Fire Protection Measures for Checmical Facilities

Orville M. Slye, Jr., PE, FSFPE
Loss Control Associates, Inc.
172 Middletown Blvd., Suite B-204
Langhorne, PA 19047

Originally this paper was intended to be a review of fire protection and process safety requirements for the high tech industry. However, on refection, the assumption that different fire protection and process safety measures were required for the high-tech industry than those in other segments of the chemical industry became an obvious false premise. The challenges for fire safety are equally daunting in all segments of the chemical process industry. Some operators have developed loss prevention goals that use performance-based fire protection analysis and design for fire protection and prevention in chemical plants. This paper will review methods commonly used to determine fire protection measures for chemical plants. The use of performance-based fire protection analysis and design to meet loss prevention goals is proposed as an alternate to specification design methods.

Loss prevention techniques practiced by the chemical industry have been partially eclipsed by process safety management efforts as a result of the application of OSHA PSM and EPA RMP requirements. Fire protection, prevention and explosion safeguards are vital to successful chemical process plant safety, but need to be included to assure overall plant safety.

A HISTORICAL PERSPECTIVE

Historically, fire and explosion are the predominant causes of chemical plant losses. The J & H Marsh and McLennan 30 year review of Large Property Damage Losses in the Hydrocarbon-Chemical Industries (1) shows that losses categorized by Type of Loss were nearly evenly distributed between fires (31%), explosions (30%) and 36% involved Vapor Cloud Explosions (VCE). In the landmark study Hazard Survey of the Chemical and Allied Industries (2) in 1968, Arthur Spiegelman of the American Insurance Association reported on a study of over 1,000 incidents reported by the Manufacturing Chemist s Association. These incidents were examined by MCA in 317 detailed case histories of major fires and explosion losses in the chemical and allied industries. These 1962 and 1966 studies of 317 case histories, 38.5% were the result of fire only, 35% from explosions only and 26.5% involved fire and explosion. While the initiating cause may be different due to changes in chemical industry processes and operations, the root causes for these incidents remain in place. Prevention, detection and control of fires and explosions in chemical plants appears to be a consistent requirement. This historical perspective illustrates that adoption of effective measures for prevention, control and extinguishment of fires and explosions in chemical plants requires a high priority.

DETERMINING FIRE PROTECTION MEASURES

Typically there are four effective approaches used to determine and establish fire protection requirements for an industrial facility. These approaches are summarized in Table 1.

TABLE 1
TYPICAL CHARACTERISTICS OF LOSS PREVENTION METHODS

METHOD	CHARACTERISTICS
Meet Federal, State, Local Codes	Compliance with consensus codes only
Company Codes and Standards	Historical based, general reliance on consensus codes
Insurance Company Recommendations	Ranges between consensus code compliance to high protected risk approach
Performance-Based Engineering Analysis and Design	Fire prevention, protection and control measures based on hazard analysis and uniquely focused on controlling consequences of hazard.

The following summaries provide details on each of the separate design approaches to loss prevention and fire protection design.

Consensus Code Compliance - This approach is characterized by project requirements that focus on OSHA, fire or building code compliance often at the exclusion of basic fire safety practices. Consensus codes establish minimum fire safety requirements primarily for public safety with some emphasis on life safety for plant personnel. Since a great deal of these codes are based on adoption of preventative measures as a reaction to fire or explosion incidents, their application to a new developing technology is often of limited value. To be incorporated in a consensus code document, a process or a unit operation would have experienced a number of fire or explosion incidents which is unlikely where there is a limited operating experience.

The most difficult loss prevention challenge is the retroactive application of codes or standards to existing plants. If industry standards or basic safety principles have been ignored for a majority of the plant history upgrading to even the minimum level of safety contained in the codes is difficult. Frankly, in these instances application of even minimum codes may be extremely costly and involve a lot of compromises to achieve compliance. Examination of existing plants using performance-based fire protection analysis could yield reasonable but highly effective alternative solutions for fire protection of an older facility.

Company Guidelines and Standard Practices - In this approach to loss prevention, corporate and industry standards form the basis for fire prevention, protection and explosion prevention/protection measures. These standards and codes require routine upkeep to avoid institutionalization of out of date measures. This approach to loss prevention presents the challenge of updating to reflect current technology, the danger of obsolescence and institutionalizing measures that are less than adequate and continuation of measures that may not be required to assure adequate fire protection.

