Upgrading the SANAE IV base in Antarctica

After running around the clock for 18 years, it was finally time to refurbish the base and equipment in South Africa's SANAE IV base in Antarctica — no easy task considering the remote location and extreme weather conditions.

By Ilana Koegelenberg, DPW, and Royal HaskoningDHV

South Africa has a long and successful history in Antarctica, contributing significantly in the scientific field to the international and local communities. When the South African National Antarctic Expedition (SANAE) III base reached the end of its lifespan, a new base was planned by the Department of Public Works (DPW). The planning as well as architectural and electrical design of SANAE IV was done by DPW, with the structural design done by Endecon and the design of the mechanical systems by GH Marais and Partners (merged with Royal HaskoningDHV).

DPW teams started the construction of the SANAE IV base during the 1995/1996 Antarctic summer season, and construction and commissioning were completed during the 1996/1997 season.

SANAE IV has been constructed on a rocky outcrop named Vesles Karvet (Norwegian) and consists of Blocks A, B, and C. Block A consists of accommodation and ablution facilities on the second level, with offices, laboratories, and a medical facility with an operating theatre on the first floor. Block B consists of accommodation, entertainment, and ablution facilities on the second level, with the kitchen, dining room, stores, and waste room located on the first floor. Part of Block C consists of a double-volume hangar area and helipad for the helicopters, while the balance of Block C houses plant rooms for the generators and heat recovery systems, the wastewater treatment plant, workshop, stores, offices, and a gymnasium, all located on the second level.

The base had been in continuous operation for 24 hours a day, seven days a week since 1997; meaning, the base had been in operation around the clock for 14 years when DPW commenced with the planning of the refurbishment in 2012 (18 years when the refurbishment commenced at the end of 2015). The operational period can really be appreciated by comparing this period with a similar local facility that typically operates 8–12 hours a day, weekdays only. By comparison, it can be said that the SANAE IV facility and systems had had the equivalent runtime of 45 years.

CLIENT BRIEF

DPW's brief for the refurbishment of the base required, among other things, the following:

The base had to remain fully operational during the refurbishment process. The existing power, water, heating, and effluent systems could not be switched off for more than a day without seriously impacting on the day-to-day operations of the base (and risk freezing up). Also, it was crucial that the base remained operational to enable the Department of Environmental Affairs' (DEA's) scientific teams to continue with their research programmes.

Energy-saving measures had to be implemented. This required that systems be designed using the latest available technology. The requirement for energy-saving measures is critical, as the transport of year teams, maintenance/construction teams, food, consumables, fuel, and so on, is limited to the Antarctic summer period (December to February) of each year.

Systems and equipment had to be easily maintainable and previous problems experienced with systems had to be addressed — for example, a typical problem experienced is the loading of the old effluent plant between takeovers (10 people during the year versus the summer personnel complement of ± 90 people).

GETTING STARTED

Following an investigation of the current situation and lengthy planning, DPW and Royal HaskoningDHV completed the refurbishment documentation process early in 2015. The existing workshop was identified as the new main plant room. The workshop was temporarily moved to the hangar while things like the new generator sets, pumps, tanks, and heat exchangers were installed.

The old plant room could only be demolished after the successful commissioning of the new systems. Other systems and plant rooms had to be relocated in a similar way to ensure the uninterrupted operation of the base.

One of the biggest challenges was actually getting to the base and getting all the equipment there. As mentioned, SANAE IV can only be reached during the Antarctic summer season, either via the *S.A. Agulhas* departing Cape Town and offloading at the German base Neumayer, or by plane, landing at the Russian base Novolazarevskaya, with a second flight (smaller plane) from there to SANAE IV. The equipment had to be specified to survive being exposed to the harsh -20°C conditions during transport.

Photos by Royal HaskoningDHV

1. New potable water tanks – a work in progress.
2. Sludge tank.
3. Effluent plant pipes and pumps.
4. The new ice smelter installed.

But not only did the planning have to include getting all the equipment and tools to the base, but also bringing back the old system. Nothing could be left behind.

