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PACKAGED SUBSTATION

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1. OVERVIEW

What should be taken into account before installing an electrical equipment into use is its working environments. Highly reliable equipment would not only fail to perform its capabilities fully but also might require highly frequent maintenance, if operated under unfavorable environments.

Especially in a desert region or seaside area, it is indispensably necessary to take into account the high temperature, high humidity and air with a content of sand, dirt, dust and brine. This tells us the fact that a properly airconditioned electric room is required. On the other hand, to construct a building at a site located in such area, it is often difficult to secure the labor required while working efficiency may decline, and hazardous operations probably having to be often done.

A packaged substation has all of its systems installed and wired in its manufacturing factory and does not require any building-construction work. And it has been previously provided with the optimum environments for electrical equipment.
300 sets of packaged substations since 1970 and have delivered them widely, covering all over the world from the extremely cold Siberia to the highly humid and dustful Middle East, with Japan inclusive as well.

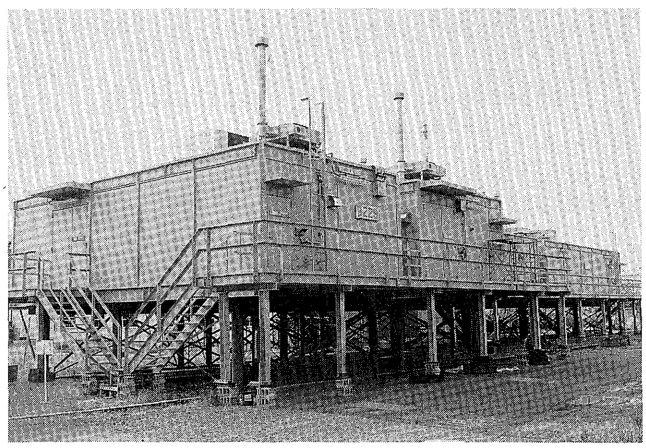
More recently, we have manufactured and delivered a total building number of 65 modules to sixteen substations in the Middle East. Technological features of these substations will be introduced herein to the reader.

2. STRUCTURAL FEATURES OF PACKAGED SUBSTATION

On a packaged substation, such electrical equipment as switching and control devices are installed, wired, adjusted and tested in factory. After that, they are transported as a completed electric room, which is to be locally set up on the foundation. To withstand an impact during transit, the packaged substation has its main beam constructed of the H-shape steel having a sufficient strength.

With a unit large scale substation, it is manufactured in factory as divided into a certain number of modules. When locally installed, the packaged substation has all of its components locally connected with a corridor. Thus, an interconnecting construction has been adopted to promptly form one substation. The corridor has a cable pit under the floor so as to dispense with any work of external wiring for an intermodule connection. Besides, an electromagnetical released type fire-resistant door is provided so that every module can be separated in the case of emergency, such as a fire or the like. And it interlocks with a fire alarm system referred to later.

Fig. 1 Packaged Substation for Middle East, under inspection at Fuji's assembly yard



In a dustful region, the door through which the operator is normally getting in and out is of double construction and provided with an air lock chamber.

Fig. 1 shows the package substation with four modules combined into one building. In the scene, a local assembly operation is simulted in factory for a comprehensive test prior to its shipment while checking every fitting of connections.

2.1 External wall steel plate

The packaged substation must have a service life expectancy of thirty years as an electric room to protect the electric equipment accommodated therein. It is necessary, therefore, to make a satisfactory study on the specifications of the steel plate which is to be applied to the external wall.

To protect the steel plate against corrosion, galvanizing is preferable. A coated zinc film will permit zinc to rust prior to iron so that zinc oxides will form a continuous coat of high adherence. Thus, galvanized steel plate is protected against external corrosive environments. A reference is made to the zinc life tests conducted in a seaside area and in an industrial area as the result of an expoure test at outdoor locations according to iron/steelmakers' data. And a 14.4-ounce:m^2 galvanized plate is selected. Welds on the galvanized steel plate are subjected to a surfacing treatment with a zinc paint so that the galvanizing performance may be reproduced as far as practicable. For surface protection, moreover, the galvanized steel plate is undercoated and then finish-coated. Periodic re-coating, moreover, permits every packaged substation to fully clear a desired life expecancy.

