Technical Information

TI 33Q01J20-01E

Guidelines for Installation Environment

YOKOGAWA ◆

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Introduction

Electronic equipment and instrumentation such as DCS (Distributed Control Systems) and electronic single loop controllers play a major role in plant operation. Failure of the DCS or electronic instrumentation during plant operation could lead to serious accidents.

In particular, care must be taken to prevent failures due to condensation, dust, corrosive gas, etc., as these could cause serious damage that would have adverse effects on plant reliability.

Failures occur especially when combinations of condensation and dust, or condensation and corrosive gas occur.

Many such failures can be avoided by taking appropriate measures in design and manufacture, as well as by improving the user's operating environment and providing coated printed circuit boards for use in hostile environments.

Generally when a failure occurs where preventative environmental measures have not been taken, improving only the environment will cost several times what it would have cost to safeguard the environment beforehand from anomalous factors. Moreover, environment-related failures become even more serious over time and great attention must be given even if there are time constraints when employing the electronic equipment.

These guidelines are intended to ensure that the DCS and electronic equipment provide a higher degree of reliability for a longer period of time. They are based on the measures that Yokogawa has taken to prevent failures caused by condensation, dust, or corrosive gas present in the installation environment, and are intended to supplement the basic standards for the installation environment described in the installation guidelines for each piece of equipment.

For more information on inspection of the equipment installation environment and provision of preventative measures according to the installation environment, contact Yokogawa Sales.

Documentation Conventions

Symbol Marks

Throughout this manual, you will find several different types of symbols are used to identify different sections of text. This section describes these icons.

CAUTION

Identifies instructions that must be observed in order to avoid physical injury and electric shock or death of the operator.

WARNING

Identifies instructions that must be observed in order to prevent the software or hardware from being damaged or the system from becoming faulty.

IMPORTANT

Identifies important information required to understand operations or functions.

TIP

Identifies additional information.

SEE ALSO

Identifies a source to be referred to.

Clicking a reference displayed in green can call up its source, while clicking a reference displayed in black cannot.

Drawing Conventions

Some drawings may be partially emphasized, simplified, or omitted, for the convenience of description.

Trademark

- All other company and product names mentioned in this technical information are trademarks or registered trademarks of their respective companies.
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Guidelines for Installation Environment

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1. Classification of Environment-related Failure Factors

The environmental factors which can lead to the malfunctioning of DCS or other electronic equipment can be classified as follows:

- Condensation
- Dust
- Corrosive gas: Sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen oxide (NO_X), chlorine (Cl_2), ammonia (NH_3), ozone (O_3), etc.
- Other factors that can cause atmospheric corrosion: sea salt particles, etc.

Although the presence of even a single factor in the installation environment affects electronic equipment more than in normal environments, a combination of two or more factors can have an extreme impact.

2. Failure Examples by Environment Factor

The following are examples of failures caused by the factors mentioned in Chapter 1.

2.1 Failures Caused by Condensation (High Humidity)

In a humid environment, condensation can occur due to slight changes in humidity. When the atmospheric temperature is 25°C and the relative humidity is 80%, condensation is caused when temperature decreases by 2°C to 3°C. Especially where there is an extremely narrow clearance, capillary condensation can occur even at levels lower than coastal humidity, a phenomenon which generates water drops by the liquid's surface tension in capillaries even at saturated vapor pressure. This capillary condensation can also occur in narrow clearances that have been formed by dust adhesion. Circuit faults and analog signal errors are caused by electrolysis (rust, silver migration, etc.) and insulation deterioration is caused by condensation. This may further lead to short-circuiting, pattern breakdown and component failures.

2.2 Failures due to Accumulation of Dust

Usually there are not many instances in which failures are caused at low humidity by the accumulation of dust on a circuit board or other objects. Some of the exceptions are shown below:

Examples of circuit malfunctioning at low humidity due to dust accumulation or other factors:

- When dust builds up on photosensors, the optical path may be obstructed, resulting in failure.
- Electrical insulating dust entering circuits, in particular the contacts of open-type switches or connectors, triggers circuit malfunctioning.
- Conductive dust accumulation not only increases the number of circuit operation faults and analog signal errors due to deteriorated insulation, but can also produce operation failure due to short-circuiting.
- High voltage circuits such as power supply circuits are especially likely to absorb dust. The adherence of carbon fibers to these parts may cause breakdown or even burning of the parts.
- When salt from sea breezes accumulates, chemical condensation occurs at relatively low humidity and causes corrosion.
- If oil is dispersed in the atmosphere and oil mist adheres to plastic parts of the instrument, the plastic may erode and crack.
- When oil adheres to cards (circuit boards), circuit operation failure and analog signal errors due to deteriorated insulation will increase in number.
- The coating of the cards (circuit boards) will melt and will flow along the card edge, causing contact problems.

IMPORTANT

Care must be taken for locations with high humidity, as the accumulation of dust on electronic equipment can trigger capillary condensation also at lower than coastal humidity, thereby resulting in erosion.

2.3 Failures due to Corrosive Gas

When electronic equipment is installed in environments with high temperatures and the presence of corrosive gas, dry corrosion occurs in which metal corrodes by reacting with such gas without moisture intervention.

IMPORTANT

If condensation occurs in corrosive gaseous environments, an electrolyte solution of the corrosive gas is made from the condensed moisture, which accelerates corrosion faster than the dry corrosion through the gas only, causing a broken wire or insulation deterioration.

3. Problems and Corrective Measures Taken in the Installation Environment

As mentioned above, a combination of two or more factors in the installation environment can have more serious impact on electronic equipment failures than a single factor. It is only natural that taking precautionary corrective measures is more effective and inexpensive than after failures actually occur. This chapter explains examples of problems that can lead to the presence of failure factors such as condensation, dust, and corrosive gas by classifying them under the following headings, as well as outlining their corrective measures:

- Installation of electronic equipment
- Instrument room conditions
- Transportation of electronic equipment

Should any failures occur, contact Yokogawa.

3.1 Installation of Electronic Equipment

The following are typical examples of possible detrimental effects on electronic equipment installed in the instrument room.

3.1.1 Forced-draft Fan Cooling

- When the cable riser leading to a cabinet inlet is not sealed with putty
  The fan cannot blow cold air as appropriately as designed, and the air might escape through an inlet that has not been sealed with putty, resulting in deterioration inside the cabinet or other problems due to raised temperatures.
- When the cabinet's filters are unclean due to lack of regular maintenance
  The fan cannot blow a sufficient amount of cold air, which may result in deterioration of the electronic equipment in the cabinet due to raised temperatures.

3.1.2 Induced-draft Fan Cooling

- When the cable riser leading to a cabinet inlet is not sealed with putty
  Polluted underfloor air, which may be hot, humid and dusty, and contain corrosive gas, might be taken in through an inlet that has not been sealed with putty. Therefore if the underfloor air is not clean, electronic equipment may corrode or other problems may result.
- When the cabinet's filters are unclean due to lack of regular maintenance
  As filters with increased ventilation resistance cannot let sufficient air pass, air and dust enter the inside of the cabinet through other clearances that are not equipped with filters, causing corrosion or other problems.
- When the cabinet's internal pressure is too low
  Too low internal pressure allows dusty air to enter the cabinet through accidental clearances, causing corrosion or other problems.

3.2 Condition of the Instrument Room

The following are typical problems with regard to the instrument room's conditions for different failure factors:

3.2.1 Common Conditions that can Lead to Condensation, Dust, or Corrosive Gas

- A powerful exhaust fan installed in the room sucks much rainwater or polluted air into the room.
- The room has free contact with the outside air (windows are open).
- The room has poor airtightness, and outside air enters the room.
- The entrance for external cables is not sealed with putty; so rainwater enters through the entrance for external cables and accumulates below the floor (in the wiring pit).
- A free access floor is used that is linked to the position under the floor of the adjacent room. A bad environment in the adjacent room influences the room.
- There is a considerable amount of dust and corrosive gas in a plant, which is discharged from products and the materials they are made of, and can easily enter the instrument room.
- Electronic equipment is installed near air outlets that contain dust and corrosive gas.

