# Advanced Microwave Imaging Electro Fusion Inspection Capability Examples

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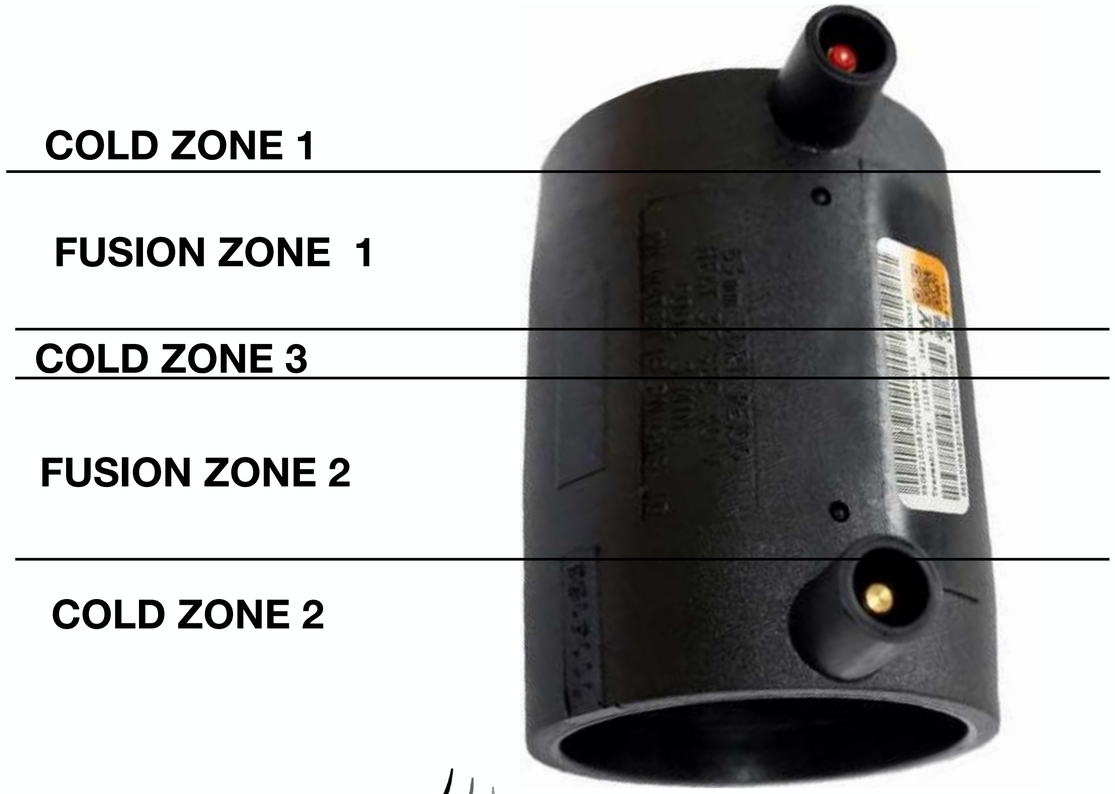
# Electro Fusion Terminology

- Electrofusion couplers have multiple zones once they have been fused
- The zones that are labeled “Cold” are where no wires are present (hence no fusion)
- There are 2 fusion zones, one on each side of the coupler where the wires are present
- The inserted pipes meet at the center of the coupler, Cold Zone 3, but there is a gap between the inserted pipes that needs to be no greater than some value to prevent overheating in the center (exposed wires)
- The inspection technique needs to evaluate the completeness of the fusion in the two fusion zones as well as ensure a proper center gap

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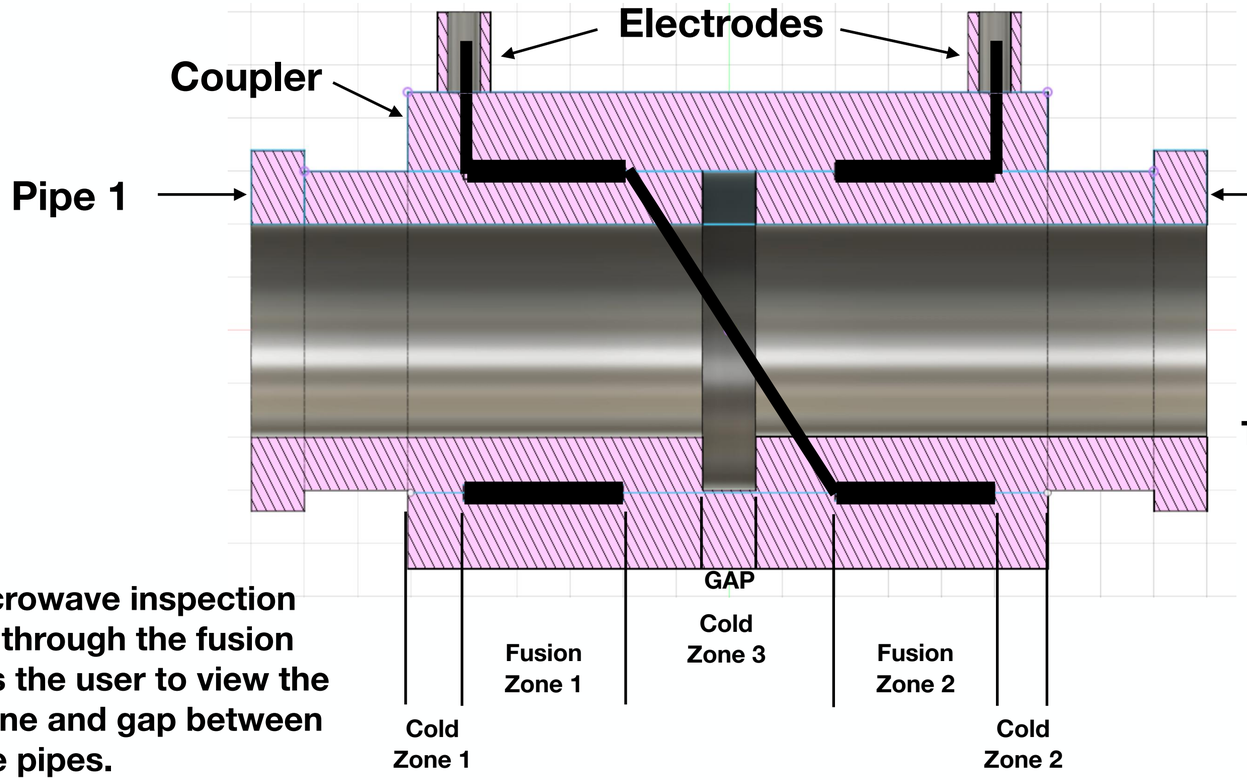
# Cross Section EF Coupler

The electrodes can be removed prior to inspection to make it easier to cover the entire electrofusion coupler fusion zones.




