PREVENTIVE MAINTENANCE FOR FIRE ENGINEERING SYSTEM IN RESIDENTIAL BUILDINGS (CASE STUDY)

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ABSTRACT

In order to protect life and properties of the residents, a proper Fire Safety Management System (FSMS) is essential in a residential building. An FSMS includes an effective Fire Service System (FSS) and a good maintenance system. Such a system comprises an appropriate system design of fault detection systems, an inspection and testing system including an inspection and preventive maintenance schedule, personnel training and safety awareness of maintenance operation.

This paper presents the factors and the causes using statistical analysis of data and mathematical method of Downtime Distribution - "Lognormal Distribution' to estimate the system life period of FSS and to establish a practicable maintenance method to reduce the downtime and the cost for the FSS.

1. INTRODUCTION

Mid-year population in 2001 in Hong Kong is 6,732,000 and the percentages of public permanent housing and private permanent housing are 49.7 % and 49.1 % respectively [1]. From the statistics provided by Housing Department, permanent residential flats have been increased by 20.7 % from 1,932,000 in 1996 to 2,224,000 in 2001 [2]. Proper maintenance of the Fire Service Installation (FSI) in these permanent housing is an important issue in Hong Kong, which is a critical factor in the protection of the lives and properties of the residents.

Adequate maintenance of such Fire Service System (FSS) is very important. A good maintenance system requires proper system design which includes fault detection systems, an inspection and testing system such as appropriate inspection and preventive maintenance schedule, personnel training and safety awareness of maintenance operation.

It has been found that malfunction or fault of the FSS is frequent which would pose potential danger to the residents of a building. Therefore, this paper will concentrate on the investigation of the causes for fault and duration of FSS in a building and aimed to recommend the method to reduce the downtime of the FSS so as to increase the fire safety and properties protection.

2. LITERATURE REVIEW

According to the statistics from Fire Services Department, false/unwanted alarms generated from faulty automatic alarm systems contributed about 78.8 % (35,296 false/unwanted alarm calls) of 44,789 fire calls in 2001 [3,4].

Under the law and regulation of Hong Kong, either a temporary permit or an occupation permit is required for the FSI. Secondly, the component, devices or system shall be maintained in an efficient working order at all times in order to satisfy the requirements of Director of Fire Services [5]. In addition, the FSS in a building should be maintained, inspected and certified by a registered FSI contractor at least once every 12 months.

To ensure a well-performed and reliable FSS, FSI is a must. The requirements of FSI in residential buildings are already stipulated in the Code of Practice of Minimum Fire Services Installation of Hong Kong. Other International Standards such as the British Standard [6-15] and Loss Prevention Council standards [16] of UK, the National Fire Protection Association standards [17-28] of United States are also applicable to local situations. The system description and the frequency of inspections and testing of these three different standards are summarized in Table 1.

It can been seen from Table 1 that the system requirements in US, UK and Hong Kong are similar in general. All the essential items are supported by their corresponding clauses, for example, remote alarm transmission system: UK – BS5839, HK – FSI (Part II: 2.1), US – NFPA 72 (Chapter 7). Comparing Table 1 with the specification of inspection for public housing (Table 2), the statutory inspection frequency seems to be more optimum. It is because the high inspection frequency in public housing may lead to unnecessary stoppage of the FSS and in turn affect the overall efficiency of the FSMS for a building.

Table 1: System description, frequency of inspection and testing of different standards

