PLANT CAPACITY on the Shearwater oil and gas production platform, in the central North Sea, has been brought up to design level by newly designed separation swirl tubes, developed by Shell Global Solutions.

The Shearwater platform lies in the Central Graben, Block 22/30b, about 200 km east of Aberdeen, in 90 metres of water. It is one of the industry’s most technically challenging and successful developments. The pioneering $1.4bn development is operated by Shell UK Exploration and Production and backed by licence co-venturers Shell, ExxonMobil and BP.

Demanding conditions
When it came on stream, in September 2000, Shearwater was the largest producing high-pressure, high-temperature field in the North Sea and the venture was a focus for technologies specifically developed to handle the unusually demanding conditions. The Shearwater gas condensate reservoir has wells up to 17,000 feet deep and is characterised by reservoir pressures of up to 1,000 bar, temperatures of up to 193°C, the presence of hydrogen sulphide and carbon dioxide, and a high-salinity aquifer.

After separation from the condensate, the gas is processed offshore through a glycol drying plant, a hydrogen sulphide removal plant and a turbo-expander-driven cold plant. On leaving the platform, the gas has a hydrocarbons dew point, dryness and hydrogen sulphide level of sales-gas quality. No further processing is required and onshore the gas is simply metered and sent into the UK network for industrial and domestic use.

Before the gas is fed to the low-temperature conditioning plant and then into the export pipeline, water vapour is removed in a tri-ethylene glycol (TEG) contactor to avoid condensation in, and consequent corrosion of, the subsea line. The TEG process uses dry glycol to absorb the water.

However, carryover of condensate from the TEG inlet-separator section was restricting the overall plant capacity to around 75% of the 410m cubic feet a day design capacity. At higher throughputs, the liquid hydrocarbons being carried over to the glycol contacting section were vaporised as the glycol was regenerated and the venting system of the glycol regenerator was restricting the capacity of the whole plant.

Originally, a vane-pack separator was installed in the bottom of the TEG contactor above a schoepentoeter feed-inlet device. This equipment was designed to catch any liquid hydrocarbons entrained with the gas and safeguards the contactor from contamination. The vane-pack separator had been chosen for its simple and compact design. However, more liquids were being produced from the reservoir than had been expected, meaning the vane-pack separator was unable to function efficiently enough. Separation swirl tubes, which have been in use in many other applications since the early 1980s, offered a tried-and-tested, but less-compact, alternative.

Removing the bottleneck
To remove the bottleneck, the TEG contactor’s inlet-scrubber separator needed to be upgraded to the more sophisticated Shell SMS (Schoepentoeter, Mist mat, Swirl tube) configuration. This required the replacement of the existing vane-pack demister by a mist mat and Shell Global Solutions’ proprietary separation swirl-tube demister. Separation swirl-tube demister equipment was commercially available, but its standard configuration was too tall for direct installation into the TEG contactor vessel.
Modification of the vessel was precluded by time constraints and the need to avoid hot work during any shutdown. In addition, incorporation of standard swirl tubes into the vessel would have compromised several critical dimensions, leaving out the mist mat, which would have reduced efficiency to an unacceptable level.

Advances in swirl-tube technology
The Royal Dutch/Shell Group has more than two decades of experience of designing separation swirl tubes and receives operational feedback from more than 300 units using the technology. Many of the units are installed in offshore exploration and production facilities. Access to this wealth of experience has enabled major advances in separator swirl-tube technology.

Moreover, a substantial effort has been made over the last few years to improve understanding of the theory behind the technology. The efficiency of test swirl-tubes is measured under controlled conditions and the results of these experiments are compared with a physical model describing cyclone behaviour. This experimental approach, underpinned by a physical model, has greatly improved theoretical understanding and enables swirl-tube performance to be predicted under a wide range of conditions.

Shell Global Solutions was developing an alternative demister, equipped with high-performance separation swirl tubes, when it was asked to address the TEG contactor bottleneck. Critically, this improved version of the standard separation swirl-tube demister has shorter tubes and could be installed without modifying the TEG contactor vessel.

However, only a prototype existed, which had been tested at atmospheric conditions using air and water. Without tests under the high pressures representative of the operating conditions experienced on the Shearwater platform, the risks of installing the high-performance unit were deemed to be too high. The challenge was rapidly to test the new high-performing, short, separation swirl-tube demister to determine if it would operate as designed at high pressures and successfully remove the bottleneck in the Shearwater platform’s production.

Against the clock
The debottlenecking solution was needed within the normal four-week shutdown period with minimum modification inside the TEG contactor and with no, or very little, hot work. The platform was due to be shut down for operational reasons two months before the scheduled August shutdown, so all shutdown work was brought forward, which placed great demands on the project teams. This left only six months to test the prototype under high-pressure conditions and to have the hardware manufactured, and installed and working on the Shearwater platform.

Testing the technology
Shell Global Solutions’ Amsterdam facilities for research on gas-liquid separation and trays for distillation columns, which includes air-water and hydrocarbons-testing equipment, were swiftly put into use to test the prototype, high-performance, separation swirl-tube demister under conditions that more closely matched those in Shearwater’s TEG contactor.

The testing process for the new high-performance deck was designed by Shell Global Solutions. Sulzer Chemtech Nederland, working in close co-operation with Shell Global Solutions, designed the hardware. The prototype deck was tested against a standard swirl-tube deck for reference. The pressure drop and gas-liquid separation efficiency were recorded under pressures of up to 11 bar using a hydrocarbon (in this case butane), rather than air and water.

The performance of the high-performance deck equalled that of the standard deck, despite its more compact design. The prototype performed so well that no design changes were required.

The project began in early January 2003. Evaluation, reporting and risk evaluation of the application of new technology were completed by the end of March 2003. A positive decision to install the new separator was taken in early April 2003. A new set of internals was manufactured by Sulzer Chemtech Nederland and installed in June 2003, during the platform’s rescheduled shutdown period.

Delivering results
Following the modification of the TEG contactor, the Shearwater platform has been operating smoothly and at its designed production levels. Moreover, despite the restricted time scale, the project was completed within budget, ahead of schedule and with an excellent safety record.