A NEW, IMPROVED PIPELINE AUT GIRTH WELD INSPECTION SYSTEM

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ABSTRACT

Automated ultrasonics is steadily becoming the standard method of inspection of pipeline girth welds throughout the world, particularly using phased arrays. Phased array AUT systems were first developed a decade ago, and proved to be much more flexible and capable than multiprobe systems, particularly for offshore special applications. A new version has been developed, which incorporates all the techniques developed previously, e.g. seamless pipe, thick section inspections, small diameter pipe inspections, clad pipe, and is significantly more powerful and flexible. A number of technical improvements have been made to software, instrumentation, computers, umbilical and probe pan. Overall, the new system has all the old system capabilities, plus significantly increased applications capability. Lastly, the new system requires no additional training and qualification. Some results with the new system will be shown.

INTRODUCTION

Figure 1 : Photo of typical pipeline AUT operation

Automated ultrasonics is steadily becoming the standard method of inspection of pipeline girth welds throughout the world. In addition, old technology multiprobe systems are rapidly being replaced by newer phased arrays. Olympus NDT developed the first phased array system a decade ago, which proved to be much more flexible and capable than multiprobe systems, particularly for offshore special applications. As such, the original system effectively became the global standard in AUT. A new system has been developed, which incorporates all the techniques developed for the original system, e.g. seamless pipe, thick section inspections, small diameter pipe inspections, clad pipe, and is significantly more powerful and flexible.

Compared with the original system, the new system:

- Has much improved ultrasonic performance
- Is more robust
- Is easier to upgrade
- Is more maintainable
- Is highly modular, i.e. flexible
- Has increased applications capability
- Requires no additional training and qualification.

The new system can be configured to match the application, e.g. from thin onshore gas pipelines to thick risers and tendons, by changing the instrumentation and packaging. The instrumentation can be removed and placed near the weld if convenient. The umbilical is improved with lengths from 5m to 25m. The scanner is lighter and lower profile, with waterproof TOFD pre-amp. The instrumentation is upgraded to the Focus LT, including multiple units up to 128/256, while the software is based on TomoView 2.8 and is upgradeable. A much higher data transfer speed allows additional inspection techniques to be used simultaneously. For example A-scan compression is available for full data collection on S-scans. The ability to display strip charts, S-scans and merged views on the same display layout is good for detailed defect analysis. The computer is switched to a server for improved robustness. GPS is used for location, with wireless data transfer. Overall, the new system has all the original system capabilities, plus significantly increased applications capability. In addition, the new system has been designed so that no additional training is required for experienced operators, and no additional system approvals should be required outside regular project qualifications.

BACKGROUND

Historically, pipeline automated ultrasonic testing (AUT) was developed in Alberta by NOVA Corp and TransCanada Pipelines Ltd. from the 1960's on (1). The technique used linear scanning for speed, strip charts for rapid data analysis, zone discrimination (i.e. tailored weld inspections), and customized calibration blocks. The technique developed to such an extent that two codes were written: ASTM E-1961 primarily for onshore use (2), and DNV OS F101 for offshore (3).

At that time, the only ultrasonic technology available was multiprobes, which required large, heavy probe pans, which were inflexible. At the end of the 1990's, R/ D Tech (now Olympus NDT) developed a phased array system equivalent to the multiprobe systems (4). Physically, the phased array systems had much smaller probe pans, were lighter, and significantly more flexible. The arrays had an automated Focal Law set-up (called the "Garden Gate"), which was a major convenience. Phased arrays could perform additional scans, which allowed many different inspection options. For example, the original phased array system could generate 128 channels in four views, which was a major improvement over multiprobe systems' 24 channels. Subsequently, other manufacturers have developed phased array pipeline AUT systems, though the original system remains the market leader.

Additional applications typically came from offshore requests, e.g. seamless pipe, high quality thick pipe, small diameter pipe, and clad pipe (5). The seamless pipe was addressed by running multiple set-ups simultaneously (6), the premium thick pipe by using additional beams, and the small diameter pipe by using an additional scanner. Clad pipe is similar to the nuclear austenitic pipe inspections – also best performed by phased arrays, and uses a different approach with multiple S-scans. The original phased array AUT system has been used to address all these procedures. However, in some applications, an improved or more powerful system would have helped; as a result, a completely re-designed phased array AUT system has been developed to address these applications, and to take advantage of new technology.