3.2.2 Condensation Related to Humidity and Temperature

- Air conditioners are not effective in some areas of the instrument room, because of the room's shape or the direction of air outlets.
- The instrument room is consistently humid, or occasionally becomes hot.
- Part of the instrument room's wall comes in contact with the ground and the room becomes humid during prolonged periods of rain or other incidents.
- The instrument room is humid due to some causes triggered by rainfall.
- The instrument room has windows through which electronic equipment is exposed to direct sunlight or through which outside air enters, or there are glass windows without curtains that are occasionally left open.
- Warm or humid air from outside enters a room that is cooled by an air conditioner when the doors are opened or closed (including for wiring connection work).
- Humid, high temperature outside air enters the room when the air conditioner is turned off, after the room has been cooled.
- The drainage for the air conditioner is located inside the instrument room.
- The air conditioner in the instrument room is out of order.

3.2.3 Dust

- If outdoor shoes are allowed inside the instrument room, dust enters the room from outside and accumulates inside electronic equipment.
- The instrument room is not cleaned.
- The filters of the air conditioner in the instrument room have not been maintained and the dust has not been removed.

3.2.4 Corrosive Gas

- The instrument room is located near the sea and electronic equipment is exposed to sea breezes.
- Corrosive gas enters the instrument room. Possible causes include that corrosive gas is present in the wiring pit and that a cable inlet is not fully sealed with putty.

3.3 Transportation or Installation of Electronic Equipment

- Unused electronic equipment has been left, including in an installed condition and in storage, over a long period of time in a hot, humid environment without an air conditioner. This may cause condensation.
- Electronic equipment is moved from a cold to a hot place in a short time. This may cause condensation.

3.4 Corrective Measures

3.4.1 Measures against Problems in Installing Electronic Equipment

The following are applicable measures against problems in installing electronic equipment in a cabinet (measures to collectively safeguard it against condensation, dust, and corrosive gas):

- The cable riser leading to the cabinet should be sealed with putty.
- The cabinet filters should be kept clean by regular maintenance.
- The cabinet should be filled with clean air to increase the internal pressure.
- The insides of cabinets should be cleaned regularly.
- To prevent the printed circuit boards from deteriorating insulation and corrosion, they should preferably be provided with a resistant coating for environments which are always exposed to high temperatures, humidity and corrosive gas atmospheres.

3.4.2 Instrument Room Measures

Common Measures against Condensation, Dust, and Corrosive Gas

The following are applicable measures against common problems of condensation, dust, and corrosive gas.

- Excessively powerful exhaust fans which suck in much rainwater or outside air should be removed from the instrument room.
- The instrument room should be fully enclosed so as not to be influenced by external conditions.
- To reinforce sealing inside cabinets, the entrance for external cables into cabinets should be sealed with putty.
- If a free access floor is used in the instrument room, space under the floor of the instrument room should also be separated from the outside.
- No windows should be provided between the instrument room and the outside. If there are any unavoidable reasons for the necessity of windows, seal up the clearances or the windows in their entirety in order to prevent direct sunlight from entering the room.
- A double door should be provided to prevent entry of the outside air.

Measures against Condensation Caused by Humidity

The following are applicable measures against problems that can specifically cause condensation resulting from humidity:

- The drainage for the air conditioner should not be located inside the instrument room.
- An air conditioner of the appropriate efficiency should be installed in the instrument room to keep temperature and humidity at consistent levels. Air from air conditioners should be evenly distributed to every nook in the room.
- Two or more air conditioners should preferably be installed (This is to prevent failure due to condensation which may be caused by a sudden rise in temperature in the event of an air conditioner failure).
- Power to the air conditioner should be turned on continuously whenever possible.
- The relative humidity of the instrument room must be kept at 50% ±10% by using an air conditioner. There should be no sudden temperature or humidity changes.
- Air from air conditioners should not blow directly on electronic equipment.
- A hygrothermograph should preferably be installed at the air suction port of the equipment, to record the temperature and humidity daily, so that any possible failures can be dealt with promptly.

Measures against Dust

The following are applicable measures against problems that can specifically cause dust:

- Strictly prohibit the use of soiled shoes in the instrument room. If this is not possible, use a dust removing mat outside the entrance to the instrument room.
- Clean inside the instrument room regularly.
- Clean the air conditioner in the instrument room regularly to avoid the accumulation of dust.

Measures against Corrosive Gas

The following are applicable measures against problems in the instrument room that can specifically be caused by corrosive gas:

- An air-cleaning device with the capability of removing corrosive gas should be provided in the instrument room.

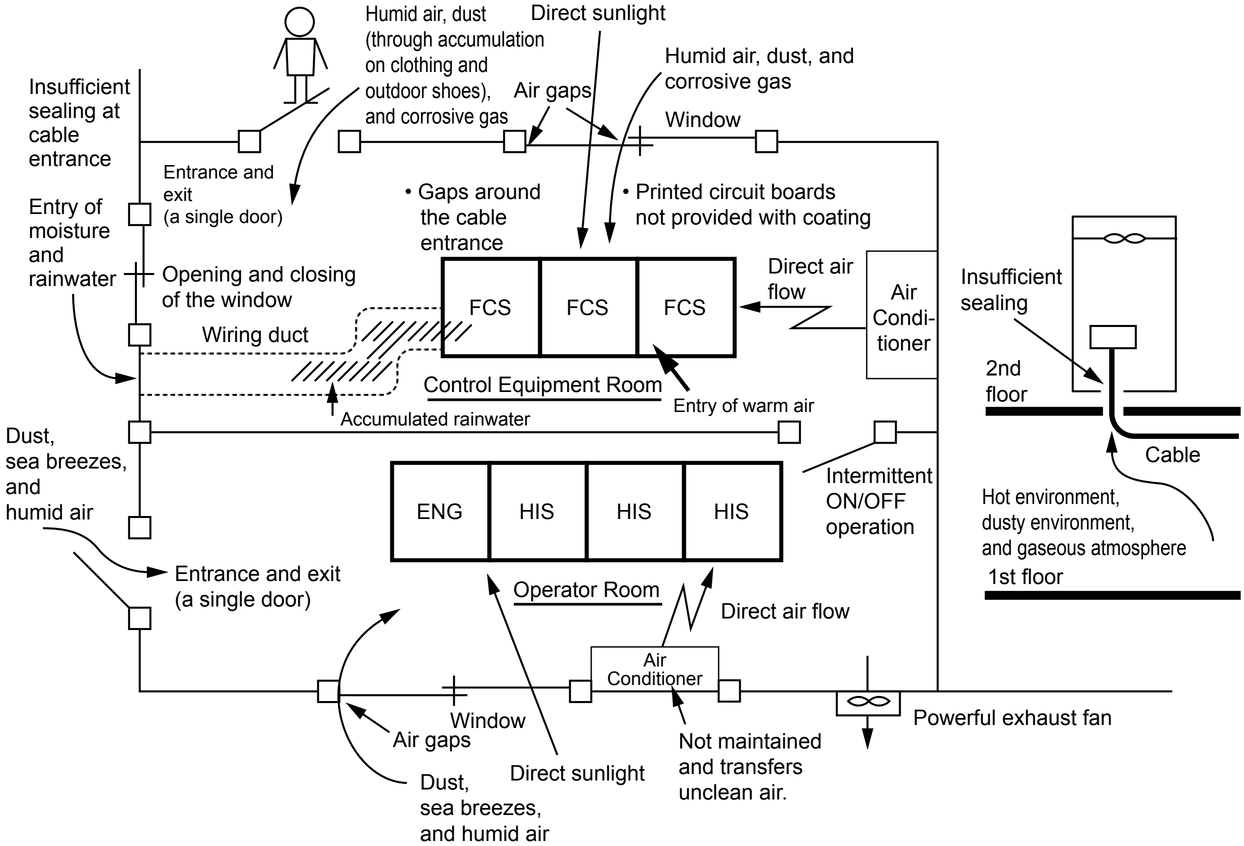
3.4.3 Transportation or Installation of Electronic Equipment

- Transportation and storage requirements for each piece of equipment should be satisfied.
- Electronic equipment that is not being supplied power should not be left in a hot, humid environment without using an air conditioner.
- When electronic equipment is stored or not to be used for a prolonged period, it should be sealed in plastic with a supply of desiccant.
- Electronic equipment should be stored out of direct sunlight.
- Condensation should be avoided under all conditions while electronic equipment is in storage.
- Electronic equipment should not be stored in an atmosphere where corrosive gas is present or in a coastal area.
- If, after being unpacked, electronic equipment is to be stored without being supplied power, ensure the storage location meets the installation environment requirements for the equipment.
- Electronic equipment should be unpacked indoors with the required environmental conditions satisfied.
- If electronic equipment has been subjected to condensation but not corrosion or any other serious problems, turn off the equipment and contact Yokogawa sales.
- When wiring is installed to cabinets, the instrument room should also be temporarily sealed with cloth or other materials, to prevent the outside atmosphere from entering through the underfloor wiring pit. If moist air enters the room from under the floor when an air conditioner is used and the room is cool, this will cause condensation.
- When the instrument room is under construction, the outside atmosphere should not be permitted to enter the room through the open entrance or cable inlets.
- When the equipment has been cooled by the air conditioner, do not suddenly turn off the air conditioner whether or not the equipment is operating or if the instrument room is under construction. Keep the air conditioner blowing for some time; then turn it off.

