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Development of Model Based Safety Assessment for Smart Factory

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Abstract: In the late 18th century, the tertiary industrial revolution, which began with the invention of the steam engine, began with the introduction of computer development and automation systems. In the future, it is expected that the construction of a smart factory using the advanced Internet and artificial intelligence (IoT, Internet of Things), artificial intelligence (AI) and robots will become the core of the fourth industrial revolution have. Therefore, the government considers building a smart factory of manufacturing as an innovative model and new growth engine, and aims to build 20,000 smart factories by 2022. To date, it has supported the establishment of smart factories in some 2,500 businesses across the country. Through the establishment of smart factories, it is expected to have advantages over existing production methods such as networking of production process, customized production, optimization of process operation, multi-product complex production, procurement and logistics innovation, However, it is anticipated that the identification of hazardous factors newly caused by the automation and smartization of machinery and proper coping with them will become a key element of safety management at the workplace. In particular, despite the differences in the level of automation and smartization, there is a lack of appropriate means to evaluate them, and systematic customized safety management has not been achieved. Therefore, we propose a model that can evaluate the automation and smartization level of the manufacturing site. To do this, we surveyed the safety standards of domestic and overseas machinery applied to domestic and foreign smart factories. The questionnaires were developed through the brainstorming method, and the survey was conducted on automobile and semiconductors related businesses, which are undergoing smart factory construction both at home and abroad. Through these data, we proposed a safety assurance model based on automation and smartness through expert meetings. The safety assurance model (checklist) developed through this study is utilized to secure the safety of the Smart Factory, and it is expected to secure the safety of automation machinery that can be newly emerged at the manufacturing site.

Keywords: Smart Factory, Check List, Safety Assessment

1. Introduction

1.1 Research background

The Third Industrial Revolution, so-called knowledge information society has begun with computer development and introduction of automated system started with invention of steam engine in the late 18th century. Hereafter, construction of smart factory using Internet of Things (IoT) broadly classed as sophisticated internet and AI, artificial intelligence (AI), robot is expected to be the core of The Fourth Industrial Revolution. Hence, the Korean Government has an object in view to continuously expand smart factories of small businesses up to 20,000 by 2025. In detail, localize element technology like sensor, robot in a brief period of time and collaborate with VR, AI and wearable robot in the medium term. In a long term, to make manufacturing platform based on AI and IoT. Improvement of manufacturing productivity and cooperation between types of businesses are expected. Smart factory relevant market in the world is expected to grow continuously to 60.1 billion dollars (about 68trillion) in 2021. Especially, growth of communications technology is expected to be the highest (8.13%),

and logic control (PLC), distributed control system (DCS) (5.31%), industrial robot (5.19%), sensor industry (4.53%) follow after.

1.2 Necessity and objective of the research

Through construction of smart factory, positive sides different from existing production process such as networked production process, customized production, optimization of process operating, multi-product complex production, revolution of procuration and distribution, cooperation of machine and worker. In particular, to grasp and appropriately handle harmful risk factor which can be newly aroused by introduction and automation, smartification of new machinery is the core element of workplace safety management. However, despite of different level of automation and smartification of each workplace, lack of moderate measure makes systematic level customized safety management unfulfilled. Therefore, in this research, we'd like to suggest model which can assess level of automation and smartification of manufacturing site and discuss following safety management plan.

2. Research method

We investigated real condition of smart factory in home and abroad, safety standards mainly used in smart factory. We developed survey using brainstorming method and carried out factual survey, visiting automobile and semiconductor business workplace in home and abroad where smart factory is developed. Through this data, went through expert's conference, we suggested safety secure model in relation to automation and smartification.

2.1 Industrial Accident Analysis

Number of victim of manufacturing industry in 2012 was 27,284 and it decreased to 21,058 in 2016, about 17.9% (Fig. 2). Among these, number of victim of machinery was increased from 5,775 in 2012 to 6,012 in 2016, about 4.1% (Fig. 3). We can see that the number of victim of machinery takes a large part in whole number of victim of manufacturing business. Also, machinery replacing human has a higher percentage.

