Ninth Indian Expedition to Antarctica, Scientific Report, 1994
Department of Ocean Development, Technical Publication No. 6, pp. 275-282

Life Support Systems at Indian Antarctic Station: Maitri

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Abstract

The life support systems at Indian Antarctic Station Maitri, comprising central heating, electricity generation and supply, water supply and waste disposal systems are run and maintained throughout the year. The various equipments used and procedural details are dealt with in the text.

Introduction

Life support system in the cold and windiest region must function under severe climatic constraints. Thermal considerations and analysis are necessary for freeze protection, foundation stability, thermal stress and economical operation of various components of the life support systems in a location, such as Antarctica. Although the thermal characteristics are precisely defined, the application and control of the same is complicated. In practice, it is often the unexpected or unforeseen conditions that result in danger or failures.

The following life support systems exist in Maitri Station:

1. Central Heating System
2. Water Supply System
3. Electricity generation and Supply System
4. Waste Disposal System

Central Heating System (CHS)

The Central Heating System comprises four numbers of oil fired hot water generators (Boilers), distribution piping and radiators, the latter located in working and living rooms. Return hot water from various radiators is collected in an expansion tank.

Water from this tank is fed to the boiler through feed pump for heating and circulation. Initially, the heat transfer fluid was based on Mono-Ethylene Glycol and water in the ratio of 60: 40. Shortly after commissioning, the Central heating system suffered heavy corrosion resulting in choking of pipe lines and radiators. The anti-freeze fluid was drained and the central heating system was flushed with potable water. Accumulated corrosion products were cleared and necessary repairs and replacements were carried out. The system was then filled with potable water instead of anti-freeze fluid. The corrosion in the heating system reduced to a little extent, however choking of radiators and failure of pipe lines still continued. The system was open to the risk of freezing in the event of stoppage of boilers.

Fig. 1. Aviation fuel fired, hot water boilers in the Boiler room of Maitri station.

Description of CHS

Hot water Generators

Hot water generators consist of 4 numbers of aviation fuel fired boilers (Fig.l) for producing hot water upto a maximum temperature of 80 to 85 °C. The boilers are of 2,00,000 KCal/hr (6 GPH) capacity with a 25 mm helical coil. The coils are made of carbon steel material of boilers quality confirming to DS 3059.

Fuel Supply

Fuel supply consists of 2 numbers of MS tanks of size 1.5 m x 1 m x 1.75 m having a capacity of 2500 litres each and a daily tank of 0.75 m x 0.90m x 0.90m size. These tanks are made out of MS. Weekly tank is filled from a bulk storage tank, kept outside the station. Daily fuel tank is filled from the weekly tank. Pumping is automatically done to the daily tank through the level controllers. Fuel is supplied to boilers from the daily tank.

Primary Heating Circuits

Primary heating circuit of the complex consists of 4 numbers of hot water generators connected in parallel. Hot water circulates through various coils fitted inside the tanks, radiators (installed in rooms) and expansion tank (installed in boiler room). Water from the expansion tank is fed to hot water generators (boilers) through circulating pumps.

Hot Water Supply

Hot water, to utilities like bathrooms, wash basins etc. is supplied from a hot water tank of 1000 ltrs capacity. The hot antifreeze-mixture required for duct heating of the fresh water line, between the pumphouse and main station, is supplied from a water tank Fitted inside boiler room. Both these tanks are fitted with heating coils through which hot water from boiler is circulated for heating.

Cold Water Supply

Two numbers of stainless steel tanks of capacity 2,500 litres, are provided within the boiler room. Fresh water from the lake is pumped into these tanks every day. Water stored in these tanks is heated through hot water heating coils connected to primary hot water heating circuit. Water from these tank is supplied to expansion tank, hot water tanks, bathrooms, kitchen, wash basins, laundry room etc.

Room Heating

Living and other rooms are heated by hot water radiators of size 1 m x 1m.. They are made out of MS elliptical tubes and pipes. Hot water from central heating system is connected to these radiators. Temperature of the rooms is normally maintained at 24° C.

Snow Melt Plant

Snow melt plant, of stainless steel make having capacity of 1,000 litres, is installed inside the boiler room. A hot water coil and a hot water sprinkler are provided to the snow melt plant for quick melting and heating.

Piping

ERW carbon steel pipes of 20 to 80 mm dia. are used for circulation of hot water throughout the station complex. Radiators and hot water coils are connected to these pipes.

Expansion Tanks

Two expansion tanks of capacity 1,000 litres each, have been installed inside the boiler room. These tanks are made of MS. Hot water coils have been fitted at the bottom of the tanks. One expansion tank is used for collection of hot water from the return line of the hot water circulation. The second tank is used for heating and circulation of antifreeze fluid. This hot antifreeze fluid is used for space heating of the water supply duct which runs between the main station and the pump house.

Pumps

There are different types of mono-block centrifugal pumps ranging from 0.5 HP to 3.75 HP installed inside the boiler room. Most of the pumps are operated semi-automatically either by level controller or differential pressure controller.