NEW SYSTEM OVERVIEW

Changes have been made in the following areas:

- Hardware
- Software
- Mechanics
- Umbilicals

This will lead to:

- Improved performance
- More robust system
- Easier to upgrade
- More maintainable
- Highly modular
- Increased applications capability
- Similar price (depending on configuration).

Overall, this will lead to a more configurable system, improved mechanics and umbilical, hardware upgraded to Focus LT, twice as many available channels, and the software upgraded to TomoView 2.8. All the previous functions will still be available, e.g. the Garden Gate automatic set-up, with many new capabilities and a flexible system configuration. More specifically, the traditional gray boxes will still be available, but instrumentation can be located externally if the application demands. A robust server will be used instead of the PC for reliability. The motor controller will be downsized significantly. The instrumentation can now be placed at any reasonable distance from the probe pan, with umbilical lengths from 5 m to 25 m. The umbilical can contain up to 256 ultrasonic cables.

NEW SYSTEM – INSTRUMENTATION BOX

The traditional instrumentation box (see Figure 2), which is robust and temperature-resilient, will be more accessible. Now, it can go inside or outside the cabin. The phased array instruments are removable for convenience and maintenance. In addition, a UPS is inside the box in the event of a power cut.

Figure 2: Photos of gray instrumentation box, front and back.

The new system is driven by the new Focus LT (see Figure 3), which is “smaller, cheaper, lighter and faster” than the original Focus (7). These units take less room than the current Focus unit. Either one or two Focus LT units can be used, configurable to the application. More important, the Focus LT units can be 64/128 or 128/256 channels, which allow lots of channels for matrix array applications such as austenitic welds, cladding and improved focusing on thick pipes (8).

Figure 3: Top, Photo of Focus LT with laptop. Bottom, photo of Focus LT for PipeWIZARD V4

The motor controller is a new Galil motor control drive unit, approximately half the size of current MCDU (see Figure 4). It is located inside the box.

Figure 4: Photo of Motor Control Unit.

The original system computer has been replaced by a server, which is more robust, more reliable, more stable and more maintainable. For example, the operator can "hot swap" the hard drive, power supply etc. These servers use advanced array technology for reliability.

Lastly, the instrumentation uses GPS for location, and wireless communication. This is critical in remote areas, where many pipelines are built. Satellite communication and pcAnywhere allows data transfer and trouble shooting – literally, anywhere. The set-up can be debugged from any base via wireless, satellite and remote control since the only onsite adjustable set-up parameter is the wedge separation.

UMBILICALS

With the instrumentation mounted safely in the AUT cabin, the original system required a long umbilical with 128 micro co-axial cables. This umbilical tended to suffer from internal fretting, which was inconvenient and expensive. The umbilical has now been re-designed to eliminate the internal fretting, and is robust. It is protected by metallic braid over the full length, with a reinforced shield at the probe pan end. This umbilical has been extensively fatigue tested, and field tested at -40 C in Siberia and in the United Arab Emirates. Overall, the umbilical is reliable.

The new umbilical is shielded, more rugged, and more flexible. In addition, the umbilicals are configurable. A typical configuration for offshore might be for the first 20 m to be metal braid protected, and the last 5m to be metal stainless steel sheath protected. A typical configuration for onshore might be 20 m with all metal braid protection.

PROBE PANS AND SCANNERS

For larger pipes, the probe pan will be the same as for previous versions (see Figure 5).

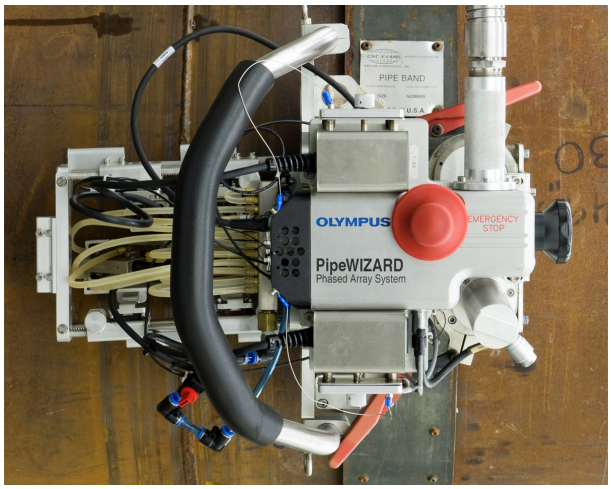

Figure 5: Photo of PipeWIZARD probe pan.

