Chapter 12 Work Environment

Section 1 Work environment, accidents, and disasters

As shown in Figure 12-1, H.W. Heinrich, one of the pioneers of the disaster prevention technique, illustrated how accidents and disasters occur, which is known as Heinrich's domino theory. Figure 12-1 is known as Heinrich's Five Dominoes and represents the following causal relationships:

(1) Disasters caused by accidents

(2) Accidents caused by unsafe actions of people or imperfections of objects in their surroundings

(3) Unsafe actions and conditions caused by personal defects (physical or mental)

(4) Personal defects caused by adverse social and environmental conditions

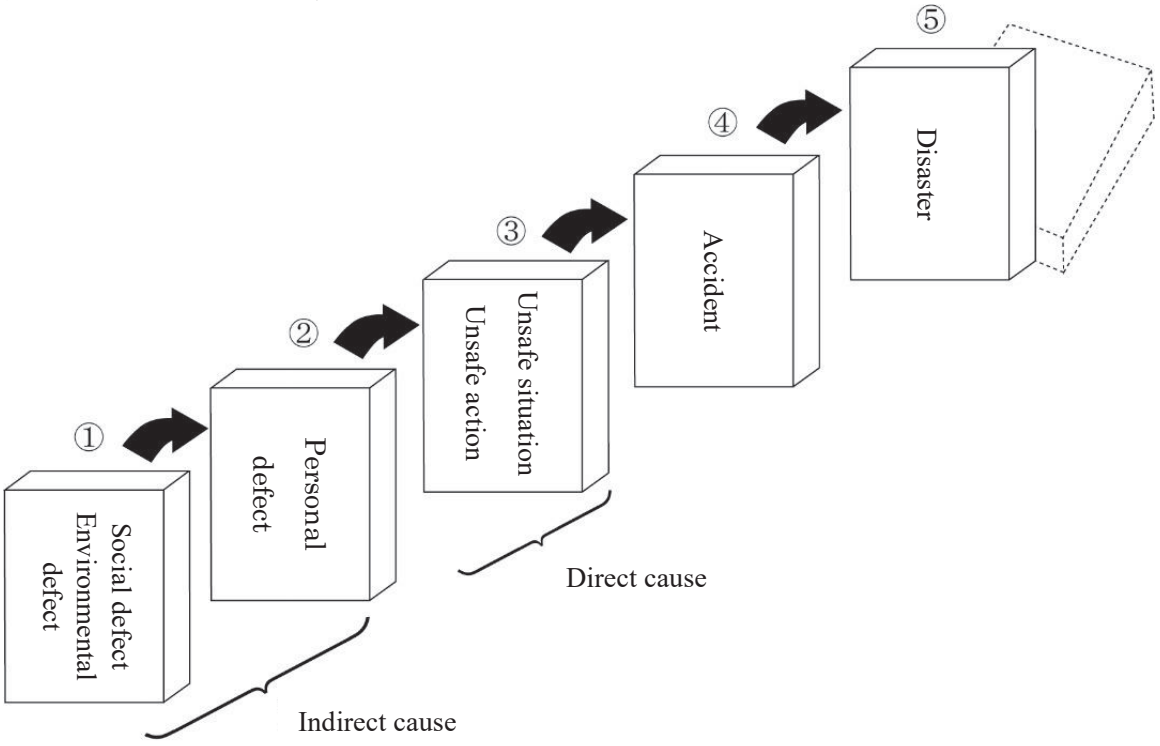

Figure 12-1 Heinrich's Five Dominoes

Thus, accidents and disasters are caused by several defects. Therefore, if any one of these defects is removed, accidents and disasters will not occur.

In this chapter, we consider removing the first domino (Figure 12-1). In other words, we demonstrate the work environment setups for each of the following items: (1) temperature and humidity, (2) air and ventilation, (3) lighting and illumination, and (4) noise and vibration.

Deficiencies in the work environment lead to accidents and disasters and cause health issues (Table 12-1).

