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Integrated Time of Flight Diffraction Set Up Software

Jan Verkooijen
The Sonovation Group of Companies
Oosterhout, The Netherlands

Alex McLay
Sonovation Ltd
United Kingdom

Abstract

The Time of Flight Diffraction Technique (TOFD) is becoming increasingly used as an alternative to Radiography within both the construction industry and the in service inspection of pressure vessels and pipe work. TOFD, like any other technique requires to be applied in a concise manner, in order to achieve the theoretical targets of high probability of detection (POD), a low false call rate and proof of coverage. The introduction of European and ASME standards has brought some coherence to the application of TOFD for fabrication inspection.

However, a difficulty lies in the determination of actual coverage by TOFD on different geometries. Although for instance ASME specifically requires documented evidence of the coverage achieved, common practice is that at best a table is included in the procedure indicating the setups for the different weld geometries involved. To produce a documented examination strategy showing component coverage is cumbersome without software aids. Even with software tools such as professional drawing packages, producing such scan plans is not a simple task if many different geometries are involved.

Sonovation felt there was a need to assist industry in simplifying this requirement by producing a simple to use software program that will assist in visualizing the coverage achieved for any setup.

This paper will describe the logic behind this software package and demonstrate how it can assist companies in not only preparing procedures but acting as a validation tool then on to its use within organisations QA and Data Base systems.

1. History

Over the past 20 years Sonovation and many others have been working on the application of TOFD, which in the beginning was restricted mainly to verification and sizing of defects found with other NDT methods. This required skilled operators with a high degree of mathematical and scientific background to fully understand the application for specific challenges, mainly in In-Service Inspection. Many international projects have been carried out to improve the understanding of the advantages and limitations of TOFD. This led to the understanding that advantages of TOFD were not restricted to sizing alone, but could also be used for detection of defects. This has also opened the door to the application of TOFD as a quality control tool during manufacture. To be fully useable and accepted as a replacement for traditional NDT methods such as radiography, it was necessary to introduce:

- A standardised way to apply TOFD.
- Training and certification of operators.
- Acceptance criteria.

Over the years, the above requirements have been laid down in European [1] [2] [3] as well as American Standards [4]. Although this is a great improvement, standards are by default general and do not address specific applications and geometries. This leaves Notified Bodies, Authorised Inspectors, Design Engineers and Fabricators with the problem of assessing whether a specific TOFD inspection is providing them with a full code compliant inspection.

3. The Aims of ScanPlan®

As part of the development project Sonovation specified the basic requirements of the software routine and these were laid down as:

- To formulate TOFD procedures in accordance with existing Codes and Standards.
- To assist inspection companies to routinely produce easily understood examination plans as contractually required.
- To assist in preparation for validation and performance demonstration to prove the efficiency of the proposed technique.
- To improve the insight into the quality and coverage of inspections.
- To record all parameters and settings and make them available for the subsequent inspection and analysis.
- To assist Design Companies and Fabricators with inspection friendly design.

Many months of meetings with such organisations were held to discuss the exact their exact requirements. These meetings directed the development to where we are today.

