implementation; and
- Summarization of perceived advantages and disadvantages.

## 1.3 Applicable Codes and Standards Activities

LLSD has direct applicability to virtually all codes and standards relating to the built environment, and its potential impact and interaction with the model codes and standards is very sweeping. In particular, it has a direct relationship to the enabling life safety and building code documents that provide over-arching requirements for the built environment, such as:

- NFPA 101®, *Life Safety Code®*, 2006 edition
- NFPA 5000, *Building Construction and Safety Code®*, 2006 edition

- ICC *International Building Code*®, 2006 edition

One existing document in the model codes and standards arena that is particularly noteworthy is NFPA 101A, *Guide on Alternative Approaches to Life Safety*. The 2007 edition of NFPA 101A provides alternative approaches to life safety based on the 2006 Life Safety Code, and is intended to be used with the Life Safety Code and not as a substitute. Specifically, section 1.4 of the Life Safety Code permits alternative compliance with the Code under equivalency concepts where such equivalency is approved by the authority having jurisdiction (NFPA 101, 2006). The methods contained in NFPA 101A can be used to help determine equivalency where used as part of the technical documentation submitted to the authority having jurisdiction. The basis of performance that is sought by NFPA 101A, is a level that is equivalent to the base performance as found in NFPA 101.

This study has been conducted under the auspices of the Fire Protection Research Foundation, whose mission is to plan, manage and communicate research in support of the NFPA mission. On this basis, this study is believed to be applicable, either directly or indirectly, to certain NFPA Technical Committee Projects, and to the NFPA High Rise Building Safety Advisory Committee. While arguably this study can be extrapolated to numerous NFPA projects and documents, the following are the committees that are directly involved with similar pertinent subject matter:

- Technical Correlating Committee on Safety to Life
- Technical Correlating Committee on Building Code
- Technical Committee on Uniform Fire Code
- Technical Committee on Alternative Approaches to Life Safety
- Technical Committee on Industrial, Storage, and Miscellaneous Occupancies
- High Rise Building Safety Advisory Committee

# 2. Overview of Leadership in Life Safety Design

## 2.1 Definition of LLSD

Leadership in Life Safety Design (LLSD) is a comprehensive building evaluation protocol used to measure enhanced safety features in a structure. It has recently been proposed as a fire safety counterpart to other popular approaches in the areas of environmental and energy quality measurement for structures.

LLSD is envisioned to provide a method for categorizing and quantifying the performance levels of specific building parameters for application to the design of a building. This would provide a simple rating system easily understood by individuals other than fire protection professionals (i.e. the general public), and indicate the extent to which a building exceeds the required minimum code.

LLSD is a safety measurement approach that is an extension of methods used for assessing code compliance. When reviewing the basic approaches to safety measurement, two types of generic assessments become apparent: fire risk and code compliance. To provide a better understanding of LLSD, the following background is offered on a fire risk type assessment and a code compliance type assessment.

In a fire risk type assessment, one estimates expected fire loss as a function of characteristics of the building. In its fully detailed and explicit form, this involves the development of a set of representative and collectively comprehensive fire scenarios, coupled with estimation of probability and severity of the scenarios, leading to an estimate of predicted losses per year. In a simplified form, the selected scenarios may be few in number and of unknown representativeness or comprehensiveness. Probability estimation may be replaced with a subjective weighting scheme, and predicted severity may be replaced with a dimensionless severity score. Both subjective weighting and dimensionless scoring are characteristic of an index number approach.

A code compliance type assessment, in its simplest form, is a list of code provisions and associated judgments as to the building's compliance or non-compliance with those provisions. A more sophisticated version might use weights for the code provisions to indicate estimated relative importance of each provision to the predicted fire risk. For example, a damaged or missing exit sign might be given less weight than a chained and locked exit door. Another refinement is to define degrees of compliance. This is straightforward if the code or standard itself defines levels of protection, as was the case several decades ago with the standard for home smoke detector installation (NFPA 74, 197, pg 74-10). However, multiple levels of protection is a concept that is not explicitly recognized in the NFPA codes and standards arena today, despite its ubiquitous use in an implicit manner through various fire safety options and design alternatives. Multiple levels of safety should not be confused with an evaluation tool like NFPA 101A, which measures and identifies how a particular building meets or exceeds the Life Safety Code, and does so without evaluating multiple levels of safety for a similar application.

LLSD is an extension of these refined methods for assessing code compliance. It still works off a list of building characteristics, but it is not necessary for all of them to be reflected in a code or for the highest rating on any of them to be limited to a state of compliance with the highest level of code-defined protection. Essentially, you can get extra points for doing more than the code requires, which is the basis for a "code-plus" approach (Solomon, Mar 2008). An LLSD system defines how many extra "points" are earned for a particular building characteristic as a function of what is included with the building. 'Characteristics' need not be limited to built-in features and systems but can extend to contents and furnishings and to the behavioral and organizational systems put in place and maintained for the building, such as sprinkler maintenance, exit drills, and so on.

## 2.2 Origin and Development

Although the Leadership in Life Safety Design concept is relatively recent, it belongs to the broader family of risk indexing methods. From a historical standpoint, some fire risk indexing methods have existed for decades and have seen widespread use. For example, the insurance industry has used risk indexing in certain rating schedules since the beginning of the 20$^{th}$ century (Dean, 1906).

One of the more widely recognized available methods that parallels LLSD is Leadership in Energy & Environmental Design (LEED), promulgated by the U.S. Green Building Council (U.S. Green Building Council, 2007). LEED evolved during the mid 1990's with involvement from volunteers linked to the Natural Resources Defense Council and other organizations supporting environmental protection. Its widespread use today has provided a model for the consideration of other similar concepts, and arguably its success has been an influence on the rise of concepts like LLSD.

The specific origins of LLSD can be traced to two companion guidelines developed in May, 2002 by the Council on Tall Buildings and Urban Habitat (Solomon, Mar 2008). These guidelines are the *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* (CTBUH, 2002). In particular, the *Building Safety Enhancement Guidebook* establishes a set of broad building component categories, and includes a series of enhancements that could be implemented by a building owner to upgrade (as a voluntary compliance option) their level of building safety, reliability, or performance. This document provides the basic framework for LLSD.

The relationship of LLSD to high rise buildings has its genesis in part in this earlier work of the Council on Tall Buildings and Urban Habitat, and high rise buildings continue to be a noteworthy potential application of LLSD. High rise buildings received significant focus after the catastrophic collapse of the multiple structures at the World Trade Center complex in New York City on September 11, 2001. This was a catalyst for further activity on high rise building safety and related concepts like LLSD. After the World Trade Center disaster several important studies were initiated, including the Building Performance Study (BPS) conducted by the American Society of Civil Engineers on behalf of the Federal Emergency Management Agency and the three year study on the building failures conducted by the National Institute of Standards and Technology (NIST NCSTAR 1, 2005).

During preparation of these studies, various changes were proposed and considered throughout the model code arena. Some changes were already being contemplated, such as in the NFPA codes and standards making process which had already been engaged in proactive changes to their applicable documents such as NFPA 101, Life Safety Code and NFPA 5000, Building Construction and Safety Code (NFPA 101 & NFPA 5000, 2003 & 2006 editions). These initiatives following the World Trade Center disaster provided a setting that encouraged the review of LLSD and similar concepts.

Another group that has had pivotal involvement in the furthering of LLSD is the NFPA High Rise Building Safety Advisory Committee. This group was formed in the NFPA codes and standards system by the NFPA Standard Council to address the special concerns associated with high rise buildings. This action was based on recognition of the unique physical challenges of these structures and the mixture of multiple occupancy types that are typically found in modern high rise buildings (NFPA Standards Council Minutes, Apr 2004). At that time, the Standards Council set the scope and purpose of the High Rise Building Safety Advisory Committee in part as follows:

> “This Committee provides review, assistance and recommendations to NFPA technical committees, and to other activities within the NFPA system, on the very broad range of subjects that encompass the tall building environment. This includes, but is not limited to: reviewing and developing proposals/comments on NFPA documents; studying external information to assist with determining its relevance to an NFPA program or committee project; referring pertinent information to the Public Education Division for their consideration; recommending research activities for consideration by the FPRF; and providing implementation or other advice related to recommendations of the NIST-WTC investigation.”

At their inaugural December 2004 meeting, the High Rise Building Safety Advisory Committee reviewed the *Building Safety Assessment Guidebook*, developed by the Council on Tall Buildings and Urban Habitat (CTBUH). A suggestion concerning the feasibility of further codifying the content of the CTBUH document was made. The LLSD concept was put forth and identified as an initiative worthy of further consideration, to be administered either by NFPA or any other organization that could or would be a sponsoring organization for all or part of the concept (HRBSAC Meeting Minutes, Dec 2004). During the first several years of the committee’s deliberations, LLSD became further recognized as a methodology to potentially enhance and measure the level of safety that could be provided in the high rise environment. At that time, various proposed changes to NFPA 101 and NFPA 5000 were independently being processed. Some of which had a direct effect on high rise buildings. Some of these proposed changes, however, were viewed as an optimum level of performance or could not be readily codified. These discussions led to the review and recommendation of the LLSD approach as a reasonable and workable concept that offered a plausible alternative.

The High Rise Building Safety Advisory Committee formally proposed this concept to the NFPA Standards Council at a joint meeting in March of 2006, with the intent of elevating the concept into the mainstream building and design arena (NFPA Standards Council Minutes, Mar 2006). After a review of the available information at the time, the NFPA Standards Council tabled further action on LLSD pending a more detailed evaluation and analysis. This was one of the fundamental motivations for this particular study.

In 2007, a fire grant from the U.S. Department of Homeland Security was awarded to the Fire Protection Research Foundation for a project on "Measuring Code Compliance Effectiveness" to further enhance an existing methodology to measure the effectiveness of code compliance enforcement as it relates to fire safety. "Measuring Code Compliance Effectiveness" provides a management tool for use by state and local fire prevention personnel and others responsible for code compliance activities. LLSD is effectively a sub-part of this larger parallel project because it is a comprehensive evaluation protocol for buildings.

# <u>3. Fire risk Indexing Approaches</u>

## 3.1 Background

Fire risk indexing methods describe a family of fire safety decision making processes that include LLSD. Fire risk indexing is a kind of measurement that is a type of fire risk assessment. Quantitative fire risk assessment originated with the insurance rating schedule, and is representative of a methodology that bridges fire science and fire safety (Watts, SFPE Handbook of Fire Protection Engineering, 2002, pg 5-125).

Fire risk indexing provides a means for modeling fire safety, and involves the analysis and rating of the hazards and other applicable characteristics of a building to provide a straight-forward indication of relative fire risk. A risk index is defined as a single number measure of the risk associated with a facility (American Institute of Chemical Engineers, 1994). Some of the approaches used in today's fire protection community have existed for decades, and some, such as certain rating schedules used by insurance companies have a much longer historical genesis dating back to the Great London Fire of 1666 and earlier (NFPA Volunteer Firemen Magazine, 1943).

Fire risk indexing approaches are also referred to by other designations such as rating schedules, index systems, numerical grading, and point schemes (Watts, ASTM STP 1150, 1992). Typical fire indexing methods are difficult to describe because of the seemingly endless possible applications they address. Examples of recognized fire risk indexing approaches include the following: (Watts, SFPE Handbook of Fire Protection Engineering, 2002, pg 5-126)

- <u>Insurance Industry Indexing Methods</u>: Used to manage the risk of protected properties, with approaches such as the commonly used "*Specific Commercial Property Evaluation Schedule*"; and the "*Gretner Method*" which is widely used in parts of Europe.
- <u>Indexing Methods for Industrial Applications</u>: Provide a means to systematically identify and address industrial applications with significant loss potential, such as "*Dow's Fire and Explosion Index*" developed in 1964 by Dow Chemical Company, and the "*Mond Fire, Explosion, and Toxicity Index*" which is a refined sub-set version of the "*Dow Fire and Explosion Index*".
- <u>Hierarchical Approach:</u> Used to improve the evaluation of fire safety through a systematic method of appraisal, such as an approach developed by the University of Edinburgh to address hospital fire safety in the United Kingdom.

An index number based system like LLSD is no different than any existing established code in that there is no direct validation. For both index number systems and traditional codes and standards, any explicit or formal evidence to show that they measure or deliver safety is elusive and difficult to obtain.

From one perspective, a well-constructed index number system provides greater clarity on achieving code or other requirements rather than the simple yes/no approach that the existing prescriptive codes offer. Further, the current codes generally provide no credit for safer features, such as having a one story building versus a multi-story building. An index number system demonstrates flexibility to know what is important, how to measure what is important, and subsequently to provide a way to know how much safety is enough.

From another perspective, an index number system purports to convey a lot more detailed information about the level of safety, and effectively replaces the yes/no of the code with a number from a continuous scale. The implication of more precise measurement would arguably carry with it a higher presumption of need for validation. This same lack of validation might ultimately be more of a deficiency in a measurement system approach than in a packaged set of decisions called a code.

