

Analysis Of Conventional Type Fire Alarm System In PKU Muhammadiyah Gombong Hospital Building

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Abstract

The reliability of active fire protection systems is an important aspect for hospital buildings because it accommodates physically limited (immobile) patients and sensitive medical equipment. This study evaluates the spatial effectiveness, operational reliability, and feasibility of conventional fire alarm installations in Building J (Al Mukmin Isolation) and Building G (Chemotherapy, Radiotherapy, and LINAC) of PKU Muhammadiyah Gombong Hospital based on SNI 03-3985-2000 regulations and Public Works Regulation No. 26/PRT/M/2008. Using a comparative quantitative descriptive approach, the detector distribution over an area of 6,210 m² is very effective macro with an effectiveness index of 123% (130 actual units compared to 106 units of minimum requirements). However, at a micro level, an anomaly was identified in the form of a deficit of 6 units of Rate of Rise (ROR) type heat detectors in critical medical areas, which expanded the average actual protection coverage of heat detectors to 88 m² (exceeding the maximum SNI threshold of 46 m²). Although the system's feasibility level is in the "Good" category (90.00%), the lack of automatic integration of elevators (elevator recall) and AC systems (AHU shutdown), as well as a backup battery capacity that only lasts 30 minutes are critical weaknesses that require immediate engineering action.

Keywords: Conventional Fire Alarm System, KOR Heat Detector, Hospital, SNI 03-3985-2000, Spatial Effectiveness.



INTRODUCTION

Fire is a non-natural disaster caused by human or technical factors that threatens life, damages infrastructure, and has profound psychological impacts (Attamami, 2022). In public service environments, hospitals are classified as having the highest fire risk due to the complexity of operational, mechanical, and electrical systems that operate continuously 24/7. This risk of internal failure is triggered by the accumulation of electrical short-circuit hazards, the use of reactive laboratory chemicals, anesthetic gas leaks, and the storage of high-pressure medical oxygen cylinders (Wirawan, 2019). Sociologically, the vulnerability in these environments is extreme because the majority of building occupants are inpatients in a physically weak or critical condition with limited mobility (immobile) (BBC, 2015; Arrazy et al., 2014).

To ensure operational safety, national regulations such as the Minister of Health Regulation No. 66 of 2016 concerning K3RS, SNI 03-3985-2000, and Law No. 28 of 2002 require the implementation of a reliable active protection system as an absolute requirement for obtaining a Certificate of Functional Worthiness (SLF) in buildings (Sari & Sukwika, 2020). As a preventive measure, PKU Muhammadiyah Gombong Hospital installed a conventional fire alarm system centered on *Master Control Fire Alarm unit* (MCFA) 30 zones to protect Building J (Al Mukmin Isolation) and Building G (Chemotherapy, Radiotherapy, and LINAC) with an area of 6,210 m². The selection of conventional technology was based on the physical reliability of the circuit, ease of electrical maintenance, and efficiency of initial investment costs (Hadi, 2018). Although physically robust, conventional systems only report macro-zone-based hazard signals without identifying specific coordinate points (Rosiana, 2024). This limitation requires spatial accuracy in detector placement to avoid empty areas of protection (*blind spot*) and press the false alarm number (*false alarm*) (Sholeh et al., 2021). This evaluation aims to examine in depth the spatial effectiveness of actual detector distribution, false alarm rates, the level of compliance with national regulations, and the preparedness of emergency safety management (*Code Red*) at the hospital.

RESEARCH METHODS

The analysis of the reliability of this active protection system is carried out through direct collection of geometric spatial data in the field, which is then processed quantitatively by comparing it to the national fire safety regulation standard parameters. The theoretical minimum number of detectors (N) for each room is calculated based on the parameters of the room's net floor area (A) against the maximum protection area of one detector unit (S) in



accordance with the provisions of the sensor type based on SNI 03-3985-2000. The basic equation for determining the number of detectors is as follows:

$$N = \frac{A}{S}$$

Based on the technical provisions of SNI 03-3985-2000, the maximum protection limits for each type of detector are set as follows:

For smoke detectors, the maximum protection area (S) is set at 92 m² per unit with a maximum distance between detectors of 9 meters. The calculation equation is stated as:

$$N_{smoke} = \frac{A}{92}$$

For heat detector type *Rate of Rise (ROR)*, maximum protection area (S) is set at 46m² per unit with a maximum distance between detectors of 7 meters. The calculation equation is stated as:

$$N_{heat} = \frac{A}{46}$$

The effectiveness index of the distribution of installed detector quantities is analyzed using the comparative percentage formula:

$$Efektivitas = \frac{Jumlah\ Detektor\ Terpasang}{Jumlah\ Detektor\ Standar} \times 100\%$$

The level of circuit reliability in anticipating external disturbances is assessed by calculating the False Alarm Rate (*False Alarm Rate/FAR*) with the following mathematical formulation:

$$FAR = \frac{\sum FA}{T} \times 100\%$$

Where $\sum FA$ represents the total number of false alarm events within a given observation period, and T represents the accumulated frequency of alarm activity recorded on the control panel. The overall system suitability level is calculated using the suitability percentage scoring method against ten mandatory technical compliance parameters:

$$P = \frac{Skor\ Aktual}{Skor\ Maksimal} \times 100\%$$

The obtained compliance percentages are then classified into fire safety audit assessment levels based on the provisions of the Directorate General of Human Settlements. The "Good" category is achieved if the compliance percentage is in the range of 80% - 100%, the "Sufficient" category

is in the range of 60% - 80%, and the "Poor" category is below 60%. All stages of data collection, processing, and testing are systematically arranged to maintain the objectivity of the analysis results.