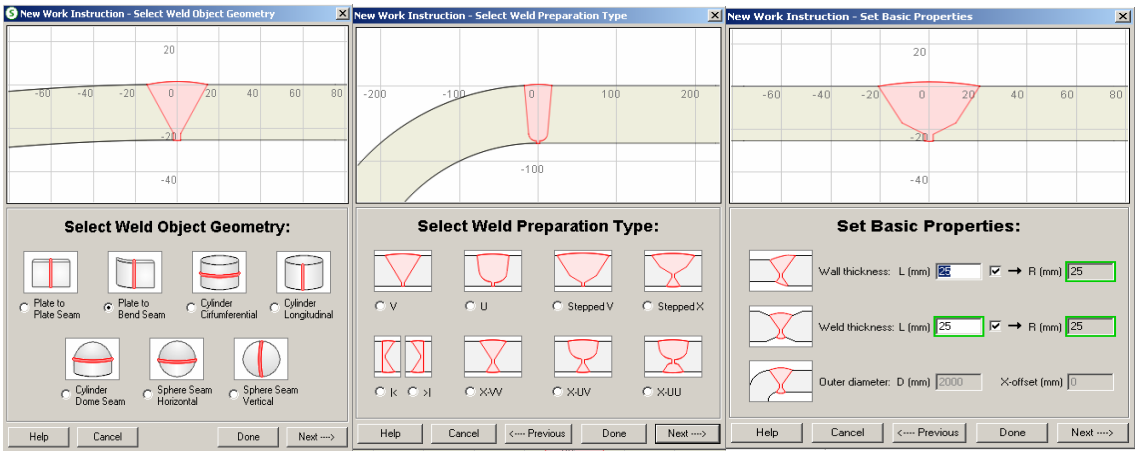
4. ScanPlan® Development

Over a number of years, the software has evolved from a spread sheet application for the internal use by Sonovation, into a stand alone Windows program. During the years of internal use, many thousands of scan plans have been developed. Many of these have led to inspections which were validated or have undergone a performance demonstration which has adequately proven the validity of the software.

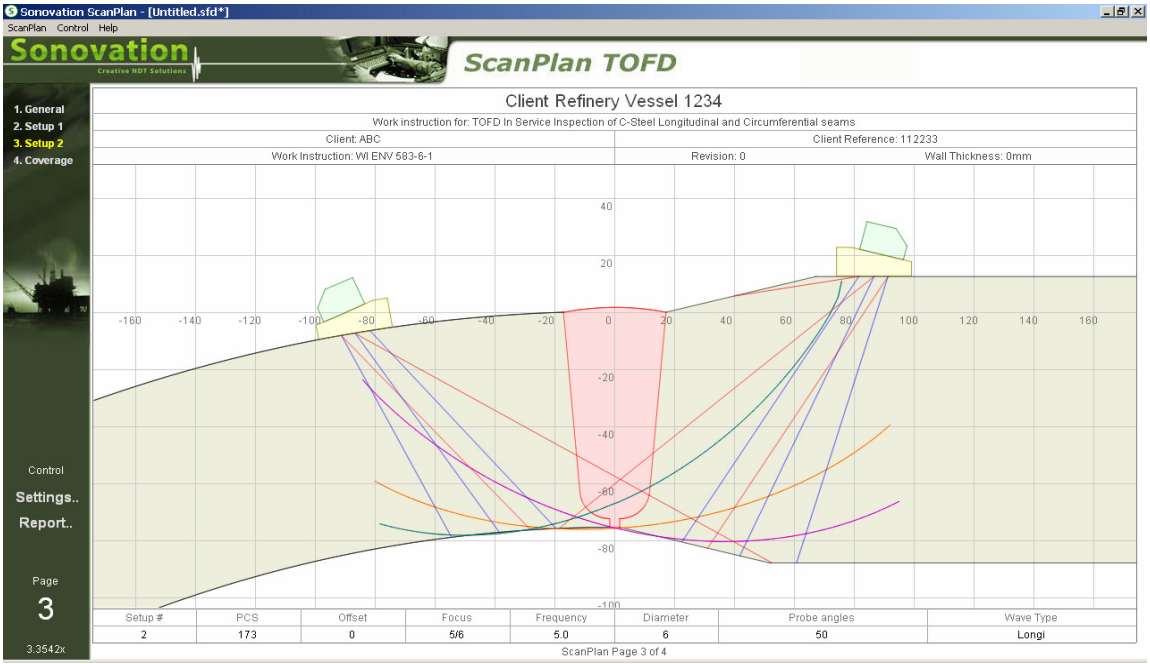
5. Software Input

Basic Input

The basic input for ScanPlan® is the geometry of the object under test, together with the weld detail. At the outset it was decided that ease of use would be one of the key parameters. A level II TOFD operator with a little bit of additional training in the use of the software would have to be able to produce a valid examination strategy for the component. The system therefore is build upon a database which holds a number of basic geometries and weld preparations. With the intuitive flow of the program the operator can adjust the parameters to the specific component and weld preparation.



Once the geometry has been established, the software suggests a basic examination strategy which is based upon experience and the requirements of the standard chosen. The result can now be further optimised for the specific configuration, because the software immediately has processed the set up and calculated a number of key parameters which are to an extent visualized on the ScanPlan® display.
Most importantly a choice of Codes and Standards is demanded, several Codes are now available and will be extended with demand and time.



The software calculates the nominal Probe Centre Separation (PCS), probe characteristics (Frequency, diameter et cetera) and inspection coverage. The inspection coverage is displayed by the beam spread and the longitudinal wave loci for the back wall

and near surface zones. Where required, the transverse wave of the beams and the corresponding loci can also be displayed
To further the insight into the inspection quality, a large number of relevant ultrasonic parameters are calculated. Amongst these are the resolution and error bands as a function of depth.