Description of System	Regulation & Standard			Inspection & Testing Frequency		
	UK(BS standard)	Hong Kong	US(NFPA regulation)	UK(BS standard)	Hong Kong	US (NFPA regulation)
Remote alarm transmission system (Fire station link)	BS 5839	FOC Rule FSI: Part II(2.11)	NFPA 72 : Chapter 7	A	Bi-W	N/S
Fire service pump (feed pump, sprinkler pump, booster pump & fixed fire pump set)	BS IEC 61366:Part 7	FSI: Part II(2.21)	NFPA 25: Chapter 8	Q	A	Inspection - W Maintenance - A
Fire detection and fire alarm system	BS5839	FSI: Part II(2.11) &FOC	NFPA 72 : Chapter 10	Q	A	Refer NFPA code table 10.4.3
Automatic fixed installation / fixed automatically operated approved appliance using FM200, CO2, BCF, BTM, etc as gas agent	BS 5306:Part 4 & 5	FSI: Part II(2.3)	NFPA 2001	Q	A	A
Fire hydrant system	BS 5306: Part 1	FSI: Part II(2.14)	NFPA 14	A	A	A
Hose reel system	BS 5306: Part 1	FSI: Part II(2.14)	NFPA 14	A	A	A
Dry riser	BS 5041: Part 3	FSI: Part II(2.21)	NFPA 1142: Chapter 9	H	A	A
Sprinkler system	BS 5306: Part 2	LPC & FSI: Part II(2.23)	NFPA 13	A	A	A
Fire shutter	BS EN 1634: Part 1	FSI: Part II(5.2)	NFPA 80: Chapter 10	A	A	A
Battery and charger	BS 5839	FOC & FSI: Part II(2.12)	NFPA 70: Chapter 7	N/S	A	A
Portable hand-operated approved appliances	BS 5306: Part 3	FSI: Part II(2.19)	NFPA 10	A	A	A
Cleansing of fire services & sprinkler , water tank	LPC - TB24: 1997:1	FSI: Part II(2.24) & LPC	NFPA 22	A	A	Refer NFPA 25: Ch.9 table 9.1
Emergency standby power - generator	BS5514: Part 3	FSI: Part II(2.8)	NFPA 110	M	A	Refer NFPA 111: Ch.7 table 7.9.3
Emergency lighting	BS 5266: Part 1	FSI: Part II(2.9)	NFPA 111: Chapter 6	M	M/A	Refer NFPA code table 7.9.3
Exit sign	BS 5499	FSI: Part II(2.10)	NFPA 101: Chapter 7	M	A	Visual inspection <30 days
Firemen's lift	BS 2655: Part 1	CoP of Lift (Maint.) & FSI: Part II(2.15)	N/S	M	A	N/S

W: Weekly checks with checklist
M: Monthly checks with checklist
Q: Quarterly checks with checklist
A: Annual checks with checklist and test certificate
N/S: Not specified

Table 2: Specification of inspection for public housing

Items	Description of system	Inspection and testing frequency
1	Remote alarm transmission system	Every two weeks
2	Fire service pump	Quarterly
3	Fire detection and fire alarm system	Quarterly
4	Automatic fixed installation / fixed automatically operated approved appliance using FM200, CO_2, BCF, BTM etc., as gas agent	Quarterly
5	Fire Hydrant / Hose reel system and street hydrant	Half-yearly
6	Sprinkler system	Half-yearly
7	Battery and charger	Annually
8	Portable hand-operated approved appliances	Annually
9	Cleansing of fire services & sprinkler tank	Annually

3. CASE STUDY

A public estate in Kowloon Central District was selected in the case study. There are 11 domestic blocks with 3,551 units in this public estate, which occupied an area of about 202,500 m^2. The type and distribution of the breakdown of the FSI in a building were surveyed. Besides, the routine maintenance schedules and details of the fire system component (e.g. fire service pump, alarm and sprinkler) will be reviewed.

A preliminary survey was carried out to obtain a sample of data to check for the validity of the survey methodology and a full survey would be conducted in the next stage of study.

In this preliminary survey, two domestic blocks (Block A and Block B) are chosen as the samples in this case study. There are a total of 16 floors with 626 units in the two blocks. Recent fire service records from 1999 to 2001 including the date, time, location, possible causes, and types of alarm were studied. The fire protection systems included automatic sprinkler systems, hose reel and fire hydrant systems, and automatic and manual detector systems. As there are public institutions in Block A, there is installation of sprinkler system which is not usual for residential buildings.

The existing periodic maintenance schedule of the FSS for these two blocks is summarized as follows:

Nine categories should be inspected and tested under the existing maintenance schedule. It was noted that the checking of the remote alarm transmission system would be carried out in every two weeks. The testing of (ii) fire services pump, (iii) fire detection and fire alarm system and (iv) automatic fixed installation / operated approved appliances would be performed quarterly. The inspection of (v) fire hydrant / hose reel system / street hydrant and (vi) sprinkler system would be carried out half-yearly. The checking of (vii) battery and charger, (viii) portable hand-operated approved appliances and (ix) cleansing of fire services and sprinkler tank would be completed annually. Details of each system items are listed in Appendix II.

It is considered that the frequency of inspection was too high as compared with the statutory requirement. For example, the frequent inspection of hose reel system may increase to rate of wear and tear of the hose and lead to unnecessary replacement in a shorter period of time.

The characteristics and percentage (no.) of system failure of FSI in building sites were extracted as in Table 3 and Fig. 1.

