Design Approaches to NFPA-13 - The Standard for the Installation of Automatic Sprinkler Systems

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With Power Comes Responsibility

The decisions we make impact lives.
Contractor’s Perceptions of Change Orders

Goals

- Identify the definition of responsible charge in the design of a sprinkler system.
- Define engineer vs. contractor responsibilities.
- Identify design approaches for construction documents applied to NFPA-13.
- Establish levels of contractor competency based on project complexity.
- Use a case study for the application of design approaches.
- Answer the question – What is the right level of fire protection to optimize installation cost.
Question

When do we know that the fire protection systems we installed don’t work?

Questions on Design Liability

You do not have to raise your hands

Why here has been involved with design/build projects?

Who has seen bid documents asking the contractor to “design” a project without a stamp?

Who here has seen documents asking the contractor to hire an Engineer of Record?

Do you know what type of engineer stamped the plans?
Questions on Design Liability

- Who has seen a design based on only the direction of “Install Per NFPA 13”?
- Who has seen a project based on only direction to meet FM Guidelines?
- Have you been asked to establish “engineering precedence”?
- Have you ever considered the implications of contractor competency?

National Council of Examiners for Engineering & Surveying (NCEES)

To implement a design, the PE does the following:

1. **Contract Drawings** - engineering discipline drawings sealed by a licensed PE, which establishes the engineering precedence.
   - a. Engineering precedence involves establishing a specific set of design criteria which is specific to each individual project.

2. **Supervision** – a licensed PE is required in the review of engineering discipline installation shop drawings for compliance with the Engineer’s design and specifications.

3. **Oversight** - a licensed PE is required in the installation of an original permitted design (new construction and alterations require permit).
FP Design Delegation Process
Professional Engineer (PE) Role

Engineering Documents
- Design Drawings & Specifications (PE sealed)

Establish Engineering Precedent by
- Calculations & layout parameters
- Systems integrations
- Specifications of all submittals—listings, fire tests
- Qualifications of Engineering Technician (ET)
- Sequence operations
- Acceptance test protocols & procedures
- Operation & maintenance manuals
- Inspection, testing, & maintenance procedures

FP Design Delegation Process
Engineering Technician (ET) Role

The Engineering Technician (ET) works only under PE Supervision through Engineering Precedent established by PE

ET can NOT establish Engineering Precedent - PE Specifications define all Engineering Precedent details.

The ET performs:
- Submittals - material, components, products.
- Layout of system to field conditions w/ EP calculations.
- Working or Shop drawings.
- Conducts acceptance tests.
What Contractors CANNOT Do

 Contractors are **NOT** trained (or allowed by Law) to perform Code Analyses and establish design criteria. Therefore they cannot establish design intent.

 ONLY the Engineer of Record can establish design intent and design precedence.

SED Law Article 145
Professional Engineering Practice

- Sec. 7201. Definition of practice of engineering. The practice of the profession of engineering is defined as performing professional service such as consultation, investigation, evaluation, planning, design or supervision of construction or operation in connection with any utilities, structures, buildings, machines, equipment, processes, works, or projects wherein the safeguarding of life, health and property is concerned, when such service or work requires the application of engineering principles and data.

- Sec. 7202. Practice of engineering and use of title "professional engineer". Only a person licensed or otherwise authorized under this article shall practice engineering or use the title “Professional Engineer”.
The licensee performing the design has to sign and certify that it has met these parameters.

The licensee delegating the work must specify all of the design parameters that the design must meet.

Licensees shall, to the best of their knowledge, include all relevant and pertinent information in an objective and truthful manner within all professional documents, statements and testimony.

The licensee who has delegated the design function, upon receiving the design, must review and approve the design as meeting the design parameters that were specified and to ensure that the designed element can be integrated into the overall project.

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2015 IBC

107.2.1 Information on Construction Documents.

Construction documents shall be dimensioned and drawn upon suitable material. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this Code and relevant laws, rules and regulations.

107.2.2 Fire Protection system shop drawings.

Shop drawings for fire protection systems shall be submitted to indicate conformance with this Code and the construction documents and shall be approved prior to the start of system installation.
Design Liability Overview

- The Professional Engineer (or Registered Architect) is in responsible charge for correctness and compliancy of the design AND installation of automatic sprinkler systems.

- The Engineer's role is to establish engineering precedence by identifying the minimum level of protection and establishing minimum design criteria to allow for a Code Compliant installation.

- The Contractor’s role is to provide a Code Compliant installation based on the engineering precedence established by the Engineer.