Risk indexing requires a process for deciding what is important. It provides a structure for measuring the extent to which the important attributes are present and contribute to fire safety, and it requires a calibration process to demonstrate how much is enough. It does not create knowledge, but instead only organizes it.

## 3.2 Development and Evaluation of Fire Risk Ranking Criteria

Any particular fire safety ranking system will have its limitations, and the question of how they should be developed and evaluated is important to assure its credibility, including addressing scientific rigor in the development of fire risk indexing methods (Building Research Board, 1988). Upholding this scientific rigor requires criteria for the development and evaluation of fire risk ranking, but it also needs additional qualities to be practical. It must be easily implemented, transparent, readily documented, technically versatile, and maintainable.

Table 3-2 provides a summary of criteria for development and evaluation of fire risk ranking proposed by Watts (Watts, Fire Safety Science – Proceedings of the Third international Symposium, 1991). Each of these 10 criteria provides an important and useful backdrop for developing and evaluating fire risk indexing methods. It is helpful to review LLSD and any other approach against these criteria.

Table 3-2: Summary of Criteria for Development and Evaluation of Fire Risk Ranking (Watts, SFPE Handbook of Fire Protection Engineering, 2002, pg 5-138).

| # | Criterion | Description |
|---|---|---|
| 1 | Documentation | Method should be thoroughly documented according to standard procedures. |
| 2 | Universe Selection | Partition the universe rather than select from it. |
| 3 | Significance | Attributes should represent the most frequent fire scenarios. |
| 4 | Lexicon | Provide operational definitions of attributes. |
| 5 | Credibility | Elicit subjective values systematically. |
| 6 | Update Mechanism | Attribute values should be maintainable. |
| 7 | Interaction Consistency | Treat attribute interaction consistently. |
| 8 | Assumptions | State the linearity assumption. |
| 9 | Simplified Results | Describe fire risk by a single indicator. |
| 10 | Predictive Capability | Evaluate predictive capability. |

Three characteristics provide the primary basis of an in-depth review of any fire risk index, including LLSD. These characteristics represent the basic features of the indexing method and are: (a) set of building characteristics or attributes with importance weight; (b) a rating scale of levels for each building characteristic or attribute; (c) a formula for how they (i.e. (a) and (b)) interact. When evaluating a proposed method like LLSD, these three characteristics should be considered as a point of reference during the evaluation.

Of the ten aspects highlighted in Table 3-2, and while considering the aforementioned three characteristics of fire risk indexing methods, the following observations are offered. First, criteria *#1 -- Documentation*, *#9 -- Interaction Consistency*, and *#10 -- Assumptions* represent general features common to all fire risk indexing approaches. Second, several of the criterion deal with a set of building characteristics or attributes with importance weights, and most notably this would include criteria *#2 -- Universe Selection*, *#3 – Significance*, *#4 – Lexicon*, *#5 – Credibility*, and *#6 – Update Mechanism*. Third, criterion *#5 – Credibility* is also related to the rating scale levels for each building characteristic. Finally, criteria *#7 – Interaction Consistency* and *#8 – Assumptions* relate to the formula for how a rating scale interacts with a set of building characteristics or attributes with importance weights.

## 3.3 Programs and Applications with Characteristics Similar to LLSD

Several risk indexing programs and applications exist that provide a useful backdrop to compare with LLSD. These have diverse characteristics and are reviewed in an attempt to better illustrate concepts relating to LLSD. The following provides information on similar concepts and programs and are listed in no order of priority other than alphabetically. This list is not considered exclusive, and, for example, does not mention other potentially applicable programs such as the NIOSH "Prevention Through Design" initiative. (NIOSH Press Release, May 2008). The programs and applications addressed here in further detail include:

- AIB Professional Excellence in Building Awards;
- BSC Building Security Council Rating System;
- Chicago Life Safety Evaluation System for High-Rise Residential and Historic Commercial Buildings;
- CTBUH Building Safety Assessment Guidebook and Building Safety Enhancement Guidebook;
- EB-FSRS Fire Safety Ranking System for Existing High-Rise Nonresidential Buildings;
- ICC Guidelines for the Rehabilitation of Existing Buildings;
- ISO Building Code Effectiveness Grading Schedule;
- ISO Management System Documents;
- NFPA 101A, Guide on Alternative Approaches to Life Safety; and
- USGBC Leadership in Energy & Environmental Design (LEED).

### *3.3.1 AIB Professional Excellence in Building Awards*

Various examples exist in the architectural community of programs that recognize excellence in building design and construction. One example is the Professional Excellence in Building

Awards administered by the AIB, Australian Institute of Building (Australian Institute of Building, 2007). This is not a risk rating system in the conventional sense, but it does provide an example of a program that provides a publicly acknowledged ranking method within the building community.

The AIB Professional Excellence in Building Awards is more general than a traditional point indexing method and it addresses more than the building life safety. Like other similar recognition programs it presents a publicly transparent means of evaluating buildings on a broad scale. In this case the awards are focused on recognizing the highest standards of building construction and management, research, and development of projects in Australia. The program addresses the building and construction management process and not the structures themselves. It uses the following six award categories: commercial; residential; technology and innovation; ecology sustainable development; research & development; and a general category (Australian Institute of Building, 2008 Awards Nomination, 2008).

### *3.3.2 BSC Building Security Council Rating System*

A new initiative referred to as the "Building Security Council Rating System" is under review and development by the Building Security Council (BSC), which is a non-profit entity created in November 2005 under the auspices of the American Society of Civil Engineers (Building Security Council, Jan 2008). The Building Security Council Rating System is intended to address the threat of terrorism and similar security concerns in a holistic manner, with the added purpose of helping to enhance public safety in buildings and encouraging more innovation and collaboration between building design professionals.

The basic concept is to establish a rating system that allows building owners to review, evaluate and upgrade their building security in a manner that is both practical and cost-efficient. The process is based on the voluntary pursuit of a security rating by an interested building owner through the submittal of detailed building information to a set of independent reviewers. Oversight is provided by a rating evaluation committee, which is subsequently evaluated against standardized rating criteria from which a final rating is assigned.

The proposed Building Security Council Rating System provides a classification scheme based on a verification of the level of additional features or enhancements used in the building. This would be based on a menu of project enhancements such as: security programs; augmented structural systems; redundant or enhanced building systems; built-in security measures; and site improvements.

It is intended that the program will be subsidized through fees to the building owners. A due diligence marketing survey from the Building Security Council has reportedly provided positive feedback. The Building Security Council is likewise considering a certification program, among other initiatives, to provide a mechanism for assuring compliance. However, the Building Security Council is currently pursuing protection against litigation under the "Safety Act Protection" through the U.S. Department of Homeland Security, and they may not go forward unless they obtain this protection.

The “Safety Act Protection” was originally intended for private companies with devices and products meant to further Department of Homeland Security initiatives (Howe, Journal of Homeland Security, May 2004). The Building Security Council has liability concerns if a so-called certified building experienced a perceived failure, and they may not continue supporting the Building Security Council Rating System without the “Safety Act Protection” or other ways of limiting their organizational exposure.

### *3.3.3 Chicago Life Safety Evaluation System For High-Rise Residential and Historic Commercial Buildings*

As a more specific example of a fire risk indexing system, the City of Chicago recently enacted the Life Safety Evaluation System for High-Rise Residential and Historic Commercial Buildings (City of Chicago News Release, Jan 2004). The Chicago Life Safety Evaluation System has been required since early 2005 as an alternative to a public safety ordinance that would have required retrofitting of all high-rises in the city with automatic fire sprinkler protection. Buildings are required to be evaluated and scored on 18 different criteria and must achieve a “passing” score in order to avoid retrofitting with fire sprinklers. This evaluation system followed several loss-of-life high rise fires in Chicago that prompted retroactive life safety related improvements to high rise buildings within the city. Most noteworthy was the high-rise fire in the 37 story Cook County Administration building on 17 October 2003 that resulted in six fatalities (Madrzykowski & Walton; NIST Special Publication 1021; July 2004.)

The implementation of this initiative illustrates the technical rigors of performing life safety evaluations on numerous large structures in a jurisdiction using limited inspection resources, within a defined time-frame, and in a satisfactory manner using credible and knowledgeable personnel (City Of Chicago, Dec 2005). Some question exists as to whether the ordinance will be effective, and more time will be required to fully evaluate its effectiveness. Additionally, questions on the base line of performance found in the Chicago evaluation tool compared to other minimum code type criteria are debatable.

### *3.3.4 CTBUH Building Safety Assessment Guidebook and Building Safety Enhancement Guidebook*

The *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* are two companion documents developed in 2002 by the Council on Tall Buildings and Urban Habitat (CTBUH, 2002). The intent of the Assessment Guidebook is to outline specific building features used to evaluate a building’s safety and security features, while the Enhancement Guidebook utilizes similar specific building features that if applied would provide predictable further enhancements to the building. These two documents were directly involved with the creation of LLSD. As such they are addressed in further detail later in this study.

### *3.3.5 EB-FSRS Fire Safety Ranking System for Existing High-Rise Nonresidential Buildings*

A proposed fire safety ranking system known by the acronym EB-FSRS has been proposed for buildings in Hong Kong. It has similar characteristics to the type of system envisioned with LLSD. This proposed system is intended to assess the fire safety provisions in existing high-rise nonresidential buildings in Hong Kong (Chow, Journal of Architectural Engineering, Dec 2002).

The application of the EB-FSRS model to high-rise buildings has strong similarities to the origin of concepts associated with LLSD, which likewise has origins related to high-rise applications.

The objective of the EB-FSRS is to measure the fire safety provisions in certain buildings to determine how they deviate with the expectations of current applicable fire codes. The approach uses a 15 maximum point fire safety ranking system, and has been exposed to a trial implementation using 37 identified existing high-rise nonresidential buildings in Hong Kong to demonstrate its application. The approach is comparable to that used by NFPA 101A, *Guide on Alternative Approaches to Life Safety*, although it claims to have the different objective of helping business occupants develop fire safety schemes rather than providing a type of equivalency design.

**Table 3-3-5: Brief Summary of Parameters Considered by Proposed EB-FSRS Fire Safety Ranking System for Existing High Rise Nonresidential Buildings in Hong Kong**

| Group | Safety Parameter | Point Criterion |
|---|---|---|
| Passive Building Construction | Building Height | If Height≤50m, then=+1; Otherwise=0 |
| | Egress Route | If # of Exits≥Code, then=+1; Otherwise=-1 |
| | Staircase Width | If Staircase Width≥Code, then=+1; Otherwise=-1 |
| | Smoke Door | If Smoke Doors, then=+1; Otherwise=-1 |
| | Interior Finish Features | If Interior Finish≥Code, then=+1; Otherwise=-1 |
| Fire Service Installation | Hydrant/Standpipes | If Hydrant/Standpipes in Good Condition, then=0; Otherwise=-1 |
| | Manual Alarm System | If Fire Alarm System in Good Condition, then=0; Otherwise=-1 |
| | Fire Detection | If Fire Detection in Good Condition, then=+1; Otherwise=0 |
| | Sprinkler System | If Sprinkler System in Good Condition, then=+1; Otherwise=0 |
| | Portable Extinguishers | If Portable Extinguishers in Good Condition, then=0; Otherwise=-1 |
| | Smoke Control System | If Smoke Control System in Good Condition, then=+1; Otherwise=0 |
| | Emergency Lighting | If Emergency Lighting in Good Condition, then=+1; Otherwise=-1 |
| | Exit Signs | If Exit Signs in Good Condition, then=+1; Otherwise=-1 |
| Control of Risk Factors | Fire Load Density | If Fire Load Density≤1135MJm$^{-2}$, then=+3; Otherwise=-3 |
| | Occupant Density | If Occupant Density≥Code, then=+2; Otherwise=-2 |

The attributes of the proposed EB-FSRS are divided into three main groups. These are: (a) passive building design based on applicable building department codes, (b) fire service installations based on applicable fire department codes, and (c) control of risk factors appearing in those codes. Table 3-3-5 illustrates the various safety parameters used to compile the 15 maximum possible points in the proposed EB-FSRS Fire Safety Ranking System (Chow, Journal of Architectural Engineering, Dec 2002, pg 118). This illustrates a clear index ranking based on certain distinct fire safety characteristics. The three basic classification groups have evolved to address control, design and implementation issues unique to applications in Hong Kong.

### *3.3.6 ICC Guidelines for the Rehabilitation of Existing Buildings*

One relatively widely referenced indexing system for use with existing buildings is the Guidelines for the Rehabilitation of Existing Buildings from the International Code Council (ICC "Guidelines for the Rehabilitation of Existing Buildings", 2000). This contains guidance for preserving existing buildings while achieving appropriate levels of safety, and provides a way for design professionals to determine if they need a more in-depth analysis.

The document provides useful information on a range of issues and concerns that may be encountered when rehabilitating an existing building. This includes high rise building life safety, historic buildings, energy conservation, and accessibility. The document also addresses permitting, change of occupancy, and enforcement concerns. Prior to the 2000 edition, the document was titled the *Uniform Code for Building Conservation* (Uniform Code for Building Conversation, 1997).

