

# Application of ISO/IEC Guide 51 to COVID-19 infection control for the occupational safety

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**Abstract:** COVID-19 is around the world. We attempt to apply three-step method in ISO/IEC Guide 51: 2014 to COVID-19 infection control in the workplace. The results show that the COVID-19 infection control measures include the eradication of the virus, the destruction of infectivity, the detoxification and weakening and the elimination of opportunities for infection as “Inherently Safe Design Measures”, the avoidance of contact as “Safeguarding and Complementary Protective Measures” and the reduction of contact and the avoidance of seriousness as “Information for Use”. Among these specific measures, the New Normal, especially in the manufacturing industries, would be “telecommuting” and “unmanned workplaces”, which are part of the elimination of opportunities for infection, and “changes in flow lines” and “changes in airflow”, which are part of the avoidance of contact. Where “telecommuting” and “unmanned workplaces” are feasible, they should be implemented as much as possible, and where they are not, attempts should be made to minimize human-to-human contact by “changes in flow lines”. In addition, in the area of “changes in airflow”, there are high expectations for future research on how to establish a ventilation design for COVID-19, in which but also the source would be workers themselves, not only combustible gases and toxic gases.

**Key words:** Safety of machinery, ISO/IEC Guide 51: 2014, Three-step method and protective measures, The “New Normal”, COVID-19

## Introduction

In March 2020, the World Health Organization (WHO) declared the COVID-19 epidemic a global pandemic<sup>1)</sup>. Since the declaration of a state of emergency in Japan on 7 April 2020<sup>2-4)</sup>, many economic activities, including daily

life, have been transformed. In addition to measures such as the avoidance of the “Three Cs (Closed spaces, Crowded places and Close-contact settings)”, hand disinfection and the wearing of masks, there is a need to refrain from activities, including the closure of schools, and to encourage people to work from home, something that has never been done before<sup>5)</sup>.

Of particular note is the introduction of telework, which had been considered difficult to achieve in the workplace, and its unexpected spread<sup>6)</sup>. In addition, a new perspective on safety in manufacturing has been introduced in the con-

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text of COVID-19 infection prevention. For example, at some sites, ventilators have been developed to detect people and increase their ventilation capacity when they approach<sup>7</sup>.

Although each of these technologies is groundbreaking in its own right, it is necessary to develop an appropriate theoretical framework for the development and dissemination of these technologies under the strategy of infection control. Therefore, in this report, we tried to apply the 3-step method and protective measures of “Safety aspects-Guidelines for their inclusion in standards” in ISO/IEC Guide 51: 2014 to COVID-19 infection control in the workplace from the viewpoint of occupational safety, especially safety of machinery<sup>8</sup>. Based on these trials, we proposed the 3-step method as countermeasures against COVID-19 infection, and discussed directions for the “New Normal” in the manufacturing industry in the future. On the other word, the novelty of this manuscript is that the concept of ISO/IEC Guide 51: 2014 risk reduction method (3-step method) has been applied to measures of COVID-19.

### **Application of “Safety of Machinery — General Principles for Design — Risk assessment and risk reduction (ISO/IEC Guide 51: 2014)” to COVID-19 infection control**

The main principles of machinery safety are summarized in the “Safety Aspects-Guidelines for their inclusion in standards” in ISO/IEC Guide 51: 2014. In summary, ISO/IEC Guide 51: 2014 states that a safe machine is designed based on a risk assessment by eliminating or reducing risks using the 3-step Method and Protective Measures; step 1: Inherently Safe Design Measures, step 2: Safeguarding and Complementary Protective Measures and step 3: Information for Use. In other words, ISO/IEC Guide 51: 2014 consists of a risk assessment and a set of prioritized risk reduction measures called the 3-step method.

Risk assessment is, according to Fukuda (2019), a procedure that specifies the steps from the determination of the limits of machinery to the assessment of the risks<sup>9</sup>.