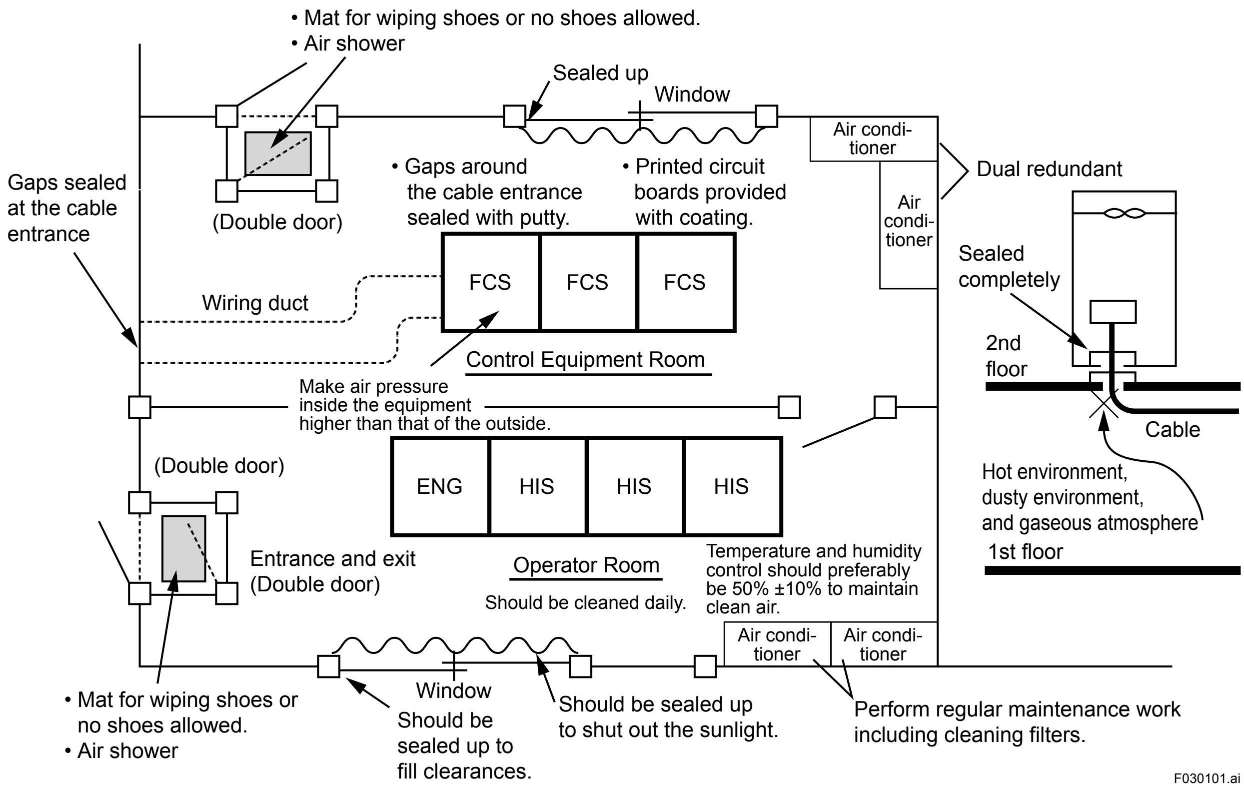
3.5 Example of Corrective Measures for Failure Factors in Installation Environment

The following shows an example of corrective measures for environments for the instrument room in which electronic equipment is used.

<Example of Instrument Room in Unsatisfactory Environment>



<Example of Satisfactory Instrument Room>



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3.6 Corrective Measures by Failure Factor

Condensation

Table List of Corrective Measures by Failure Factor

	High temperature	Insufficient sealing	Related to air conditioner	Stored
Industries with poor environments	Unable to specify (chemical, metal, paper making, water service, petroleum, etc.)	Unable to specify (chemical, paper making, petroleum, Pharmaceuticals, etc.)	Unable to specify (chemical, steel making, paper making, petroleum, semiconductor, Pharmaceuticals, etc.)	Unable to specify
Details of failures	Condensation -> deteriorated/reduced insulation -> circuit operation failure, greater differences -> corrosion/pattern breakdown, short-circuit parts failure, etc.	Same as left (very conspicuous due to dust attached)	Same as left (very conspicuous due to dust attached)	Same as left (very conspicuous due to dust attached)
Phenomena	Constant high humidity Walls of the instrument room in contact with the ground -> very humid at the time of much rainfall	The entrance for external cables is not sealed, and the rainwater enters under the floor. The windows are open. The building is not airtight. The cable riser is not sealed. Humid outside air enters the room.	When the room is cooled by an air conditioner, humid, high-temperature outside air enters through the open door or from below the floor. (Such outside air is sucked in the equipment by fan, etc.) The air conditioners are turned off sometimes.	The equipment is left under the humid, high-temperature conditions without being air-conditioned or being supplied with power.
Preventative measures	The humidity and temperature are controlled within the specified range by installing the air conditioners. (Installation of two air conditions is preferred) If the temperature and humidity are always high, consult Yokogawa sales.	The entrance for external cables and cable riser should be sealed with putty. For the humid environment, install the air conditioners to keep the temperature and humidity within the specified range. If the temperature and humidity are always high, consult Yokogawa sales.	At the time of startup, means should be provided to prevent outside air from entering through the opened door or the entrance for external cables during the work with the air conditioners turned on.The equipment power should be turned off. Do not turn off the air conditions suddenly. Keep air blowing for some time, and turn it off. If it is humid when power is supplied, install the air conditioners to maintain the humidity and temperature within the specified range. Use a double door to prevent outside air from entering. If the temperature and humidity are always high, consult Yokogawa sales.	If the equipment is not used for a long term during the storage, use the vinyl bag to enclose it and put a desiccant inside. If the temperature and humidity are always high, consult Yokogawa sales.
Countermeasures after failure	If condensation or corrosion occurs, consult Yokogawa sales.	Install the air conditioners and keep the temperature and humidity within the specified range. The entrance for external cables and cable riser should be sealed with putty. Seal up the building apertures. Do not keep the windows open. Remove any powerful exhaust fan. If condensation or corrosion occurs, consult Yokogawa sales.	Install the air conditioners and keep the temperature and humidity within the specified range. The entrance for external cables and cable riser should be sealed with putty. Do not open the windows. Seal up the building apertures. Use the double door to prevent outside air from entering. If condensation or corrosion occurs, consult Yokogawa sales.	
Periodic inspection	Record and monitor the temperature and humidity at the air inlet.	-	-	-

