

Fire Life Safety Commissioning

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Synopsis

This workshop will cover fire life safety commissioning. An overview of fire life safety system components and code requirements will be given by Mike Abrams (who is NICET and NBFAA certified). He will discuss the stringent requirements he encounters in Clark County, and the more universal expectations of the International Building Codes Section 909.

The difference between HVAC system acceptance and Fire Life Safety Code compliance will be examined. Included will be a detailed breakdown of commissioning phases, prefunctional forms, functional testing scenarios, and working with an AHJ (Authority Having Jurisdiction) using examples from his projects. Mark Leafstedt, PE, CCP will go through the means and methods of fire life safety commissioning. His experience ranges from schools and hospitals to major casinos.

The workshop will conclude with information regarding the certification and expertise required to perform fire life safety commissioning for providers who may want to add this service to their existing business. Question and answer periods are also included in this session to ensure the audience is able to use the information provided. The goal of the presentation is to promote and encourage further development of fire life safety commissioning in every marketplace. Commissioning in Las Vegas is provided as an example for what some experts consider to be a “worst-case” example of the rigors that may be encountered while commissioning a smoke control system.

About the Authors

Shannon Steward is the Account Executive for TestMarcx. Her role in this presentation is to introduce the topic and the featured speakers for the presentation. She will provide a backdrop for the importance of Fire Life Safety Commissioning, and she will give an overview of the speakers and content. She will moderate the question and answer sessions, and provide the conclusion about how this service can be incorporated into a commissioning provider’s business. Shannon is an accomplished speaker and acts as the Chair of the Building Commissioning Marketing Committee. With a background in construction management, she has been involved with the marketing and promotion of Building Commissioning for four years.

Mike Abrams has been in the engineering and construction industry for twenty-six years. He is certified by the National Institute for Certification in Engineering Technologies (NICET) in the field of Fire Alarm Systems. He is a member of the National Burglar and Fire Alarm Association (NBFAA) as an instructor for fire alarm systems. Mike has taught courses for NBFAA

applications of fire detection systems. He has also taught courses to the Federal Aviation Administration on the fundamentals of fire protection. His extensive experience includes over fifty major clients including: Las Vegas Casinos, military facilities, hospitals, corrections facilities, and office buildings. He will provide an overview of Fire Life Safety codes in this presentation.

Mark Leafstedt is a licensed Professional Engineer, certified Commissioning Provider, and President of TestMarc_x. Mark has been involved the Construction industry since obtaining his bachelor's degree in Mechanical Engineering in 1979 from Iowa State University. He became a licensed Professional Engineer in 1984 and is currently registered in Nevada, Colorado, California, Texas, New Mexico, Arizona, and Mississippi, where TestMarc_x provides Building Commissioning Services for a wide variety of industries and clients.

During the past twenty-six years, Mark has been employed in the role of owner, in the facilities engineering group of a major University; he has performed the role of contractor, for an international supplier and installer of digital control systems; and he has performed the role of designer, for two medium sized mechanical engineering consulting firms. Experience in each of these roles has helped to provide him with insight and perspective into the challenges that each of these construction disciplines brings. During this time he has worked on construction projects for notable companies/organizations such as Amgen, Lucent Technologies, Hewlett Packard, Los Alamos National Labs, Sandia National Labs, Caesars Entertainment, MGM/Mirage, Clark County School District, University of Colorado Hospitals, University of California San Francisco, Rockwell International, Symbios Logic, Lockheed Martin Corporation, and the Denver Art Museum.

Part One—Viva Las Vegas

According to 2003 statistics published by *Insider Viewpoint Las Vegas*, there are about seventy-eight major casinos in Las Vegas. Seven out of the top ten world's largest hotels reside within a five-mile radius of each other in Las Vegas. Last year, approximately thirty-five million tourists visited the city, spending thirty-one and a half billion dollars. They stayed in the approximately one hundred and twenty-five thousand hotel rooms available in Las Vegas.

Every twenty four hours, three hundred and sixty-five days a year, two acres of LV land are developed for commercial or residential use. A recent report by the Milken Institute named Las Vegas as number two in the country for economic performance.

According to the McGraw-Hill Construction Information Group (for 2005), there are eight hundred and eighty-nine commercial and public projects valued at one-million or more, under planning in Clark County for a total of more than twenty-four billion dollars. Another three-hundred fifty-seven projects are currently under construction and are valued at four point three billion dollars. About fifty residential, timeshare and casino projects are in planning or construction in Las Vegas, with a total of eighty new towers on the books.

With all of this construction and with its dependence on tourism as its source of revenue, the Las Vegas construction market is acutely aware of the value of occupant comfort and the need for working buildings. The casinos located on the Las Vegas Strip lose approximately 7 million dollars a day for each day they are not open; therefore, the demand for safe, comfortable, and reliable structures is higher here than anywhere else in the country.

However, this wasn't always the case.

Under-designed disaster

In 1980, the second largest hotel fire in history swept through the twenty-six story MGM Grand Hotel, killing eighty-four people, injuring six-hundred and seventy nine, and casting a shadow over this lucrative industry.

According to a *Las Vegas Review Journal* article¹ published on the twentieth anniversary of the fire,

[a]n investigation found the fire seized on the hotel's greed in constructing the resort and on a series of installation and building design flaws. Fire marshals had insisted sprinklers be installed in the casino during the building's construction in 1972. The hotel refused to pay for the \$192,000 system, and a Clark County building official sided with the resort. Authorities later said the sprinkler system could have prevented the disaster at the hotel.