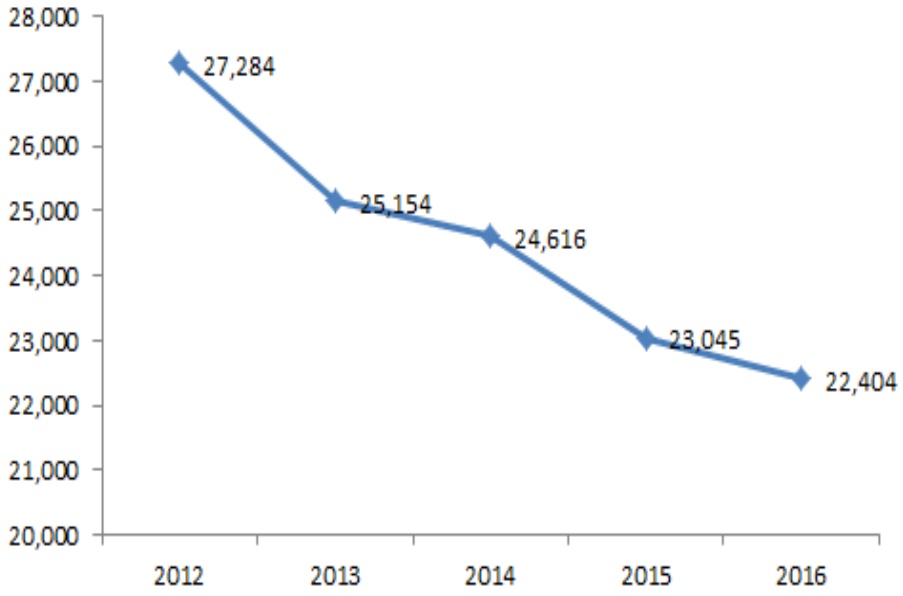


Figure 1. Number of total disaster victim in manufacturing industry

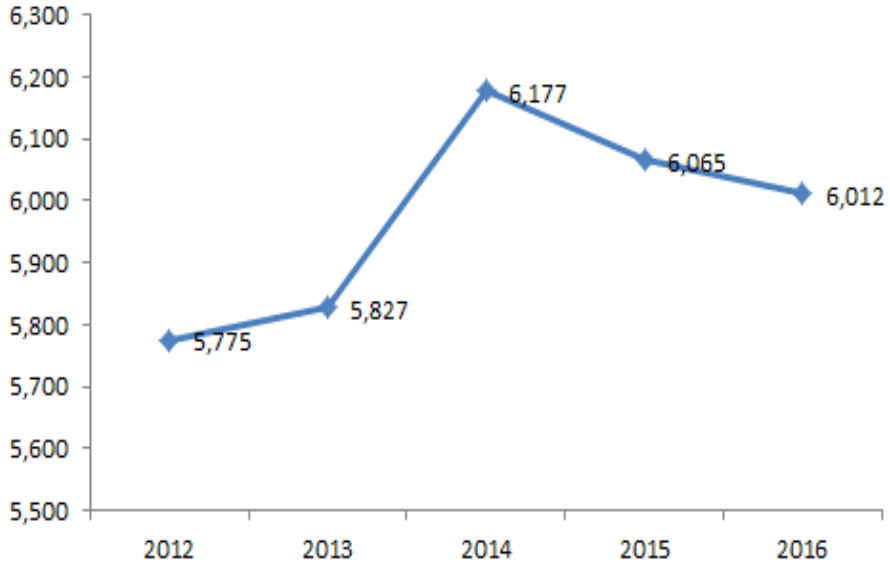


Figure 2. Number of disaster victim in machinery in manufacturing industry

We conducted calamity analysis on 124 smart excellent workplace applying smart factory including car manufacturer. As we see in Fig. 4, the figure decreases from 2012 to 2016 about 28%. It shows the decreasing tendency of the whole number of victim. In Fig. 5, number of victim of machinery decreased from 2012 to 2016 about 29%. Because of this, dependence to machinery of smart factory increases every year, but the rate of machinery accident maintains the status quo. So it means smartification affects improvement of workplace safety.

