COMPARISON OF DESIGN & PERFORMANCE OF SPRINKLER SYSTEM IN KOREA FIRE CODE AND NATIONAL FIRE CODE

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ABSTRACT

One of the notable changes in Korean Industry in 1990's was globalization. Many of Korea plants have been built in the foreign countries and many of foreign plants have been build in Korea. And it is believed that many foreign insurance companies will begin their business in Korea soon, as Korea will open their insurance market to them. While sprinkler system plays very important role in total fire protection system, Korean sprinkler system design has not been studied in depth. Thus, it is not easy to convince the performance of Korean sprinkler system and compare it to NFPA 13, Standard for the Installation of Sprinkler System. Design guideline from both system will be listed and compared in detail. Fire water demand from both system will be reviewed to evaluate its adequacy. Water spray density and actuation time will be estimated, too.

INTRODUCTION

It has been frequently asked where does the Korean sprinkler system regulation come from. Some of them looks having same roots and some of them doesn't. Since Korean government opened their market to foreign countries and becoming a member of OECD, much of foreign investment have flown into Korea and many of Korean firms have extended their production facilities to foreign countries.

Most in each cases fire protection engineers who are responsible to design and install the sprinkler system become disturbed, as they don't understand the other system. In many cases Korean Fire Protection regulations give more difficulties in understanding their design intent, as they are so much compressed and don't give explanation.

Most of people just imagine the Korean regulation about sprinkler system requires more water demand. It is very important to understand each system and evaluate them with same ruler. Spray density, and system demands will be

evaluated and compared. And the actuation time from each system, based on wet pipe system, will be estimated, too.

COMPARISON OF DESIGN REQUIREMENTS

Integral parts of design requirements for sprinkler system from Korean regulation and National Fire Code 13, Standard for the Installation of Sprinkler System, are listed and explained for the development of comparison of two system. Most of design requirements for Korean sprinkler system are stated in the Fire Protection Technical Code published by Dep't of Home Affairs. Installation of sprinkler system is stated in Article(Kwan) 3 of Chapter(Jang) 2.

System Water Requirement

Korean Regulation ; Numbers of Actuated Heads are clearly listed in the table and the total amount of fire water are the products of listed actuated heads and 1.6 M^3 per head. Considering listed flow of each head, 80 lpm, it is assumed that the duration of sprinkler actuation is 20 minutes. The numbers of listed actuated heads vary with three occupancy classifications. They are buildings lower than 10 stories(including 10 stories) above ground, apartment houses and buildings higher than 10 stories. The numbers of sprinkler heads assumed to be open during the fire is 10, for buildings higher than 10 stories is 30. Buildings lower than 10 stories divided into three occupancies again; plant buildings including warehouse(the number of heads are 30), commercial buildings such as department store, super market, retail shop, and outlet store, or complex occupancy. The numbers of heads for those buildings are 30(for the other occupancies of buildings lower than 10 stories which is not described herein assume 20 heads with exception of 10 heads for height of heads is lower than 8 M).

NFC 13 ; The water supply requirement for sprinklers shall be calculated from the density curves or be based upon the room design method. Both of the methods must utilize the area density curves which specify the amount of water spray in the unit area. Each occupancies, totally 5 occupancies(light hazard, ordinary hazard group 1, ordinary hazard group 2, extra hazard group 1, extra hazard group 2), has its own spray density. Based on the area to protect and the hazard occupancies the numbers of sprinkler heads to be operated varies from 7 to 34. Different from Korean regulation the amount of water flow through each heads is not same. It is inverse proportional to the numbers of heads actuating. For example in the case of light hazard when the area of operation is 139 M2, the

spray density is 4.1 lpm/m^2. But when the area of operation goes to 279M2, the spray density drops into 2.9 lpm/m^2. Assuming the coverage area for each sprinkler is 21.16 m^2, the numbers of operating sprinkler heads vary from 7 to 14. The range of spraying density, numbers of sprinkler heads and system water demand per each hazard occupancies are illustrated in the table 1.

