

**UNIVERSITY COLLEGE TATI (UC TATI)****FINAL EXAMINATION QUESTION BOOKLET**

|                  |                         |
|------------------|-------------------------|
| COURSE CODE      | : DND 3034              |
| COURSE           | : ULTRASONIC TESTING II |
| SEMESTER/SESSION | : 1-2022/2023           |
| DURATION         | : 3 HOURS               |

**Instructions:**

1. This booklet contains **4** questions. Answer **all** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise up your hands and ask the invigilator.

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO**

**THIS BOOKLET CONTAINS 7 PRINTED PAGES INCLUDING COVER PAGE**

### QUESTION 1

- a) In Immersion Testing, the transducer is placed in the water, above the test object, and a beam of sound is projected.
- Define the immersion testing of Ultrasonic Testing (2 marks)
  - Describe **two (2)** advantages of immersion tanks technique (4 marks)
  - Explain **two (2)** advantages of water jet technique compared to immersion tanks technique. (4 marks)
  - Calculate the minimum water gap distance from front probe to front steel wall if the steel length, width and height are 200 mm, 70 mm and 40 mm respectively. (3 marks)
  - Illustrate and label all the signals of Immersion testing for position 2 in figure 1. (7 marks)

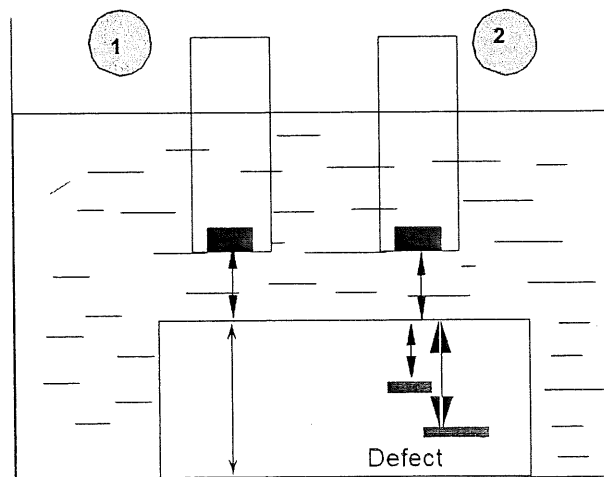


Figure 1

- b) The reference level, **b** at 50 % FSH is 51 dB. The maximum signal amplitude indication is obtained at 90 % FSH by using 60° probe. The indication beam path is 54 mm, defect length is 30 mm and the plate thickness is 45 mm. By referring to Table 8.2 Ultrasonic Acceptance-Rejection Criteria for Statically Loaded Non-Tubular Connections, calculate the followings:
- The indication level, **a**. (4 marks)
  - The attenuation factor, **c**. (2 marks)
  - The indication rating, **d** including discontinuity severity class. (4 marks)

## QUESTION 2

a) Time of Flight Diffraction (TOFD) technique is based on diffraction of ultrasonic energy from tips of discontinuities, instead of geometrical reflection on the interface of the discontinuities (conventional UT).

- List **four (4)** different types of sound waves are generated in the construction of a TOFD image. (4 marks)
- Describe **two (2)** advantages of TOFD technique compared to conventional UT technique. (3 marks)

b) Figure 2 shows the sound propagation in TOFD technique. 32 mm double-vee butt weld pipe of Stainless Steel is prepared to be inspected by using TOFD technique. The second arrival time,  $t_1$  is  $12.35 \mu\text{s}$  and the third arrival time,  $t_2$  is  $15.05 \mu\text{s}$ . The probe separation, **2S** between probes is 100 mm. Calculate the followings:

- The first arrival time,  $t_L$ . (2 marks)
- The defect depth,  $d$  from the top surface to the upper defect tip. (4 marks)
- The defect depth from the upper tip to the lower tip of defect,  $a$ . (4 marks)
- The fourth arrival time,  $t_{BW}$ . (3 marks)

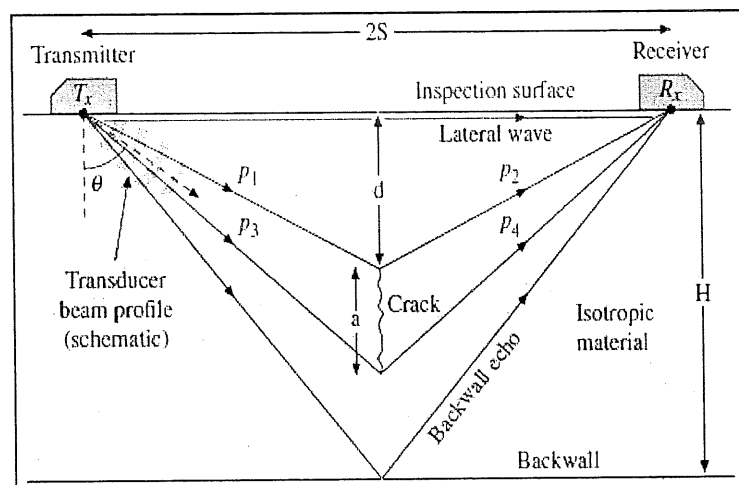
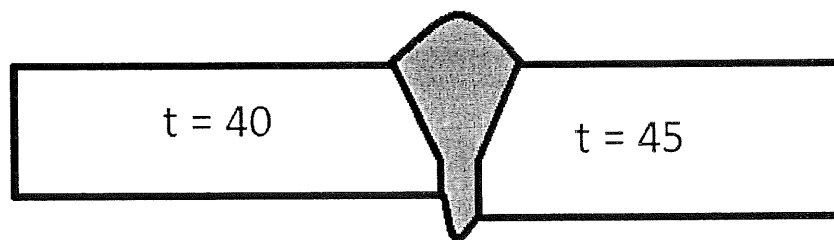