Table 12-1 Major health issues owing to environmental and working conditions

Environmental and working conditions		Major health problems
Conditions caused by environmental conditions	1 Due to thermal conditions	Heatstroke, frostbite, and cold sores
	2 Due to lighting, hazardous rays, and ionizing radiation	Myopia, cataracts, electro-ophthalmia, and ionizing radiation damage
	3 Noise, vibration, and ultrasonic waves	Hearing loss, leukorrhea, arthralgia, bone and joint deformities, and ultrasonic disorders
	4 Due to abnormal atmospheric pressure	Decompression sickness
	5 Hazardous gases, vapors, and dust	Metal fever, lead poisoning, mercury poisoning, chromic acid poisoning, carbon monoxide poisoning, vinyl chloride poisoning, organic solvent poisoning, pneumoconiosis, skin disorders, and occupational cancer
	6 Conditions caused by oxygen	Oxygen deficiency disease
Conditions caused by working conditions		Low back pain, back pain, cervico-omo-brachial syndrome, and bouncy finger (spring fingers)

Section 2 Temperature/humidity

Unlike ordinary homes and offices, workplaces require a certain degree of temperature and humidity for the production process or other environments that cannot be avoided in the course of work, resulting in uncomfortable conditions.

Temperatures between 18 and 24 °C are considered suitable in a work environment. Humidity is closely related to temperature, and one indicator of this relationship is the discomfort index shown in the following equation:

Discomfort index = (dry bulb temperature (°C) + wet bulb temperature (°C)) × 0.72 + 40.6.

The relationship between this discomfort index and comfort and discomfort is shown in Figure 12-2. Therefore, as shown in the figure, the working environment guidelines for temperature and humidity can be determined.

Even with the same temperature and humidity, our estimation of the temperature differs depending on the state of the current airflow. When wind blows, generally evaporation of sweat is promoted, conduction increases, and feel cool or cold. However, when the temperature is very high and the humidity is high, the wind makes us feel hot and humid.

