SOUND BYTES

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Email ID: soundbytesisnt@gmail.com
Official Newsletter of ISNT Chennai Chapter

To include the news about ISNT's Mega event as early as possible and for administrative convenience Sound Byte, hence forth will be published on 1st January, 1st April, 1st July and 1st October.

PASSION, VISION, MISSION, ACTION.

A new management team has now taken responsibility of carrying forward the excellent work of the previous ISNT team. I am honoured that the NGC of ISNT has chosen me as its President for the next 2 years. This is a very important responsibility and I hope that with support and contributions from the NGC and all ISNT members, we will be able justify the confidence placed on us.

Some of the key targets for ISNT over the next 2 years may be

- to double the corporate life-members and to increase individual life-members by 50%,
- to significantly increase the interactions with the academia, training institutes, and other educational institutions and increase the student memberships to 500,
- to further increase the recognition and presence of ISNT in the global community through increased participation in the key committees of AFFNDT, EPFNDT, and ICNDT as well as forging sustainable partnerships with sister NDT societies worldwide,
- to become an internationally recognized provider of ICN training and certification program based on ISO9712,
- to forge win-win relationships with societies representing the welding, manufacturing, foundry, aerospace, auto, etc. industries and finally ,
- to improve synergy between the different entities of ISNT including NCB, TMB, PFMB, and QUNEST, and to further strengthen each of these entities
- to further strengthen the Chapters of ISNT across India and to start at least 2 additional Chapters within India ,
- to imitate new ISNT Chapters in other countries such as middle-east Asia, South-east Asia, Africa, among others,
- to increase revenue sources and improve the sustainability of ISNT through new offerings and expanding existing activities,
- To keep the ISNT community updated on the latest technologies and standards, particularly with the emergence of Artificial Intelligence into the NDT practices.
- to reorganize the administration of ISNT towards a more corporate governance structure.

After a roaring success of the NDE2023 in Pune, kudos to the organisation team, we now embark towards the next year conference NDE2024 to be held in Chennai between 12-14 December 2024. The NDE conferences represent our Marquee event that annually brings the academia, training, instrument, service and user communities together. Every NDE20xx conference has seen new initiatives such as Startup Pavilions, Industry Sessions, etc and we hope to continuously innovate on bringing new and improved value propositions to the conference stakeholders.

ISNT has also taken the responsibility of hosting the NDE4.0 International conference that was awarded by the ICNDT. This event will be held in Taj Yashwantpur, Bangalore during March 2025. This event will provide an opportunity for ISNT to showcase the emergence of India as a technology developer and leader in NDE4.0 Technologies.

Each of the above goals will be challenging. I urge every ISNT stakeholder to roll-up-your-sleave, answer the bugle call and be a partner towards demonstration our resolve to both the NDT community in ensuring pole position for ISNT internationally.

Prof. Krishnan Balasubramanian
President
Indian Society for NDT

Indian Society for Non-Destructive Testing, Chennai Chapter
Module 59, 3rd floor, Readymade Garment Complex. SIDCO Industrial Estate, Guindy, Chennai 600 032. Phone 044-45532115, 7200086075.

Dear Readers,

Seasons Greetings and Very Very Happy New Year to all.
Knock (1993), Knock (2002), Knock (2011), Knock (2017) and KNOCK (2024).
Yes, you guessed it right. Opportunity in the guise of National Conference and International Exhibition is for the FIFTH time knocking at our door. The ball is in our court. Kindly remember that right from 1993 - when the chapter was just two years old, our chapter has raised the bar of the conference every time.
High jump in sports is an excellent model for comparison. The world record in 1912 was 5'2 ½" using scissors technique. Next was eastern cutoff and the record was 6' 5 ½". Third one was western roll and the height was 6' 7 ¾". Straddle technique followed and the bar was raised to 7' 5 ¾". Then Fosbury Hop increased it further and presently it stands at 8' ¼". So it is proved that raising the bar necessitates that the technique be changed.

Similarly to raise the bar in 2024 NDE Conference we have to change the techniques.

At this juncture I wish to bring forth a unique confluence of 4 events that as per me is happening for the first time in the history of ISNT.

- A chapter is chosen as the venue to conduct the NDE conference for the year.
- The President of ISNT is past chairman of the chapter.
- The Secretary of ISNT is past secretary of the chapter.
- One of the joint secretaries is also from the same chapter.
- The chapter wins the Best Chapter Award continuously for the second time.

Let us all celebrate this confluence of events in a befitting manner by raising the bar several notches.

NDE 2023 conference was conducted at Pune with several novel techniques and the bar has been raised several notches. (An article appears in this issue of Sound Bytes about the same written by Shri.Bikash Ghose and Shri.Karuppasamy. Readers are requested to read the same). So it is not going to be a cake walk to surpass that.

If we are to raise the bar of NDE 2024 again then we have to invent new techniques in all the fields of the conference. Are we ready to accept the challenge? We invite suggestions from our readers.

Ram

Venue and Theme of previous NDE Seminars conducted by ISNT Chennai

Seminar	Date and Venue	Theme
NDE 1993	2-4 December 1993 at Welcomgroup Park Sheraton Hotel & Towers	NDE-2000, Quality & ISO-9000
NDE 2002	5-7 December 2002 at Raja Muthiah Hall, Chennai	Predict, Assure, Improve
NDE 2011	7-10 December 2011 at Chennai Trade Centre	Enrich & Excel in Engineering thro'NDE
NDE 2017	14 – 16 December 2017 at Chennai Trade Centre	Safety, Reliability, Sustainability

Addition of Members – Three New members added during last 3 months. Total Members – 906

Courses Conducted

1. UT Level-II course was held from 22nd August 2023 to 2nd September 2023. Course Director: Mr.S.R.Ravindran Examiner: Mr.E.Sathya Srinivasan (SNT-TC-1A) /Mr.C.Srinivasan (IS 13805).
2. RT Level-II course was held from 4th October 2023 to 14th October 2023. Course Director: Mr.S.Chockalingam Examiners: Mr.P.Anandan (SNT-TC-1A) / Mr.C.Srinivasan (IS 13805)
3. Surface NDT (MT & PT) Level-II was held from 16th November 2023 to 25th November 2023. Course Director: Mr.E.Sathya Srinivasan Examiner: Mr.P.Anandan (SNT-TC-1A) / Mr.C.Srinivasan (IS 13805).
4. UT Level-II course was held from 12th December to 23rd December 2023. Course Director: Mr.S.R.Ravindran Examiner: Mr.E.Sathya Srinivasan (SNT-TC-1A) /Mr.C.Srinivasan (IS 13805).

Courses Planned for the next 3 months

1. **RT Level-II from 31st January 2024 to 10th February 2024**

EC meeting

1. The fourth EC meeting for the financial year 2023-2024 was held on 27th August 2023 at ISNT office premises. 16 members attended the meeting.
2. The fifth EC meeting for the financial year 2023-2024 was held on 8th October 2023 at ISNT office premises. 20 members attended the meeting.
3. The sixth EC meeting for the financial year 2023-2024 was held on 17th December 2023 at ISNT office premises. 19 members attended the meeting.

Certificate of Authorisation

ISNT Chennai Chapter is the 1st Chapter of ISNT to receive the CoA from TMB to conduct IS 13805 Level II Certification program in 7 methods **ET, LT, MT, PT, RT, UT and VT Level-II** which is valid up to 1st September 2028. We shall be having a surveillance audit every year.

Training Management Board,
Indian Society for Non-Destructive Testing

Certificate of Authorisation

This certificate is issued to **ISNT CHENNAI CHAPTER, CHENNAI,** in recognition of its Quality System meeting the requirements of ISNT:TMB:03 as Authorised Training Centre . This Certificate of Authorisation will remain valid for a period as noted below subject to satisfactory continuation of the Quality System and adhering to the terms and conditions of Indian Society for Non-Destructive Testing and services provided as listed in the Schedule of Authorisation.

Name & Location of Authorised Training Centre:
ISNT CHENNAI CHAPTER,
Module No.59, Readymade Garment Complex,
3rd Floor, SIDCO Industrial Estate,
Guindy, Chennai-600032
Tel:044-45532115

Scope: Training delivery in Non-Destructive Testing methods : ET, LT, MT, PT, RT, UT, and VT according to IS 13805 Standard

Date Authorised : 2 September, 2023
Date of Expiry : 1 September, 2028
Certificate Number : IS-ATC/2302

Sign
Controller of Authorisation

TRAINING MANAGEMENTBOARD, INDIANSOCIETYFORNON-DESTRUCTIVE TESTING.
Regd. Office: Modules60&61, 3rd floor, Readymade Garment Complex,
SIDCO Industrial Estate, Guindy, Chennai-600032.India.
Website:www.isnt.in
TMB: Form:02

Training Management Board,
Indian Society for Non-Destructive Testing

Schedule of Authorisation **Certificate No.: IS-ATC/2302**

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ISNT CHENNAI CHAPTER,
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Tel:044-45532115

2. **Non-Destructive Testing Methods/Technique approved:**

NDT Method	Technique
Eddy current Testing	-
Leak Testing	-
Liquid Penetrant Testing	-
Magnetic Particle Testing	-
Radiographic Testing	-
Ultrasonic Testing	-
Visual Testing	-

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HO news & other chapter news

For ISNT Head office announcements and Webinars of other chapters Kindly refer to the Website of HO of ISNT (www.isnt.in).

