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Photos by Royal HaskoningDHV

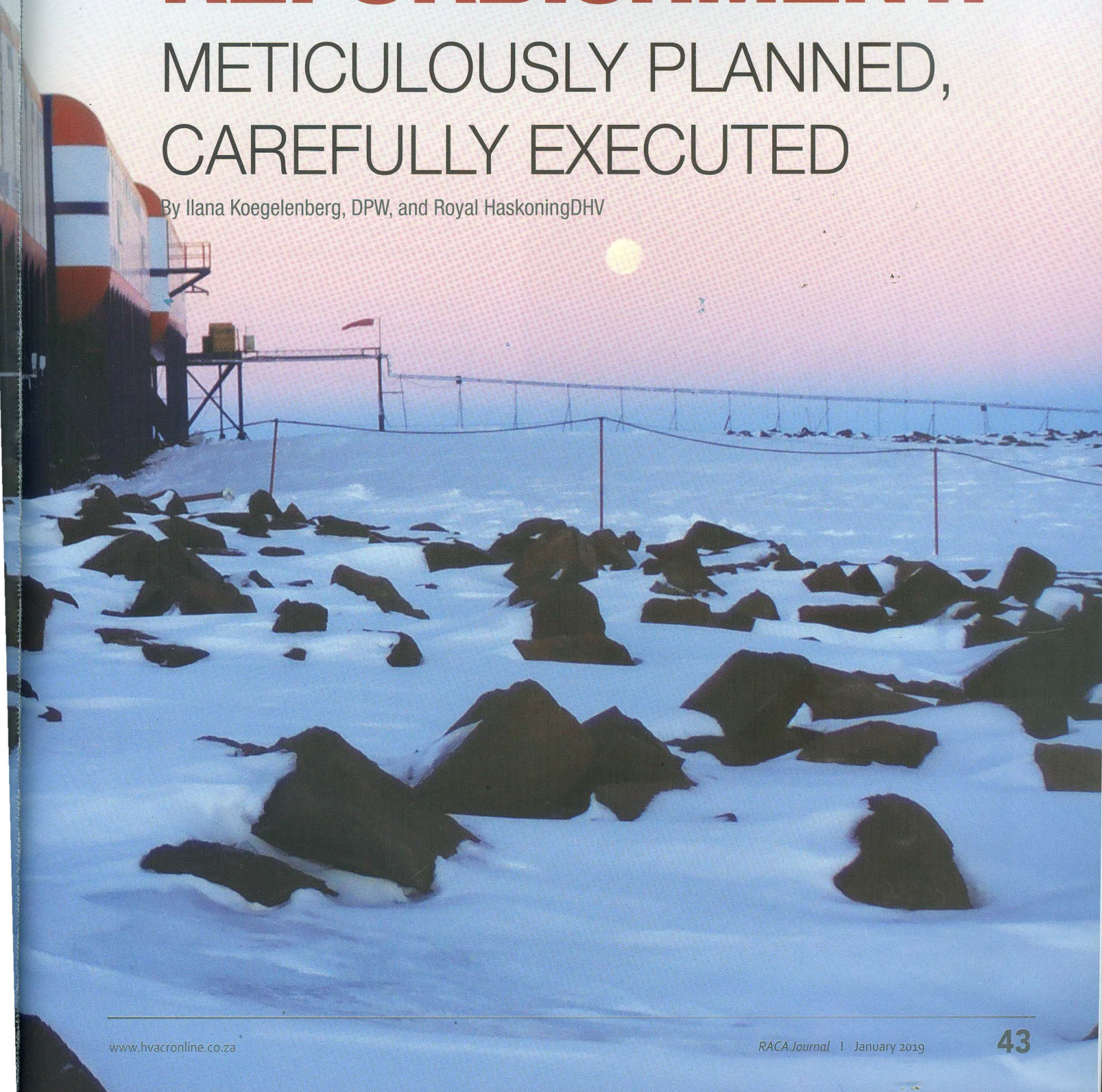




SANAE IV ANTARCTICA REFURBISHMENT:

METICULOUSLY PLANNED,
CAREFULLY EXECUTED

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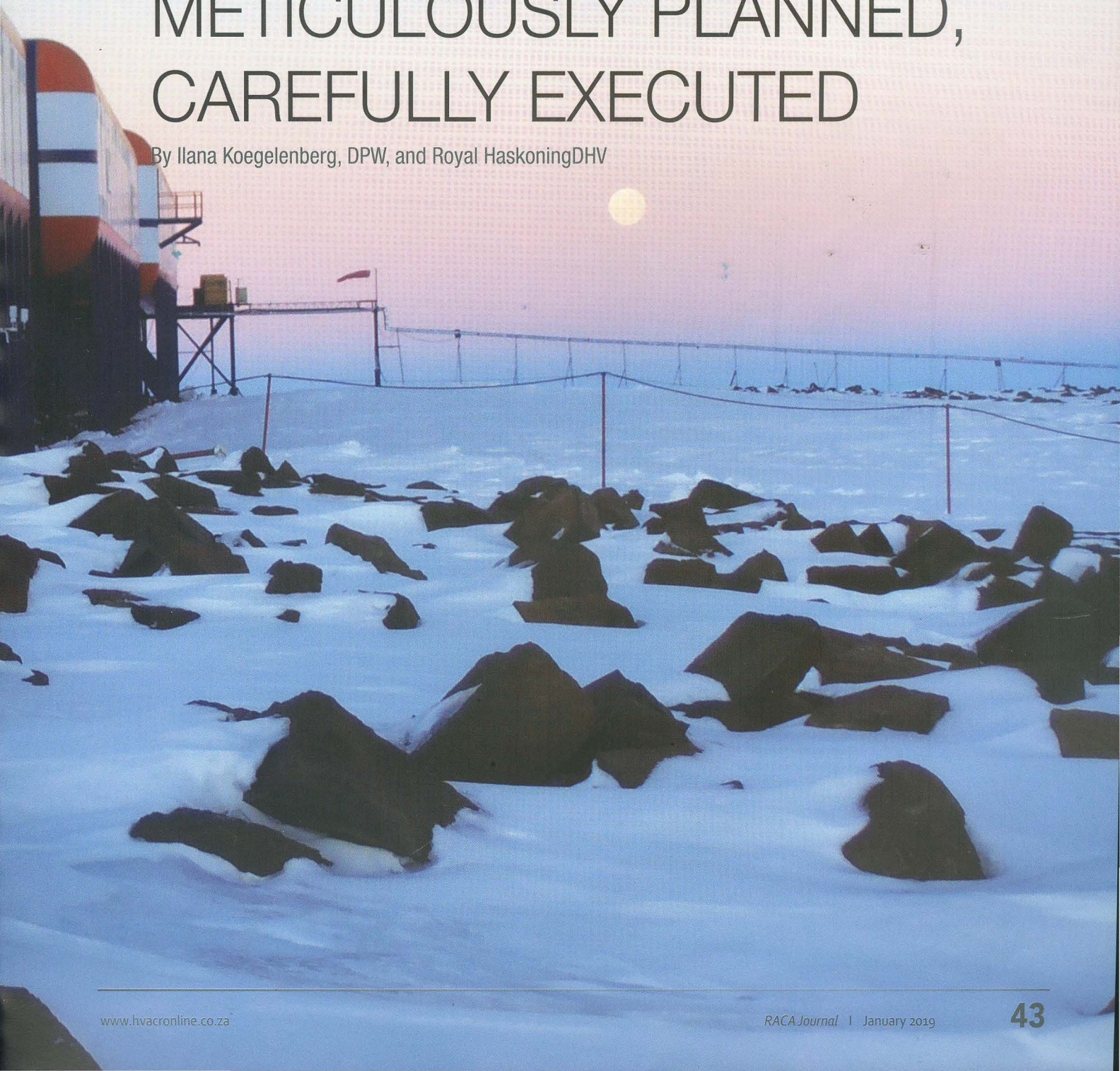




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After running around the clock for 18 years, it was finally time to refurbish the base and equipment in South Africa's SANAE IV base in Antarctica — no easy task considering the remote location and extreme weather conditions.



Photos by 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 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, Vesles Karvet (Norwegian), and consists of Blocks A, B, and

1. Heat exchangers and circulation pumps nestled between the FCU and domestic hot water tanks. Note the ventilation duct.
2. Diesel bunkers – view from the north-west.





C. Block A consists of accommodation and ablution facilities on the second level, and offices, laboratories, and a medical facility with 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; the balance of Block C houses plant rooms for the generators and heat recovery systems, wastewater treatment plant, workshop, stores, offices, and a gymnasium located on the second level.

The base is kept at 18°C and includes a walk-in freezer and cold room. Each block has its own fan coil units (FCUs) serving each of the two floors, with an extra one for the braai and one for the plant room. The FCUs were built locally in Cape Town by Air Options.

