



ASIPP

# Research on Non-destructive Examination of bracket welds of ITER In-Vessel Coils (IVC)

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Abstract No. 4MP4-12

Abstract Date and Time: 21 Sep 2017, 10:15-12:15

Location: Poster Area (Level -1)

## I. INTRODUCTION

The ITER In-Vessel Coil system is comprised of Edge-Localized Mode (ELM) and Vertical Stabilization (VS) coils. The ELM coils are used to mitigate the Edge Localized Modes and the VS coils are used to provide Vertical Stabilization of the plasma. There are 27 ELM coils and 2 VS coils. All the ELM and VS coils are supported by the clamped brackets bolted to the rails which are welded to the vacuum vessel wall, as shown in figure 1.

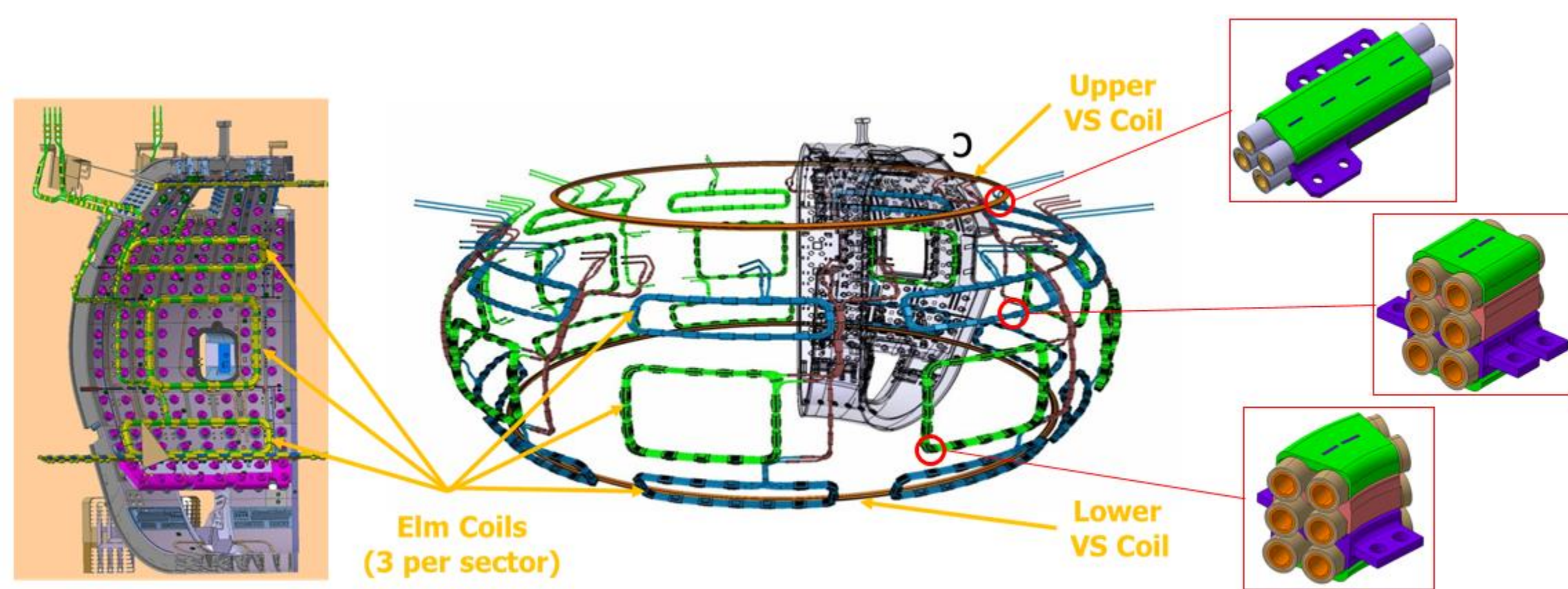


Figure 1. Overview of the IVCs and brackets

Designed bracket for IVC coils is a kind of building block type three or four stacked components with arcuate groove matching with round conductor. It is composed of four parts for the three winding layers of ELM coils and three parts for the two winding layers of VS coils, as shown in Figure 2 and Figure 3. Each bracket for ELM coil is integrated with six turns conductor by three symmetrical longitudinal outer sidewall welds. While for VS coil, each bracket is integrated with four turns conductor by two symmetrical longitudinal outer sidewall welds. Various amounts of straight comb plates are inserted through brackets internal slot and welded at top and bottom under the same compression force as for the separate modules welding as we called comb welds.