The relatively small fusion zones and the gap between the pipes are the only areas of concern for the inspection.

The AMWI microwave inspection signal passes through the fusion wires and allows the user to view the actual fusion zone and gap between the pipes.

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# Advantages of Microwave Inspection

**Microwave inspection saves money and is more reliable than other methods for inspecting HDPE EF couplers.**

| | |
|---|---|
| **Increased sensitivity to “cold fusion”** | **Microwave inspection takes advantage of the sensitivity of the reflected signal to the degree of crystallinity achieved in the fusion zone to determine an acceptable fusion, which results in a more reliable inspection.** |
| **Easily detects other common flaws** | **Other flaws, such as voids and foreign material inclusions can also be easily detected and located with the AMWI system.** |
| **Easy installation, simple methodology and no clean-up** | **Microwave inspection with the AMWI system requires no couplant and directly images the gap between the pipes, making the inspection much simpler and quicker than other methods.** |

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# AMWI Inspection Enhancements

- Multi Frequency system allows for imaging at specific depths in part
- This allows us to focus on the plane of fusion in an electrofusion without effects of other unimportant regions
- Simplifies accept/reject criteria for quick disposition of EF installation and eliminates cutout of good fusion reducing installation cost
- Equipment built for ease of setup and use, reduces inspection time and increases inspection throughput saving money and time
- Analysis software image explained on next image

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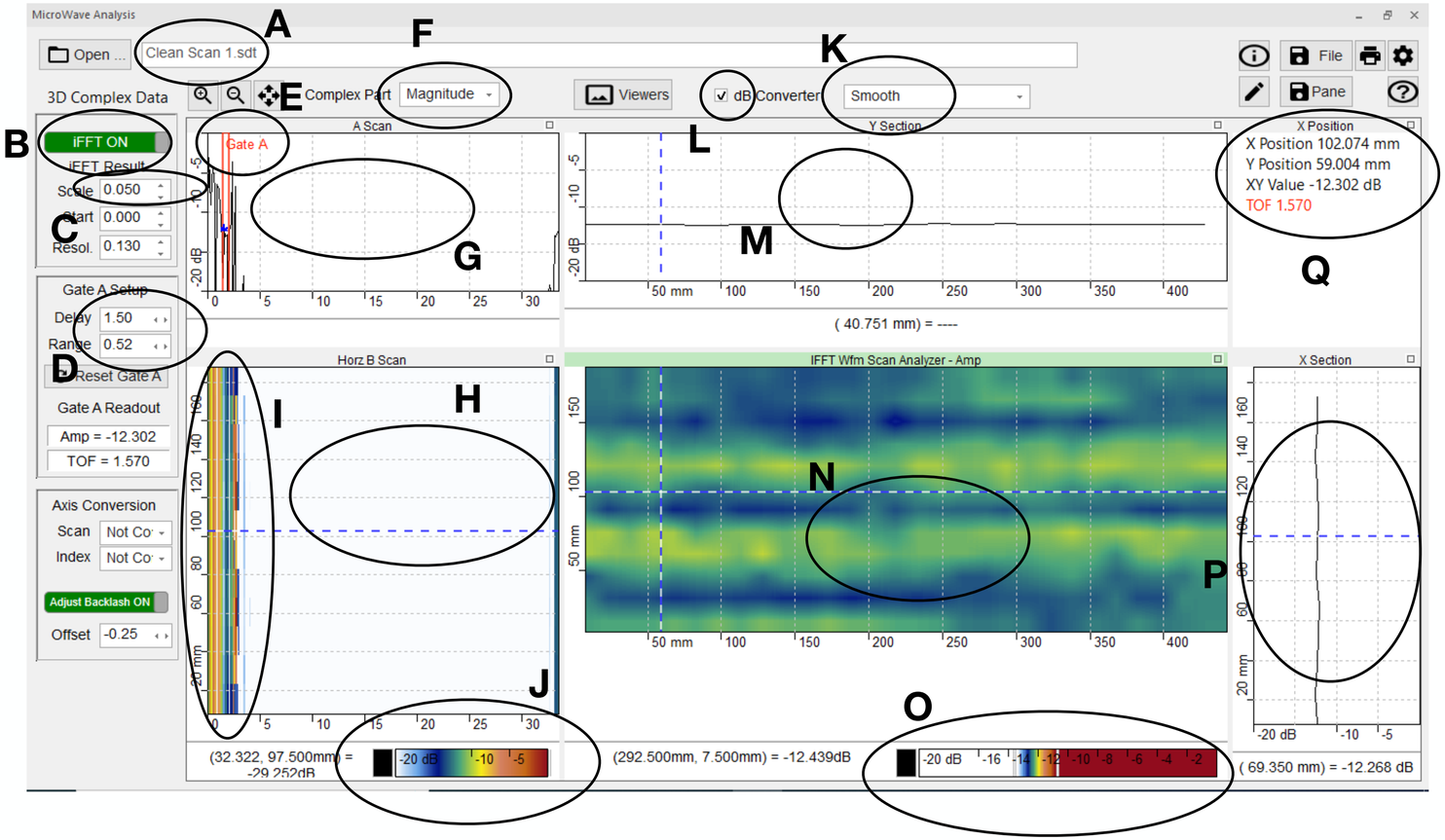
# AMWI Analysis Software Image




A - Data File Name
B - Toggle between Frequency Mode or IFFT (Depth) Mode
C - Scale or Gain
D - Gate A Setup Delay (Time, n-sec) and Range (Time, n-sec)
E - Gate A physical location in A Scan
F - Data Select (Real, Imaginary Magnitude, Phase)
G - A scan field
H - Horizontal B Scan (Depth slice in C Scan)
I- Data field in Horizontal B Scan
J - Color scale for Horizontal B Slice data
K - C scan image control, smooth, pixels, etc
L - dB Selector (dB or raw data)
M - Y Section data (Horizontal line in C Scan)
N - C Scan Image
O - Data scale for C Scan
P - X Section data (Vertical line in C Scan)
Q - Pos., amp., and TOF location for dotted line cross in C scan