4. RESULTS

The preliminary research mainly focuses on the fault and downtime of FSS in two public domestic buildings in Hong Kong. The fault cases were classified into FS pumps, hydrant, hose reel, sprinkler head, detector, manual call point, control value, alarm bell, exit sign and emergency generator. The findings are summarized in Table 3 and Fig. 1. The total numbers of system failure for Block A and Block B were 132 and 120 respectively. It is clearly shown that most fault cases are generated from two FSI, they are detector and manual call point.

Table 3: Outline of percentage of system failure and no. of fire service installation for block A & B (1999-2001)

Item	Description	Frequency of system failure Percentage (number)		No. of FS Installations	
		Block A	Block B	Block A	Block B
1	FS pump	4 (5)	3 (3)	6	3
2	Hydrant	9 (12)	10 (12)	69	32
3	Hose reel	13 (18)	12 (14)	48	32
4	Sprinkler (head)	3 (3)	2 (3)	77	63
5	Detector	39 (51)	41 (49)	25	42
6	Manuel call point	19 (25)	18 (21)	48	32
7	Control value	1 (2)	2 (3)	2	2
8	Alarm bell	7 (10)	8 (10)	48	32
9	Exit sign	3 (4)	2 (3)	35	36
10	Emergency generator	2 (2)	2 (2)	1	1

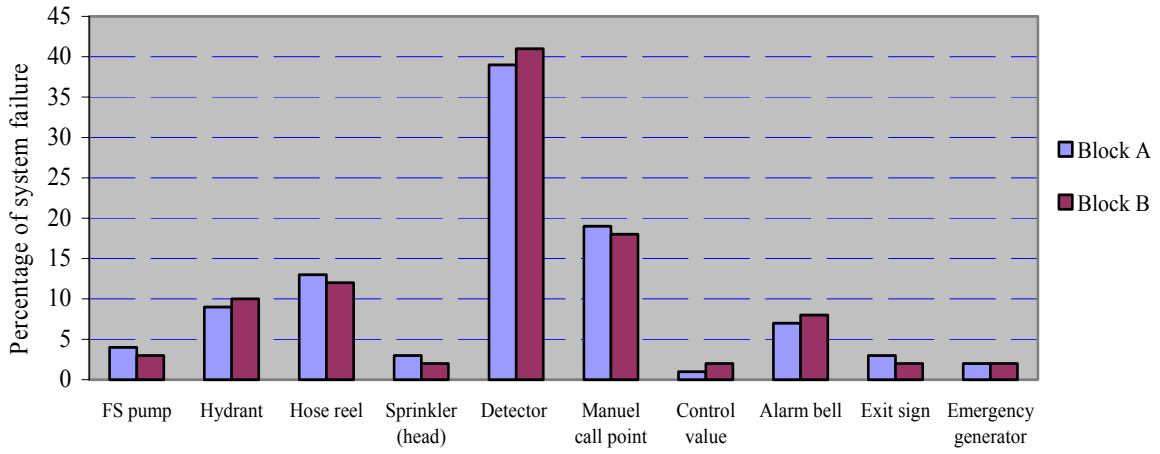

Fig. 1: Percentage of system failure in FS Installation from 1999 to 2001

Both blocks demonstrate a similar pattern of failure. For detector system, the survey revealed 51 fault cases in Block A and 49 fault cases in Block B. The overall percentage of fault amount to 39% and 41% of all FS faults for Block A and B.

For the manual call point, there were 25 fault cases in Block A and 21 fault cases in Block B. The fault percentages are 19 % and 18 % respectively. The third highest number of fault cases was found in hose reel, with 13% in Block A and 12 % in Block B. The fault percentages were low (equal and lower than 10%) for other systems.

From the above, it is decided that a more detailed analysis would be carried out on the detector system and the manual call point.

The seven major causes of the fault of the detector system are shown in Fig. 2. They are renovation work, human error, ambient condition, panel fault, equipment decade and maintenance.

Other than the reason of renovation works (20 %) and the maintenance works (30 %), it was found that the highest down rate is caused by the ambient condition (23 %). Such a high percentage may be caused by the following situation: Normally, the detectors are installed in pumps rooms as FS pump rooms, sprinkler pump rooms and potable/flushing pump rooms. Poor maintenance in water tanks and malfunction of ventilation fans resulted in a very high relative humidity level. The humidity had accelerated the decay of electronic components in the detector and the fault rate in this system.

The causes of breakdown for manual call point are shown in Fig. 3. They are also classified into seven categories: maintenance, vandalism, ambient condition, human error, panel fault and equipment decade. The figure indicated that, excluding the 32% of fault due to maintenance, a very high percentage for system down is by vandalism (28%). To lower the fault generated from vandalism, proper protection to the manual call point unit was found not enough. It appears that proper protection of the FS equipment requires also appropriate management measures (e.g. strengthen patrol of important equipment) and civic education to the public.