Controls

A central control board which controls the complete fuel supply, water supply and also the safety alarms are fitted inside the boiler room.

Each boiler is fitted with individual control panel for maintaining the various parameters of the boiler. Pumps are used for pumping water, fuel and antifreeze fluid.

Lake water used for heating system is not of boiler feed quality. The pH of the water is 7 and during winter, its value goes further down (6.6). The pH value of water was increased by adding sodium hydroxide to maintain the value between 9 and 9.5 and to increase the efficiency of the boilers. Dissolved oxygen in the water is also high. To check this, oxygen relieving agent (MAXTREAT - 3220) was dosed at the ratio of 1:15,000 and also the contact between water surface and atmosphere was covered by thermocol blankets. This has been found quite effective to reduce corrosion. pH and oxygen in the tank water were constantly monitored.

The fuel consumption of boiler increased with the fall of temperature and the rise in winds. The boilers which were fitted with new coil and/or decarbonised coil gave satisfactory performance in keeping the station at an optimum living condition.

A huge calorie of heat was lost due to leakage at the building joints and improper insulation of hot water circulation pipe lines. These shortcomings were checked effectively by using flexible polyurethene foam.

Maintenance

Effective maintenance of heating system was done during the wintering which involved:

1. Cleaning of accumulated rust by flushing the heating pipes, radiators and expansion tank with chemicals and fresh water. Choked radiators were cleaned and replaced wherever necessary.
2. Installation of additional radiators in Utility Bay, Green House, and Dark Room by extending the hot water pipe line. Due insulation was provided to this, wherever it came in contact with outside temperature.
3. The snow melt tank, lying unused since its installation was connected to hot water tank, thus increasing the hot water storage capacity from 1000 to 2000 litres.
4. Covering of entire length of pipe line by P.U. foam to prevent it from choking frequently.
5. Fitting of new coil in three boilers and decarbonisation of one of the coils.

Water Supply System

Water supply to the Maitri station (Fig.2) has been catered by pumping water from a lake (approximately 255 metres away). The pump house erected in the lake at a distance of 80 m from the bank is installed with submersible pump and a self priming centrifugal pump, which are connected by concentric stainless steel jackets and heated electrically. To ensure a smooth flow from pump to the tank in boiler room, the entire copper pipe line has been enclosed in an air tight insulated duct supported by steel structure. Besides, the duct also houses two additional tubes carrying antifreeze fluid mono-ethylene glycol and water in the ratio of 60 : 40. Connected to the central heating system, these tubes maintain a temperature between 8 and 10 deg C inside the duct to prevent freezing of water in the pipe line. The

Fig. 2. Water-supply pipe line between the Pump House and Maitri station.

water is pumped into two stainless steel tanks located in the boiler room. These tanks having capacity of 2,500 ltrs are connected to hot water generators and further to utility points. A control panel suitable for operation of pumps, trace heating and solenoid valve is kept inside the boiler room for remote operation. A snow melt tank, of 1000 litres capacity has also been provided in boiler room as a stand-by for any emergency.

It has been found that the use of 12 mm dia. GI pipe is not suitable due to its high corrosion rate which in turn results in choking of the pipe line. Once the pipe is choked, the rusted material deposits at joints. Thus it enhances the chance of water to freeze. However, the best way of avoiding the above problem is to use copper pipes of greater dia. (25 mm and above). It can also be done by using trace heating all along the pipe so that the flow of water/liquid is constantly maintained.

While investigating the frequent leakages, it was found that the mechanical joints between two pipes were not suitable due to contractions of pipes at sub zero temperatures. To by-pass this, flexible hose joints were added to connect two pipes which in turn helped to bear the thermal expansion and contractions. If at all the mechanical joints have to be used, it may be advisable to use 'O' rings made of silicon rubber.

Electric Supply System

Four numbers of 62.5 KVA Ruston gensets (Fig.3) constituted the part of main power generating systems at Maitri. One 62.5 KVA genset was run at a time and any shortfall was made up by running a stand-by 30 KVA genset. Since the requirement of power was much more than what was generated, the running of various electrical gadgets was phased throughout the day.

The break-up of electrical load is given below:

	Permanent Load (in KW)			Temporary Load (in KW)	
i)	Station lighting	5	i)	Kitchen/Ref cont	10
ii)	Satcom domes	6	ii)	Rood lights	4
iii)	Lounge	2	iii)	HFcomm.	5
iv)	Drier room	3	iv)	Sat. coram (Summer)	4
v)	Washing machine	2	v)	Trace heating for pump house	3
vi)	Green House	7	vi)	Pumps	4
vii)	Boiler room	13	vii)	Summer activities	20
viii)	Summer huts	2	viii)	Welding	5
ix)	Deep freeze	6	ix)	W/shop	5
	Total	**46**		Total	**60**

Disposal System

Waste is generated due to transportation of stores from the main land as well as by the very process of survival and human activity. Since Antarctica has a fragile environment, it is very essential that waste be either destroyed or taken out of Antarctica.