The article explained:

Where the fire started, a wire that was not properly grounded could have been discovered had the area been inspected. A compressor was not properly installed. A piece of copper was not insulated correctly. A fire alarm never sounded. A supposedly smoke-free

stairwell that was a crucial escape route filled with smoke. The laundry chutes failed to seal, and defects existed in the heating, ventilation and air-conditioning systems -- all contributing to the spread of smoke.

The fire burned undetected for hours until it flashed over just after 7 a.m. and began spreading at a rate of nineteen feet per second through the casino.²

Of the two million square feet of space, most of it was not sprinkled. Those areas protected by sprinklers included portions of the twenty-sixth floor, the showroom, the arcade, the restaurant, and convention areas. The plan for fire protection included a manual alarm system, with bells and public address system; the design intent was that five minutes after signaling the security station, a general alarm would sound. On November 21st, 1980, no alarm sounded during the fire.

Over-the-Top Code Changes

Three months later, a second fire occurred at the Las Vegas Hilton, resulting in eight deaths and one-hundred and ninety-eight injuries. In the decade following those tragic fires, the lodging industry became actively involved in NFPA's code-making process, working on codes and standards, such as NFPA 1, Fire Prevention Code; NFPA 101®, Life Safety Code®; NFPA 72, National Fire Alarm Code®; NFPA 13, Installation of Sprinkler Systems; NFPA 13D, Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes; and NFPA 13R, Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.³

According to the NFPA³, “in the United States today, it's safer to stay at a hotel than it is to stay in your own home. In the last two decades, the number of hotel fires has declined by nearly two-thirds, even though the number of hotels has risen sharply.”

Clark County also made extreme local code changes. According Clark County TV (a government-access channel) Reporter Randy Swallow,

In 1981, a blue ribbon committee of fire and building officials enacted a battery of code changes (which) require outfitting, or retrofitting hotel casinos. Clark County's fire safety standards are among the highest anywhere. These are some of the safest buildings on the planet, thanks to some of the most stringent fire and building safety codes adopted in the wake of the MGM Grand fire.³

As Kathy Zagorski, Assistant Fire Chief of Clark County looks back, she can only say, “If any consolation families who lost loved ones, the MGM fire resulted in new codes, standards today that protect people in high rises...this was in result of the MGM and Hilton Fires.”⁴

As a commissioning provider headquartered in Las Vegas, TestMarcx has experienced these codes and standards first-hand. To be able to meet these requirements, a thorough understanding of the most up-to-date standards is required. The means and methods to achieve it within the

project schedule are another critical aspect of Fire Life Safety and Smoke Control commissioning.

Part Two--2003 IBC Building Code, Section 909

Introduction

A fundamental difference between Building Commissioning and Smoke Control/ Life Safety Commissioning is that Building Commissioning is owner-driven requirements and Smoke Control/ Life Safety Commissioning is a Code driven requirement. Whereas the owner or their representatives will provide the oversight for Building Commissioning, it is the Authority Having Jurisdiction (AHJ) who provides the oversight for Smoke Control/ Life Safety Commissioning. Building Commissioning can and does often occur after a facility has received a Certificate of Occupancy. However, a Certificate of Occupancy can not be issued until such time the AHJ has determined that the Life Safety System complies with the provisions of the applicable Code.

History of the Current Building Code

The first building regulations occurred as early as 1630. One example of this is the City of Boston's mandate that "*no man shall build his chimney with wood nor cover his roof with thatch.*" In 1865, the first laws were enacted in New Orleans allowing for the inspection of public buildings. The Great Chicago Fire of 1871 provided momentum for the development of building codes in the United States. The responsibility for enforcement of the Building Code falls to state and local government. This enforcement authority is derived from the 10th Amendment of the U.S. Constitution which gives states the right to legislate for the protection of the public health, safety, and welfare.

With the exception of California, which adopted NFPA 5000 as their Model Building Code, all of the remaining states have adopted The International Building Code (IBC) in one form or another. Prior to the issuance of the IBC, there were three organizations of building officials who were responsible for developing and enforcing building codes in the United States. These three organizations were:

- Building Officials and Code Administrators (BOCA) in the Northeast and Midwest
- International Conference of Building Officials (ICBO) in the West
- Standard Building Code Congress International (SBCCI) in the Southeast

In 1994 BOCA, ICBO, and SBCCI co-founded the International Code Council (ICC) to reduce the complexity of the current regulatory system. The Council's mission was simple. Develop a single model code to simplify the regulatory system in the United States. The first draft of the IBC was prepared in 1997 with the First Edition of the IBC published in March of 2000. This presentation will focus on the 2003 Edition of the IBC published in December 2002.

The IBC provides the minimum requirements. However, many jurisdictions will adopt amendments to the code providing requirements more stringent than what is prescribed in the IBC. For example, the IBC removed smoke control requirements from high-rise structures, except shaft enclosures. Many jurisdictions have adopted an amendment to add smoke control requirements for high-rise buildings.

There is ongoing discussion by the code committee to add smoke control requirements to high-rise structures so it is important to stay abreast of all new editions to the Code.