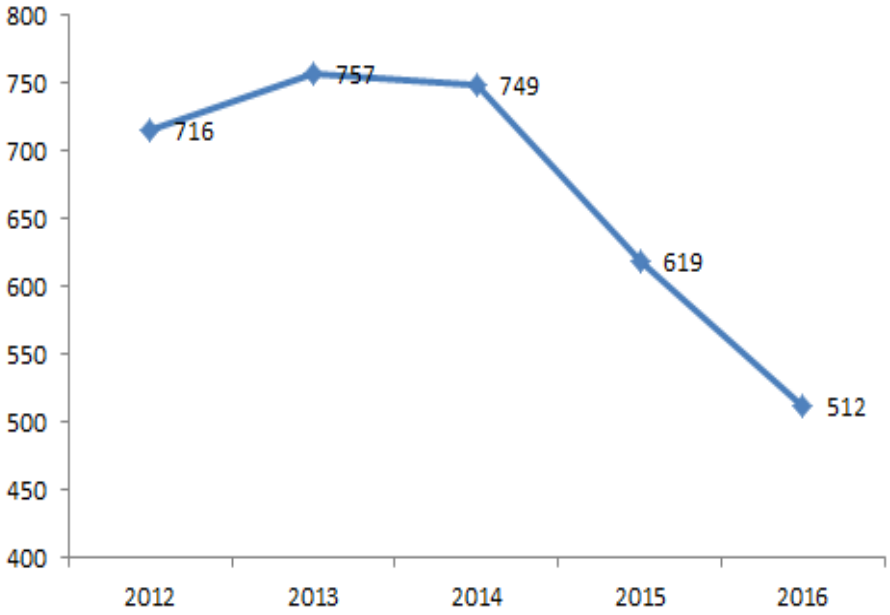


Figure 3. Number of total disaster victim applying smart factory industry

Although construction of smart factory helps develop workplace safety, new risk factor can be come up by the introduction of new technology. First, importance of control system is increased according to smartification. Second, fusion of machinery like industrial robot, conveyor, cooperation robot, AGV is achieved. Third, auto save of harmful dangerous substance or enhancement of transporter can cause new problem. Fourth, the lack of technical regulation in design and use of smart factory. Fifth, lack of human resource who can conduct safety management against introduction and construction of smart factory. We need safety assurance method of smart factory that appropriate with domestic circumstances to improve these problems.

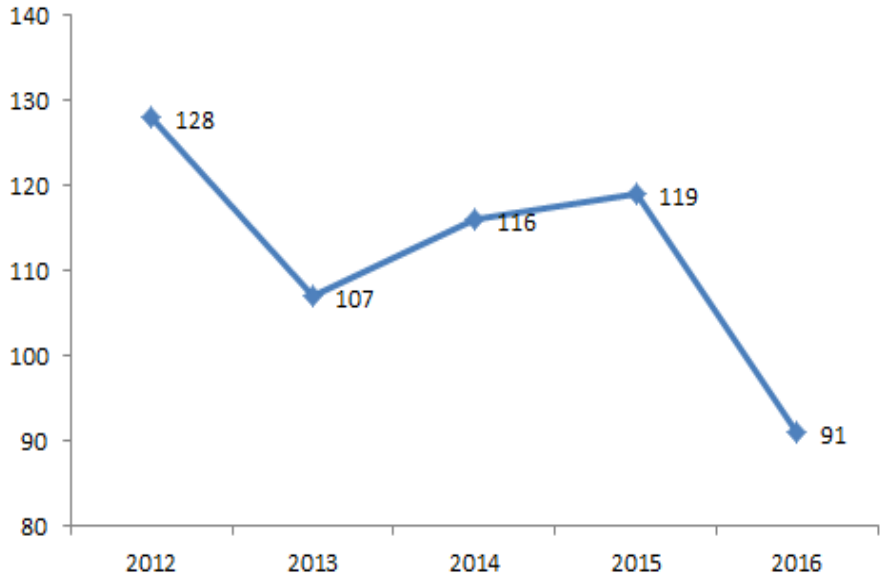


Figure 4. Number of disaster victim applying smart factory industry in manufacturing industry

2.2 Factual Survey

We conducted factual survey of current state of safety and smartifiaiton targeting automobile business and semiconductor business among domestic main force manufacture business. We distributed about 30 outputs and email to complete vehicle, part company, 1/2 vendor client in automobile business and semiconductor business. We got result through gathered factual survey data sorting and analysis. As a result of examination, analysis work of process was subdivided and scientificated, and business efficiency of the worker has reinforced. It can introduce automatic equipment, automatize distribution using tag, transfer is simplified by electromagnet transportation, and is at an early stage. General machinery applies domestic safety standard, but safety certification of smartificated related machinery applies the standard of the corresponding country, as it was imported. Especially there are a lot of German products and IT applies to EU standard. But when used in home, they change German parts as it is, since there is no adequate application standard. And if deterioration goes on and it's changed, there is no way to assess its safety properly. And there is no special change of safety health management organization according to smartification. Malfunction of facility like emergency maintenance or repair leads to most of the accidents, and there is no according manual.

3. Model Development

There are a great difference in each workplaces' smart factory advancement level. There were also some differences in the workplace where we visited for factual survey according to the scale, type of production goods, employed machines and working environment. But demand for smart factorize of the manufacturing business producing company is increasing so many manufacturing sites are expected to be smartificated. However, smart factorization is working out on site without evaluation of safety of smart factory's machinery. So development of safety evaluation model considering level model of

smart factory is meaningful. Through this, they can realize safety level according to smartification of manufacturing business site in workplace and carry forward improvement of factor-starved.

