Weatherford

Case Study: Bayu Undan pipeline and Darwin LNG project, precommissioning and commissioning services for 26-28 inch dual diameter 312.3 miles (502.6km) pipeline and 188,000m^3 LNG tank in northern Australia.

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Introduction, Project Details and Challenges/Solutions:

Introduction:

As part of the construction and commissioning of the Darwin liquefied natural gas (LNG) project, Weatherford's Pipeline & Specialty Services (Weatherford P&SS) group performed several important operations, contributing to the successful startup of the ConocoPhillips LNG plant in Darwin, Australia.

Project Details:

The 26 inch LNG export pipeline runs from the Bayu Undan platform complex in the Timor Sea to the Darwin LNG terminal at Wickham Point (Fig. 1). The pipeline total length of 312.3 miles (502.6km) consists of 502km of 26 inch diameter pipe and 1,969 feet (600m) of spool pieces; there is a 28 inch subsea isolation valve (SSIV) and a 28 inch platform riser at the receiving end. The technical operations performed included hydrotesting, dewatering, drying, and nitrogen purging of the LNG pipeline; nitrogen purging and testing of the plant's pipework system; and air drying and nitrogen purging of the 50 million gallon (188,000m^3) LNG storage tank. Weatherford P&SS used its unique range of precommissioning and commissioning technology to complete the operations incident free and ahead of schedule.

Challenges/Solutions:

Significantly, the precommissioning operations were performed from the onshore terminal, and the pipeline was therefore pigged in the reverse direction. This resulted in the pig design needing to cater for a 1.9 inch (48.2mm) diameter increase in the receiving riser section after travelling a distance of 312.3 miles (502km) and negotiating an SSIV. Weatherford P&SS are extremely proud and excited about this configuration of pipeline dewatering pigging, which it believes had never previously been undertaken anywhere in the world. Extensive modelling and trials were carried out at the Weatherford P&SS research and development technology centre in Edinburgh, UK (Fig. 2), to finalize the ideal pig configuration and urethane grade. The pig was given a final trial on the SSIV and pipework in Singapore (Fig. 3) before its installation, which proved successful.

The dewatering operation involved propelling six of the multi diameter long run pigs with high pressure, super dry compressed air, at a velocity averaging 0.5 m/sec. The pig train was designed to desalinate the pipeline during the dewatering process and leave a minimal layer of water on the internal pipe to achieve efficient air drying. The compressor spread used consisted of a series of high volume/high pressure compressors and driers specifically designed for use in long deepwater pipeline precommissioning operations. Weatherford P&SS boasts the largest portable fleet of high pressure compressors in the world. The dewatering operation proved to be a complete success and extremely efficient, with water removal rates being amongst the best ever achieved.

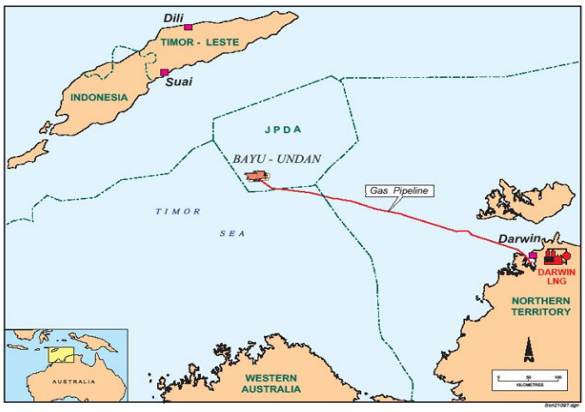

Figure 1: Bayu Undan pipeline route

Figure 2: Weatherford P&SS pipeline research loop in Edinburgh, Scotland

Challenges/Solutions:

Figure 3: Field trials in Singapore prior

Figure 4: Condition of pigs after dewatering completed

Figure 5: Condition of pigs after dewatering completed

The urethane wear experienced on the pigs was consistent with the modeling; thus, the pigs proved to be particularly effective (Fig. 4 & 5). As a result of the efficient dewatering operation, the subsequent air drying of the pipeline to a stable dewpoint of -4°F (-20°C) was achieved within the predicted time frame. Upon completion of the drying operations, the pipeline was purged and packed with nitrogen to a pressure of 8psig (0.5barg) and isolated in readiness for introduction of the gas. The supply of liquefied nitrogen in Darwin being limited, Weatherford P&SS used membrane technology to produce the nitrogen for the purging operation. The onsite membrane unit produces nitrogen directly from the air, consequently an unlimited supply was therefore guaranteed. Also, the high risk and expense of transporting liquefied nitrogen to the site were thus eliminated. Additionally, the technology significantly reduced the possibility of schedule disruption for extra purging. The Bayu Darwin pipeline remains the longest offshore pipeline constructed, installed, and commissioned offshore Australia.

