

# **Time of Flight Diffraction**

## **(ToFD)**

### **Course Curriculum**





**AFRICAN NDT CENTRE**  
**COURSE CURRICULUM**  
**TIME OF FLIGHT DIFFRACTION (ToFD)**  
**LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 2 of 7

## Table of Contents

|                                                 |   |
|-------------------------------------------------|---|
| Who we are?.....                                | 3 |
| How to Book Your Training Course .....          | 3 |
| Contact Us.....                                 | 3 |
| ANDTC Vaal .....                                | 3 |
| ANDTC Constantia Kloof .....                    | 3 |
| What is Time of Flight Diffraction?.....        | 4 |
| About the Course .....                          | 4 |
| PCN Level 2 .....                               | 4 |
| PCN Level 3 .....                               | 4 |
| Qualification Requirements .....                | 5 |
| Prerequisites .....                             | 5 |
| Training Hours .....                            | 5 |
| Product Sector.....                             | 5 |
| Experience Requirements .....                   | 5 |
| Documents to be Submitted for Examination ..... | 5 |
| Learning Outcomes.....                          | 6 |
| PCN Level 2 .....                               | 6 |
| PCN Level 3 .....                               | 6 |
| What to Bring? .....                            | 6 |
| Special Notes .....                             | 6 |
| Training and Examination Information.....       | 7 |
| Syllabus Reference .....                        | 7 |



**AFRICAN NDT CENTRE**  
**COURSE CURRICULUM**  
**TIME OF FLIGHT DIFFRACTION (ToFD)**  
**LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 3 of 7

## Who we are?

African NDT Centre (Pty) Ltd is an NDT training and service provider organization located in Roodepoort, South Africa, providing complete solutions for NDT training and inspection.

**We conduct training for PCN certification for level 1,2 and 3 in the following methods:**

- PCN - Eddy Current Testing (ET)
- PCN - Ultrasonic Testing (UT)
- PCN - Magnetic Particle Testing (MT)
- PCN - Liquid Penetrant Testing (PT)
- PCN - Radiographic Testing (RT)
- PCN – Radiographic Interpretation (RI)
- PCN – Basic Radiation Safety (BRS)
- PCN – Visual Testing (VT)
- PCN – UT Phased Array (PAUT)
- PCN – UT Time of Flight Diffraction (TOFD)

## How to Book Your Training Course

To book a training course, simply contact us via phone or email and we will be happy to discuss your requirements. If necessary, we can provide advice on which type of training and certification is appropriate for you or your company.

Courses can be booked and paid online on the following links:

ANDTC Constantia Kloof Campus: <https://andtc.com/courses-constantia-kloof/>

ANDTC Vaal Training Centre: <https://andtc.com/courses-vaal/>

Training courses are conducted on a regular basis at both our branches, and PCN examinations are run ongoing at our Roodepoort Examination Centre.

## Contact Us

### ANDTC Constantia Kloof

**AFRICAN NDT CENTRE (PTY) LTD**

21 Constantia Boulevard, Constantia Kloof  
Roodepoort, 1709, Gauteng

**Phone or WhatsApp:** +27 (0)69 122 9848

**Email:** [Bookings@andtc.com](mailto:Bookings@andtc.com)

**Web:** [www.andtc.com](http://www.andtc.com)

**PCN ATO Authorization Number: 0838**

### ANDTC Vaal

**AFRICA NDT VAAL (PTY) LTD**

8 Leeuwenhoek Street, Duncanville,  
Vereeniging, 1939, Gauteng

**Phone or WhatsApp :** +27 (0)73 223 1832

**Email:** [info@andtc.com](mailto:info@andtc.com)

**Web:** [www.andtc.com](http://www.andtc.com)

**PCN ATO Authorization Number: 0837**



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Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 4 of 7

## What is Time of Flight Diffraction?

Time of Flight Diffraction (TOFD) is an advanced ultrasonic NDT method that detects and accurately sizes internal flaws (especially planar defects like cracks, lack of fusion, and lack of penetration) by measuring the time difference between diffracted ultrasonic signals from the tip of a defect, not relying on amplitude like conventional UT.