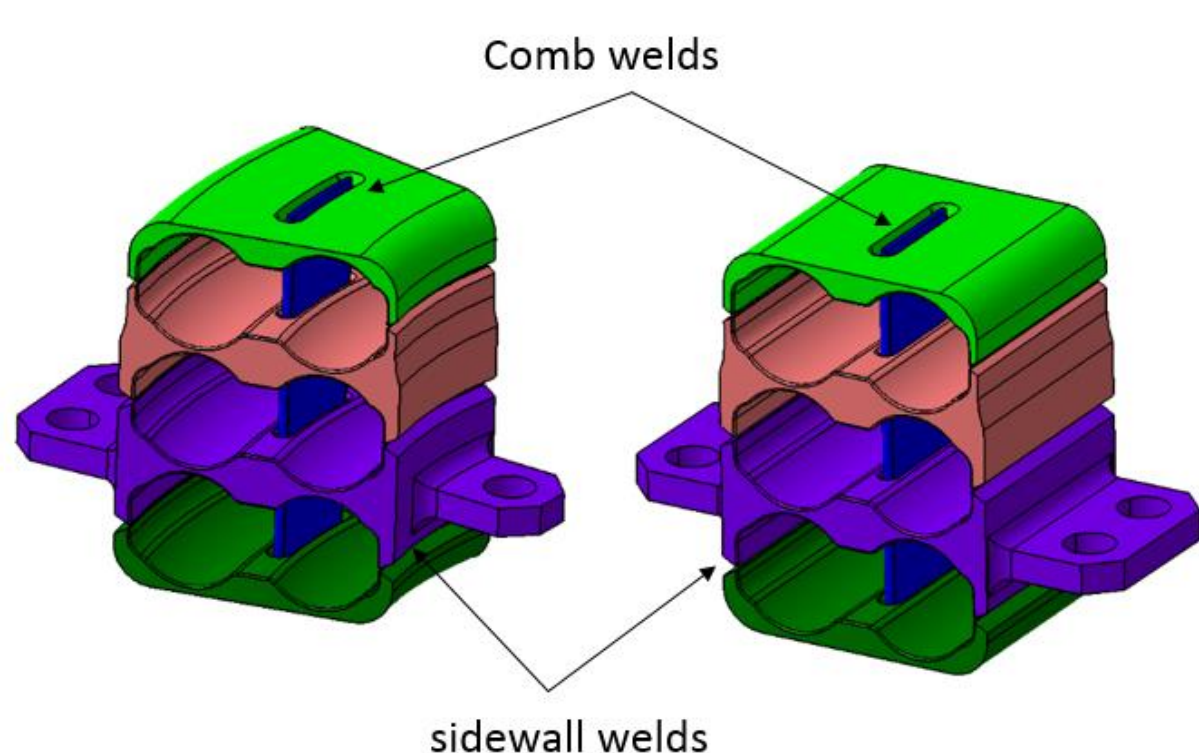


Figure 2. two kinds of ELM brackets

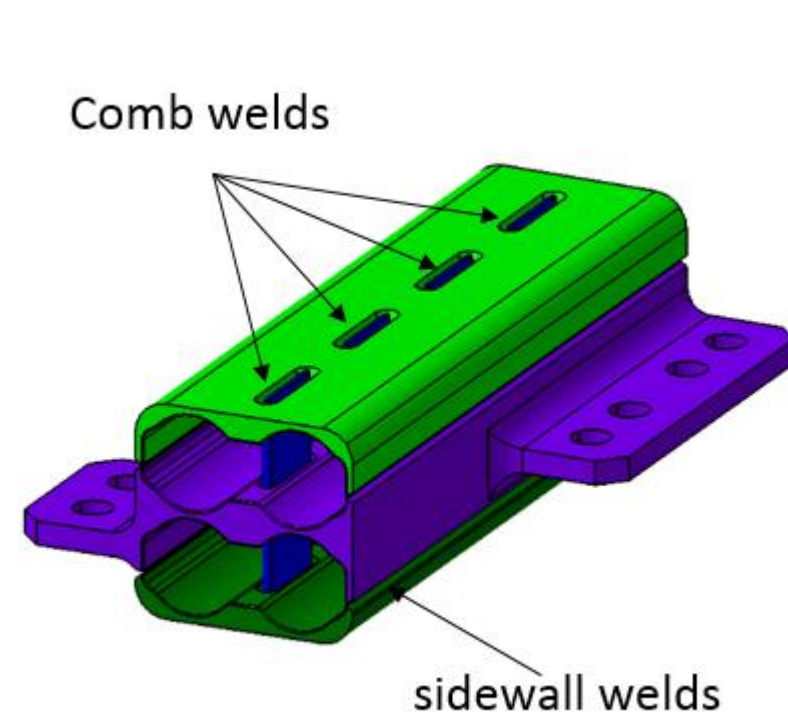


Figure 3. VS brackets

## II. Weld design and NDE test requirement

For the ELM bracket, there are total 6 sidewall welds and 2 comb welds. The same kind of grooves with different depth are designed. In the figure 4, the weld marked in the same colour circle have the same weld information. For the VS bracket, 4 sidewall welds and 8 comb welds are designed. Details information of the welds are presented in the figure 