The base has been in continuous operation 24 hours a day, seven days a week since 1997; that is, 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 the equivalent runtime of 45 years.

Antarctica is a continent with weather extremes: winter temperatures in the region of -50°C (dry bulb) and hovering just below zero on the very best of summer days



1. Heat exchangers in the new generator plant room.
2. Central heating buffer tank.
3. New generator plant room on completion.



(normally -10°C to -20°C in summer). During storms, the wind reaches speeds of 200km/h, making outdoor activities impossible. Furthermore, the base can only be reached during the Antarctic summer, which is from the beginning of December until the end of February. This meant that planning and access for the construction teams of the contractor, Nolitha, were limited to this summer 'window' of three months.

CLIENT BRIEF

DPW's brief for the refurbishment of the base required, inter alia, the following aspects.

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 annual residence teams,

1. New plant room — preparation of the floor.
2. Some arctic humour ...
3. BEFORE: The original plant room — pipes and pumps.
4. West loading platform in lowered position.





maintenance/construction teams, food, consumables, fuel, and the like is limited to the Antarctic summer 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 staff complement of about 90 people).

GETTING STARTED

Following a status quo investigation 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 the new generator sets, pumps, tanks, heat exchangers, and so on 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* ship departing from 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

TF DESIGN serves a wide variety of clients across the entire industry. We specialise in the fields of Heat Transfer and Thermodynamics, but, are also strongly involved in general Mechanical design.

Our typical projects usually involve the building of custom designed equipment for our clients. We complete the entire process - from the initial concept design, implementation of design, manufacturing and finally, on-site installation and commissioning.

TF Design designed, manufactured and commissioned the snow smelter system intended for the SANAE IV base in Antarctica.



THERMODYNAMICS FLUIDS & DESIGN

Tel: +27 (0)21 887 9288

Fax: +27 (0)21 887 9299

e-mail: jacquesk@tfdesign.co.za

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equipment had to be specified to survive being exposed to the harsh -20°C conditions during transport.

Planning had to be meticulous as literally everything had to be taken there (no quick going back). From the ducting to the FCUs and everything in-between had to be included.

HVAC equipment that could not be built locally was imported from Germany and sent to Cape Town, from where it was shipped to Antarctica. From there it was lifted onto the ice bank by crane and then hauled with a sleigh through the snow and ice to the base.

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

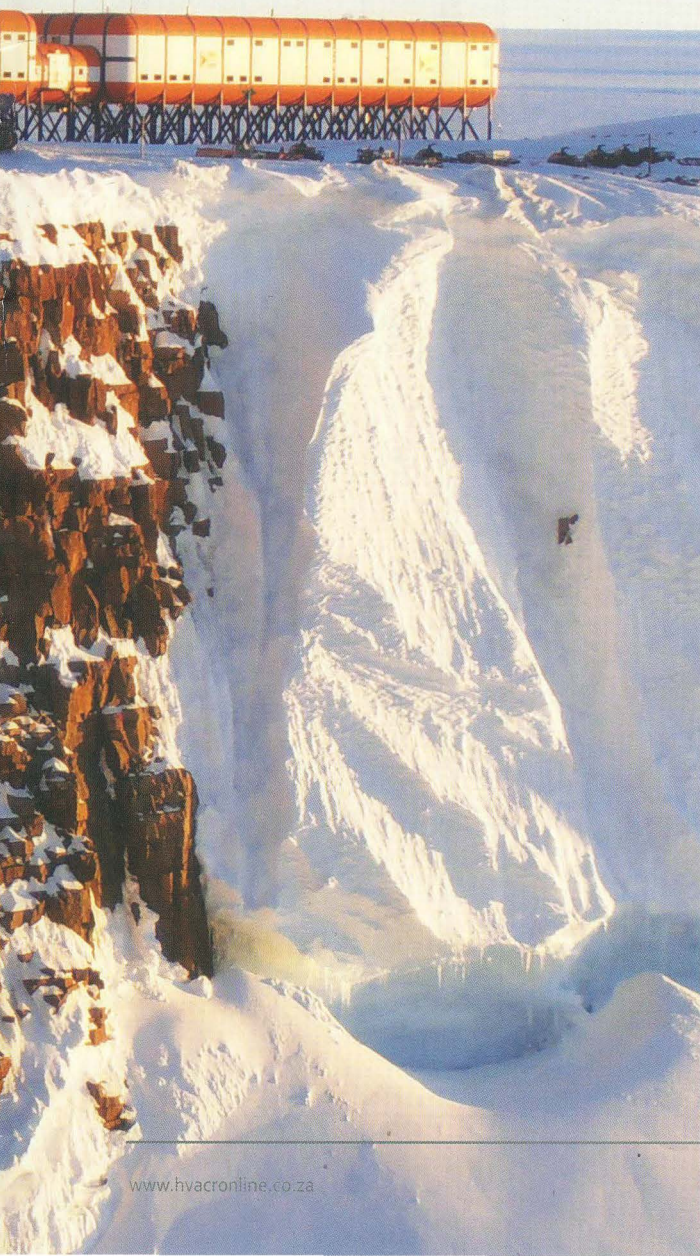
Tier III compliant engines (CAT) were installed, thus ensuring that engines' NOx emission will be limited in accordance with international standards. Water-to-water heat exchangers on the engine block and air-to-water heat exchangers on the exhaust pipes ensure maximum heat recovery; heat which will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