BEST CHAPTER AWARD 2023

New office bearers of ISNT

New office bearers of ISNT along with NDE 2023 organizing committee

Report on Unleashing the Power of Advanced Technologies—NDE 2023

By Shri. Bikash Ghose, Group Director, NDT Division (HEMRL) , (DRDO), Pune

The 33rd Annual Conference and Exhibition on Non-Destructive Evaluation and Enabling Technologies (NDE 2023) organised by the Indian Society for Non-Destructive Testing (ISNT), the Official Technical Society for NDT/NDE in India, at The Hotel Orchid in PUNE held during 7th – 9th Dec 2023. The event was inaugurated by Dr Sameer V Kamat, Secretary Department of Defence R&D and Chairman DRDO on 7th Dec 2023. Dr V Narayanan, Distinguished Scientist and Director of Liquid Propulsion Systems Center (LPSC), ISRO was the Guest of Honour of the inaugural function. The theme of the conference was "Transformative NDE: Unleashing the Power of Advanced Technologies".

In the keynote address during the inaugural function, Dr V Narayanan talked about the role of NDE for the success of space mission. He mentioned about the criticality of the components for the functioning of the space system and how NDE technologies are unavoidable for safety and functioning of systems. He highlighted that NDE is a critical component across various industries, ensuring structural integrity, safety, efficiency, ageing, life estimation and life assessment.

In the inaugural function of the Conference, Dr Sameer V Kamat highlighted the importance of Non-Destructive Evaluation Technologies for each industry. He highlighted how the destructive test is important for R&D but NDE is the solution for quality assurance of usable systems. He appreciated about the fact that the conference is attended by the participants from wide spectrum of industries which indicates about the large stakeholders involved in NDE. He suggested all to frame a technology road-map at the end of the conference for the NDE community. Dr S V Kamat released the souvenir and also launched NDT certification programme of ISNT named as International Certification in NDT (ICN). Dr Kamat and Narayanan distributed various National NDT awards diuring the inaugural programme.

During the inaugural function, D D Joshi, President ISNT briefed about ISNT and it's activities. Uday Kale Convener NDE2023 delivered welcome address and Bikash Ghose, Chairman of NDE2023 briefed about the Conference. J Hiremath had delivered vote of thanks. Thet state-of-the art exhibition with 71 exhibitors from India and abroad showcasing NDE products, technology and services was inaugurated by Dr V Narayanan. After the inaugural function, Dr V Narayanan, Director LPSC, ISRO delivered a memorial talk on "Rise of Indian Space Programme – Pride of our Nation". Another memorial talk was delivered by industry luminary Shri Ashish Bhandari, MD and CEO of Thermax Group on "NDT's connect with the World of Tomorrow".

The 3 days conference had a footfall of about 1400 participants. The event was well supported by industries such as Reliance Industries, Tata Steel, DRDL, BDL, Bharat Forge, Solar Industries, Thermax Ltd, KSB Pumps etc.

The conference had 162 technical presentations, 4 interactive workshops, 71 exhibitors and 49 keynote talks from R&D community and various industry.

ISNT launched its own skill development certification scheme "International Certification in NDT (ICN)" fully compliant with ISO 9712:2021. ICN is the only scheme from India that has been included in ICNDT Mutual Recognition Agreement that will ensure recognition of ICN certification with the partner countries. National Certification Board (NCB) of ISNT is the only NDT certification body in the country that has been accredited by NABCB, Quality Council of India as per ISO 17024. This scheme will give a boost to the industry and in line with the industrial revolution 4.0 and will meet the call of Atmanirbhar Bharat.

An Overview of Magnum Opus—NDE 2023

By Shri. C. Karuppasamy, DGM - MTCP Assembly, L&T Rubber Processing Machinery , Kanchipuram

No moment passed without some benchmarks being set during December 7-9, 2023. NDE 2023 has set a set of bench marks and opened new avenues for forthcoming conferences. The collective positive approach of the Pune chapter ensured that it happens.

As an Engineer I was able to witness the stupendous work done by ISNT, resulting in unfolding before my eyes. Digital registration and utilization of AI at many events was delightful to watch and participate in and was one of the proofs of the theme of the conference.

Success often begins by adopting out of the box ideas, as the conference organising committee of ISNT did. A warm welcome with a delegate kit was provided by the reception committee. The total number of delegates was 850 and the footfalls for the exhibition were in the order of 1400-1500. The hotel premises were all decked up and wore a festive look, which added glamour to the technological event.

During the inauguration, attended by 600-800 persons, the prestigious annual awards of ISNT totalling nine were declared.

Our Chapter won the Best Chapter Award sponsored by Choksi Imaging for a record 8th (Eight) time.

Since the number of technical papers presented were 216, 5 parallel sessions were structured and well attended. The daily schedule were displayed at all the meeting halls for the convenience of the delegates.

Question and answer sessions after each presentation provided clarity of the thought of the presenter.

I attended a few and what impressed me was the presentation on Magnetic Rope Testing of stay ropes because of its utility value.

The principle for MRT is:

1) Annular magnets magnetize the ropes to near saturation.
2) Flux flow circuit results in the rope and the outer yoke.
3) Discontinuities will cause stray field (leak flux) from the rope and wire breaks will cause dispersion of flux.
4) Sensors (Hall generators and Induction coils) display & record both signals.
5) Data presented respectively as loss of metallic cross sectional area and Local Flaw traces.

Readers are directed to the conference proceedings for a detailed review.

Exhibition:

The hallmark of NDE conferences is not only the quality of papers presented both orally and through posters but also the array of the products exhibited by national and international prominent NDT equipment manufacturers. NDE 2023 was adorned by 80-85 stalls covering an area of 4,000 Sq. mts of air conditioned German Hanger type was very well appreciated by the visitors attracting a footfall of 1400-1500 from the industries in Pune and Mumbai.

Other innovations are the start up session and a session on ISNT – ICN Programme well appreciated by Mr.David Gilbert—General Secretary of ICNDT.

Cultural Program:

A cultural Progamme regarding our Indian culture of 1 ½ hours was both entertaining and showcased to foreign delegates our heritage.

Annual General Body Meeting:

AGM was conducted on 8th December 2023 evening (80—100 attendees) with the existing body and the new office bearers taken charge at the end of AGM. After assuming office the newly elected President Dr. Krishnan Balasubramanian delivered a welcome address.

Musical Treat:

There was a concert by a musical band who rendered old and latest Hindi and Regional languages songs and was well received by the audience with dancing and foot tapping.

Conclusion:

In total the conference was a successful one with lots of takeaways. As we are hosting the NDE 2024 next year, my recommendations are that we may focus on the following area to surpass the marks created during 7-9 December 2023.

1. Increase the membership base of our chapter, especially, corporate membership and invite more young engineers as volunteers.
2. Focus on time management for presenters.
3. Increase the delegates numbers and get more exhibitors and get their involvement from foreign companies
4. Communication amongst chapters may be improved.
5. Quality of food shall be of a high order considering diverse taste of National and International participants and usage of plastic shall be eliminated.
6. Participation of local companies and academic institutions shall be increased.
7. The theme shall be appealing and popularise it through involvement of local organisations and institutions.

Note by SB

Readers are invited to view the large number of photographs available at www.isntnde.in to appreciate the enormity of the event.

Overview of Time-of-flight Diffraction (ToFD) Method for weld inspection

By Dr. R J Pardikar

continuated…...

3.0 ToFD detection Process (DataAcquisition): It uses high angle refracted longitudinal wave probes in the pitch-catch mode. In ToFD data acquisition consists of collecting A-scans. The other parameter collected is position or a pseudo-position by collecting A-scans at a fixed clock rate (ie A-scans versus time). In the detection process, a Pitch Catch configuration between two probes (one for sending and another one for receiving,) that are positioned symmetrically across the weld for the beam centre of the Transmitter and receiver to focus at a strategic position in the weld. The focus is typically at 66% (2/3) of the thickness in a single ToFD group inspection. The **compressional wave probes** having the same frequency and angle are used for scanning.T he probes are scanned across both sides of the weld in non-parallel and parallel direction (Ref FIG 1) When the moving direction of the probe is consistent with the propagation direction of the acoustic beam, it is called *Parallel scanning*. When the moving direction of the probe is perpendicular to the propagation direction of the acoustic beam, it is called *Non-parallel scanning.* The nonparallel scanning can be used as the initial detection during TOFD technique, and the defect can be initially located, but the defect cannot be located away from the centre of the weld. The parallel scanning can accurately locate the defect away from the centre of the weld. When the transmitted longitudinal wave meets the defect, diffraction wave is generated at the upper and lower points of the defect. When the instrument receives the A-scan signal, D-scan image is generated synchronously. In the image, diffracted waves from the defect tips appears between the lateral wave and the back wall reflection. (Ref FIG 2).

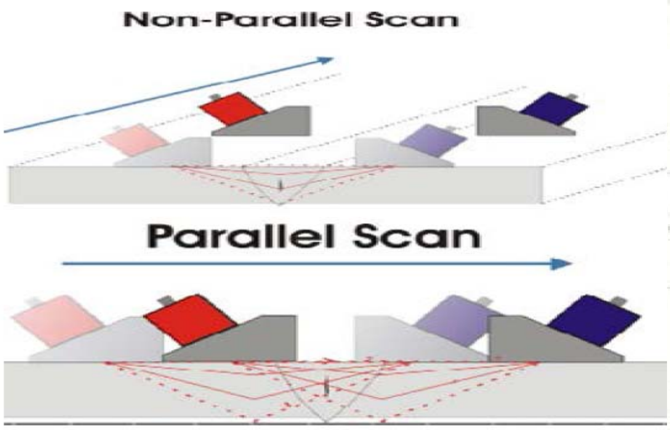


FIG. 1 ToFD-Scanning

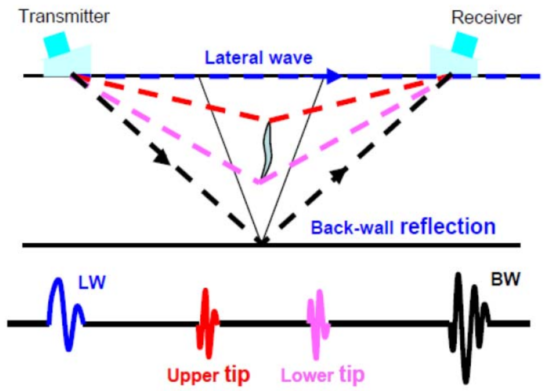


FIG. 2 ToFD- Basic Principle

Several aspects of Fig. 2 must be noted to recognise some of the features of ToFD. The transmitter produces a single pulse which provides all the signals detected at the receiver. Only the sound path distances determine the different arrival times of the signals indicated. The fig. 2 assumes a single compression mode is present and ignores mode conversions.