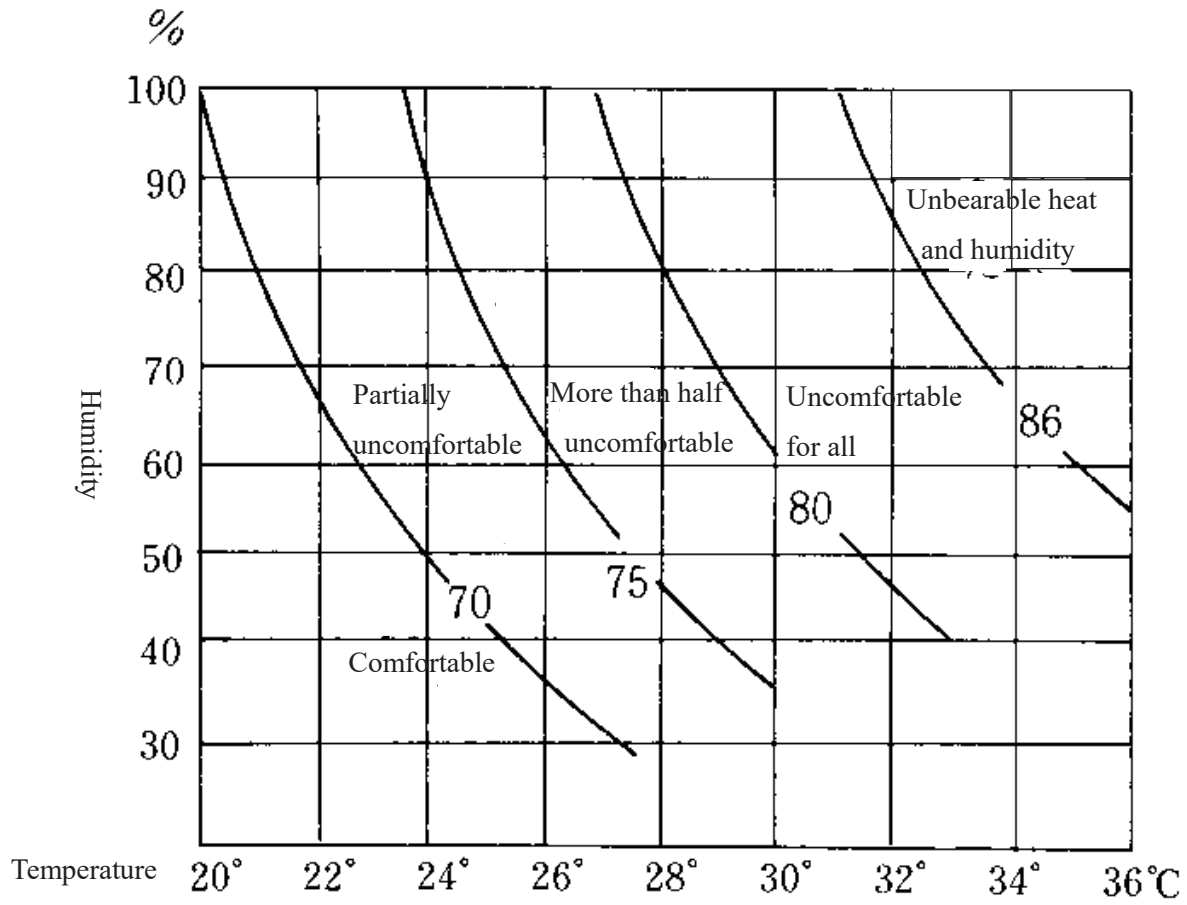

Figure 12-2 Discomfort index

Section 3 Air and ventilation

In the indoor air environment where common operations are performed, the concentration of dust, carbon dioxide, carbon monoxide, and other pollutants increases with human activity, which can impair comfort and adversely affect work efficiency. These, along with temperature and humidity mentioned in the previous section, are our most familiar work environments, and their effects cannot be ignored.

The focus should be on dust, specified chemical substances, lead, and organic solvents because their concentrations in the air in the working environment significantly fluctuate per place over a period. To prevent exposure to such hazardous substances, the use of local exhaust ventilation, push–pull ventilation, or total ventilation is the most common and effective method.

Standards for a working environment have been established and are listed in Table 12-2.

Table 12-2 List of sanitation standards for offices/workspaces

Item				Standard
Air environment	Air volume			10 m^3/person or more
	Windows and other openings			The area of the largest open area must be at least 1/20 of the floor area (if the area is less than 1/20, a ventilation system must be provided).
	Indoor air quality standards	50 ppm or less		50 ppm or less
		0.5% or less		0.5% or less
	Temperature	Heating and other measures shall be considered.		Heating and other measures shall be considered.
		The temperature should not be significantly lower than the outside temperature (the difference from the outside temperature should be within 7 °C).		The temperature should not be significantly lower than the outside temperature (the difference from the outside temperature should be within 7 °C).
	Air conditioning equipment	Quality of supply air	Suspended dust (~10 microns or less)	0.15 mg/m^3 or less
			Carbon monoxide	10 ppm or less
			Carbon dioxide	0.1% or less
			Formaldehyde	0.1 mg/m^3 or less
		Indoor air standards	Airflow	0.5 m/s or less
			Room temperature	Strive to maintain the temperature between 18 and 28 °C
			Relative humidity	Strive to maintain the humidity between 40% and 70%
	Mechanical ventilation system	Quality of supply air	Suspended dust	0.15 mg/m^3 or less
			Carbon monoxide	10 ppm or less
			Carbon dioxide gas	0.1% or less
			Formaldehyde	0.1 mg/m^3 or less
		Airflow in a room		0.5 m/s or less

Section 4 Lighting

Lighting and illumination in the workplace significantly impact comfort and work efficiency. Even the slightest deviation from optimal conditions can strain the visual environment and create health problems. For example, under conditions where workers cannot see well or cannot see without effort, the visual function becomes not only burdened, but also thus errors increase, leading to an increase in defective products and a decrease in production and various health issues or unexpected injury caused by the extra inhalation of dust and gas because of the proximity of the eyes to the workbench.