Smoke Control Requirements

- **High Rise Exit Enclosures:** IBC Section 403.13 High rise exit enclosure is defined as serving more than 75 feet above lowest level of fire department vehicle access.
- **Atriums:** IBC Section 404.4: An atrium is defined as an opening connecting two or more stories.
- **Covered Malls:** IBC Section 402.9 (if served by an atrium as defined in Sections 404):
- **Underground Buildings:** IBC Section 405.5. An underground building is defined as having a floor level used for human occupancy more than 30 feet below lowest level of exit discharge.

The Fundamentals of Smoke Control Systems

Overview

A Smoke Control System is a combination of architectural, electrical, and mechanical system design approach that utilizes air flow and/or air pressure to contain or remove smoke during a fire event.

Smoke Control Systems are often defined as active or passive systems. An active smoke control system utilizes mechanical air handling equipment, i.e. supply fans, relief fans or smoke exhaust fans to contain or remove smoke in the zone of origin.

A passive smoke control system utilizes construction barriers to maintain the smoke in the zone of origin. Typical passive smoke control systems would be found in equipment rooms and motel rooms. Passive smoke control systems are intended to prevent the smoke from migrating outside the smoke zone of origin to adjacent zones.

The three active smoke control methods to contain or remove smoke are as follows:

Pressurization Method (IBC Section 909.6):

The pressurization method is the primary means of controlling smoke by maintaining a minimum of 0.05-inch water gage pressure differentials across the smoke barriers in fully sprinkled building. The design intent of the pressurization method is not to maintain a tenable environment in zone of origin but to prevent the migration of smoke from the smoke control zone of origin to the adjacent smoke zone(s). Smoke exhaust fans are utilized to exhaust the zone of origin. Pressurization fans are typically not required in adjacent zones to achieve the 0.05-inch water gage pressure differentials across the openings.

Airflow Design Method (IBC Section 909.7):

The airflow design method is used prevent migration through openings in a fixed and permanently open position. The design intent of the Air Flow Design Method is to limit smoke migration from the fire zone of origin by limiting the airflow at the opening. A multi-level enclosed parking garage with openings at each level is an example of a place where an Airflow Design Method would be utilized.

Exhaust Method (IBC Section 909.8):

The exhaust method is utilized in large open spaces, such as covered malls and atriums in Las Vegas; this method is frequently used in the casinos. The design intent of the Exhaust Method is to maintain the layer of smoke at least 10 feet above any walking surface. This is achieved by providing smoke exhaust fans with airflow calculated on the volume of the space and make-up air fans, typically 80% of the calculated volume of the exhaust.

Section 909 of the 2003 International Building Code

Much of the first few sections of the Code are dedicated to design criteria for the design professional. This paper will only discuss the key sections applicable to commissioning of the mechanical smoke control systems.

- Section 909.3: states that smoke control systems are required to undergo special inspections and tests sufficient to verify proper commissioning of the smoke control design in its final installed condition. Section 909.3 refers the reader to Section 1704 which requires the owner or the registered design professional, acting as the owner's agent to employ special inspectors for multiple disciplines such structural, concrete, etc... The design engineer, as part of the contract documents is required to prepare testing criteria, clearly identifying how each zone is to be tested
- Section 909.4 requires the submission of Rational Analysis. A Rational Analysis, sometimes referred to as a Fire Protection Report is prepared by the Fire Protection and/or Mechanical Engineer-of-Record. The Rational Analysis will identify the smoke control methods utilized for the facility, i.e., Pressurizations Method, Passive Containment, Exhaust Method, Airflow Method.
- Sections 909.5 through 909.9.4 provide the design criteria which must be utilized when designing the Smoke Control System. These sections of the Code are pertinent to the Fire Protection Engineer or Mechanical Engineer of Record
- Sections 909.10 through 909.10.5 discuss the requirements of the fans, ducts, automatic dampers, etc.. used for Smoke Control Systems
- Section 909.11 requires two sources of power to all components associated with the smoke control system and the requirement for all equipment associated with the smoke management system relying on volatile memory to be equipped with a UPS.
- Section 909.12 discusses the requirements for the fire alarm detection and control equipment.
- Sections 909.13 through Section 909.13.3 references the requirements when control air tubing is utilized for smoke control systems.
- Section 909.14 requires all junction boxes, access panels and terminations used for smoke control systems and detection devices to be clearly marked.

- Section 909.15 requires “Control Diagrams” to be kept on file with the building department, fire department and in fire command center. Control Diagrams are identify all devices associated with the smoke control system(s) and identify their operation when smoke control is initiated.
- Section 909.16 through Section 909.16.3 describes the operation of the firefighters smoke control panel.
- Section 909.17 indicates the need for the smoke control system to configure within a prescribed period of time as detailed in Rational Analysis.
- Sections 909.18 discusses the requirements of acceptance testing of the smoke control system.
- Section 909.19 states that a certificate of occupancy can not be obtained until the smoke control systems has proven to be fully functional in accordance with the provisions of section 909 and the fire department has received instructions on the operation of the system. This section allows for temporary certificate of occupancy for phased construction, provided the occupied portion of the building complies with the provisions of this section and the remaining portion does not pose a hazard to the occupants.
- Section 909.20 through 909.20.6.2 discussed the design principles for smoke proof enclosures.
- Section 909.21 discusses the requirements for underground building smoke exhaust systems.

RE-CERTIFICATION:

The 2000 Edition of the Uniform Fire Code, Section 1001.5.5 states the following:

“Mechanical smoke-control systems, such as those in high-rise buildings, buildings containing atria, covered mall buildings and mechanical ventilation systems utilized in smoke proof enclosures and for smoke removal systems utilized for high-piled combustible storage occupancies, shall be maintained in an operable condition at all times. Approved persons shall conduct tests. A written record of tests shall be maintained and shall be made available to the inspection authority.”