The heat recovery systems increased the typical engine/system efficiency from $\pm 35\%$ to $\pm 80\%$. The hot water thus generated is circulated to fresh air FCUs to heat the base and is also used to heat domestic hot water via heat exchangers. Vertically configured, close-coupled centrifugal pumps with





*BEFORE:
Generator
plant room
in 1997.*



integral speed drives were installed to ensure optimum performance, ease of maintenance, and better utilisation of the limited plant room space.

Water generation system

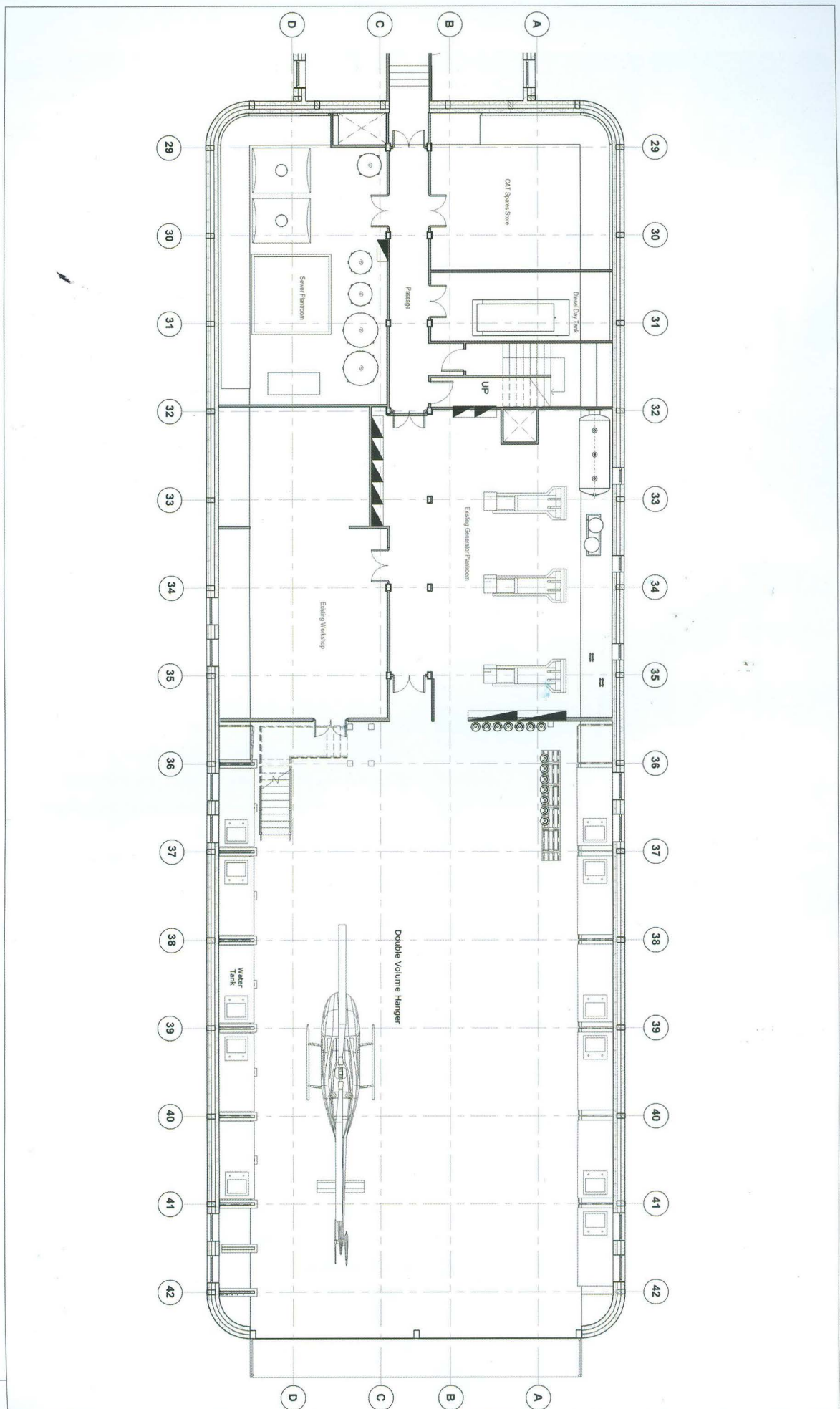
A new snow smelter with increased capacity was installed just below surface level, approximately 200m east of the base. Particular attention was paid to increase the thermal insulation of the snow smelter, thereby increasing the efficiency of the heating system (in line heaters versus the old dry elements)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