Insurance Company Recommendations - This loss prevention method is focused on compliance with consensus codes and additional insurance company standards. As with a minimum code compliance approach, this method can also fail to meet requirements for basic loss prevention or fire safety. Insurance company recommendations can often fall short of protection in high tech or non-standard operations within a facility. Using these standards may not protect the process or facility from extensive losses, including those from business interruption, impact on the adjacent community, or for specific chemical process plant hazards. The insurance company also has the advantage of being able to spread the impact of a fire incident over a number of co-insurers, use exclusions for certain hazards or exclude losses for which the plant owner does not have similar financial protection.

Performance-Based Engineering - This loss prevention method is gaining recognition in national building and fire codes. The performance-based method is based on the use of codes or standards, possibly from a company standard or an industry group, that specifically states fire safety goals. Four interrelated fundamental fire safety goals are recognized (3) including:

- Providing life safety for public, building occupants, and emergency responders
- Protection of property including buildings, facilities, contents
- Providing for the continuity of operations - protecting the mission, production or operations in the facility
- Limitation of the environmental impact of fire.

Acceptable methods that might be used to demonstrate compliance with requirements are referenced and methods for meeting goals are detailed in the SFPE Engineering Guide. Methods may be based on quantifying equivalencies to an existing prescriptive-based document, identify one or more prescriptive documents as approved solutions or performance criteria could be specified without reference to prescriptive requirements. Any solution that demonstrates compliance may be acceptable depending on the loss prevention goals.

A key requirement is the evaluation of the extent of hazard and determination of prevention, protection and control measures based on the hazard and their consequences. Emphasis is based on determination of the hazard and matching the control measures to the unique consequences of the hazard the location, company or political entity instead of attempting to meet generalized fire safety goals of an industry or municipality.

As an example the designer may be faced with a hazard in which the down time from a fire can not exceed four hours. The engineered approach provides options to prevent, protect and control the effects of fire so that down time is limited to four hours.

APPLICATION OF PRESCRIPTIVE APPROACHES TO PROCESS INDUSTRIES

A review of the various fire safety prescriptive measures in typical codes (see Attachment 1) illustrates typically mandated code measures for a chemical plant. When a prescriptive code is the design reference, the resulting fire protection design fall short of providing protection against extensive losses. Protection provided to meet minimum standards often is less than adequate for facility loss prevention goals. For example, personnel can be safely exited and the public protected from a fire in a process building that complies with consensus codes but fire and explosion damage can prevent use of the process area without extensive repairs or replacement.

Three of the most commonly used national codes are compared in Attachment 1. NFPA 30 has the most flexibility for providing solutions that meet loss prevention goals. Chapter 5 of NFPA 30 contains performance language which requires a full review of loss prevention, fire protection and process safety requirements. The building codes are focused on a one method fits all solution which often fails to result in measures that assure that loss prevention goals are met for protection of the process area.

APPLICATION OF PERFORMANCE APPROACHES TO PROCESS INDUSTRIES

The use of risk assessment methods - both qualitative and quantitative - to analyze the safety of a process is commonly utilized in chemical plant process safety and risk management planning. These methods typically focus on overall facility safety or a portion of a process unit where unique or complex hazards require evaluation of protective measures. Risk analysis techniques have not been used to the same degree to evaluate the effectiveness or appropriateness of fire prevention, protection and control measures. Instead, reliance on company tradition and experience, insurance company requirements, regulatory requirements and the standard design practices of the design team have been the more traditional methods to determine fire protection and loss prevention measures.

The use of a systematic methodology to determine fire safety measures in a complex facility, such as a chemical plant, will result from the introduction of performance codes in modern fire and building codes. The use of engineered performance determined fire protection designs in process plants will be slowly adopted as a normal practice. Fire protection and safety engineers should start to establish systematic methods for the determination of fire prevention, protection and control measures in a process facility. The use of systematic design analysis to determine fire protection measures will reverse continuing losses from fire and explosion which will not be reduced with the use of prescriptive codes and standards. The application of an engineered and performance-based approach to the determination of fire prevention, protection and control measures is a timely and overdue approach to plant fire safety.