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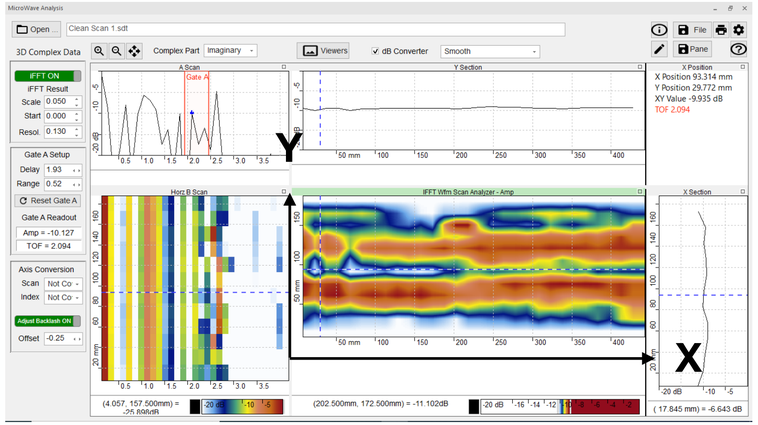
# Electrofusion Data Setup

- The AMWI inspection system is set up to scan (step motor) across the length of the fusion
- Index around the pipe 360 degrees if possible
- This produces a C Scan image and data in the AMWI Analysis Software that looks like this:





**X - Circumference of EF**
**Y Length of EF**

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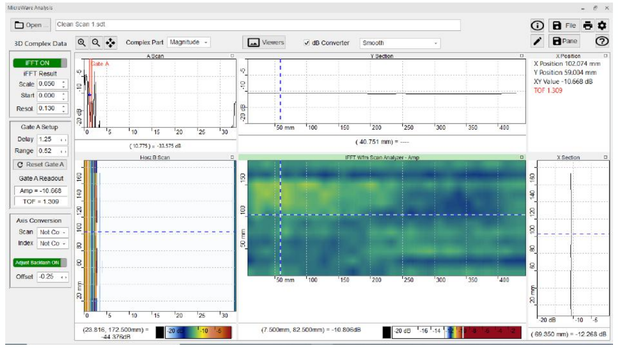
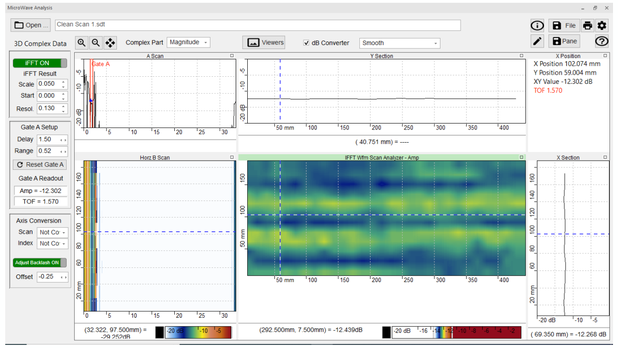
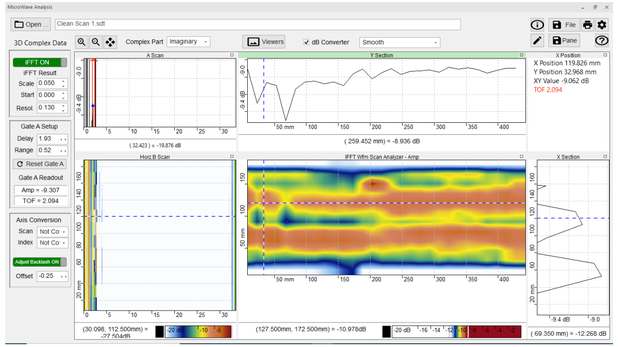
# EF Inspection Process



Delay = 1.25



Delay = 1.50



Delay = 1.93

Once the data is collected as shown, we must next determine at what depth the fusion plane lies

In the IFFT Mode, change the delay (nano-seconds) until you get a clear image of Zone 1, Zone 2, and Zone 3

That delay will be at approximately the center of the fusion plane

In this case, a delay of 1.93 n-seconds will be used to evaluate the fusion.

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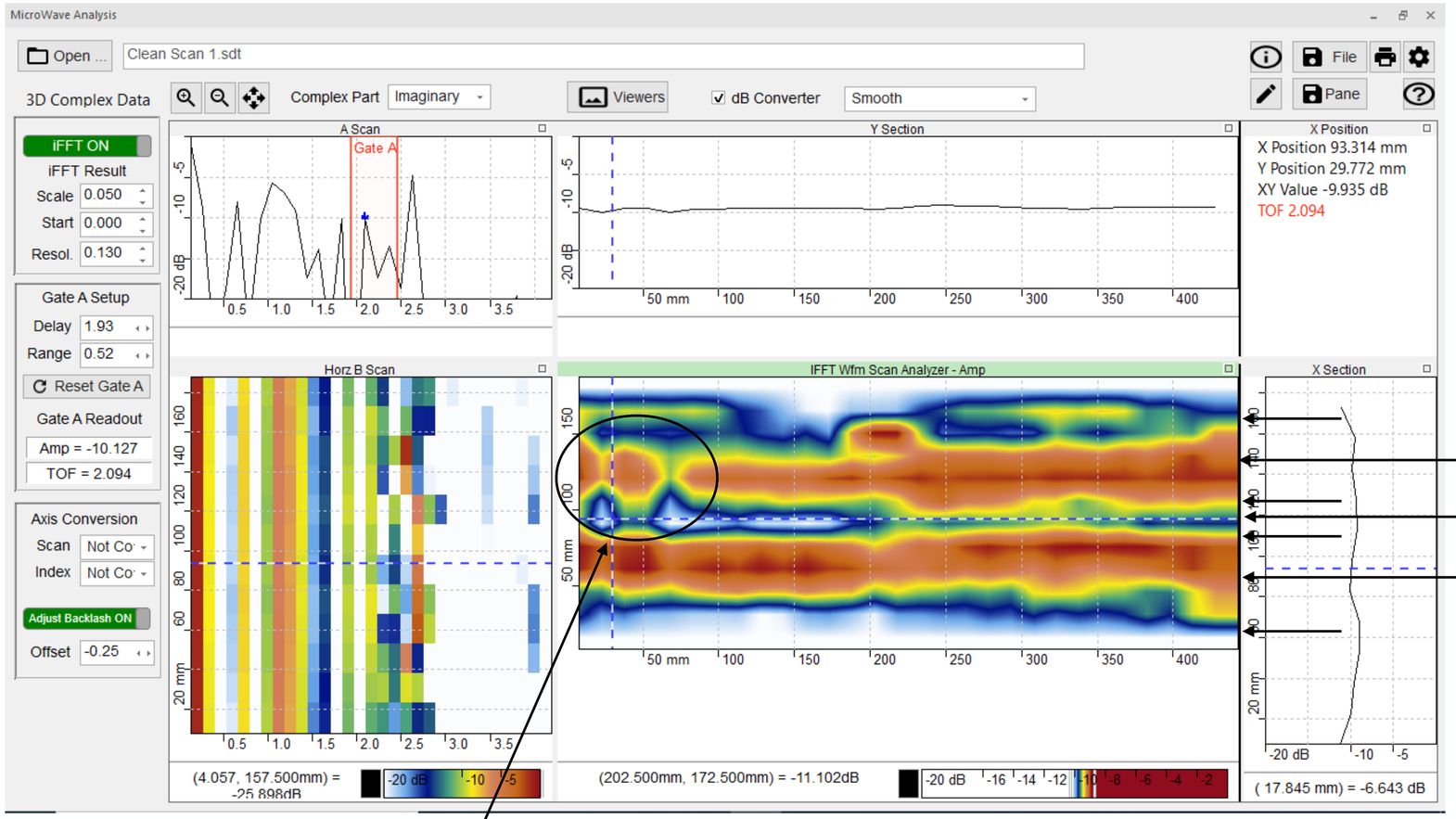
# Good Sample - Initial Review