TOFD = "Ultrasonic Holography" — it maps the entire weld volume in a single scan with high accuracy ( $\pm 1$  mm in height).

How It Works:

1. Probe Pair
2. Signal Types (in A-scan):
3. Time of Flight Measurement
4. D-Scan Imaging

Applications:

- Weld inspection (pipelines, pressure vessels, structural steel).
- Crack sizing (fatigue, stress corrosion, HIC).
- In-service inspection (CUI, mid-wall flaws).
- Thick welds ( $>12$  mm) — ideal up to 300 mm.
- Austenitic & dissimilar welds (with L-wave probes).

Limitations:

- Dead zones: Near surface ( $\sim 3$  mm) and near back wall.
- Requires two-sided access (or single-side TOFD with creep wave).
- Poor for volumetric defects (porosity, slag — low diffraction).
- High skill level (Level 2/3).
- Sensitive to surface condition (needs clean, parallel).

## About the Course

### PCN Level 2

This course equips participants with a solid understanding of ToFD theory and its practical application on welds preparing and qualifying them as PCN Level I or II in ToFD.

### PCN Level 3

This guidance course targets the PCN Level 3 requirements for ToFD practitioners. Its primary goal is to familiarise candidates with the examination scope and required knowledge level. It helps identify weaker subject areas and provides advice on any additional training needed.



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**LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 5 of 7

## Qualification Requirements

### Prerequisites

- Matric (Grade 12) with Mathematics and/or Science
- Basic understanding of physics principles (recommended)
- For Level 3: Previous PCN certification as required by PCN standards

### Training Hours

| Level 2 | Level 3 |
|---------|---------|
| 10 Days | 5 Days  |

**Note:** Direct access to Level 2 or 3 requires the total days shown in the table for Levels 1 and 2, or Levels 1, 2 and 3 respectively.

### Product Sector

**Multi Sector** - This course prepares candidates for certification across multiple product sectors as defined by PCN standards.

### Experience Requirements

| Level 2   | Level 3   |
|-----------|-----------|
| 12 Months | 36 Months |

**Note:** Experience may be acquired either prior to (for Level 1 and 2 entry only) or following success in the qualification examination. However, the chances of success in a PCN examination may be significantly reduced if candidates have little or no current experience in the application of the NDT method in the sector concerned.

### Documents to be Submitted for Examination

- PCN UT Level 2 Cert
- ID
- PSL 57-A Initial Examination Application
- PSL 30 - Log of Experience
- PSL 44 - Vision Requirements
- CP-27 Code of Ethics
- PCN ID (wallet or e-certificate) -only for existing PCN certificate holders
- Proof of either holding PCN certification or successful completion of BINDT PCN Online Product Technology- cert with QR code
- One government-approved identity document (Passport/ID Card/Driver's License)
- Note: Blank PSL and CP forms can be collected from ANDTC offices during course or downloaded from BINDT website.



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**COURSE CURRICULUM**  
**TIME OF FLIGHT DIFFRACTION (ToFD)**  
**LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 6 of 7

## Learning Outcomes

### PCN Level 2

Upon completion, the candidate shall be able to:

1. Master TOFD Theory & Wave Physics
2. Set Up & Calibrate TOFD Equipment Independently
3. Write & Execute TOFD Written Instructions
4. Perform Full TOFD Inspection with Encoded Scanning
5. Accurately Detect, Locate & Size Defects
6. Interpret TOFD D-Scan & Apply Acceptance Criteria
7. Produce Digital TOFD Reports (Audit-Ready)
8. Perform Practical Examination (PCN Level 2 TOFD)

### PCN Level 3

Upon completion, the candidate shall be able to:

1. Master Advanced TOFD Physics & Signal Analysis
2. Design & Qualify TOFD Procedures for Critical Applications
3. Supervise, Audit & Train Level 1&2 TOFD Personnel
4. Interpret Complex TOFD Data & Resolve Ambiguities
5. Lead TOFD Program & Code Compliance
6. Integrate TOFD with PAUT & Digital Systems
7. Prepare for PCN Level 3 Examination (TOFD)

## What to Bring?

- Own PPE (coveralls or lab coat, safety boots)
- PCN wallet card or other form of photographic identification

## Special Notes

- African NDT Centre reserves the right to disqualify participants from the certification program when personnel are found not to meet PCN requirements
- Participants are not allowed to use their own equipment during training and examination. African NDT Centre provides all necessary ET equipment and accessories
- Professional dress code must be followed during the entire training and examination period
- Once enrolled, joining instructions will be sent via email with all necessary information communicated telephonically.



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Doc No : CC-TOFD  
Issue : 2  
Date : 01/07/2024  
Page : 7 of 7

## Training and Examination Information

The training program comprises daily assessments after completion of each chapter, and participants are required to achieve above 70% marks. Based on daily assessment performance, candidates are awarded successful completion of training.

Participants are then required to undergo PCN examination which consists of:

- Theory examination
- Practical examination
- NDT instruction writing (Level 2 only)

Candidates must obtain a minimum of 70% in each examination element to achieve PCN certification as Level 1, 2, or 3.

PCN certification is valid for 5 years from the date of certification. The certificate must be renewed according to PCN requirements.

## Syllabus Reference

This curriculum is aligned with the PCN examination syllabus as published in **PCN24/GEN/Appendix Z1 - NDT Examination Syllabi, Issue 1, February 2024**.

The detailed syllabus breakdown covering all topics for Level 1, 2, and 3 is available in our comprehensive course documentation (Document No: CC-PTOFD, Issue 2, dated 01/07/2024 noted as Annexure A)

African NDT Centre regularly reviews and updates the curriculum in line with scientific, industrial, and technological developments in eddy current testing, as well as any changes to PCN certification requirements.



**AFRICAN NDT CENTRE  
COURSE CURRICULUM**

**TIME-OF-FLIGHT-DIFFRACTION TESTING LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01.07.2024  
Page : 1 of 4

**ANNEXURE A**

| Contents                      | Level 1                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Level 2                                                                                                                                                                                                                                                                                                                                                                                                                                             | Level 3        |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| 1.0<br>General Theory         | Candidates for this exam will already hold UT Welds Level 1. Refer to CC-UT.                                                                                                                                                                                                                                                                                                                                                                            | Candidates for this exam will already hold UT Welds Level 2. Refer to CC-UT.                                                                                                                                                                                                                                                                                                                                                                        | Not Presented. |
| 2.0<br>Sector Specific Theory | 2.1 Background to the Importance of the TOFD Technique.<br>2.2 History of TOFD Development.<br>2.3 Principles of TOFD.<br>2.4 Diffraction Process.<br>2.5 Basic TOFD Set-up.<br>2.6 Types of TOFD Scan.<br>2.7 Summary of Advantages and Disadvantages of TOFD, including limitations.<br>2.8 Basic Hardware.<br>2.9 Advantage of Digital Recording.<br>2.10 Digitisation of the Analogue Ultrasonic Signals.<br>2.11 Amplitude.<br>2.12 Sampling Rate. | As level 1, but in addition:<br><br>2.67 Flaw Sizing with the Pulse Echo Technique.<br>2.68 Comparison of Flaw Sizing Accuracy for Different Techniques.<br>2.69 Angular Variation of Diffraction Signals.<br>2.70 Effect of Change in Probe Separation and Importance of Calibration with Lateral and Back Wall Signals.<br>2.71 Change in Probe Separation.<br>2.72 Importance of Calibration.<br>2.73 Error due to Variations in Couplant Depth. | Not Presented  |