In addition several basic changes can be made now, for instance if the technician does not have the correct ultrasonic transducer wedges, he can complete the "Transducer Tool Box" with his available wedges and the software will automatically calculate an alternate solution. Similarly if there is an obstruction present near a weld, the PCS can be changed accordingly and the new solution will immediately be given.

Work Instruction Input

The input of all relevant inspection data regarding the following parameters is catered for.

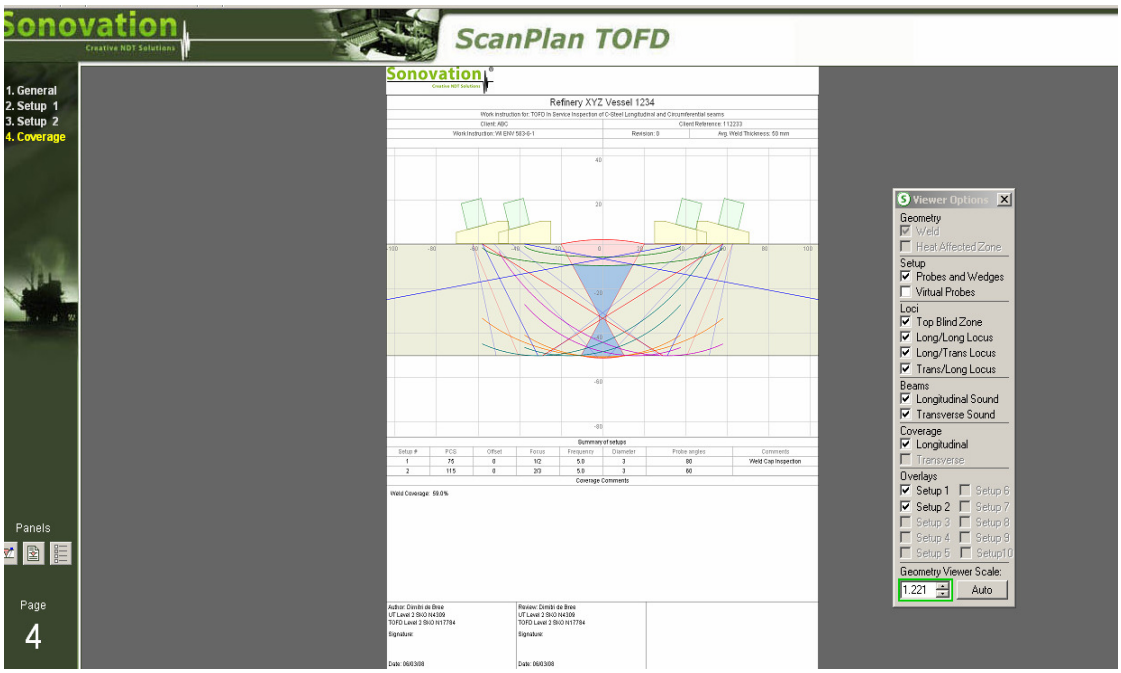
- Work Instruction and procedure identification.
- Client and project information.
- Inspection company information.
- Procedure Author information.
- Procedure validation attestation.
- Object under test details.
- Test Specification used.
- Report Options.

Libraries of technicians can be stored; their (third party) qualifications and certifications will be displayed automatically.
All the points come together to offer a complete procedural application as shown below.

Viewer Options

On this panel it is possible to interrogate the procedure in accordance with coverage of the proposed procedure. The software displays the longitudinal and mode converted main beams with corresponding beam spread. In addition, the software shows the behaviour of the relevant beams within the inspection area, by displaying relevant near- and far surface loci for both longitudinal and mode converted beams. From this, the actual percentage coverage of the inspection area is calculated and demonstrated.

The following screen shot demonstrate the effectiveness of this.



