



Institute for Energy

# ULTRASONIC INSPECTION RESULTS OBTAINED IN THE ENIQ 2<sup>nd</sup> PILOT STUDY

ENIQ Report nr. 33

# ENIQ

European Network for Inspection and Qualification

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*November 2007*

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Approved for publication by the ENIQ Task Group for Qualification

Documents published by ENIQ, the European Network for Inspection and Qualification, belong to one of the following 3 types:

**Type 1 – Consensus Document**

A *consensus document* contains harmonised principles, methodologies, approaches and procedures, and stresses the degree of harmonisation on the subject among ENIQ members.

**Type 2 – Position/Discussion Document**

A *position/discussion document* may contain compilations of ideas, expressions of opinion, reviews of practices, or conclusions and recommendations from technical projects.

**Type 3 – Technical Report**

A *technical report* is a document containing results of investigations, compilations of data, reviews and procedures without expressing any specific opinion or valuation on behalf of ENIQ.

The present document “Ultrasonic inspection results obtained in the ENIQ 2nd pilot study” (ENIQ Report nr. 33) is a Type 3 document.

## FOREWORD

The present work is one outcome of the activity of the ENIQ Task Group for Qualification (TGQ) on the ENIQ Second Pilot Study.

ENIQ, the European Network for Inspection and Qualification, is driven by the nuclear utilities in the European Union and Switzerland and managed by the European Commission's Joint Research Centre (JRC). It is active in the field of in-service inspection (ISI) of nuclear power plants by non-destructive testing (NDT), and works mainly in the areas of qualification of NDT systems and risk-informed in-service inspection (RI-ISI). This technical work is performed in two task groups: TG Qualification and TG Risk.

A key achievement of ENIQ has been the issue of a European Qualification Methodology Document, which has been widely adopted across Europe. This document defines an approach to the qualification of inspection procedures, equipment and personnel based on a combination of technical justification (TJ) and test piece trials (open or blind). The TJ is a crucial element in the ENIQ approach, containing evidence justifying that the proposed inspection will meet its objectives in terms of defect detection and sizing capability. A Qualification Body reviews the TJ and the results of any test piece trials and it issues the qualification certificates.

ENIQ has previously conducted a pilot study to assess the feasibility of the ENIQ Methodology in practice. This first pilot study was successful but, because the component chosen for the study was an austenitic weld, could not fully explore the use of TJs. This is because techniques such as mathematical modelling, at the time of the study, tended to be applicable only to isotropic materials. Assessment of the inspectability of austenitic welds usually requires the use of test pieces with the same metallurgical structure. Accordingly, ENIQ decided to conduct a second pilot study using a ferritic nozzle to shell weld.

The main objective of the 2nd pilot study was to show how to fully exploit the potential of TJs in the qualification of inspection procedures and thereby reduce the number of test piece trials on full-scale components. As the subject of the study, a ferritic BWR-type nozzle to shell weld was selected. A TJ was produced, partly relying on modelling, to predict whether a designated ultrasonic inspection would be successful in detecting the specified defects. In parallel, a mock-up (ENIQ 21) with deliberately introduced defects was fabricated and inspected with the inspection system specified in the TJ. Predictions and inspection results were compared.

This report is a compilation of the ultrasonic non-destructive inspections results obtained on the ENIQ 21 BWR-type nozzle to shell weld mock-up. The report has been divided into three different sections

- 1) Inspection results from **Inside** inspection of the **Un-clad** test piece
- 2) Inspection results from **Outside** inspection of the **Clad** test piece
- 3) Inspection results from **Inside** inspection of the **Clad** test piece

The two first series of measurements was carried out at the premises of Westdyne TRC (Sweden) in 2002 and 2004, the final part was carried out at the JRC of the European Commissions in the Netherlands in 2005.

This study has been conducted within the frame of ENIQ Task Group for Qualification.  
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This ENIQ Type 3 document was approved for publication by the ENIQ Task Group on Qualification.

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APPENDIX 4: TABULATED RESULTS FOR THE INSIDE INSPECTION OF THE CLAD TEST PIECE



# **PART I:**

## **INSIDE INSPECTION OF THE UN-CLAD TEST PIECE**

### **1 INTRODUCTION**

This part of the report documents the ultrasonic non-destructive testing results obtained from the detection and sizing performed on the ENIQ nozzle assembly 21. The inspection was carried out from the inside surface on the un-clad assembly at the TRC premises in 2002. The objective of the trials was to assess the feasibility of the proposed inspection procedure for the ultrasonic inspection of the nozzle to shell weld from the inner surface.