Risk assessment is a method of estimating and evaluating the magnitude of risk as a “combination of the probability of occurrence of harm and the severity of that harm” derived from potential sources of danger in the machine concerned. The 3-step method is the method to eliminate or reduce the risks depending on the magnitude of each risk if the risk assessment results in the need for risk reduction measures.

On the other hand, in the field of machinery safety, when

an accident happened, the process diagram (Fig. 1) from the hazard to the occurrence of harm may be used to investigate the cause. Using the same diagram, we tried to consider the process diagram from the COVID-19 to the onset of infection as shown in Fig. 2. First, the hazard is the COVID-19 as a virus. The person is defined as the employee, since we are concerned here with employees in the manufacturing industry. The hazardous situation is the situation in which the employees is exposed to COVID-19. Inadequate measures, etc. are defined as inadequate infection control measures. The hazardous event is defined as an increase in the likelihood of infection of employees. Successful avoidance results in no symptoms or a reduction of infection (near-miss), whereas failure to avoidance results in the onset of infection or an increase in infection (occurrence of harm).

In the field of safety of machinery, the process from the hazard to the occurrence of harm is further developed, and the measures taken up to the hazard, the person and the hazardous situation are classified as “Inherently safe design”, the measures from the lack of measures to the hazardous event and are classified as “Safeguarding and Complementary protective measures”, and the measures taken up to the success or failure of avoidance are classified as “Information for use”. Then, those three steps are used to propose the new measures against an accident. For example, “inherently safety design measures” conceptually consider “spatial separation”, “elimination of hazard”, “exclusion of people” and “weakening of hazard (energy reduction)”. Following the 3-step method, each measure is considered, and from there, the implementers of each measure are further considered. Infection control measures against COVID-19 and who should implement these measures are described later.

Thus, applying the 3-step method of ISO/IEC Guide 51: 2014 to the COVID-19 infection control, the direction of infection control in the workplace becomes clearer. The application of this method highlights not only the measures and the implementers of the measures, but also the evaluation of the effectiveness, economic efficiency, and practicality of the measures. The application of this method highlights not only the measures and the implementers of the measures, but also the evaluation of the effectiveness, economic efficiency, practicality of the measures and so on. An example of this application is shown in Table 1.