This was quite a tough job, as only 25 people could make the journey to the base and, between them, they had to complete all the upgrades — electrical, HVAC, wet services, and so on. As they could only stay for the summer, the crew worked long days to get everything done on time.

INSTALLATION DETAILS

The following notable design features, energy-saving measures, and latest sustainable technology systems were installed.

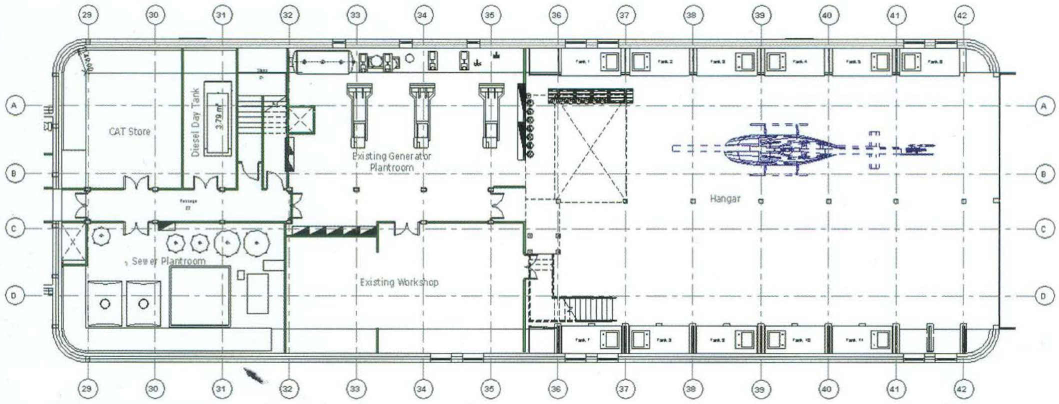
Engines and heat recovery systems

Tier III compliant engines (CAT) were installed, thus ensuring that engines' NOx emission is limited in accordance with international standards. Water to water heat exchangers on the engine block and air to water heat exchangers on the exhaust pipes ensure maximum heat recovery — heat which will normally be rejected to atmosphere.

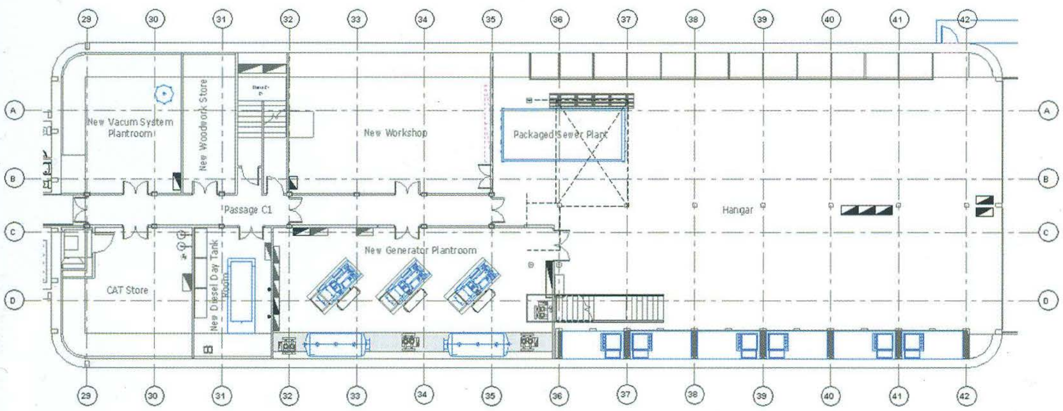
The heat recovery systems increased the typical engine/system efficiency from ±35% to ±80%. The hot water thus generated is circulated to fresh air fan coil units in order to heat the base and is also used to heat domestic hot water via heat exchangers. Vertically configured, close coupled centrifugal pumps with integral speed drives were installed to ensure optimum performance, ease of maintenance, and better utilisation of the limited plant room space.

Effluent system

The effluent collection system installed in the mid-1990s was of the standard cistern and urinal type, with gravity draining from the second-floor ablution facilities to



Block C original layout.



Block C new plant layout.

underfloor tanks in the links. Effluent was pumped from these tanks to a standard biological reactor wastewater treatment plant in Block C.