Dust Accumulation

Table List of Corrective Measures by Failure Factor

	Stored	Dusty	Conductive dust (carbon fibers, etc.)	Splash of oil mist
Industries with poorenvironments	Water utility	Cement, paper making, steel making, metal industries, etc.	Carbon resin, carbon, material production, iron and steelmaking, metal industries	Chemical fiber (spinning)
Details of failures	Rust/corrosion and partial failure have been caused by long-term storage.	The same failure as under the highly humid environment occurs. Light of the photosensor is shut off, and the switch contact is defective. Contact operation is not satisfactory.	Reduced insulation and shortcircuiting cause circuit operation failure and increased errors. High tension parts such as power supply are broken or burnt.	Deteriorated insulation causes circuit operation failure and increased error. The coating melts, causing connector contact failure.
Phenomena	The equipment is left under the humid, high-temperature conditions without being air-conditioned or being supplied with power.	Outside dust enters through the open window and wall apertures. The cable riser is not sealed. Dust enters from under the floor. People enter the room with dirty shoes. The fan filter is not cleaned.	The room is located close to the carbon factory, and carbon particles is sucked into the room by the fan. Or the carbon particles sticking to the human clothing and dirty shoes are sucked by the fan into the equipment.	Oil mist fills the room, and is sucked by the fan in the equipment. Oil mist sticks to the cable and enters the room. The equipment is installed at the outlet of the air including oil mist.
Preventative measures	If the equipment is not used for a long term during the storage, use the vinyl bag to enclose it and put a desiccant inside.	Use the double door. Do not allow entry into the room with dirty shoes. (Use the dust removing mat.) Clean the cable pit after connection. Seal up the window apertures. The cable riser should be sealed with putty. Send the dry, clean air into the cabinet.	The printed circuit board should be provided with coating. The windows should be designed not allow entry of dust. The cable riser should be sealed with putty. Use the double door. Use the air shower before entering the room. It should be strictly prohibited to enter the room with, dirty shoes.	The printed circuit board should be provided with coating. The equipment built into the cabinet should not contact the oil mist. The oil mist should sticking to the cable should not enter. Allow fresh air to enter the equipment and increase the internal pressure. Do not place the equipment at the air outlet.
Countermeasures after failure	If condensation or corrosion occurs, consult Yokogawa sales.	Use the cleaner to clean inside the printed circuit board and cabinet. Perform the above items depending on the case. If condensation or corrosion occurs, consult Yokogawa sales.	Clean inside the cabinet. Clean the instrument room. Perform the above items depending on the case. If condensation or corrosion occurs, consult Yokogawa sales.	Clean inside the cabinet. Clean the instrument room. Perform the left items depending on thecase. If condensation or corrosion occurs, consult Yokogawa sales.
Periodic inspection	-	Clean the instrument room every day with a cleaner. Clean the fan filter.	Clean the instrument room every day with a cleaner. Clean the fan filter.	-

Gas Atmosphere

Table List of Corrective Measures by Failure Factor

	Entry of sea breeze and salt	Chlorine gas	Nitric acid gas	Hydrogen sulfide and sulfurous acid gas	Ammonium gas
Industries with poor environments	The factory is close to the seaside, is located on the sea, or close adjacent to the salt making factory.	Chemical, papery making, metal, food industries, water service	Factories using nitric acid and nitric acid gases	Electric power, steel making, petroleum refining, gas industriess,paper making, sewage disposal plant, non-ferrous metal refinery, etc.	Chemical fertillzer, sewage disposal
Details of failures	Sticking of salt causes condensation and electrolyte solution causes corrosion, the pattern is broken.	The metal is corroded. (Metal corrosion is conspicuous when it is humid and is reduced when not very humid.)	Deteriorated insulation causes circuit operation failure and increased error. The metal corrodes, causing connector contact failure and shortcircuiting.	Iron, nickel and chrome are rusted, and aluminum, copper and zinc are corroded (by sulfurous acid gas), affecting the gold, silver, platinum and palladium. This causes contact failure and shortcircuiting of the IC lead wires.	Stress corrosion cracking for copper alloy (stress corrosion cracking at contact portion)
Phenomena	The factory is located at the seaside, and sea breeze enters the room through the window. It is sucked into the equipment. Salt enters from the salt making room located nearby.	Chlorine gas is used in the adjacent factory. The window is open, and the door is often opened and closed. The cable riser is not sealed. The outside air is sucked by the fan into the equipment.	The equipment is installed within the nitric gas atmosphere of the nitric acid factory. The nitric gas enters inside the equipment.	The room apertures and cable riser are not sealed, and gas enters inside the equipment.	Same as left Proximity use of copper made unit and phenol resin.
Preventative measures	The relative humidity of the instrument room must be kept at 50%±10% by the use of air conditioners. There should occur no sudden temperature change or condensation. Use a double door to prevent entry of the salt-laden air.	The relative humidity of the instrument room must be kept at 50%±10% by the use of air conditioners. Sudden temperature rise or condensation should notbe allowed to occur. Use a double door; it should not be left open. Seal up the building; apertures. The cable riser should be sealed with putty. Allow fresh air to enter the equipment and increase the internal pressure.	Same as left	Same as left	Same as left
Countermeasures after failure	The relative humidity of the instrument room must be kept at 50%±10% by the use of air conditioners. Use a double door to prevent constant opening of the door. Seal up the building apertures. The cable riser should be sealed with putty. If condensation or corrosion occurs, consult Yokogawa sales.	The relative humidity of the instrument room must be kept at 50%±10% by the use of air conditioners. Sudden temperature rise or condensation should not be allowed to occur. Use a double door; it should not be left open. Seal up the building; apertures. The cable riser should be sealed with putty. Allow fresh air to enter the equipment and increase the internal pressure. If condensation or corrosion occurs, consult Yokogawa sales.	Same as left	Same as left	Same as left
Periodic inspection	-	-	-	-	-

4. Installation Environment Checklist

To prevent condensation and dust entry before turning on the power during or after the instrumentation work, conduct the inspection according to this document. If any failure is found, be sure to remedy it.

Table Inspection Items during or after the Instrumentation Work to be Conducted before Tuning on the Power

	Daily inspection and management items	Remarks
Ambient environment	☐ Check if water leaks from the panel floor or ceiling. ☐ Check if rainwater enters the cable duct or the wiring pit. ☐ Check if wind and rain are blown into the room. ☐ Confirm that the air conditioners are operating. ☐ Confirm that dehumidifiers are operating. ☐ Make sure that the cable duct and bottom are covered (sealed with putty) to prevent dust and moisture from entering. ☐ Check if the dust seal may be removed while electronic equipment is transported. ☐ Check that the damage prevention measures for transportation have been sufficiently implemented, such as protecting the equipment with plywood sheeting or similar. ☐ Check if outside air is entering from the door or windows. ☐ Check if any dust enters from entrance to instrument room. ☐ Check if the cabinet and its surrounding area are cleaned. ☐ Check if there is any object which may drop. ☐ Check if any dust enters from the ventilation air port. ☐ Check if salt, iron particles, corrosive gas or carbon enter the room. ☐ Check if the equipment is exposed to direct sunlight.	
Product status	☐ Check if condensation or its trace can be found inside and outside the cabinet. ☐ Check if discoloration or corrosion has occurred inside and outside the cabinet. ☐ Check if condensation or its trace can be found on the cards. (Check if the cards in the cabinet include any blurred characters and the like by the random inspection and make sure that the cabinet is completely normal.) ☐ Check if the dust is accumulated inside the cabinet.	

5. Supplementary Data-related Standards of Environment Definition 1

Installation in environments with high temperatures and humidity, dust, and corrosive gas as described in this document is also referred to in the "Installation Standards for Information and Control Equipment for Industrial Use" (JEIDA-63, 2000) issued by The Japan Electronic Industry Development Association. The following are its key points:

Relationship between Environment and Reliability

The reliability and servicing life of electronic equipment greatly depend on the operating environment. It is essential for ensuring reliable operation and prolonged servicing life that the equipment is used not only within the range of environment resistance standards but also in a more satisfactory environment. For instance, if a piece of equipment is always used at 35°C when its operating temperature ranges from 5°C to 40°C, generally its estimated failure rate almost doubles compared with operation at 25°C.

If corrosive gas is present in the environment, the corrosion of the equipment's contacts and printed circuit boards is accelerated more than in a cleaner environment, resulting in a reduced servicing life. Moreover, if dust can be easily generated in the environment, filters must be cleaned and replaced more often.

Scope

It is recommended that users indicate information about the environment conditions under which equipment is to be installed and that they control equipment for industrial use in compliance with these standards.

It is also recommended that manufacturers of the equipment indicate operating environment conditions for system equipment in compliance with these standards. Should the equipment be used in an environment that does not satisfy the conditions specified by the manufacturer, the equipment would not be guaranteed by the manufacturer if any failure occurred, nor would its required reliability be ensured. The equipment may not even achieve its specified performance. If it is not possible for the equipment to achieve the performance of a class specified by these standards, special classes may be specified by consultation between the user and the manufacturer.

5.1 Temperature and Humidity

5.1.1 Influence of Temperature and Humidity

The room and building where the equipment and recording medium are installed or the environment for their transportation and storage shall meet the specified temperature and humidity requirements. If the temperature and humidity requirements specified for the equipment and recording medium are not met, the following adverse effects may occur:

If temperature and humidity factors are combined with other factors such as corrosive gas, dust, static electricity, the adverse effects will be more serious; so care should be taken to avoid this.