A performance-based fire protection engineering analysis and design methodology which is acceptable to a majority of chemical process industry stakeholders needs to be developed. The lack of an established methodology should not however be an obstruction to the use of a systematic engineered approach to fire safety. There are a number of methodologies that may be adopted for performance-based analysis and fire protection design in a chemical plant. An effective check-list is the NFPA Fire Safety Concepts Tree (NFPA 550, *Guide to the Fire Safety Concepts Tree*). Attachment 2 contains an example of the use of the Tree to a typical process area.

NFPA in conjunction with the Society of Fire Protection Engineers (SFPE) recently published the SFPE Engineering Guide to Performance-Based Fire Protection: Analysis and Design of Buildings. The guide contains a step by step guide to performance-based design which is summarized in Figure (1). The steps in the design process are accurate for all types of performance-based analysis and design procedures. Caution should be taken in using all of the SFPE Guide text and examples which are primarily focused on the building environment and not the process plant. Careful consideration of details may be required even though the process is a sound concept for a design activity.

Further guidance on systematic process facility design is available in standard reference texts and documentation which can assist in executing a fire protection design that meets loss prevention goals. Typical fire protection and loss prevention references for a process plant are listed in Attachment 3.

SUMMARY

Fire protection of chemical plant assets is a highly challenging task and requires careful consideration of the loss prevention goals of the facility, corporation and other stakeholders. Compliance with codes and standards is a beginning and if diligently observed, code provisions will assure safety for the public and employees.

The ever increasing complexity of the chemical process industry highlights the requirement to provide adequate loss prevention measures for a process facility. Systemized approaches to determination of loss prevention goals and the application of fire and explosion mitigation measures should be the standard practice of all plant operators. Continued reliance on code compliance is a false objective and can result in extensive losses from fire and explosion from which the facility can not recover.

Application of the NFPA Fire Safety Concepts Tree is a proven method to assure life safety and property protection loss prevention goals are addressed during the design and operation of a facility. Chemical process designers and fire protection engineers should utilize performance-based analysis and design to assure that chemical process facilities meet loss prevention goals.

Bibliography

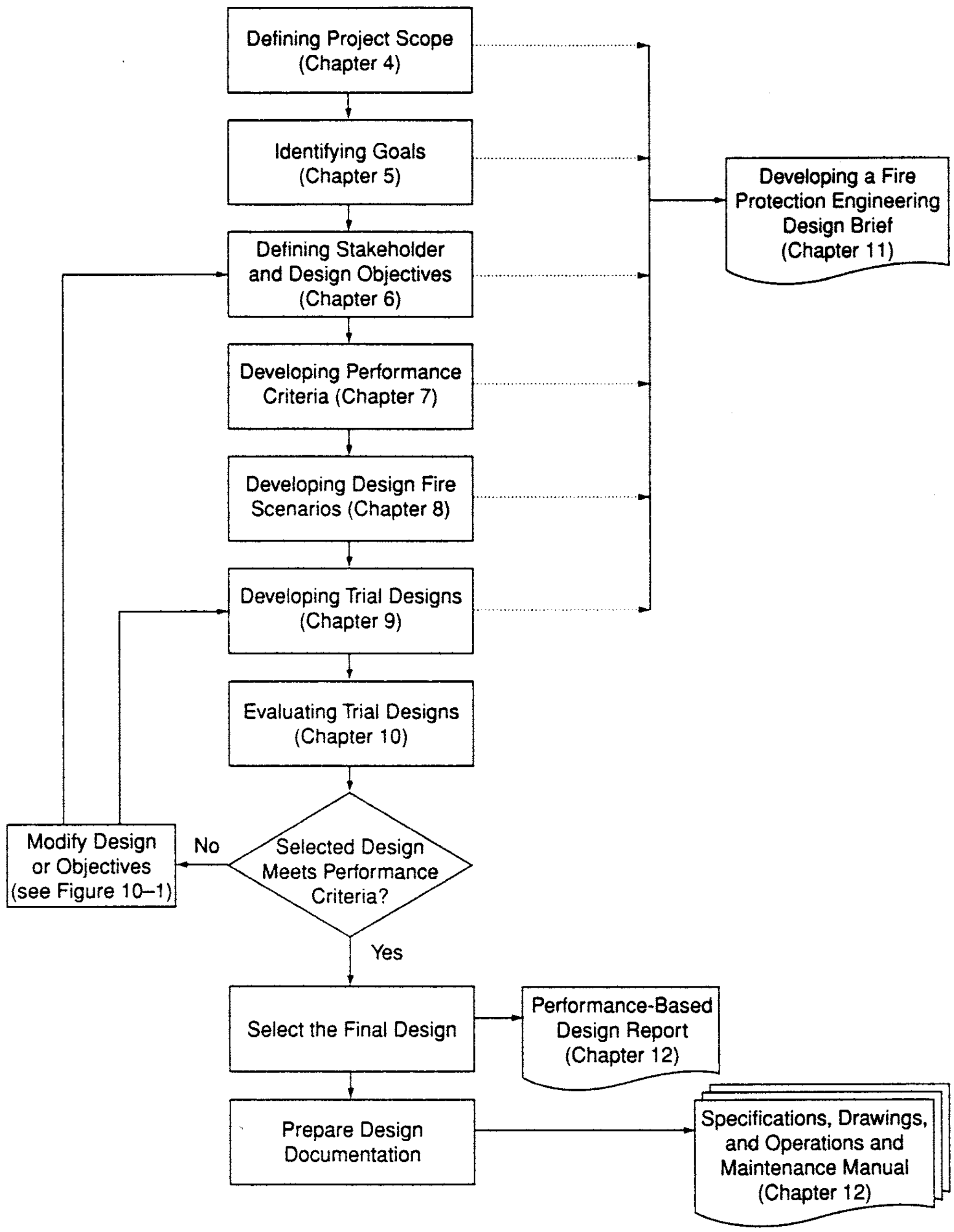
1. Large Property Damage Losses in the Hydrocarbon-Chemical Industries A Thirty-year Review, J & H Marsh & McLennan Consulting Services, Eighteenth Edition - 1998, NY, NY.