In an indutrial application, the packaged substation is required to have a fire-resistant construction and/or a pressurized explosion-proof construction, though dependent upon a classified area of the location. This will be detailed in the next section.

2.2 Fire resistant construction

Some packaged substation has a building designed to meet the fire-resistance specifications stipulated in both JIS and BS.

For wall materials, a 25mm thick fiber-admixed calcium silicate board and a 125 mm thick rock wool felt are inserted between external and internal steel plates in a wall construction designed to satisfy the requirements set forth in BS 476 "Fire Tests on Building Materials and Structures, Part 8, Test Methods and Criteria for the Fire Resistance of Elements of Building Construction." For test, both wall and door have been manufactured and tested for performance in the Japan Testing Center for Construction Materials. The external wall of a test specimen is heated with a burner so as to reach a temperature of 925°C in one hour in accordance with theBS 476. During this test, a temperature rise at every part of the internal wall is recorded and monitored. After completion of heating, it has been confirmed that every portion of the packaged substation is completely free from any problems, such as cracks, fusions, breakages and the like.

Figs 1 and *2* show a chart of the temperatures recorded on both external and internal walls during the heating test.

Fig. 2 Heating temperature measurement result

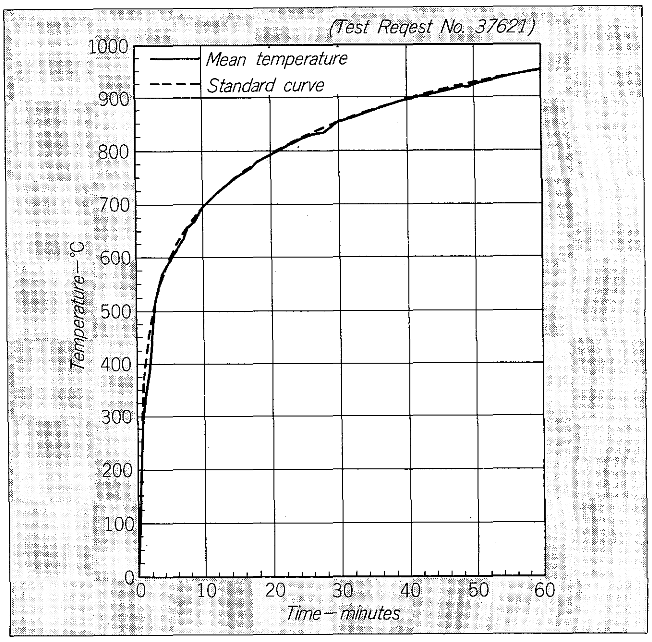
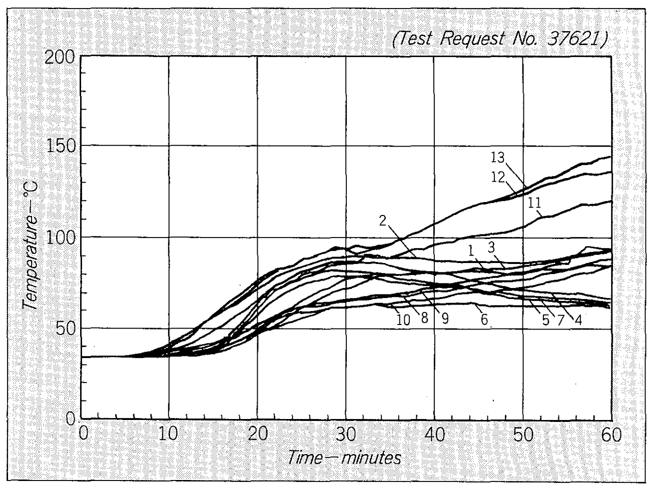