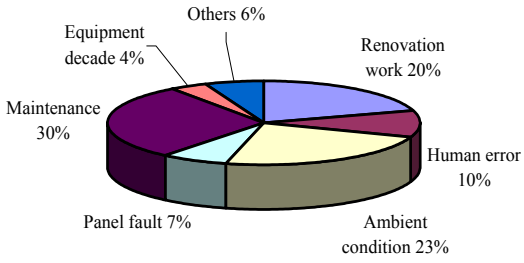

Fig. 2: Cause / percentage of breakdown for detector system

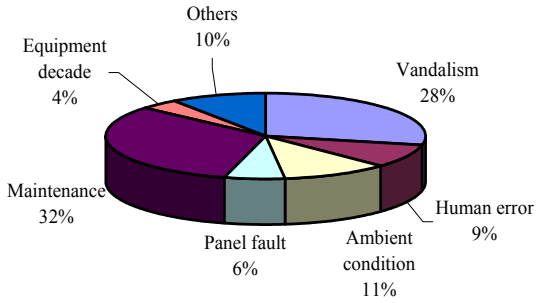

Fig. 3: Cause / percentage of breakdown for manual call point

5. DOWNTIME DISTRIBUTION

In the preliminary research, the detector system was selected for further analysis using the mathematical method as the detector failed the most except the maintenance downtime.

The 'Lognormal Distribution' [29] was applied to determine the probability density functions of the times to restore the system when a part fails. Lognormal distribution has been widely used in government specification worldwide in modeling the probability of active repair or restoration times. By using this model, the mean time to repair the system could be determined accordingly. The result of the analysis could be visualized as a table or graph. By studying the downtime of components in an FSS, there is a basis in improving the preventive maintenance system (e.g. by optimizing the inspection and testing frequency of individual component in the system).

Refer to the Appendix I – Calculation method of Lognormal Distribution. Using the existing downtime data of detector system and apply the equation, the following table and graph were determined (Table 4, Table 5 and Fig. 4).

From Fig. 4, the mean value of the time-to-restore is 1.9456 hr, i.e. the average restore time (the system downtime) is 1.9456 hr. The median value of time-to-restore is 0.9932 hr and the most frequency occurring to the time-to-restore is 0.7488 hr.

Table 4

Group number	Time to repair t_i	$\log_e t_i = t_i'$	$(t'_j)^2$	Frequency n_j	$n_i t_i'$	$n_j(t'_j)^2$
1	0.25	-1.38629	1.92181	1	-1.38629	1.92181
2	0.50	-0.69315	0.48045	4	-2.77259	1.92181
3	0.75	-0.28768	0.08276	5	-1.43841	0.41380
4	0.95	-0.05129	0.00263	6	-0.30776	0.01579
5	1.25	0.22314	0.04979	4	0.89257	0.19917
6	1.50	0.40547	0.16440	2	0.81093	0.32880
7	1.75	0.55962	0.31317	6	3.35769	1.87902
8	2.00	0.69315	0.48045	5	3.46574	2.40227
9	2.25	0.81093	0.65761	2	1.62186	1.31522
10	2.50	0.91629	0.83959	4	3.66516	3.35835
11	2.75	1.01160	1.02334	2	2.02320	2.04667
12	3.00	1.09861	1.20695	2	2.19722	2.41390
13	3.25	1.17865	1.38923	1	1.17865	1.38923
14	3.50	1.25276	1.56942	2	2.50553	3.13883
15	3.75	1.32176	1.74704	2	2.64351	3.49408
16	4.00	1.38629	1.92181	2	2.77259	3.84362
17	4.25	1.44692	2.09357	1	1.44692	2.09357
			Total	51	22.67653	32.17595