Recent consideration exists to extend the concept of a point scoring system to other aspects of the ICC family of documents, or at least to certain specific subject areas within these documents. For example, a point scoring system methodology has been proposed as a substitute for the Height and Area Table in the International Building Code (Noonan, Alliance for Smoke Containment and Control, Aug 2007). These are only under consideration at this time and implementation of this and other similar concepts is pending.

### 3.3.7 ISO Building Code Effectiveness Grading Schedule (BCEGS)

The Building Code Effectiveness Grading Schedule (BCEGS) is a point indexing system used by insurance companies to evaluate the risk associated with their insured properties (ISO "Mitigation On-Line", Jan 2008). The program is administered by ISO (formally Insurance Services Office), and it assesses the building codes and their enforcement within a particular community with a special focus on mitigation of losses from large-scale natural disasters.

Jurisdictions that have well-enforced and up-to-date codes generally have fewer losses, and the insured properties in such communities can receive favorable adjustment in their insurance rates. This is especially important in communities prone to large-scale natural disasters such as windstorms and earthquakes. Unlike LLSD that is focused toward a particular building or structure, the BCEGS assesses whole communities.

The BCEGS system uses a point scoring system from 1 to 10 with 1 being the highest classification. ISO began implementing the program in hurricane prone states, followed by states with a high seismic exposure before implementing it throughout the rest of the United States. The program is similar to ISO's Public Protection Classification Program used for decades to rate the public fire protection services (i.e., fire department) in a particular community.

### 3.3.8 ISO (International Organization for Standardization) Management System Documents

The other ISO of interest is the International Organization for Standardization, which uses the same acronym as the ISO that was the former Insurance Services Office but is distinctly different and has no direct affiliation. The International Organization for Standardization is a non-governmental organization that provides a network of national standards institutes from 157 countries, based on a system of one member per country. They have a Central Secretariat in Geneva, Switzerland that coordinates this system (Grant, NFPA Journal, Jan – Feb 2002).

Among the more than 17,000 standards in the ISO portfolio are the ISO 9000 and ISO 14000 families of documents, which are among the world's most widely used standards. For example, the 2000 edition of ISO 9001 is implemented by more than three quarters of a million organizations in 161 countries (ISO Management Systems, Jan – Feb 2007). The ISO 9000 and ISO 14000 families of documents address the broad topics of quality management and environmental management, respectively. These management system standards provide a framework for managing certain types of processes that have similarities to other risk indexing approaches.

Various models have evolved in parallel with the proliferation of the ISO 9000 and ISO 14000 series documents, including some that utilize point indexing methods (Zhang, Total Quality Management & Business Excellence, Jan 2000). But aside from their use of certain indexing approaches, the ISO 9000 and ISO 14000 initiatives illustrate the immense potential growth of certain cottage industries that have arisen dealing with collateral aspects such as certification, enforcement, training and accreditation (Guler, et al, Administrative Science Quarterly, June 2002] This suggests that other similar initiatives, perhaps like LLSD, may also have inherent sideline support activities such as certification that could someday become appreciable.

### *3.3.9 NFPA 101A, Guide on Alternative Approaches to Life Safety*

A fire risk indexing system provided by the National Fire Protection Association (NFPA) is addressed in their document NFPA 101A, *Guide on Alternative Approaches to Life Safety* (NFPA 101A, 2007). This is a companion document to NFPA 101, Life Safety Code, and it addresses a measuring approach that is referred to as the FSES, Fire Safety Evaluation System (NFPA 101, 2006).

NFPA 101A was first published in 1988. Since then seven editions have been published up to the 2007 edition. Prior to the 1988 edition, it was published as several appendixes within NFPA 101. Much of the content of NFPA 101A was originally prepared by the Center for Fire Research of the National Institute of Standards and Technology (then the National Bureau of Standards), before being modified and included with the document. NFPA 101A is administered by the Technical Committee on Alternative Approaches to Life Safety, which is a committee within the Life Safety Code project.

NFPA 101A is intended to be used in conjunction with NFPA 101, and it compares the difference in the level of safety provided in the required (mandatory) safeguards of a particular building according to NFPA 101, from the level of safety provided if the building conforms exactly to NFPA 101. NFPA 101 provides the traditional prescriptive requirements that have evolved since the document was first created in 1913. It also includes a performance oriented approach that allows alternative design options to meet the stated goals and objectives of NFPA 101. In a basic sense, NFPA 101A provides another approach to meet the goals and objectives of NFPA 101 through the use of a formalized structure. This concept is illustrated in Figure 3-3-9. NFPA 101A has been evolving over the past several decades. It includes evaluation systems for the following occupancies: health care, detention and correctional, board and care, business, and educational.

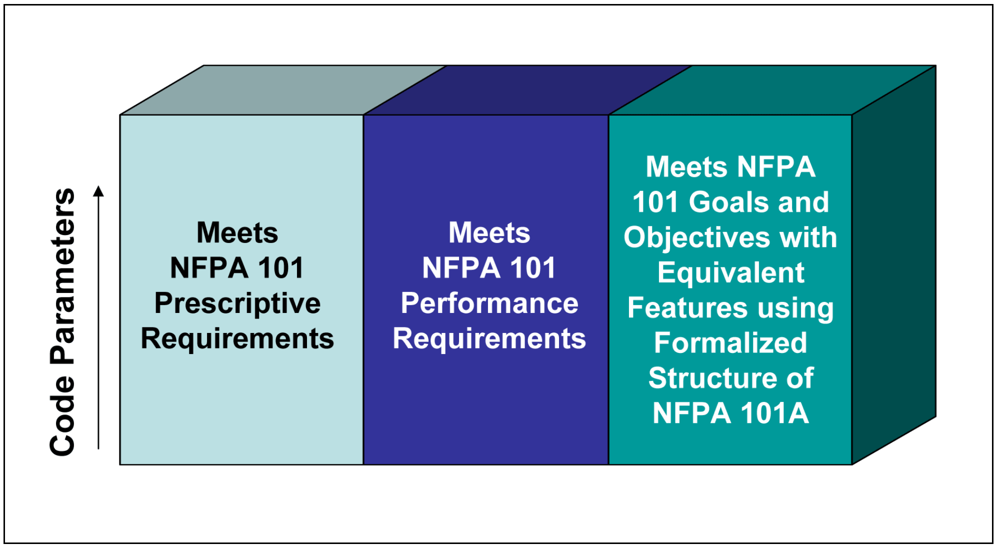


Figure 3-3-9: Difference in Life Safety Code Compliance Measured by NFPA 101A

An important characteristic of NFPA 101A is that it measures and identifies how a particular building meets or exceeds the Life Safety Code, but it does so without evaluating multiple levels of safety for a similar application. The concept of minimum code requirements is fundamental to model codes and standards, and these minimums are set as the baseline requirements. When the concept of multiple levels of safety has surfaced in the past within the NFPA consensus codes and standards process, it has not been viewed favorably (NFPA 74, 1975). For example, in the mid 1970s the multiple levels of protection defined by NFPA 74 used for household fire warning equipment were explicitly deleted from the document (NFPA 1978 Annual Meeting, TCR pg 74-2 and TCD 550). When the NFPA Standards Council has addressed this issue, it has indicated the need to maintain clarity on a single minimum level of safety (NFPA Standards Council Minutes, Jan 2002). For LLSD, if the promotion of multiple performance levels is viewed as being recognizable multiple levels of safety, a process to explain and justify the deviation from the baseline criteria will have to be argued.

### *3.3.10 USGBC Leadership in Energy & Environmental Design (LEED)*

The Green Building Rating System™ operates under the Leadership in Energy & Environmental Design (LEED) program administered by the U.S. Green Building Council (U.S. Green Building Council website). This program has blossomed over the last decade and arguably provides one of the best comparative models from which to examine the virtues of LLSD.

Other components of the Leadership in Energy & Environmental Design program, in addition to the Green Building Rating System, include Project Certification for independent, third-party verification that a building project meets some level of green building and performance measures, and Professional Accreditation for distinguishing building professionals who have exhibited the knowledge and skills to successfully steward the LEED certification process. The primary purpose of the LEED program is to promote the practice of designing and constructing energy and environmentally sustainable green buildings.

The LEED program has proliferated since its introduction in the mid 1990s. The ratings are based on the emerging popularity of green building design concepts including: reduced energy demands, improved efficiencies in heating and cooling demands, and use of low environmental impact construction materials. An example of the maturation of this program is symbolized by the evolution of supporting standards to address building sustainability relating to green buildings, such as ASTM E2432, *Standard Guide for General Principles of Sustainability Relative to Buildings* developed by the ASTM E06.71 Sustainability Subcommittee (ASTM E2432, 2005). This ASTM Subcommittee has other related standard work items in progress, including a new standard to address the minimum attributes of a building that promotes sustainability. From a user perspective other advantages are readily apparent with the LEED program. For example, with high rise buildings there are potentially significant incentives, such as building space being more marketable for major tenants. Iconic buildings, such as high profile public buildings, will have a positive value-added image of both the building and the city itself magnified.

Today the green building concept is relatively widespread and becoming more popular, although the concept is only now gaining traction among legislators who see LEED as an incentive for developers to gain zoning bonuses. While comparisons to the LEED program are in order, it is somewhat easier to measure cost-benefit advantages with LEED as opposed to measuring cost-benefit advantages to real or perceived safety enhancements that may result when an LLSD program is implemented. In addition, the consequences of a safety enhancement or feature not performing as advertised can be significant when contrasted to one or more elements from the LEED program that do not meet expectations.

# 4. Prototypical LLSD Application

## 4.1 Background

LLSD is envisioned to provide a method for categorizing and quantifying the importance of specific life safety parameters of a building. This would provide a simple rating system easily understood by individuals other than fire protection professionals (i.e. the general public), and indicate the extent to which a building exceeds the required minimum code.

Through the use of a formula, an overall life safety rating for the building could be derived that would identify a relative performance level for the building, such as, for example: bronze; silver; gold; and platinum. Each category would have to show some minimum level of enhancement to show how optimum design options have been included in the design of the building. This provides a reflection for how the building exceeds the minimum applicable building design requirements, as illustrated in Figure 4-1. The general intent of LLSD is to provide a comprehensive life safety evaluation of an eligible building.

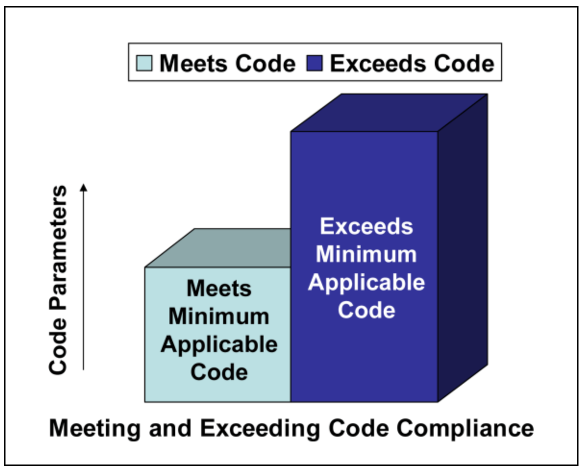


**Figure 4-1: The "Code-Plus" Approach of LLSD**

## 4.2 Assessment and Enhancement Guidelines

The origins of LLSD as we know it today can be traced to two companion guidelines developed in May, 2002 by the Council on Tall Buildings and Urban Habitat (Solomon, Mar 2008). These guidelines are the *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* (CTBUH, 2002).

The intent of the Assessment Guidebook is to outline specific building features that are normally required in codes and that can be used to evaluate a buildings safety and security features, while the Enhancement Guidebook utilizes similar specific building features that if applied would provide predictable further enhancements to the building. In the broadest sense, the Assessment

Guidebook provides helpful information to better understand how a building *meets* the minimum applicable code, while the Enhancement Guidebook provides similar helpful information for how a building *exceeds* the minimum applicable code. As such, the Enhancement Guidebook is the document identified as directly supporting the genesis of "code-plus" approach that provided a basis for the prototypical LLSD application.

**FIRE**

F.1 AUTOMATIC SPRINKLER SYSTEM
F.2 STANDPIPE SYSTEM
F.3 ALARM SYSTEM
F.4 FIRE OR SMOKE DETECTION SYSTEM
F.5 WATER SOURCE FOR FIRE PROTECTION SYSTEM
F.6 SMOKE EXHAUST SYSTEM
F.7 EMERGENCY POWER SYSTEM
F.8 EMERGENCY LIGHTING SYSTEM
F.9 COMMUNICATION SYSTEM
F.10 BUILDING AUTOMATION SYSTEM
F.11 EMERGENCY EQUIPMENT
F.12 FIRE COMMAND CENTER
F.13 BUILDING CONTENTS
F.14 EXTERIOR WALL CONSTRUCTION

**Figure 4-2a: Building Safety Assessment "Fire" Checklist (CTBUH, 2002).**

The range of possible hazards to a building or structure is significant. Both the Assessment Guidebook and the Enhancement Guidebook sub-divide these into the five categories of fire, earthquake, windstorm, explosion and bio-chemical. Fire is a primary concern since it can occur directly or indirectly as the result of another initiating event, such as an earthquake that triggers a subsequent fire on top of the structural damage it causes directly. Other examples of building hazards not explicitly included can generally be extrapolated into this construct, such as other natural disasters like flooding from a tsunami, or other components from a CBRNE (chemical, biological, radiological, nuclear or explosion) type of accidentally or intentionally triggered terrorist event.