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COURSE CURRICULUM

**TIME-OF-FLIGHT-DIFFRACTION TESTING LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01.07.2024  
Page : 2 of 4

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>2.13 Selection of Frequencies for Filtering.</li><li>2.14 Amount of Data collected during an Inspection.</li><li>2.15 Grey scale imaging and B-scans.</li><li>2.16 Signal Averaging.</li><li>2.17 Pulse Width Control.</li><li>2.18 Software.</li><li>2.19 On-line.</li><li>2.20 Analysis and Off-line Facilities.</li><li>2.21 Precision and Resolution.</li><li>2.22 Beam Spread Considerations.</li><li>2.23 Basics for Calculation of Beam Spread.</li><li>2.24 Example of Selection of Number of Scans for an Inspection.</li><li>2.25 Choice of Probe Angle.</li><li>2.26 Transducer size and frequency.</li><li>2.27 Choice of Probe Centre Separation.</li><li>2.28 Calibration of Setting of Gain.</li><li>2.29 Digitisation Rate.</li><li>2.30 Signal Averaging and Pulse Width.</li><li>2.31 No Signals – common faults.</li><li>2.32 Manual versus Mechanical Scanning.</li><li>2.33 General.</li><li>2.34 Manual Scanning.</li><li>2.35 Mechanical Scanning.</li><li>2.36 Sampling Interval.</li><li>2.37 Summary of Choice of Parameters for TOFD Scan.</li><li>2.38 Introduction.</li><li>2.39 Timing Errors.</li></ul> | <ul style="list-style-type: none"><li>2.74 Error due to Variations in Surface Profile.</li><li>2.75 Velocity Error.</li><li>2.76 Index Point Migration Errors.</li><li>2.77 Other Errors.</li><li>2.78 Multiple Arcs.</li><li>2.79 Procedure Writing.</li><li>2.80 Equipment and Probe Checks.</li><li>2.81 Equipment Checks.</li><li>2.82 Screen Height Linearity.</li><li>2.83 Amplitude Linearity.</li><li>2.84 Time Base Linearity.</li><li>2.85 Probe Index Emission Point.</li><li>2.86 Beam Angle.</li><li>2.87 Beam Spread.</li><li>2.88 TOFD Combined Probe Delay.</li><li>2.89 Sensitivity.</li><li>2.90 Resolution.</li><li>2.91 Probe Checks.</li><li>2.92 Material Velocity Measurement.</li><li>2.93 Probe Frequency.</li><li>2.94 Probe Pulse Length.</li></ul> |
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COURSE CURRICULUM

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Doc No : CC-TOFD  
Issue : 2  
Date : 01.07.2024  
Page : 3 of 4

2.40 Near Surface Problems.  
2.41 Off-axis Error and Back Wall Blind Zone.  
2.42 Off-axis Depth Error.  
2.43 Back Wall Blind Zone.  
2.44 Errors in Couplant Thickness, Surface Height Variations and Velocity.  
2.45 Large Grained Materials.  
2.46 Overall Errors and Monitoring Growth  
2.47 Overall Errors.  
2.48 Monitoring Defect Growth.  
2.49 Data Assessment – flaw characterisation.  
2.50 Shear Waves.  
2.51 Pores and Slags in TOFD Records.  
2.52 Internal Cracks.  
2.53 Upper Surface Breaking Cracks.  
2.54 Lower Surface Breaking Cracks.  
2.55 Effect of Changing Defect Profile.  
2.56 Weld Root Flaws.  
2.57 Check Transparency.  
2.58 Transverse Flaws.  
2.59 Analysis Software.  
2.60 Linearisation.  
2.61 Lateral/Back Wall Straighten and Removal.  
2.62 Parabolic Cursor.  
2.63 Synthetic Aperture Focusing Technique (SAFT).  
2.64 Split Spectrum Processing.



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**COURSE CURRICULUM**

**TIME-OF-FLIGHT-DIFFRACTION TESTING LEVEL 1, 2 and 3**

Doc No : CC-TOFD  
Issue : 2  
Date : 01.07.2024  
Page : 4 of 4

2.65 Curved Surface.  
2.66 Complex Geometry.

Note 1: TOFD Level 3 courses not available through ANDTc.