# BLISTER DEFECT ANALYSIS OF $U_3Si_2$/Al NUCLEAR FUEL CLADDING BY ULTRASONIC TEST

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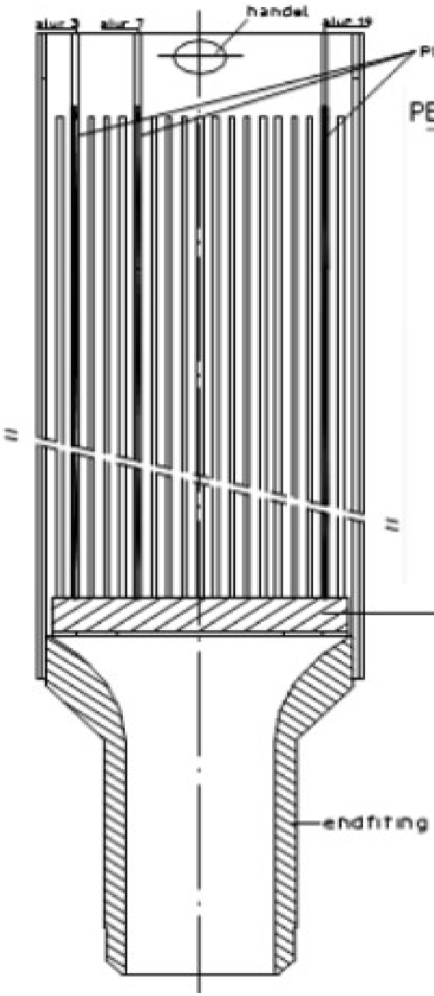
# Introduction

## Nuclear fuel development



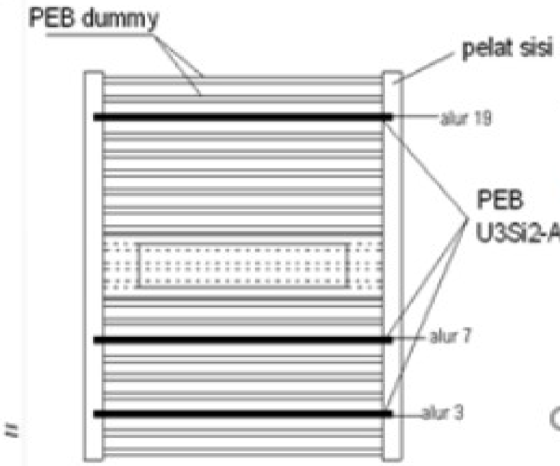




Table 1. Fuel plates element specifications $U_3Si_2$/al uranium loading level 4,8 gU/cm$^3$

| Clasification | Value |
|---|---|
| Enrichment $^{235}U$ | $19.75^{+0.2\%}$ & $19.75_{-0.5\%}$ |
| Number of fuel element in 1 bundle | 3 Fuel element |
| Composition $^{235}U$ / fuel element | 18,36 ± 0,30 g |
| Composition $^{235}U$ / bundle | 55,08 ± 3,80 g |
| Zona 1 tolerance | nominal ± 20 % |
| Zona 2 tolerance | nominal + 25 % |

Table 2. Dimension measurement data

| No | Kode Fuel | Length,mm | Width,mm | High,mm |
|---|---|---|---|---|
| 1 | CBBJ 249 (3) | 629,00 | 70,70 | 1,40 |
| 2 | CBBJ 250 (7) | 629,00 | 70,71 | 1,39 |
| 3 | CBBJ 251(19) | 629,00 | 70,70 | 1,39 |

# Introduction

One of the PIE activities in RMI Hotcell is to do non-destructive tests (NDT) on several types of nuclear fuel including the type of plate (NFP $U_3Si_2$ / Al)

The existence of a fabrication process and the effect of irradiation on NFP $U_3Si_2$ / Al in the reactor can cause anomalies or defects in the cladding, one of them is blister defects.

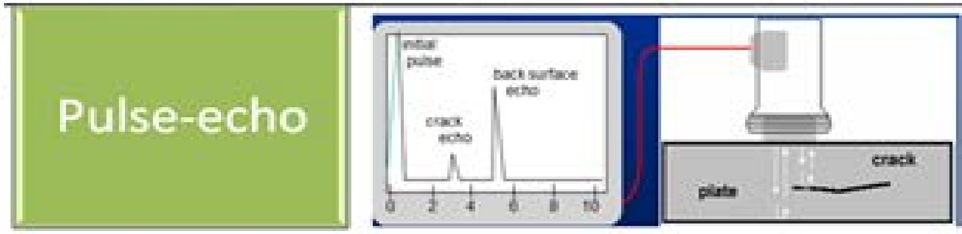
The use of an ultrasonic (UT) type immersion in the analysis of NFP $U_3Si_2$ / Al cladding blister defects was chosen because of the efficiency of the analysis time and reliable in post irradiation testing techniques.