Fig. 3 Reverse side temperature measurement result



3. VENTILATION AND AIRCONDITIONING FAILITY

The airconditioning facility comprises an open-air intake/filtering unit, a pressurizing unit, a cooling/dehumidifying unit and an exhaust unit. The open-air intake/filtering unit removes the moisture drops, dirt and/or brine contained in the open air. The pressurizing unit prevents dirt and brine from entering from the exterior through an inter-module gap or when the door is opened and closed. The cooling/dehumidying unit cools down and dehumidies the hot and highly humid air taken in. The exhaust unit performs the function of preventing an overpressurization while keeping modules at an appropriate internal pressure.

The extent to which sand and dirt are suspended in the air depends upon an altitude above the ground level. The conditions required for a sandstorm to take place are a wind velocity of 10 meters per second or more and a relative humidity of approximately 50%. The dust temporarily swirled by such a sandstorm has a particle size of as large as 80 thru 1,000 μm only, without containing a fine particle size. The dust having so large a particle size is swirled up to an altitude of about one meter only above the ground and has a rapid rate of settling. That is, it will soon drop onto the ground but is swirled up again. This cycle takes place repetititively. Finely particled dust, on the other hand, will be swirled up due to a shock of the coarse

Table 1 Dust density in air at sand storm

Sand Storm: Wind Speed: 10 m/sec.		
1 m	0.02 g/cm^3 (20 g/m^3)	
3 m	570 mg/m^3 77% > 10 μm	
8 m	6 mg/m^3 31% > 10 μm	
Two Days Following:		
3 m	11.3 mg/m^3	< 5 μm
8 m	0.67 mg/m^3	
Clear Days:		
. . . .	0.2 mg/m^3	

Particle Size (μm)	Percent (%) by Weight Sand Storms		Percent (%) by Weight Settling Period	
	3 m	8 m	3 m	8 m
< 0.1	14	1	7	1
0.1 to 0.5	14	7	7	9
0.5 to 1.0	14	12	10	15
1 to 5	14	33	29	42
5 to 10	9	16	46	25
10 to 20	9	9	5	6
20 to 40	12	10		
40 to 80	29	10		
80 to 120	19	2		
120 to 160	7	2		
160 to 200	1	2		

NOTE) A total of particle size distribution percentages exceeds 100. It should be understood that such excess has arisen from an analytical technique applied.

particled dust when it drops onto the ground. The finely particled dust, once swirled up, is going upwards due to an uprising air current and to a wind. Such fine dust is settling down so slowly that it will remain suspended in the air for a long time. *Table 1* is a comparison of concentrations in the open air between the two categories of dust at altitudes of 3 and 8 meters above the ground. From the table, though it is a mere example, it may be gathered that the dust concentrations between the two altitudes mentioned above have a difference of one hundred times during the sandstorm and of approximately 17 times in two days thereafter.

The packaged substation reported herein has an air dust concentration suppressed, first of all, with the open air taken in at a height of 9 meters above the ground in such an area full of fine dust as a desert region. For filtering, moreover, an intertial separating type dust louver is employed in the first stage while a washable type mesh filter is applied to the second stage to filtrate the open air. The dust which has invaded is finally filtrated with a pleated medium type filter located at the inlet of the airconditioner.

A packaged substation located on a platform floating on the sea must have a filter capable of removing brine. Besides, it must not have its filtering efficiency decreased significantly due to the brine sticking thereto nor must any brine enter as dissolved. The moisture drops and mist over an ocean platform are a variation of sea water, whose higher wave crests are blown away and uprisen. Their quantity, however, will never exceed the rainfall of a squall in a tropical region. To remove such water drops and the sodium chloride (NaCl) occupying about 80% of the sea brine and to prevent them from resplashing, a weather louver is employed in the first filtering stage, a gathering medium coalescer in the 2nd stage and the duracel in the third stage to remove NaCl. And a pleated medium type filter is employed at the airconditioner inlet to circulate the internal air.