When installed at high temperature:

- Increased failure rate and reduced service life
- Increased errors of analog signal (during operation)
- Operation failure (at the time of startup and during operation)
- Equipment overheating (during operation)
- Growing rust and corrosion
- Deteriorated grease

When installed at low temperature:

- Increased errors of analog signal (during operation)
- Operation failure (at the time of startup and during operation)
- Deteriorated grease

When installed in high-humidity environment:

- Electric corrosion and operation failure when the dew condensation and dust pollution are combined (accompanied by abrupt temperature change)
- Growing rust and corrosion
- Reduced insulation
- Deteriorated grease
- Solidified toner

When installed in low-humidity environment:

- Equipment operation failure and faults by static discharge fault
- Paper feed failure for printer, etc.
- Operation failure due to expansion and deformation of recording medium

When temperature change rate is large:

- Electric corrosion and operation failure when dew condensation and dust pollution are combined
- Operation failure due to temperature variations in the equipment

Failure rates of information and control systems for industrial use are susceptible to the ambient temperature change. Therefore, the ambient temperature should be maintained within the ranges indicated in Section 5.1.6 “Precautions for Installing the Air Conditioning System” with air conditioners.

The following shows the failure rate of the electronic devices due to temperature change.

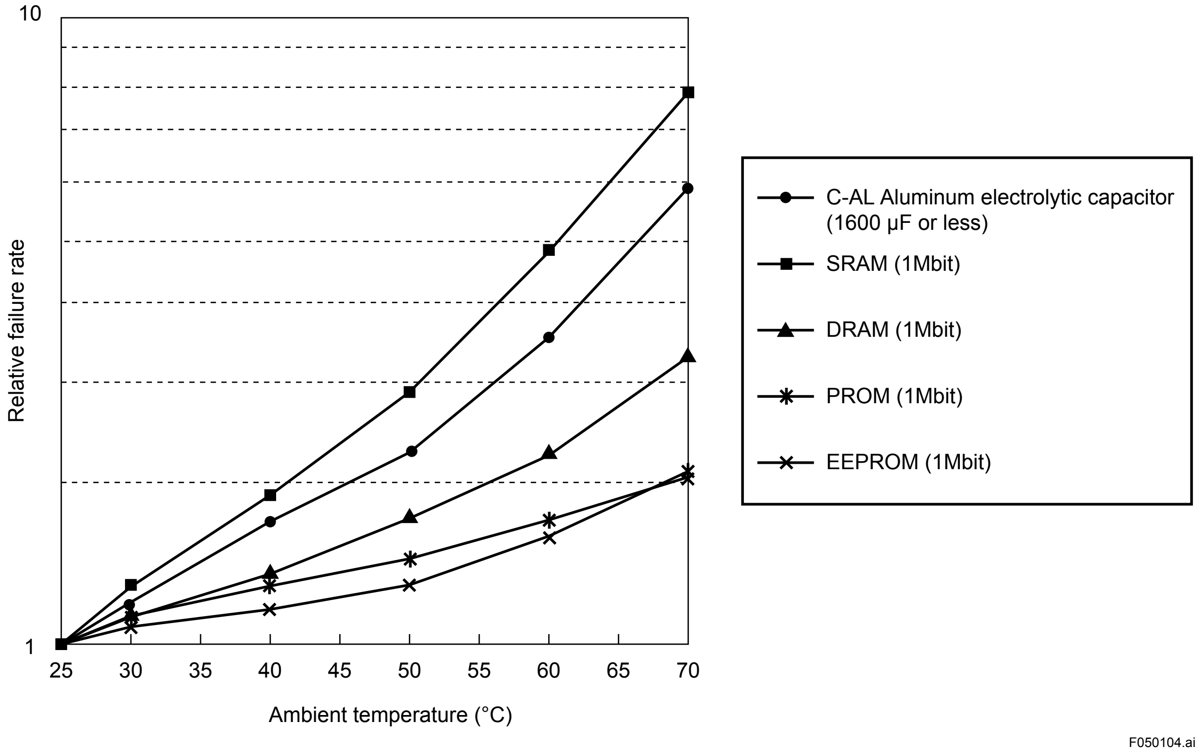

Figure Examples of Failure Rate Change of Electronic Devices by Temperature Change (Example of Calculation by MIL-HDBK 217F)

5.1.2 Classification

The temperature change rate and relative humidity ranges for the normal operation and maintenance of information and control systems for industrial use are set according to the following classifications:

Temperature (°C) (*1):	Class A:	15°C to 30°C
	Class B:	5°C to 40°C
	Class S1:	0°C to 50°C
	Class S2:	-10°C to 60°C
	Class S3:	-25°C to 70°C (transportation or storage only)

*1: Ambient air temperature surrounding information and control equipment.

Temperature change rate:	Class A:	Within ±5°C/hr
	Class B:	Within ±10°C/hr
	Class S1:	Within ±15°C/hr
Humidity (*2):	Class A:	40% to 70% RH, (no condensation) at a wet bulb temperature of 26°C or less
	Class B:	20% to 80% RH, (no condensation)at a wet bulb temperature of 30°C or less
	Class S1:	10% to 90% RH, (no condensation)at a wet bulb temperature of 30°C or less
	Class S2:	5% to 95% RH, (no condensation) at a wet bulb temperature of 30°C or less
	Class S3:	5% to 100% RH, (including condensation) at a wet bulb temperature of 30°C or less (transportation or storage only)

*2: The following figure shows the range of each classification in terms of air diagrams. When the absolute humidity is high, dew condensation is caused by even a slight temperature change. Thus, care should be taken to prevent abrupt temperature changes. Preferably operation should be started after setting the temperature and humidity to the values specified as optimal for operation.

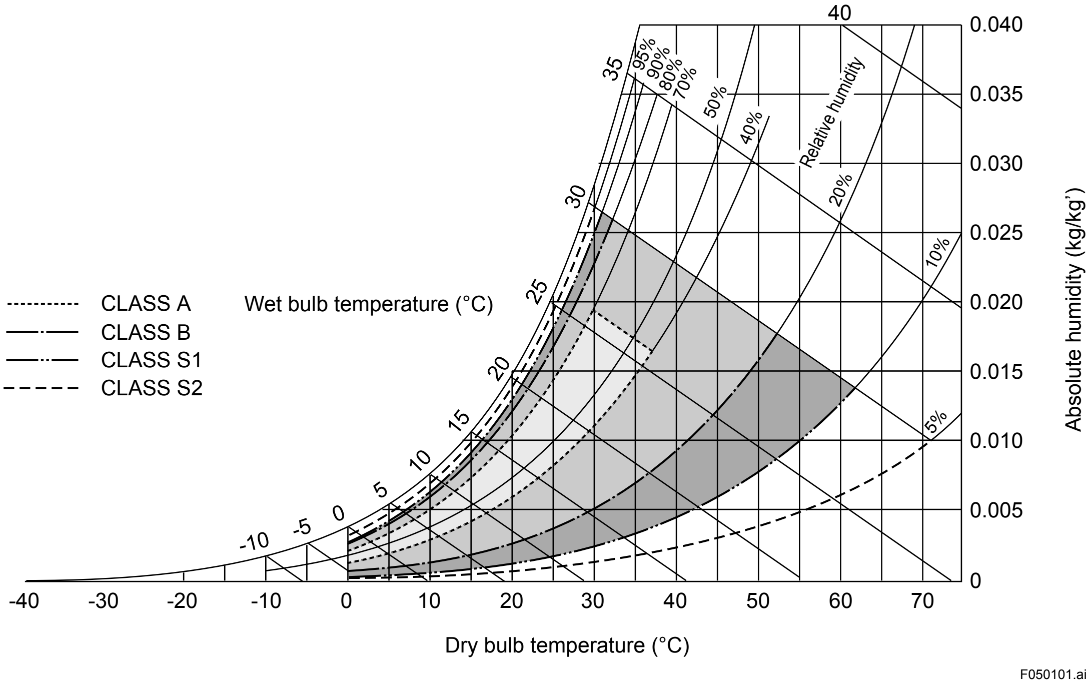

Figure Humidity Ranges According to Classification

For equipment which does not conform to the above classifications, the temperature and humidity ranges can be set separately. In that case, it is preferable to use the following values:

Table Recommended Temperature and Humidity Values

Temperature (°C)	-25, -10, 0, 5, 10, 15, 20, 30, 35, 40, 50, 60, 70
Temperature change rate (°C/hr)	±5, ±10, ±15, ±20
Humidity (%RH)	5, 10, 20, 30, 40, 60, 70, 80, 90, 95, 100

5.1.3 Time Period for Transportation and Storage

When equipment is stored for a long term, temperature differences between day and night will cause stress, which in turn will cause deterioration of the parts, of the oil and grease, and of the aluminum electrolytic capacitor due to extended suspension of the power supply. The storage conditions specified under this standard are applicable to storage periods of two or three months. If the equipment is to be stored for a longer time, the environmental storage conditions must be determined separately through discussions between the user and the manufacturer.