Procedure for smart factorize level safety evaluation is like Fig.5. Evaluation group is classified as basic machine, smart machine, production system, enterprise system. Safety evaluation of each articles are evaluated as excellent, normal, unsatisfactory considering safety matter required to the relevant machine or system. We give evaluation grade for each machineries and decide colligation safety rate of the relevant workplace. Smart factory level safety evaluation table is like Fig.6.

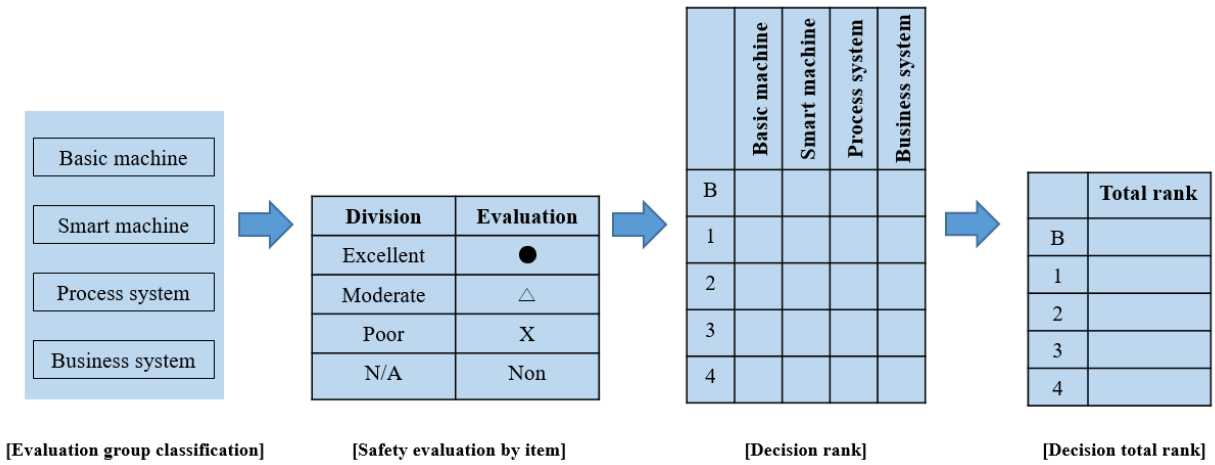
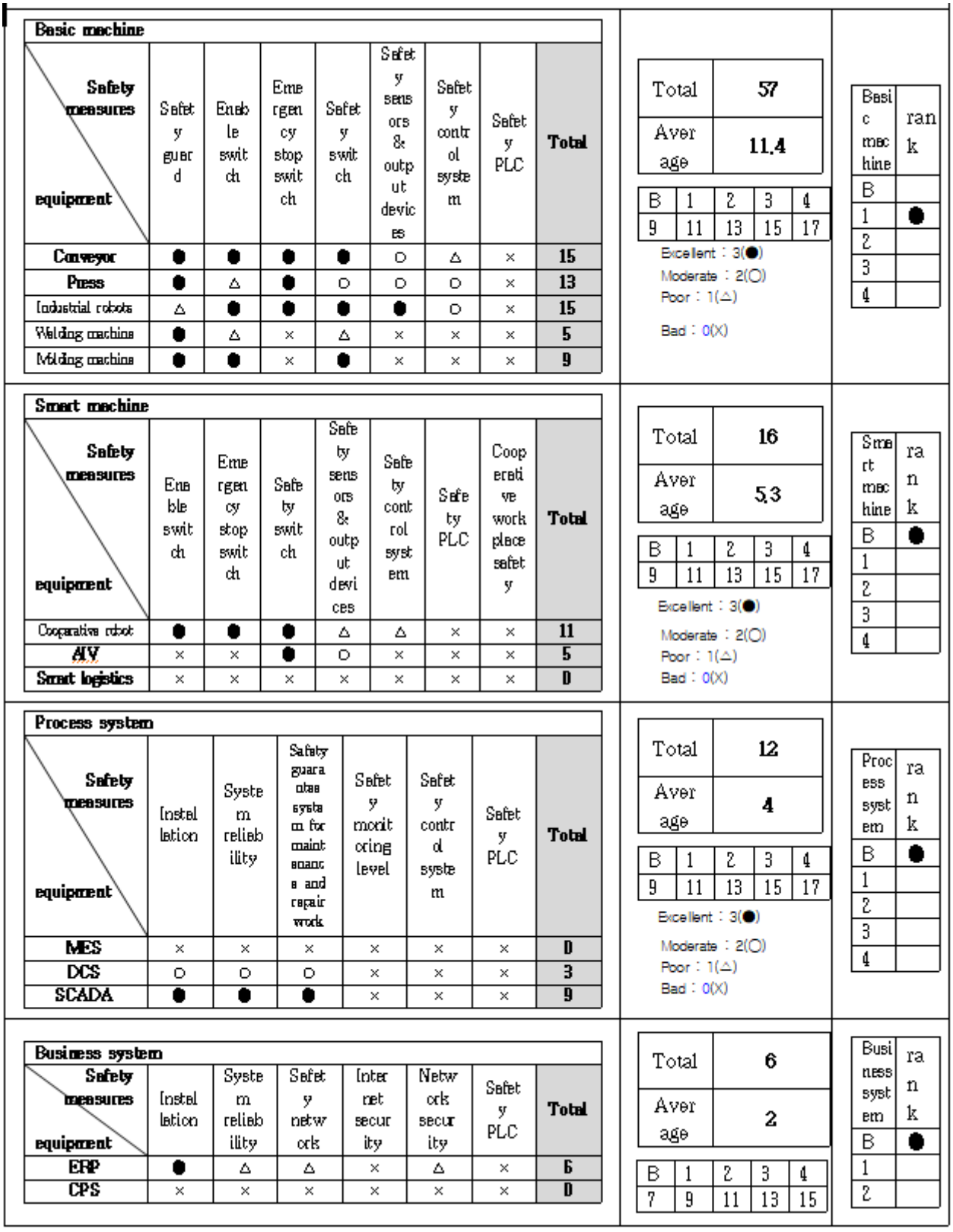