For smaller pipes, new ring scanners are available (see Figure 6). Four rings will cover up to 20” (500 mm) diameter, with adjustable diameters. These scanners will be easy to mount, and easy to position with a jig. The probe pan can be very quickly mounted. The umbilical itself connects directly to the rings. In addition, the small diameter probe pans can also be operated manually.

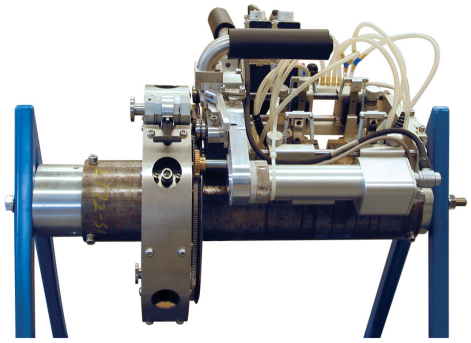
Figure 6: Small diameter Ring-Type pipe scanner in addition to standard PipeWIZARD (optional)

Above 100 mm in diameter (i.e. almost all applications), there are two possible probe pan combinations:

- PA and dedicated TOFD, or
- PA and transverse pair

Below 100 mm, we are limited to one PA pair only.

On the buggy, the Emergency button has been moved to eliminate breakage risk. It is now external and rapidly replaceable. In addition, this eliminates sealing problems

SOFTWARE AND APPLICATIONS

The real advantage of moving to the TomoView 2.8 software platform is that upgrades and improvements to the software can be made easily as standard TomoView.

The Focus LT units transfer data much faster (4 MB/sec cf. 0.7 MB/sec for v2). This allows A-scan data compression for full data collection, and to run multiple set-ups simultaneously.

An important advantage of the new software in the v4 is the ability to display strip charts, plus S-scans and merged views on the same display layout. This capability is well beyond the v2 capability, and more than required by either zone discrimination code. Specifically, the number of channels has been increased to 256 panes in 9 or more display layouts; this should be very useful for seamless pipe inspections. The standard TomoView "merge function" is available, as is velocity compensation with refracted angle.

The "Setup Creator" function from the original system has been improved, with more standard weld profiles. This technique permits automated set-ups, with the operator simply inputting the weld profile and appropriate parameters (see Figure 7).

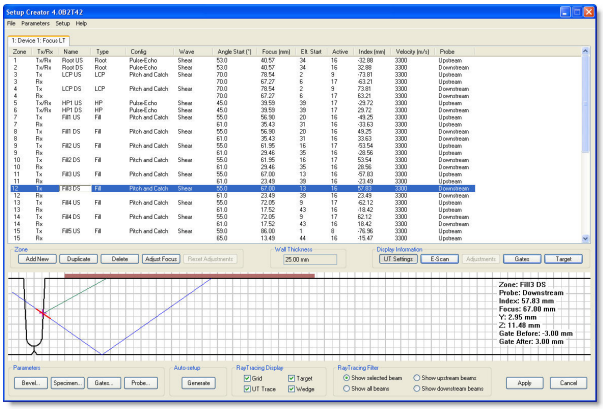

Figure 7: Example of new Setup Creator tool for J-bevel weld

With two 64/128 Focus LT units giving 128/256 power, the operator can run 128 elements on each side for thicker pipes or for 2D arrays. The new system offers potentially new applications, especially cladding and austenitics, and is good for detailed defect analysis, e.g. accurate sizing using back-diffracted S-scans (9). The increased number of channels and upgraded software permit 2D arrays for improved focusing, and for detecting transverse defects. Specifically, the new system can drive TRL-PA (Transmit-Receive L-wave – Phased Array) probes for austenitic steels. Figure 8 shows typical TRL-PA probes.

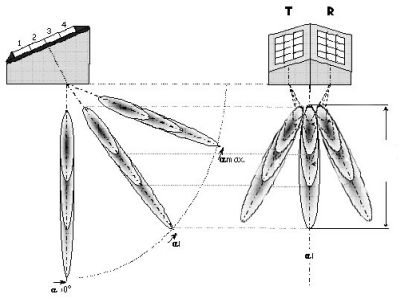

Figure 8: Schematic showing typical TRL-PA probes.