To compare the design parameters cleary each parameters are analyzed and illustrated in the table 2.

Duration of Operation

While KFC requires 20 minutes of sprinkler operation time, NFC requires three different duration time, 30 min., 60 to 90 min., 90 to 120 min. based on the different hazard occupancy. It is also shown in table 2.

Time to Actuation

Sprinkler heads are a kind of heat detector. It has rated temperature to actuate and sensitivity that gives differences in actuating time at the given temperature. The sensitivity is expressed as Response Time Index(RTI). Actuation time of sprinkler heads is dependant to the installation distance, fire growth rate and RTI of the heads. There is no description of RTI in KFC, and the installation distance is fixed. Thus, there is no way to control the actuation time to the fire growth rate in KFC. If the sprinkler actuate too late, the fire size will be bigger and it

Table 1. NFPA Sprinkler Design Water Demand

	operat'g area (m^2)	spray density (lpm/m^2)	oprat'g head (ea)	water demnd (lpm)
light hazard	139	4.1	7	568
	279	2.9	14	795
ordinary	139	6.1	7	852
group 1	372	4.1	18	1514
ordinary	139	8.1	7	1136
group 2	372	6.1	18	2271
extra hazard	232	12.2	17	2839
group 1	465	8.1	34	3785
extra hazard	232	16.3	17	3785
group 2	465	12.2	34	5678

* Protected area per each sprinkler; 21.16 m^2 for light & ordinary hazard and 13.69 m^2 for extra hazard.

become very difficult to put up with the fire. It will also increase the numbers of sprinkler heads and as a result the fire water flow through each sprinkler heads will be decreased. This will cause less spray density eventually and prevent from extinguishing fire, too. NFC listed various range of RTI, which will give designer the freedom of selecting of sprinkler heads up to the fire growth rate.

Hydraulic Calculation

KFC doesn't show guideline of hydraulic calculation under the condition of simultaneous operation of multiple sprinkler heads. This often misled the designers to calculate the water heads out of elevation and the friction loss with single operation of the most remote sprinkler head. This results in the lack of system water supply and pressure.

RESPONSE TIME CALCULATION

To compare the sprinkler actuation time between KFC and NFC expected response time was calculated based on the same occupancy and fire rate with two sprinkler systems following guideline from KFC and NFC.

Design Condition

Occupancy : Office Building
Fire Growth Rate : Moderate Fire
Fire to Ceiling : 2.5 m
Room Temperature : 25 °C
Head Rating : 72 °C
Program Used : FPETOOL V3.2

Result of Simulation

Firstly a sprinkler system followed by KFC design guideline was simulated. RTI of the sprinkler head was $300(m/s)^{0.5}$ and the axial distance of the head and flame center was 2.3 m. Detector was activated at 306 seconds after the ignition of fire. The fire size at the time of detection was 1053 kw and the ceiling jet temperature was 152 °C. All the conditions but ceiling jet temperature are safe for evacuation at the time of sprinkler actuation. The maximum tenable temperature is about 110 °C. But it's not easy to adjust the detection time, as there is no choice of RTI. The only way to shorten the detection time is to install the heads more

Table 2. Comparison for Design Parameters of KFC and NFC 13.