**FIRE**

F.1 REDUNDANT WATER SERVICES
F.2 REDUNDANT FIRE PUMPS
F.3 DIVERSE AND SEPARATE ROUTING OF STANDPIPE AND SPRINKLER RISERS
F.4 ENHANCED FIRE ALARM SYSTEM DESIGN
F.5 REDUNDANT FIRE COMMAND CENTERS
F.6 HARDENED CONSTRUCTION OF FIRE COMMAND CENTER
F.7 REDUNDANT EMERGENCY POWER
F.8 HARDENED EMERGENCY POWER DISTRIBUTION FEEDERS
F.9 FANS FOR SMOKE MANAGEMENT SYSTEMS
F.10 BATTERY-OPERATED UNITS FOR EMERGENCY LIGHTING
F.11 ADDITIONAL EMERGENCY PHONES
F.12 IN-BUILDING REPEATER SYSTEM
F.13 REDUNDANT OR WIRELESS COMMUNICATIONS
F.14 VESTIBULES AT STAIRWAYS WITH SEPARATE PRESSURIZATION
F.15 RETROFIT WITH AUTOMATIC SPRINKLER SYSTEM
F.16 RETROFIT WITH VOICE ALARM/COMMUNICATION SYSTEM
F.17 AREAS OF REFUGE
F.18 PENETRATIONS IN REQUIRED FIREWALLS, FIRE BARRIERS, FLOORS AND CEILINGS
F.19 BUILDING MATERIALS WITH LOW HEAT RELEASE RATES
F.20 EMERGENCY RESPONSE EQUIPMENT
F.21 PROTECTED FIREFIGHTER'S ELEVATORS
F.22 IMPROVED FIRE/SMOKE CONTAINMENT AT BUILDING PERIMETER
F.23 IMPROVED TRACTION ON STAIR TREADS
F.24 EXTERIOR ACCESS TO FIRE CONTROL CENTERS
F.25 PERSONAL SAFETY/EVACUATION KITS FOR BUILDING OCCUPANTS

**Figure 4-2b: Building Enhancements "Fire" Checklist (CTBUH, 2002)**

Figure 4-2a illustrates the building safety assessment checklist for fire as contained in the *Building Safety Assessment Guidebook*, while Figure 4-2b illustrates the possible building enhancements fire checklist from the *Building Safety Enhancement Guidebook*. The context for these assessment and enhancement checklists is represented in Table 4-2a and Table 4-2b, which provides a summary of all the primary elements included in these two guidebooks.

The primary goal of the Assessment Guidebook is to assist the public in making more informed personal safety choices about building safety and security (CTBUH, 2002). It also helps to begin the process of educating the public about building functionality, and provides direction for anyone interested in more detailed information on this subject. The document has an orientation toward commercial and residential type properties.

**Table 4-2a: Summary Part 1 of Primary Elements Included in the *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* (CTBUH, 2002).**

| **Building Safety Assessment Checklist** | **Possible Building Enhancements Checklist** |
|---|---|
| General<br>G.1 Emergency Preparedness Plan<br>G.2 Emergency Procedures Training<br>G.3 Inspections And Tests<br>G.4 Proximity Of Adjacent Buildings<br>G.5 Security Systems<br>G.6 Access<br>G.7 Building Control Systems | General<br>G.1 Fire And Hazard Assessment<br>G.2 Emergency Preparedness Plan<br>G.3 Emergency Procedure Training<br>G.4 Inspections And Tests<br>G.5 Building Design Documentation<br>G.6 Proximity Of Adjacent Buildings<br>G.7 Building Control And Security Systems<br>G.8 Remote Location Information<br>G.9 Card Readers<br>G.10 Public Infrastructure |
| Fire<br>F.1 Automatic Sprinkler System<br>F.2 Standpipe System<br>F.3 Alarm System<br>F.4 Fire Or Smoke Detection System<br>F.5 Water Source For Fire Protection System<br>F.6 Smoke Exhaust System<br>F.7 Emergency Power System<br>F.8 Emergency Lighting System<br>F.9 Communication System<br>F.10 Building Automation System<br>F.11 Emergency Equipment<br>F.12 Fire Command Center<br>F.13 Building Contents<br>F.14 Exterior Wall Construction | Fire<br>F.1 Redundant Water Services<br>F.2 Redundant Fire Pumps<br>F.3 Diverse And Separate Routing Of Standpipe And Sprinkler Risers<br>F.4 Enhanced Fire Alarm System Design<br>F.5 Redundant Fire Command Centers<br>F.6 Hardened Construction Of Fire Command Center<br>F.7 Redundant Emergency Power<br>F.8 Hardened Emergency Power Distribution Feeders<br>F.9 Fans For Smoke Management Systems<br>F.10 Battery-Operated Units For Emergency Lighting<br>F.11 Additional Emergency Phones<br>F.12 In-Building Repeater System<br>F.13 Redundant Or Wireless Communications<br>F.14 Vestibules At Stairways With Separate Pressurization<br>F.15 Retrofit With Automatic Sprinkler System<br>F.16 Retrofit With Voice Alarm/Communication System<br>F.17 Areas Of Refuge<br>F.18 Penetrations In Required Firewalls, Fire Barriers, Floors And Ceilings<br>F.19 Building Materials With Low Heat Release Rates<br>F.20 Emergency Response Equipment<br>F.21 Protected Firefighter's Elevators<br>F.22 Improved Fire/Smoke Containment At Building Perimeter<br>F.23 Improved Traction On Stair Treads<br>F.24 Exterior Access To Fire Control Centers<br>F.25 Personal Safety/Evacuation Kits For Building Occupants |

The Assessment Guidebook is broad in nature. It provides a foundation to increase comprehension and awareness about building safety and security. It does not attempt to make specific recommendations about courses of action for a particular building but instead provides an information gathering methodology to assist in making design enhancements and personal safety decisions. While the general nature of the document admittedly does not cover every conceivable type of possible building or structure, it is helpful by providing a basis for comparing buildings or structures for the purpose of performing qualitative evaluations.

The Enhancement Guidebook differs from the Assessment Guidebook by providing conceptual options to be considered following an assessment (CTBUH, 2002). This document establishes a set of broad building component categories, and includes a series of enhancements that could be implemented by a building owner to upgrade their level of building safety, reliability, or performance. These elements can be applied just to a specific system or attribute or they can be viewed as a package of multiple features that work in concert with one another to step up the level of building performance. This document provides the basic framework for LLSD.

**Table 4-2b: Summary Part 2 of Primary Elements Included in the *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* (CTBUH, 2002).**

| Building Safety Assessment Checklist | Possible Building Enhancements Checklist |
|---|---|
| Egress<br>E.1 Floor Exiting<br>E.2 Condition Of Stairs<br>E.3 Stairwell Lighting<br>E.4 Stair Construction<br>E.5 Stairwell Pressurization<br>E.6 Vestibules<br>E.7 Signage<br>E.8 Areas Of Refuge | |
| Explosion<br>Ex.1 Neighboring Facilities<br>Ex.2 Location Of The Building<br>Ex.3 Building Configuration<br>Ex.4 Parking<br>Ex.5 Lobby Control<br>Ex.6 Loading Dock And Mailroom<br>Ex.7 Facade<br>Ex.8 Nature Of Construction<br>Ex.9 Seismic Considerations<br>Ex.10 Protection Of Mission Critical Facilities, Emergency Equipment And Utility Feeds<br>Ex.11 Retail | Explosion<br>Ex.1 Refer To Fire Enhancements<br>Ex.2 Standoff Distance<br>Ex.3 Supplementary Reinforcement To Key Structural Elements<br>Ex.4 Blast-Absorbing Or "Hardened" Walls<br>Ex.5 Progressive-Collapse Resistance<br>Ex.6 Separate Explosive Sources From Critical Structural Elements<br>Ex.7 Enhanced Connectivity Of Structural Elements<br>Ex.8 Laminated, Tempered, Ceramic Or Wired Glass<br>Ex.9 Exterior Skin Designed For Blast Protection |
| Bio-Chemical<br>Bc.1 Air Intake Grills<br>Bc.2 Mechanical Equipment<br>Bc.3 Detection System<br>Bc.4 Air Filtration System | Bio - Chemical<br>Bc.1 Air Filtration Systems<br>Bc.2 Air Quality Detection Systems<br>Bc.3 Air Intake Grills<br>Bc.4 Public Area Systems<br>Bc.5 Security System |
| Natural Hazards<br>Nh.1 Nature Of Construction<br>Nh.2 Age Of Building<br>Nh.3 Structural Upgrades<br>Nh.4 Masonry<br>Nh.5 Proximity Of Adjacent Buildings<br>Nh.6 Anchorage Of Heavy Items | Natural Hazards<br>Nh.1 Refer To Fire Enhancements<br>Nh.2 Higher Performance Levels<br>Nh.3 Proximity Of Adjacent Buildings<br>Nh.4 Equipment Anchorage<br>Nh.5 Passive Energy Dissipation |

The primary goal of the Enhancement Guidebook is to provide a resource for building design and construction professionals, building owners, and facility managers to consider possible upgrades and enhancements beyond the minimum building code requirements. This approach intends that the safety enhancement and other factors such as implementation cost, be evaluated on a case-by-case basis in combination with all other safety systems being considered.

The approach used is based on analyzing the potential hazards and assessing the risks, with an emphasis on performance based design that reaches beyond the finite prescriptive requirements found in many codes used for the built environment. Unlike the Assessment Guidebook, this approach has a focus that is well suited for high profile, iconic or high-risk types of occupancies, although nothing is readily evident that inhibits the approach from universal application.

Today, the building community has a heightened sense of awareness for asymmetrical threats, that is, threats that are not directly considered in the design but occur indirectly through a chain of events. The Enhancement Guidebook offers a broad resource for building design and construction professionals, building owners, and facility managers who desire enhanced safety and security for a specific building. The checklist approach is not intended to be exhaustive, and it is not prioritized in a specific order or sequence.

## 4.3 Proposed LLSD Concept Elements and Parameters

Recent attention toward LLSD has been provided by the NFPA High Rise Building Safety Advisory Committee, which has used the *Building Safety Assessment Guidebook* and the *Building Safety Enhancement Guidebook* as a backdrop for their revitalized focus on LLSD. At a joint meeting in March 2006 with the NFPA Standards Council, they formally presented the concept for consideration within the NFPA codes and standards process. At that time, the Council tabled further action pending a more in-depth analysis and evaluation of the concept (NFPA Standards Council Minutes, Mar 2006).

The draft LLSD model as conceived by the High Rise Building Safety Advisory Committee is based on twelve basic categories that address a range of building features and characteristics such as type of construction, building systems, component features, building geometry, etc… Each of these twelve basic categories is further subdivided to address specific building features. They are generally independent from each other, although for any application there is always some level of inter-relationship. The twelve building parameters that comprise the backbone of LLSD are illustrated in Table 4-3.