Many jurisdictions do not enforce this section of the code. The time and expense required for all of the personnel necessary to commission a mechanical smoke control system can be millions of dollars. The costs and disruption for a large complex facility to recertify the smoke control system can be excessive.

In Las Vegas, the Southern Nevada Fire Chiefs’ Association adopted an ordinance requiring all properties served by a mechanical smoke control system to implement and recertification program. This ordinance requires the properties to test twenty percent per year, such that one-hundred percent of the system will be tested over a five-year period. All of the jurisdictions, except Clark County Nevada, are enforcing this ordinance. Las Vegas, and the majority of all large properties, is located in Clark County.

Part Three--Means & Methods of Life Safety System Commissioning

Introduction

There is very little difference between the process of commissioning a Life Safety System and the commissioning of a HVAC system, other than the simple fact that the performance or failure of a Life Safety System could mean the difference between life and death. A failure in an HVAC system generally only causes occupant discomfort or a rise in energy costs. Despite the perception of some people experiencing a failure of an HVAC system - that they will soon perish if the A/C doesn't come back on - the reality is that in the case of HVAC system failure, the only thing that dies is productivity, not people.

In the IBC or UBC, the commissioning process is provided by an agent known as a 'special inspector.' This is the same title given to testing entities for environmental, structural, material, concrete, and even amusement ride inspections. In Las Vegas (or Clark County, Nevada) the term used is QAA or Quality Assurance Agency.

How Hard Can it Be?

In some respects, commissioning a life safety system could be construed to be more basic and less variable than commissioning an HVAC system. One would think that the potential results from a smoke event would be pretty straightforward, black and white, nothing like the vastly grey and varying interpretations that could be placed on how to control a VAV air handling system. And, in a sense, this is true, *if* all the details of the control of the life safety system have been worked out and clearly documented prior to construction. But of course, this is rarely the case. The complexity comes from the sheer number of components and clarifying which input device controls which output device. There are also significant differences in the level of detail, timing, and intensity.

Differences in Detail

The detail required in commissioning a life safety system is typically spelled out in the codes and local amendments. It is appropriate to remember that the codes are only the minimum standards and different jurisdictions have different levels of expertise concerning the requirements. In life safety system testing, there is no such thing as sampling or statistical testing, or at least there shouldn't be. The liability is too great. Every single input device and every single output device is functionally tested to verify that it does what it is supposed to do and nothing more.

Differences in Timing

Timing is another difference. If all deficiencies and issues in an HVAC system are not resolved prior to owner occupancy, the owner may be unhappy and the building may not work with optimum performance. If all deficiencies and issues in a Life Safety system are not resolved prior to owner occupancy, the owner doesn't get a Certificate of Occupancy (CO) or a

Temporary Certificate of Occupancy (TCO). With very few exceptions, that will result in a *very* unhappy owner. It may not be the fault of the commissioning provider, but even an innocent bystander will get spattered in a mud slinging contest. There is no commissioning of a life safety system during the warranty period. There is not an Outstanding Deficiencies and Issues log. In fact, the CO is generally required long before the owner occupies the building so that the little details of furniture, phones, employee training, and organizing a move can be taken care of. The essence of this requirement, beyond the obvious: “The Contractors have to be complete!” is that the commissioning process *has* to proceed concurrently with construction.

Additionally, the commissioning provider may find it beneficial to ‘coach’ the contractor and subcontractors during construction to clarify the requirements and scheduling, so that the All Systems Test and demonstration to the Authority Having Jurisdiction (AHJ) proceeds smoothly. Many times, the commissioning provider is the only entity on the project that can see the ‘forest for the trees’ primarily because they have the specific experience and are not caught up in the minutia of construction.

Differences in Intensity

Intensity and panic ensue on a project when the Contractor realizes that there are roughly three weeks worth of work remaining to be done, and one week in which to accomplish this. All the scheduling and completion concerns the commissioning provider has hopefully documented in the previous months suddenly make sense. Each subcontractor understands very well what they need to do to complete their specific task. What often gets missed is the understanding that not all tasks can be completed at the same time. We refer to this event as the *C³d syndrome* or ‘*construction completion congestion*’. The construction sequencing and clarity that walls and ceilings have to be done so that devices can be hung, so that electrical power can be provided, so that equipment can function, and programming can be completed, so that functionality can be tested, is often overlooked. So, what are the responsibilities of each commissioning team member?

Roles and Responsibilities

The roles and responsibilities for commissioning a life safety system are again, very similar to those required for commissioning an HVAC system, with a few non-negotiable differences. The roles and responsibilities that we will discuss are intended only to encompass the construction phase commissioning of a project.

Prime Contractor

The Prime Contractor’s role is primarily one of constructing the envelope, but also of coordinating and scheduling. We spoke of the *C³d syndrome*. It is imperative that the Prime Contractor has a clear roadmap of not only how to get from point A to point Z, but when.

Salient points of responsibility for a Prime Contractor with respect to Commissioning:

- Provide a detailed and updated project schedule.