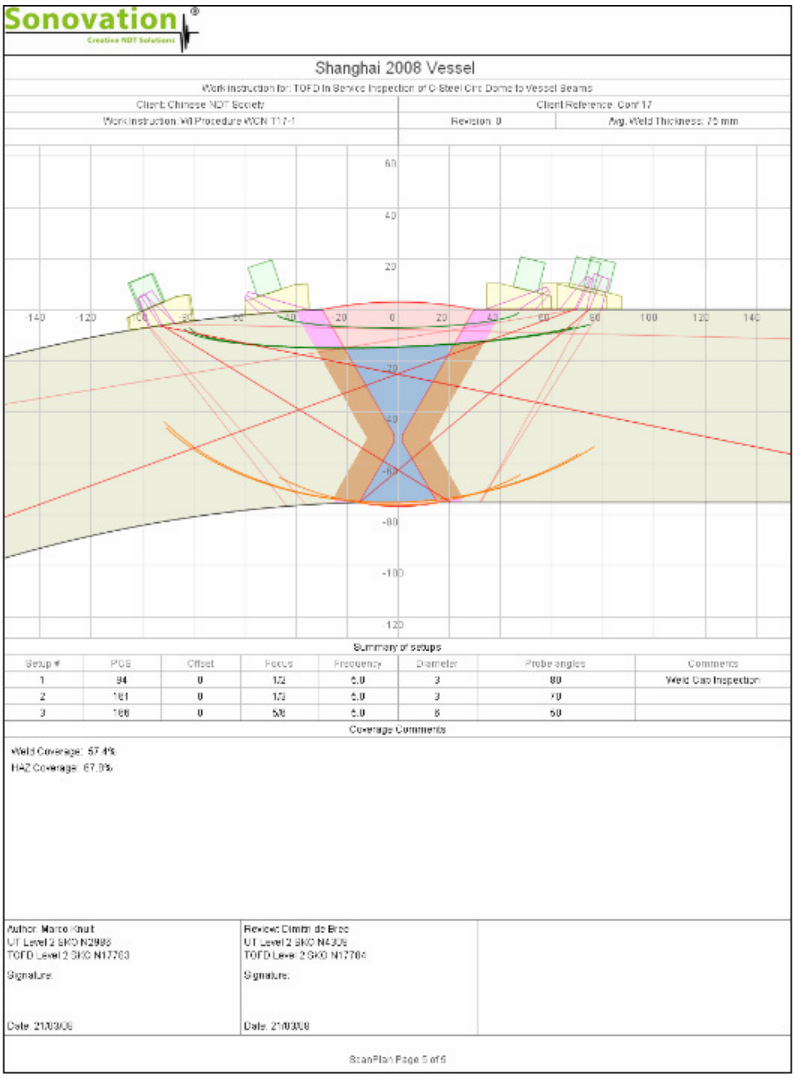
Documentation Available

It is now possible to produce 3 different types of documentation.

- A general view of the weld and all geometrical parameters.
- Individual transducer set ups.
- General view with percentage coverage attained and the complete list of set ups for that particular solution.

These pages can form part of the procedure, the technicians work instruction, it can be sent digitally to a 3rd party for validation or it can form part of a weld design review.

The following diagram demonstrates the overall coverage of the selected method with the relevant inspection details.



6. Equipment Integration

ScanPlan® is part of a family of integrated software packages. Although all packages can work stand-alone, they can interact via a data base, which holds all relevant data of an inspection. Relevant data consists of the client, site and component information, together with the inspection data. With the setup information generated by ScanPlan®, all information is readily available to start the inspection. Within the Inspection system, this information can be used to automatically set up and calibrate the system, ready for the inspection! Most inspection instrumentation in use today can be modified to work in conjunction with ScanPlan® to also make use of this quality improvement by avoiding set up inaccuracies.