This system was replaced with a vacuum system, which effectively reduces the water consumed by toilets and urinals by 80%. The vacuum system has also made drainage from the kitchen, laboratories, and medical facility easier and the link tanks and pumps could be removed, thus eliminating the maintenance problems experienced with the old systems' tanks and pumps.

The vacuum pumps (in Block C) pump the effluent into a receiving (buffer) tank from where it is transferred to the new packaged (containerised) effluent treatment plant installed in the hangar area.

The new effluent treatment plant makes use of Martin Membrane Systems' technology and incorporates a mechanical pre-treatment section with centrifuge, flotation system, anoxic tank, aeration tank, filtration tank (0.1-micron membranes), fans, pumps, and the like in a single, easily maintainable package. The new system is considerably more efficient in purifying the water, ensuring that only purified water is pumped over the cliff edge. Sludge is captured in containers and brought back to South Africa for safe disposal. The new plant also enables a much smoother transition between summer and winter effluent loads.

Water generation system

A new snow smelter with increased capacity was installed just below surface level, approximately 200m east of the base. Particular attention was paid to increase the thermal insulation of the snow smelter, increasing the efficiency of the heating system (in-line heaters versus the old dry elements) and improving the control system.

Vertically configured Wilo pumps are used for continued circulation of the water between the two snow smelter tanks and to pump water to the base. Inside the base, water is stored in six insulated, stainless-steel storage tanks that have been installed against the eastern wall of the hangar. Each tank has a capacity of 6 367ℓ, providing a total storage capacity of just over 38 000ℓ.

Water is continuously circulated through the base via a set of bag filters and an in-line heat exchanger. The decision to use bag filters of 95 micron was based on two criteria: less space required comparing a bag to a cartridge system for the flow rate required, and also because replacement bags are cheaper compared to filter cartridges.

BMS system

The entire control system was replaced with a Johnson Controls' building management system (BMS) employing current technology. The new BMS

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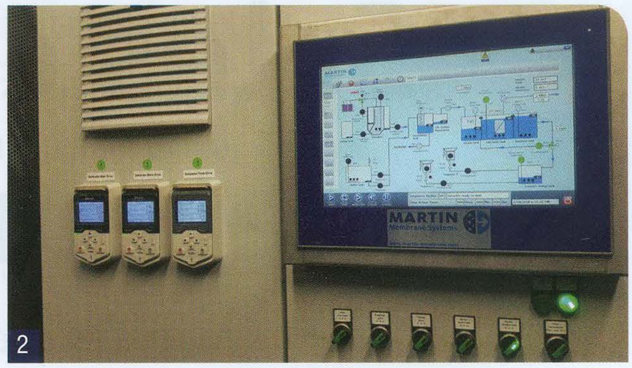

1. Circulation pumps. | *2. Controls for the new effluent plant.* | *3. The newly completed showers.*

performs overall monitoring and control of all systems as well as energy. Sensors are installed in all systems in the base and include temperature sensors, pressure sensors, air and water flow sensors, and CO_2 and O_2 sensors.

All critical parameters of all systems can be monitored from the radio room in Block A. There is also a satellite link to the DEA (and soon DPW) offices in Cape Town. This link will enable DPW to monitor the systems and to provide assistance to the year team as required.

FINISHING UP

The refurbishment project will be concluded during the 2018/2019 season. This project is a fine example of the work undertaken and successfully concluded by DPW, their consultant Royal HaskoningDHV, and the contractor Nolitha.

The final product will ensure the successful operation of the base for the next 20 years. ***PA***

LIST OF PROFESSIONALS

Owner / client		Department of Public Works
End user		Department of Environmental Affairs
Developer		Department of Public Works
Project manager		Department of Public Works
Consulting engineers	Electrical, mechanical, wet services, structural, and civil	Royal HaskoningDHV
Contractors	Main building, HVAC&R, wet services, and electrical	Nolitha
Product suppliers	Gensets	CAT
	Effluent plant	Martin Membrane Systems
	Vacuum drainage system	Jets
	Snow smelter	TFD
	Pumps	Wilo
	Controls	CAS
	BMS	Johnson Controls