Lateral wave is just the term given to the compression mode that is just below the test surface and has the shortest metal distance between the transmitter and receiver. If the plate thickness is not too great a portion of the pulse will travel to the far side of the plate and reflect to produce the signal identified as **the back wall**. Flaws within the plate thickness will be seen at points between the lateral wave and back-wall signals. Figure 2 indicates the signals as viewed in un-rectified mode (ie RF) so as to provide phase information. Assuming the lateral wave is a reference phase, it is illustrated as having a positive rise time. The diffracted upper tip and reflected back-wall signals then have negative phase with respect to the lateral wave. When diffraction is detected from the lower tip its phase will be the same as the lateral wave. Gray scale imaging techniques are applied to the RF (AC) signal phases and enable weld integrity o be observed in real time.

3.1 ToFD - Phase shift: Phase shift are an essential part of TOFD. In order to easily see the phase shifts in the D-scan, a Gray scale is used. On the A-scan the phase inversions are easily seen but for the D-Scan, the Gray scale is essential. In the Gray scale the positive amplitude is shown as white and negative amplitude as black.

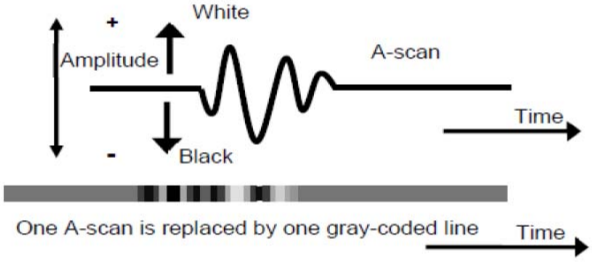


FIG. 3 ToFD – Gray scale

The Gray scale is the most effective option to convert the amplitude displacements on a normal A-scan with a small bar of grey shading representing the amplitude at each point along the time base. Each A-scan then became a line of shading with the zero-voltage indicated by a mid-range grey and maximum positive and negative voltages indicated by the extremes (i.e. black and white).

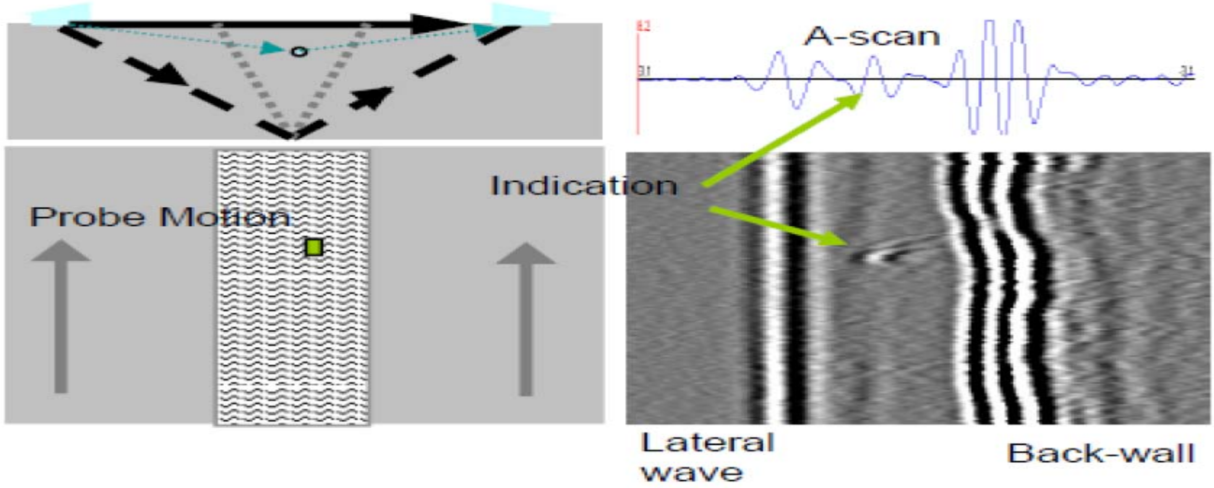


FIG.4 A-scan converted to grey-scale with probe motion.

4.0 Process parameter selection of TOFD:

4.1 Probe Selection: Initial probe selection will be based on the material tested. ToFD considerations for frequency are identical to pulse-echo. Coarse grained materials and very thick materials will require lower frequencies to over come the attenuation effects. Then the probe size is considered, and this is also based, at least partially, on the material tested. To some extent larger probe dimensions produce a higher intensity pulse over a greater distance. But the need for divergence is better addressed using smaller probe dimensions.

Probe refracting angle is selected based on the geometry of the component tested. Very thick sections will require small, refracted angles to ensure the back wall can be detected. When the weld cap is not removed it will present a restriction that may require a higher angle of refraction to ensure that the near surface is adequately addressed. Because of the large divergence in ToFD probes, the actual angles used may be off by as much as 5deg and no significant deterioration of the technique will result.
Thickness of the component tested may be sufficiently large so that no single probe pair can be expected to cover the entire thickness. Guidance on all these items can be found in the several codes and standards now available for ToFD. EN/TS 14751 provides a table indicating the minimum number of zones that must be used to address the thicknesses of welds tested by ToFD (Ref Table 1)

Table 1

Recommended ToFD set-ups for simple butt-welds dependenton wallthickness

Thickness t (mm)	Number of ToFD set-ups	Depth-range Δt / mm	Centre frequency f / MHz	Beam-angle (degrees) (α long waves)	Element – size (mm)	Beam intersection
6-10	1	0-t	15	70	2-3	2/3 of t
10-15	1	0-t	15-10	70	2-3	2/3 of t
15-35	1	0-t	10-5	70-60	2-6	2/3 of t
35-50	1	0-t	5-3	70-60	3-6	2/3 of t
50-100	2	0-t/2	5-3	70-60	3-6	1/3 of t
		t/2-t	5-3	60-45	6-12	5/6 of t; or t for $\langle \alpha \le 45^\circ C)$
100-200	3	0-t/3	5-3	70-60	3-6	2/9 of t
		t/3-2t/3	5-3	60-45	6-12	5/9 of t
		2/3t-t	5-2	60-45	6-20	8/9 of t; or for $\langle \alpha \le 45^\circ C)$

4.2 ToFD – PCS (Probe Centre spacing): The beam exit point distance between the two probes is called the Probe Centre Spacing and is an essential variable for both inspection strategy and calibration of UT data required for depth and height sizing. Following is the formula for calculatingPCS:

PCS = (2T X FD) X TAN Ø

Where, T= Thickness.

FD = Focal Depth (Typically 66% of the thickness for Single Group ToFD)

TAN Ø = Tangent of beam angle (Typically 60 or 70 degrees of the thickness for Single Group ToFD)

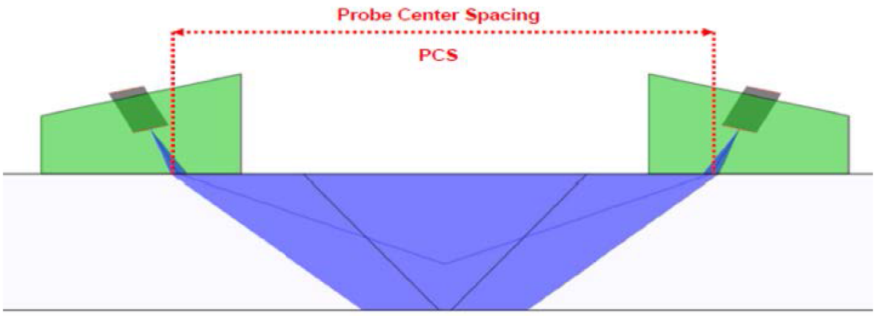


FIG. 5PCS (Probe Centre spacing)

For optimum probe separation for maximum volume en-sonification, a wide probe separation would be used. Optimum probe separation for resolving a separation between the upper and lower tips of a flaw would be when the total distance travelled is a maximum and that occurs with a minimum probe separation.

When considering the optimum diffraction pressure for detection of diffracted signals from flaws, a PCS that provides 120 included angles of the probe beam axes at the flaw tip is required.

5.0 TOFD sensitivity:

TOFD is not an amplitude-based ultrasonic inspection method. However, TOFD still requires sufficient gain to be applied to ensure that the subtle variations in phase displacements on the A-scans which can be discerned from the background noise.

Three options for setting sensitivity in TOFD:

Reference signal amplitude.

Background noise level.

A set amount of gain over a repeatable target.

For all examination levels the sensitivity shall be set on the test object. The amplitude of the lateral wave shall be between 40-80% full screen height (FSH). In cases where the use of the lateral wave is not appropriate (e.g., surface conditions, use of steep beam-angles), the sensitivity shall be set such that the amplitude of the back wall signal is between 18-30dB. Above FSH. When the use of neither a lateral wave, nor a back wall signal is appropriate, sensitivity should be set such that the material grain noise is some where between 5-10 %FSH.