- Include a detailed description of commissioning activities, with input from the CxP (Commissioning Provider).
- Employ for the project, an MEP (Mechanical/Electrical/Plumbing) Coordinator that is knowledgeable in the sequencing and construction of MEP systems. Do not depend on having subcontractors coordinating and sequencing themselves.
- Provide rapid dissemination of commissioning documentation, including: questions, concerns, issues logs, and responses.
- Facilitate commissioning meetings.
- Be an advocate for the commissioning process and promote quick resolution to issues with the Subcontractors.
- Do not depend on word of mouth descriptions of levels of completeness. Journey to the field in person for a visual inspection.
- Provide equipment such as ladders, flashlights, and radios to facilitate the All Systems Test.
- Manage and communicate to the Owner an accurate reflection of the schedule consequences (i.e. delays) that occur with design changes during construction.

Subcontractor

The Subcontractor's role is primarily one of constructing the system(s) they are contracted to install and assisting with the commissioning process.

Points of responsibility for a Subcontractor with respect to Commissioning include:

- Providing input into the Prime Contractors project schedule.
- Reviewing the scheduled commissioning activities. Offer insight into needs and requirements of what critical path items will be required in the schedule.
- Attending commissioning meetings.
- Avoiding defensive posturing and promote proactive responses and resolutions to commissioning issues.
- Journey to the field in person for a visual inspection, avoiding dependence on verbal descriptions of levels of completeness.
- Provide any proprietary equipment required to verify equipment functionality.

Designer

The designer's role in the construction administration phase is to respond to questions and design related issues in the field. Generally, once most of the details of the smoke control logic are worked out, the designer's active obligation shifts from mandatory attendance to contractual obligation and personal preference. However, the designer must play a very proactive role and respond to questions quickly. Unfortunately, because of the uncompromising nature of life safety systems and the occasional unforeseen last minute requirements of an AHJ, and despite thorough review and sign-off of a design during the design phase, last minute questions concerning construction detail still arise. These issues should be dealt with thoroughly and rapidly so that the responsibility for any missed completion dates is not mistakenly assigned, in action or in perception, to the designer.

The designer should also avoid pushing all responsibility for issue resolution back into the field and hide behind a performance based specification. Having the design team as a proactive partner in the commissioning process will make the process proceed more smoothly. It is also important to note that in the 2003 IBC (section 909.18.8.3), the engineer or record is required by code to sign, seal and date the final commissioning (or Special Inspection) Report confirming that based upon the test results, the design intent has been achieved.

Owner

The owner's role is primarily one of remaining calm amidst the chaos. The owner is required in many jurisdictions, to directly hire the Commissioning Provider (CxP). This naturally is a preferred method and provides a clear and distinct elimination of any real or perceived conflicts of interest. There are many cases, however, where the owner delegates all responsibilities of cost to the construction team and/or the design team. This is a viable solution, given the CxP is not contracted at any level lower than the prime contractor/architect and the prime understands and is accountable for his responsibilities. Of course, if a prime contractor subscribes to the PM (Pure Magic) version of project management and scheduling, it is difficult to achieve the commissioning goals in any case. The difference is, however, that the CxP is not caught up in the financial backlash that invariably occurs when completion dates are missed.

Commissioning Provider (CxP):

The commissioning provider is part coach, part task-master, part expert, part judge, and part mediator. It is important to clarify up front with all parties that the CxP has no authority to enforce compliance with any uncovered deficiency, nor does the CxP have any responsibility with respect to the design, modifications to the design, construction completion, and resolution of deficiencies, warranty or successful acceptance by the AHJ. However, CxP should also strive to build a commissioning team on the project that believes that implementing CxP suggestions will increase the chances for success on the project.

In a team environment, the protocol of identifying and communicating deficiencies and issues in a factual, professional, blameless, and sometime accommodating manner is critical. Allowing for personal egos and pride of workmanship, and working from the basis that each team member is doing the best job they know how, allows those same team members to accept each deficiency or issue without immediately taking a defensive posture.

Points of responsibility for the Commissioning Provider:

- General Tasks:
 - Coordinate and manage the life safety commissioning activities.
 - Coordinate directly with each Subcontractor with respect to their responsibility and contractual obligations as it relates to life safety commissioning.
 - Obtain, assemble and submit life safety commissioning documentation.
 - Meetings:
 - Meet with the Client and representatives of the Authorities Having Jurisdiction (AHJ) to review the Smoke control commissioning program and modify as required.

- Attend Commissioning/Construction/Design meetings to coordinate and resolve design and construction issues and deficiencies as they relate to the Life Safety System.
- Design and Construction Document Review Phase:
 - Review the life safety systems design documentation and interface with other systems.
 - Compare sprinkler zoning with smoke barrier zones
 - Review the documented life safety component submittal information. This includes the fire alarm system, the fire protection system, the temperature control system, the mechanical system and the electrical system.
 - Note any inconsistencies or deficiencies in the system.
- Documentation Development Phase:
 - Develop the smoke control commissioning plan and schedule.
 - Develop Functional Performance Testing Criteria for review and submission to the Authority Having Jurisdiction (AHJ).
 - Conduct and coordinate the installation verification inspections with the Engineer and AHJ.
 - Reports: Provide the following reports and forms:
 - Smoke control commissioning Plan for preliminary submission of testing procedures to the AHJ.
 - Functional Performance Testing Scenarios
 - Testing & Validation Forms
 - Daily Log & Report Forms
 - Non-Compliance Forms
 - Final report with all required testing documentation to support an application for a Certificate of Occupancy.
- Pre-Functional Testing Phase:
 - Be present during portions of the start-up activities and prefunctional testing to assist and witness the execution of startup.
 - Perform site observations to review the construction progress of the smoke control system and identify any design or construction issues and deficiencies for resolution. The deficiencies and issues log will be maintained at the site.
 - Visually inspect all smoke barriers for code compliance.
- Functional Performance Testing Phase:
 - Witness the functional performance testing of the smoke control system. Devices, equipment, components and sequences for smoke management shall be individually tested. These tests will consist of determination of function, sequence and, where applicable, capacity of their installed condition. The tests will include the individual components' interaction. The CxP will assist in defining all required testing teams for each testing scenario which will include personnel from other contracting disciplines, design team members and owner members. It will be the responsibility of the General Contractor and/or Architect to coordinate these personnel.
 - Inspect the following: Automatic Dampers, Fans, Control Diagrams, Marking & Identification, Control Air Tubing, Power systems