The purified air with those filters must be fed into the module to pressurize it so that no open air will enter through gaps and/or when a door is opened and closed. To this end, a blower is employed, which is so controlled as to keep the internal pressure constant combinedly with a internal-pressure-regulating electric damper.

Both open-air intake and pressurizing units, meanwhile, are of such double construction as to cause an automatic changeover to the standby units, thus allowing a continuance of operation even upon maintenance of the filter element or in the event of an abnormality in the pressurizing unit.

A packaged station to operate in a hazardous area, moreover, is manufactured in accordance with the NFPA 496. Requirements involved are an internal pressure of 2.54 mm and aobve in water column, with all doors closed, while the wind must flow out of their opening at a current velocity of at least 0.305 meters per second or more, with all the doors closed. Doors are required to have an opening area enough not to hinder the operator from making easy access to the packaged substation. To normally extrude a constant flow of wind out of such openings, on the other hand, it is necessary to take in a large quantity of air constantly. Directly taking in a large quantity of the hot open air would require too large a capacity of the cooler, leading to a waste of electric power. With a heat exchanger employed, therefore, the exhaust air cooled down is used to cool down the hot open air. The NFPA496, furthermore, provides for an obligation to clean the air before activating

Fig. 4 Typical single-line diagram

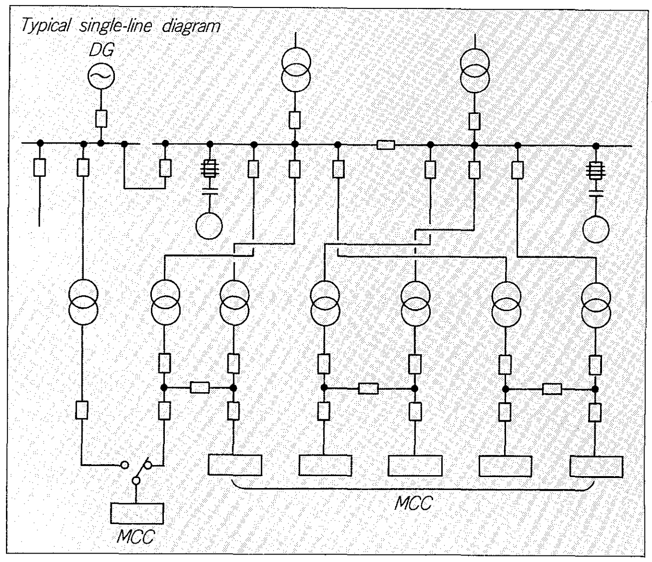
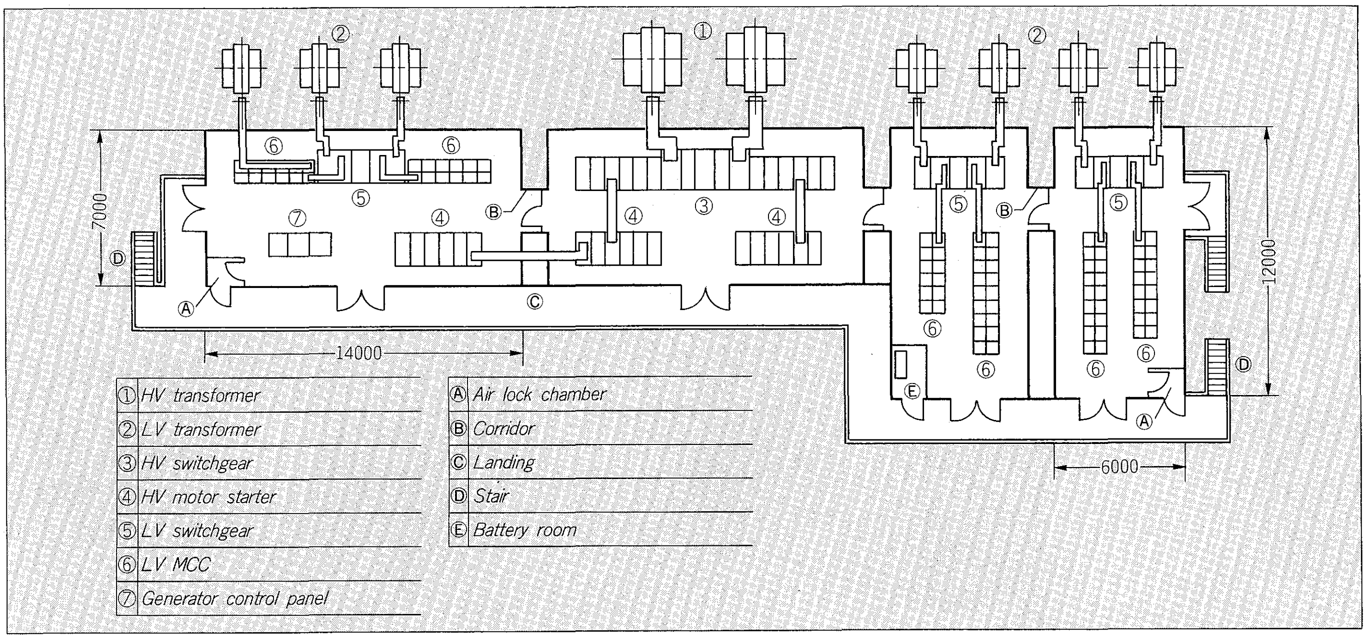