The trials employed Tandem technique, shear and longitudinal waves as the primary detection techniques, and Time of Flight Diffraction (TOFD) as the primary sizing technique.

### **2 SCOPE OF WORK**

The scope of work consisted of

- Scanning test block ENIQ assembly 21 from the inside surface using the pulse echo tandem technique at a frequency of 1,5 MHz, with one focal depth.
- Scanning test block ENIQ assembly 21 from the inside surface using the pulse echo 45°, 60° and 70° shear wave technique at a frequency of 1,5MHz.
- Scanning test block ENIQ assembly 21 from the inside surface using the pulse echo 70TRL technique at a frequency of 2MHz, with focus depth 8 and 12mm.
- Scanning test block ENIQ assembly 21 from the inside surface using the TOFD technique having 4 different focal depths within the inspection zone at a single frequency of 5MHz.
- To analyse the results and make an assessment of the detection capability
- To analyse the results and make an assessment of the sizing capability
- To report, comment and make recommendations for further improvements and developments of the inspection procedure.

### 3 REFERENCE DOCUMENTS

- Inspection procedure for the 2nd ENIQ Pilot Study, 1st Draft
- Method Of Working, MOW version 1,0
- Technical Justification for the 2nd Pilot Study, Draft for Discussion.

### 4 EQUIPMENT

The inspection was performed using the following equipment:

#### 4.1 Scanning system

**Table 1 Scanning System**

Ultrasonic System	R/D Tech Tomo S/V Software version	Serial No 15297-05 1.4R7
Manipulator	Force ATS1	Serial No JRC
Drive Control Software	MCDU-02	Serial No 16497-04
Analysis Software	R/D Tech TomoView	Version 1.3R0
Pre Amplifier	Panametrics 5670	Serial No 1648
Couplant	Water	

#### 4.2 Cables

**Table 2 Cables**

Item	Cable Length	Cable Type	Connector Type
1	10.0 Metres	Coax RG174 - 50Ω	Lemo 00 plug – Lemo 00 plug
2	5.0 Metres	Coax RG174 - 50Ω	Lemo 00 plug – MCX 50-2-5c/111
3	2.0 Metres	Coax RG174-50Ω	MCX 50-2-5c/111 – Lemo 00 plug

#### 4.3 Transducers

**Table 3 Detection and length sizing probes (f.d. = focal depth)**

Probe Identity	Probe Type and Frequency	Crystal Size [mm]	Probe size [mm]	Probe Function
RTD01-3	T 45° 1.5 MHz	32x25	40x40x30	Detection Length sizing
RTD01-5	T 60° 1.5 MHz	32x22	40x40x30	Detection Length sizing

RTD01-7	T 70° 1.5 MHz	32x18	40x40x30	Detection Length sizing
RTD01-3 RTD01-4	TANDEM 1.5 MHz	32x25	40x40x30	Detection Length sizing
RTD01-9	TRL 70° 2 MHz	2(25x15) f.d.12mm	40x40x30	Detection Length sizing
RTD01-10	TRL 70° 2 MHz	2(Ø18) f.d.8mm	40x40x30	Detection Length sizing

**Table 4 Height sizing probes**

Probe Identity	Probe type and Frequency	Crystal size [mm]	Probe size [mm]	Probe Function
27100115 27100116	L 0° 5 MHz	Ø6	Shoes 20x20x15	TOFD Height sizing

#### 4.4 Calibration blocks

##### 50mm wide A2

Material	Carbon Steel
Radius	100 mm
Surface	Flat
Purpose	Shear transducers: delay, index, and angle

##### 50mm wide A1

Material	Carbon Steel
Radius	25/50 mm
Surface	Flat
Purpose	Longitudinal transducers: delay, index, and angle

##### JRC-10722A

Material	Carbon Steel
Thickness	100 mm
Surface	Flat
Purpose	Shear and longitudinal sensitivity

##### JRC-10729A

Material	Carbon Steel
Thickness	165 mm
Surface	Flat
Purpose	TANDEM delay and sensitivity

##### JRC-10720

##### JRC-10721

Material	Carbon Steel
Thickness	60 mm
Surface	Flat
Purpose	TOFD delay and sensitivity

## 4.5 Test Block

ENIQ assembly 21, drawing JRC-10692B, see appendix 1.