5. After a long discussion, the final design of the welds have been approved by IO.

In the technical specification, an appropriate NDE approach should be established to detect surface and volume defects to all sidewall and comb welds. R&D of the NDE are carried out at ASIPP. Considering the real bracket assembly, penetrant test will be performed for surface defects in the weld and PAUT method are performed for the volume defects.

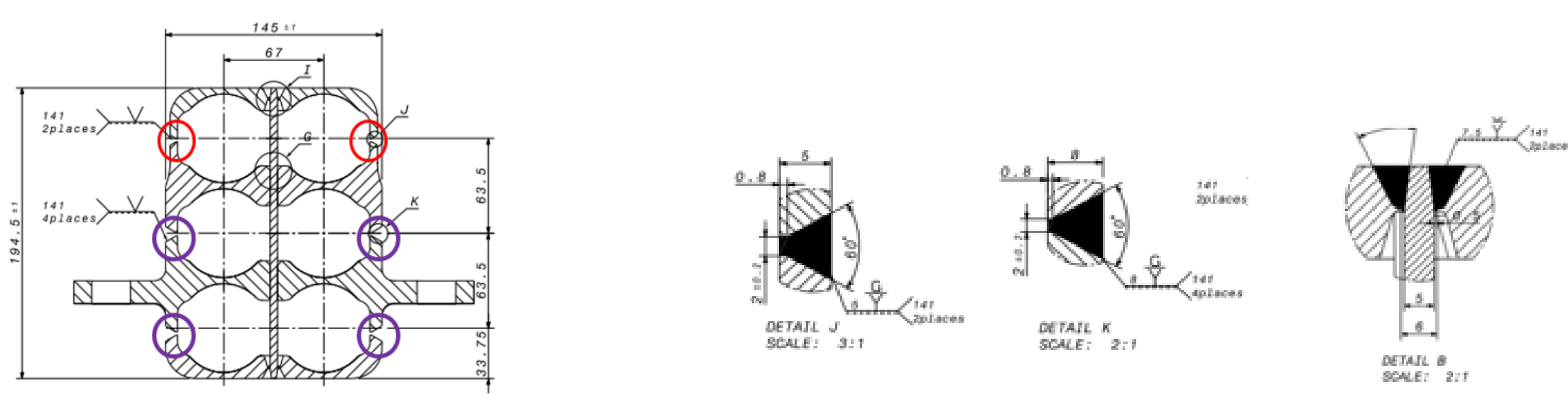


Figure 4. Sidewall and comb welds design in the ELM bracket.

