pipeline operators are well-versed in the benefits of hot tapping subsea pipelines. Since the 1960s, the process, which requires diver assistance, has been a popular method of facilitating pipeline repair, tie-ins and chemical injection, as well as inserting instrumentation and providing access for temporary isolation tools.

As the quest for oil and gas moves into deeper waters, however, many subsea field infrastructures and developments under construction lie in depths to 3000 m. Consequently, demand for a pipeline intervention process that is not limited by divers who cannot work in waters deeper than 300 m is at an all-time high.
Operators are keen to embrace remote-controlled hot tapping technology that does not require divers to operate it. Concern for diver safety and efficiency also fuels this demand. By conducting a hot tap remotely, divers would no longer work in shallow water or be adversely affected by environmental conditions, such as those found in wave breaking zones and shore approach areas.

In response to this call to reduce diver exposure or eliminate them from the subsea hot tapping equation, T.D. Williamson (TDW) has developed the Subsea 1200RC tapping machine (Figure 2). The system makes it possible to carry out the actual hot tapping operation via remote control from a laptop aboard a diving support vessel (DSV). As a result, accuracy, diver safety and execution speed are dramatically improved. The system is completely diverless when pre-installed tees are present. In the event that pre-installed tees are not present, divers are still required to install the tapping assembly and the hot tap fitting.

By offering operators a way to access subsea pipelines in any water depth for construction, operational, or maintenance purposes, TDW believes that the field-proven Subsea 1200RC tapping machine will revolutionise the future of offshore pipeline intervention and maintenance.

**Challenges subsea**

Divers are experienced in performing mechanical tasks associated with the subsea tie-in operation, such as bolting, rigging, and manipulating valves, among others. The primary challenge lies in the fact that divers must perform the hot tap itself. This is the most critical component of the subsea tie-in operation: when the pilot drill penetrates the pipeline and the cutter cuts its way into a live pipeline. The challenges are twofold: firstly, divers are not typically hot tapping technicians. They are professional divers employed by the installation contractor. They work under the guidance of the hot tap technician, who is located on the vessel deck and communicates with the divers through the vessel intercom during the tapping process. The divers do receive hot tap training from the hot tap technicians during the dry mock-up tests before the offshore campaign, but they are not professional hot tapping technicians.

Secondly, there are a limited number of telltale sensors on current subsea machines, with no topside visibility. These sensors are necessary to monitor what is going on inside the fitting during the critical cutting period. This limits the ability of the diver — and the hot tapping technician — to fully monitor and control the tapping process. The diverless system developed by TDW helps to overcome both of these challenges.

**The traditional subsea hot tapping process**

Hot tapping involves drilling a hole into a live pipeline without shutting it down or releasing its contents. Currently, subsea hot tap operations are carried out from a DSV that carries the equipment and divers to the hot tap location. Divers are deployed and the hot tap assembly is lowered to the subsea pipeline. Hot tap operations in shallow waters are conducted in a horizontal mode at the 3 o’clock and 9 o’clock positions.
to ensure a flat, sideways tie-in connection, compared to a vertical tap at the 12 o’clock position that results in an upwardly protruding tie-in connection, which requires that large protective structures be installed over the tie-in works.

The average hot tap follows a set sequence. First, a hot tap assembly is prepared and pre-tested on the deck of the DSV. The assembly consists of a hot tap machine, permanent isolation valve and hot tap fitting that are bolted together. Typically, the fittings themselves are two mechanically-bolted clamp-halves. The assembly is then lowered with the two clamp-halves in open position over the pipeline, and divers bolt the two clamp-halves shut. To ensure its integrity, the annulus between pipe and fitting is leak-tested against the tapping machine while the valve is in an open position.

The hot tapping procedure begins by operating a pilot drill positioned in front of the hot tap cutter to create a small hole in the pipeline. This pilot hole serves to stabilise the larger hot tap cutter and retain the portion of cut pipe (coupon) after the larger cutter completes the hole. Then the primary tap is made into the pipeline with the appropriate size cutter. Following the tap, the valve is closed, and the coupon and tapping machine are recovered. In the case of preparing for a tie-in, for example, the permanent hot tap valve may then be connected to a spur line. As soon as the valve is opened, the new connection may be put into service.