The test block is of ferritic material with a nozzle to shell weld, containing a total of 11 induced defects. All defects are of a longitudinal orientation with respect to the weld direction.

Note: At present 11 defects exist in the block, while the drawing stating 17. Further 6 defects will be manufactured in the block after cladding.

Relevant flaws: no. 1, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

## 5 INSPECTION

### 5.1 Transducer Calibration and Inspection Settings

All transducers were calibrated according to the ENIQ procedure. Inspection settings as defined under appendix D in the procedure was used.

### 5.2 Sensitivity

Since the cladding of the nozzle will be performed at a later stage, no gain compensation was added to the inspection sensitivity as stated in the procedure (these values will be derived from parametric studies).

However, a general 6 dB was added to all the detection transducers. See also chapter 5.3 regarding transfer measurements.

**Table 5** Sensitivity settings for detection probes

Probe Identity	Angle	Ref. block	Reference reflector	Calibration sensitivity	Inspection sensitivity
RTD01-3	45° Shear	JRC-10722	Ø6,4 at 35mm	80% of full screen height	Calibration +6dB
RTD01-3 RTD01-4	Tandem	JRC-10729	Ø8 at 40mm	80% of full screen height	Calibration +6dB
RTD01-5	60° Shear	JRC-10722	Ø6,4 at 35mm	80% of full screen height	Calibration +6dB
RTD01-9	70° Shear	JRC-10722	Ø6,4 at 35mm	80% of full screen height	Calibration +6dB
RTD01-9	70° Long	JRC-10722	Ø3,2 at 10mm	80% of full screen height	Calibration +6dB
RTD01-10	70° Long	JRC-10722	Ø3,2 at 5mm	80% of full screen height	Calibration +6dB



**Table 6 Sensitivity settings for height sizing probes**

Probe Identity	Angle <sup>#1</sup>	Ref. block	Reference Notch	Calibration sensitivity	Inspection sensitivity
27100115 27100116	(50°)	JRC-10720	Notch 3 Depth 10mm	80% of full screen height	Lateral wave 30-50%
27100115 27100116	(50°)	JRC-10720	Notch 5 Depth 20mm	80% of full screen height	Lateral wave 30-50%
27100115 27100116	(50°)	JRC-10721	Notch 3 Depth 35mm	80% of full screen height	Lateral wave 30-50%
27100115 27100116	(50°)	JRC-10721	Notch 1 Depth 50mm	80% of full screen height	Lateral wave 30-50%

<sup>#1</sup> The angle indicated is with the with the angle shoe

In cases with saturated signals, a complementary inspection scan was performed with the gain reduced to reference level. Table 5 and Table 6 document all transducers with relevant settings.

### 5.3 Transfer measurements

Transfer measurements were performed using the two 45° transducers, comparing signal amplitudes from the calibration block JRC-10729A and the ENIQ assembly 21.

The nozzle base material did not show any divergences, but for the weld material a difference of 4 to 6dB was measured, compared with the calibration block.

The measurements were performed in a 'static mode', it is assumed that in a 'dynamic mode' (i.e. scanning) there would also be a measurable difference in the base material, due to the rougher surface on the nozzle.

### 5.4 Scan patterns

Scanning was performed using a series of bi-directional stepped raster patterns with a step of 0,5° which equals just over 3 mm at the weld centre line.

The scan axis was defined as being perpendicular to the weld centre line and the index axis along the weld centre line.

### 5.5 Datum Convention

Co-ordinate system specified in the ENIQ procedure was slightly modified to correspond to the defect drawing JRC 10692, so that the circumferential reading was comparable without mirroring the index axis position.

## 6 EVALUATION

Evaluation was done according to the ENIQ procedure with evaluation criteria as below. An indication must exceed reference level on three consecutive scan-lines to be reported.

**Table 7 Evaluation criteria**

Transducer type	Evaluation criteria
Shear wave probes	20% of reference level = 16% of full screen height
Longitudinal probes	50% of reference level = 40% of full screen height

## 7 DEFECTS TO BE DETECTED AND SIZING REQUIREMENTS

According to the Technical Justification, the maximum acceptable defect is 30x15 mm. The required sizing performance is specified as in Table 8. The tolerances are applicable to any defects, which exceeds the validation defect size.