Vertically configured Wilo pumps are used both 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 installed against the east wall of the hangar. Each tank has a capacity of 6 367ℓ, providing a total storage capacity of just over 38 000ℓ.

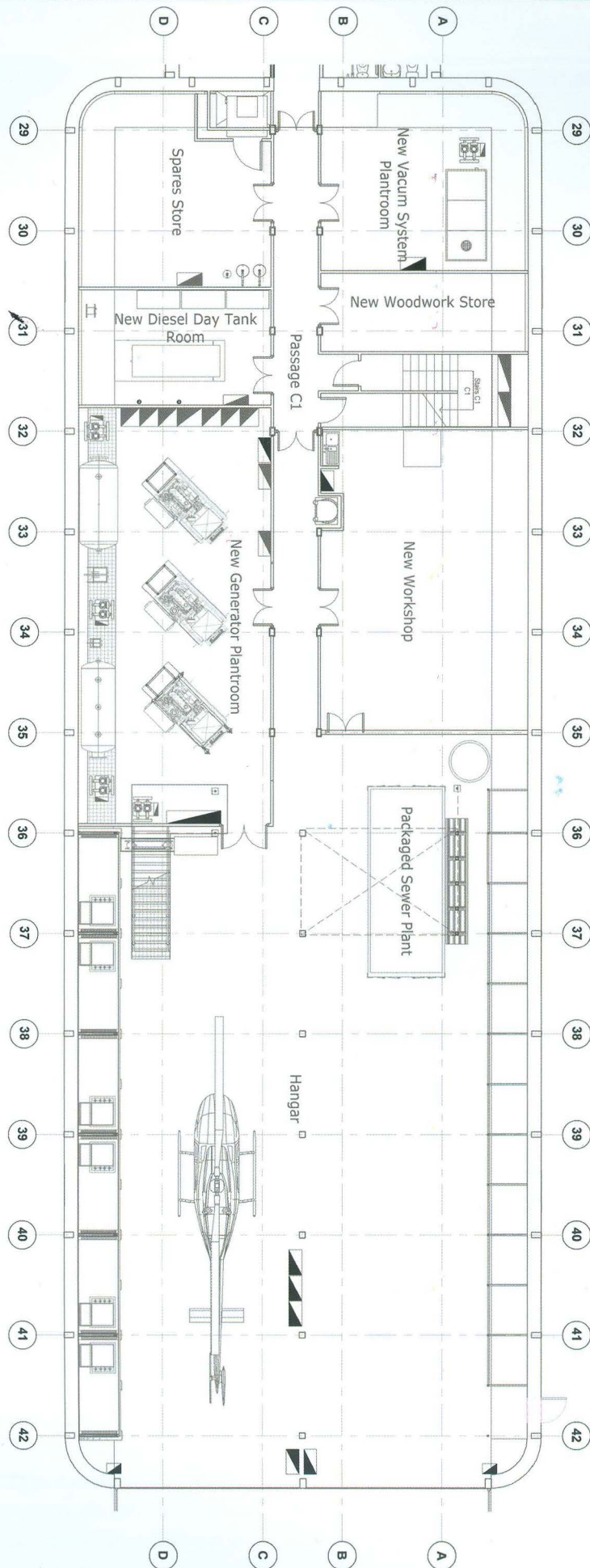
Water is continuously circulated through the base via a set of bag filters and an in-line heat exchanger. The decision to use bag filters of 95 micron was based on two criteria: less space required comparing a bag versus a cartridge system for the flow rate required, and also because replacement bags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

The effluent collection system installed in the mid-nineties was of the standard cistern and urinal type, with gravity draining from the second floor ablution facilities to underfloor tanks in the links. Effluent was pumped from these tanks to a standard biological reactor wastewater treatment plant in Block C.