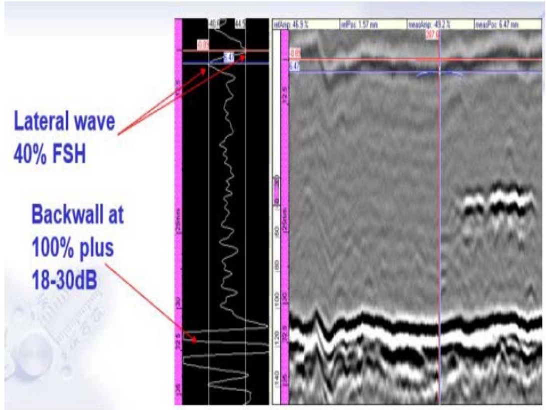


FIG. 6 ToFD Sensitivity setting

6.0 ToFD – Flaw Depth and Height Measurement:

The TOFD technique can be depicted in a mathematical model (Fig.7) Assuming that the defect is oriented in a plane perpendicular to both the inspection surface & the line joining transmitter as well as receiver along the inspection surface and that the defect is midway between the transmitter & receiver. Pythagoras's theorem will be useful in sizing the defect. It is assumed that the ultrasonic energy enters and leaves the specimen at the index points of probes. When a flaw is assumed to be midway between the two probes, depth **d** to the flaw is given by:

$$d = \sqrt{\left(\frac{c}{2}\right)^2 \bullet (t - 2t0)^2 - S^2}$$

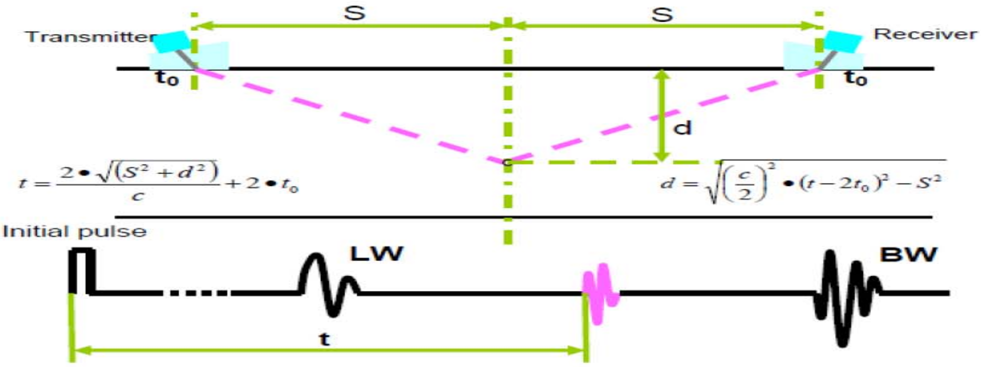


FIG 7 Flaw depth measurement

Where, c is the acoustic velocity, **t** the time in the metal, **to** the time in thewedge and **S** is half the probe spacing (ie half the PCS).

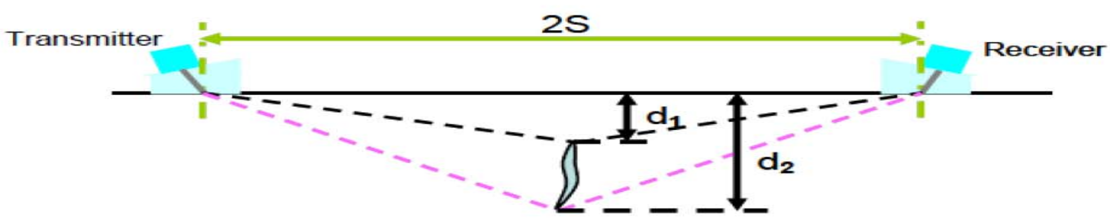


FIG 7A . Flaw height from ToFD

Simply identifying the same parameters for the lower tip signal allows theflaw height to be determined.Depth **d2** is calculated using the same formula as used for the upper tip sowe need only subtract the depths to determine the flaw height. This is thengiven as:

$$h = d_2 - d_1$$

7.0 TOFD INSTRUMENT REQUIREMENT: An ultrasonic system for ToFD must be capable of providing a means of transmitting, receiving, storing, displaying and analysing ultrasonic signals. It must also provide a fixed spacing between the transmitting and receiving probes. it is generally considered preferable to ensure that probe motion is encoded, and the position of the probe-pair maintained within prescribed tolerances with respect to a reference position such as the weld centreline. Most electrical functions on the ultrasonic instruments are controlled by solid state integrated circuits. By means of Boolean logic, these allow control of system inputs and signal outputs. Many input controls and some outputs are feasible as digital signals. Digital controlled ultrasonic instruments have many advantages.

The instrument shall provide a linear "A" scan presentation for both setting up scan parameters and for signal analysis. Instrument linearity shall be such that the accuracy of indicated amplitude or timeis±5% oftheactualfull-scaleamplitudeortime. The ultra-sonic pulser may provide excitation voltage by tone burst, unipolar, orbipolar square wave. Pulse width shall be tun-able to allow optimization of pulse amplitude and duration. The bandwidth of the ultrasonic receiver shall be at least equal to that of the nominal probe frequency and such that the−6dB bandwidth of the probe does not fall outside of the −6dB bandwidth of the receiver. Receiver gain control shall be available to adjust signal amplitude in increments of 1dB or less. Pre-amplifiers may be in-cluded in the system. ***Analog to digital conversion of waveforms shall have sampling rates at least four times that of the nominal frequency of the probe***.

FIG 8 Basic ToFD Instrument

7.1Data Display and Recording.

The data dis-play shall allow for the viewing of the unrectified A-scan so as to position the start and length of a gate that determines the extent of the A-scan time-base that is recorded. Equipment shall permit storage of all gated A-scans to a magnetic or optical storage medium. Equipment shall provide a sectional view of the weld with a minimum of 64Gray scale levels. (Storage of just sectional images without the underlying A-scan RF waveforms is not acceptable.)Computer software for TOFD displays shall include algorithms to linearize cursors or the waveform time-base to permit depth and vertical extent estimations. In addition o storage of waveform data including amplitude and time-base details, the equipment shall also store positional information indicating the relative position of the wave form with respect to the adjacent wave form(s), i.e., en-coded position.

8.0 ToFD - Modelling the weld inspection: A requirement of nearly all national or international standards is the inclusion of a description of the volume coverage of the test piece. This isvariously called the scan plan, the scanning technique, written instructions or the procedure, depending on the terminology used in the specific industrial venue.

With the complexity of three-dimensional issues when addressing nozzlesand the complexities of beam divergence to ensure volume coverage in ToFD, many users have found it convenient to develop computer assisted drawings. Several options have developed:

1.Spreadsheet based.2 Simple ray tracing.3 Complex ray tracing.4 Finite element modelling.

ToFD has not found much use in scan plan developments using he complex ray tracing and finite element modelling. For most ToFD applications spreadsheet-style models and simple ray trace models have proven adequate

8.1 Simple ray trace beam modelling: Scan Plan by Sonovation and ESBeam Tool by Eclipse Scientific Products have incorporated the ability to design the part, select the optimum wedge angle and probe and position them on the component to estimate the coverage that might be expected**.**

In order to meet the requirements of codes and the stated need for technique details, a detailed list of parameters on the probe, scan sample increment (eg 1 sample/mm) digitisation rate, calibrations, ranges, etc would be added to the images showing angles, volume coverage and scanning directions.

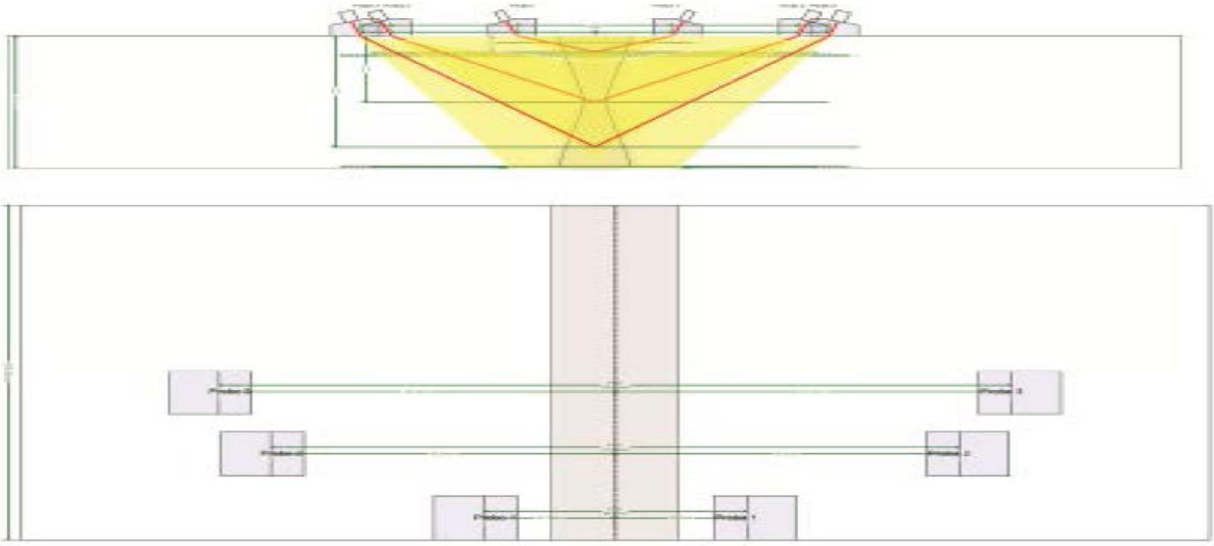


FIG.9 Simple ray trace modelling for ToFD.