5.1.4 Recording Medium

The storage temperature and humidity requirements for the recording medium employed in the information and control system should preferably be set within the ranges shown in the following table:

Table Recording Medium Storage Conditions

Recording medium	Storage conditions	
Flexible disk	Temperature Humidity	5°C to 50°C 10% to 90% RH
Magnetic tape	Temperature Humidity	5°C to 30°C 20% to 80% RH
Cassette tape	Temperature Humidity	5°C to 30°C 5% to 80% RH
Magnetic disk (HDD)	Temperature Humidity	-20°C to 60°C 10% to 80% RH
Optical disk (CD-ROM)	Temperature Humidity	-20°C to 50°C 5% to 90% RH
Optical disk (MO)	Temperature Humidity	-10°C to 55°C 5% to 90% RH
DVD	Temperature Humidity	-10°C to 50°C 5% to 85% RH

5.1.5 Temperature and Humidity Control

Install the equipment in a fully enclosed indoor location, free from the direct influence of the weather. Constant control of the temperature and humidity after installation of the equipment is pivotal to the detection of environmental failures in the earlier stages and to ensure normal system operation and maintenance. It will also facilitate detection of the causes of the trouble. For temperature and humidity control, use a hygrothermograph. The following describes the major points to be considered:

- The equipment's air inlet is the optimum place to install the hygrothermograph. Note that there is a difference in the measuring conditions for the standard value (1.5 meters above the floor level); so relative distance must be determined for the control.
- Differences in the temperature and humidity occur depending on the room conditions. It is preferable to use two or more measuring points.

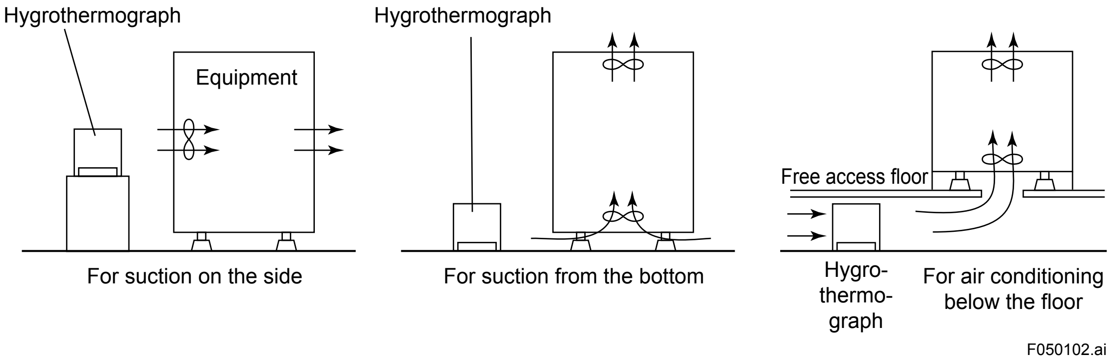

Figure Hygrothermograph Installation Position

5.1.6 Precautions for Installing the Air Conditioning System

In order to ensure the correct operation and maintenance of the system, the temperature and humidity must be set within the range specified for the equipment and recording medium. The air conditioning system is extremely important and should be installed to meet the following conditions:

- The air conditioning system should be used specifically for the information and control system.
- Two or more air conditioners should be installed.
  (Information and control system failure occurs frequently due to a sudden rise in temperature immediately after the failure of one of the air conditioners.)
- Temperature and humidity should be maintained within the specified ranges indicated below at all times.

  Temperature: 25°C ± 2°C in summer or 20°C ± 2°C in winter

  The temperature difference between summer and winter has been determined in order to prevent extreme variations in humidity.

  Humidity: 50% ± 10% RH
- Excellent circulation
- The air conditioners should be provided with filters to remove dust and corrosive gas.
- The air conditioners should be controlled to maintain the specified conditions necessary for the equipment to meet information and control system temperature and humidity requirements.
- Entry of outside air may introduce corrosive gas and dust, therefore inside air should be used in circulation whenever possible.
- The humidifier employed to improve low humidity conditions should preferably be of the boiling type or pure water type, since the service water direct spray type (supersonic type and mist spray type) may release calcium or salt contents.

Reference Standards

- Japan Standards Association: Industrial-process Measurement and Control Equipment-Operating Conditions Part 1 Climatic Conditions (IEC 60654-1, 1993)
- Japan Electric Measuring Instruments Manufacturer’s Association: General Rules for Indication of Industrial Instrument Performance (JEMIS 022)
- Japan Electric Measuring Instruments Manufacturer’s Association: Installation Environment for Microcomputer Applied Measuring Instrument Control Equipment (JEMIS 033, 1997)
- Japan Automobile Manufacturers Association, Inc.: General Rules on Environmental Test Method for Automotive Electronic Equipment (JASOD 001)
- Japan Standards Association: Environmental Standards according to Equipment (JIS X6223, X6243, X6277, and X6281)
- Japan Standards Association: Operating Environment Conditions for Process Measuring and Control Equipment for Industrial Use (JIS C1804, 1995)

5.2 Dust

5.2.1 Dust Conditions

Classification of Dust Environments

The following shows the classifications of dust environments:

Class A: 0.1 mg/m^3 or less

Class B: 0.3 mg/m^3 or less

Class S: 10 mg/m^3 or less (*1)

*1: The upper limit value of 10 mg/m^3 in Class S conforms to the permissible concentration of harmful dust particles in a notification issued by the Ministry of Health, Labor and Welfare. General dust particle concentration is permitted up to 15 mg/m^3, but we have adopted the stricter value. The Class S value represents the limit where humans can comfortably exist. The reference for dust concentration is approximately 0.07 mg/m^3 in clean, non-smoking rooms, and is 0.2 mg/m^3 in rooms where smoking is permitted.

5.2.2 Measures Against Dust

The following two methods are available to protect the information and control system from dust:

- One method is to provide dust preventive measures in the room where the information and control system is to be installed. When the control room is custom built and the system is installed in an environment sealed off from the outside there is not a dust problem. When the information and control system is to be installed in the operation room, however, installation of a dust collector is essential. Even if the control room is custom built, it is essential to prohibit entering the room with soiled shoes. Problems due to cigarette smoking cannot be ignored (rather than the adverse effects of the smoke itself, indirect accidents such as dropping ash on the keyboard, flexible disks or similar accessible components cannot be ignored). To prevent this, smoking must be prohibited. Even when a dust collector is installed, it is necessary to pay attention to secondary pollution (generation of ozone, etc.), and the re-dispersion of the collected dust and fine particles after filtration in cases where filtering type collectors have been installed.

- When the control room is not custom built or when the environmental improvement is not sufficient, the equipment itself or the enclosure itself including the equipment should be protected against dust as a second dust preventive measure. For sedimentary dust, a dust preventive cover should be provided to avoid the entry of dust, or the equipment should be designed to have the smallest possible number of apertures or openings. However, an enclosed structure is essential to combat airborne dust or sedimentary dust which tends to be re-dispersed. When the equipment and enclosure are provided with dust preventive measures, the most important issue will be the problem of heat. When equipment is installed at the work field, the ambient temperature may be greatly increased. Dissipation of this heat is not easy when the equipment itself generates heat, therefore the interior of the equipment will become considerably hot. To prevent this, it is essential to study how to discharge the heat out of equipment which is provided with dust preventive measures. To solve this problem, use of a heat exchanger will be more effective than the method of cooling the equipment directly using outside air.

  Air filters are installed on the cooling air inlets for most equipment using forced cooling systems. Therefore, these filters must be cleaned and replaced on a periodic basis, so that they will not become clogged with dust.

Supplementary Description

For information and control systems, attention must be paid to invisible dust as well as to dust visible to the naked eye. None of the currently available filters can remove all the dust entering the equipment. Preparation of an environment with minimum dust or improvement of the environment is extremely important to avoid unexpected problems.