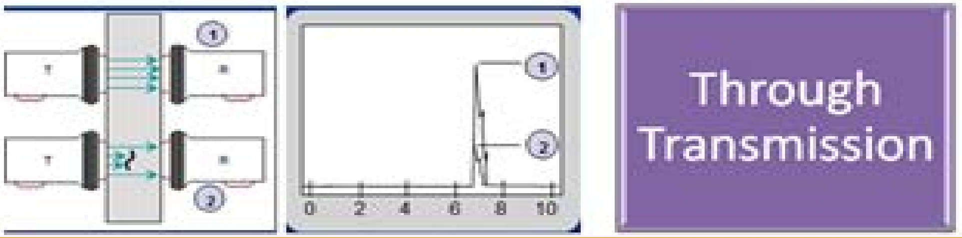
The scope of this study consists of two phases of activity, namely the determination of the operating parameters of the test and signal analysis over the test. (Detect blister defects)

# Introduction



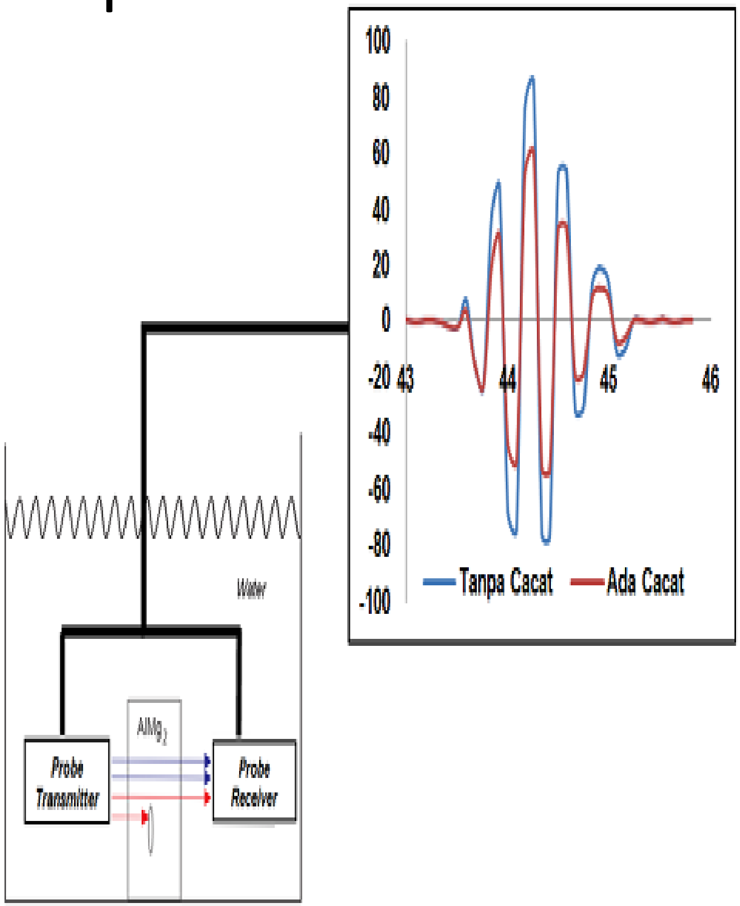
- Pulse-echo and Through Transmission
- Normal and Angle Beam
- Contact and Immersion