RESULTS AND DISCUSSION

A physical inspection of the circuits was conducted in all rooms in Building J (Al Mukmin Isolation) and Building G (Chemotherapy, Radiotherapy, and LINAC). Based on a recapitulation of spatial data in the field, a comparison of the minimum theoretical requirements with the actual installed quantity was calculated. Complete data from the comparative calculations for all 39 rooms are presented in Table 1.

Table 1. Comparative Analysis of Standard Detector Requirements for Buildings J and G

No	Room	Area (A)	Standard (S, m2)	($N_{standar}$)	(N_{aktual})	Difference	Detector Type	Information
1	Satellite Pharmacy and Infectious Linen	150	46	4	2	-2	Heat Detector	Not enough
2	CT-Simulator and LINAC Control	140	46	4	2	-2	Heat Detector	Not enough
3	LINAC room	130	46	3	2	-1	Heat Detector	Not enough
4	Radiotherapy Technician	160	46	4	2	-2	Heat Detector	Not enough
5	UPS, Electrical Panel, and Radiotherapy Corridor	170	46	4	9	5	Heat Detector	In accordance
6	Additional Utility and Administration / Archives Room	140	46	4	4	0	Heat Detector	In accordance

7	Lab	130	46	3	4	1	Heat Detector	In accordance
8	Mixing Cytostatics and Oncology Pharmacy	160	46	4	2	-2	Heat Detector	Not enough
9	Storage of Cytostatic Drugs and PPE	150	46	4	2	-2	Heat Detector	Not enough
10	Cytostatic Medical Waste	140	46	4	2	-2	Heat Detector	Not enough
11	IT and Server Room	130	46	3	2	-1	Heat Detector	Not enough
12	Medical Record Archives	160	46	4	2	-2	Heat Detector	Not enough
13	Lobby and Screening of Isolated Patients	120	92	2	2	0	Smoke Detector	In accordance
14	Isolation Administration and Nurse Station	110	92	2	2	0	Smoke Detector	In accordance
15	On-call Doctor's Room and Medical Personnel PPE	200	92	3	3	0	Smoke Detector	In accordance
16	APD Donning and Doffing Room	180	92	2	3	1	Smoke Detector	In accordance
17	Patient Isolation Room	140	92	2	2	0	Smoke Detector	In accordance

No	Room	Area (A)	Standard (S, m2)	($N_{standar}$)	(N_{aktual})	Difference	Detector Type	Information
18	Observation and Medical Procedure Room	130	92	2	2	0	Smoke Detector	In accordance
19	Isolation Corridor	170	92	2	5	3	Smoke Detector	In accordance
21	Radiotherapy Administration and Waiting Room	110	92	2	6	4	Smoke Detector	In accordance
22	Nurse Station and Doctor Consultation	200	92	3	3	0	Smoke Detector	In accordance
23	Patient Examination and Radiotherapy Simulator	180	92	2	3	1	Smoke Detector	In accordance
24	Medical Physics	150	92	2	2	0	Smoke Detector	In accordance
25	Waiting Room 1	150	92	2	7	5	Smoke Detector	In accordance
26	Isolation Inpatient Room	180	92	2	3	1	Smoke Detector	In accordance
27	Negative Pressure Isolation Room	170	92	2	3	1	Smoke Detector	In accordance
28	Nurse Station and Doctor's Room	220	92	3	4	1	Smoke Detector	In accordance

29	Patient Monitoring Room	210	92	3	4	1	Smoke Detector	In accordance
30	Medical Equipment and Oxygen Room	160	92	2	2	0	Smoke Detector	In accordance
35	Chemotherapy Administration and Waiting Room	130	92	2	5	3	Smoke Detector	In accordance
36	Oncology Administration	150	92	2	4	2	Smoke Detector	In accordance
37	Lobby	160	92	2	7	5	Smoke Detector	In accordance
38	Waiting Room 2	120	92	2	3	1	Smoke Detector	In accordance
39	Medical Staff Room	210	92	3	3	0	Smoke Detector	In accordance

Source: Data Processing Results of Detector Needs Formula and Recapitulation, Research May 2026

The operational compliance of the fire alarm system circuit as a whole is also assessed based on mandatory technical compliance with national standards. The assessment matrix for the conformity of the circuit's technical parameters to regulations is presented in Table 2.