**Fusion zone 1 looks complete and regular**

**Fusion zone 2 looks complete and regular**

**The gap in Zone 3 is present**

**Fusion Zone 1**

**Cold Zone 3**

**Fusion Zone 2**

**Internal Features of Coupler**

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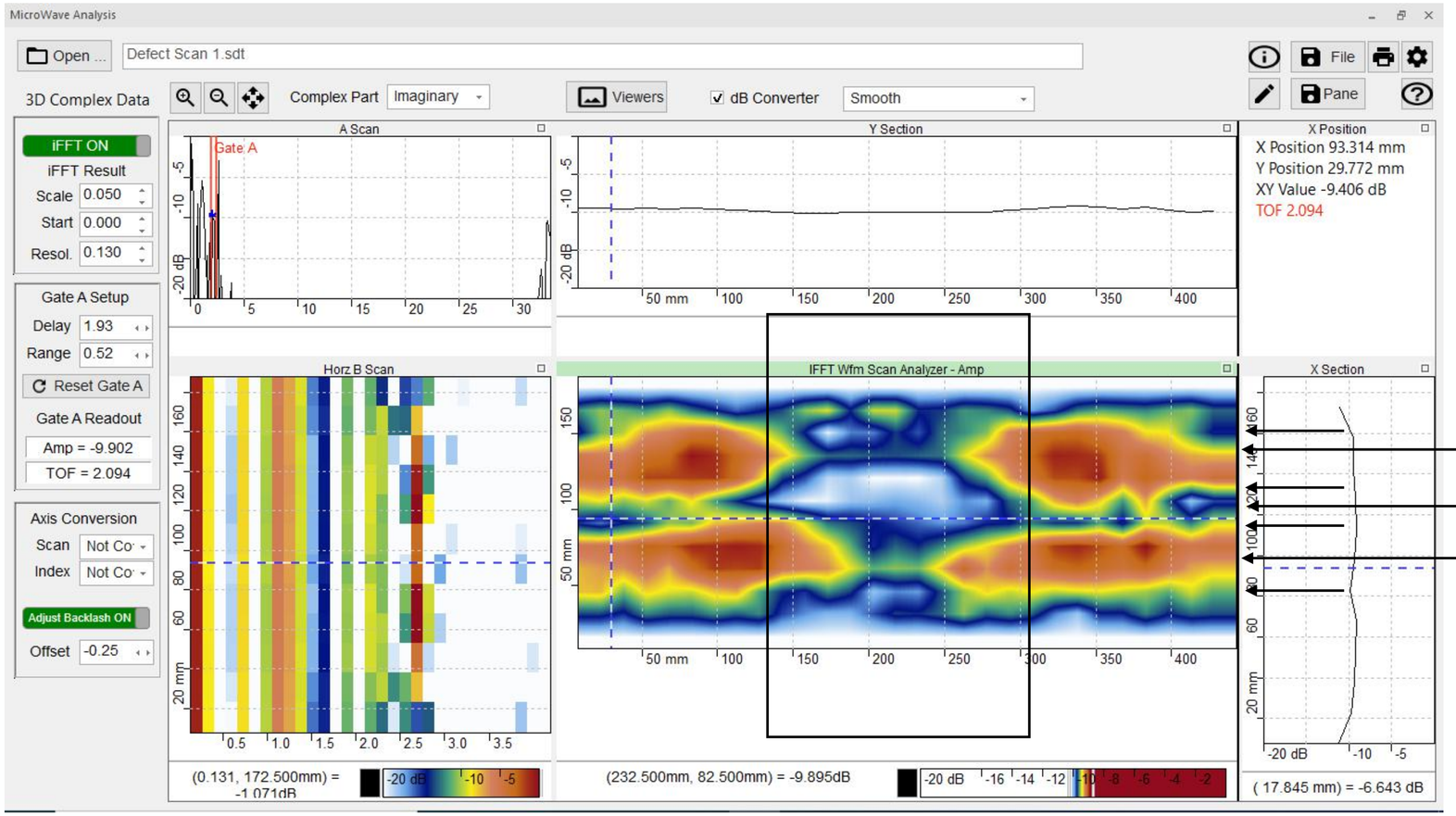
# Defective Sample - Initial Review