- We have all signed an agreement stating that we will only practice and sign and seal plans in which we are “qualified by education and experience”.

You do not look good in handcuffs!
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"Install per NFPA-13"

- How many of you have ever seen Construction Documents which only included the information to “Install per NFPA-13”?
- Direction to only “Install per NFPA-13” does not provide the minimum level of required and pertinent information required by SED Article 145 and the 2015 IBC.
- Why not? Let’s look an example of what can happen.
A structural engineer was hired for a design-build project for a new storage building at an industrial facility.

It was intended that this engineer serve as the Engineer of Record for all trades, MEP, FP, civil, architectural, etc.

The engineer verbally told a contractor to provide a quote to “install ESFR sprinklers per NFPA-13”. No Construction Documents to establish design intent were provided.

The sprinkler contractor hired a licensed Fire Protection Engineer to help develop the shop drawings and hydraulic calculations.

The installation cost from the contractor’s bid was about $750,000.
The project involved a two story S-1 plastics storage building, type IIB construction and about 105,000 square feet per floor.

The building consisted of 24”+ deep steel beams. Due to the depth of the steel, this required the contractor to install sprinklers about 6 feet on center in every single bay.

The contractor was not paid for this cost increase, initially.

The FP engineer and sprinkler contractor then learned that the Owner was going to store Exposed, Expanded plastics on racks within this building. NFPA-13 (2013), as adopted by the Building Code and as the sprinkler contractor was asked to bid on, does not provide guidance for rack storage of Exposed, Expanded plastics.
This storage arrangement increased the sprinkler design criteria by about 600 gpm, requiring a larger fire pump, larger sprinklers, larger piping, and about 500’ of recently installed 8” underground main to be replaced with 12” pipe.
“Install per NFPA-13”

- The cost implications of this “design error” exceeded $750,000.
- Because the design criteria could not be established by NFPA-13 (2013), the engineer had no option but to award a change order.
- This all could have been avoided had the engineer established design intent and precedent as required by the Building Code before the contractor bid the job.

Two Design Methods

- Design-Bid-Build (Complete Sprinkler Design)
- Design-Build (Performance Specification)
Design-Build
(Performance Specifications)

- Performance specifications are commonly provided as the design method for Design-Build of fire sprinkler systems.
- With this method, the Engineer provides the contractor with the minimum level of design criteria required to establish design precedence.

What is required for a Performance Specification?

- To establish the minimum level of engineering precedence for a contractor to bid on, the Engineer must provide:
  - Building Construction Type per Chapter 3 definitions of NFPA-13.
  - Building Occupancy Hazard Classification and/or Storage Commodity Classification per Chapter 5 of NFPA-13.
  - Extent of each sprinkler system, including:
    - Coverage areas of each wet, dry and pre-action sprinkler system.
    - Locations of sprinkler protection (i.e. below ceilings only, above and below ceilings, in any specific combustible concealed spaces, etc.).
  - Minimum design criteria required (Chapter 11 or storage chapters of NFPA-13) to allow the Contractor to perform hydraulic calculations. This includes the design density, size of the design area and requirements for hose stream allowances.
  - Adequate building floor plans, reflective ceiling plans and building sections to develop an Code Compliant sprinkler layout.
What is Typically NOT required to be provided in a Performance Specification

- Contractor hiring an Engineer of Record (unless identified in the performance specification)
- Type of sprinkler(s) to be installed
- Sprinkler and piping layout (Chapter 8 of NFPA-13)
- Preliminary hydraulic calculations (some AHJ’s do require it)

Remember, per the SED Article 145, the PE only needs to provide the minimum relevant and pertinent information to allow the contractor to install a Code Compliant system.

Cons - Performance Specifications

- Most times, you are not bidding apples-to-apples.
  - The Owner/Architect/Engineer lose the ability to direct how the sprinkler contractor installs the system, unless specific design guidelines is provided.
- Greater margin for error, from either the engineering or installation standpoint.
- Higher probability of promoting illegal and unethical engineering practices.
Cons - Performance Specifications

- The architect or engineer who produces the performance specification does NOT have reduced liability, even if your Bid Drawings required the contractor to hire the Engineer of Record.

![Laptop and blueprints](source: soundmaskingspecs.com)

How to Resolve Problems with Performance Specifications?

- Require a minimum level of contractor qualification (discussed in next section)
- Require the Contractor’s engineer to provide documentation proving their education and experience in fire protection, if applicable.
- **Just don’t do it.**
  - We will see later how complete sprinkler designs can help you avoid headaches AND can save the Owner money.
Design-Bid-Build Method

- Design-Bid-Build projects (i.e. complete designs) provide the same level of design criteria as Performance Specifications.
- The difference is that this design method for sprinkler system includes a complete sprinkler and piping layout and preliminary hydraulic calculations per NFPA-13.