In addition, the Setup Creator and system can run different types of scans. Figure 9 shows an example of an E-scan for the root and an S-scan for the cap.

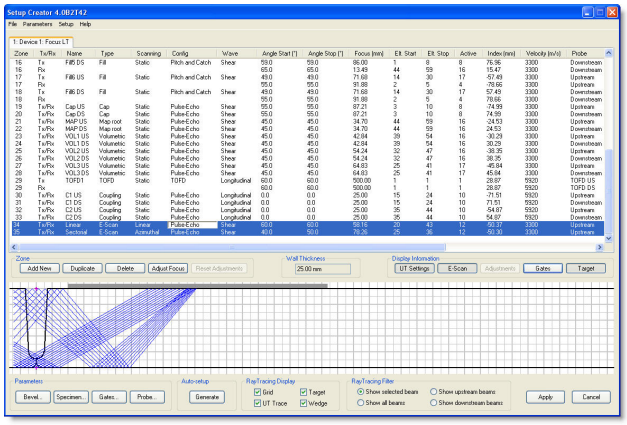

Figure 9: Setup Creator image of E-scan and S-scan combination

The software permits automatic interpretation of data by displaying the defect information on the bevel profile including the circumferential position of the defect and by conducting a comparison with pre-established and job specific Engineering Critical Assessment (ECA) criteria, as shown in Figure 10.

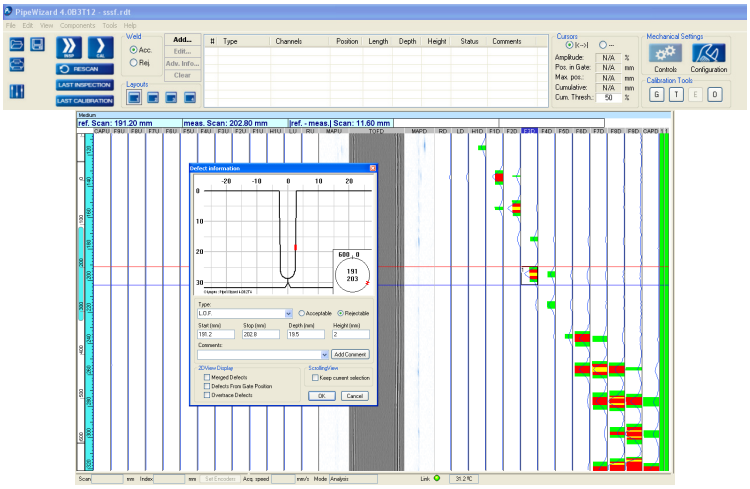

Figure 10: Automatic data interpretation display.

APPLICATIONS

The new system will be able to routinely perform special applications that previously were unavailable or difficult to set-up (10). These include:

- Additional scans, particularly in the root region for thick pipes.
- Seamless pipe inspections using multiple windows, except v4 allows many more windows and better coverage than v2.
- Use of 2D arrays, with the TomoView Advanced Focal Law calculator.
- TRL-PA inspections of austenitics and clad pipes.
- Special applications, such as unusual weld profiles.
- Extra thick pipe inspections, e.g. risers and tendons, using improved focusing.
- Conventional inspections, i.e. ASME-style raster scans.
- Additional analysis techniques, such as S-scan back-diffraction for sizing.

UPGRADING ORIGINAL SYSTEMS TO NEW SYSTEMS

It is possible to upgrade current units to upgraded units. A package is available, depending on what upgrades are required:

1. Software is fully upgradeable to new TomoView versions
2. Hardware is upgradeable to a large extent, especially the umbilicals (already replaceable), and the instrumentation (Focus replaceable by Focus LT's)

TRAINING AND QUALIFICATIONS

The new system software displays and hardware been designed so that no additional training is required for experienced operators; they should be familiar with the new system. Furthermore, no additional qualifications should be required as the new system is essentially identical to the original system --- at least in the basic format and functions.

CONCLUSIONS

1. An updated version of the standard PipeWIZARD v2 has been produced, PipeWIZARD v4.
2. The new system has changes in the hardware, software, mechanics and umbilicals.
3. These changes lead to improved performance, a more robust system, easier software upgrades, more maintainable, highly modular, increased applications capability and a similar price (depending on configuration).
4. Additional training is not necessary for the new units.

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