**Table 4-3: Twelve Parameters for LLSD as Proposed by the NFPA High Rise Building Safety Advisory Committee**

| | |
|---|---|
| 1.0 | Building Configuration, General Conditions |
| 2.0 | Building Enclosure |
| 3.0 | Fire Resistive Construction |
| 4.0 | Elevators |
| 5.0 | Stairs and Enclosure |
| 6.0 | Areas of Refuge / Special Access / Egress |
| 7.0 | HVAC / Fire Protection / Electrical |
| 8.0 | Education / Information / Operations |
| 9.0 | Innovation and Special Design |
| 10.0 | Structural |
| 11.0 | Security |
| 12.0 | Bio-Chemical |

As presented at that time, the High Rise Building Safety Advisory Committee envisioned the LLSD program as being modeled similarly to the Leadership in Energy and Environmental Design (LEED) activity sponsored by U.S. Green Building Council. The High Rise Building Safety Advisory Committee indicated that LLSD was intended to be voluntarily implemented, and based on a "code plus" approach that would account for safety provisions beyond those mandated by the minimum requirements of the applicable building code. The LLSD might also be used to better define and address those risks of concern to the building owner. Buildings could be identified as LLSD certified, with a level of certification established similar to that used for the LEED program. Figures 4-3a through 4-3d illustrate the proposed draft worksheets for LLSD, as presented by the High Rise Building Safety Advisory Committee to the NFPA Standards Council (NFPA Memorandum from HRBSAC to NFPA Standards Council, Jan 2006).

| Points | Yes | No | | |
|---|---|---|---|---|
| | | | **1.0** | **Building Configuration, General Conditions** |
| Prerequisite | | | 1.1 | Meet All Local Building Codes And Standards |
| | | | 1.2 | Building/Site Separation |
| 1 | | | | ≥ 12′-0″ Lot Line |
| 1 | | | | ≥ 24′-0″ Lot Line |
| 1 | | | | Maximize building protection in adjacent scenarios |
| 1 | | | | Maximize building standoff distance from explosive source |
| | | | 1.3 | Building Height |
| | | | | 0 - 8 Floors |
| (1) | | | | 9 - 40 Floors |
| (2) | | | | 40 – 80 Floors |
| (3) | | | | 80 – 120 Floors |
| (4) | | | | > 120 Floors |
| | | | 1.4 | Building Use / Function |
| (1) | | | | Iconic Status |
| (1) | | | | Critical Function |
| (1) | | | | At Risk User |
| | | | 1.5 | Vehicular Stand-off |
| 1 | | | | No Vehicular Access At Building Footprint |
| 1 | | | | 12′-0″ Vehicular Separation |
| 1 | | | | 24′-0″ or Greater Vehicular Separation |
| | | | **2.0** | **Building Enclosure** |
| Prerequisite | | | 2.1 | Non-Combustible, Fire Safing & Smoke Seal |
| 1 | | | 2.2 | 3′-0″ 1-Hour Rated Spandrel Separation |
| 1 | | | 2.3 | Laminated, Tempered, or Wire Safety Glazing |
| 1 | | | 2.4 | Fire-rated (ceramic) Glazing |
| 1 | | | 2.5 | Blast Resistant Wall Systems |
| 1 | | | 2.6 | Stronger anchorages, stiffer support structures, 4 sided glazing systems |
| | | | **3.0** | **Fire Resistive Construction** |
| Prerequisite | | | 3.1 | Superstructure Protection Per Local Code |
| 1 | | | 3.2 | Columns, Girders, Beams 3-Hour Rated |
| 1 | | | 3.3 | Increase Slab Construction 1-Hour |
| 1 | | | 3.4 | Increase at Stair, Elevators, Vertical Shafts, & Corridor 1-Hour |
| 1 | | | 3.5 | Use of Impact Resistant & Adhesion Enhanced Fireproofing (equal to Cementicious Spray FP) |

**Figure 4-3a: LLSD Concept Draft Checklist, Part 1 of 4**

At the core of LLSD is a risk indexing methodology that uses a weighted point scoring system. This provides a way to measure the positive impact of features that enhance a particular building, and conversely, negative values for a characteristic that is deemed to detract from the buildings safety and security. The most controversial aspect of the LLSD approach is each point value itself, as these values are not entirely objective and are rooted in fuzzy logic (i.e., decision making based on imprecise data). For instance, the number of stories is an example of a building feature that adds or detracts from the effort of achieving an overall level of life safety for a particular property, based on the inherent physical challenges presented by the total building height.

| Points | Yes | No | | |
|---|---|---|---|---|
| | | | **4.0** | **Elevators** |
| Prerequisite | | | 4.1 | Fire Command Elevator Serve All Floors |
| 1 | | | 4.2 | All Elevators Provided w/1-hour Vestibules |
| 1 | | | 4.3 | Enhanced Elevator Enclosure: Hoistway equipped sensors, heat and water resistant electrical components. Elevator lobby contains smoke stop doors and enclosure. For fire brigade use and limited evacuation |
| 1 | | | 4.4 | Protected Elevator Enclosure: All enhanced components plus pressurized elevator cab(s), two hour fire rated lobby with doors, direct access to pressurized egress stair, all contained with a blast resistant core. |
| | | | **5.0** | **Stairs & Enclosure** |
| Prerequisite | | | 5.1 | Separation 30′-0″ Minimum |
| 1 | | | 5.2 | Increase Exiting Width 12″ |
| 1 | | | 5.3 | Additional Stair Tower Beyond Exiting Requirements (may be sissor) |
| 1 | | | 5.4 | Stair Pressurization |
| 1 | | | 5.5 | Stair Pressurization with Smoke proof Vestibules |
| 1 | | | 5.6 | Structurally Enhanced Impact Resistant Stair & Vestibule Enclosure |
| 1 | | | 5.7 | Stair Separation ≥ ½ Diagonal Floor Plate Distance |
| 1 | | | 5.8 | Reduce Max Travel Distance to Stair 50% |
| 1 | | | 5.9 | Direct Rated Egress to Exterior from Stairs |
| 1 | | | 5.10 | Photo Luminescent Markings & Pathways |
| | | | **6.0** | **Area of Refuge / Special Access / Egress** |
| Prerequisite | | | 6.1 | 2′-6″ x 4′-0″ Clear Space at Each Stair Floor Landing with Communication System |
| 1 | | | 6.2 | Refuge Area 3-Hour Rated Pressurized with Direct Access to Fire Command Elevator(s) w/Rated Corridor to all Egress Stairs |
| 1 | | | 6.3 | Refuge Floor 3-Hour Rated. Requirements per 6.2 with Fire Rated Spandrel and Glazing- Number of floors required base on overall building height and occupancy |
| 1 | | | 6.4 | Roof Top Access (Heliport Requirements Similar to L.A. Municipal Code) |
| 1 | | | 6.5 | Exterior Evacuation System |

**Figure 4-3b: LLSD Concept Draft Checklist, Part 2 of 4**

The previously mentioned twelve basic parameters in Table 4-3 are generally considered independent from one another, but some interdependence cannot be avoided. Although LLSD does not provide a direct mechanism to address this interdependence, it does, on the other hand, allow for its occurrence and does not inhibit it. For example, certain features that contribute to building security such as vehicle barriers may equally compromise access by fire apparatus, causing a give and take relationship. In another case, a certain enhancement might likewise complement another parameter rather than offset it. An example would be the use of a more resilient connection in the structural steel frame that enhances the performance under both a blast load as well as a fire event.

| Points | Yes | No | | |
|---|---|---|---|---|
| | | | **7.0** | **HVAC / Fire Protection / Electrical** |
| Prerequisite | | | 7.1 | Per Code – Emergency Power Dual Source Fire Command Center Building Management System |
| 1 | | | 7.2 | Dual Feed Sprinkler with 2-Hour Back-up Water Source (water storage tanks) |
| 1 | | | 7.3 | Separate electrical feeds (back-up generator) for fire pump(s) |
| 1 | | | 7.4 | Floor Pressurization / Smoke Evac. System (Purge) |
| 1 | | | 7.5 | Increase Fire Protection (Sprinkler Design Area) by 100% |
| 1 | | | 7.6 | Structurally Enhanced Impact Resistant Enclosures for Sprinkler Storage & Emergency Electrical Risers |
| 1 | | | 7.7 | Reinforce equipment anchorages to prevent failure during event and prevent further destruction of main structure |
| 1 | | | 7.8 | Fire Brigade Cache Rooms; Direct Access to Egress Stairs or dedicated fire brigade elevator |
| 1 | | | 7.9 | Redundant water service |
| 1 | | | 7.10 | Redundant water pumps at remote and protected areas of the building |
| 1 | | | 7.11 | Connect all HVAC systems to building information system (BIS) and security |
| 1 | | | 7.12 | Separate public and tenant HVAC Systems |
| 1 | | | 7.13 | Air intakes not at street or ground level of property |
| 1 | | | 7.14 | Air filtration systems for all intake air |
| 1 | | | 7.15 | Air quality detection system connected to BIS |
| | | | **8.0** | **Education / Information / Operations** |
| Prerequisite | | | 8.1 | Overall Building Fire Hazard Assessment Emergency Preparedness Plan |
| 1 | | | 8.2 | LLSD Accredited Design Professional |
| 1 | | | 8.3 | 3rd Party Building Commissioning |
| 1 | | | 8.4 | Emergency Procedure Training for tenants and building staff |
| 1 | | | 8.5 | Yearly Full Floor Evacuation Drills |
| 1 | | | 8.6 | Full As-Built Document Off-Site |
| 1 | | | 8.7 | Condensed version of as-built document available on site and with fire jurisdiction |
| 1 | | | 8.8 | Off-Site or Black Box Recording of Communication Building Management System |
| | | | **9.0** | **Innovation & Special Design** |
| 1 | 4 | | 9.1 | Special or Innovative Life Safety Features (Max 4 Points) |

**Figure 4-3c: LLSD Concept Draft Checklist, Part 3 of 4**

The driving motivation that has given rise to LLSD is based on consideration of design features that would mitigate or significantly minimize the impact of extreme events such as a terrorist attack or large scale natural disaster (e.g. earthquake, hurricane or tornado). However, the enhancements incorporated into the building also provide intervention for more probable events that are of a much lesser magnitude than a large-scale significant event. For example, general improvements can be expected for the level of safety to both the building occupants and to the first emergency response community.

When the High Rise Building Safety Advisory Committee presented LLSD to the NFPA Standard Council, the package itself included more than just the worksheets needed to implement the concept. The Committee also addressed the various elements needed to achieve a successful institutionalized program to support all aspects of LLSD. This recognizes the important details of a full program, such as an on-going mechanism for developing the evaluation criteria (like through a consensus standard), establishing a certification infrastructure, partnering with other groups to fulfill training and education needs, and so on. For example, the proposed plan for the formal development of LLSD included the following needs:

- Identify subject matter to be included;
- Identify a value system and scoring for various safety features to be considered;
- Determine the format for maximum usability and applicability for new and existing structures;
- Identify how NFPA' s Technical Committee should be involved;
- Explore possible partnering relationships with other organizations, both private and governmental (e.g. AIA, CTBUH, NIST, SFPE, etc); and
- Develop and implement a supporting certification program.

| Points | Yes | No | | |
|---|---|---|---|---|
| | | | **10.0** | **Structural** |
| Prerequisite | | | 10.1 | Wind Tunnel Analysis |
| 1 | | | 10.2 | Separate explosive force from critical structural components |
| 1 | | | 10.3 | Supplementary reinforcement to key structural components |
| 1 | | | 10.4 | Redundant Structural Design Features to Mitigate Progressive Collapse. |
| 1 | | | 10.5 | Enhancement of connectivity of structural elements |
| 1 | | | 10.6 | Blast Resistant Design Features |
| 1 | | | 10.7 | Passive energy dissipation components (seismic enhancements) What is the model code? What are the minimum requirements? |
| | | | **11.0** | **Security** |
| 1 | | | 11.1 | Security Screening for all Occupants & Visitors |
| 1 | | | 11.2 | No Public Parking in Structure |
| 1 | | | 11.3 | Continuous Video Monitoring |
| 1 | | | 11.4 | Integration of building controls (BIS) with security and fire command center, etc. |
| 1 | | | 11.5 | Card/ proximity readers at primary entrances or exits |
| | | | **12.0** | **Bio-chemical** |
| 1 | | | 12.1 | See Section 7.0 for HVAC interrelationships |
| 1 | | | 12.2 | Additional Criteria?? |
| 1 | | | 12.3 | Are there any code minimums?? |

| Points | Yes | No | | |
|---|---|---|---|---|
| | | | **Project Totals** | |
| | | | Points | LLSD Certified |
| | | | +5 | LLSD Silver |
| | | | +10 | LLSD Gold |
| | | | +15 | LLSD Platinum |

| | |
|---|---|
| | **Local Code Equalization** |
| Base | Example: NFPA 5000 / NFPA XX / NFPA XXX |
| (+ - ) | Municipal Building Codes |
| (+ - ) | Other National Building Codes |

**Figure 4-3d: LLSD Concept Draft Checklist, Part 4 of 4**

## 4.4 Evaluation of Proposed LLSD Features

### *4.4.1 Stakeholder Profile*

There are various stakeholder groups involved with LLSD. A profile is provided for the most obvious stakeholders who participate or would be involved with the program. This includes the following seven stakeholder groups: architect and engineers, building owners/managers, consumers, code enforcers, first responders, insurers, program sponsors.

Figure 4-4-1a illustrates these seven stakeholder groups with a visual indication that suggests their interrelationship. At the center of the LLSD program is the program sponsor, or sponsors if more than one sponsor. The First Responders and Enforcers (i.e. Authority Having Jurisdiction) at the top have a perspective of oversight and ultimate approval. A base foundation is provided by the building owners/managers and architects & engineers.