There are five types of lighting methods: direct, indirect, semi-indirect, general, and local lighting. The selection should be made according to the type and method of work. The following points should be considered during the selection process:

(1) Illuminance should be appropriate for the type of work. The required illuminance is specified in the JIS illuminance standard (Z9110-2010), an example of which is listed in Table 12-3.
(2) Illuminance should not be dazzling under normal working conditions.
(3) The light source should not move.
(4) The light source should not create strong shadows on the work surface and floor.
(5) The light source should not create a large difference between the ambient brightness and brightness of the work surface. (General lighting should be at least 1/10 of the brightness of local lighting.)
(6) The light color should be suitable for the nature of the work.

Table 12-3 Illuminance requirements according to JIS (Table 10 for factories)

Type of area, task, or activity		Ēm(lx)	Uo	UGRL	Ra	Notes
Work	Extremely detailed visual work in precision machine and electronic component manufacturing and printing plants (e.g., assembly a, inspection a, testing a, and sorting a)	1500	0.7	16	80	Ra ≥ 90 when color is important, 2000lx for ultra-precise viewing tasks.
	Fine visual work such as sorting and inspection in textile factories, typesetting and proofreading in printing factories, and analysis in chemical factories (e.g., assembly b, inspection b, testing b, and sorting b)	750	0.7	19	80	Ra ≥ 90 when color is important, 1000lx for precision viewing tasks.
	Ordinary visual work in general manufacturing processes (e.g., assembly c, inspection c, testing c, sorting c, and packaging a)	500	0.7	-	60	Ra ≥ 90 when color is important.
	Limited to rough visual work (e.g., packaging b and packing a)	200	-	-	60	

	Very rough and limited visual work (e.g., packaging c and packing b, c)	100	-	-	60	
	Design and drafting	750	0.7	16	80	
	Monitoring of instrument panels and control panels in control rooms	500	0.7	16	80	1) Control panels are vertical in several cases. 2) Dimming is desirable. 3) For VDT work, refer to JIS illuminance standard (Z9110-2010) 4.8.
	Clerical work in the warehouse	300	-	19	80	
	Loading, unloading, moving loads, etc.	150	-	-	40	
Office spaces	Design and drafting rooms	750	-	16	80	
	Control room	200	-	22	60	
Public spaces	Warehouse with operations	200	-	-	60	
	Warehouse	100	-	-	60	200lx for persistent use.
	Electrical room and HVAC machine room	200	-	-	60	
	Toilet and washroom	200	-	-	80	
	Stairs	150	-	-	40	Liminal areas are provided at entrances and exits to avoid sudden changes in brightness.
	Indoor emergency stairs	50	-	-	40	
	Corridors and passageways	100	-	-	40	
	Exits and entrances	100	-	-	60	

Notes The following three categories shall be used according to the nature of the object and work to be looked at with regard to same type of task name.

a) “a” in the table represents smooth objects, dark objects, objects of weak contrast, particularly expensive objects, cases related to hygiene, cases requiring a high degree of precision, and cases requiring long working hours.

b) “b” in the table represents the intermediate between a) and b).

c) “c” in the table represents objects that are coarse, light-colored, sturdy, and inexpensive.

Section 5 Noise and vibration

Noise causes discomfort to people, interferes with conversations and signaling, often adversely impacts safety, affects physiological functions, and can cause hearing impairment. (1) loud sound, (2) sound concentrated in a narrow frequency band (pure sound), (3) high-frequency sound, and (4) steady sound that is exposed for a long time are considered risky, with the acceptable standard being 85 decibels (dB). When noise prevention is not possible at the noise source or transmission path, **earplugs** should be used. If used properly, earplugs can reduce noise by 30-40 dB at >2000 Hz and by 10-20 dB between 200 and 2000 Hz. Table 12-4 lists the noise level and ambience of the place for reference.