- Provide testing and validation of the following components and systems as they relate to the smoke control system: Detection devices, Ducts and Dry Wall Shafts, Dampers, Fans, Smoke Barriers, and Controls.
- Track smoke control commissioning deficiencies until correction. The smoke control commissioning process scope of work includes a complete validation and testing of all devices per IBC 909 and local code amendments.
- Commissioning Completion Phase:
 - Submit the final Report to the AHJ and review pertinent issues.
 - Respond to AHJ Report review comments to achieve a final approved Report.
 - Coordinate with the Prime Contractor to schedule the AHJ for acceptance testing.
 - Assist in the coordination of AHJ acceptance testing teams with descriptions of personnel, equipment, location and testing objectives.

Life Safety Commissioning Phases

Design & Construction Documentation Review:

One of the most important pieces of the commissioning process is the review of the design documentation. This is the first opportunity to identify issues that could impact the acceptance testing schedule, not to mention an essential step toward developing functional testing scenarios.

Items to review include:

- Confirmation that fire protection sprinkler zones match the smoke barrier boundaries.
- Confirmation that all required fire/smoke dampers are shown on the mechanical drawings. The contrast to this is to confirm that the designer did not exceed the requirements for fire/smoke dampers and specify far more than what is required.
- Confirmation that someone has actually developed the 'control drawings'.
- Confirmation that the fire alarm contractor picked up all the initiation, input and output devices as well as coordination with the temperature controls contractor.
- Confirmation that equipment utilized for smoke control purposes is specified to be in compliance with codes and local amendments.
- Confirmation that the firefighter's smoke control panel is in compliance with codes and local amendments.
- Strategize to develop methods to test pressure differentials in very large passive zones.

Control Diagrams are an essential part of the smoke control design. They are typically developed by the mechanical design consultant or the life safety consultant, but can be developed by the Contractor responsible for operation of the smoke control system. In cases where none of the involved entities have the desire or expertise to develop the control diagrams, it can be a bit of a struggle to clarify the importance of these documents and it is an opportunity for the CxP to step up to the plate and assist with the development as a value added service. In any event, the Engineer of Record is required to sign off on the documents. Items required in Control Diagrams are:

- All smoke boundaries

- Every (and only) initiation device (e.g. duct and/or area smoke detectors, sprinkler flow) utilized for smoke control
- Every (and only) output device (fire/smoke dampers, fans on/off, magnetic door holds, HVAC reconfiguration) utilized for smoke control.
- Every (and only) input device (damper end switches, fan status, electrical power status, door position status) utilized for smoke control.
- A logic matrix of initiation devices versus output devices. This should be inclusive and detailed to include every device utilized for smoke control.
- Passive versus active smoke zones.
- Provide device tags and descriptors.

Document Development Phase:

After the project has moved into the construction phase, the commissioning process enters a Document Development phase. This phase is distinctly different from the Design & Construction Document Review Phase. Rather than reviewing the documentation provided by others, the CxP is actually creating the Commissioning Plan. For those readers that are newer to commissioning, the Commissioning Plan is the roadmap that the CxP develops and uses throughout the commissioning process to know where the process is going, and precisely spells out how the CxP should proceed to get there.

There are many variations on this theme, and we typically divide our commissioning plan into roughly ten to fifteen sections. The commissioning plan for commissioning a life safety system is somewhat different than what would be used for commissioning an HVAC system. For the sake of clarifying some of the differences, we will compare an outline of a life safety system commissioning plan versus an HVAC system commissioning plan.

Section	Life Safety System Outline	HVAC System Outline
1	Acceptance Letter	Executive Summary
2	Executive Summary	Commissioning Team
3	Commissioning Team	Mechanical System Overview
4	Overview of Acceptance Testing Procedures	Overview of Commissioning Procedures
5	Fire Protection Report	Record Document - Sequences of Operation
6	Smoke Management Sequences/Matrix	Pre-Functional Testing Checklists
7	Component Testing Forms	Functional Testing Procedures
8	Functional Testing Scenarios & Results	Deficiencies & Issues Log
9	Test & Balance Report	Daily Logs
10	Product Data Sheets	Miscellaneous Data
11	Deficiencies & Issues Log	
12	Daily Inspection Reports	
13	Non-Compliance Reports	
14	Miscellaneous Data	

Immediately, you can see that the first section of the life safety report is an acceptance letter. This is required by code. It is the acceptance letter where all required signatures and stamps are gathered, which includes at a minimum the CxP, the Engineer of Record and approvals by the AHJ. When possible, it is beneficial to get sign-off by the owner and the prime contractor.