2. Hazard Survey of the Chemical and Allied Industries, Technical Survey No. 3, Arthur Spiegelman and E.W. Fowler, American Insurance Association, 1968.

3. SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings, National Fire Protection Association and Society of Fire Protection Engineers, Quincy, MA and Bethesda, MD, 2000.

4. NFPA 550, Guide to the Fire Safety Concepts Tree, 1995 edition, National Fire Protection Association, Quincy, MA.

Figure 1



STEPS IN PERFORMANCE-BASED ANALYSIS AND
THE CONCEPTUAL DESIGN PROCEDURE

Source: SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings.

ATTACHMENT 1
CONSENSUS CODE MEASURES FOR CHEMICAL PLANTS

This example of consensus code requirements for a process plant is based on the following design:

- The process is a solvent based mixing, blending and reactor area consisting of two mix kettles and two reactor/mix kettles. Pumps, dispensing and handling of solvents and products are also contained in the fire area.

- Solvents are Class IB hydrocarbons and polar solvents.

- The area is the only process location in the facility with bulk flammable solvents. The area is located on an exterior wall.

- The factory building is a non-combustible Type 2 construction located in a rural area.

- Public fire department is a volunteer organization with minimum industrial fire experience primarily oriented towards residential and commercial fire problems.

- Fire protection water is provided by private fire systems with a single 2,000 gpm fire pump taking suction from a fire water tank sized for 2 hours of fire flow at 3,000 gpm. (360,000 gallons).

- Products from the area are key ingredients in a new developing product for the semi-conductor industry. Customers are used to short lead times for the product in a just in time type delivery arrangement with average delivery timed for less than a shift lead time.

This example was prepared to illustrate the differences in requirements based on three codes and standards when applied to an exemplar process area. These provisions are illustrative and should not be considered to be all inclusive. Each loss prevention review requires careful consideration of the requirements, dependent upon the insurance company involved. In addition, the Authority Having Jurisdiction (AHJ) will also have direct review and comment upon the design and will likely require modifications to code compliance issues to assure a safe operating environment for the jurisdiction in which it is installed.

Consensus Codes

NFPA, Building Code requirements for a dispensing and process operations area are summarized in the following table for illustrative purposes. Depending upon the location, provisions can be added or substituted for those provisions in this example.