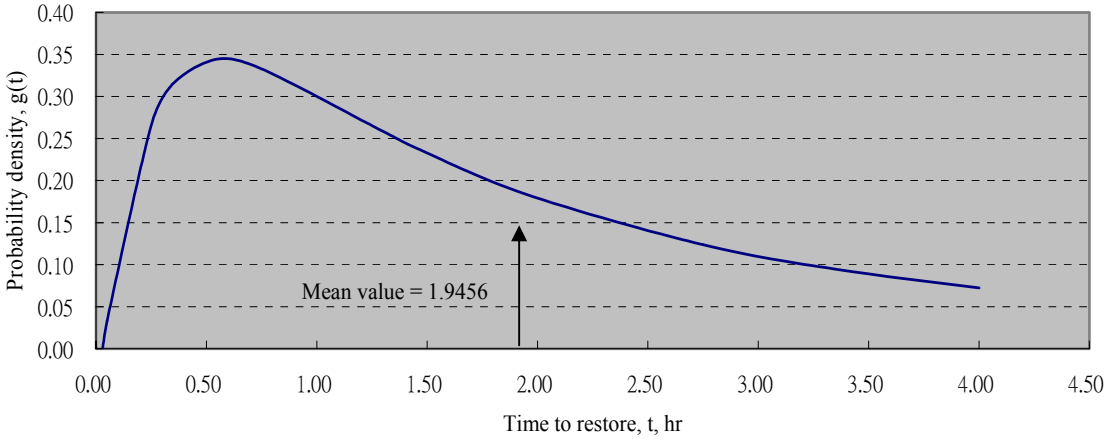

Fig. 4: Plot of lognormal pdf of the time-to-restore data in Table 2 in terms of the logarithms of t

Table 5

Time to repair, t, hr	Probability density g(t)
0.03	0.00000
0.05	0.03307
0.25	0.26576
0.35	0.31567
0.55	0.34459
0.75	0.33273
1.25	0.26528
1.35	0.25175
1.45	0.23878
1.95	0.18355
2.75	0.12379
3.35	0.09459
4.00	0.07231

6. FURTHER RESEARCH

In the coming semester, the fault characteristics of other FSI will be studied after collecting the data from the remaining blocks of the estate under study.

Besides, questionnaires will distributed to professionals and technical staff such as engineers, inspectors, and technicians to collect their points of view on the current maintenance schedule on different FSI.

Based on the experience of the working professionals and the test results, it is expected that an improved maintenance planning and method could be derived and the downtime and the maintenance cost of the FSS can be reduced.

7. CONCLUSIONS

A preliminary research for the subject was conducted, which included the following:

- Literature review was performed on the aspect of Fire Services Installation Regulation & Standard and mathematical analysis using Lognormal Distribution. The FSI standard and regulation in Hong Kong is comparable to Western countries in the aspect of system description, frequency of testing and inspection, etc.
- The distribution of faults of the FSI in residential buildings (e.g. especially aged buildings) in Hong Kong was identified.
- Preliminary survey of selected building was conducted for FSI. The result showed that detectors and manual call points was the most frequently breakdown equipment in the FSS in the building under study.
- Mathematical analysis was conducted on detectors fault statistics to indicate the fault characteristics.
- Based on the preliminary survey, the scope of the detailed research in the coming semester was discussed.

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Q & A

Q1: You have selected two residential blocks for the study. What is the difference between the two residential blocks?

Chu: The two blocks are identical, except that in Block A it has an accommodation of public institution on ground floor, which contains sprinkler installation.

Q2: What conclusion can you draw from the study of the cause of breakdown of the fire services installations for the two blocks?

Chu: The aim of this study is not to conclude the cause of breakdown of various fire services installation within the two blocks. It is to find out the fault characteristics, for example, the failure frequency of the fire services installations, such that the lognormal distribution could be applied to determine the probability density functions of the time to restore the system when a part of the system fails.

Q3: What is the definition of 'time to restore'?

Chu: 'Time to restore' means the time for a fire services installation to resume its normal operation upon maintenance or after downtime.

APPENDIX I: CALCULATION METHOD OF LOGNORMAL DISTRIBUTION

1. To determine the lognormal pdf of the times to repair given in Table 4, it should be calculated from

$$\bar{t}' = \frac{\sum_{i=1}^{N} t'_i}{N} \tag{A1}$$

for ungrouped data, where

$$\bar{t}' = \frac{\sum_{j=1}^{N} n_j t'_j}{\sum_{j=1}^{N'} n_j}, \quad (t' = \log_e t) \tag{A2}$$

for grouped data, where n_j is the number of identical observations given in the fourth column of Table 4, N' is the number of different-in-value observed times to repair, or the number of data groups which for this problem is N'=17, given in column 1 of Table 4, and N is the total number of observed times to repair, or

$$N = \sum_{j=1}^{N'} n_j \tag{A3}$$

which for this problem is 51; and

$$\sigma_{t'} = \left[\frac{\sum_{j=1}^{N} n_j \left(t'_j\right)^2 - N\left(\bar{t}'\right)^2}{N-1} \right]^{\frac{1}{2}} \tag{A4}$$

Consequently, the lognormal pdf, representing the data in Table 4,

$$g(t) = \frac{1}{t\sigma_{t'}\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{t'-\bar{t}'}{\sigma_{t'}}\right)^2} \tag{A5}$$

2. The mean time to repair the system when the part fails, it is observed from

$$\bar{t} = e^{\bar{t}' + \frac{1}{2}(\sigma_{t'})^2} \tag{A6}$$

3. The median of the times to restore the system, which is obtained from

$$\breve{t} = e^{\bar{t}'} = \text{anti}\log_e \bar{t}' \tag{A7}$$

$$\breve{t} = 0.9932 \text{ hr.} \tag{A8}$$

This means that in a large sample of t's, half of the t's will have values smaller than the median of time, and the other half will have values greater than the median of time.