The Overview of Acceptance Procedures versus the Overview of the Commissioning Process is substantially different. The typical Overview of the Commissioning Process follows along the lines of the generic BCA or PECEI outline. An Overview of Acceptance Procedures will instead list each paragraph of the code with a description of how that paragraph will be executed.

The Fire Protection Report or Life Safety Report is referred to in section 909.4 of the IBC as a “Rational Analysis”. The Rational Analysis is a written report that will identify the smoke control methods utilized for the facility and is considered to be a part of the design documents.

Rather than *pre-functional checksheets*, life safety system testing utilizes *component testing forms*. Components required to be tested and accepted by the CxP include duct detectors, exhaust fan override verification, fire/smoke damper inspection, smoke control panel verification, waterflow activation testing and heat detector activation testing.

The Functional Testing Scenarios for a life safety system are recommended to include an individual check-off place for every single output device and annunciation for the selected action. In contrast, an HVAC system FTP will typically have a stated objective (e.g. maintain discharge air setpoint), with a series of events and associated expected results. A life safety system scenario has only a single event (e.g. initiate a waterflow switch for system 1-3), with a listing of associated components and the expected configuration. If every device is not individually visually inspected and verified for proper operation, the AHJ may question the validity and force a retest.

Another difference is that the life safety report has a test & balance (TAB) section. The TAB requirements for life safety testing are substantially different from standard TAB expectations and are usually contracted either through the CxP or directly to the owner. It is also typically a good choice to use a different TAB subcontractor than the firm balancing the HVAC systems. The reasons include: the scope of work and required expertise is substantially different (and most likely not specified in the contract documents); the schedule is different; and lastly, this avoids any potential real or perceived conflict of interest.

Product data sheets are required in the report for the fire/smoke dampers, duct detectors and other components that are tested.

The deficiencies and issues logs are similar. However, life safety commissioning also requires non-compliance reports. The non-compliance reports go to the AHJ and represent a fairly serious show-stopper for the prime contractor. Thus, discriminating use of a non-compliance report to document primarily only significant issues that will involve the designer; or deficiencies/issues with seriously lagging resolution is recommended. In other words, not all deficiencies become non-compliance reports.

Another very important document development phase task is the development of the commissioning schedule. Now, ignoring for the moment that commissioning is the tail of the dog (and we get wagged a lot), the CxP has the most knowledge of the order of testing tasks and realistic time frames. The more detailed and realistic the schedule is, the further away from the tip of the tail you get to sit. Of course, when the prime contractor compares your 100 task

commissioning schedule occurring over an 8 week period to his single task commissioning schedule occurring over a 2 week period, there is generally an animated discussion and compromise on the duration. But at least the Prime is now thinking about a 100 task event.

Associated with the commissioning schedule is a review of the Prime Contractors schedule. Occasionally there are entertaining moments when the startup of pumps and fans is scheduled to occur several weeks before power is scheduled to arrive. But beware; the prime contractor may not always share the humor.

Pre-Functional Testing Phase:

Not everyone believes in a pre-functional testing phase; perhaps better stated, some believe that cutting out the pre-functional testing phase will save money on the commissioning costs. Usually they are wrong, but not always.

We have dealt with one particular Prime Contractor on various projects that has in their employ, an individual whose sole purpose is to prepare the life safety systems for testing (this is a good thing!). His title is 'life safety coordinator' This individual spends a great deal of time working through all the variations and iterations of the smoke control matrix, coordinating with the contractors involved in the installation of the life safety systems, pre-testing each of those systems and riding herd on each subcontractor to perform and resolve deficiencies in the installation. Essentially, he plays the role of a project coach with the added benefit of actually having the authority to tell subcontractors what to do. He is not the project PM, not the MEP coordinator and he plays a fundamental role in preparing the life safety systems for the CxP; but this is definitely the exception and not the rule.

To put this in perspective, we recently completed a twenty story project with this same Prime Contractor with a commissioning estimate in excess of \$150,000. With the Life Safety Coordinator onboard, we were able to finalize all life safety commissioning for less than \$100,000.

On the other hand, we recently completed another project where the bulk of the pre-functional testing was negotiated out of the commissioning contract. The fees were slightly less than \$100,000. All the experience and expectations the Prime had for their personnel in providing the Life Safety Coordination tasks pretty much went by the wayside when the *C^{3'd} syndrome* set in and all the subcontractors were struggling and focused only on completing construction, giving no thought whatsoever to functionality. Needless to say, the project sailed past the scheduled completion date and every commissioning dollar negotiated out (plus a few extra) went back in with small issues like a 33% failure of fire/smoke damper operation, exhaust fans utilized for smoke control that did not meet code and missing code required monitoring of power. This is avoidable.

The bulk of our work includes a pre-functional phase that runs concurrently with construction which allows us to better bond with the project and project subcontractors and assist in heading off issues that could present problems at the end of the project. Any issues that can be caught

and corrected long before the final functional testing begins, benefits everyone on the project and ultimately saves far more money than the cost of including this in the CxP's scope.

So is pre-functional testing important? *Absolutely!* Should it be provided by the CxP? *We think so (but we're slightly prejudiced).* Can it be provided by the Prime Contractor? *Only if it is a dedicated task.* Can it be provided by a Subcontractor? *We think that scenario misses the whole point, but then again, we've worked with some extraordinary contractors on occasion.*

Functional Testing Phase:

Let's start this section with a series of questions.

- When does functional testing begin?
- Does it begin when all construction is totally complete?
- How can functional testing be phased?
- How can a CxP avoid multiple tests on the same system?