COMPARISON OF CODE PROVISIONS BLENDING AND REACTOR ROOM

	NFPA 30	**BOCA 1999 Building and Fire Codes**	**ICC 2000 Building and Fire Codes**
Location	5-3.2 Specifies: - Min distance to property line or, - Engineering evaluation of processes and sound FP or - > 25 ft, 2 hr fire rated wall with openings, or - 4 hr wall w/o openings - Unstable liquids from plant facilities by 25 feet or 2 hr fire division - Accessible from one side for fire fighting	Table 307.8 limits amounts of hazardous materials and the example area is an H-2 Occupancy (307.4) - With an open system example will likely exceed exempt amounts - H-2 Area limited to 11,200 ft^2 and 40 ft or 3 stories high (Table 503) - In 1 story storage and factory buildings H-2 fire area limited to 10% of total building up to max H-2 area limits (507.1.2) - Area limits can be increased by street frontage and unoccupied space on lot (506.2) - Min spacing from public street of 30 feet (507.2, 503.2) - Fire separation to adjacent areas to be 4 hour fire rated (Table 313.1.2)	Table 307.7 limits amounts of hazardous materials, the example area is an H-2 occupancy due to use of open amounts of liquids - H-2 Area limited to 11,000 ft^2 and 2 stories high (Table 503) - In 1 story storage and factory buildings H-2 fire area limited to 10% of total building area up to max. H-2 area limits (507.5) - Area limits can be increased by street frontage and unoccupied space on lot (section 506) - Min spacing from public street of 20 feet (506, 507.2) - Fire separation to adjacent areas to be 3 hours with 5 foot separation and 0 rating with greater >= 30 feet. - Process vessels (F3405.3.4) located distance from lot lines to Table 3405.3.4 (modified table 5-3.2.1 from NFPA 30) and includes pressure rating scale of above and below 2.5 psig. Can be modified if 4 hour blank wall is provided to distances in building code and explosion control provided for Class IA liquids.

	NFPA 30	BOCA 1999 Building and Fire Codes	ICC 2000 Building and Fire Codes
Construction	5-3.3 - Fire resistive or non-combustible - Combustible permitted with automatic sprinklers or equivalent protection approved by AHJ - Protect structural load-bearing supports and equipment supports by: * Drainage * Fire resistive Construction, coatings or systems * Water Spray * AHJ approved alternatives * No basement use * Smoke and heat venting OK * Exits to prevent being trapped, exits unexposed by drainage facilities * Adequate aisles * Explosion deflagration venting if using Class IA (to NFPA 68)	Table 503 establishes height and area limitations of buildings and while it allows H-2 occupancies in combustible buildings limits size to 5,100 ft^2 and one story in Type 5 A protected combustible construction. - Fire resistive requirements by type of building and details of structural design - No basement use allowed - Explosion deflagration venting required (417.5.1) where Class I liquids are present (See 307.4 definition of H-2 area) - storage, handling, processing and transport in accordance with fire code. - fire code refers to NFPA 30	Table 503 establishes height and area limitations of buildings. Allows H-2 occupancies in combustible buildings and limits size to 3000 ft^2 and one story in type 5B (Combustible) and 7,500 ft^2 in type 5A construction. - Fire resistive requirements same as BOCA code - No basement use allowed - Explosion deflagration venting required (414.5.1) (F3405.3.7.6.2)
Ventilation	5-3.4 Ventilation in areas using Class I, II, III liquids - @ or below 25% LFL confirm: * Calculate rate using fugitive emissions, or sampling during operations, or 1 CFM/ft^2 - Mechanical or natural, to safe location outside - Recirculation provisions - make-up air to cover all areas - Local/spot OK to 75% of total	**Storage tank** areas ventilated at rate to maintain vapors at or below 25% LFL. - determine by calculations based on fugitive emissions, or sampling during normal operating conditions. - provide make-up air to avoid short-circuiting ventilation.	Continuous mechanical ventilation at 1 cfm/ft^2 to include - introduction of intake air to include all floor areas or pits - local or spot ventilation when needed -