## **Discussion**

In applying the three-step method to COVID-19 infec-

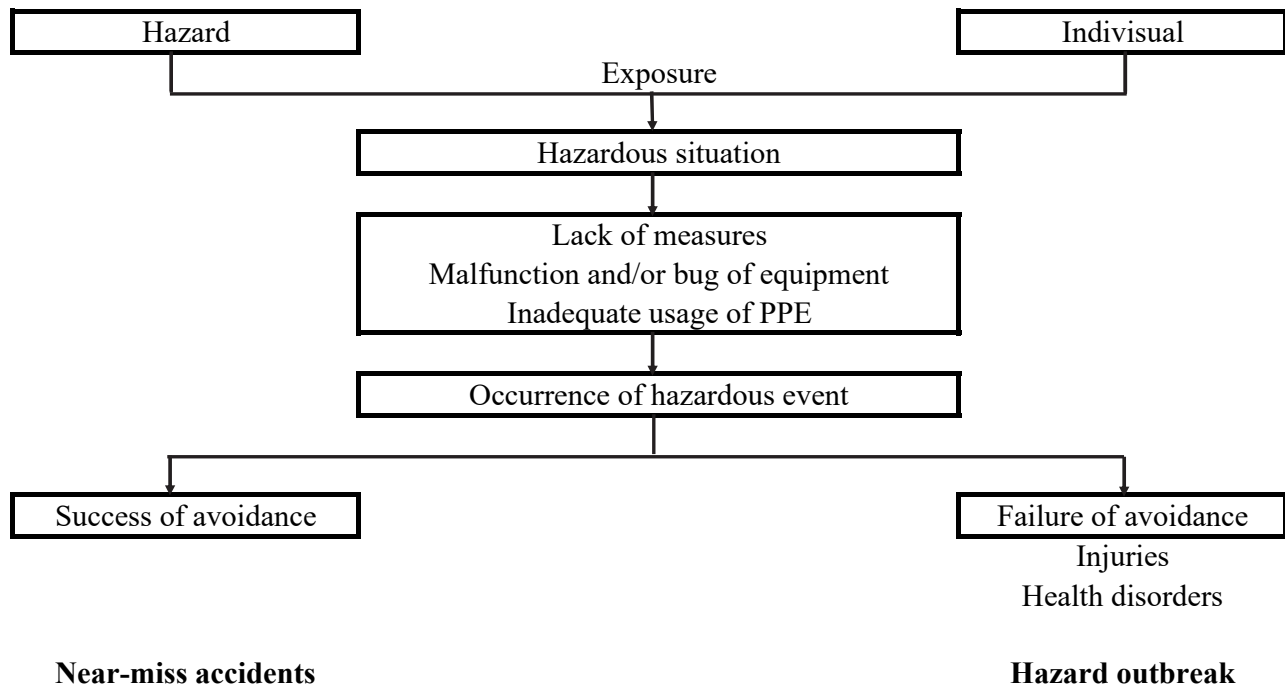


Fig. 1. Process from hazard to occurrence of hazardous event

tion control, the target population was restricted to employees in the manufacturing industry. In the order of the 3-step method, “Inherently safety design measures”, “Safeguarding and Complementary Protective Measures”, “Information for use”, and their conceptual classification, specific measures, possibility of avoiding hazardous situation, effectiveness, economy, and practicality are discussed below.

#### *Inherently safety design measures*

In view of the order of priority, the inherently safety design measures include virus eradication, non-toxicity and weakening, as well as the elimination of infection opportunities.

As for the eradication of the virus, there is still insufficient information on the structure of the virus, its behavior, and the mechanism of infection, etc., and the application of practices seems like to be difficult in this situation because it takes time. Secondly, vaccination of some medical personnel has been started, and it can be said that it is very effective as the inherently safe design measure to achieve weakening. Although there are still some problems to be solved, such as the validation of the efficacy and the adaptation to mutant strains, a more rapid vaccination is waited for general persons. The medical community is expected to be the main implementer of these measures, but the govern-

ment is also expected to play an important role in supporting research on the virus and providing vaccines promptly.

To remove the opportunity for infection, the government of Japan has imposed emergency restrictions. Initially, the state of emergency was set until 7 February 2021, but in view of the subsequent spread of the disease, it was extended until 21 March 2021. It is still partially in force as of April 2021. This has led to a serious economic recession, not only for the restaurants whose business is directly restricted, but also for the travel-related business in general because of restrictions on going out. This measure is effective in the sense that it eliminates the opportunity to come into contact with the virus, but its long-term implementation is extremely harmful to the economy. As for the request to restaurants to shorten their opening hours, if they do not respond to the request without justifiable reasons, the government will issue instructions based on the Special Measures Law and publish the names of the restaurants. If the approach based on regulation is to be prolonged in the future, it will be necessary to establish a legal framework not only in terms of penalties but also in terms of remedies. Needless to say, these measures will be implemented by the government.

In addition, telecommuting and unmanned workplaces, which may be difficult to apply in some occupations, can