Continued on page 52



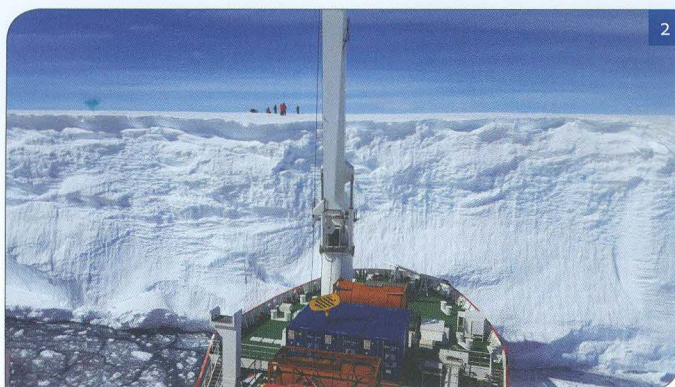
Block C Original layout.



Block C new plant layout.



Continued from page 49



1. Engine plant room.
2. S.A. Agulhas II – offloading near the German base.
3. Evaporative coolers for one of the freezer rooms.

This system was replaced with a vacuum system, which effectively reduced the water consumed by toilets and urinals by 80%. The vacuum system 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.

BMS system

The entire control system was replaced with a Johnson Controls' building management system (BMS) employing current technology. The new BMS 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 CO₂ and O₂ 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 annual residence team as required.

GENERAL

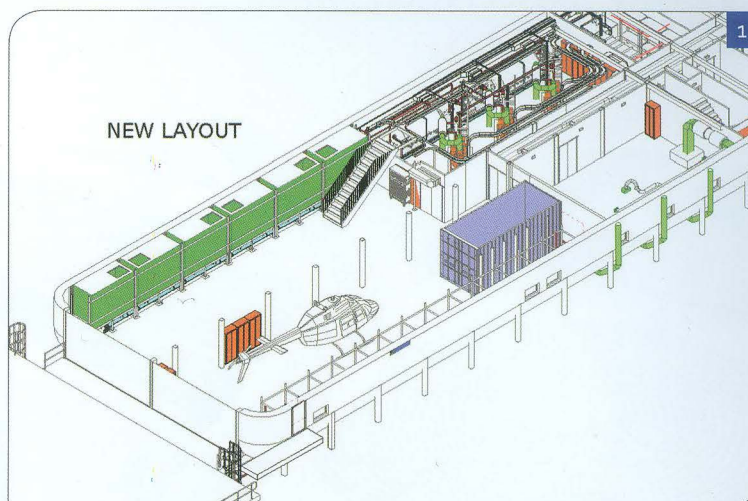
Many other improvements were made, including:

- The kitchen and dining room layout and flow were improved, and macerators and a flotation system were installed to remove grease from kitchen wastewater.
- The waste room was relocated to the western side of the base to improve loading/unloading of goods and waste and to ensure personnel safety.



- Old light fittings were replaced with LED lamps.
- DBs and control panels were replaced to ensure adherence to current standards and to improve layout and ensure general conformance and maintainability.
- The old CO₂ gas suppression system in Block C (protecting the main genset plant room and the diesel day tank room) was replaced with an environmentally friendly and safe Novec system from 3M (Sevo Systems), with all components complying with SANS, UL, and ISO standards.
- General fire detection and protection were improved. More breathing sets and suits were provided, fire escapes were added, and the fire detection system was upgraded to accommodate the new plant-room layout.
- A walkway was installed on the roof of Block A to make access to scientific instruments easier and safer. Wind tunnel tests were conducted to ensure that the walkway would not have negative effects such as dumping of snow on the leeward side.
- A new safety net was installed at the cliff edge.
- The entire building and systems were modelled in Revit.

Continued on page 55



1. Drawing of the layout of the new hangar installation.
2. 3D schematic of the hangar layout.
3. One of the new fan coil units installed.





Continued from page 53

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. **RACA**



1. New pipeline to base from snow smelter.
2. New snow smelter being installed.

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
	FCUs	Air Options