For reference in regard to dust particles, a single deep inhalation of cigarette smoke releases approximately 10,000,000 particles with at least 0.5 μm diameter in the air.

Reference Data

- Japan Standards Association: Test dust (JIS Z8091)
- Japan Ordnance Association: Environmental Test Method and Engineering Guidance (MIL-STD-810D [July 19, 1983])
- Japan Standards Association: General Rules on Control Switch (JIS C4520)
- Japan Standards Association: General Rules on Dust-preventive and Dust-resistance Test for Automotive Parts (JIS D0207)
- Japan Association of Industrial Health: Recommendations on Permissible Concentrations (1988), Vol. 30, 1988
- Association for Working Environment Measurement: Permissible Concentration of Chemical Substances and Physical Environmental Factors (Recommendations for fiscal 1983-84 and proposed revisions)

5.3 Corrosive Gas

5.3.1 Influence of Corrosive Gas

Corrosive gas is not only discharged in the factory production process but also contained in the exhaust gas discharged from automobiles. Hydrogen sulfide gas expelled in areas with natural hot springs and gases generated from stagnant river beds near streets may cause problems. The development of industries and the growing population in urban areas has caused wide-reaching air pollution.

The environmental regulation standards for health protection that are stipulated for the atmosphere, the environment in general rooms and in industrial labor environments include the air pollution prevention act, building environment health control standards and recommendations on permissible concentrations issued by Japan Association of Industrial Health.

The major issues that arise from atmospheric corrosion in the information and control system are as follows:

- Contact faults in switches and connectors
- Wiring breakdown and local corrosion of the piping
- Rust, wear, corrosion, corrosion fatigue and rupture
- Migration of the printed wiring board and shortcircuiting by whiskers
- Electro-corrosion due to current leakage
- Rust and local corrosion on the outer casing

Unlike other environmental conditions such as temperature and humidity, the influence of corrosive gas on equipment does not appear immediately. Trouble occurs several months to several years after the equipment has been delivered. When such trouble is detected, corrosion may have already progressed to a considerable degree. If the equipment comes into contact with some other object during maintenance and repair, the trouble may be caused.

The influence of corrosive gas is very serious. When the specified level is exceeded, results do not appear immediately, unlike situations involving temperature and humidity. Therefore, it is essential to set up standards for the equipment pertaining to corrosive gas, and to provide countermeasures through consultation between the manufacturers and users before the system is installed.

5.3.2 Types of Corrosive Gases

The following gases affect the information and control systems:

- Sulfurous acid gas (SO_2)
- Hydrogen sulfide (H_2S)
- Nitrogen oxide (NO_X)
- Chlorine (Cl_2)
- Ammonia (NH_3)
- Ozone (O_3)

The table below shows the sources of these corrosive gases, followed by a description of their influence.

Table Sources of Corrosive Gases

Corrosive gas	Sources
Hydrogen sulfide (H_2S)	Gases discharged from oil refining, the gas industry, the ammonia industry, papermaking, the steelmaking industry, the atmosphere in volcanoes, natural hot spring areas and sewage disposal plants
Sulfurous acid gas (SO_2)	Combustion of oil and coal as fuels and materials, gases discharged from gasification equipment plants, gases discharged from the iron and steel industry, the non-ferrous metal refining industry, the sulfuric acid industry, the sulfur refining industry, the papermaking industry, and gases discharged from incinerators
Nitrogen oxide (NO, NO_2)	Gases discharged from solid fuel boilers, the sulfuric acid industry and internal combustion engines such as automobiles
Chlorine (Cl_2)	Gases discharged from the chemical industry, the papermaking industry, and water disposal plant processing
Ammonia (NH_3)	Gases discharged from the chemical fertilizer industry, and from phenol resins
Ozone (O_3)	Photochemical generated smog and electric dust collectors

Sulfurous Acid Gas

Metal objects are said to become rusty faster in urban environments than in rural ones. This is because the rusting speed of metal, especially of iron, is aggravated by the amount of sulfurous acid gas contained in the atmosphere. Furthermore, the progress of the corrosion differs greatly according to the temperature, humidity and presence of dust. It tends to increase in relation to the concentration of sulfurous acid gas.

Nickel (Ni) and chromium (Cr) also oxidize the sulfurous acid gas in the air, creating a thin layer of sulfuric acid, which erodes nickel and chromium. Furthermore, sulfurous acid gas also erodes aluminum and zinc which are much used in information and control systems.

Hydrogen Sulfide

Hydrogen sulfide gas causes serious detriment to such precious metals as gold (Au), silver (Ag), platinum (Pt) and palladium (Pd) which are used for the contacts of information and control systems. It also reacts with paint containing lead compounds, changing it into black lead oxide. This gradually oxidizes over time, causing the paint surface to become white.

Silver is changed into silver sulfide (Ag_2S) by the hydrogen sulfide gas and increases the resistance at electric connections. For such dynamic contacts as relays and switches, the increase of the resistance is greater with mechanical on-off operations than without such operations. This is believed to be due to the fact that the thin film of silver sulfide is abraded by the on-off operations. When stress is applied, the silver sulfide tends to grow in whiskers, which may cause shortcircuiting.

Conversely, in the case of gold, platinum and palladium, the contact resistance tends to increase when on-off operations are performed. This is assumed to be because the on-off operation of the contacts gives rise to a “mechano-chemical reaction” which promotes sulfurization of the contact point.

In cases with static contact such as connectors, the silver used as contact material is not exposed to the atmosphere in the connected state; therefore, contact resistance does not increase very much. However, when it is kept in the open state, contact resistance increases very much. Thus, problems may occur when the connector is kept open for long time due to modifications or additional installation of equipment.

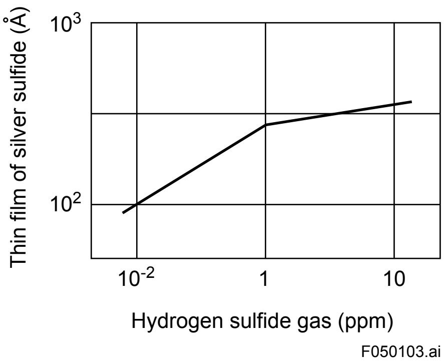

Figure Influence of Hydrogen Sulfide Gas on Sulfurization of Silver

As described above, hydrogen sulfide gas has serious effects on the reliability of the contact parts. The printed wiring board connector test method under conditions with an atmosphere of hydrogen sulfide gas is specified in “Sulfurization Test Procedure for Printed Wiring Board Connectors” (JEIDA-25-1974).

Nitrogen Oxide

Nitrogen monoxide (NO) affects the information and control system by reduction when it is changed into nitrogen dioxide (NO_2), which then reacts with the moisture (water) in the air to become nictric acid (HNO_3), thereby affecting the information and control system. Secondarily, ultraviolet rays or a certain type of hydrocarbon participate in the reaction generates a peroxide such as ozone (O_3). When special conditions such as atmospheric conditions are added, so-called photo chemical smog will be generated. This may deteriorate rubber products including packing materials used in the equipment.

Salt

Chlorine gas (Cl_2) and hydrochloric acid (HCl) are extremely corrosive and corrode almost all the metals used in the information and control system. They also damages and cause deterioration of many of the plastic and rubber products, causing swelling and cracking and similar aging. The effect of chlorine gas differs greatly according to humidity. At lower humidity levels, its effect is reduced.

In the industrial field, salt (NaCl) is electrolyzed to produce chlorine. When hydrochloric acid (HCl) is to be produced from this, liquid oxygen and hydrogen are directly combusted and the gas is cooled. In this case, chlorine is mixed with the exhaust gas discharged from the cooling tower. The chlorine used for sterilization of the water service also causes problems.

Ammonia

Ammonia is less corrosive than other acid gases but it causes stress corrosion cracking of the copper alloy. The stress corrosion cracking often occurring in the contact parts is caused when the brass used close to phenol resin is exposed to the ammonia gas generated from the resin.

Ozone

Ozone corrodes and deteriorates rubber and plastic products rather than metals. When the plastic material often used for the connector insulator is corroded by ozone, the spring holding parts will deteriorate, resulting in reduced contact force of the contact piece, which, in turn, may cause trouble. The concentration of the ozone which causes corrosion and deterioration cannot be described generally; it differs according to the type of the rubber, the applied stress and other elements.