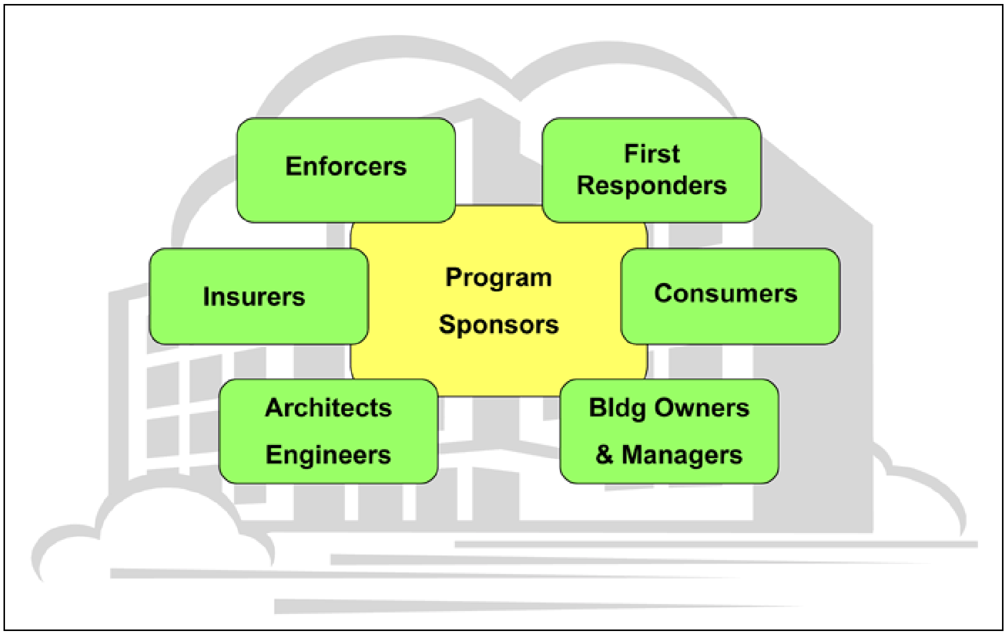


**Figure 4-4-1a: Primary Stakeholders Involved in LLSD Concept**

#### *4.4.1.1 Architects and Engineers*

Architects and Engineers are grouped for convenience to represent those involved with the design and construction of a building. The traditional definition of an architect is: "someone who creates plans to be used in making something, such as buildings", and in similar fashion, the definition of an engineer is: "a person who uses scientific knowledge to solve practical problems" (WordNet 3.0, Princeton University, 2006).

Architects and Engineers involved in building design and construction of a building could generally be expected to find value in an LLSD approach. Not only does it offer a tactical structure that promotes the incorporation of life safety features and arguably simplifies the design process, but in the unlikely event of a disaster, it also may be seen as sharing some of the accountability and responsibility of the building design with LLSD. Those who design buildings have strong motivation to avoid litigation if a disaster was to occur within their designed building, and LLSD offers a line of defense. Some architects and engineers who fail to recognize these virtues may, on the other hand, see LLSD as superfluous and creating additional steps in the design process that they might consider unnecessary with no value-added.

#### *4.4.1.2 Building Owners*

The incentive for building developers, owners and operators to embrace LLSD would likely be positive for those with long term vision, and possibly mixed for those with shorter term financial goals. An LLSD program would allow those who have a pre-meditated and conscientious approach to addressing safety concerns to take credit for an enhancement in the level of safety for their buildings beyond that which is mandated by applicable safety regulations. This may, for example, be attractive to building owners who are able to utilize a positive LLSD rating to enhance efforts to lease rental space, or perhaps by a developer to better establish project funding.

Building developers, owners and operators may also recognize LLSD as a contributing means for limiting liability impact if a worst case event were to occur. One example of this is the significant built-in fire safety features typically required by large international hotel chains, which have lowered the occurrence of hotel fire disasters in recent decades (Grant, NIST BFRL Annual Meeting, Apr 2008). These hotel chains have a strong incentive to reduce their direct losses from fire disasters and avoid costly litigation, and additionally to assure that their hotel guests will be safe. LLSD could be potentially attractive to such hotel chains as a means of minimizing fire disasters and mitigating subsequent litigation if a worst case event did occur.

A lingering question on the success of a hypothetical LLSD program is: "What is the incentive for a building owner or operator to use LLSD?" Here the difference between the LEED and LLSD programs provides stark contrast for building owner or operator. Having a "green building" under the LEED program, the building owner or operator has the inherent advantage of saving money by being energy efficient. Similar inherent and obvious on-going cost savings are more elusive for the LLSD program. Direct financial return on investment is abstract and much more difficult to measure than cost savings from being energy efficient. LLSD minimizes the severity and frequency of a possible unlikely adverse event, and thus reduces the potential risk. Yet the attractiveness of reducing the risk of an adverse event, unlike the direct savings gained in LEED by reducing utility costs, may be difficult for a building owner or operator to readily appreciate.

#### *4.4.1.3 Consumers*

Consumers are a separate and distinct group that resides among the ultimate end-users of a particular facility. They are generally at least one step removed from the responsibility for the facility, despite their presence as a primary occupant. An example would be the rental tenants in an office space, the guests at a hotel, or the attendees in a place of public assembly like a sports stadium. Consumers generally account for the vast majority of the building occupants who are at risk, and yet they are not directly responsible for the facility costs or improvements required to assure safety. Certain LLSD features address topics that might directly involve and engage consumers, such as mandates for a fire safety director for each tenant or floor, provisions for emergency plans for various building emergencies, use of elevators for evacuation purposes, and assurances that planning includes persons with disabilities.

#### *4.4.1.4 Enforcers*

LLSD is a point indexing system that has more advantages than disadvantages for those involved with enforcing fire-related portions of codes. An authority having jurisdiction would benefit from a structured point index system that would provide clarity for the implementation of certain life safety features. LLSD would also promote a better working relationship within the code enforcement landscape since building owners would have greater incentive to meet and exceed the minimum code requirements.

LLSD could be arranged and implemented so that it does not involve any additional permitting, and this would be good news to building code enforcement departments. Enforcers based within fire departments have the additional incentive to support a program that promotes safer buildings that could someday save the lives of fire fighters by reducing the impact of an unwanted fire event.

A looming question for enforcers performing inspections are liability and litigation concerns. Failure to adequately perform their duties has the potential to result in extreme loss situations, and subsequent litigation is a concern. In general, enforcers are more favorably inclined toward structured and proven programs like LLSD, which would help enable a defense against legal proceedings following a disaster. The topic of liability and litigation are addressed later in the study.

#### *4.4.1.5 First Responders*

First responders such as fire fighters, police, or emergency medical personnel would generally benefit from LLSD, since LLSD ratings would provide them with valuable information about the building, and LLSD would promote community-wide safety improvements. The typical operating mode of first responders is to enter into a structure with hazardous conditions while the occupants of that structure are evacuating or taking some other action of self preservation. Building enhancements that result from an LLSD program make it easier and more intuitive for the building occupants to take an appropriate action frees up first responder resources to focus on management of the actual triggering event such as a fire. The array of enhancements may also permit first responders to reach the area of the event, remain in close proximity to the event for a longer time period, and manage it more effectively.

#### *4.4.1.6 Insurers*

The insurance market had enjoyed decades of stability until Hurricane Andrew in 1992 provided the first wake-up call, followed by the active hurricane season of 2005 that re-shaped the catastrophic re-insurance market (Lewis, New York Times Magazine, Aug 2007). The loss paid by insurers from Hurricane Katrina alone was a record 40.6 billion dollars, with 100 billion dollars in damage payout from U.S. weather disasters in 2005. The turbulence of catastrophic loss in the new millennium is re-defining the approaches and risk-taking culture of insurance companies.

With the geographic concentration of wealth in today's world, large scale insurance losses are not limited to weather related natural disasters causing a wide swath of destruction. Large losses can occur in single buildings. For example, after all the settlements were cleared the collapse of the World Trade Center Towers resulted in 4.5 billion dollars of insurance payments (Bagli, The New York Times, May 2007). In summary, turbulence in the world of insurance is causing underwriters to take a fresh look at how they insure for potentially high-value/high-visibility losses. Mega-structures that are candidates for LLSD, such as iconic high rise buildings, will be addressed by a more focused insurance market.

Aside from broad trends in the insurance market, various insurance incentives do exist for individual policyholders, but these approaches have traditionally not been a driving factor to support the implementation of concepts like LLSD. For example, the Building Code Effectiveness Grading Schedule handled by ISO looks at multiple aspects of the adopted code to provide a rating, but this information is not openly and publicly shared. Another program relating to LLSD is the residential program for fortified homes called "Fortified… for Safer Living" from the Institute for Business and Home Safety (IBHS "*Fortified… for safer living"* Program, Oct 2006). This offers ways to go beyond the building code of the particular jurisdiction with a focus toward protecting against natural disasters, but this is a public education centric campaign responding to the needs of the insurance industry, and is not the same as a hard rating system for buildings like LLSD.

The insurance industry is not expected to be a source of incentives for establishing LLSD. Building safety improvements tend to be driven more by the demands of the public than by insurance premiums. An analogy that supports this thought is the safety features that have evolved in motor vehicles. Today a new car has air bags, seat belts, and various other safety features that people demand. These enhancements were driven by public opinion and not by the insurance industry, and the same could be expected with LLSD.

#### *4.4.1.7 Program Sponsors*

The organization or multiple organizations that arguably have the most to directly gain or lose from an LLSD program are the program sponsors. While other stakeholder groups are able to participate from a sidelines vantage point, the sponsor or sponsors are directly responsible and accountable for the success of the LLSD program, and equally responsible and accountable for problems and/or failures.

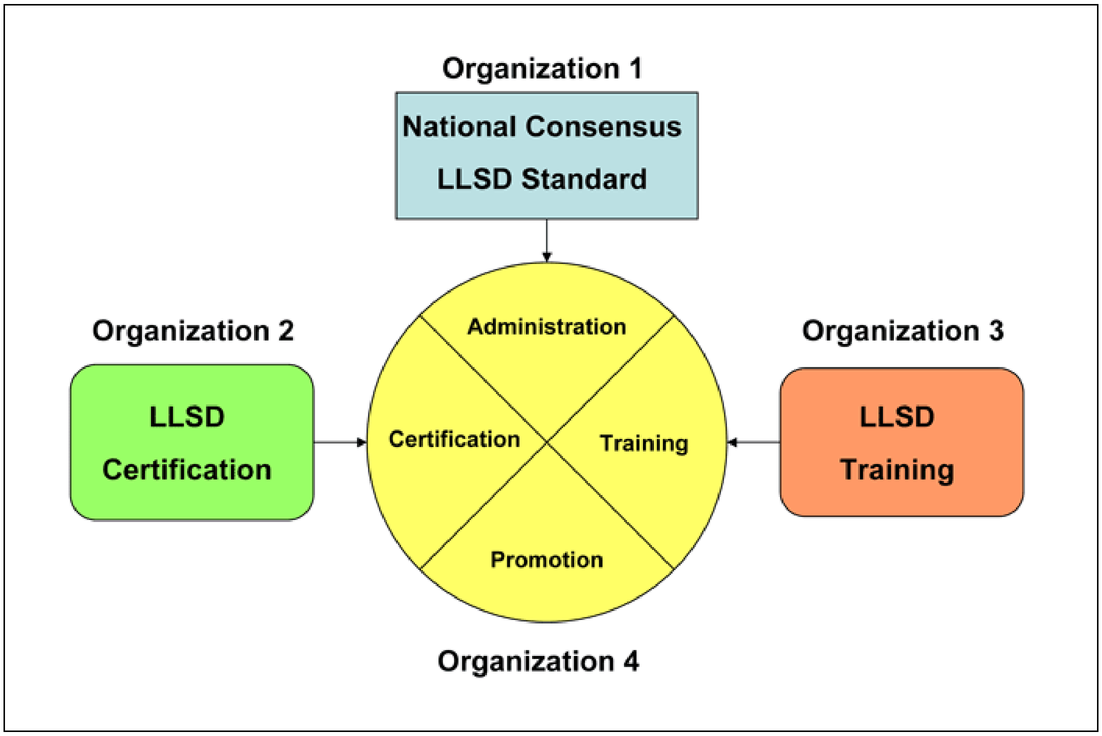


**Figure 4-4-1b: Example LLSD Program Components Handled by Multiple Organizations**

For LLSD to succeed as an instituted program requires the implementation of several distinctive components, and it's possible for this to be handled by a single organization or by different organizations separately handling these different components. A single organization has the advantage of direct managerial control of the program, while proper arrangement of multiple sponsoring organizations has the advantage of optimizing the individual strengths of each organization involved.

Figure 4-4-1b illustrates this concept based on four possible organizations each handling a distinct activity within the LLSD program. For this situation, the central host is organization 4, with organizations 1, 2, and 3 each handling a specific sub-portion of the program and feeding back to organization 4 which has primary oversight for the overall program. This, of course, is an example of one of many possible arrangements, and is not intended to suggest a single or optimum approach.

### *4.4.2 Occupancy Applications*

LLSD has a wide range of possible applications. It may be better suited for some of these applications than others, and the perceived advantages and disadvantages will likely differ for each type of occupancy.

The concept of "occupancy type" is used in the model codes to differentiate the different broad categories of possible building applications in today's built environment. Each of these is a potential area of application for LLSD. To further illustrate the available possible applications, Table 4-4-2a summarizes the types of occupancies from the 2006 edition of NFPA 101, Life

Safety Code (NFPA 101, 2006). This provides a convenient breakdown of the different possible areas of application for LLSD. Additional clarification is offered by Table 4-4-2b, which provides specific examples for certain common occupancies.