Pros - Complete Sprinkler Design

- You will get an apples-to-apples bid.
  - Unless you have an under qualified contractor (biggest con), which is discussed in the next section.
- You know the design is Code Compliant and will work BEFORE the system goes out to bid.
  - You will know about how many sprinklers are required, what size piping is needed, and if a fire pump is necessary or not.
- You will actually reduce installation cost, even though the engineering design fee is higher.
  - Discussed later in the presentation.
Design-Build Demand Factors for Owners

- Single Point of Responsibility/Accountability
- Faster by up to 34%
- Cheaper by up to 6%

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Contractor Competency

- Who has ever considered the impact of contractor qualifications when designing and specifying a fire sprinkler system?
- NFPA-13 does not provide minimum contractor qualification requirements. Therefore it is up to the design professional to specify the appropriate level of contractor competency based on the complexity of the project.

Contractor Qualifications

- Fire Sprinkler Contractors are certified by the National Institute for Certified Engineering Technicians (NICET)
- NICET Level IV
- NICET Level III
- NICET Level II
- NICET Level I

www.pearsonvue.com/nicet/
NICET Level I

- Requires a minimum of 6 months of experience with aspects of plan preparation, including preparation and compiling of CAD drawings, including layout of sprinklers and assisting in field surveys.
- Personal Recommendations are **NOT** required.
- Submission of relevant major projects is **NOT** required.
- Must pass Level I Examination.

 NICET Level II

- Requires a minimum of 2 years of water-based fire protection systems layout and related work experience. This must include at least 12 months of complete NFPA-13, NFPA-13R and/or NFPA-13D sprinkler systems and standpipe systems detailing (layouts).
- One year of experience may be granted for five years experience in any one or combination of the following:
  - Special hazard suppression system installation
  - Special hazard systems layout
  - Inspection and testing of water-based systems
  - Sprinkler system installation
- One year of experience may be granted for five years experience in any one or combination of the following:
- Personal Recommendations are **NOT** required.
- Submission of relevant major projects is **NOT** required.
- Must pass Level I and II Examinations.
**NICET Level III**

- Minimum experience required for Level II PLUS and additional 3 years of water-based fire protection systems layout, involving the complete layout of sprinkler and standpipe system, including hydraulic calculations, which may include project management and/or code compliance.
- Personal Recommendations are required to show a capacity for independent engineering technician responsibilities.
- Submission of relevant major projects is **NOT** required.
- Must pass Level I and II Examinations.
- Must pass Level III General Examination.
- Must pass Level III Hydraulics Examination.

**NICET Level IV**

- Minimum experience for Level III PLUS and additional 5 years of full-time involvement with layout of water-based systems, which must include management of multiple layout projects involving multiple work teams, coordination with installers, are responsible interactions with clients, engineers and AHJs.
- Experience must demonstrate knowledge of and experience in designing wet-pipe, dry-pipe, deluge and pre-action sprinkler systems, and may include foam and fixed-water spray.
- Must submit sufficient experience of major experience to show senior responsibility for a water-based system project layout project of substantial complexity.
- Personal recommendations are required to show a capacity for senior engineering technician responsibilities.
- Must pass all previous exams plus the Level IV examination.
Case Study #1

- Involved a new high end condo (three stories plus attic) building.
- An NFPA-13 system was required to be installed.
- Despite efforts and by adhering to the project chain of commands, the FP engineer was unable to adequately coordinate with MEP engineers to the extent needed during design.

Case Study #1

- The Engineer required a NICET Level IV contractor in the specifications, with the intent that the contractors experience would ease coordination efforts during design.
- After the design was complete, a year passed before the project was bid out.
Case Study #1

Prior to bid, several key changes to the construction of the building were made, but the FP engineer was not made aware of these changes.

The project was awarded to the low bid GC, who obtained quotes from four NICET IV qualified sprinkler contractors.

The NICET IV bids ranged from about $300,000 to $320,000.

The overall project was about $1 million over budget and the GC was asked for value engineering options.

One option the GC provided was to provide a NICET III contractor, who had provided the GC with a quote for about $230,000.
Case Study #1 Results

- The contract was awarded to the NICET Level III sprinkler contractor. Given the project complexity, the contractor’s competency level was sufficient enough to perform the hydraulic calculations.
- After the project began, the contractor began to find the changes to the building design that the FP engineer was never made aware of.