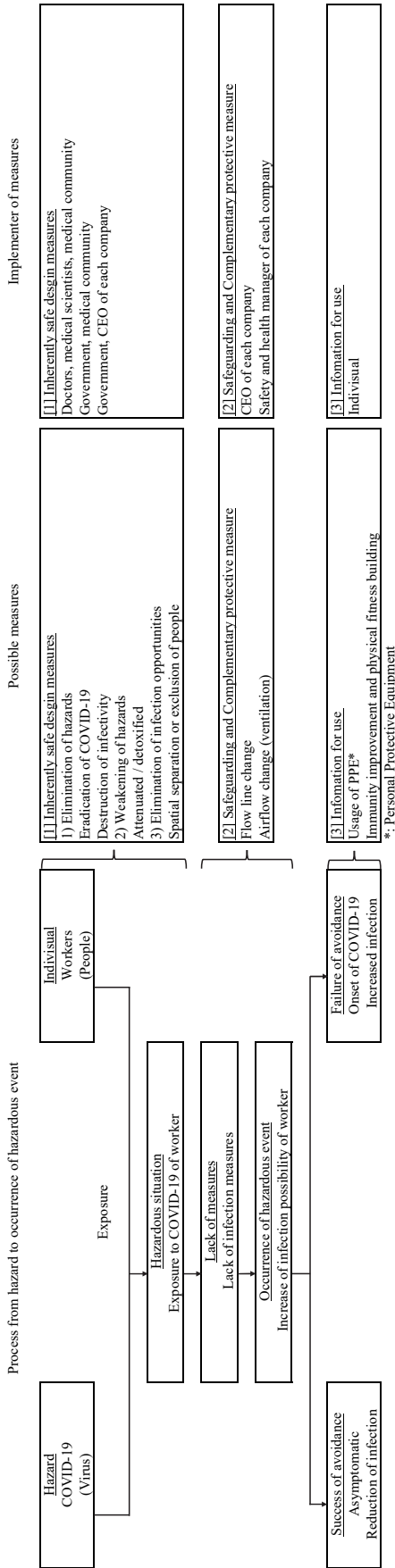


Fig. 2. Measures considered to be a process diagram leading up to the occurrence of harm using COVID-19 as a hazard and its implementers.

Table 1. Example of applying the 3-step method of ISO/IEC Guide 51: 2014 to COVID-19

Risk reduction measures	Step 1 Inherently safe design measures			Step 2 Safeguarding and Complementary protective measure		Step 3 Information for use	
	Elimination of hazards	Weakening of hazards	Spatial separation or exclusion of people	Flow line change	Airflow change (ventilation)	Decrease contact	Avoiding aggravation
Conceptual classification	Elimination of COVID-19	Atenuated Detoxified	Elimination of infection opportunities	Flow line change	Airflow change (ventilation)	Decrease contact	Avoiding aggravation
Specific measures	Medical treatment (Modification of Virus)	Vaccine	Telecommuting	Unmanned workplace		PPE	Immunity improvement Physical fitness building
Possibility of avoiding dangerous situations	○	○	○	△	△	△	x
Effects	Fundamental problem solving	Avoiding aggravation	Non-contact	Difficult contact	Difficult contact	Decrease contact	Anti-infection Anti-severity
Economical effect (Cost) for individual	Unknown	Low (free) High for Government	Change of Lifestyle	High	High	Low	Low
Time for implementation	Slow	In progress (limited)	Quick	Slow	Slow	Quick	Quick
Actual situation	Unknown	Occurrence of competition	Third time: Serious economic blow	Possible	Under promotion	Practical	Practical
Practicality	Difficult	Easy	Difficult	Very difficult	Somewhat easy	Easy	Easy
Weaknesses	Developing	Developing	Third time: Need for legislation	Depends on job type	Depends on economy	Depends on individual	Depends on individual

eliminate opportunities of infection. The former is a new style of production that has developed dramatically with the spread of COVID-19. The realization that face-to-face meetings, business negotiations, etc. are not always necessary, the discernment and selection of conventional working styles, and the ingenuity to optimize communication by avoiding contact have started, and friendly competition is still continuing. The development of industrial robots, the introduction of AI and ICT equipment, etc., have been explored as the future of industrial workplaces with or without COVID-19, but COVID-19 seems to have accelerated the process. Although there are some problems, such as the disparity between companies in terms of the economics of unmanned operations and the time required for full-scale introduction, this is a major step in the direction of future industry. The implementers of these measures will find it difficult to put them into practice unless the CEO of the workplace puts them in place.

