Subsea Automated Ultrasonic Inspection

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ABSTRACT

Aging platforms, tighter maintenance schedules and the demand for quantitative and operator independent data as input for advanced RBI systems are all leading to an increase in the use of automated ultrasonic inspection systems also for inspection of subsea components like platform structures and pipelines.
Whether automated ultrasonic subsea inspections are performed as diver assisted or ROV assisted, the challenges are much higher than for similar inspections performed topside, and so is the demand for quality documentation as inspection and repair costs are significantly higher for subsea components.
The high costs achieved by involving supply ships, divers, ROV and automated systems makes it cost worthy to perform strict preparations for each job and to qualify each step in the operation in order to avoid costly mistakes found during the offshore operation.
This paper describes the process of equipment development, personnel training, qualification of the entire inspection system and the subsea inspection process, based on actual subsea inspections performed in the North Sea.

EQUIPMENT DEVELOPMENT

In view of future demands for ultrasonic inspection of subsurface structures of offshore platforms FORCE Technology in year 1999 started design for upgrading of its 15-year-old P-scan diver assisted subsea inspection system. The new design should include arrangements for a ROV assisted version of the subsea inspection system.
A team of FORCE Technology specialists in offshore inspections conducted the design process and diver assisted operations.
One of the practical elements was design and construction of the tool skid that could include the whole subsurface inspection system and also do the very critical cable handling in a safe manner.

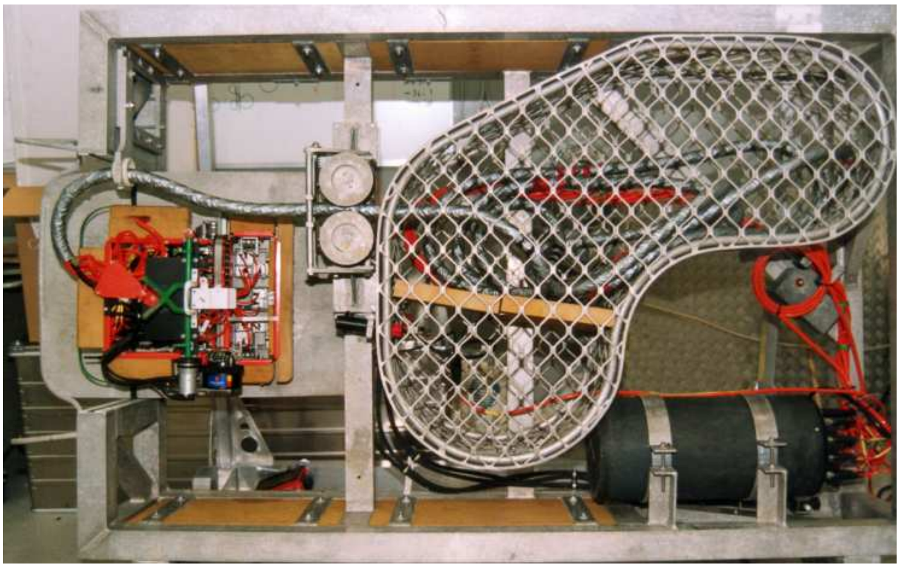

Figure 1: Tool skid with the complete inspection system. The scanner is placed on a platform where a calibration block is integrated. The cable handling system is operated by hydraulic power supplied by the ROV. The P-scan system 4 is placed in an electronic's pressure bottle. One cable is connected to the ROV's umbilical. All communication is through this cable.

The tool skid was designed for mounting underneath a ROV with manipulators.
The detailed development and construction of instrumentation and inspection solutions was elaborated in close connection with preparations for actual inspection cases.

THE SIRI CASE

Early in year 2000 a development program was established for ultrasonic inspection of girth welds on the legs of the Siri platform.
The development program financed by Statoil Denmark, involved Stolt Offshore as ROV operator/contractor and FORCE Technology as ultrasonic inspection specialists. MSL Engineering served as advisers for Statoil on requirements to be set for inspection performance.
Siri sits in 55 meters of water in the Danish sector of the North Sea. The platform is a 3-leg jacked-up structure, set on a steel storage tank. The three legs are 3.5 meters in diameter with circumferential girth weld every third meter. The wall thickness ranges from 63 mm to 114 mm. The girth welds are ground flushed to ensure a smooth surface and covered with sprayed aluminium. A selected set of these welds is intended inspected at regularly intervals.
The development program included:

- Modification of the AUS-4 scanner for ROV manipulator handling.
- Assembling of AUS-4 scanner, the P-scan system-4 data acquisition and data processing unit, calibration blocks and cables in a robust “tool skid” that could be mounted underneath a ROV.
- Testing of the subsea P-scan units for water pressure corresponding to an operational depth of 400 meters (test pressure 600 meters). The high test pressure was selected by FORCE Technology because other platforms in the North Sea have structures much deeper than Siri.
- Elaboration of detailed inspection procedures.

Figure 2: Test of prototype frame for ROV handling. The test uses a manipulator similar to the ROV manipulator.