Fusion Zone 1

Cold Zone 3

Fusion Zone 2

**Fusion zone 1 looks incomplete (right side) and irregular in center**

**Fusion zone 2 looks incomplete (center) and irregularly shaped in several**

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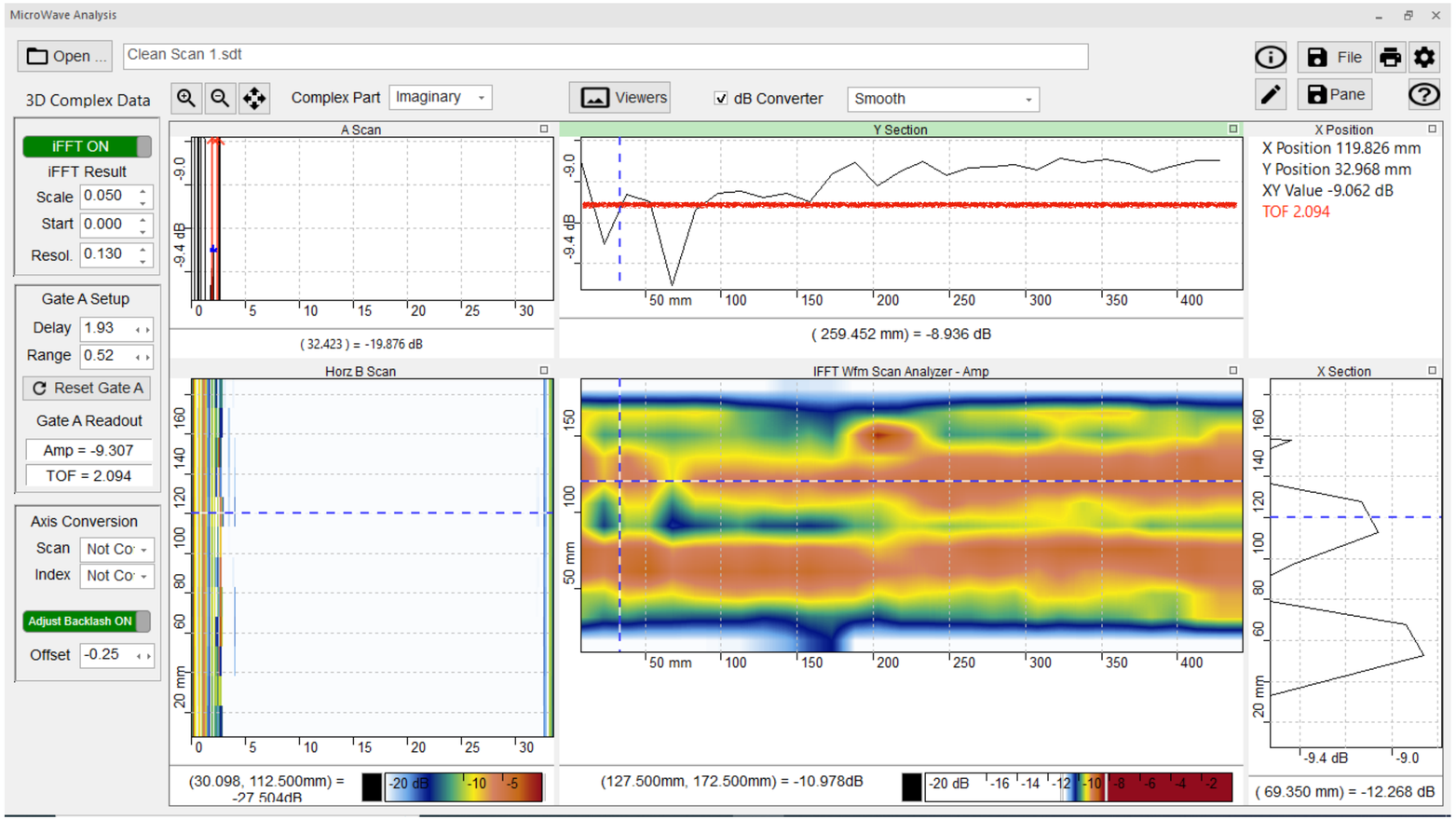
# Zone 1 Accept/Reject




**Zone 1 Accept ≥(-)9.15 dB**

**Zone 1 Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found previously.**

**Center the dotted line in the C scan in the center of the Zone 1 fusion and zoom in on the Y Section data**

**Record the minimum value of the data found in Zone . Neglect data due to any internal features in the coupler.**

**This will be the Accept/Reject criteria for Zone 1.**

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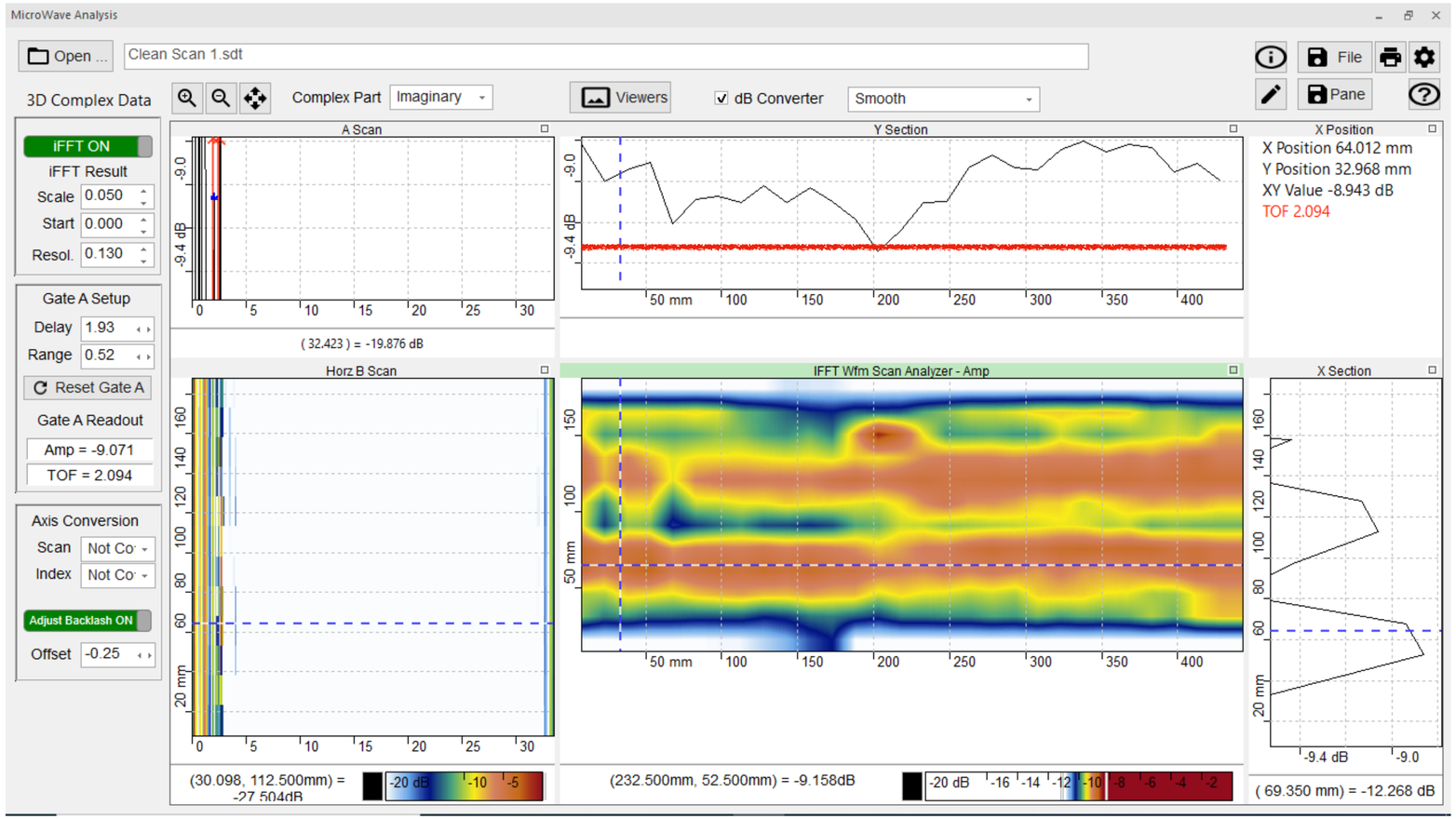
# Zone 2 Accept/Reject