Here, the Ministry of Health, Labour and Welfare (MHLW) published a list of practical examples of “new lifestyles”. Those are: a) telework and rotating work, b) staggered commuting, c) spacious office, d) online meetings, and e) ventilation and masks for face-to-face meetings. In this way, the government is also calling for the establishment of telework as the New Normal. Here, the MHLW published a leaflet on the practical example of “New Lifestyle” and listed five new styles of working: a) telework and rotating work, b) staggered commuting, c) spacious office, d) online meetings, and e) ventilation and masks for face-to-face meetings. In this way, the government is also calling to establish the telework as the New Normal.

On the other hand, the Japan Business Federation (Keidanren) has published “Guidelines for Prevention of COVID-19 Infection in Manufacturing Workplaces”, which stipulates the following basic approach to preventing infection.

“Recognizing that measures to prevent infection in the workplace will lead to the prevention of the spread of infectious diseases in society as a whole, business operators should establish a system of countermeasures, evaluate the risk of infection according to the characteristics of each workplace, and take measures accordingly. In particular, in order to prevent the spread of infection to employees, consideration should be given to commuting patterns, individual infection prevention measures should be thoroughly implemented, and measures to improve the working environment should be enhanced”.

In addition, the guideline lists specific measures to be

taken as follows: (1) infection prevention system, (2) health assurance, (3) commuting, (4) work, (5) rest and rest areas, (6) toilets, (7) facilities and equipment, (8) access to business premises, (9) enlightenment of employees on infection prevention measures, etc., (10) measures to be taken when an infected person is confirmed, and (11) others.

Among them, in (4) work, it says: “We aim to reduce congestion on public transport by considering various types of work, such as teleworking (working from home or satellite offices), staggered commuting, rotational work (working on multiple days and times), variable working hours, and a three-day week, mainly in administrative departments”. Thus, teleworking is limited to administrative departments, etc., and some believe that it is still too early to call teleworking and unmanned workplaces the New Normal for manufacturing sites in the manufacturing industry.

#### *Safeguarding and Complementary Protective Measures*

Step 2 is the avoidance of contact. In order to prevent physical contact between employees in the workplace, changes in the production line (changes in the flow of traffic) can be considered. The workplace can also be properly ventilated (changes in airflow) to avoid contact with the virus itself.

The changes in the flow of people is also of great related to the safety of human-machine coordination. In the cooperative safety of human and machine, attempts to minimize the contact between human and machine should be considered, but also attempts to minimize the contact between human and human are necessary in COVID-19 infection control. In order to make a manufacturing line that takes into account the flow of people, it is essential to change the general layout.

In addition, changes in airflow require ventilation design and equipment based on computational fluid dynamics more than ever before. In addition to dust, combustible gases, and toxic gases, which have been the subject of previous studies, there are high expectations for future research on how to establish and develop ventilation design and equipment for COVID-19, in which people are the source.

The implementers of these measures are the CEOs and health and safety managers of workplaces, and it can be said that this is a reasonable method that each company can implement on its own.

As mentioned above, “Keidanren”, in its “Guidelines for Prevention of Infection by Novel Coronaviruses in Manufacturing Workplaces”, states in (4) Work, “In order to prevent droplet infection, work spaces and personnel arrangements should be designed so that employees can maintain a



certain distance from the front of their faces, as far as possible, of 2 meters. If it is not possible to maintain a certain distance each other, the partitions should be provided between them. Ventilate the whole building and individual work areas. If windows can be opened, open them at least twice an hour (more frequently in cold weather). Mechanical ventilation does not need to be combined with window opening. A CO<sub>2</sub> monitor or similar device can be used to check the effectiveness of ventilation". In addition to the above, "Zoning should be provided for each process area, so that employees do not walk between their assigned area and other areas unnecessarily. Also, in manufacturing plants above a certain size, shifts should be managed in groups as much as possible".