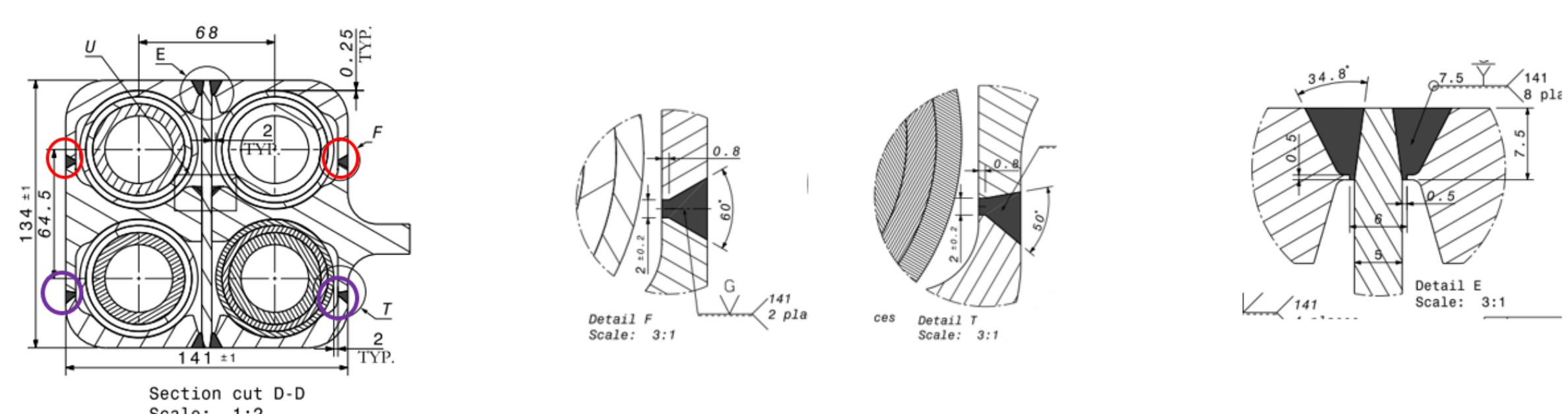


Figure 5. Sidewall and comb welds design in the VS bracket.

## III. Acoustic field distribution simulation

Ultrasonic module in CIVA simulation software is utilized for visualizing the coverage of acoustic fields. It can give more useful information to determine appropriate detection parameters, especially for the scanning position of the probe. We choose weld J and weld F to simulate, the results are presented in the figure 6 and figure 7. For the weld J, acoustic field can cover the weld with sector scanning in the 2nd leg of examination as shown in figure 6. While for the weld F, linear scanning combined with sector scanning should be used due to the space limit as shown in the figure 7.



Figure 6. simulation results for weld J



Figure 7. simulation results for weld F

## IV. Experiment results

Referring to test requirement and considering fabrication process of the IVC bracket, the reference block and artificial reference notches for calibration of PAUT are designed which is shown in figure 8. These signals shall be used to generate the Distance Amplitude Correction curve (DAC) or Time-Corrected Gain (TCG) for the amplitude reference level. Figure 9 gives the DAC curve and TCG curve.