4. The time by which one-half of the restorations of such systems will be completed is the median, or

$$\breve{t} = 0.9932 \text{ hr.} \tag{A9}$$

5. The most frequency occurring, or observed, time to restore such systems is mode of the pdf of the t's, and is given by

$$\tilde{t} = e^{\bar{t}' - \sigma_{t'}^2} = \breve{t} e^{-\sigma_{t'}^2} \tag{A10}$$

Consequently,

$$\tilde{t} = 0.7488 \text{ hr.} \tag{A11}$$

APPENDIX II: PROPOSED PERIODIC MAINTENANCE PROCEDURE OF FIRE SERVICE SYSTEM

Remote Alarm Transmission System:

Items of Work	Observations
1. Call the Fire Signal Transmitter and request for 'Fire Signal Test' on the alarm transmitter.	
2. Give the name, FA number and location to Chubb's operator.	
3. Wait for advice to initiate the test.	
4. Simulate the alarm signal at least 6 seconds before resetting.	
5. Confirm with Chubb's operator whether the test is being satisfactory and completed.	5. Satisfactory transmission of the signal to the Fire Signal processing Agent. CHUBB COMMUNICATIONS CENTRE"

Fire Services Pump (feed pump, sprinkler pump, booster pump & fixed fire pump set):

Items of Work	Observations
1. Inspect the pumping system when the pumps are in operation.	1. There should not be sign of leakage.
2. Inspect the bearing of pump & motor sets and the lubrication system.	2a. The grease on the grease nipple should be fresh and soft. 2b. There should be no sign of overheating and abnormal noise and vibration.
3. Inspect the mounting of pump and motor sets.	3. There should not be sign of excessive vibration/corrosion.
4. Inspect the packings for pumps and valves including ball valves in sump and roof tanks, gate valves, non return valves and globe valves, etc. Replace packing gland by approved non-asbestos type as necessary.	4. There should not be sign of leakage.
5. Clean all strainer filter screens	5. They should be free from debris and dirt.
6. Remove dirt and blockage in sump tanks.	
7. Inspect the rubber sheets, gaskets to all valves (including ball valves in sump and roof tanks), pipes and fittings of the pumping system.	7. There should not be sign of leakage.
8. Warm up the motor and carry out the insulation test.	8. The insulation value should reach acceptable figure.
9. Make necessary adjustment for pumps, motors, switch gears, starters, float switches and all other equipment in connection with the pumping system both in pump room, the storage tanks and at the site of submersible pump and surface mounted pump installation.	
10. Check coupling pins and bushes.	10. There should not be sign of excessive wear.
11. Check coupling alignment. Adjust the alignment if necessary by Contractor.	11a. There should be no sign of excessive vibration. 11b The alignment of pump & motor set to be within +/- 0.125 mm.
12. Check holding down bolts. Re-tighten by contractor as necessary.	12. They should be fixed properly.
13. Check the operation of the valves, to grease valve	13. The valves should be operated freely in opening

spindles if necessary by Contractor.	and closing.
14. Check the condition and function of control cubicle.	14a. The cubicle should be fixed properly, free from rust/stain/scratch/debris and with all labels/marking fixed in correct position. 14b. The door lock and hinge should be operated smoothly. 14c. All the wiring should be mounted tidily and fixed tightly in terminal blocks. 14d. All isolating switches, MCCBs, MCBs, fuse units, contactors, relays and timers should be fixed firmly & free from overheat. 14e. The magnetic coil of contactor should be free from humming noise and exercise vibration. 14f. All pumps should be started/ stopped with proper indication according to the design.