LLSD has its origins with the NFPA High Rise Building Safety Advisory Committee, and the application of LLSD to high rise buildings is generally supported by the committee (NFPA HRBSAC Meeting Minutes, Dec 2004). High-rise buildings present special life safety challenges because of limited egress of typically large numbers of occupants, limited fire fighter ingress, and inherent physical limitations for fire protection methods such as water delivery. High-rise buildings are often mixed occupancies, with multiple floors devoted to specific occupancy types. For example, a typical modern high rise building might include storage in sub-grade levels (such as a parking garage), mercantile on lower floors, business on middle floors, and hotel or residence on upper floors.

A certain type of building that has strong public exposure and as such may be a candidate for LLSD are so-called "iconic" structures (Jencks, 2005). These are landmark buildings that are important factors in defining the character of the city's landscape. Because of their public exposure, an unwanted fire in such a structure could have far-reaching consequences beyond the immediate direct fire loss. Fire losses are traditionally recognized for both their "direct losses" measured in definable monetary units (e.g. insurance coverage for specific property loss), and "indirect losses" for the harder to define impact beyond the direct losses that measure, among other characteristics, the intangible social and human cost of fire (Perkins, May 1913). Iconic structures are often national and/or international heritage sites with significant public exposure, and as such an unwanted disaster could have significant long-term and far-reaching detrimental effects that reach far beyond the monetary direct loss of the structure. Arguably, iconic structures are especially attractive for a program such as LLSD.

**Table 4-4-2a: Alphabetical List of Types of Occupancies (NFPA 101, 2006 edition)**

| | | |
|---|---|---|
| 1 | Ambulatory Health Care<br>(6.1.6.1, NFPA 101-2006) | A building or portion thereof used to provide services or treatment simultaneously to four or more patients that provides, on an outpatient basis, one or more of the following:<br>(1) Treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others<br>(2) Anesthesia that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others<br>(3) Emergency or urgent care for patients who, due to the nature of their injury or illness, are incapable of taking action for self-preservation under emergency conditions without the assistance of others |
| 2 | Apartment Building<br>(6.1.8.1.5, NFPA 101-2006) | A building or portion thereof containing three or more dwelling units with independent cooking and bathroom facilities. |
| 3 | Assembly<br>(6.1.2.1, NFPA 101-2006) | An occupancy (1) used for a gathering of 50 or more persons for deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation, or similar uses; or (2) used as a special amusement building, regardless of occupant load. |
| 4 | Business<br>(6.1.11.1, NFPA 101-2006) | An occupancy used for the transaction of business other than mercantile. |
| 5 | Day-Care<br>(6.1.4.1, NFPA 101-2006) | An occupancy in which four or more clients receive care, maintenance, and supervision, by other than their relatives or legal guardians, for less than 24 hours per day. |
| 6 | Detention and Correctional<br>(6.1.7.1, NFPA 101-2006) | An occupancy used to house one or more persons under varied degrees of restraint or security where such occupants are mostly incapable of self-preservation because of security measures not under the occupants' control. |
| 7 | Dormitory<br>(6.1.8.1.4, NFPA 101-2006) | A building or a space in a building in which group sleeping accommodations are provided for more than 16 persons who are not members of the same family in one room, or a series of closely associated rooms, under joint occupancy and single management, with or without meals, but without individual cooking facilities. |
| 8 | Educational<br>(6.1.3.1, NFPA 101-2006) | An occupancy used for educational purposes through the twelfth grade by six or more persons for 4 or more hours per day or more than 12 hours per week. |
| 9 | Health Care | An occupancy used for purposes of medical or other treatment or care of four or more persons where such |

| | | |
|---|---|---|
| | (6.1.5.1, NFPA 101-2006) | occupants are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupants' control. |
| 10 | Hotel<br>(6.1.8.1.3, NFPA 101-2006) | A building or groups of buildings under the same management in which there are sleeping accommodations for more than 16 persons and primarily used by transients for lodging with or without meals. |
| 11 | Industrial<br>(6.1.12.1, NFPA 101-2006) | An occupancy in which products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted. |
| 12 | Lodging or<br>Rooming House<br>(6.1.8.1.2, NFPA 101-2006) | A building or portion thereof that does not qualify as a one- or two-family dwelling, that provides sleeping accommodations for a total of 16 or fewer people on a transient or permanent basis, without personal care services, with or without meals, but without separate cooking facilities for individual occupants. |
| 13 | Mercantile<br>(6.1.10.1, NFPA 101-2006) | An occupancy used for the display and sale of merchandise. |
| 14 | One- & Two-<br>Family Dwelling Unit<br>(6.1.8.1.1, NFPA 101-2006) | A building that contains not more than two dwelling units with independent cooking and bathroom facilities. |
| 15 | Residential<br>(6.1.8.1, NFPA 101-2006) | An occupancy that provides sleeping accommodations for purposes other than health care or detention and correctional. |
| 16 | Residential Board and Care<br>(6.1.9.1, NFPA 101-2006) | A building or portion thereof that is used for lodging and boarding of four or more residents, not related by blood or marriage to the owners or operators, for the purpose of providing personal care services. |
| 17 | Storage<br>(6.1.13.1, NFPA 101-2006) | An occupancy used primarily for the storage or sheltering of goods, merchandise, products, vehicles, or animals. |

The regulatory oversight for a specific occupancy has implications for LLSD. For example, typical state and federal regulation and the different needs for safeguarding public safety for detention and correctional facilities are dramatically different than for a mercantile occupancy. As such, how the LLSD would hypothetically be applied for detention and correction facilities would be expected to be different than for a mercantile occupancy.

How the public enters and uses a particular occupancy is also a distinctive feature relating to LLSD. For example, the public has limited access into an industrial facility, but significant access into a hotel. Because LLSD is a method of providing public recognition of the life safety of a building, the risk exposure to the public is important. Thus, the degree of appreciation for a publicly transparent rating system like LLSD would be greater with a hotel than an industrial occupancy.

**Table 4-4-2b: Examples of Certain Occupancies (NFPA 101, Annex A, 2006 edition)**

| | |
|---|---|
| Assembly | Armories; Assembly halls; Auditoriums; Bowling lanes; Club rooms; College and university classrooms, 50 persons and over; Conference rooms; Courtrooms; Dance halls; Drinking establishments; Exhibition halls; Gymnasiums; Libraries; Mortuary chapels; Motion picture theaters; Museums; Passenger stations and terminals of air, surface, underground, and marine public transportation facilities; Places of religious worship; Pool rooms; Recreation piers; Restaurants; Skating rinks; Special amusement buildings; Theaters. |
| Business | Air traffic control towers; City halls; College and university instructional buildings, classrooms under 50 persons, and instructional laboratories; Courthouses; Dentists' offices; Doctors' offices; General offices; Outpatient clinics (ambulatory); Town halls. |
| Day-Care | Adult day-care occupancies, except where part of a health care occupancy; Child day-care occupancies; Day-care homes; Kindergarten classes that are incidental to a child day-care occupancy; Nursery schools. |
| Detention and Correctional | Adult and juvenile substance abuse centers; Adult and juvenile work camps; Adult community residential centers; Adult correctional institutions; Adult local detention facilities; Juvenile community residential centers; Juvenile detention facilities; Juvenile training schools. |
| Educational | Academies; Kindergartens; Schools. |
| Health Care | Hospitals; Limited care facilities; Nursing homes. |
| Industrial | Drycleaning plants; Factories of all kinds; Food processing plants; Gas plants; Hangars (for servicing/maintenance); Laundries; Power plants; Pumping stations; Refineries; Sawmills; Telephone exchanges. |
| Mercantile | Auction rooms; Department stores; Drugstores; Restaurants with fewer than 50 persons; Shopping centers; Supermarkets. |
| Storage | Barns; Bulk oil storage; Cold storage; Freight terminals; Grain elevators; Hangars (for storage only); Parking structures; Stables; Truck and marine terminals; Warehouses. |

Some occupancy types have evolved an informal form of self-regulating-oversight, and LLSD could be attractive in such situations. For example, because of litigation and adverse public optics over recent decades, some of today's major hotel chains take proactive preventative fire protection measures. A transparent scoring system available to the travelling public would be beneficial to the hotel property owners who would benefit from the positive public optics provided by LLSD.

### *4.4.3 Liability and Litigation*

One characteristic looming as an unknown with potentially significant consequences is the liability associated with a program like LLSD. The organization or multiple organizations that support and sponsor LLSD are directly responsible and accountable for the success of the LLSD program, and will likely be equally responsible and accountable for problems and failures.

What happens if a building that's highly rated according to LLSD suffers a severe fire event? Does the LLSD rating imply some level of accountability? This is a distinct difference between LLSD and LEED. For a LEED rated building the consequence of failure is a relatively long-term passive and private occurrence, while failure for LLSD could be a potentially dramatic scenario involving loss of life or other high-profile consequences.

Litigation relating to building inspections is no stranger to the courts. One of the more noteworthy court proceedings involving fire and building inspectors occurred after the 1942 Cocoanut Grove Fire in Boston, MA USA that resulted in 492 fatalities. About a month after the fire, a grand jury convened by the state attorney general and the county district attorneys office indicted 10 individuals, including Boston Building Commissioner James Mooney and the inspector for the Boston Fire Department, Lt. Frank Linney, who was charged with being an accessory after the fact to manslaughter and willful neglect of duty (Grant, May-Jun 1991).

Boston Fire Department Inspector Lt. Frank Linney had inspected the Cocoanut Grove approximately a week before the fire and had turned in a routine report, terming the Grove's safety conditions as "good." The one-page report was reprinted in its entirety on the front pages of the local newspapers. Linney, Mooney and others went to trial throughout 1943 and were eventually acquitted, although the club owner was found guilty and received a jail sentence. These court proceedings established a legal precedent that highlights the accountability faced today in the legal system by public fire and building inspectors (Esposito, 2005)

Fire inspectors, building inspectors, fire marshals, and their jurisdictions can be held liable if a fire occurs and inspection practices are found to be negligent (Crawford, 2002). Several important court cases have shown that the authority having jurisdiction can be held accountable following a fire, if the hazard could have been mitigated through proper inspection practices, or by a failure to inspect, seek correction for noncompliance, or re-inspect a known deficiency (Wood, Sep 2001). These include the following incidents:

- Adams v. State, 555 P. 2nd 235 (1976): A motel fire in Alaska resulting in five fatalities, where the State of Alaska was found at fault for not issuing a citation for identified deficiencies.
- Coffey v. City of Milwaukee, 74 Wis. 2d526, 247 N.W. 2d 132 (1976): An office building fire in Wisconsin, where the city was found at fault for failure to detect and replace a defective standpipe.
- Halvorsen v. Dahl, 89 Wash., 2d 673, 574 P. 2d. 1190 (1978): A hotel fire in Washington involving one fatality, with the city found at fault for not following through on ensuring corrective action on a violation.
- Wilson v. Nepstad, 282 N.W., 2d, 664 (1979): An apartment fire in Iowa involving multiple fatalities, with the city found at fault on the issuance of an inspection certificate for a safe habitat.
- Thompson v. Waters 267PA99 NC (2000): A new single family dwelling suffered construction defects, and the local county building inspector was found at fault for negligence for overlooking defects.

From the perspective of the LLSD sponsoring organization(s), protection against liability could possibly be established through legislative means. One legislative act of particular interest is the “Homeland Security Act” enacted by the U.S. Congress in 2002. More specifically, the “Homeland Security Act” includes the “Support Anti-terrorism by Fostering Effective Technologies Act of 2002,” or the “SAFETY Act” as it is more commonly known (Howe, May 2004). After the anthrax attacks during late 2001, manufacturers of biohazard detection equipment hesitated addressing these applications for fear of excessive liability if hazard detection was not perfect. The “SAFETY Act” was passed to alleviate these fears and to promote rapid and unimpeded innovative development of anti-terrorism technologies.

The SAFETY Act uses the term “technologies” in a broad sense to encompass products, equipment, services (including support services), devices, and information technologies. It is on this basis that the Building Security Council is currently pursuing protection against liability under the SAFETY Act for their proposed Building Security Council Rating System. At this time it is unknown if the SAFETY Act protection will be given to their proposed Building Security Council Rating System. More importantly, it is likewise unknown how the SAFETY Act applies to LLSD.

### *4.4.4 Perceived Characteristics*

LLSD provides a thought-provoking approach to supplement the conventional application of code requirements in the built environment. The primary goal of traditional model codes relating to the built environment is to establish minimum performance levels to safeguard the lives of occupants as well as protection of the structure and its contents when the building is subjected to both foreseeable and unforeseeable events such as fires, explosions, terrorist’s threats, natural disasters, and other threats.