Table 12-4 Noise level and on-site perception

dB	On-site perception	Examples
140		
130	Ears hurt, leading to headache	
120		Jet engine noise
110		When the window of a train is open when traveling in a tunnel
100	Desire to cover ears	When a train passes under the guard
90	Inability to talk to the person in front of you	Noisy factory
80	Cannot speak unless you raise your voice very high	Elevated railroad (inside a car)
70	Consciously speak louder	Crowded city and ordinary machine shop
60	Area feels noisy but able to have a normal conversation	Busy office interior
50	Ongoing light background noise that is disturbing	Office and quiet walking passerby indoors
40	Quiet but area not free from sound	Listening while in a crowd
30	Quiet and calm	Inside a broadcasting studio during a quiet night
20	Area feels silent	Sounds of leaves rustling
10		Whispering voice
0		Minimum audible sound in a soundproof room

The following methods can help prevent noise:

(1) Reduction by improving location and layout, among others

(2) Measures to counter sound sources

(3) Room noise reduction through sound absorption

(4) Reduction by sound insulation

(5) Noise reduction by vibration isolation

The frequency of vibration ranges from 10 to 500 Hz, which can cause neurological symptoms in the fingers and upper extremities, Raynaud's phenomenon in the fingers, and other circulatory disturbances in people who use tools such as chain saws and rock drills that must be held by the hands for long periods. Vibration disorders do not commonly occur; however, increased vibration can cause discomfort, irritation, and other neuropsychiatric effects and reduce work efficiency and accuracy. Thus, vibration must be maintained at an appropriate level.

The permissible limit of vibration is related to frequency, amplitude, and time. Figure 12-3 shows the relationship between vibration frequency and amplitude.