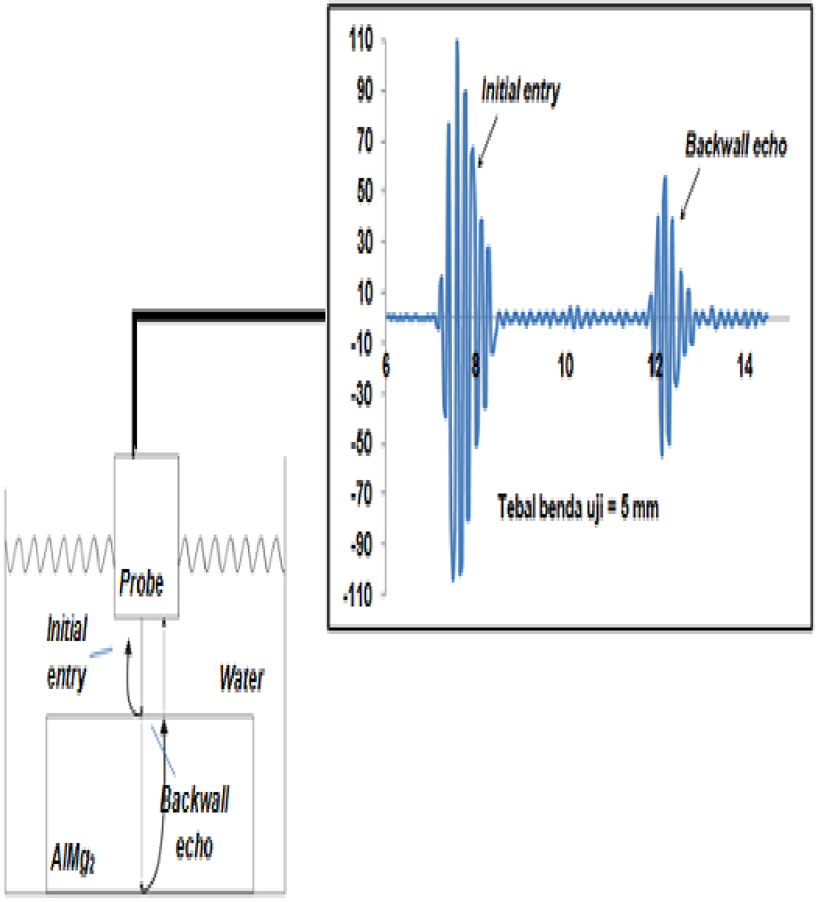



# Introduction

Through transmission technique




Pulse-echo technique



# Methodology

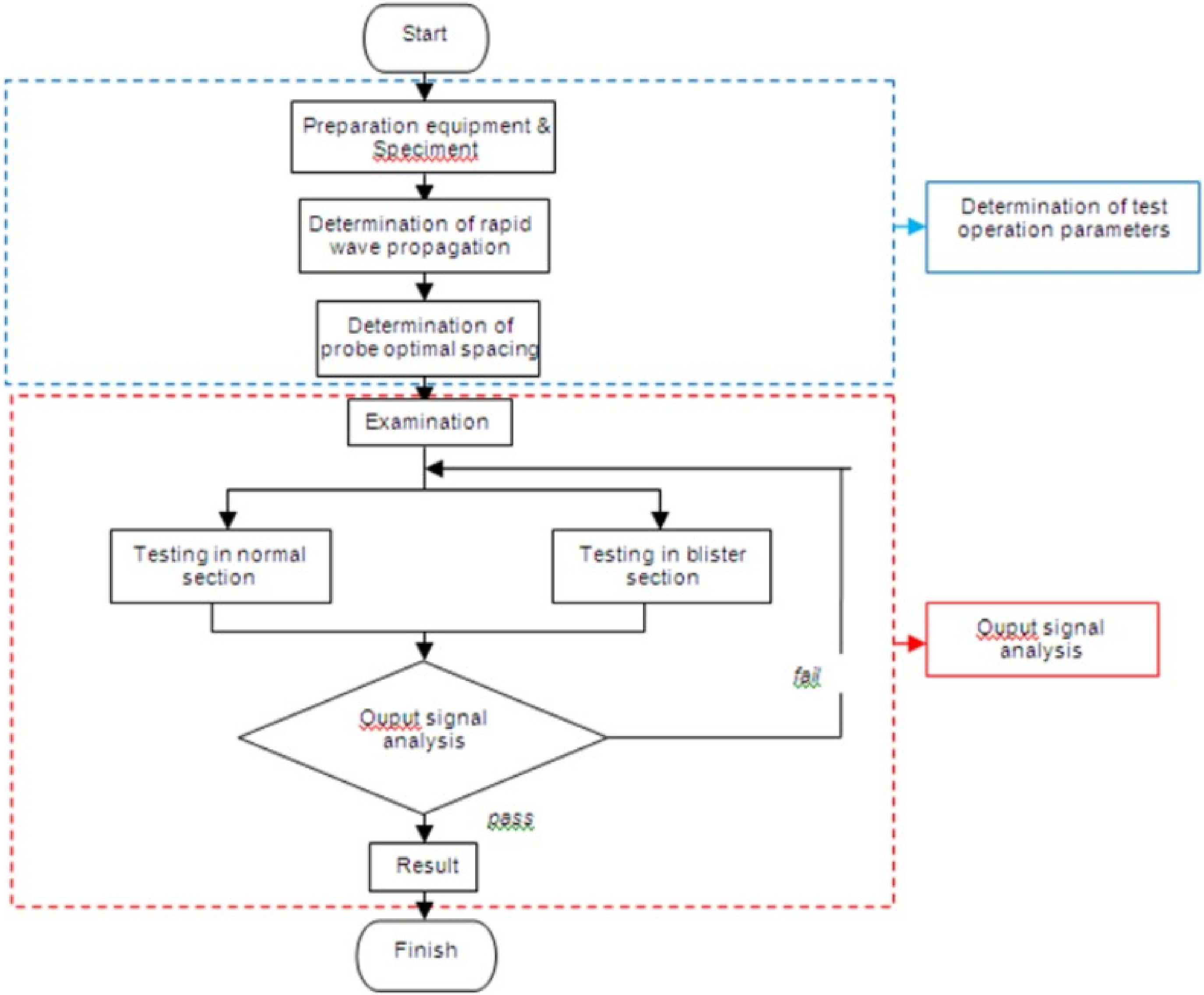



Figure 3. Examination Flowchart

**Schematic Research**

# Methodology

## Table setting of parameters

| No | Tool & Material | Info |
|---|---|---|
| 1 | Cladding sampel nuclear fuel (Almg2) | Thickness 1,3 mm (normal) |
| 2 | Ultrasonic Flaw Detector Sonoscreen ST10 (Tipe A-Scan) | Gain 38 dB<br>Voltage 200 V<br>Pulse width 90 ns<br>PRF 2 kHz |
| 3 | Probe (RTD-Appluss)<br>Water Immersion | Radiation resistance up to 10^8 Rad<br>Frequency 5 MHz<br>Probe diameter 5,5 mm<br>Focal width 3mm<br>Optimum distance 19,5 mm<br>Longitudinal wave |
| 4 | Pulse - Echo | 6 – 32 mm (per 2 mm) |
| 5 | Through Transmission | 36 – 42 mm (per 1 mm) |