**Zone 1 Accept ≥(-)9.3 dB**

**Zone 2 Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found previously.**

**Center the dotted line in the C scan in the center of the Zone 2 fusion and zoom in on the Y Section data**

**Record the minimum value of the data found in Zone . Neglect data due to any internal features in the coupler.**

**This will be the Accept/Reject criteria for Zone 2.**

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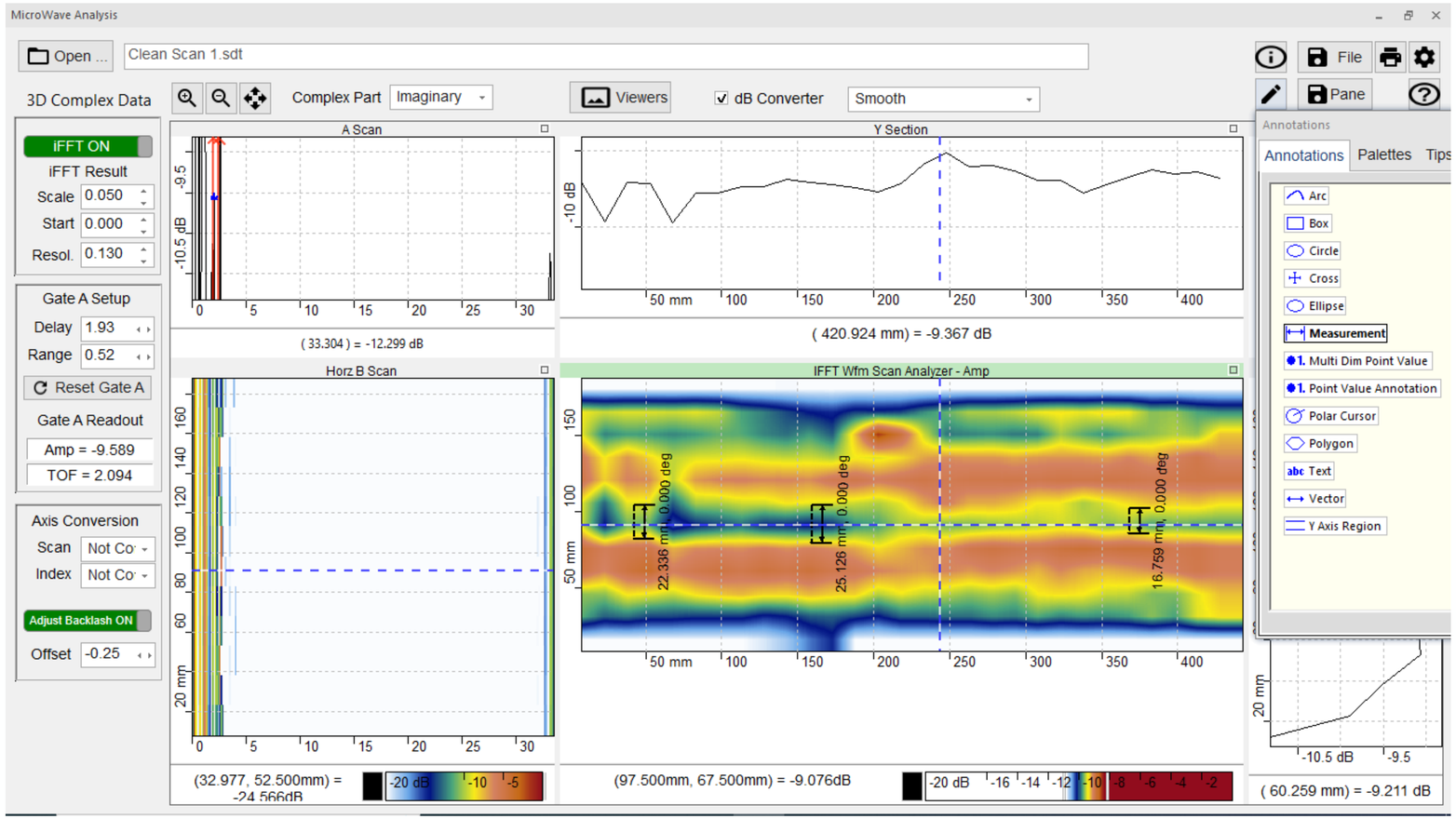
# Determine GAP Size in Good Sample




**Gap 16.8mm to 25.123mm**
**ACCEPT**

**Gap Size Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found previously.**

**Center the dotted line in the C scan in the center of the Zone 3 GAP and zoom in on the Y Section data**

**Using the measurement tool in the tool box on the right, measure the gap in three places. Neglect data due to any internal features in the coupler.**