Figure 2

**QUESTION 3**

- a) Phased Array Ultrasound Testing (PAUT) is an advanced method of ultrasound testing. Phased Array differs from conventional Ultrasound testing in many ways.
- State **four (4)** basic parameters of Phased Array probes. (4 marks)
  - Identify **two (2)** types of PAUT probe. (2 marks)
  - Explain **two (2)** advantages of PAUT. (4 marks)
  - Describe **two (2)** main differences between Phased Array Ultrasound Testing and Conventional Method Ultrasonic Testing. (4 marks)
- b) 12-inch Carbon Steel butt weld pipe test piece is prepared to be tested by using shear wave PAUT probe. The test frequency is 15 MHz and the individual element size,  $e$  is 0.452 mm. calculate the followings:
- The ultrasonic wavelength. (2 marks)
  - The maximum steering angle for Phased Array inspection. (4 marks)
- c) Figure 3 shows two pieces of carbon steel plate with nominal thickness for each plate are 40 mm and 45 mm respectively was welded and inspected by using ultrasonic testing. Slag inclusion was found during the inspection by using 45° shear wave probe. The length of Slag inclusion is 45 mm. The defect depth is 30 mm and the d rating is about +12.4 dB. By referring the Table 6.3 UT Acceptance-Rejection Criteria (Cyclically Loaded Non-Tubular Connections in Tension), interpret on your own words about the finding stated above. (6 marks)

**Figure 3**

**QUESTION 4**

- a) Internal Rotary Inspection System (IRIS) is an ultrasonic method for the nondestructive testing of pipes and tubes. The IRIS probe is inserted into a tube that is flooded with water, and the probe is pulled out slowly as the data is displayed and recorded.
- List **five (5)** type of signals generated by the Internal Rotary Inspection System (IRIS) on steel tube that contain no defect. (6 marks)
  - Explain the general concepts of ultrasound generation and propagation in IRIS. (6 marks)
- b) 6 meter length of Brass tube was inspected by using IRIS. The results show that, the time taken for the first echo,  $T_0$  and second echo,  $T_1$  are  $34.6 \mu\text{s}$  and  $39.4 \mu\text{s}$  respectively. The delay time,  $T_{\text{delay}}$  is  $30.12 \mu\text{s}$ . Calculate the followings:
- The remaining wall thickness, **WT** of Brass tube. (4 marks)
  - The internal diameter, **ID** of Brass tube. (4 marks)
- d) Describe the Discontinuity Severity Class for Table 8.2 UT Acceptance-Rejection Criteria (Statically Loaded Non-Tubular Connections and Cyclically Loaded Non-Tubular Connections in Compression) for the followings:
- Class B (2 marks)
  - Class C (2 marks)

-----End of Question-----

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## ATTACHMENT 1

Table 1: Material Velocity

| Medium          | Compression Velocity (m/s) | Shear Velocity (m/s) | Acoustic Impedance, Z |
|-----------------|----------------------------|----------------------|-----------------------|
| Air             | 330                        | -                    | 0                     |
| Aluminium       | 6400                       | 3130                 | 17.2                  |
| Brass           | 4370                       | 2100                 | 37                    |
| Cast iron       | 3500                       | 2200                 | 25                    |
| Copper          | 4760                       | 2330                 | 42.5                  |
| Gold            | 3240                       | 1200                 | 63                    |
| Oil             | 1440                       | -                    | 1.3                   |
| Perspex         | 2740                       | 1320                 | 3.2                   |
| Carbon steel    | 5960                       | 3240                 | 46.5                  |
| Stainless steel | 5740                       | 3130                 | 44.8                  |
| Silver          | 3700                       | 1700                 | 36.9                  |
| Tin             | 3380                       | 1610                 | 24.7                  |
| Tungsten        | 5170                       | 2880                 | 100                   |
| Water           | 1480                       | -                    | 1.48                  |