5.3.3 Other Factors Responsible for Atmospheric Corrosion

Other factors responsible for atmospheric corrosion include temperature, humidity and brine particles.

Temperature

The influence of the temperature in atmospheric corrosion does not include dry corrosion where water is not a factor. Temperature promotes corrosion by its effect on moisture (water) and other factors.

Humidity

In addition to the direct effect of moisture on metals and plastics, humidity reacts with other factors. This reaction results in two types of corrosion: (a) corrosion caused by the acid which is produced by corrosive gas in combination with moisture, and (b) electrochemical corrosion caused by the combination of electrochemical corrosion and different metals; where the electrochemical corrosion is produced by a soluble material in the dust that is present reacting with moisture (water).

Dust

The influence of dust is found in two types of corrosion: (a) corrosion caused by dust clinging to the surface of the information and control system which attracts corrosive gas and moisture, and (b) corrosion caused by an electrolytic solution which is produced when a soluble material in the dust that is present transforms into condensed dew due to chemical condensation, even when the relative humidity has not reached 100% due to the dust.

Sea salt particles

Sea salt particles clinging to the information and control system produce dew condensation by chemical condensation, and change into an electrolytic solution, thereby causing corrosion. The major components of the sea salt particles are sodium chloride ($NaCl$: approximately 75%) and magnesium chloride ($MgCl_2$: approximately 10%), with a critical humidity at 20°C of 75% and 33% respectively.

5.3.4 Classification of Corrosive Gas Environment

Classification of Corrosive Gas Environment

A corrosive gas environment is classified according to the type of corrosive gas, and temperature, humidity and pollution which are interactive factors for atmospheric corrosion. These factor levels are given evaluation scores, and are classified according to the total scores as follows:

Environment	Class	Total evaluation scores
Excellent: Cold and dry with no detectable gas	Class A	≤9
Normal: Relatively cold and dry with little gas	Class B	10 to 25
A little humid with little gas	Class S1	26 to 36
Hot, humid, and a little gaseous	Class S2	37 to 50
Hot, humid, and gaseous	Class S3	≥51

The table below shows the evaluation scores for each factor:

Environmental factor \ Category			1		2		3		4	
			Measurement	Score	Measurement	Score	Measurement	Score	Measurement	Score
Annual average temperature (°C)		A	≤20	1	≤25	2	≤30	4	>30	8
Annual average humidity (%)		B	≤50	1	≤60	8	≤75	16	>75	24
Gas (ppm)	SO_2	C1	≤.04	1	≤.08	3	≤.2	6	≤5	9
	NO_2	C2	≤.02	1	≤.05	3	≤.1	6	≤5	9
	H_2S	C3	≤.003	1	≤.01	8	≤.1	14	≤10	20
	Cl_2	C4	≤.002	1	≤.01	10	≤.1	20	≤1	30
	NH_3	C5	≤.1	1	≤1	2	≤10	4	≤100	8
Pollution degree (equivalent salinity) (mg/cm^2)		D	≤.03	1	≤.06	8	≤.12	16	>.12	24

Total evaluation score = A + B + C1 + C2 + C3 + C4 + C5 + D

About Classification of Environments

Information and control equipment systems are used under a variety of combinations of atmospheric corrosion factors, and are influenced by the complex environment. To identify the characteristics of these influences, each factor is given a certain evaluation score in light of its impact on metal. When an actual environment is to be evaluated, each factor is measured and the corresponding scores are totaled (A + B + C1 + C2 + C3 + C4 + C5 + D). The environment is then classified based on the total score. Individual scores for the factors are determined according to a sufficient number of actual results measured.

Atmospheric corrosion factors cause the information and control equipment systems to corrode, resulting in irreversible damage. The degree of corrosion is influenced by the type and concentration of gas, temperature and humidity, and the time period for which the system is exposed to the factors. Even if a gas is not concentrated, it can cause a considerable degree of corrosion when temperature and humidity are high, or when the gas is present over an extended period of time. To this end, basically the measurements for each factor are determined from averages which were obtained over a prolonged period. In classifying the environment, it is also necessary to take the number of years which the information and control system has been used into account, and a 10 year period has been used as a guideline.

Class A indicates excellent environments in which proper facilities are installed that can improve the environment for information and control equipment systems, and corrosion does not occur to such an extent that the system’s reliability would be affected.

Class B indicates the most common environments in which proper facilities are not installed that could improve the environments for information and control equipment systems. Corrosion does not occur to such an extent that the system’s reliability would be affected in a Class B environment, either, as is the case with Class A. However, information and control equipment systems can easily be subject to corrosion, once corrosive gas or dust enters an environment when it is not dry enough. Therefore it is important to make every possible effort to avoid the entry of corrosive gas and dust, as well as to perform detailed inspections regularly. A typical Class B environment is low both in temperature and humidity with a negligible amount of two or more corrosive gases present, is low in temperature and humidity, but a particular corrosive gas and a negligible amount of pollution are detected, or is relatively low in humidity and a particular corrosive gas or a negligible amount of pollution is evident.

Classes S1 to S3 are high both in temperature and humidity with the presence of corrosive gas, and are highly polluted, in which it takes from several months to a few years to result in corrosion that can damage information and control equipment systems. Corrective measures for Class S1 to S3 environments include improving installation locations, and tightly enclosing the system.

Reference Data

- Watanabe, et al.: Symposium on Corrosion Engineering and Weather Resistance for Electric and Electronic Equipment (1988)
- Japan Standards Association: Methods for Determination of Ammonia in Exhaust Gas (JIS K0099, 1998)
- Japan Standards Association: Methods for Determination of Sulfur Oxides in Exhaust Gas (JIS K0103, 1999)
- Japan Standards Association: Methods for Determination of Nitrogen Oxides in Exhaust Gas (JIS K0104, 1984)
- Japan Standards Association: Methods for Determination of Chlorine in Exhaust Gas (JIS K0106, 1996)

- Japan Standards Association: Methods for Determination of Hydrogen Sulfides in Exhaust Gas (JIS K0108, 1983)
- Japan Standards Association: Operating Conditions for Industrial-process Measurement and Control Equipment (IEC 60654-4, 1987)
- Japan Standards Association: Classification of Environmental Conditions (IEC 60721-3, 1997)
- Japan Standards Association: Instrument Society of America (ISA-S71.04, 1985)
- Ministry of the Environment: Quality of the Environment in Japan (1999)

6. Supplementary Data-related Standards of Environment Definition 2

One of the methods for measuring an environment involves exposing a sample in the environment over a specific period of time and determining the degree of corrosion in the environment from the sample. This method does not measure corrosion factors. The sampling method is described in the IEC 60654-4 and ISA-S71.04, 1985 standards. The following are the key points of ISA-S71.04, 1985:

Outline of Corrosive Environment Classificaion

The classification of the environment in which the process control equipment is installed is determined by the ANSI/ISA S71.04 “Environmental Conditions for Process Control Systems” standard. The environment having an atmosphere which contains steams and mists (liquids, coded L), dusts (solids, coded S), or corrosive gases (gases, coded G) is classified into four categories according the levels of these substances determined.

The four categories of the corrosive gas environment are defined as follows:

G1 (mild): A well-controlled environment in which corrosive gas is not the major cause adversely affecting the reliability of plant equipment. The corrosion level on the copper test piece is below 0.03 μm (see note below).

G2 (moderate): An environment in which corrosive gas can be detected and it could be determined that the gas is the major cause adversely affecting the reliability of plant equipment. The corrosion level on the copper test piece is below 0.1 μm (see note below).

G3 (harsh): An environment in which corrosive gas is frequently generated to cause corrosion and that it is necessary to provide special measures or employ specially designed or packaged plant equipment. The corrosion level on the copper test piece is below 0.2 μm (see note below).

GX (severe): A corrosive gas-polluted environment that demands special protective chassis for the plant equipment, specifications of which should be seriously determined by the user and a power unit manufacturer. The corrosion level on the copper test piece is 0.2 μm or more (see note below).

Note: Copper test pieces are used to determine the level of corrosion for the classification of the plant environment. The test piece is an oxygen-free copper sheet, which is 15 cm^2 in area, 0.635 mm in thickness, 1/2 to 3/4H in hardness. The test piece is placed in the plant site for one month and checked for any change before and after the test to determine the degree of corrosion (see table below). If the test period is shorter than one month, the result is calculated to obtain equivalent data using a expression defined by the standard.

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Guidelines for Installation Environment

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