	NFPA 30	BOCA 1999 Building and Fire Codes	ICC 2000 Building and Fire Codes
	required - Equipment and ventilation limits flammable vapor and air mix to interior and max 5 ft from equipment exposing class I liquids to the air.		
Drainage	5-3.5 - Water & spills to safe location by using scuppers, curbs, systems for fire spread control - Discharge thru separators to public sewer, waterway - Prevent discharge to public sewer, waterways, or off property	No requirements	Spill control (required in F 3405.3.7.5.3 arranged to requirements in 2704.2) sized for largest vessel using sloped or recessed floors inside or outdoors, sumps and collection systems - Contain or drain spill and fire protection water indoors - 20 minutes of fire protection water flow for containment. - outdoors requires volume of 24 hour rainfall to 25 year storm design - outdoor requires monitoring to detect hazardous materials (can be visual) or where subject to water intrusion a water detection device with alarm.
Electrical Equipment	5-3.6 - Meet area electrical classification in Table 5-9.5.3 and National Electrical Code	F3203.8 requires ignition source control for electrical equipment - implies electrical area classification. 2701.3 requires conformance with NFPA 70 National Electric Code which requires use of area classification for hazardous areas.	F3403.1 - Requires classified areas in accordance with Table 3403.1.1 (chart appears to be copy of Table 5-9.5.3 in NFPA 30 - 1996)

	NFPA 30	**BOCA 1999 Building and Fire Codes**	**ICC 2000 Building and Fire Codes**
Liquid Handling, Transfer and Use	5-3.7- Class I in closed tanks or containers - Class II & III in closed tanks or containers when temperature above flash point - Provide for prompt, safe disposal of leaks, spills - No Class I in area with open flames or other ignition sources in electrical Classified areas -Use air or inert gas pressure to transfer with major safety measures - PRV to tank, pump suction, or safe location from positive displacement pumps - Listed flexible connectors in vibration areas and listed hose for transfer stations.	- F3203.9 Report to code official promptly - F3203.5.3 - same provisions as NFPA 30 for dispensing using inert gas or pressure	F3405.2 - Class I,II and IIIA liquids - PRV to tank, pump suction, or safe location from positive displacement pumps - Use air or inert gas pressure to transfer with major safety measures - Piping, hose and valves approved or listed for intended use. - Vessels bonded for class I liquids - No heating. Lighting or cooking appliances utilizing Class I liquids operated in a building or structure (F3405.3.3) - Self-closing, tight fitting, non-combustible lids on mixing or blending vessels for Class I liquids and Class II and III liquids heated above flash point.
Equipment	5-3.8 - Designed and arranged to prevent escape of liquids and vapors and min. Quantity in event of accident	F3203.2 - construct and tested to NFPA 30 requirements	
Control of Ignition Sources	5-9 - lists general provisions to control common ignition sources, static electricity, electrical installations	F3203.8 - general ignition sources controls required.	
Fire Hazard Management	5-11 - Requires means to identify evaluate and control hazards - Review operations to ensure hazards from loss of containment are provided with plans for fire prevention and emergency action		

	NFPA 30	BOCA 1999 Building and Fire Codes	ICC 2000 Building and Fire Codes
	- Determine by engineering evaluation fire prevention and control measures - Written emergency action plan - Repeat review for changes in process materials, equipment, process control or operating procedures or assignments		
Fire Protection & Suppression	5-12 - Outlines portable and fixed fire control measures and minimum requirements such as fire water supply, control agents, sprinklers, foam, etc as required by an engineering evaluation. - Detection and alarm required based on engineering evaluation - Emergency planning and training - Inspection and maintenance.		F-3405.3.7.3 - H-2/3 occupancies required to be equipped with an approved automatic fire-extinguishing system in accordance with Chapter 9

ATTACHMENT 2

APPLICATIONS FOR THE FIRE SAFETY CONCEPTS TREE

The NFPA Fire Safety Concepts Tree provides a systematic means to examine all fire safety features and demonstrate how they influence the achievement of fire safety goals and objectives.

The Fire Safety Concepts Tree provides a structure for the analysis of the potential impact of codes and standards to a particular fire safety problem. The Tree can identify gaps and areas of redundancy in alternative fire protection strategies as an aid in making fire safety decisions.

The Tree is structured so that the logic of the tree is directed toward achieving specified objectives, such as managing the fire risk. Three basic fire safety objectives are joined in the tree – life safety, property protection and operational continuity. Other operating objectives can be includes such as averting a catastrophic loss, avoiding public anxiety, preserving for posterity and environmental protection.