Fire Detector and Fire Alarm System:

Items of Work	Observations
1. Test the condition of wiring, controlling and indicating equipment of all zone circuits.	1. They should be in good working order.
2. Test the alarm condition on each zone.	2. Common alarm circuits should be activated.
3. Test the manual call points. Record the test results.	3. Alarm condition should be initiated for the operation of one such call point in each zone.
4. Inspect the activation of common alarm circuits.	4. The alarm bells should be operated, in particular the furthermost connected bell and signal should be transmitted to Fire Signal Processing Agent if equipped with a remote fire station link. The activation should result in the start/stop of the fire pumps as desired.
5. Inspect and note the operation of all indicators including fault warnings and of all alarm bells.	5. They should be operated correctly.
6. Examine the batteries and chargers including primary batteries with reserves and secondary batteries when applicable. Report any necessary replacement.	6. They should be in good serviceable condition.
7. Test all electrical circuits in accordance with the contractual requirements.	7. The system should be operated satisfactorily, when the control or any indicating equipment is actuated. All cabling, fittings and equipment should be secured, undamaged, adequately protected and properly serviced.
8. Test each and every heat/smoke detector by injection of inert gas. Report any necessary replacement.	8. All detectors should be maintained in good working condition, clean, free from corrosion and not covered with distemper, paint, dust, etc.
9. Isolate the main supply and let the installation maintained by battery for a period of 30 minutes.	9. During this period, at least one detector should be actuated and functioned properly.
10. Isolate the battery supply and let the installation maintained by main supply via battery charger for a period of 30 minutes.	10. During this period, at least one detector should be actuated and functioned properly.

Automatic Fixed Installation/Fixed Automatically Operated Approved Appliance:

Items of Work	Observations
1. Test the condition of wiring, controlling and indicating equipment of all zone circuits.	1. They should be in good working order.
2. Test the alarm condition on each zone.	2. Common alarm circuits should be activated.
3. Inspect the activation of common alarm circuits.	3. The alarm bells should be operated, in particular the furthermost connected bell and signal should be transmitted to Fire Signal Processing Agent if equipped with a remote fire station link.
4. Inspect and note the operation of all indicators including fault warnings and of all alarm bells.	4. They should be operated correctly.
5. Examine the batteries and chargers including primary batteries when applicable. Report any necessary replacement.	5. They should be in good serviceable condition.
6. Test all electrical circuits in accordance with the contractual requirement.	6a. The system should be operated satisfactorily, when the control or any indicating equipment is actuated. 6b. All cabling, fittings and equipment should be secured, undamaged, adequately protected and properly serviced.
7. Test each and every heat/smoke detector by injection of inert gas. Report any necessary replacement.	7. All detectors should be maintained in good working condition, clean, free from corrosion and not covered with distemper, paint, dust, etc.
8. Inspect all gas cylinders. Recharge if necessary.	8a. There should be no sign of external damage or corrosion 8b. The gas content should be up to the specified standard in accordance with the relevant rules and regulations.
9. Inspect all warning notices and operating instructions.	9. They should be fixed in proper position.
10. Inspect/test all time delay devices.	10. They should be in correct working order.
11. Inspect/service all automatic/manual release mechanism.	11. They should be operated properly.
12. Inspect the operation of mechanical release unit.	12. It should be in satisfactory operating conditions.
13. Inspect safety cutouts for other equipment including power supply, air conditioning plant, ventilating fans etc.	13. The safety cut outs should be operated satisfactorily at the simulated conditions.
14. Inspect all directional valves. Ensure the valves are returned to the design setting after test.	14. They should be operated smoothly in opening and closing.

Fire Hydrant/Hose Reel System and Street Hydrant:

Items of Work	Observations
1. Inspect the lowest, middle and topmost outlets of hydrant/hosereel system by wet drill which consists of coupling lengths of hose to the hydrant outlets and open the valves. A butterfly valve and rubber hose of sufficient length should be connected to the hydrant outlet when performing the test. Test & record the pressure and flow of the water	1a. Water jet should be produced at the nozzles. 1b. The result should meet with the design values.