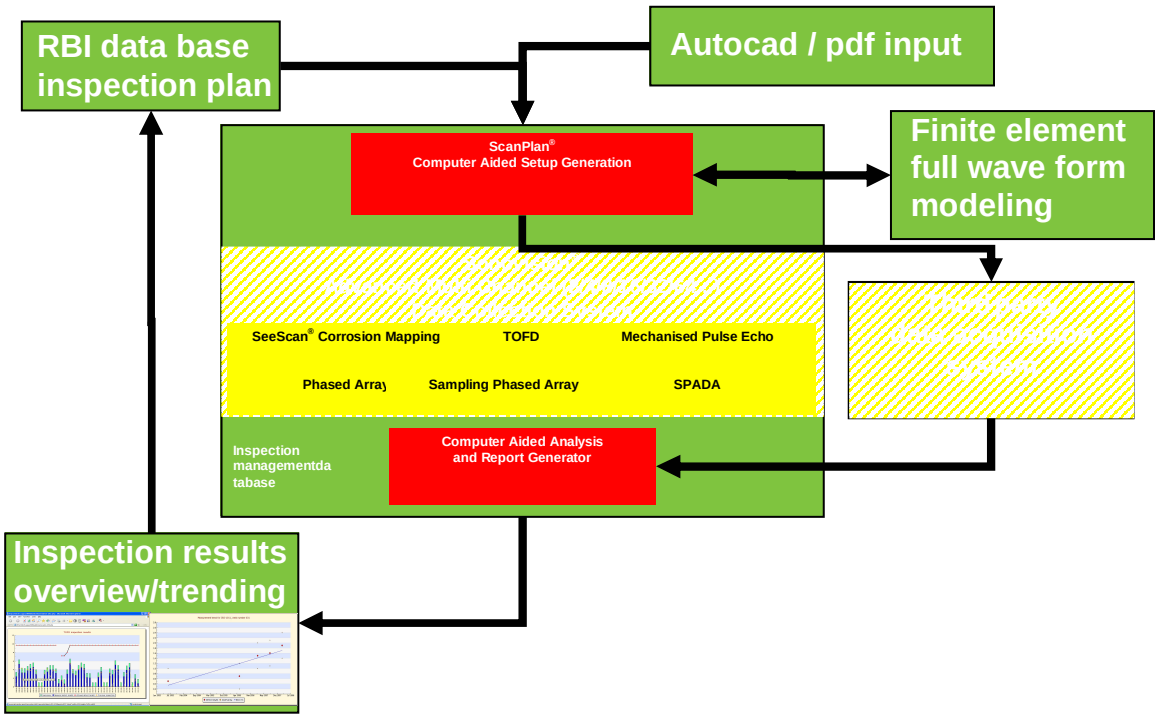
Once the inspection is carried out, the project data file is expanded to include the actual scans produced and can even include the data analysis results to make reporting truly comprehensive.

Because of its database nature, the full system can communicate with most databases in use today, such as Reliability Centred Maintenance and Risk Based Inspection data bases, which puts all relevant information straight into the asset owner's hands as described further.

Future Developments

Future Developments include the following:-

- Integration with Pulse echo techniques.
- Integration with Phased Array techniques (Conventional PA and Sampling PA).
- Integration with systems to provide detailed calibration procedures.
- Closer integration with Inspection Management Systems.
- Integration with Project Management Systems
- Integration with Finite Element Full Waveform modelling systems



8. Integration with Management Systems

Plant operators strive to optimisation of plant availability. To this end, systems are in use to plan inspection and maintenance such that downtime can be minimised. Risk Based Inspection and Reliability Centered Maintenance are but two of these system. ScanPlan® is laid out as a data base that can communicate easily with the data base already in use by the plant operator. ScanPlan® can easily take in inspection details required to perform the inspection as mentioned in 5.2 from an RBI database. Once the inspection has been performed, the tabulated findings are added to the file received from the RBI database and sent back to the RBI database. Within the RBI system the results can then be evaluated or trended and a new inspection target date can be established and fed into ScanPlan® again to complete the circle!

9. Conclusions

- ScanPlan® has now been used by the Sonovation Service companies for more than two years and has proven itself to offer significant time savings plus technical advantages in preparing professional procedures.
- ScanPlan® concurs with the requirements of European Codes (ref 1, 2, 3)
- ScanPlan® concurs with the requirements of the Asme Code Case (ref 4)
- ScanPlan® has been of great value in improving the quality of practical applications of the TOFD technique during fabrication inspection.
- ScanPlan® is part of a full suite of software programmes which includes a toolbox for data analysis support, a report generator and a data base to enable easier tracking of complete projects. It also interacts with client's databases to improve Reliability Centred Maintenance and Risk Based Inspection systems.

References

[1] EN 583-6, Non-Destructive Testing Part 6, use of the Time of flight diffraction technique as a method for detection and sizing of defects.
[2] CEN/TS 14751, Welding - Use of time-of-flight diffraction technique (TOFD) for examination of welds.
[3] prEN 15617, Non-destructive testing of welds - Time-of-flight diffraction technique (TOFD) - Acceptance levels.
[4] ASME Boiler and Pressure Vessel Code, Case 2235, Use of Ultrasonic Examination in Lieu of Radiography, Section I; Section VIII, Divisions 1 and 2; and Section XII.