**Compare to the recommended gap provided by the vendor (if available).**

**Otherwise, accept if gap is 12.7mm $\leq$ 25.4mm.**

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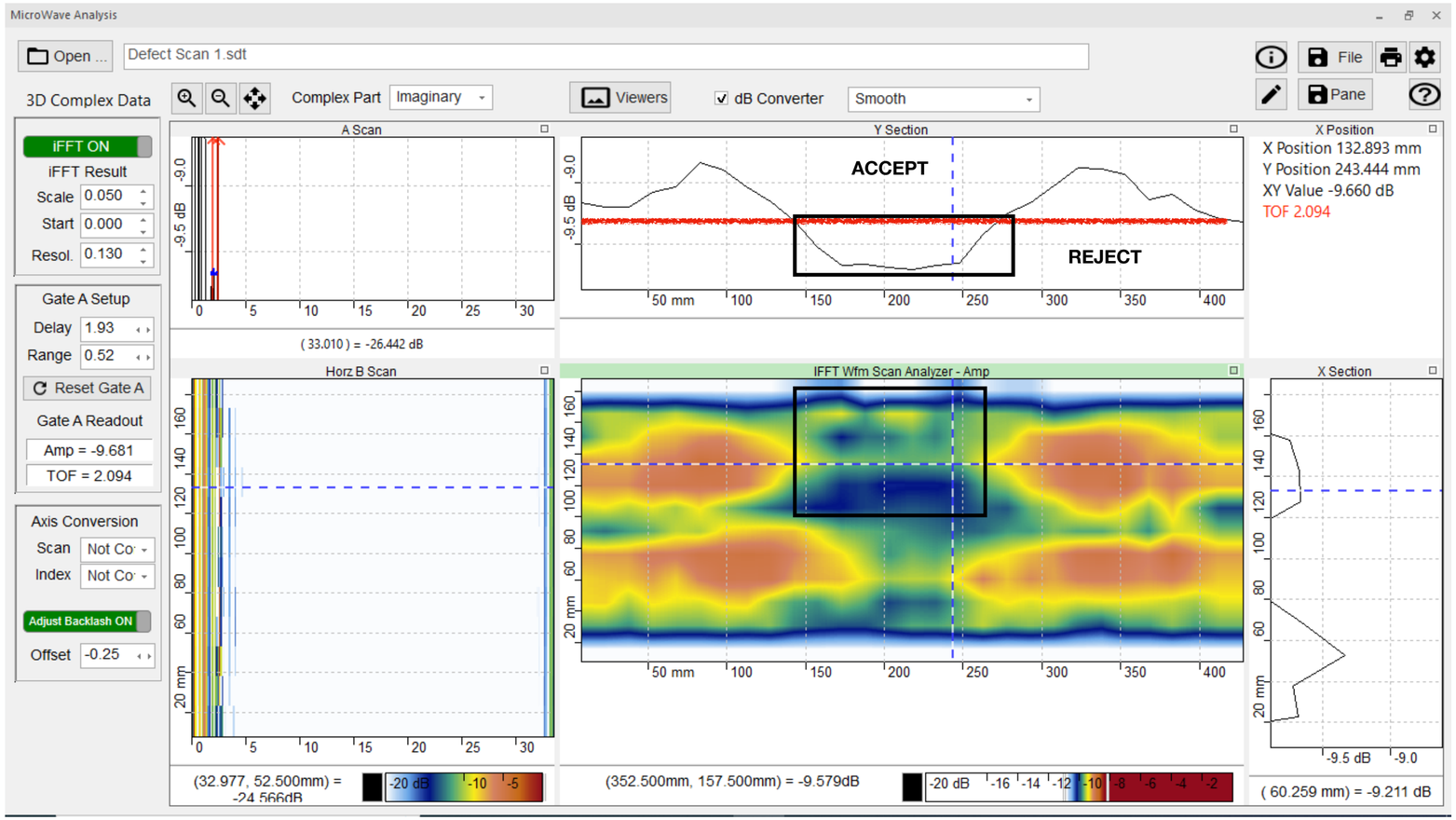
# Bad Fusion Zone 1




**Indication from X = 140mm to X = 275mm crosses the entire fusion zone. Fusion is a REJECT**

**Zone 1 Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found for the good fusion.**

**Center the dotted line in the C scan in the center of the Zone 1 fusion and zoom in on the Y Section data**

**Draw a line in the Y Section data at the minimum value found for Zone 1 or 2 of the good fusion.**

**Note any location(s) where the data crosses below that line. Neglect data due to any internal features in the coupler.**

**Any indication that crosses the entire fusion zone could be a potential leak path and the fusion is a REJECT.**

**Otherwise, REJECT if any indications occupy a single X length greater than 25% of circumference or multiple lengths that add up to 25% of the circumference.**

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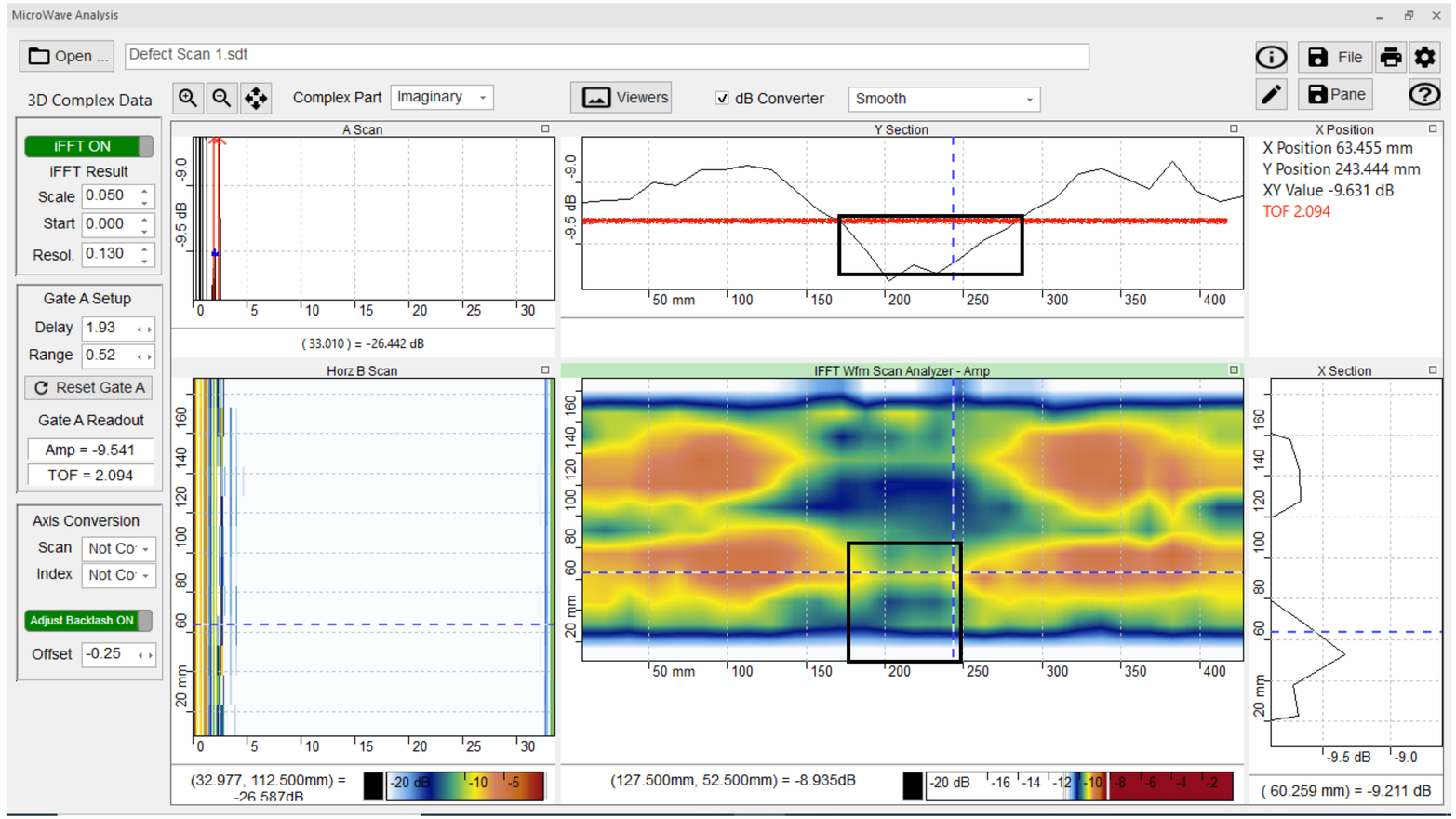
# Bad Fusion Zone 2