9.0 TOFD-DATA VISUALISATION AND INTERPRETATION:

TOFD data is routinely displayed as a gray scale image of the digitized A-scan. TOFD images are generated by the stacking of these gray scale transformed A-scans. The lateral wave and back wall signals are visible as continuous multicycle lines. The mid wall flaw shown consists of a visible upper and lower tip signal. These show as intermediate multicycle signals between the lateral wave and the back wall. TOFD gray scale images display phase changes, some signals are **white-black-white**; others are **black-white-black.** This permits identification of the wave source (flaw top or bottom, etc.), as well as being used for flaw sizing. Depending on the phase of the incident pulse (usually a negative voltage), the lateral wave would be positive, then the first diffracted (upper tip) signal negative, the second diffracted (lower tip) signal positive, and the back wall signal negative (Ref fig. 2).This phase information is veryuseful for signal interpretation; consequently, RF signals and unrectified signals are used for TOFD. The phase information is used for correctly identifying signals (usually the top and bottom of flaws, if they can be differentiated), and for determining the correct location for depth measurements.

ToFD Interpretation can be broadly grouped into two categories:
1.Quality assessment. 2. Data assessment.

quality assessment means the characteristics of the data collected. We must determine if the data collected is possible to interpret. Data must provide clear and unambiguous information about the structure tested.

Data assessment: Data assessment is also a multistage operation. D-scans are reviewed and if any indications are seen their origins need to be determined. Not all indications are flaws and not all flaws are defects. Flaws need to be compared to the allowed limits to assess if the component is acceptable or not.

Limited characterisation is only possible with TOFD.Characterisation capabilities of ToFD to a simple, but very useful schemegrouping flaw indications into one of three types:

1 **Point-like**:Indications identified as flaws but having neither length nor height.No lower tip discernible separate from upper tip signal.

2 **Thread-like**:Indications identified as flaws. They have length but no height.No lower tip discernible separate from upper tip signal.

3 **Planar**: Indications identified as flaws. They have length and height.Lower tip discernible separate from upper tip signal.

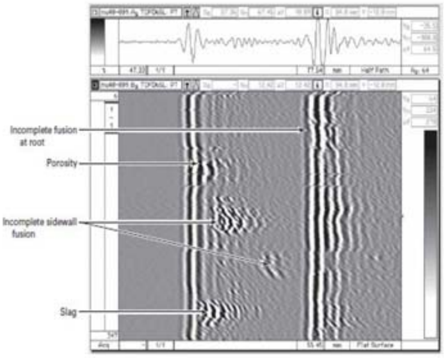


FIG 10 A TOFD Display with Flaws and Displayed A-Scan

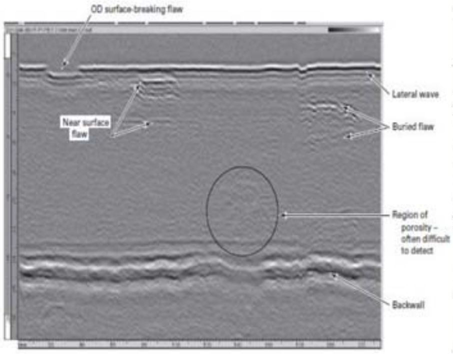


FIG 10 BToFD Image Analysis

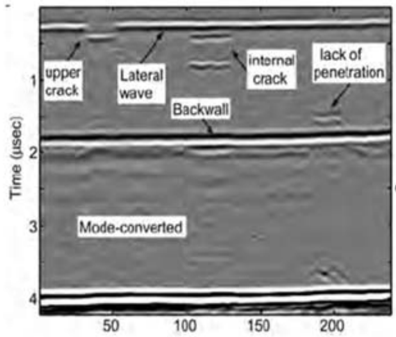


FIG 10CToFD Image Analysis.

10.0 TOFD EVALUATION:

10.1 Single flaw images: Point flaws like porosity, showup as single multicycle points between the lateral and back wall signals. Point flaws typically display a single TOFD signal since flaw heights are smaller than the ring down of the pulse (usually a few millimetres, depending on the transducer frequency and damping). Point flaws usually show parabolic "tails" where the signal drops off towards the back wall.

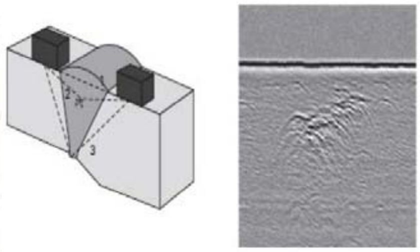


FIG 11. A TOFD Display Showing the Image of the Porosity

10.2Near-surface-breaking(OD Surface) flaws: shows perturbations in the lateral wave. The flaw breaks the lateral wave, so TOFD can be used to determine if the flaw is surface-breaking or not. The lower signal can then be used to measure the depth of the flaw. If the flaw is not surface-breaking, i.e., just subsurface, the lateral wave will not be broken. If the flaw is near-subsurface and shallow (that is, less than the ringing time of the lateral wave or a few millimeters deep), then the flaw will probably be invisible to TOFD. The image also displays a number of signals from point flaws.

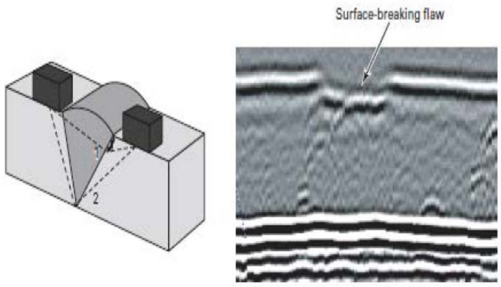


FIG11B TOFD Display of the Outside (OD) Surface-Breaking Flaw

10.3Far-surface-breaking (ID Surface) flaws: shows no interruption of the lateral wave, a signal near the back wall, and a related interruption or break of the back wall (depending on flaw size).

10.3.1 Lack of root penetration: is similar to an inside (I.D.) far-surface-breaking flaw . This flaw gives a strong diffracted signal (or more correctly, a reflected signal) with a phase inversion from the back wall signal.

10.3.2Concave root flaws : are similar to lack of root penetration. The top of the flaw is visible in the TOFD image, as well as the general shape. The back wall signal shows some perturbation as expected.

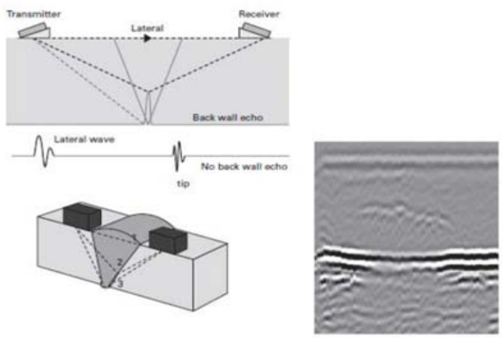


Fig 11 cToFD display showing Surface breaking flaws

10.4Midwall flaws: show complete lateral and back-wall signals, plus diffraction signals from the top and bottom of the flaw. The flaw tip echoes provide a very good profile of the actual flaw. Also note the hyperbolic curve that is easily visible at the left end of the top echo; this is similar to the effect from a point flaw and permits accurate length measurement of flaws. If a midwall flaw is shallow, i.e., less than the transducer pulse ring-down (a few millimeters), the top and bottom tip signals cannot be separated. Under these circumstances, it is not possible to differentiate the top from the bottom of the flaw.

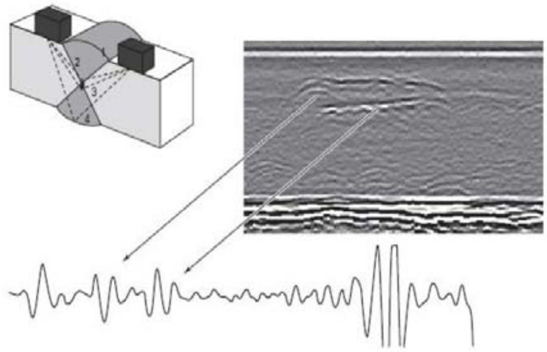


FIG 11 D ToFD display showing the midwall flaw

10.5Sidewall lack of fusion: is similar to a mid wall flaw with two differences. First, the flaw is angled along the fusion line, so TOFD is effectively independent of orientation, which is not a problem for TOFD. Second, the upper flaw signal is partly buried in the lateral wave for this particular flaw. In this instance, the upper tip signal is detectable since the lateral wave signal amplitude is noticeably increased. However, if this were not the case, then it would be unable to accurately measure the flaw depth.

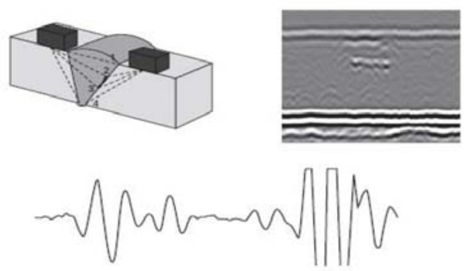


FIG 11 E ToFD display showing the Sidewall lack of fusion

10.5.1 Inter pass lack of fusion: shows as a single, high amplitude signal in the mid wall region. If the signal is long, it is easily differentiated from porosity or point sources. It is not possible to distinguish the top and bottom, as these do not exist as such. Note the expected phase change from the lateral wave. Inter pass lack of fusion signals are generally benign.

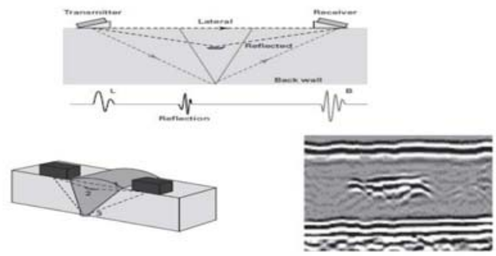


FIG 11 F ToFD display showing interpass lack of fusion

10.6 Transverse cracks are similar to a point flaw. The TOFD scan displays a typical hyperbola. Normally, it would not be possible to differentiate transverse cracks from near-surface porosity using TOFD; further inspection would be needed.