The training of personnel was done in the FORCE laboratories in Denmark as dry trials performed on a full-scale mock-up. The training program involved:

- Communication between topside PC and subsea system, tilt camera and light via ROV optical fibres.
- Manipulator operated calibration test on the test block in the tool skid.
- Manipulator controlled transfer of scanner from tool skid to inspection target and back again.
- Ultrasonic inspection of the target.

A successful demonstration of performance terminated the development program. The subsurface equipment was during the demonstration placed in the 170 m³ test tank in the FORCE laboratories in Denmark. In order to simulate real field conditions the operating personnel was working from a control room installed in a container. Operation of scanner and ROV manipulators was done using cameras only.

Figure 3: Top side control room during the qualification. The qualification simulated real working conditions. Operation of scanner and ROV manipulator was done using cameras only.

The subsea inspection system was mobilised to Siri in July 2000. After removal of marine growth by ROV using water jetting the inspection system was interfaced with the ROV and a few pilot “dry-tests” were carried out before deploying the coupled system.

Figure 4: Tool skid mounted under ROV

During subsea inspection the ROV is positioned nearby the inspection area. Here the manipulators integrated in the ROV take the scanner and place it at the inspection area, where the scanner is released when a guide shows contact of the magnetic wheels. From that moment the FORCE team takes over control of the scanner movements while the ROV moves to a stand-by position less than 12 meters away for transmission of data and video surveillance of the inspection.

The first element of the inspection was to locate the exact position of the aluminium coated welds. Each weld was identified by the ultrasonic data collected when running the scanner across the expected weld position. The next element of course was to inspect the weld for longitudinal defects at the inner and outer surface. Time of flight diffraction (TOFD) data was collected simultaneously. After completion of a weld inspection the ROV manipulators released the scanner and brought it back in the tool skid.

Six of the circumferential welds and in addition 2 welds in the caisson were inspected in July 2000. A total of 83 meters in 70 hours were inspected. The same welds were also inspected in June 2002. The max. inspection depth was approximately 50 meters.

THE HEIDRUN CASE

In 2003 FORCE Technology inspected welds on tension legs of Heidrun, the Statoil platform placed on a depth of 360 meters off the Norwegian coast.
Statoil contacted FORCE Technology because the Heidrun maintenance people knew that the major components of the latest version of the ROV operated P-scan subsea inspection system had been developed for operation depth of 400 meters.
The tension legs of the Heidrun platform are 24” diameter pipes constructed by welding together 12 meters long sections with a wall thickness of 38 mm. These tension legs were examined very detailed during the production phase and all welds were inspected by automated ultrasonic methods. Now, about eight years after start of platform production these welds should be inspected again with the best possible subsea technology.

Figure 5: Heidrun with tension legs to the bottom

Plans for demonstration of ability and subsequent implementation of the inspection job were established. It was a customer demand that the quality of the subsurface inspection should be comparable with or even better than the quality of inspections done dry during the previous production control.

In the first half of 2003 inspection procedures were elaborated and trained. The inspection ability of personnel and the ultrasonic system was demonstrated by dry tests on the aluminium-coated welds in a sample section of a tension leg.

In August 2003 the FORCE team arrived at Heidrun with the P-scan subsea ultrasonic inspection system shown on figure 1. The system includes also a PC to be placed topside.
Arrived on the platform the tool skid was mounted underneath the Heidrun ROV and communication between subsea system and topside PC via ROV umbilical (optical fibre) was established.

The inspection procedure included a full volumetric inspection using puls-echo technique for detection and TOFD for sizing of defects if any. It was possible to inspect up to 5 welds in a normal 12-hour shift. During the inspection period set for 2003, inspections of all welds (except for 4) on two tension legs were completed.

Figure 6: Scanner AUS-4 for operation by ROV manipulators

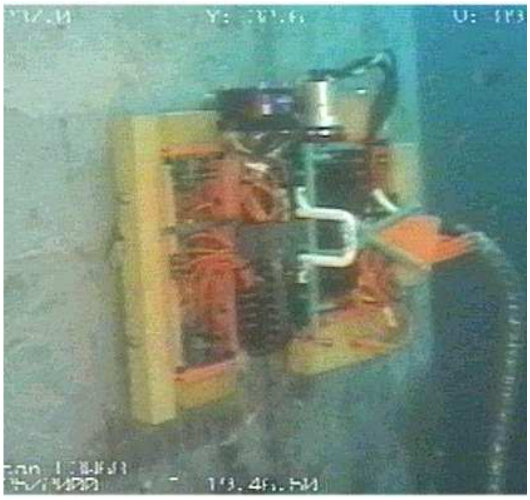

Figure 7: Scanner AUS-4 at work subsea

The inspected welds were located in depths ranging from about 60 meters to 325 meters and at that time this was probably a depth record for automated ultrasonic inspection.