Case Study #1 Results

- The multiple changes to the design led to about $80,000 in change orders (bringing the total sprinkler system installation cost up to about $310,000).
- Remember that the original NICET Level IV bids ranged from $300,000 to $320,000.
- Why did this occur? Who’s Responsible For This Mess?
- What does this teach us?
Case Study #2

- Required retrofit sprinkler installation for a 100,000 square foot existing plastics manufacturing and storage building.
- The project also required a fire pump house to be constructed and a 150,000 gallon aboveground water storage tank to be installed.

Case Study #2

- During the design phase, the engineer made site visits on a monthly basis. Over time the engineer noted that changes were made to the building floor plan, just about during every site visit.
- Besides the complexity involved with the high hazard areas, the fire pump and the water tank, the Engineer specified a NICET Level IV requirement to have an experienced contractor that would be able to coordinate with the constantly changing building conditions.
Case Study #2 Results

- A qualified NICET Level IV contractor was awarded the job.
- The total project cost was about $4.2 million.
- The total project had only 0.3% of the construction value in change orders, after the engineer made a maintenance feasibility change when reviewing the shop drawings.

Sprinkler Contractor Submittals

- Product submittals:
  - Sprinklers, piping, valves, hanging and bracing components, fittings, couplings, fire pump equipment, electrical devices, etc.
- NFPA-13 Compliant Working Drawings
  - a.k.a. shop drawings
- Water Supply Information
  - Hydrant Flow Test Information
- NFPA-13 Compliant Hydraulic Calculations
Working Drawings - NFPA-13
Section 23.1

- Occupancy class of each room
- Hydrant flow test information
- Make, type, model, temperature rating and K-factor of sprinklers including SIN
- Total number of sprinklers
- Approximate capacity of dry pipe systems (if applicable)
- Pipe type and schedule of wall thickness
- Pipe size, pipe cut lengths, and locations of elevation changes
- Location of pipe hangers
- Hydraulic note points and hydraulic data nameplate information

Working Drawings - Good Example
Water Supply Information

- Hydrant flow test is required to be “recent” and completed within 1 year of shop drawing submittal to AHJ
- Location and elevation of static and residual test gauges
- Flow location
- Static Pressure
- Residual Pressure
- Flow
- Date and Time
- Names of people conducting testing

Hydraulic Calculations - Summary Sheet

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Hydraulic Calculations
by
ABC Company, employee garage

9/19/2018

Hydraulic Calculations

Design data:
- Occupancy classification: [details provided]
- Design: [details provided]
- Area of application: [details provided]
- Coverage per sprinkler: [details provided]
- Special sprinklers: [details provided]
- No. of sprinklers estimated: [details provided]
- Inflow demand: [details provided]
- Hose streams: [details provided]
- Total water required: [details provided]

Name of contractor: [details provided]
Name of designer: [details provided]
Address: [details provided]
Authority having jurisdiction: [details provided]

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Hydraulic Calculations - Hydraulic Graph

Hydraulic Calculations - Node Analysis

Pressure / Flow Summary - STANDARD

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- Use a case study for the application of design approaches.
- Answer the question – What is the right level of fire protection to optimize installation cost?
A sprinkler system retrofit for an existing medical office building was required for about a 35,000 sq. ft. area.
11,000 sq. ft. was rack storage of paper records.
A performance specification and a complete design were developed and bid out to volunteering contractors.
Provided Hydrant Flow Test Data

**HYDRAULIC DESIGN CRITERIA**

**WATER FLOW TEST**
- STEady: 94 gpm
- PEAK: 114 gpm
- FLOW: 156 gpm
- TIME: 8:00 AM
- LOCATION: FLOW TEST HYDRANT

Provided Storage Area Floor Plan

**STORAGE ROOM PACK LAYOUT LOCATIONS**

**TYPICAL DOUBLE ROW PACK LAYOUT**
Design #1 - Performance Specification

- Provided the contractor with all required design criteria (sprinkler type, piping material, occupancy classifications, design criteria, general notes and details, etc.).
- Performed a preliminary hand calculation to estimate the required size of the fire pump.

Performance Spec Drawing Notes

**SCOPE OF WORK**

1. Provide an NFPA-13 compliant sprinkler system throughout the building.
2. Provide hangars and piping as required per NFPA-13.
4. Provide an NFPA-25 compliant fire pump calculation. The expected sprinkler flow design is the fire pump size shall be used to provide the flow demand of all NFRA and existing sprinkler system.