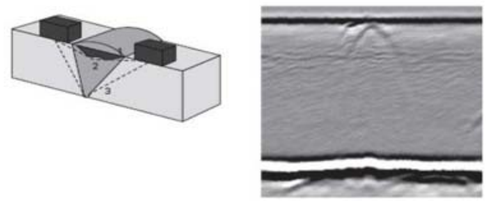


FIG 11 G ToFD display showing the Transvers crack.

11.0 Advantages of TOFD: There are many advantages for using TOFD for weld inspection.
1.A single pass fast scanning Technique. ToFD provides volumetric coverage by linearly scanning wide beam transducers at relatively high speed and processing all positional and inspection data in nearly real time.**2 ToFD Not** related to orientation of defect.**3**Sensitive to all kinds of defects.4 Easy discrimination of defects and geometry. **5** A High precision sizing technique. Generally, levels of accuracy attainable by ToFD are within ±0.5mm in terms of (critical) through wall extent and ±0.5-1.0mm in terms of length.**6**Through thickness height of crack can be measured precisely. **7**High Probability of Flaw Detection (POD).**8** Lower False Call Rates (FCR).**9** High Accuracy of Flaw Location Measurement.**10**ToFD systems provide digital storage of all relevant parameters. They can be retrieved and redisplayed at any time**.11**TOFD is an ultrasonic imaging technique capable of substituting Radiography.12Reduced operator dependence.

12.0 Limitations of ToFD:

12.1Weak signals:

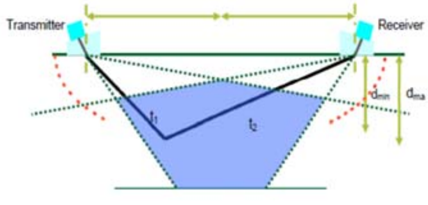


FIG 12 AFlaw position Uncertainty

Typically, the diffracted signals associated with ToFD are 20-30dB lower than those associated with specular reflections using pulse-echo techniques. Electrical noise is a common problem with many ToFD systems and attempts to reduce this noise generally involve the use of pre-amplifiers near the probe or remote pulser/pre-amp combinations.

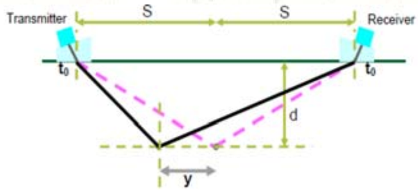


FIG 12B Flaw position uncertainty

12.2 Dead Zones: There are three blind areas (Dead zones) in TOFD detection.

1.Lateral wave dead zone.2 Back wall dead zone.3 Spatial resolution.

12.2.1Solution to minimise Dead Zones: Generally, short pulse width, increasing probe frequency and reducing PCS distance are used to reduce the upper surface blind area. Off-Axis deviation (flaw position) blind area is due to the fact that the diffraction signal on the ellipse track has the same propagation time with the echo on the bottom surface, and the diffraction signal outside the ellipse track is covered by the echo on the bottom surface and cannot be displayed. Generally, scanning with a certain distance offset to the blind area direction is used to reduce the axis deviates from the blind area.

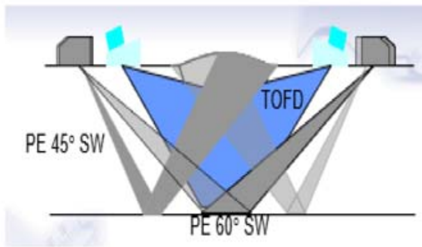


FIG 12 C ToFD + PE

12.2.2 To minimise the lateral wave Dead zone and Back wall dead zone ToFD is performed. in combination with Pulse echo probes of 45 & 60 degree.

12.3Flaw classification limitation: ToFD provides no opportunity for the echo-dynamic assessments seen in manual methods. ToFD signals may be grouped into one of three flaw types:1 Point-like.2 Thread-like.3 Planar.

12.4Material limitation: TOFD requires the use of high frequency probes. This limits its application to low attenuation materials that include carbon and low alloy steels. TOFD has limited application, for highly attenuative materials such as stainless steel and nickel alloys.

12.5Access limitation: Due to the nature of the method being pitch-catch, application of TOFD requires access to both sides of the weld.

13.0Summary:TOFD is a high-performance non-destructive testing (NDT) technique, which can be used to accurately detect and size cracks, fusion faults and other defects in a welded construction. TOFD is also an excellent and widely accepted pre-service and in-service inspection tool. It is a single pass fast scanning Technique not related to orientation of defects. This technique is substantially more accurate than conventional UT for measurement of through wall height of crack .The application of TOFD technique in high wall thickness parts has obvious advantages, such as easy operation, high sensitivity and high detection rate, high reliability, high POD but it also has some limitations, such as the problem of blind area on the surface and the problem of low signal-to-noise ratio for structural parts with coarse grains.

RADIOGRAPHIC EXAMINATION OF ENVELOP PIPES – A CASE STUDY

BY SHRI R. SUBBARATNAM (RETD. IGCAR SCIENTIST)

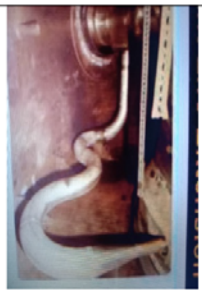
INTRODUCTION:

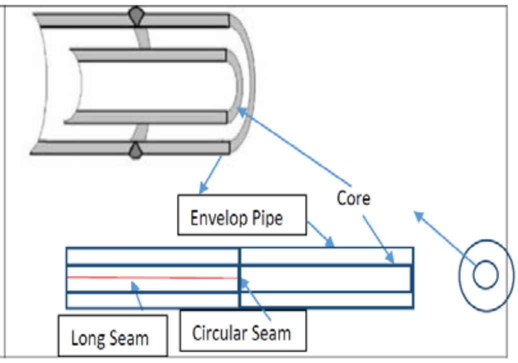
Fast breeder test reactor (FBTR) uses Sodium as coolant in the reactor. The basic transformation is the primary sodium takes heat (~350 Deg C) in the reactor and transfer to the secondary sodium. The secondary sodium (~200Deg c) gives the heat outside the reactor to produce the steam. This steam runs the turbine to produce electrical power.

Envelop pipes (Double Envelop) are used in many industries like Nuclear, Petrochemical etc. In Nuclear industry particularly sodium cooled fast breeder reactors, these envelop pipes are used for safety(Liquid sodium reacts violently with air / water - sodium in core pipe should not face atmosphere – fire hazard) and used for heating or cooling by circulation of gas (Nitrogen). The core pipe constituents' mostly liquid sodium.

Major problem with respect to radiography is, envelop pipe weld examination, in achieving the required sensitivity and ascertaining the minimum gap between the core pipes and envelop pipe, which is critical. Normally envelop pipe is constructed by two half segmental pipes welded using longitudinal and circular welds for required shape and length of pipe.

Construction: The Core pipe (25 mm Dia to 63 mm Dia) (AISI 316L) is encircled by Envelop pipe (63 mm Dia to 114mm Dia) (AISI 316L). Envelop pipes are constructed by two half pipes welded by two long seams and circular seams to the required lengths and shapes (serpentine), as per the requirements as photo shown below. Some areas will have multiple core pipes (up to7 nos in Steam Generator (Pic at bottom))in a common envelop. Construction details are as given in below drawing and picture.



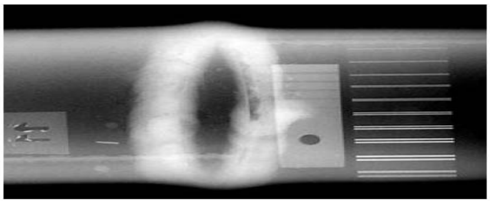


Top photo - View of one of the critical piping – Sodium outlet– serpentine bends with envelop before thermal insulation – Restricted Space for Radiography

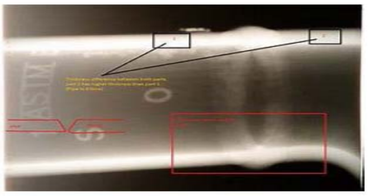
THE REQUIREMENTS AND PROOBLEM/S:

Radiographic Examination Requirements: As the welds are in critical areas, all the welds are to be radiographed to the stringent sensitivity requirements. Also the minimum gap between the core and envelop pipes are to be maintained and has to be ascertained by radiography as other NDE are not providing the details and henceother NDE not suitable.

Sensitivity Requirements:
The sensitivity requirements for all critical pipe welds are ASTM 5-1T up to 6 mm thick and ASTM 5 -2T for more than 6mm (6-10 MM) thick.
No problem in radiographic examination of Core pipe in achieving sensitivity, ASTM 5 – 1T according to the core pipe thickness, using X ray with smaller focus.
But in the case of envelop it has two problem. First is achieving sensitivity the other is gap measurement.
The total penetration thickness in case of envelop is minimum of four wall thickness, two walls of core pipe and two of envelop. But the sensitivity requirement is same as ASTM 5 – 1T / 2T (according to the pipe single wall thickness). This was found very difficult with respect to achieving the sensitivity.
Solution: Sensitivity requirements is very high, tight and hence, it was decided to use x–ray with lower focal spot size, with in limited SFD space for exposure(~500mm in most cases), to meet the sensitivity requirements and has been achieved in all the cases. It was noted that the area coverage also becomes less in certain cases (core pipe thickness is more), it will cover only core pipe area. As the coverage is less it requires more exposure in certain areas / conditions according to core pipe thickness.
Gap Measurement: It is necessary to measure the minimum gap between the core and envelop pipes as this will lead to differential flow of envelop gas for cooling or heating the core pipe liquid leading to thermal instability. Also the welding distortion (AISI 316L) will change the gap, which is maintained properly during fit up. Out of other NDE's radiographic examination was found best suited in this case.
Problem: Radiographic examination with x ray as stated above to meet the sensitivity requirement, will not provide the results of gap measurement. This radiograph will not provide the clear cut edges of core and envelop pipes to measure the gap. This is due to the variable energy of x ray beam, for the set energy level to penetrate required total wall thickness, leading differential radiographic density across thickness, making the selection of points for gap measurement difficult, please refer picture below.



