Precise Acoustic Positioning During Offshore Oil Field Development

Located 70 km (120 miles) southeast of Hong Kong in 370 meters (1,210) ft) of water, the Liuhua project is a state-of-the-art production system comprised of twenty five sub sea trees. The Liuhua field is the largest oil reservoir to date in the China Sea. Drilling and technical challenges at the site required the use of cutting-edge technologies to develop the field. Sonardyne's Compatt and Paroscientific's Broadband Depth Sensors are two of the advanced technology instruments used.

Established in 1971, Sonardyne is an international group of companies manufacturing subsea instrumentation. Sonardyne specializes in the use of sound for underwater navigation, positioning, data communication and control. Sonardyne's Compatt, the **Comp**uting and **T**elemetry **T**ransponder, has been the market-leader for subsea positioning for over two decades. The latest generation of this transponder is Compatt 5.

Compatt 5 is based on a new electro-mechanical design and employs the latest acoustic signal processing technology. This new platform is designed to take Compatt forward for many years with regular upgrading of capability, easily installed by the user.

Sonardyne has offered Digiquartz Broadband Depth Sensors as an option in Compatt for over 20 years. The transponders are a component in Sonardyne's Long Baseline (LBL) system which is used world-wide in subsea survey and construction work.

LBL systems are typically used:

- As tidal references to make periodic corrections to water depth
- For measurement of relative heights on piles and structures
- In spool piece metrology

This application note describes the acoustic positioning techniques used during a multi-well sub sea development at 310 meters water depth in the South China Sea. Acoustic positioning played an important and comprehensive role in every aspect of the seabed engineering work, significantly contributing to the overall success of the installation. The project included the accurate setting of the conductors for 20 wells, manifold piles and pipeline bases, production jumpers between each well, and the installation of clump weights for the flexible risers attached to the Floating Production System.

The 'as-built’ well and pile locations were surveyed with a precision of +/- 0.15 meters. A sub sea gyro measured the conductor orientation to +/-0.5 degrees accuracy. A +/-0.3 meters elevation tolerance proved the most difficult to measure, as the best available pressure sensors could provide an absolute depth accuracy no better than +/-0.6 meters; however, use of a differential technique established relative heights to better than +/-0.1 meters. The riser clump weights were installed to within the required positioning tolerances of +/-1.2 meters from an anchor-handling vessel.

Jetting: Jetting consisted of circulating seawater through a mud pump assembly inside the conductor, whilst slowly lowering the pipe on its own weight and the weight of the drill collars inside the conductor. From time to time the conductor was raised to assist soil penetration. The acoustic positioning system was used to monitor the following parameters as the conductor was being jetted in:

(1) Orientation: The positioning system displayed the real time gyro orientation of the piles on the drill floor, permitting the drillers to orient the conductor to a high degree of accuracy. This allowed all the guide bases to be built the same, as each conductor could be orientated to the same azimuth, which in turn simplified the fabrication of the rigid well-to-well pipe jumpers.

(2) Elevation: It was essential that each conductor be placed within a ±0.3 meter relative height tolerance. This was necessary for fabricating the jumpers between the guide bases, as the specialized mechanical tool used to measure the hub-to-hub distances and orientations was set up using the relative heights and distances determined using the acoustic positioning system. The relative heights were measured using 2000 psi-scaled Digiquartz depth sensors included in the 'target' Compatts.

These depth sensors use quartz crystals to sense the temperature-compensated ambient pressure. The quoted measurement accuracy of the depth sensors is 0.02 % of the full scale value, giving an absolute measurement accuracy of ±0.14 meters. This equals the required tolerance, without taking into account unknown effects of tides and water density, and to a lesser extent, swell. A differential technique was, therefore, devised to monitor the difference in the depths between a reference and a target quartz pressure sensor. The four depth sensors (one included in the RovNav transceiver and three in the target Compatts), were calibrated during factory acceptance tests in an environmental chamber to check their linearity and repeatability over the pressure and temperature variations expected near the seabed during jetting operations. The differential measurement corrections established for each sensor during these tests, allowed height differences to be monitored off-shore to better than ± 0.1 meters.

For the first manifold pile, a reference transponder was set on the seabed and the depth difference to the target transponders mounted on the pile used to establish the height of the pile above the seabed. This information was presented in both a digital and analogue form, giving the drill floor the remaining distance to drill. Once the pile was set, the ROV re-positioned the reference transponder in the top of the pile to become the elevation datum for all the other piles and conductors.

(3) Attitude: Measurement of tilt was important to establish the relationship between adjacent conductors. Tilt was measured using precision dual axis inclinometers mounted on the piles. Two sets of inclinometers were used, one connected to a target transponder and the second in one of the under water gyros. The data was transmitted to the surface via acoustic telemetry and the gyro cable respectively. The selected results were displayed by the acoustic positioning system in conjunction with the orientation and elevation information. All the conductors were spudded with tilts within 0.5 degrees of vertical.

(4) 'As-Laid' Positions: After reaching the correct depth, the conductors were left to soak for up to two hours, allowing the surrounding soil to rebuild strength. During this period, the acoustic system was used to determine the 'as-laid' position. Immediately prior to releasing the piles, any conductor settlement was measured and the 'as-laid' elevation established relative to the reference pile.

This application note was submitted by Sonardyne. It is based on a paper by John D Hughes (Amoco Orient Pet. Co.) and Nigel C Kelland (Sonardyne Int. Ltd.) presented at the 11th Offshore South East Asia Conference in September 1996.

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