**HYDRAULIC DESIGN CRITERIA**

**WATER FLOW TEST**

- Station: 55 DRG
- Residual: 45 PSI
- Flow: 300 GPM

**DATE**: 9/1/2018
**TIME**: 9:00 AM
**LOCATION**: Flow Test Hydrant

**SPRINKLER NOTES**

1. All work on this fire protection system shall be electrically supervised.
2. All piping shall be in accordance with NFPA-13 and the performance specification.
3. All sprinkler work shall be in strict conformance with NFPA-13 "Standard for Installation of Sprinkler Systems".
4. Work shall be coordinated with all other trades.
5. All sprinklers installed in ceiling shall be located a minimum of 4" away from any walls, ceiling height changes or any other vertical intersecting surfaces.
6. Provide sprinklers above and below openings of doors and windows.
7. Provide head clearance on sprinklers in electric, telephone, and elevator equipment rooms.
8. Firestop all penetrations of pipes, fire walls, ceilings, floors, etc., with fire-resistant roof penetrations.
9. Provide access panels to all valves above non-accessible ceilings and changes.
10. Maintain a minimum of 18 inches from the bottom of the sprinkler outlet to the top of storage/pipe storage.
11. Provide a permanently attached hydraulic design information sheet showing the required design criteria for each hydraulically balanced system.
12. Inspectors test valve shall not exceed 7 feet above the finished floor.
**Performance Spec Drawing Notes**

**LEGEND:**

<table>
<thead>
<tr>
<th>Hatching</th>
<th>System Type</th>
<th>Hazard Classification</th>
<th>Density (gpm)</th>
<th>Remote Area (Sq. ft)</th>
<th>Max Coverage Area per Sprinkler (Sq. ft)</th>
<th>Zone Demand (gpm)</th>
<th>Reference</th>
<th>Total Area Requiring New Sprinkler System (ft²)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Wet</td>
<td>Light Hazard</td>
<td>0.10</td>
<td>1500</td>
<td>225</td>
<td>100</td>
<td>NFPA 13  (2013)</td>
<td>15,000 square ft</td>
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<td>Wet</td>
<td>Ordinary Hazard Group 1</td>
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<td>1500</td>
<td>130</td>
<td>250</td>
<td>NFPA 13  (2013)</td>
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<td>Ordinary Hazard Group 2</td>
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<td>NFPA 13  (2013)</td>
<td>400 square ft</td>
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<tr>
<td></td>
<td>Wet</td>
<td>High Flammable Storage Class II Commodity</td>
<td>Per Chapter 16 of NFPA-13</td>
<td>100</td>
<td>500</td>
<td>NFPA 13  (2013)</td>
<td>10,000 square ft</td>
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<tr>
<td></td>
<td></td>
<td>EIR Sprinkler System – No Modifications Needed</td>
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<td></td>
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</tbody>
</table>

**Performance Spec Details**

**FIRE PUMP PIPING DETAIL**

**NOTES:**
- Schematic fire pump layout only.
- Contractor is responsible for ensuring final fire pump layout and equipment meets NFPA-20 and local code requirements.

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*9/19/2018*
Performance Specification Results

- Three bids were received ranging from $161,340 to $167,000.
  - Fire pump costs ranged from $42,300 to $42,900.
- Overall, the bids associated with the performance specification were within 3.4%. Therefore we received an accurate apples-to-apples bid.
- Engineering design fee would have been at least $5,000.

Design #2 - Complete Sprinkler Design

- Provides the contractor with all required design criteria, but also includes a sprinkler and piping layout, including a detailed layout of the fire pump and equipment.
Fire Pump Room Floor Plan
Fire Pump Schematic
**Complete Design Results**

- Three bids were received ranging from $129,000 to $133,175.
- Fire pump costs ranged from $50,175 to $52,500.
- Overall, the bids associated with the complete design were within 3.2%. Therefore we received an accurate apples-to-apples bid.
- Engineering design fee would have been $15,000 to $20,000.

**Design Methods Comparison**

**Performance Specification**
- Potentially Non-Compliant Design (the system may not work)
- Average installation fee of $164,000
- Minimum engineering fee of $5,000
- Total cost to owner of $169,000

**Complete Design**
- You know the design is Code compliant and will work before bid
- Average installation fee of $131,000 (20% lower)
- Maximum engineering fee of $20,000
- Total cost to owner of $151,000

Overall, the complete sprinkler design bid package provided the Owner an 11% cost savings and ensured there will be no headaches.
Owner’s Perceptions of Change Orders

With Power Comes Responsibility

The decisions we make impact lives.
Design Approaches to NFPA-13 - The Standard for the Installation of Automatic Sprinkler Systems

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