Table 2. Matrix for Assessment of System Parameter Conformity to National Standards

No	Parameter	Field results	Regulatory standards	As per (1/0)	Reference
1	Number of detectors	130 units	According to area coverage needs	1	SNI 03-3985-2000

2	Smoke detector coverage	73 m ²	≤ 92 m ² /detector	1	SNI 03-3985-2000
3	Heat Detector Coverage	88 m ²	≤46 m ² (SNI)	0	SNI 03-3985-2000
4	Distance between detectors	8 m	≤ 9 m (SNI)	1	SNI 03-3985-2000
5	Distance of detector to wall	4 m	≤ 4.5 m (SNI)	1	SNI 03-3985-2000
6	MCP Height	1.2 - 1.4 m	1.2 - 1.5 M (PU Candy)	1	Minister of Public Works Regulation No. 26/PRT/M/2008
7	Bell alarm	Available and Active	PU Candy	1	Minister of Public Works Regulation No. 26/PRT/M/2008
8	Indicator lamp	Available	PU Candy	1	Minister of Public Works Regulation No. 26/PRT/M/2008
9	Detector distribution	Evenly distributed in the building area	SNI and PU Regulation	1	SNI & PU Regulation
10	Alarm system response	90dB	≥ 85 dB	1	Minister of Public Works Regulation No. 26/PRT/M/2008

Source: Comparative Analysis of National Regulations, May 2026 Research

Based on the results of the binary compliance matrix analysis in Table 2, this active protection circuit meets 9 of the 10 mandatory parameters evaluated. The circuit compliance percentage is calculated as follows:

$$\text{Persentase Kesesuaian (P)} = \frac{9}{10} \times 100\% \approx 90\%$$

The comparative calculation results show a circuit compliance rate of 90.00%. Based on the fire safety audit assessment level classification by the Directorate General of Human Settlements, the 90.00% compliance score places the active protection system reliability at PKU Muhammadiyah Gombong Hospital in the "Good" category (range 80% - 100%).

Table 3. Parameter Data Classification Results

Parameter	Mark (%)
Effectiveness	123%
FAR	0%
Compliance	90.00%

Source: Parameter Data Recap, Research May 2026

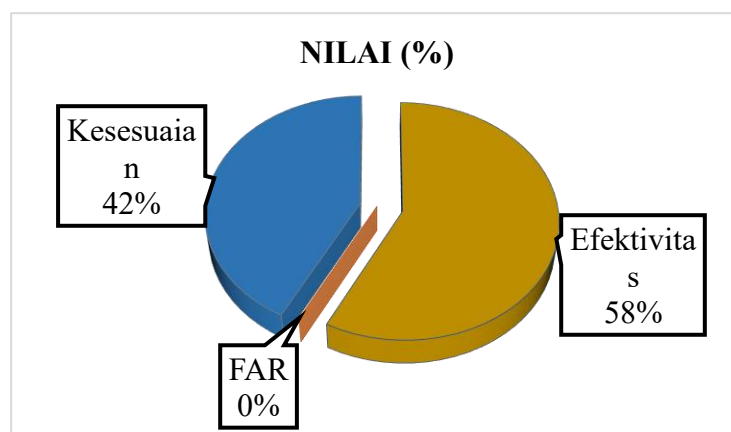


Figure 1. Parameter Data Classification Results Diagram

Source: Parameter Data Recap, Research May 2026

However, this conventional system has significant technical limitations for application in a complex, three-story hospital building. The lack of specific point-by-point localization of fires forces firefighters to perform manual visual verification from room to room along the active circuit zone.

CONCLUSION

Technical evaluation and spatial analysis of the conventional fire alarm system in the New Building (Building J and Building G) of PKU Muhammadiyah Gombong Hospital concluded that although the existing installation was categorized as "Good" with a parameter suitability level

reaching 90.00% and having a stable False Alarm Rate (FAR) of 0% during observation, this system still has critical weaknesses in the form of micro spatial distribution anomalies and the absence of automatic utility integration. The surplus quantity of 30 optical smoke detectors in the public corridor obscures the deficit of 6 ROR type heat detectors in the critical care and diagnosis room, which widens the average heat sensor protection to 88 m² per unit and violates the maximum limit of SNI 03-3985-2000 of 46 m², thus risking slowing down the sensor response time due to thermal dispersion in the room that is too wide. In addition, the absence of electronic integration to stop the air conditioning system (AHU shutdown) to cut off the circulation of toxic smoke, the absence of elevator interlock (elevator recall) to prevent elevator entrapment of patients with physical limitations, and the operational duration of the 24V DC backup battery that can only last 30 minutes (deviating from the minimum standby limit of 24 hours) are weak points in the building's active safety system which requires engineering measures to rearrange the detectors, provide a visual graphic zoning map (zone graphic map), and increase the backup power supply capacity as soon as possible to ensure the effectiveness of the hospital's Code Red protocol emergency response.

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