Fig. 5 Typical building and equipment layout



the electricity. For the purpose of cleaning, the main circuit and its controlling sequencer are housed in a panel of flame-proof construction. The sequencer in the flame-proof construction permits controlling and interlocking to be safely performed in the event of a shut down for cleaning prior to an activation of the packaged substation power and in the event of an abnormal pressure drop.

The cooling/dehumidifying unit comprises the roof-top type cooler with an air compressor and an evaporator combined into monoblock, and the duct heater. The cooler has two air compressors housed in a single case. To be operatable even at a low open iar temperature, furthermore, the cooling/dehumidifying unit is provided with a condenser fan speed control. The duct heater is provided to cover a decline of dehumidifying capability with the cooler operated in the reduced-capacity operation mode and to dehumidify with the cooler stopped at a low open air temperature.

The exhaust unit has a self-balancing damper located on the wall tomaintain the internal pressure and to prevent abnormal pressurization as well. An identical damper is also located in an independent battery room for ventilation.

4. FIRE ALARM AND FIRE EXTINGUISHING EQUIPMENT

The fire alarm system which combines heat and smoke sensors and the halon fire-extinguisher equipment interlocking the fire alarm system are provided. Once this equipment has operated, moreover, the airconditioning facility already referred to is so interlocked as to be automatically shut down to prevent the fire from spreading and the halon gas from leaking. And all the electric dampers are also so interlocked as to be fully closed.

5. SUMMARY

A modular type substation so far available has no electric room installed. An outdoor distribution board, moreover, would be inconvenient for maintenance. As a result, such modular type substation has existed as an extension of the weather-proof type outdoor distribution board. Now, we have accomplished a large packaged substation, which dispenses with a building construction work, allows a decrease in local construction term and satisfies every function available in an electric room. This packaged substation has proven really valuable in such a desert region, tropical forest, ocean platform or extremely cold district as to make a building construction work difficult to execute. And it has allowed us to place orders on a blanket basis, to execute a local work easily and to materialize a high level of reliability.

An example of the substation shown in *Fig. 3* "Power Supply Block Diagram", by the way, pertains to a packaged substation comprising such four buildings connected as shown in *Fig. 4.* Neverthless, only a week or so has been required to install the substation itself and its corridor locally.

Finally, the author would like to express the acknowledgement to Mr. Koizumi, Japan Air Filter (K.K.), and to Mr. Sugawara, Fisrt Architect Office, Fuji Electric Co., Ltd., both of whom have cooperated kindly with the author to arrange the present paper.