# Methodology

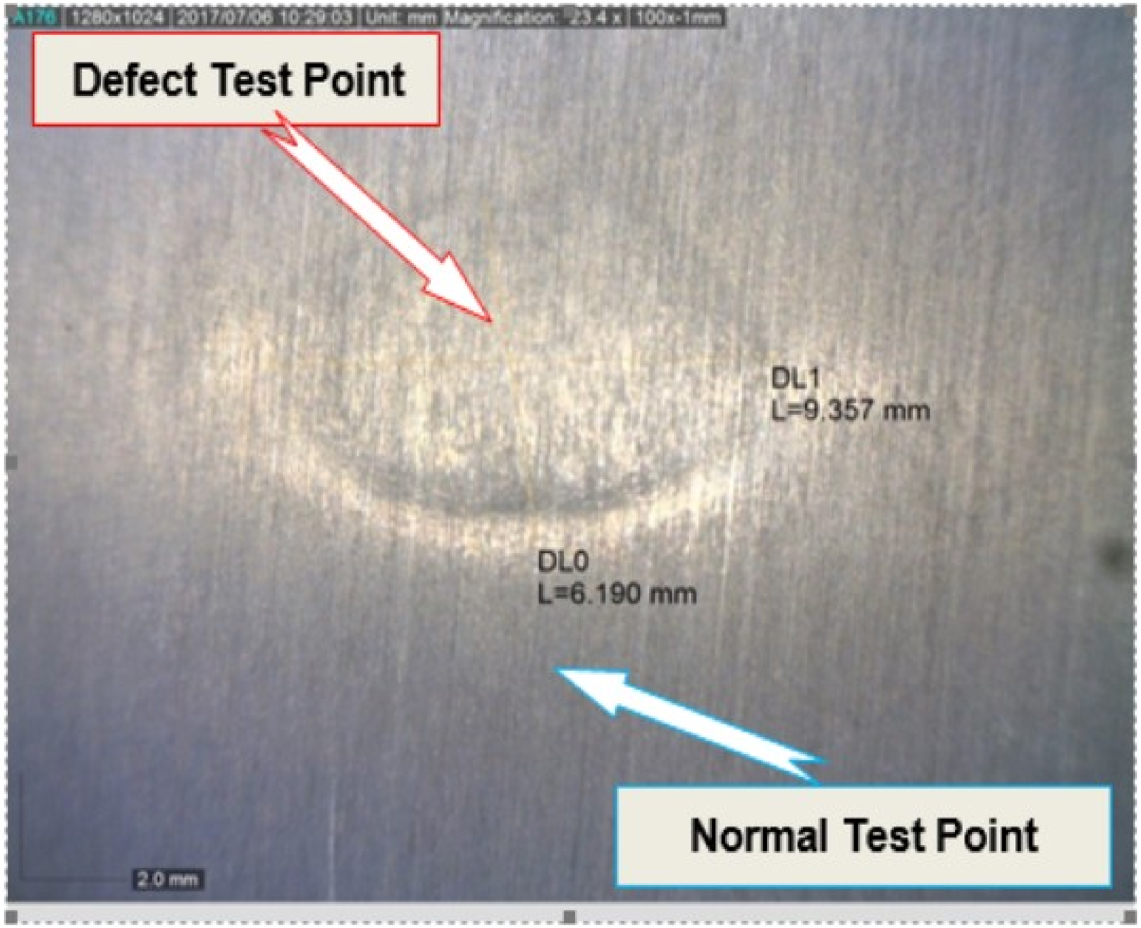



Figure 4. Top view of the blister on the sample of the specimen

# Result & Discussion

## Determination of defects with pulse-echo techniques

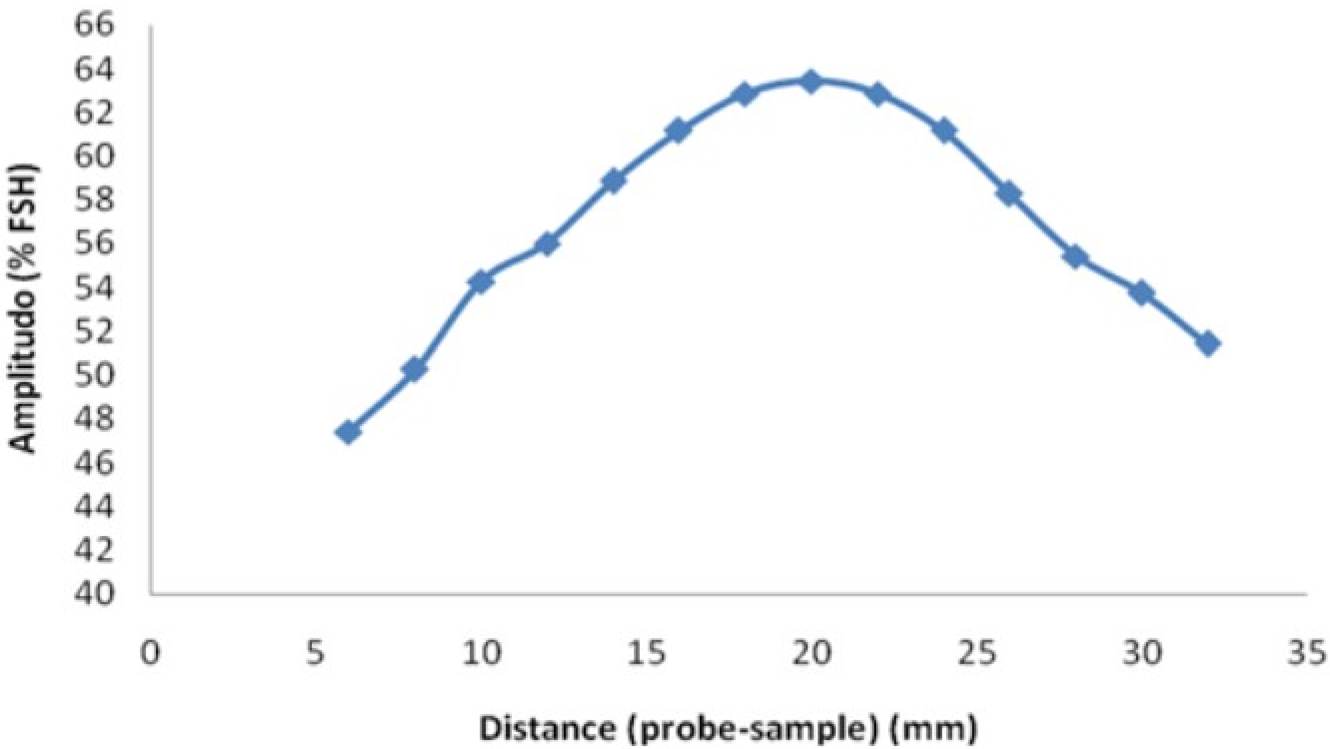
Optimal longotidinal wave propagation in water medium 1545 m/s

Determination optimal distance of the probe → Testing of fuel cladding in normal parts → Testing of fuel cladding for blister defects