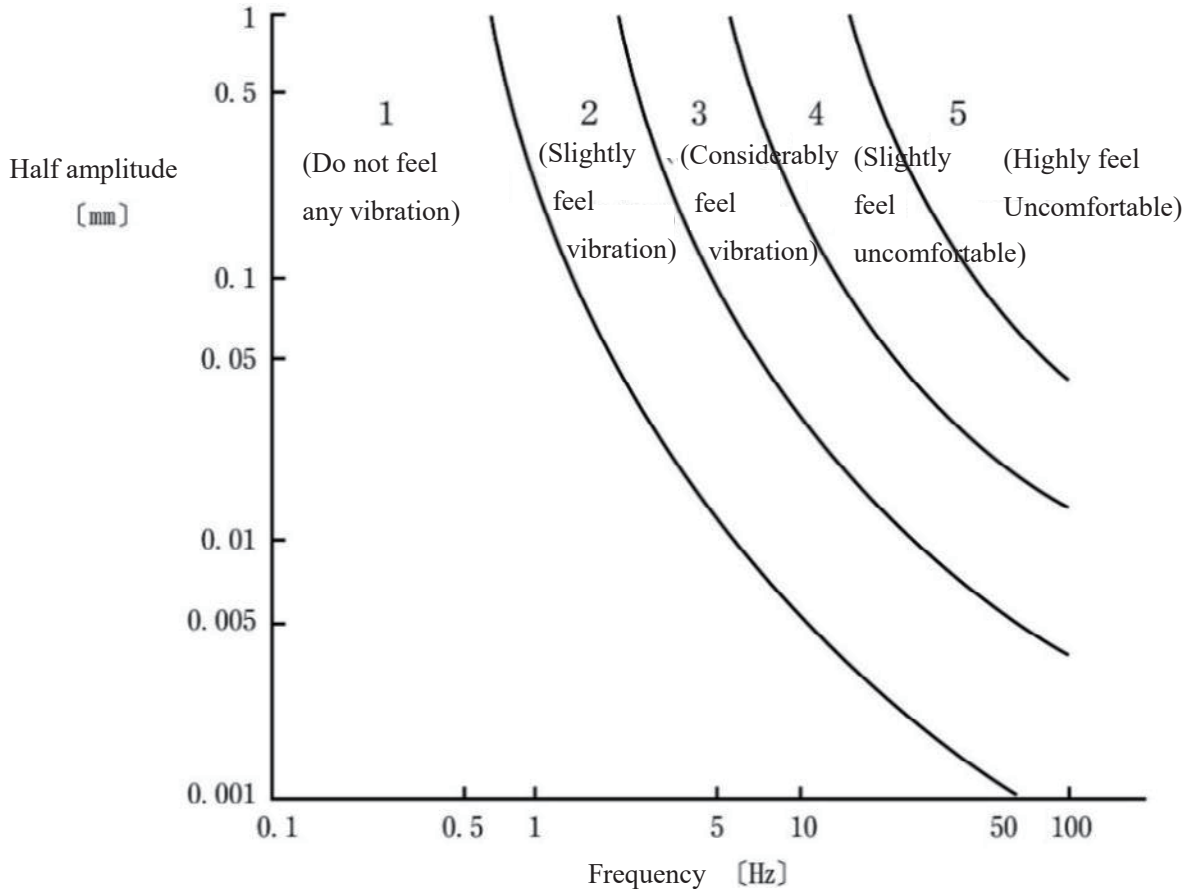

Figure 12-3 Five classification ranges of vibration sensation

Vibration prevention measures include the following steps:

(1) Eliminate the cause of vibration

(2) Interrupt the transmission path of vibration

(3) Use cushioning materials

(4) Modify the resonance point

Section 6 Disorder caused by IT equipment operations

The “Guidelines for Occupational Health Management in VDT (Visual Display Terminal) Operation” issued by the Director of the Labor Standards Bureau of the Ministry of Health, Labour and Welfare on April 5, 2002, has led to the implementation of measures to prevent disorders caused by VDT work. This is because the recent shift to information technology (IT) has considerably changed the working style in Japan, and computer operation (VDT work) has become a routine.

Since 2002, the use of IT in the workplace has significantly progressed, and the scope of workers who perform VDT work has expanded, and the work has become more diverse. Therefore, the guidelines will be revised as “Guidelines for Occupational Health Management in VDT Work” by the Director of the Labor Standards Bureau of the Ministry of Health, Labour and Welfare, on July 12, 2019.

1 Disorder caused by IT equipment operations

Subjective symptoms include eye fatigue, pain and dryness, stiff neck and shoulders, headache, back pain, lower back pain, arm pain, finger pain, numbness in the fingers, weakness in the hands, and stress symptoms.

2 Control practice (prevention)

Details are available at the URLs mentioned in the reference section. Thus, practical key points are described here.

(1) Work environment management

It includes appropriate lighting, lighting and glare prevention, noise reduction, appropriate chairs and desks for proper working posture, appropriate adjustment of information equipment, and other types of maintenance and management of the work environment.

(2) Task management

The following tasks are performed for 4 h or more per day:

Interactive operation-Creation, editing, and modification of text, tables, and related components based on the worker’s ideas; data retrieval, collation, addition, and correction; and sending and receiving e-mails

Technical operation, i.e., programming tasks-Creation and modification of computer programs and implementation of CAD tasks that include designing and drafting with the assistance of a computer (excluding simple input to CAD)

There are many types of IT equipment operation; these types possess different formats and contents. In addition, as the work effects on health significantly vary per person, uniform work management is not desirable. Therefore, it is desirable to provide IT equipment and related furniture and fixtures according to the characteristics of each worker and carefully consider the formulation of work plans that minimize the workload based on actual work conditions.

[Continuous work time and break time]

The purpose of work downtime is to prevent fatigue of workers caused by strain on their eyes, neck, shoulders, lower back, and upper limbs, resulting from gazing at the display screen, key operations, or a certain working posture for an extended period of time. Thus, they need to take a temporary break from work for a specific period and relax by looking at a distant scenery; closing the eyes; performing exercises such as stretching various parts of the body; or performing other tasks but not the so-called break time.

A short break is a pause of 1–2 min taken in the middle of a continuous work period. It is not a set time, but rather a break that workers can take at their will.

[Dry eye]

Dry eye (corneal xerosis) is a common disease; however, recently, it has been considered one of the most common disorders in information equipment operation. Blinking consciously is a good way to prevent it. Thus, during short breaks, you should blink consciously.

3 Reference URLs

Ministry of Health, Labour and Welfare “Guidelines for Occupational Health Management in Information Equipment Work

https://www.mhlw.go.jp/content/000539604.pdf

Appendix: Guidelines for Occupational Health Management in Information Equipment Work

https://www.mhlw.go.jp/content/000580827.pdf