We can only speak from direct experience, but we typically see a strong overlap between pre-functional phase and functional testing phase, because: the bigger the project the greater the overlap. So, to answer the question of when to begin functional testing, the answer might be: *when a system is ready to be tested*, which begs for a definition of "system".

This leads us to the next question of whether or not the commissioning should wait until all construction is complete. Quite honestly, in over 250 completed commissioning projects over a six year period, not once were we given the option of waiting for all construction to be complete. This is particularly true for life safety testing in Las Vegas for the singular reason that a building certificate of occupancy (or even TCO) can not be obtained until the life safety testing is complete. Let's face it; the quicker the owner opens the doors to the public, the quicker he is able to recoup his investment. The monetary value of having open doors (versus closed doors), quoted by the owner of a new Las Vegas resort, was \$10,000,000 per DAY! That's a lot of incentive!

Now, if the CxP can not wait for construction to complete, how can the functional testing be phased? Again, the larger the project, the clearer this becomes. Phasing the functional testing on the project generally means portions of systems must be tested while other portions of the same system are incomplete. For example, it is possible to functionally test a fire/smoke damper for operation and status feedback without an entire smoke zone being programmed. It is possible to pressure test a passive smoke zone with incomplete construction. It is possible to functionally test a hotel tower active smoke control without the low rise being complete. It is possible to functionally test a stairwell pressurization sequence without door seals. The secret is to construct the testing scenarios to build on one another in such a way that performance confidence is established as the testing proceeds from component level, to sub-system, to system, to all systems testing.

So, how can the CxP avoid performing multiple tests? They can't. If a CxP performs multiple tests on the same system, is he losing money? That depends. It's that pre-functional testing phase thing again. Active participation and coaching in the pre-functional startup is kind of like

teaching to the test. Everyone becomes acutely aware of what the testing will be like, which tends to make the functional testing go much smoother. Even so, there will still be functional tests that fail. The difference is that if the subcontractors can rectify the deficiency quickly, the issue can be signed and dated as complete and everyone gets to move on with a minimum of time. The converse is a deficiency that has to be brought up in a meeting, discussed, scheduled for resolution, notified of resolution and then re-verified for proper operation. With luck, the deficiency is resolved. Even then, without active participation by the CxP, the chances are very high that the subcontractor (or individual) responsible for the deficiency in the first place, will not get it right the second time either.

Commissioning Completion Phase

The Commissioning Completion Phase is considered the wrap up phase where the final report is submitted to the AHJ, reviewed and approved. Then the AHJ is scheduled to witness as many functional tests as he/she cares to perform.

This is not to say the wrap up phase is without stress. Even on the smooth projects, there is still an entropic tendency to sink into the *C^{3'd} syndrome*. The same negative monetary incentive that drives the contractors during construction is applied to the CxP at report time. There is a very real and serious expectation that a final report with hundreds of pages will be in to the AHJ on Thursday after the final testing is completed on Wednesday. This expectation requires meticulous construction of the final report during the entire commissioning process, several pots of coffee and an accommodating printer/copy machine.

Then, there are always the fine details and occasional personal AHJ expectations that create additional panic, excitement and multiple CxP trips to the AHJ's office. It is always best to accompany the final report and personally review the report with the AHJ, so that questions or comments that arise can be fielded as quickly as possible.

After approval of the report, the AHJ is scheduled for "All Systems Testing". A very important role for the CxP to take during this time is organizing the testing teams. The CxP has the greatest knowledge about what areas need to be tested, how many people it will take and how to most efficiently execute the testing. This includes copies of the test scenario for each team, instructions of the expectations for the team, sets of plans for each team, radios, ladders, repair teams in wait (hopefully kept in waiting), and a listing or personnel required in each team. For example, there will be a team in Fire Command. If testing a high rise, there could be a team on the roof, a team on the event floor and teams on the floors above and below the fire floor. In some cases the AHJ will desire a more active role in the organization, which is fine. Communication is paramount.

With luck (and systematic testing and documentation), the acceptance testing with the AHJ will go smoothly. With the final signature, everyone smiles, sighs with relief, and vows, "never again (at least until the next project)".

Part Four--Conclusion

This paper explained the origin, requirements and methods of providing Fire Life Safety Commissioning in Las Vegas. However, the importance of this service is relevant to all buildings. As proven through the MGM Grand fire, safety is the utmost occupant concern. But the benefits to the construction process are also evident in the understanding, monitoring, and proving of code compliance when inserted into the commissioning process.

While occupant comfort is sought in mechanical commissioning, the complexities of this system are often overlooked. But safety is not guaranteed to be accomplished simply by invoking a code. It must be tested and proven. The optimal time to do that is before the AHL inspects the building. This is a key aspect of commissioning that firms should consider including as part of their range of services.

¹Sunday, November 19, 2000, Copyright © *Las Vegas Review-Journal* "MGM GRAND FIRE: THE DEADLIEST DAY" by Glenn Puit

²Information from "*NFPA remembers the 1980 MGM Grand fire in Las Vegas*" *NFPA Journal*®, March/April 2001 (no author noted).³Top-to-bottom hotel fire safety Hotels worldwide use NFPA's best practices and have become safer than ever" by Hallie Ephron Touger *NFPA Journal*®, March/April 2001

⁴*Clark County Public Communications* "MGM Fire Script" Conclusions by CCTV reporter Randy Swallow.