supply on the lowest, middle and topmost hydrant at the following conditions :- i) without operating the fixed fire pump. ii) when operating the fixed fire pump or pumps.	
2. Cap the outlets of each hydrant outlet and check the operation of valves by opening/closing to their full extent.	2. The valves should be operated smoothly.
3. Test the pressure of water supply of hydrant/hosereels and hydrants fitted with parity valve. Adjust the pressure setting of parity valves as necessary.	3. The results should meet the design values. The water tightness of the system should be up to a maximum of 1700 kPa static pressure.
4. Test and check the flow and working pressure of each hosereel. Drain thoroughly and restore the hose after the test.	4. Water jet (6m for hosereel) should be produced at the nozzles.
5. Uncoil and examine every length of hose and check the availability of the White Mark' on each hose.	5a. The hose should not be damp or attacked by mildew. The washers in the female couplings should be intact and in good condition. 5b. White Mark' should be available on the hose of each and every hosereel unit. Repaint by Contractor is required if it is not clear.
6. Pressurise all piping to 1700 kPa. Report for leakage.	6. There should not be sign of leakage.
7. Inspect the fire hydrants with quick coupler.	7. The valves should be opened/ closed smoothly and the function of the quick coupler should be in good operation condition.
8. Inspect the fire service inlets.	8. The stop valve should be opened and closed smoothly and the function of the non-return valve should be in good operation condition.
9. Inspect the function of fixed, booster, feed pumps & the associated rising mains, pump control panel and the associated fire alarm system.	9. They should be in satisfactory operating condition.
10. Clean the fire service water tank annually including underground and roof storage tanks.	10. They should be free from rubbish, sludge and sand.
11. Test the flow and working pressure of the street fire hydrants.	11. The street fire hydrant should be capable of delivering not less than 33.3 L/S for one outlet & 66.7 L/S for two outlets with a minimum running pressure of 170 kPa at the outlet.
12. Inspect the ground valves in the valve pit for street hydrant.	12. The valves should be operated smoothly with no sign of leakage.
13. Check & clean sprinkler heads inside the G/F refuse chamber & at the top of the refuse chute	13. The sprinkler heads should be in good working condition, clean & free from corrosion & not covered with distemper, paint and dust, etc.
14. Inspect & test the operation of the self maintained battery kit of all exit signs.	14. The battery kit should be in good working condition.

Sprinkler System:

Items of Work	Observations
1. Test the system (connected to water supplies) by the Standard test orifice' as stipulated in the	

	latest edition of L.P.C. Rules.		
2.	Test all flow switches by open the drain valves to simulate the bursting of sprinkler heads.	2.	Test all flow switches by open the drain valves to simulate the bursting of sprinkler heads.
3.	Carry out alarm test. Note the time taken to sound the alarm gong and allow the alarm to ring for about thirty seconds.	3.	The alarm should be rung continuously.
4.	Inspect and service all sprinkler heads.	4.	All sprinkler heads should be maintained in good working condition, clean, free from corrosion and not covered by distemper, paint, dust, etc.
5.	Inspect the reading of water and air pressure gauges.	5.	Correct pressure should be maintained.
6.	Inspect the function of sprinkler pump installation including jockey pump, etc. Adjust if necessary and report any necessary repair work for follow up action.	6.	The pressure settings and sequence of operation should be correct.
8.	Clean the sprinkler water tank annually including underground and roof storage tanks	8.	They should be free from rubbish, sludge and sand.

Fire Shutter:

Items of Work		Observations	
1.	Check the condition of the fusible link.	1.	The fusible link should not be covered with paint.
2.	Check the condition of the chain/rope and counter weight.	2a.	The chain/rope hanging the weight should not be broken.
		2a	There should be enough space for the counter-weight to move up and down.
3.	Check the free operation of shutter and motor by simulating a fire signal.		
4.	Check the lubrication of the moving parts such as pulley, chain, rope, etc.	4.	Lubricant on the moving parts should be clean and fresh.

Battery and Charger:

Items of Work		Observations	
1.	Isolate the main supply and let the installation maintained by battery for a period of 30 minutes.	1.	During this period, at least one detector should be actuated and functioned properly.
2.	Isolate the battery supply and let the installation maintained by main supply via battery charger for a period of 30 minutes.	2.	During this period, at least one detector should be actuated and functioned properly.

Portable Hand-operated Approved Appliances:

Items of Work		Observations	
1.	Inspect the fire extinguisher thoroughly. All fire extinguishers shall be provided or sticked with a label after maintenance as per FSD Circular Letter No. 4/96. Report any necessary replacement to BSE.	1.	There should not be sign of corrosion or damage internally or externally.
2.	Test the fire extinguisher in accordance with the manufacturer's instructions/ pamphlets describing testing procedure from FSD and BS 5306, Part 3: 1980 or its subsequent revised edition.		

3.	Hydraulic pressure test should be carried out on the container of each fire extinguisher in accordance with the manufacturer's instructions once every four years. Record the hydraulic pressure test date on the fire extinguisher by painting through a stencil.	
4.	Check the availability of F.E. number on the surface of the fire extinguisher.	4. F.E. number should be clearly shown on the surface of the fire extinguisher.

Cleansing of Fire Services & Sprinkler Water Tank:

Risk assessment report shall be prepared by competent persons before performing the cleansing of fire services and sprinkler water tank and all these works shall be carried out by certified workers as stipulated in the Factories and Industrial Undertakings (Confined Spaces) Regulation imposed by the Labour Department.