DWDI WELD RADIOGRAPH EXAMPLE – X RAY – VARIABLE ENERGY – SENSITIVITY HIGH BUT WILL NOT SHOW EDGE / THICKNESS



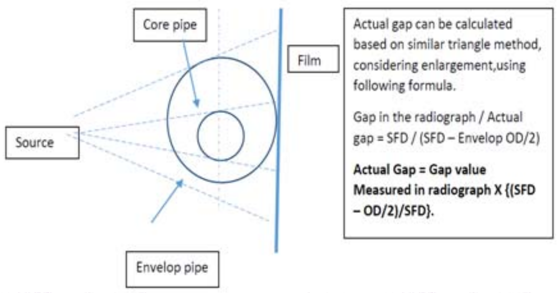
DWDI WELD RAIOGRAPH EXAMPLE – GAMMA RAY – CONST ENERGY – LOW SENSITIVITY BUT WILL SHOW EDGE / THICKNESS

Solution: Based on the above it was decided to use gamma ray (Ir 192) for gap measurement radiography, as the gamma energy is near constant. The radiography with gamma provided clear cut edges, refer DWDI on single pipe weld radiograph example picture above. The core and envelop pipes using gamma radiographs, provided details and the gap measurement was successfully done, after considering the enlargement factors {(SFD – OD/2)/SFD}. Exposure details and setup provided below for reference.

Radiographic examination - Sensitivity:
Source: MG 161 L – Philips 160 kV, 1.4/0.4 mm focal; 1.4 mm focal used; SFD: Multi Wall DI - 500 mm/Multi Wall SI - 175 mm (according to diameter); Film: Agfa D7; Technique: Multi Wall Double Image (MWDI) / MWSI (According to envelop pipe dia)

Radiographic examination - Gap measurement:
Source: Ir 192; Film: Agfa D7; SFD: 500 / 700 mm, No. of Exposure: Two at 90 Deg. Apart; No sensitivity requirements

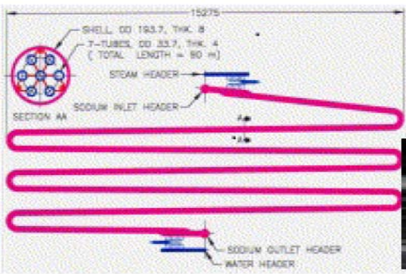
Gap MeasurementExposure Setup:



Corrective Action: Envelop pipes where the minimum gap was not noted (sometimes touching) were corrected by proper heating and cooling.

Radiography of FBTR Steam generator:

FBTR steam generator (SG) was manufactured at M/S BHEL Trichy. This construction is peculiar seven pipes (33.4 mm dia ad 4 mm WT) in a common envelop (193.7 mm dia and 8 mm WT) with serpentine bends. The internal core water pipes were identified with numbers suitably. The fig / photos provide details and complexity of the examination. In this secondary sodium (200 Deg C) flows in the outer envelope from top and the water in seven internal core pipes from bottom header and comes out as steam at top header.



FBTR- Steam Generator (2.25 Cr – 1 Mo) with seven core pipes with common envelop – see cross section (fabricated by M/s BHEL, Trichy). Basic detail: Photo of SG: and Water header close picture
The radiographic requirements at site arises when the spare has to be changed.

In this the radiography requirement is only on circular seam during ISI along with ultrasonic. Radiography was conducted using x ray to meet the specification requirements.
The radiographic exam exposure has to be carefully calculated in such a way that four wall penetration exposure or six wall penetrating exposure. Mostly the coverage part has to be selected during interpretation.

Another **peculiar problem** noted during water testing as per erection procedure. When water pumped in the bottom water header pipe no 1 water coming out in another pipe at steam header side. Hence radiography using gamma was executed at suitable different locations and the pipe routing was identified.

CAREER ASPECTS IN NDT

Awareness of NDT among students in academic Institutions

R Balakrishnan, Manager-CQ-BHEL (retd)

What are the merits and demerits of non-destructive testing?

Non-destructive testing is a means of testing and evaluating the quality of a component without causing any damage to it. Hence, it requires qualified technicians with appropriate knowledge and experience in the field of applicable method of NDT.

Non Destructive Testing (NDT) offers a **safe and reliable way** of inspecting components, that is cost effective and requires little to no disruption to workers involved in production.

It means that plant and factory operations can continue working, without any damage to equipment, or any loss of income to the company. This type of testing is used primarily to detect, identify and measure anything that could cause damage to a component such as cracks, voids or corrosion during its working life.

Non-destructive Testing

The oldest form of non-destructive testing is visual testing, a means of simply inspecting a component for surface flaws by sight alone. This is still a common, and very effective procedure even today, carried out by skilled technicians who know exactly what to look for in a component.

Afterwards, various non-destructive testing techniques have been developed based on applied physics principles. These include:

Magnetic particle testing (MT), Liquid penetrant testing (LPT), Acoustic emission testing (AT) ,
Eddy current testing (ET), Ultrasonic testing (UT) , Visual testing (VT) , Radiographic testing (RT)

There are four main advantages of non-destructive testing:

Merits of NDT

Basically Non-destructive testing is used to ascertain whether a component is safe to use. In particular where volatile materials, heavy flow, pressure high/low, temperatures and or radioactive materials are predominant.

Non-destructive testing carried out professionally has the ability to save lives. Particularly if it is being carried out in industries which rely on volatile materials and or using high-pressure equipments and machineries. The tests are carried out to ensure not only product safety, but also to ensure the safety of the person carrying out the work on any machinery or components. Mostly non-destructive tests are harmless to humans, although tests involving radiography shall be carried out following the Radiographic safety rules and regulations All NDT tests shall ensure that products are left undamaged for use or further processing.

It provides reliability

If workers in industry are looking for reliable and accurate results, non-destructive testing can provide them along with reliability. But nature of improper evaluation of NDT, results either in damage of components or failure to identify true nature of defects in the components.

It is cost effective

These types of tests can also give insight regarding either effective replacement or repair of components or equipment before a malfunction or breakdown occurs, that will save cost of operation in the long term.

It offers reassurance

Reassurance is such a simple thing, that it sometimes be the most important advantage to non-destructive testing.

When workers know they are safe, they feel more secure and this is something that can benefit productivity and output, overall.

Demerits of Non-destructive Testing

The demerits or disadvantages of non-destructive testing are very few.

Improper selection of NDT method / technique can produce wrong erroneous conclusion. Hence the appropriate method / technique shall be chosen by knowledgeable person (Level III) in NDT and the component.

Improper testing ways (methods) can also be a hindrance in arriving at proper evaluation.. These can include simple factors like:

- Components need to be cleaned before and after inspection
- Sensitivity of inspection can sometimes be affected by the finish of a component.
- Sometimes there might be a lack of depth sizing and identification of nature of defects and correct location, determining the depth signing and identifications of the nature of defects generally pose a problem and hence needs a certified personal to conduct the tests (LI), and a Level II certified personal to evaluate.
- On some non-destructive test methods, only relatively non-porous surfaces can be inspected
- Some test methods require electrical power, safety norms and appropriate environment
- Some NDT evaluation is difficult to the nature of discontinuities due to material structural Characterisation
- Quality evaluation requires knowledgeable and Experienced NDT Technicians

Next edition covers

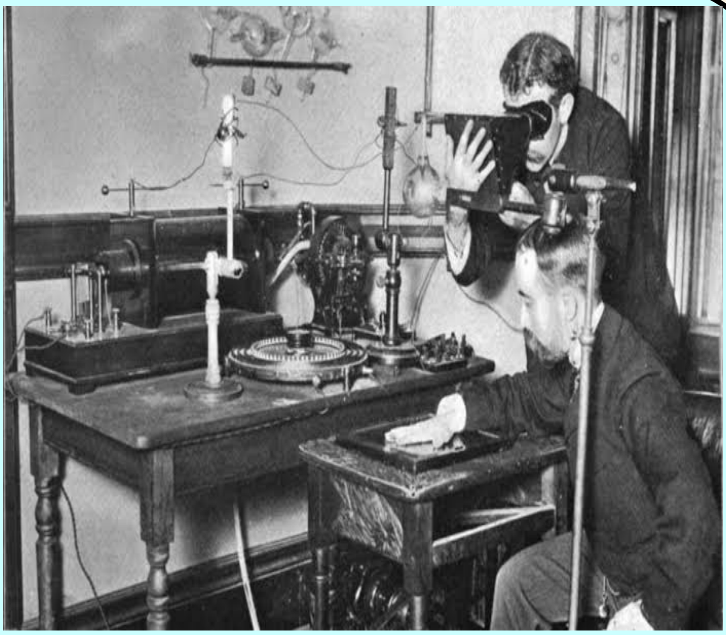
Why the academic Institutions in India fail to start graduation or diploma courses in NDT?

Snippets

Wilhelm Roentgen, Professor of Physics in Wurzburg, Bavaria, discovered X-rays in 1895— accidentally —while testing whether cathode rays could pass through glass.

On November 8, 1895, Roentgen noticed that when he shielded the tube with heavy black cardboard, the green fluorescent light caused a platinobarium screen nine feet at away to glow - too far away to be reacting to the cathode rays as he understood them. Named these mystery rays as X - rays to signify an unknown type of radiation.