Figure 5. Process of safety evaluation by smart factorization level



Basic machine

Safety measures / equipment	Safety guard	Enable switch	Emergency stop switch	Safety switch	Safety sensors & output devices	Safety control system	Safety PLC	Total
Conveyor	●	●	●	●	○	△	×	15
Press	●	△	●	○	○	○	×	13
Industrial robots	△	●	●	●	●	○	×	15
Welding machine	●	△	×	△	×	×	×	5
Molding machine	●	●	×	●	×	×	×	9

Total	57
Average	11.4

B	1	2	3	4
9	11	13	15	17

Excellent : 3(●)
Moderate : 2(○)
Poor : 1(△)
Bad : 0(X)

Basic machine	rank
B	
1	●
2	
3	
4	

Smart machine

Safety measures / equipment	Enable switch	Emergency stop switch	Safety switch	Safety sensors & output devices	Safety control system	Safety PLC	Cooperative workplace safety	Total
Cooperative robot	●	●	●	△	△	×	×	11
AIV	×	×	●	○	×	×	×	5
Smart logistics	×	×	×	×	×	×	×	0

Total	16
Average	5.3

B	1	2	3	4
9	11	13	15	17

Excellent : 3(●)
Moderate : 2(○)
Poor : 1(△)
Bad : 0(X)

Smart machine	rank
B	●
1	
2	
3	
4	

Process system

Safety measures / equipment	Installation	System reliability	Safety guarantees system for maintenance and repair work	Safety monitoring level	Safety control system	Safety PLC	Total
MES	×	×	×	×	×	×	0
DCS	○	○	○	×	×	×	3
SCADA	●	●	●	×	×	×	9

Total	12
Average	4

B	1	2	3	4
9	11	13	15	17

Excellent : 3(●)
Moderate : 2(○)
Poor : 1(△)
Bad : 0(X)

Process system	rank
B	●
1	
2	
3	
4	

Business system

Safety measures / equipment	Installation	System reliability	Safety network	Internet security	Network security	Safety PLC	Total
ERP	●	△	△	×	△	×	6
CPS	×	×	×	×	×	×	0

Total	6
Average	2

B	1	2	3	4
7	9	11	13	15

Business system	rank
B	●
1	
2	

Figure 6. Safety evaluation sheet by smart factory level

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4. Conclusion

Through documentary survey, we examined ISO standard and German research results and found domestic application of safety evaluation method of ISO machinery gadgetry, risk category, grade management is urgent. By factual survey of machinery safety related to worker's work like industrial robot, we found there are few workplace that install machineries which passed safety evaluation accords with international level. Specially, it's difficult for Small and Medium Sized Manufacturing Firms to review riskiness of safety system that can be occurred in smart factory due to the limits of technology, lack of workforce. Therefore, we developed and suggested Safety Life Cycle Check List to raise safety of smart factory machinery and prevent safety accident. If rating system inspecting workplace and make safety smart factory circumstance is introduced and workplace is managed by its evaluation grade, atmosphere of securing safety is expected to be spread. Also, through this research we can grasp current problems and by improving them, we can advance workplace safety management and contribute to the settlement of safety smart factory.

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