	Korean Fire Code	National Fire Code
operating heads(ea)	plant, warehouse 1; 30 plant, warehouse 2; 20 office & others; 10	light hazard; 7 to 14 ordinary hazard; 7 to 18 extra hazard; 17 to 34
head spacing (m)	fire rated bldg.; 3.2 not rated bldg.; 3.0 stage area; 2.4	light hazard; 4.6 ordinary hazard; 4.6 extra hazard; 3.7
protected area per head(m^2)	fire rated bldg.; 10.6 not rated bldg.; 8.8 stage area; 5.8	light hazard; 21.16 ordinary hazard; 21.16 extra hazard; 13.69
spray density (lpm/m^2)	fire rated bldg.; 7.5 not rated bldg.; 9.1 stage area; 13.8	light hazard; 2.9 to 4.1 ordinary gp 1; 4.1 to 6.1 ordinary gp 2; 6.1 to 8.1 extra gp 1; 8.1 to 12.2 extra gp 2; 12.2 to 16.3
system water demand(lpm)	plant, ware house 1; 2400 plant, ware house 2; 1600 office and others; 800	light hazard; 568 to 795 ordinary gp 1; 852 to 1514 ordinary gp 2; 1136 to 2271 extra gp 1; 2839 to 3785 extra gp 2; 3785 to 5678
duration(min)	all the place; 20	light hazard; 30 ordinary hazard; 60 to 90 extra hazard; 90 to 120
fire water (m3)	plant, warehouse 1; 48 plant warehouse 2; 32 office & others; 16	light hazard; 17 to 24 ordinary gp 1; 51 to 91 ordinary gp 2; 69 to 137 extra gp 1; 256 to 341 extra gp 2; 341 to 511

closely. But this will increase the budget and make installation more difficult.

A sprinkler system designed by NFC was calculated secondly. The axial distance was 3.3 m, and RTI of sprinkler head was 300, too. The head was actuated at 356 seconds after the ignition of fire. The fire size was 1433 kw and

the ceiling jet temperature was 148 °C at the time of detection. As pointed out in the KFC calculation, the ceiling jet temperature was high for the safe evacuation. Tested again with RTI 100, the result was satisfied. Head was actuated at 260 seconds after the ignition. The size of fire was 731 kw and the ceiling temperature was 103 °C. This means you can adjust the actuation time of sprinkler heads more efficiently with NFC than KFC.

CONCLUSION

Though two design guidelines look quite different each other, there's lot of evidences telling sprinkler design guideline of KFC comes from NFC 13. It looks like someone took the integral part out of NFC 13 and modified it when they made KFC's sprinkler guideline. By considering spray density only KFC's applicable occupancy range covers approximately ordinary hazard group 2 through extra hazard group 1. Thus, KFC is much heavier than NFC when we talk about the light hazard occupancy and weak in extra hazard protection.

Sprinkler design guideline of KFC needs to be reinforced in its contents. The main topics need further consideration in KFC's sprinkler design are;

- The design guideline for the different hazards to be protected must be varied by spray density instead of numbers of operating heads. It is not the numbers of operating sprinkler heads but the amount of water sprayed over the burning materials that mainly contribute the successful extinguish of fire.
- Operating time of sprinkler system should be adjusted not only by the installation distance but also by RTI.
- Careful studies of typical amount of hazards existing in light hazard location such as office building in Korea are strongly recommended and determine if the KFC's guideline for spray density is too heavy or not.
- Spray density for extra hazard occupancy must be studied further.
- System water demand must be considered like the way introduced in NFC 13.
- Hydraulic calculation of system water demand must be performed under the simultaneous operation of multiple heads to compensate the elevation head loss and friction loss.
- Kinds of sprinkler system must be clearly introduced to avoid its misapplication. For example many of Korean plants select preaction sprinkler system where they have to use wet type sprinkler system.
- Provide rooms for performance based fire protection design.

It is very difficult to convince the performance of fire protection system until it really undergo fire. And sprinkler system is the most widely used fire suppression

system. Thus, it is very important to convince its performance by test. Numbers of tests have been performed to convince the performance of the system in many countries. It is true that fire protection codes used be prepared by the experience and by the result of discussion. But there was rapid growth in fire protection engineering area and many codes were corrected and updated based on the test results and engineering analysis. I could find out many problems with KFC's sprinkler system design guideline. And I strongly suggest Korean fire protection authority should rewrite the code by performance base philosophy.

REFERENCES

1. Korean Institute of Fire Science and Engineering, Fire Protection Regulation, Kimundang, 1,10,1994

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