20 mm

# Result & Discussion

## Determination of Optimal Probe Distance with Pulse-Echo Technique

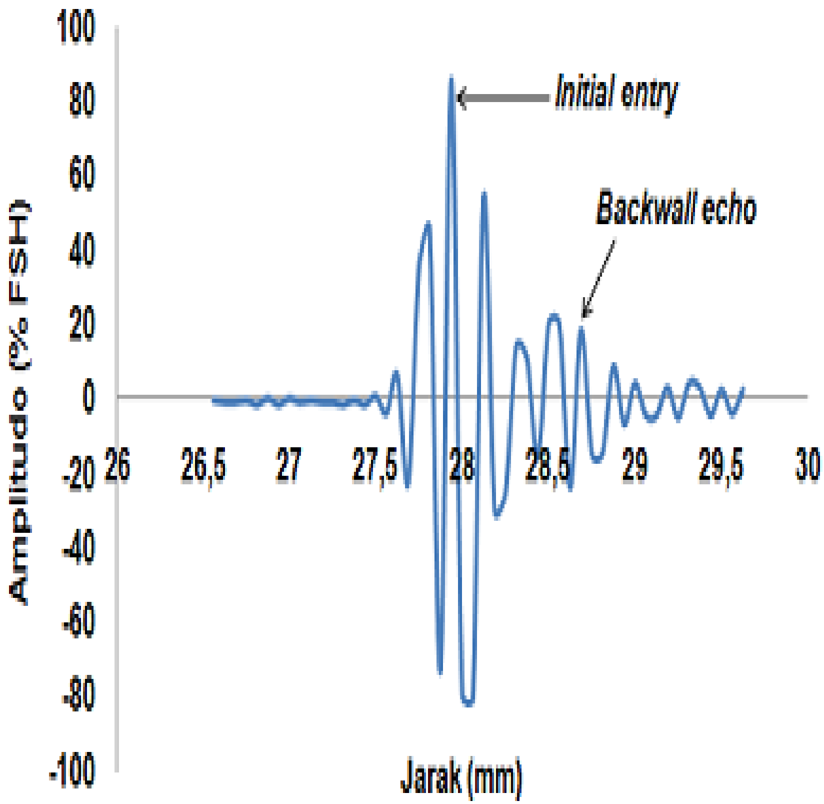



The distance probe-test specimens to amplitude with pulse-echo technique

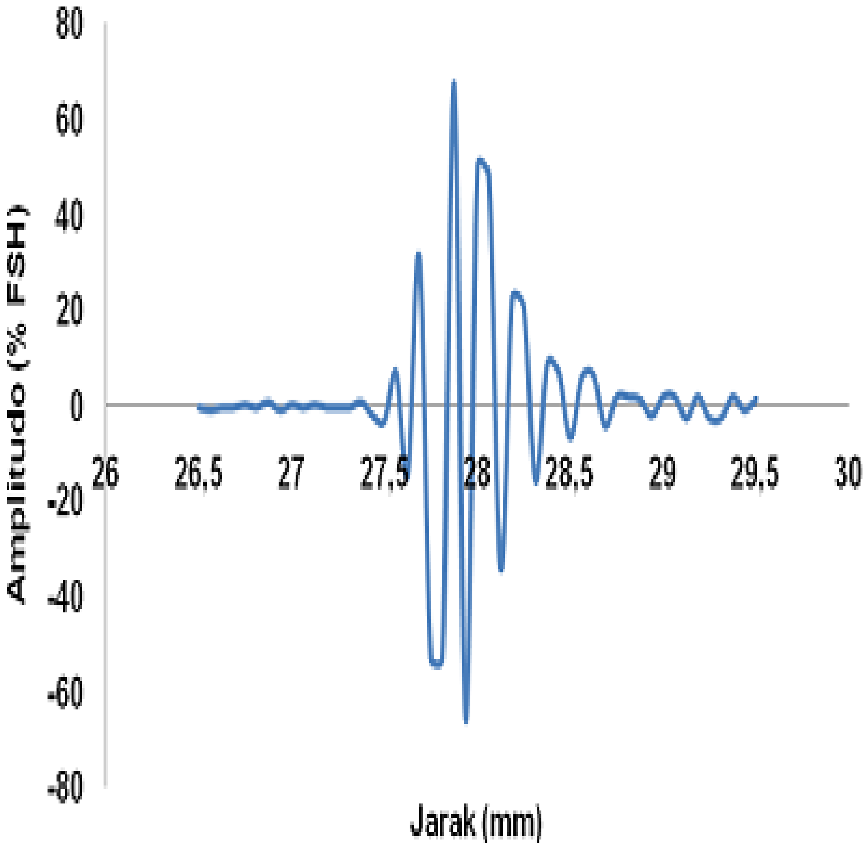
# Result & Discussion

## Output Signal of Cladding Sample Testing with Pulse-Echo Technique

### Normal Section




### Blister Section



# Result & Discussion