SUBSURFACE OIL PIPELINE

In August 2003 FORCE Technology was called for a quick mobilization for inspection of a damaged oil pipeline at a depth of 52 meters in the North Sea. Inline calliper inspections of the 20" oil pipeline had disclosed two 15 mm deep dents pressed in the concrete coated steel pipe.

In addition gyro-instrument showed clear displacement of the buried pipeline around the same location. A comprehensive and very tightly scheduled remedial action plan was initiated. A 4 tons anchor and damages in the concrete coating were found when the suspicious-looking pipe section was uncovered. Broken concrete and corrosion protection materials were removed from a two meters long pipe section and the damaged steel pipe prepared for detailed inspection.

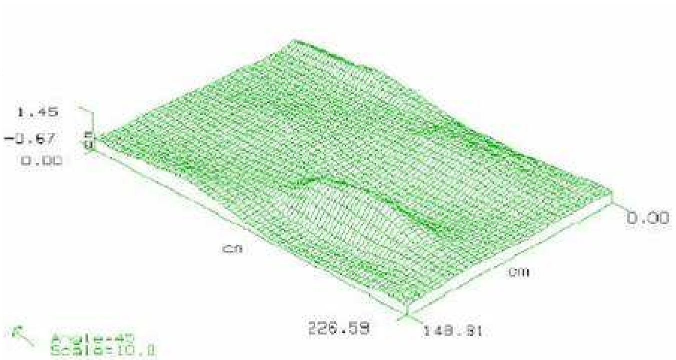

Figure 8: Graph of dents found by calliper inspection.

The department of Advanced NDE Services at FORCE Technology was called for subsea ultrasound inspection of the steel pipe for internal as well as external surface breaking defects. The 2-men team arrived on the diver supply vessel (DSV) with P-scan system 4 configured for diver assisted subsea inspection. This configuration included the scanner AUS-4, the P-scan-4 data acquisition and processing unit housed in an "electronic bottle" and a PC for online presentation of data and remote control of the subsurface units. A 100 meters long cable connects the subsurface instrumentation with the PC onboard the DSV.

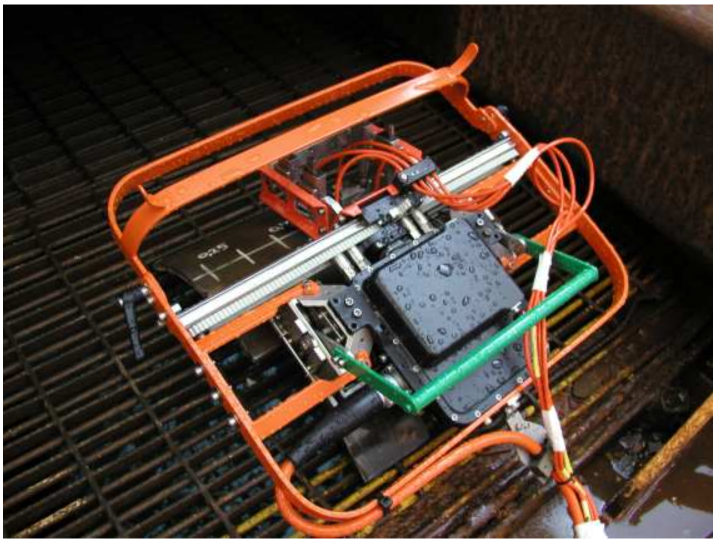

Figure 9: Scanner AUS-4 configured for diver operation

A diver mounted the scanner on the pipe and his operations were viewed on deck via the diver's video camera. The operator on deck of the DSV controlled movement of the scanner with its 4 ultrasonic transducers. The length of the damaged pipe section was divided in 9 sectors to be inspected individually both for longitudinal defects and for transverse defects. The operator on deck could view the processed US-data in the various P-scan display features and thus evaluate pipe condition simultaneously with progress of the scanner.

The inspection operation continued successfully until the 9th. sector should be scanned. At that time all computers controlling position-keeping systems of the DSV broke down. Divers were immediately taken on board the vessel and the subsurface P-scan units left on the bottom with its surface cables tied to a marker buoy at the surface. The DSV sailed to its home station in Norway for repair, while the subsurface units rested at the bottom for about 2 days. After repair the ship returned to the location. The diver went down to the subsurface instrumentation while the FORCE team connected the P-scan cable to the PC and completed inspection of the 9th. sector without further delays.

Figure 10: The diver supply vessel (DSV) Pelican

RECENT EQUIPMENT IMPROVEMENTS

The performance of the ROV assisted automated subsurface ultrasonic inspection system is expanded concurrently with demands set by customers and their subsurface structures.
Since the inspections in 2003 the system has been set up and pressure tested for operational depth of 1000 meters. The subsea inspection system has been scheduled for work in the Danish, Norwegian and UK offshore sectors as routine operations on a yearly basis.
New geometry challenges will push the development towards a flexible subsea inspection system suitable for almost any requirement.

FORCE Technology provides the subsea inspection service worldwide and the system will be updated for eddy current surface inspection as well. FORCE Technology is aiming at an operation depth of 3000 meters which will be a challenge, but possible.