Table 2: Ultrasonic Acceptance-Rejection Criteria for Statically Loaded Non-Tubular Connections

| <b>Table 8.2</b><br><b>UT Acceptance-Rejection Criteria (Statically Loaded Nontubular Connections and Cyclically Loaded Nontubular Connections in Compression) (see 8.13.1, 8.13.2(2), and C-8.25.6)</b> |                                                             |                             |                               |            |            |                            |            |           |                         |             |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------|-------------------------------|------------|------------|----------------------------|------------|-----------|-------------------------|-------------|------------|
| Discontinuity Severity Class                                                                                                                                                                             | Weld Size <sup>a</sup> in inches (mm) and Search Unit Angle |                             |                               |            |            |                            |            |           |                         |             |            |
|                                                                                                                                                                                                          | 5/16 through 3/4 [8-20]                                     | > 3/4 through 1-1/2 [20-38] | > 1-1/2 through 2-1/2 [38-65] |            |            | > 2-1/2 through 4 [65-100] |            |           | > 4 through 8 [100-200] |             |            |
|                                                                                                                                                                                                          | 70°                                                         | 70°                         | 70°                           | 60°        | 45°        | 70°                        | 60°        | 45°       | 70°                     | 60°         | 45°        |
| Class A                                                                                                                                                                                                  | +5 & lower                                                  | +2 & lower                  | -2 & lower                    | +1 & lower | +3 & lower | -5 & lower                 | -2 & lower | 0 & lower | -7 & lower              | -4 & lower  | -1 & lower |
| Class B                                                                                                                                                                                                  | +6                                                          | +3                          | -1<br>0                       | +2<br>+3   | +4<br>+5   | -4<br>-3                   | -1<br>0    | +1<br>+2  | -6<br>-5                | -3<br>-2    | 0<br>+1    |
| Class C                                                                                                                                                                                                  | +7                                                          | +4                          | +1<br>+2                      | +4<br>+5   | +6<br>+7   | -2 to<br>+2                | +1<br>+2   | +3<br>+4  | -4 to<br>+2             | -1 to<br>+2 | +2<br>+3   |
| Class D                                                                                                                                                                                                  | +8 & up                                                     | +5 & up                     | +3 & up                       | +6 & up    | +8 & up    | +3 & up                    | +3 & up    | +5 & up   | +3 & up                 | +3 & up     | +4 & up    |

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## ATTACHMENT 2

**Table 3:** Ultrasonic Acceptance-Rejection Criteria for Cyclically Loaded Non-tubular Connections

| <b>Table 8.3</b><br><b>UT Acceptance-Rejection Criteria (Cyclically Loaded Nontubular Connections in Tension)</b><br><b>(see 8.13.2 and C-8.25.6)</b> |                                                             |                                      |                                  |               |               |                               |               |               |                            |               |               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------|----------------------------------|---------------|---------------|-------------------------------|---------------|---------------|----------------------------|---------------|---------------|
| Discontinuity<br>Severity Class                                                                                                                       | Weld Size <sup>a</sup> in inches [mm] and Search Unit Angle |                                      |                                  |               |               |                               |               |               |                            |               |               |
|                                                                                                                                                       | 5/16<br>through<br>3/4<br>[8-20]                            | > 3/4<br>through<br>1-1/2<br>[20-38] | > 1-1/2 through 2-1/2<br>[38-65] |               |               | > 2-1/2 through 4<br>[65-100] |               |               | > 4 through 8<br>[100-200] |               |               |
|                                                                                                                                                       | 70°                                                         | 70°                                  | 70°                              | 60°           | 45°           | 70°                           | 60°           | 45°           | 70°                        | 60°           | 45°           |
| Class A                                                                                                                                               | +10 &<br>lower                                              | +8 &<br>lower                        | +4 &<br>lower                    | +7 &<br>lower | +9 &<br>lower | +1 &<br>lower                 | +4 &<br>lower | +6 &<br>lower | -2 &<br>lower              | +1 &<br>lower | +3 &<br>lower |
| Class B                                                                                                                                               | +11                                                         | +9                                   | +5<br>+6                         | +8<br>+9      | +10<br>+11    | +2<br>+3                      | +5<br>+6      | +7<br>+8      | -1<br>0                    | +2<br>+3      | +4<br>+5      |
| Class C                                                                                                                                               | +12                                                         | +10                                  | +7<br>+8                         | +10<br>+11    | +12<br>+13    | +4<br>+5                      | +7<br>+8      | +9<br>+10     | +1<br>+2                   | +4<br>+5      | +6<br>+7      |
| Class D                                                                                                                                               | +13<br>& up                                                 | +11<br>& up                          | +9<br>& up                       | +12<br>& up   | +14<br>& up   | +6<br>& up                    | +9<br>& up    | +11<br>& up   | +3<br>& up                 | +6<br>& up    | +8<br>& up    |

$$t_L = \frac{2S}{C}$$

$$t_1 = \frac{2\sqrt{S^2 + d^2}}{C}$$

$$d = \frac{1}{2}\sqrt{C^2 t_1^2 - 4S^2}$$

$$t_2 = \frac{2\sqrt{S^2 + (d+a)^2}}{C}$$

$$a = \frac{1}{2}\sqrt{C^2 t_2^2 - 4S^2} - d$$

$$t_{bw} = \frac{2\sqrt{S^2 + H^2}}{C}$$

-----End of Attachment-----