The Darwin LNG facility has a single tank for LNG storage. It is one of the largest above ground LNG tanks in the world, with a working capacity of 50 million gallon (188,000m^3). The facility has a ground flare rather than a conventional stack, which minimizes the visual impact of the facility and any intrusion on air traffic in the Darwin area. The LNG is stored in specially engineered and constructed double walled storage tank, which has 3 feet (984mm) thick concrete exterior walls and an inner tank made of a special steel nickel alloy to accommodate the cold LNG; the space between these walls is filled with insulation to maintain the cold environment. If a leak develops in the inner wall, any escaping LNG will be contained in this space, and sophisticated redundant monitoring systems provide constant surveillance for internal leaks. The tanks are not pressurized, and the liquid is extracted from the tank and re-gasified for delivery through pipelines to consumers.

Challenges/Solutions:

Weatherford P&SS was contracted to perform the drying and purging activities on the LNG tank (Fig. 6) after the Perlite insulation had been installed between the cavity walls. The scope of work involved drying of the tank, and was undertaken by purging the wet air through the tank vents while replacing it with super dry air at high volumes. The acceptance criteria were as follows:

Zone dew point (atmospheric pressure) A: dome space and inner tank < -4^{o}F (-20°C) B: annular space < 14^{o}F(-10°C).

Weatherford P&SS employed its unique Sirocco^{SM} air drying process (Fig. 7 & 8) instead of the traditional methods of tank drying and to adhere to the work/cost schedule. A single *Sirocco* air drying unit can produce 247,000scf/hr (7,000m^3/hr) of dry air at dew points of up to -40^{o}F (-40°C), whilst only consuming approximately 8l/hr of diesel fuel. Using traditional methods would have required a fleet of compressors and dryers that would have used approximately six times the amount of diesel fuel to run the spread. In addition, Weatherford P&SS *Sirocco* technology required 50% less transportation space and costs, and 50% less operational manpower than traditional techniques. Therefore, Weatherford P&SS choice of drying solutions addressed the specification requirements of supplying low dew point air at ultrahigh flow rates to shorten the project schedule and achieve the required project milestones while minimising costs.

It was estimated during project planning that, in order to purge the LNG tank to the required acceptance criteria of 8% or less oxygen content, a volume of 14.5 million (55,000m^3) of gaseous nitrogen would be required. Traditional methods of inerting would have involved converting liquefied nitrogen to gas with nitrogen vaporizers, which would have required around 55 standard size liquid nitrogen delivery tankers.

This volume of liquid nitrogen supply would not have been available in Darwin, and a major logistic plan would have been required to deliver such a volume to the Wickham Point site, with tankers having to travel round trip distances exceeding 249 miles (400km).

Figure 6: Bayu Undan - LNG tank

Figure 7: P&SS Sirocco^{SM} air drying unit

Figure 8: P&SS Sirocco^{SM} air drying unit

Results/Benefits and Summary:

Results/Benefits:

Rather than complying with traditional methods, Weatherford P&SS used portable, compact, nitrogen membrane units which are supplied in 10-20 feet. containers for ease of transport, and which produce nitrogen directly from air. The advantages of using these membrane units for the Darwin LNG project were significant for the client. The reduction in risk of liquid nitrogen spillage, as well as in road transportation accidents, manpower requirements, costs, environmental impact, and diesel usage were undeniable. The result for the client of using this unique Weatherford P&SS solution was that the tank drying and purging operations were completed well within the required time frame and at a significantly reduced price when compared to traditional methods, whilst reducing the risk associated with these operations.

Summary:

Weatherford P&SS research and development team configured this ideal solution in order to successfully pig 312 miles (500km) of multi diameter pipeline in the reverse direction, as well as designing a pig train capable of desalinating during the dewatering process, developing record breaking air drying achievements, using membrane technology to provide unlimited N^2 supply (thereby eliminating the risk and expense of transporting liquefied nitrogen to the work site for the purging operations), and reducing the number of compressors and dryers and the amount of fuel typically needed for drying by the use of the company's Sirocco^{SM} air drying process. Even more impressive than the solutions themselves is that they were all generated and provided by one company: Weatherford P&SS.

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