When was the first X-ray machine used in India? The first experiment using X-rays in India was carried out by Mahendralal Sircar (MLS) on 20 June 1896 by taking the photograph of a hand using the procured Roentgen's apparatus and it was noted in his diary that he did not obtain a good picture in his first attempt, probably due to over exposure.



X-ray Experimental setup used by Roentgon

Mr.M.Manimohan, Manager (Retired), NDTL, BHEL, Trichy

ULTRASONIC PULSE VELOCITY FOR CONCRETE STRUCTURE

Ref: IS 13311(Part 1) 1996 (Reaffirmed 2004)-Non-Destructive testing of Concrete -Methods of test

Mr.M.Manimohan, Manager (Retired), NDTL, BHEL, Trichy

The ultrasonic pulse velocity method is applied to assess

a) The homogeneity of the concrete,
b) The presence of cracks, voids and other imperfections,
c) Changes in the structure of the concrete which may occur with time,
d) The quality of the concrete in relation to standard requirements,

PRINCIPLE

The velocity of an ultrasonic pulse through a material depends upon the density, modulus of elasticity and Poisson's ratio of the material.
The ultrasonic pulse is generated by an electro-acoustical transducer and transmitted into the concrete.
It undergoes multiple reflections at the boundaries of the different material phases within the concrete.
A complex system of stress waves is developed which includes longitudinal, shear and surface waves.
The receiving transducer detects the onset of the longitudinal waves, which is the fastest.

Because the velocity of the pulses is almost independent of the geometry of the material through which they pass and depends only on its elastic properties, pulse velocity method is a convenient technique for investigating structural concrete.

The underlying principle of assessing the quality of concrete is that higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good.
In case of poorer quality, lower velocities are obtained.
If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making the path length longer.
Consequently, lower velocities are obtained.

The actual pulse velocity obtained depends primarily upon the materials and mix proportions of concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

EQUIPMENT

The apparatus for ultrasonic pulse velocity measurement shall consist of the following:

a) Electrical pulse generator,
b) Transducer - one pair,
c) Amplifier, and
d) electronic timing device.

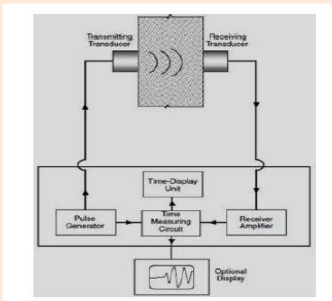


image courtesy: www.researchgate.net

Transducer

Any suitable type of transducer operating within the frequency of 20 kHz to 150 kHz (Table 1) may be used. image courtesy: www.researchgate.net

Piezoelectric and magneto-strictive types of transducers may be used, the latter being more suitable for the lower part of the frequency range.
Generally, high frequency transducers are preferable for short path lengths and low frequency transducers for long path lengths.
Transducers with a frequency of 50 to 60 kHz are useful for most all-round applications.

Table 1

Natural frequency of Transducer for different path lengths

Path Length in the concrete (mm)	Frequency (KHz)	Minimum transverse dimensions of members (mm)
Up to 500 mm	150	25
500-700	>60	70
700-1500	>40	150
>1500	> 20	300

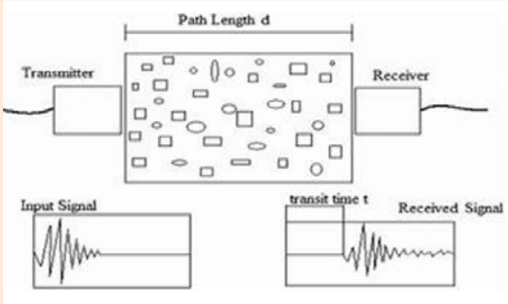
Electronic Timing Device

It shall be capable of measuring the time interval elapsing between the onset of a pulse generated at the transmitting transducer and the onset of its arrival at the receiving transducer.

The received signal may be displayed on a cathode ray tube on which the leading edge of the pulse is displayed in relation to the suitable time scale,

Another system is by using an interval timer with a direct reading digital display.

If both the forms of timing apparatus are available, the interpretation of results becomes more reliable



PROCEDURE

In this test method, the ultrasonic pulse is produced by the transducer which is held in contact with one surface of the concrete member under test.

After traversing a known path length L in the concrete, the pulse of vibrations is converted into an electrical signal by the second transducer held in contact with the other surface of the concrete member

An electronic timing circuit enables the transit time (T) of the pulse to be measured.

The pulse velocity (V) is given by:

V = L/T

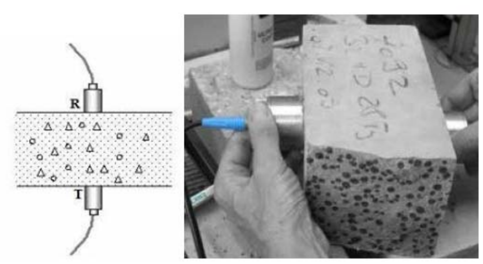


Image courtesy: Indiamart.com

Direct transmission or cross probing method

Transmitter and receiver are kept at opposite surfaces of the concrete like through transmission technique

Surface probing technique

However, in many situations two opposite faces of the structural member may not be accessible for measurements. In such cases, the receiving transducer is also placed on the same face of the concrete members.

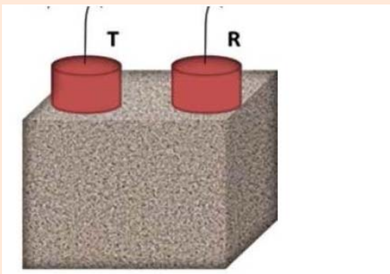


Image courtesy: Researchgate.net

Surface probing is less efficient compared to cross probing,

The signal produced at the receiving transducer has an amplitude of only2 to 3 percent of that produced by cross probing.

The test results are greatly influenced by the surface layers of concrete which may have different properties from that of concrete inside the structural member.

The indirect velocity is invariably lower than the direct velocity on the same concrete element.

This difference may vary from 5 to 20 percent depending largely on the quality of the concrete under test.

For good quality concrete, a difference of about 0.5 km/set may generally be encountered.

Couplants used are petroleum jelly, grease, liquid soap and kaolin glycerol paste.

A minimum path length of 150 mm is recommended for the direct transmission method and 400 mm for the surface probing method.

It is recommended that the minimum path length should be 100 mm for concrete in which the nominal maximum size of aggregate is 20 mm or less 150 mm for concrete in which the nominal maximum size of aggregate is between 20 to 40 mm.

Sufficient number of readings are to be taken by dividing the entire structure in suitable grid markings of 30 x 30 cm or even smaller.

Each junction point of the grid becomes a point of observation.

Transducers are held on corresponding points of observation on opposite faces of a structural element to measure the ultrasonic pulse velocity by direct transmission, i.e., cross probing.

If one of the faces is not- accessible, ultrasonic pulse velocity is measured on one face of the structural member by surface probing.

Surface, probing in general gives lower pulse velocity than in case of cross probing and depending on number of parameters, the difference could be of the order of about 1 km/sec.

INTERPRETATIONS OF RESULTS

The ultrasonic pulse velocity of concrete is mainly related to its density and modulus of elasticity. This in turn, depends upon the materials and mix proportions of concrete.

if the concrete is not compacted as thoroughly as possible, or if there is segregation of concrete during placing or there are internal cracks or flaws, the pulse velocity will be lower, although the same materials and mix proportions are used. Based on the pulse velocity measurement, the quality level of the specimen is classified as in table 2

Table 2
Velocity criteria for concrete quality grading

Sl.No	Pulse velocity by cross probing (Km/sec)	Concrete Quality Grading
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Doubtful

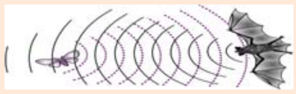
Inc case of “doubtful” quality it may be necessary to carry out further tests.
Since actual values of the pulse velocity obtained, depend on a number of parameters,
any criterion for assessing the quality of concrete on the basis of pulse velocity as given in Table 2can be held as satisfactory only to a general extent.

Reinforced Concrete

The pulse velocity measured in reinforced concrete is usually higher than in plain concrete of the same composition.

This is because, the pulse velocity in steel is 1.2 to 1.9 times the velocity in plain concrete the first pulse to arrive at the receiving transducer travels partly in concrete and partly in steel.
The apparent increase in pulse velocity depends upon the proximity of the measurements to the reinforcing bar, the diameter and number of the bars and their orientation with respect to the path of propagation.

ECHO BITES



Good morning and greetings,

This soundbytes issue is very informative and contains a spectrum of advanced NDT and conventional NDT articles.
More specifically the article about leak testing is very informative and in "Total" what is need for a field testing to a technician.
Happy to note the pages of sound bite growing "day by day" 👌 👍 👏 👏.
Also I wish to grow further.
Chittathur Srinivasan.

Dear Ram Prakash,
Excellent very
informative
G.Ramachandran

Dear Sirs,
Thank you for giving me an opportunity to enrich my knowledge of NDT test methods, Audits, and each author's potential on their topics. Sound Byte Sept 2023 is fulfilling the expectations of readers.
Chief compiler Mr. RamPrakash's introduction of conversation with computers stimulates the interest in reading & studying the contents.
Neutron Radiography, Audit preparation, ToFD for welding inspection, Leak testing methods, and Information required for studying students are found to be very useful.
My sincere gratitude to the chief compiler, board members, and respective authors for helping the readers gain knowledge on NDT.
Thanks to office bearers who are supporting the publication of soundbytes,

Kind Regards,
R.Jayagovindan, LM 6335

Indian Society for
ISNT
Non-Destructive Testing
Chennai Chapter

Chief Compiler:
Mr.B. Ram Prakash