## Determination of defects with through transmission techniques

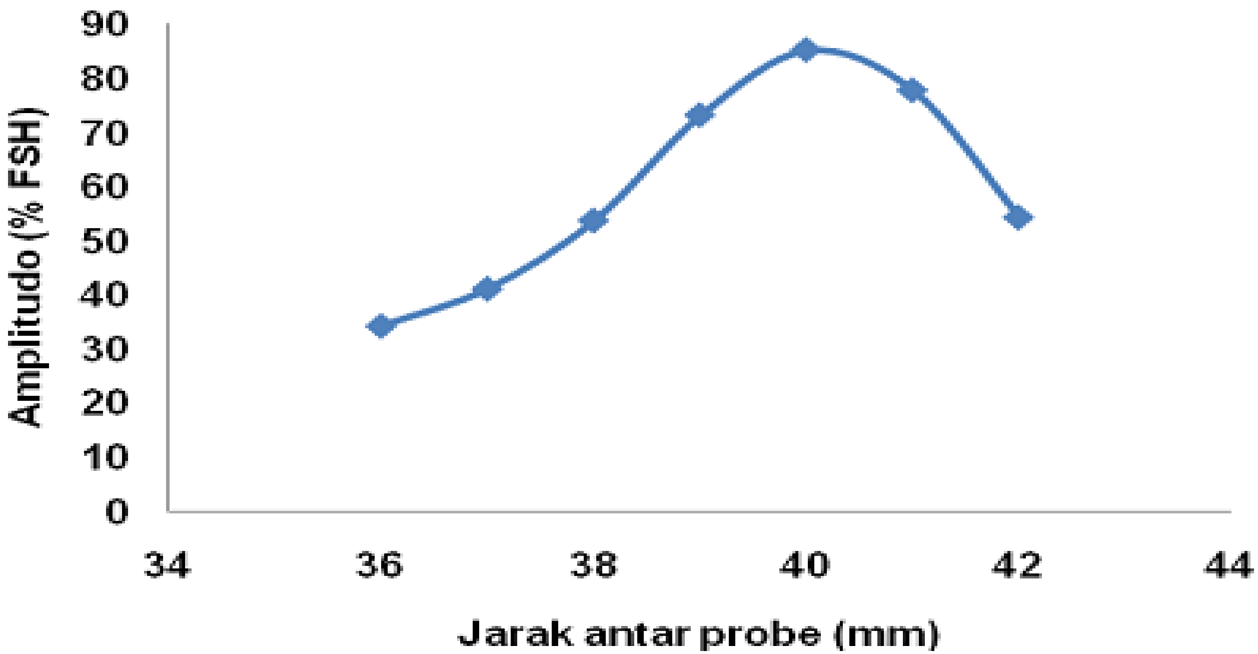
Optimal longitudinal wave propagation in water medium 1545 m/s

Determination optimal distance of the probe → Testing of fuel cladding in normal parts and blister defect parts

40 mm

# Result & Discussion

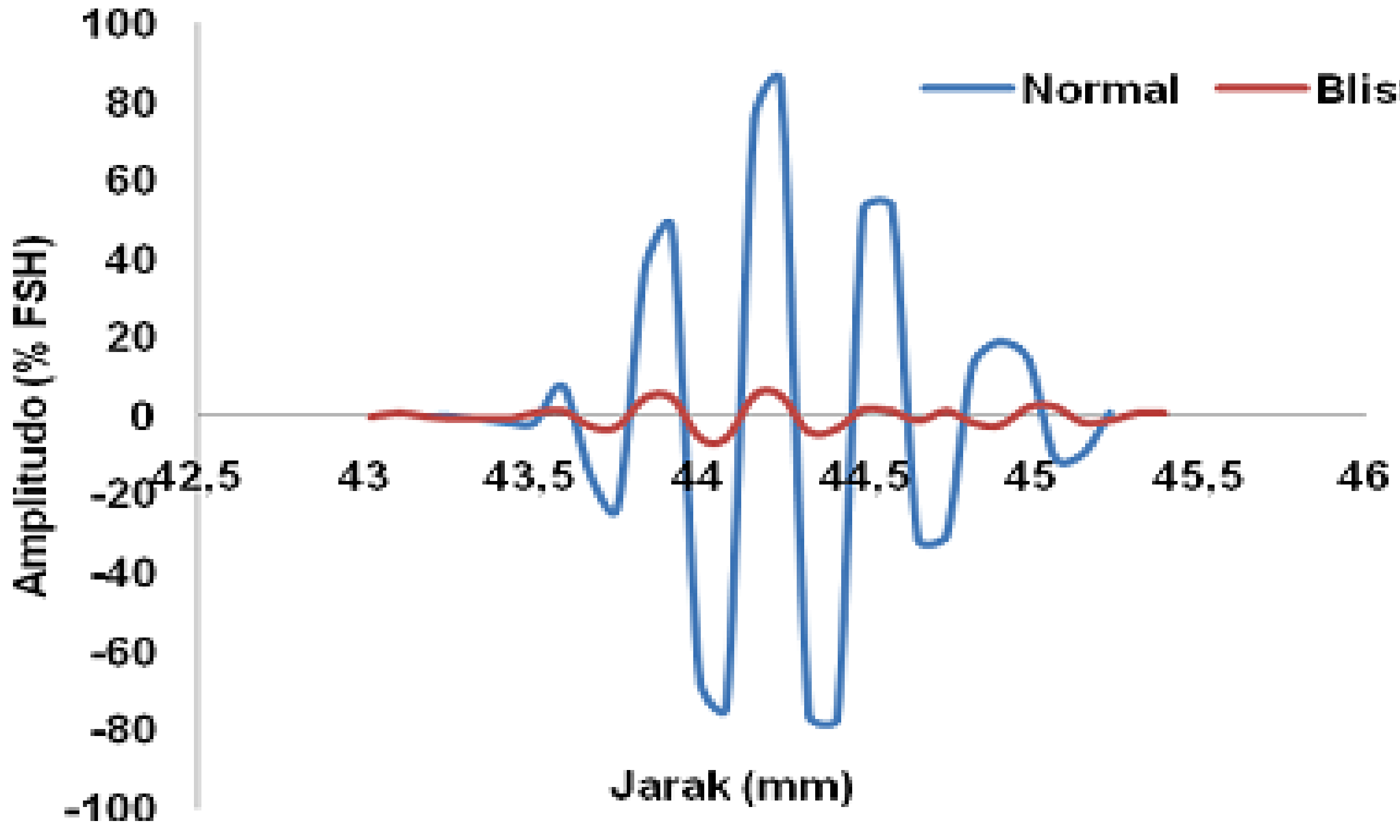
## Determination of Optimal Probe Distance with Through Transmission