**Evolving technology**

When TDW engineers set out to design the Subsea 1200RC tapping machine, they made certain that the solution was timely and reasonably priced. They also drew upon existing field-proven technologies, and planned to use conventional installation methods and marine spreads. Most importantly, it was critical that it be controlled directly by technicians, and that all subsea operations would be viewed continuously by technicians via a laptop computer onboard the DSV.

The new design is based on the TDW Subsea 1000 tapping machine, which has a proven, long track record. The team built a remote control system around it. The new system is a ‘topside-driven hot tap with passive remotely operated vehicle (ROV) interface’ concept, which means that it is a self-contained tapping machine with a built-in hydraulic and control system that is powered by a stationary ROV and operated by a technician from an on-board laptop (Figure 3). As a result, it is lightweight and the tapping operation is completely controlled by the technician. This is a great improvement over methods that rely upon ROV arms to manipulate individual valve functions.

The hydraulic and electronic power requirements are based on power supply from standard work class ROVs. (Alternatively, other subsea power units with similar properties may also be used.) Equipped with its own hydraulic power unit (HPU), the ROV stabs into the tapping machine control panel, and holds firmly onto the grabber bar throughout the hot tapping process (Figure 4).

The ROV provides hydraulic power (closed loop) to engage a motor/pump unit placed on the tapping machine frame. The motor/pump unit then sends hydraulics through a valve pack to the appropriate motor/hydraulic function. A software control program that can be operated manually or automatically was developed to operate all tapping machine functions from a laptop computer. Its primary functions include running the feed and drive motors, and engaging/disengaging the clutch. Sensors transmit information to the laptop on all critical parameters, including pressure, temperature, cutter position and proximity, rotation speed, and movement of the boring bar and cutter (Figure 5).

Some of the key pressures also have a manometer (pressure gauge) that can be monitored by the camera on the ROV panel. Sensors monitor the supply and return hydraulic line pressures, in addition to motor and drill pressures. The two cameras installed on the Subsea 1200RC tapping machine observe firstly, the rotation and position of the boring bar, and secondly, the position of the clutch cylinder.

In the event of system failure of hydraulics, electronics and machine parts, a range of generic contingencies have also been installed on the tapping machine. These involve overrides by ROV mechanical interfaces and duplicate monitoring systems. It is also designed to operate in depths down to 3000 m depending on the internal pipeline operating pressures.
Exceeding expectations offshore Asia

The Subsea 1200RC tapping machine was tested and successfully deployed in 2011 during a hot tap operation for a customer in the Java Sea at a water depth of 91 m (298 ft). The tap size was 16 in. on an existing 28 in. gas pipeline. TDW performed the operation from a DSV, and the cutting operation itself lasted around two hours. The entire operation was conducted safely, while flow through the gas pipeline remained uninterrupted.

Before the hot tap operation, a series of tests – including an integrated mock-up of the hot tap onshore – took place at the company’s facility in Singapore. During these tests, the tapping machine performed as planned, and never stalled. After the integrated system – comprised of the tapping machine, clamp, and isolation valve – was tested and approved, the operation commenced offshore (Figure 1).

The tie-in connection point was ready when the line was subsequently tied in. It is now possible for gas to be exported from the Kangean field to the existing gas export line. Instead of laying an expensive new pipeline extending hundreds of miles to the onshore receiving station, gas can be accessed at a fraction of the cost.

Historic milestones

As this operation demonstrates, the Subsea 1200RC tapping machine performed like clockwork. The hot tapping operation was successfully carried out by remote control, without diver assistance. The customer realised key benefits in the form of reduced diver intervention, enhanced safety, and increased efficiency. By using this technology, technicians working at the surface were in complete control of the hot tap machine and enjoyed an unparalleled view of critical subsea activity. By analysing the continuous transmission of data regarding pressures, temperatures, rotation and movement of the pilot drill and cutter, technicians were in a unique position to monitor all aspects of the cutting operation. Armed with this data, the technicians did not rely on divers to manually carry out the cutting operation; instead, it was carried out remotely, based on the timely and accurate readings of conditions in the cutting zone. By doing so, the operation was executed accurately and efficiently.

With a long-term objective of developing a completely diverless hot tap system, automating the hot tap process is critical. The success of the Subsea 1200RC tapping machine signals a step-change in subsea hot tapping technology. By ‘separating man from machine’, safety implications are unparalleled, especially in emergency situations that require immediate pipeline intervention and repair. Looking ahead, the potential benefits of the remote-controlled system for both offshore and onshore environments are far-reaching.