Types of wastes

Physically, the waste can be categorised as destructible and non- destructible. Non-destructible waste can only be reduced in volume but quality of waste cannot be altered. Such

Fig.3. 62.5 KVA Ruston gensets inside the Generator Block. The walk-in cold room is also seen at the far end.

waste can only be dumped at pre-marked locations and the nature be allowed to play its part, which in effect means "bio-degradation". Apparently, ice covered Antarctica does not provide suitable conditions for biodegradation by itself and as such the waste cannot be disposed off in normal way. An efficient system of waste disposal to work in sub-zero temperature is required. Even the destructible waste on incineration generates ash which calls for disposal.

Disposal of different waste is as follows:

(i) Toilet waste

There are five incinerator toilets operational in Maitri.

The toilet system consists of a stainless steel Indian style toilet fitted with a special flap to prevent percolation of foul odour from the combustion chamber. The flap opens automatically when the seat cover is lifted to permit the use of the toilet and closes on lowering the seat flap. The incinerator unit, situated below the toilet flap, consists of insulated incinerator chamber, a crucible tray for waste collection and an automatic kerosine fired burner. The gas and fumes are removed from the incinerator chamber through a suitable exhaust chimney,

The incinerator chamber has an end which can be opened to permit the removal of the crucible tray for cleaning the ashes. Ash is collected in bags and transported out of Antarctica in ship.

(ii) Kitchen and other combustible wastes

All combustible and kitchen wastes are incinerated in the garbage incinerator, 200 mts away from main building towards the western side. Ash produced is sent back to the ship for further disposal.

(vi) Non-combustible waste

Waste produced from incinerator toilets, metal cans and bottles are compacted/crushed and sent to the ship for further disposal.

(iv) Sewage treatment plant

A Klargester-biological rotating disc sewage treatment plant, has been installed at Maitri for treatment of waste water from kitchen, bath rooms, wash basins and washing machines.

The Klargester-Biodise is a complete self contained sewage treatment plant. It consists of primary settlement, biological treatment using rotating discs and secondary settlement in a single unit.

a) Primary settlement zone

Crude sewage is piped direct to the Biodisc entering the baffled primary settlement zone via a detector box which stills the flow. The heaviest solids sink to the bottom of the compartment by means of a baffle. The effluent with lighter solids still in suspension, passes into the Bio Zone inlet.

b) Bio zone

The Bio zone comprises a chamber with transverse baffles arranged so that the liquid must follow a serpentine path from zone inlet to outlet. The baffles also separate a series of slowly rotating circular discs into banks so that the sewage passes through each bank in turn. No chemicals are added at this or any other stage of the process.

Micro-organisms naturally present in the sewage adhere to the partially immersed discs to form a biologically active film, feeding upon the impurities and rendering them less harmful.

The organisms feed and multiply very rapidly in the presence of ample oxygen supply and as each portion of the film on the rotating discs is alternatively in contact with settled sewage and atmospheric oxygen, conditions are ideal for effective purification.

The thin waste film on the surface is rich in oxygen and contributes to the high organic and oxygen uptake of the biomass. Oxygen penetrates the biomass into its inner-most colonies through mixing and diffusion.

c) Sludge zone

The sludge zone from the primary and bio zones collects and consolidates in the base of the unit. The unit can accommodate a large quantity of consolidated sludge before desludging. This can be done conveniently by a slurry pump.

Biodisc sewage treatment plant installed at Maitri is capable of treating 1000 litres of water per day to final effluent standard BOD less than 20 mg/litre and SS less than 30 mg/litre. This capacity is, however, being increased to 2,500 litre by installing higher power Klargesters.

The above plant is installed in an insulated room behind the boiler room. Waste water from kitchen and utility bay is connected to the Klargester through an insulated plastic pipe. The treated effluent is collected in a pit which has a storage capacity of 10 lakh litres. A trace-heated plastic pipe with insulation has been connected to outlet connections of Klargester. The heat tracer remains energised throughout the winter to avoid freezing. The treated effluent collected in the pit freezes in winter and starts melting around middle of November. Liquid effluent is pumped out to a safe place beyond 200 metres regularly during summer.

Indicator lamps have been installed inside the boiler room for monitoring the functioning of Klargester and heat tracer. One kilo watt heater is installed inside the Klargester room to avoid freezing.

(v) Effluent Treatment Plant

An effluent treatment plant was to be erected during IX expedition. It could not be taken up due to several logistic constraints. However, a larger capacity Klargester was installed in the subsequent expedition.

Acknowledgement

The author is grateful to HAV R. Raghunathan, HAV N. Selvaraj, NK P.V. Narsaraju, NK B.D. Bhatt who constituted the work force which maintained the heating, disposal and water supply systems in the station. The Electric Supply System was maintained by EME team headed by Maj Balraj Singh. Constant help received from all the wintering members including the Station Commander Sh. R. Ravindra, is gratefully acknowledged.