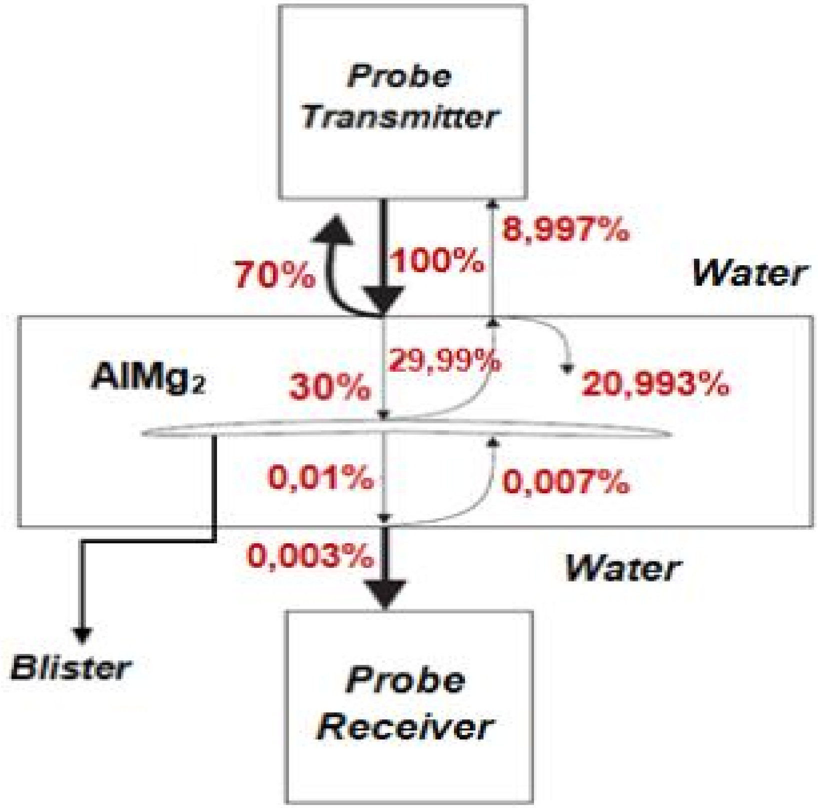

The distance probe-test specimens to amplitude with through transmission technique

# Result & Discussion

## Output Signal of Cladding Sample Testing with Through Transmission Technique



# Result & Discussion




Reflexivity Scheme and blister section testing transmission

# Result & Discussion

- Difference in output signal from pulse-echo technique and through transmission

| Pulse-echo Technique | Through transmission Technique |
|---|---|
| The resulting output signal is difficult to interpret in detecting blisters | The output signal is easier to interpret when detecting blisters |
| In the blister defect there is a signal decrease of 19% FSH | In the blister defect there is a signal decrease of 80% FSH |
| Probes must focus on identifying signals for Initial Entry (IE) and Backwall Echo (BE) | The probe is sufficiently focused on the difference in signal reduction that occurs between normal and anomalous (defective) parts |

# Conclusion

Non-destructive tests using ultrasonic tests can detect blister defects in the U3Si2 / Al fuel cladding successfully. Wave propagation in the water medium (Velocity) is optimally obtained at 1545 m/s, the optimal distance between the probe - test object with pulse-echo technique is 20 mm and the optimal distance between the two probes with the through transmission technique is 40 mm. Blister testing of AlMg2 cladding with through transmission technique decreased output signal by 80% FSH, whereas in pulse-echo technique there was only 19% decrease of signal. Interpretation of signals to detect blister defects in fuel cladding with through transmission techniques is easier to do than pulse-echo techniques.


# Thank you

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