**Table 4-4-4: Comparison of Certain LLSD and LEED Characteristics**

| Characteristic | LEED | LLSD |
|---|---|---|
| Building Owner Motivation | Strong motivation to save on energy costs and be environmentally conscious | Moderate motivation because of low impact on costs (i.e. liability) and income (i.e. attractive for tenants) |
| Designer Motivation | Moderate motivation to generally increase value of building | Strong motivation to assure safety, limit liability, and increase property value |
| Public Optics | Positive, by helping the environment | Positive, by having a 'safer' facility |
| Enforceability | Low because LEED products, systems, and programs are nice to have but not critical | High because LLSD products, systems, and programs are critical |
| Cost Recovery | Strong cost recovery that is clearly identifiable through energy savings | Low cost recovery to building owner |
| Consequence of Failure | Low because energy savings are not mandatory | High because life safety is a high priority goal |
| Maintenance Requirements | Low because consequence of failure is low if LEED components or systems fail | High, to assure the life safety components are maintained over the life of the building |

Because no two building related emergencies are identical in scope and magnitude, it is a significant challenge to design and construct buildings to address these emergencies without compromising the freedoms and lifestyles that are generally desired by the building occupants. Modern building codes, and the implementation and enforcement infrastructure that supports these codes, have evolved over time to provide a balance between the risk that society is willing to accept and the resources that it is willing to commit to mitigate that risk.

The implementation of LLSD is generally conceived as a voluntary program that building owners would willingly apply in a fashion similar to LEED. But mandatory application through regulatory oversight should not be ruled out, especially for applications that are already highly regulated and would derive additional value for the risk indexing of their life safety protection and property conservation goals. The question remains, however, as to what would be the primary motivation for "legislative mandates" for LLSD? Applications that have a high degree of regulatory oversight, such as, for example, nuclear power plants, are motivated less by life safety of the occupants than they are by other fire protection concerns.

To highlight the different characteristics of LLSD, it is helpful to draw a comparison with the LEED initiative due to its similarities and relative success. Table 4-4-4 illustrates the perceived characteristics of both LLSD and LEED. Arguably, the LEED program has different positive and negative attributes when compared with LLSD. For example, the implementation costs for LEED can readily be justified as recoverable for the building owner. A green building that is more energy efficient may ultimately recover its investment in a certain number of years through energy savings. This same measure is not true for LLSD.

## 5. Conclusions and Recommendations

The key findings in this review and analysis of LLSD, in no particular order of priority, are:

1) Most Attractive Occupancy Application. LLSD has multiple possible occupancy applications, but it appears to be most attractive for applications that are highly visible on the public conscience, such as high-rise buildings or iconic structures that symbolically define a community. It also has strong attraction to occupancies that have a highly similar organizational basis (e.g. hotels), or are highly regulated on a broad-scale (e.g. health care) as an aid to rigorous enforcement programs based on its ability to offer a structured and consistent program.
2) Characteristics. LLSD has the following characteristics: (a) Building owners may be motivated to limit liability, and may also be motivated by attracting a broader range of high profile tenants; (b) Building designers will be strongly motivated to assure safety, limit liability, and increase property value; (c) Public optics will be positive by having a safer facility; (d) Enforcement of life safety building features will continue to be inherently challenging due to the critical nature of these features; (e) Cost recovery for the building owner will likely be relatively low; and (f) the consequence of failure in an LLSD rated building could be extreme and could create raise serious questions about the validity of the LLSD program.
3) Most Similar External Programs. Among the various external programs similar to LLSD, the two that are most similar and worthy of further review are the Leadership in Energy & Environmental Design (LEED) concept administered by the US Green Building Council, and the Building Security Council Rating System (BSCRS) administered by the Building Security Council, although other external programs have strong similar characteristics, such as the Chicago Life Safety Evaluation System for High-Rise Residential and Historic Commercial Buildings.
4) Complexity of LLSD Technical Design. An important characteristic of LLSD is the complexity of its technical design and the challenges this may introduce with perceived multiple levels of safety. In particular, if the promotion of LLSD multiple performance levels is viewed as introducing multiple levels of safety, a process to explain and justify the deviation from the baseline criteria will have to be established

This review and analysis of LLSD has identified several topical areas that are worthy of further consideration. These are summarized in the following list, in no particular order of priority.

1) Partnerships and Collaborations. While it is possible that a single organization may find merit in pursuing programs supporting LLSD, the concept of multiple organizations handling different components has merit. Possible partnerships and collaborations between multiple interested organizations should be further explored.
2) Perform Implementation Analysis of Similar Programs. For comparison purposes, an analysis should be done on similar programs, with a focus on financial characteristics. The obvious choice is the currently successful LEED program. This should be done with the express intent of establishing a baseline comparison with a proposed LLSD program.

3) Monitoring of Related Laws, Rules, and Litigation. The legislative and litigious activity related to LLSD should be monitored. In particular, the activity relating to the LEED and BSCRS concepts is worthy of further analysis.

# Volume III References

The following are the references cited throughout this conceptual analysis and summary of LLSD:

American Institute of Chemical Engineers, "Tools for Making Acute Risk Decisions with Chemical Process Safety Applications", NY NY, 1994, pg. 35)

ASTM E2432, Standard Guide for General Principles of Sustainability Relative to Buildings, ASTM International, West Conshohocken PA, 2005

Australian Institute of Building, 2007 National Professional Excellence in Building Awards, Canberra, ACT, 2007

Australian Institute of Building, 2008 Awards Nomination, 2008 AIB Professional Excellence in Building Awards, Canberra, ACT, 2007

Bagli, C.V., "Insurers Agree to Pay Billions at Ground Zero", The New York Times, 24 May 2007

Building Research Board, "Report from the 1987 Workshop on Analytical Methods for Designing Buildings for Fire Safety", National Academy Press, Washington DC, 1988

Building Security Council, website http://www.buildingsecuritycouncil.org/home.html, cited 21 Jan 2008

Chow, W.K., "Proposed Fire Safety Ranking System EB-FSRS for Existing High-Rise Nonresidential Buildings in Hong Kong", Journal of Architectural Engineering, Dec 2002, pgs 116-124

City Of Chicago, "Guidelines For The Preparation Of Requests For Qualifications For The Selection Of Consulting Firms To Perform Life Safety Evaluations", Department Of Buildings, Dec 2005

City of Chicago News Release, "City Council Building Committee Receives Life Safety Evaluation at Public Hearing", 16 Jan 2004

Crawford, Jim, *Fire Prevention a Comprehensive Approach*, Prentice Hall, NJ 2002

CTBUH, Council on Tall Buildings and Urban Habitat, *Building Safety Assessment Guidebook*, Chicago IL USA, May 2002; *Building Safety Enhancement Guidebook*, Council on Tall Buildings and Urban Habitat, Chicago IL USA, May 2002

Dean, A.F., "Analytic System for the Measurement of Relative Fire Hazard (Mercantile Classes)", Western Actuarial Bureau, Chicago, Dec 1906

# Volume III References
# (Continued)


Esposito, J., “Fire in the Grove: The Cocoanut Grove Tragedy and Its Aftermath”, Da Capo Press, Cambridge MA, 2005

Grant, C.C., “Last Dance at the Cocoanut Grove, “NFPA Journal”, May-June 1991, pg. 74-86

Grant, C.C., “NFPA & WTO”, NFPA Journal, January-February 2002, pg. 64 – 69

Grant, C.C., “Profiles in Disaster, A 50 Year Legacy”, NIST BFRL Annual Meeting, Gaithersburg, MD, 2 April 2008

Guler, I., Guillén, M.F., Macpherson, J.M., "Global Competition, Institutions, and the Diffusion of Organizational Practices: The International Spread of ISO 9000 Quality Certificates", Administrative Science Quarterly, Vol. 47, No. 2, June 2002, pgs. 207-232

Howe, W., “Getting Anti-Terrorism Technologies Out for Homeland Use—That’s Why It’s Called the SAFETY Act”, Journal of Homeland Security, May 2004

HRBSAC Meeting Minutes, High Rise Building Safety Advisory Committee, National Fire Protection Association, Quincy MA, December 2004

IBHS “*Fortified… for safer living”*® (FFSL) Program, Institute for Business & Home Safety, Tampa FL, Oct 2006

ICC “Guidelines for the Rehabilitation of Existing Buildings”, International Code Council, Washington DC, 2000 edition

ICC International Building Code®, International Code Council, Washington DC, 2006 edition

ISO Management Systems, “Applying ISO management system standards to enterprise risk management”, January – February 2007

ISO “Mitigation On-Line”, website http://www.isomitigation.com, cited 21 Jan 2008

Jencks, C., “The Iconic Building: The Power of Enigma”, ISBN 0711224269, Frances Lincoln Ltd, London, 2005

Lewis, M., ”In Nature’s Casino”, The New York Times Magazine, Section 6, 26 August 2007, pg 26

Madrzykowski, D., Walton, W.D., “Cook County Administration Building Fire, 69 West Washington, Chicago, Illinois, October 17, 2003: Heat Release Rate Experiments and FDS Simulations”, NIST SP 1021; NIST Special Publication 1021; July 2004

## Volume III References
## (Continued)

NFPA 1978 Annual Meeting Technical Committee Reports and Technical Committee Documentation, NFPA 74, Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment, National Fire Protection Association, Quincy, MA, TCR pg 74-2 and TCD 550

NFPA 74, Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment, National Fire Protection Association, Quincy, MA, 1975 edition, section 2-4 Levels of Protection, pg 74-10

NFPA 101®, Life Safety Code®, National Fire Protection Association, Quincy MA, 2003 & 2006 edition

NFPA 101A, Guide on Alternative Approaches to Life Safety, National Fire Protection Association, Quincy MA, 2007 edition

NFPA 5000®, Building Construction and Safety Code®, National Fire Protection Association, Quincy MA, 2003 & 2006 edition

NFPA Memorandum from HRBSAC (High Rise Building Safety Advisory Committee) to NFPA Standards Council (via M. Puchovsky to C. Grant), "Concept of Leadership in Life Safety Design", National Fire Protection Association, Quincy MA, 5 January 2006

NFPA HRBSAC Meeting Minutes, High Rise Building Safety Advisory Committee, National Fire Protection Association, Quincy MA, December 2004

NFPA Standards Council Minutes, Item 01-87, National Fire Protection Association, Quincy MA, January 1-10 2002, New York City, NY

NFPA Standards Council Minutes, Item 04-4-22, National Fire Protection Association, Quincy MA, April 2004

NFPA Standards Council Minutes, Item 06-3-20, National Fire Protection Association, Quincy MA, March 2006

NFPA Volunteer Firemen Magazine, Article by the Insurance Company of North America, NFPA Library, Quincy MA, Nov 1943

NIOSH Press Release, "NIOSH Showcase Prevention Through Design Initiative in Safety Journal", National Institute for Occupational Safety & Health, May 4 2008, http://www.ohsonline.com/print.aspx?aid=62274, cited June 11 2008

NIST NCSTAR 1, Federal Building and Fire Safety Investigation of the World Trade Center Disaster, Final Report of the National Construction Safety Team on the Collapses of the World

# Volume III References
# (Continued)

Trade Center Tower, National Institute of Standards and Technology, Gaithersburg MD, October 2005

Noonan, F., "Risk Assessment using Scoring System Methodology (SSM) as holistic substitute for IBC Height & Area Table", Alliance for Smoke Containment and Control, Chicago, 3 Aug 2007

Perkins, F., "The Social and Human Cost of Fire", Proceedings of NFPA 17th Annual Meeting in NYC, National Fire Protection Association, Quincy MA, 13 May 1913

Solomon, R.E., "*Measuring Optimum and Code-Plus Design Criteria for the High Rise Environment*", CTBUH 8th World Congress, Dubai, 3-5 March 2008

Uniform Code for Building Conversation, International Conference of Building Officials, 1997

U.S. Green Building Council, "Why Build Green" LEED Brochure, Washington DC, 2007

U.S. Green Building Council, website http://www.usgbc.org/Default.aspx, cited 21 Jan 2008

Watts, J.M., "Criteria for Fire Risk Ranking", Fire Safety Science – Proceedings of the Third International Symposium, Elsevier, London, 1991, pg 457-466

Watts, J.M., "Fire Risk Indexing", SFPE Handbook of Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda MD, 3rd edition, 2002, pgs 5-125 through 5-138

Watts, J.M., "Fire Risk Rating Schedules", in ASTM STP 1150, Fire Hazard and Fire Risk Assessment (Hirshchler, M.M., editor), ASTM International, West Conshohocken PA, 1992, Pgs. 24-34

Wood, K., "*A Quality Control Program for the Office of the Illinois State Fire Marshal*", EFO Paper, National Fire Academy, September 2001

WordNet 3.0, Princeton University, "http://wordnet.princeton.edu", cited 18 January 2008, Cognitive Science Laboratory, Princeton, NJ, 2006

Zhang, Z., "Developing a Model of Quality Management Methods and Evaluating their Effects on Business Performance", Total Quality Management & Business Excellence, Vol. 11, Issue 1, January 2000, pgs. 129 - 137