**Indication from X = 170mm to X = 280mm crosses the entire fusion zone. Fusion is a REJECT**

**Zone 2 Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found for the good fusion.**

**Center the dotted line in the C scan in the center of the Zone 1 fusion and zoom in on the Y Section data**

**Draw a line in the Y Section data at the minimum value found for Zone 1 or 2 of the good fusion.**

**Note any location(s) where the data crosses below that line. Neglect data due to any internal features in the coupler.**

**Any indication that crosses the entire fusion zone could be a potential leak path and the fusion is a REJECT.**

**Otherwise, REJECT if any indications occupy a single X length greater than 25% of circumference or multiple lengths that add up to 25% of the circumference.**

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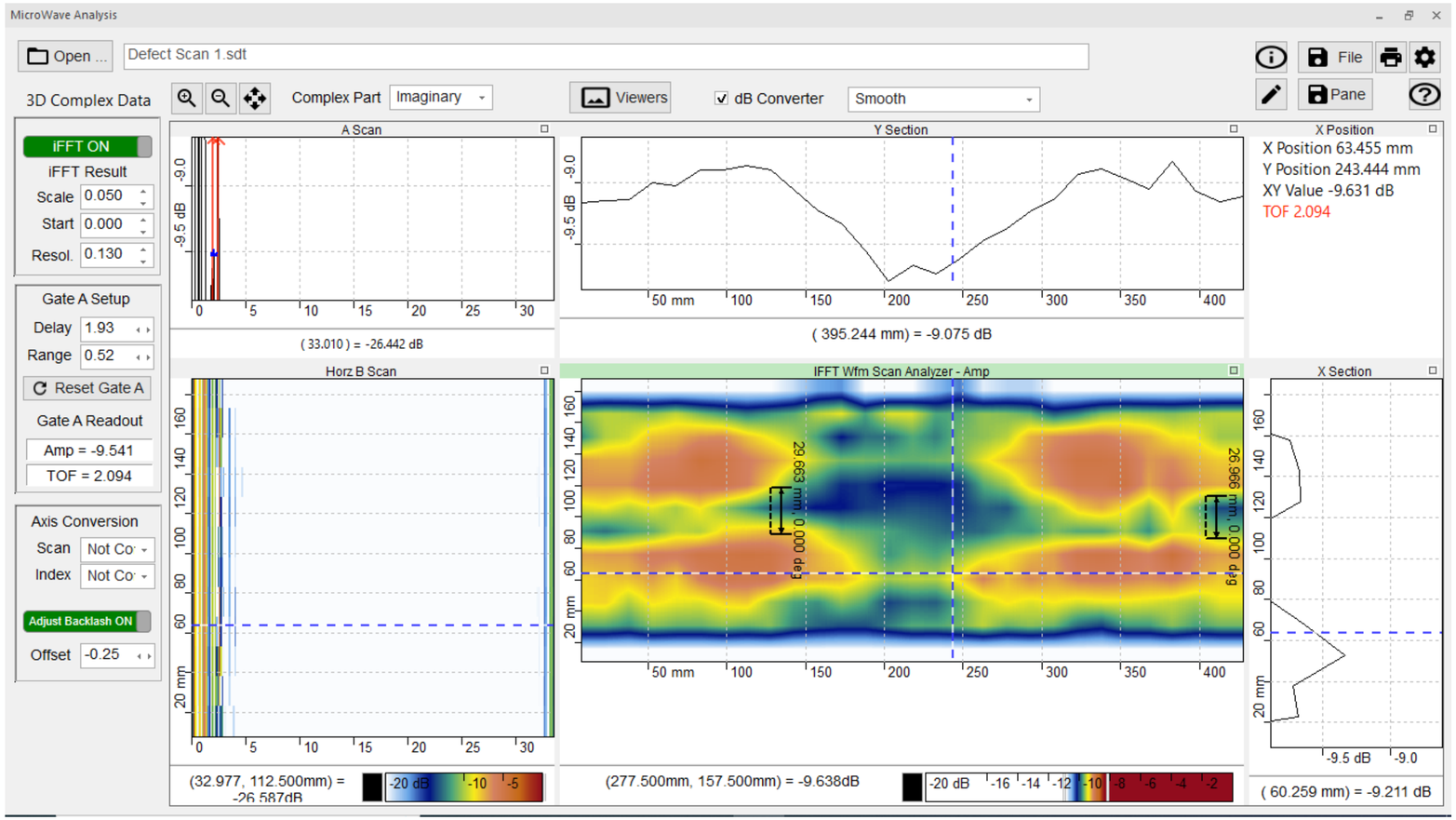
# Bad Sample Gap Review




**Gap 26.9mm to 29.6mm**
**REJECT**

**Gap Size Accept/Reject**

**Use the Imaginary data set and the IFFT settings for the fusion plane found previously.**

**Center the dotted line in the C scan in the center of the Zone 3 GAP and zoom in on the Y Section data**

**Using the measurement tool in the tool box on the right, measure the gap in three places. Neglect data due to any internal features in the coupler.**

**Compare to the recommended gap provided by the vendor (if available).**

**Otherwise, accept if gap is 12.7mm $\leq$ 25.4mm.**

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# Result

- A methodology has been established to inspect and accept/reject an HDPE Electrofusion coupler
- The method is base don the AMWI multi-frequency microwave system and its analysis software
- The inspection methods and results are easy to perform and interpret
- This inspection methodology will transform the reliability of HDPE EF’s

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