Thus, it can be interpreted that matters such as changes in the flow of people and airflow are required to be established as the New Normal.

#### *Information for use*

At present, it takes more or less time before effective measures are taken in Step 1 and Step 2 at the governmental or company level. In ISO/IEC Guide 51: 2014, the first priority is to carry out Step 1, Inherently Safe Design Measures, and if these measures do not sufficiently eliminate or reduce the risk to an acceptable level, then Step 2, Safeguarding and Complementary Protective Measures, is carried out. Any residual risk is referred to Step 3 for Information for Use. Since the spread of COVID-19 is an unprecedented crisis and the implementation of steps 1 and 2 will take time, step 3 is a simple measure that can be implemented by each staff member in the meantime. There are two feasible measures that can be taken as step 3: the use of Personal Protective Equipment (PPE) to reduce contact, and the use of basic physical strength and immunity to avoid the severity of infection. Both of these methods can be implemented inexpensively by individuals. However, since the level of measures depends on the awareness of individuals, the reliability of individual measures may vary, and the company may not be able to determine uniform measures based on the consensus of its workers. For example, the avoidance of the "3Cs" such as wearing a mask, ensuring Social Distance (SD), hand washing and disinfection are all classified as step 3. It is important to provide the "correct" information and to evaluate whether the "correct" infection control measures are taken after the information is provided.

## **Conclusions**

In this study, we attempted to apply ISO/IEC Guide 51: 2014 for safety of machinery to COVID-19 infection control. ISO/IEC Guide 51: 2014 has the 3-step method as the priority of risk reduction measures, which are "inherently safety design measures", "safeguarding and Complementary protective measures" and "information for use". In the field of safety of machinery, the process from the hazard to the occurrence of harm is used to reveal the cause of hazard and to propose risk reduction measures corresponding to the 3-step method.

We considered these ideas in the field of machine safety in connection with COVID-19 infection control, and proposed specific measures of the three-step method as COVID-19 infection control. From this point of view, the New Normal, as it is commonly called, may be "telecommuting" and "unmanned workplaces" among the inherently safety design measures. However, there are some opinions that these measures are difficult to apply to some occupations, so it is necessary to consider the feasibility of implementing them first. In areas where telecommuting and unmanned workplaces are not feasible, changes in the flow of people and airflow may also be recognized as New Normal. The "changes in the flow of people" is also very interesting for the cooperative safety of human and machine. In human-machine safety, attempts to minimize human-machine contact should be considered, but also attempts to minimize human-to-human contact are necessary in COVID-19 infection control. In addition, "changes in the airflow" will require ventilation design based on computational fluid dynamics more than ever before. How to establish a ventilation design for COVID-19 in which the source is not only dust, combustible gas, toxic gas, etc., but also human beings, is expected to be the subject of future research.

Finally, in terms of information on the use of PPE, it is not an exaggeration to say that no one argues against its use. However, it is somewhat questionable whether people correctly understand why PPE should be used, since many posters and media calls encouraging the use of PPE state that "the use of PPE is to prevent COVID-19 infection or to avoid the spread of infection".

In the discipline of Behavior-Based Safety (BBS), in order to optimize human behavior, one must clearly separate each "target behavior" from its aggregate "performance (goal)". In other words, wearing a mask is not aim to prevent COVID-19 infection, but the action to minimize the amount of virus inhaled, and the action to prevent others from being exposed to droplets containing COVID-19.

Hand washing and hand disinfection are also targeted action to remove the attached virus, and the result of each of these behavior is the prevention of COVID-19 infection (performance).

In the future, it will be necessary to verify whether appropriate information is provided and to quantitatively measure and evaluate the extent to which COVID-19 infection prevention measures are correctly implemented in the field.

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