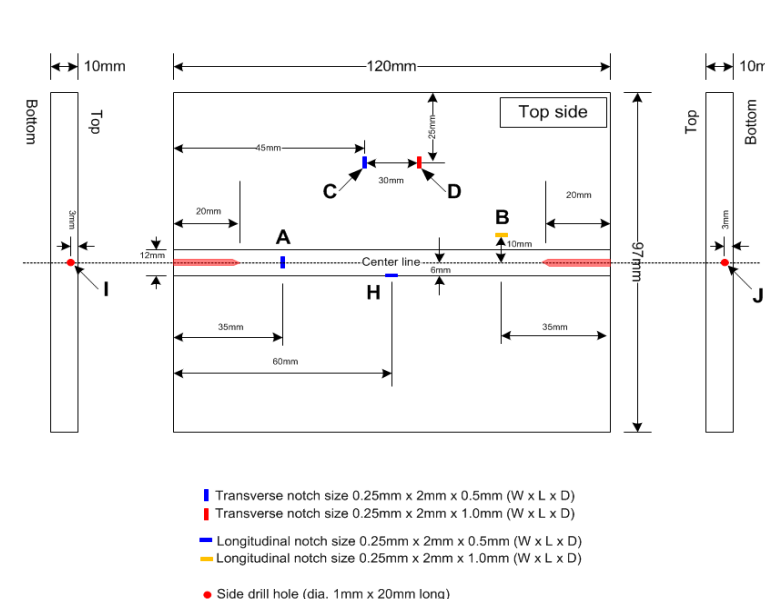


Figure 8 reference block for PAUT

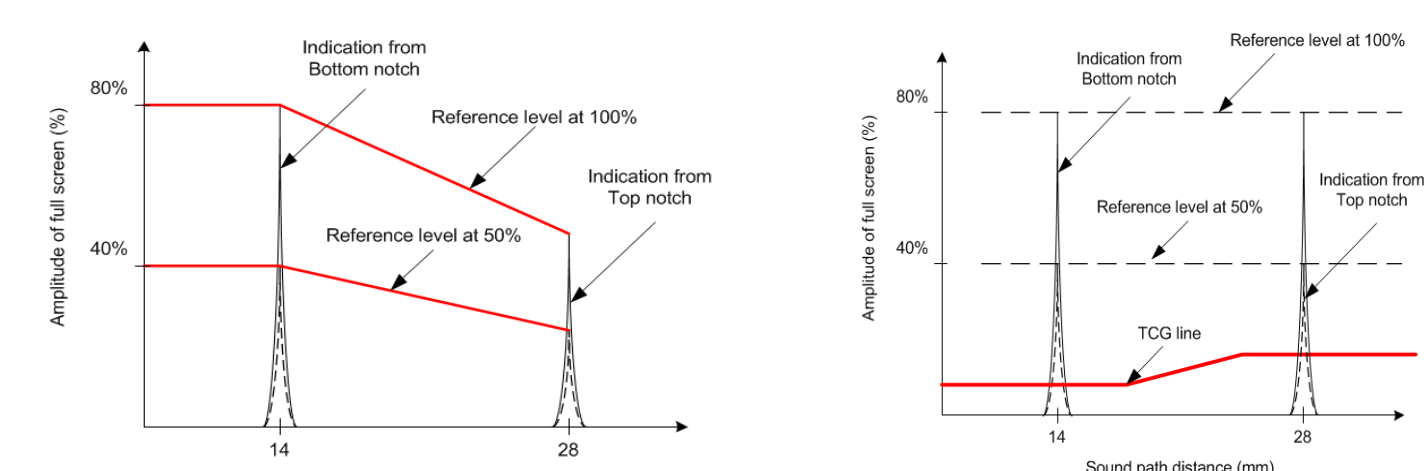


Figure 9 DAC and TCG curve



Figure 10 testing diagram

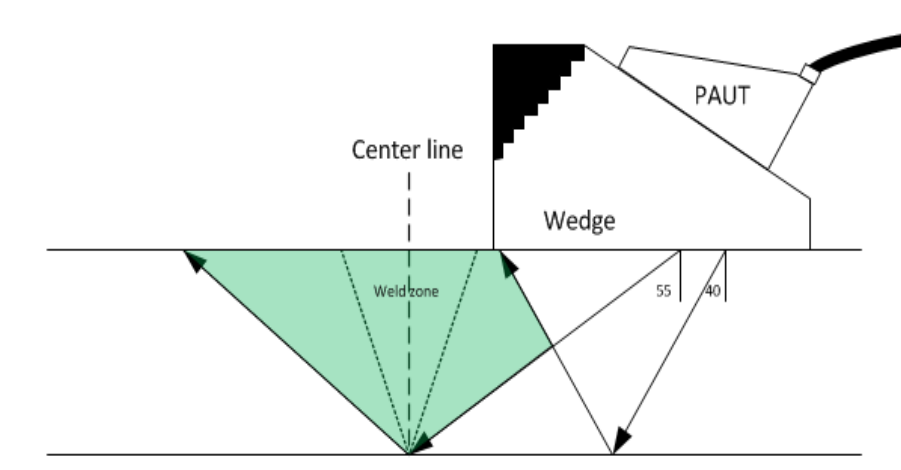


Figure 11 Flaw D- Notch image

Testing diagram are given in the figure 10 and figure 11 shows the echo image of flaw D with in 2<sup>nd</sup> leg.

## V. CONCLUSION

This paper described PAUT method used for the sidewall weld and comb weld in the IVC bracket. CIVA simulation software and experiments are utilized during experiment method established. DAC curve and TCG curve are produced for the amplitude reference level. Results indicate that all of indications at the base metal and HAZ can be detected with peak amplitude higher than 80% of FSH for both 1st leg and 2nd leg.