The top of the tree is the box labeled “FIRE SAFETY OBJECTIVES” which focuses the use of the tree to a specified objective. Strategies for achieving the objectives are divided into two categories: “PREVENT FIRE IGNITION” and “MANAGE FIRE IMPACT” which are joined by an OR gate indicated by the plus symbol in a circle at the intersection of the two strategies. These are the top two boxes in the tree and are the result of the logic inputs from below the outputs at the top of the tree. The NFPA points out an OR gate on the Tree is an inclusive or and that all concepts below the gate can be include but only one of them is necessary. Fire safety can not be achieved by Management or Prevention measures working without the other. Fire safety requires that principles from both prevention and fire impact management are present for effective fire safety. Thus an OR gate indicates that where reliability of achieving an object is improved by implementation of more than one strategy.

The PREVENT FIRE IGNITION branch of the Tree include measures representative of a fire prevention code or standard operating practices (SOP’s). Fire safety measures in this branch of the tree require continuous monitoring to ensure their effectiveness. This is a major responsibility of management of the facility to assure that effective fire prevention measures are incorporated into all parts of the operation.

The PREVENT FIRE IGNITION branches into three means of controlling the ignition of a fuel – controlling the heat source, controlling the interaction between fuel and heat energy and controlling the fuel. This is another way to view the fire triangle of heat, air and fuel.

- The elements “control heat energy sources” are commonly included in typical chemical process operations. These include controlling hot work, monitoring and preventing exothermic reactions, or using proper electrical equipment with a temperature rating below the autoignition temperature of a vapor as part of electrical area classification.

- “Control Fuel-source Interactions” joins three strategies with an AND gate. This part of the tree includes those measures that prevent fuel sources from being close to a heat source, excessive heat from contacting a fuel source and the prevents fuel sources from being too close to a heat source. Hot work permit controls that isolate fuel from hot work are a good example in this portion of the tree.

- "Control Fuel" strategies include either control of fuel ignitability or elimination of the fuels. Fuel ignitibility is commonly controlled through inerting the fuel, changing fuel composition by raising the flash point, or by vapor removal by ventilation, dilution with air, or scrubbing techniques.

Other portions of the tree can also be compared with systems, equipment and operating strategies to develop effective measures to meet fire safety objectives. Consideration of the questions raised during a review of the Tree when applied to a specific problem indicates that one size fits all approaches to fire safety are not valid approaches to complex problems. A slight adjustment in FIRE SAFETY OBJECTIVES can change a number of strategies and means of achieving fire safety. Comparing the tree to commonly applied Code and Standards generated solutions will indicate that these approaches lack the full depth needed to safeguard a chemical process facility from all of the effects of fire.

This paper is not able to devote the amount of time required to fully explore all the possibilities for the use of the Fire Safety Tree. As an example of the use of the tree and application to the example used for this paper – a mixing and reactor room handling flammable liquids, the control combustion process strategy under manage fire strategy is compared in Table A2 -1 with the information provided for the example.

TABLE A2-1
COMPARISON OF CONTROL COMBUSTION PROCESS
FOR EXAMPLE PROCESS AREA

STRATEGY OR SUB-STRATEGY	***HOW MANAGED BY CODES & STANDARDS***	***DESIGN CHANGES OR ADDITIONS***
CONTROL FUEL		
CONTROL FUEL PROPERTIES	Allows more liquid amounts for higher flash materials before implementation of control measures	1 - Change to class ii liquid 2 – Change vapor pressure 3 – Change formula
LIMIT FUEL QUANTITY	Higher the flash the more liquid allowed, or Lower amounts of liquids to below exempt level removes any control measures	1 – Reduce batch volumes 2 – Change container sizes 3 – Modify end products
CONTROL FUEL DISTRIBUTION	Encourages small storage / use quantities for control of concentration of liquids in one area	1 – Batch controls to limit feed rates, reduce amount of fuel 2 – Use small containers and limit amount in area at a time
CONTROL ENVIRONMENT		
CONTROL PHYSICAL PROPERTIES OF ENVIRONMENT	Ventilation required	1 – Provide inert atmosphere 2 – reduce heat 3 – dilute fuel quantity
CONTROL CHEMICAL COMPOSITION OF ENVIRONMENT	No requirements	1 – Provide inert atmosphere 2 – Change from vapor to liquid or liquid to solid