The validation defect is one that must be detected with a high degree of confidence and which, when account is taken of the maximum uncertainty in the measured size, does not exceed the maximum acceptable defect size.

**Table 8 Sizing requirements**

Sizing Accuracy Length	±25mm
Sizing Accuracy Height	±5mm
Location Accuracy Circumferential	±40mm
Location Accuracy Radial	±20mm
Location Accuracy Throughwall	±5mm
Validation defect Length	20mm
Validation defect Height	10mm

## 8 SUMMARY OF RESULTS

A summary of the results, following the evaluation criteria according to the ENIQ procedure, can be found in Table 9. Detailed results from each flaw and transducer can be found in appendix 2.

**Table 9 Summary of results**

DEFECT NUMBER		POSITION [mm]	LENGTH [mm]	HEIGHT [mm]	Defect tilt and skew Probe and % of FSH
Flaw 1	Real	69-89	20	5(0-5)	Tilt 0° Skew 0°
	Measured	-	-	-	Less than 3 scans
Flaw 8	Real	870-890	20	5(0-5)	Tilt 10° Skew 5°
	Measured	864-883	19	5,8	TRL8>100%

Flaw 9	Real	970-1010	40	10(0-10)	Tilt 4° Skew 0°
	Measured	968-1002	34	10,0	TRL8 71,5%
Flaw 10	Real	1016-1156	40	10(0-10)	Tilt 20° Skew 5°
	Measured	1118-1148	30	9,4	TRL8/12>100%
Flaw 11	Real	1259-1319	60	15(0-15)	Tilt 10° Skew 0°
	Measured	1261-1316	55	15,5	TRL8 87,8%
Flaw 12	Real	1424-1484	60	15(0-15)	Tilt 0° Skew 5°
	Measured	1420-1475	55	15,6	TRL8 55%
Flaw 13	Real	1570-1590	20	10(3-13)	Tilt 4° Skew 0°
	Measured	1561-1585	24	11,7(3,4-15,1)	TRL8/12>100%
Flaw 14	Real	1698-1728	30	15(13-28)	Tilt 4° Skew 0°
	Measured	1689-1744	55	24,4(13,4-37,8)	Tandem>100%
Flaw 15	Real	1845-1875	30	15(23-38)	Tilt 4° Skew 0°
	Measured	1829-1866	37	17(21,8-38,8)	Tandem>100%
Flaw 16	Real	1979-2029	50	5(3-8)	Tilt 4° Skew 0°
	Measured	1979-2043	64	5,3(3,7-9,0)	TRL 44%, Tand. 65%
Flaw 17	Real	2138-2198	60	5(8-13)	Tilt 4° Skew 0°
	Measured	2138-2196	58	6,6(7,0-13,6)	TRL 90%, Tand. 84%

## 8.1 Comments on the detection results

### 70°-TRL probes, inspection range 0-20 mm in depth

All defects positioned in the inspection range have been detected, except defect 1, a PISC type-A notch 5x20mm, with no tilt or skew. This defect has only been detected on 2 scan-lines over reporting level.

### 45°-shear wave probe, inspection range 20-60 mm in depth

No indications have been reported with this transducer.

### 60°-shear wave probe, inspection range 20-60 mm in depth

Two defects were in the inspection range for the 60°-shear wave transducer, flaw 14 and 15. Both defects were detected, with amplitudes just less than 30% of full screen height (compared with a reporting level of 16%).

### 70°-shear wave probe, inspection range 20-60 mm in depth

Two defects were in the inspection range for the 70°-shear wave transducer, flaw 14 and 15. Both defects were detected with high amplitudes, but there is a general high noise level in the area of interest, exceeding reporting level, due to this it was decided to exclude the data from the 70°-shear wave probe.

### TANDEM set-up, inspection range 20-60 mm in depth

The procedure states an inspection range of 20 to 60 mm for the TANDEM. However, since the technique can not give any position in depth, the inspection range will more or less depend on chosen focus depth and the size of the soundbeam field. Due to this all

defects except 1 and 10, were detected. These two defects are surface breaking PISC type-A notches (at present stage).

## 8.2 Comments on Length Sizing

All defects are length sized within the stated tolerances of  $\pm 25$ mm. All PISC type-A notches are within  $\pm 10$ mm, but in some cases the signal response from the middle of the notch is under reporting level, though over the reporting level in both edges. Still the defect has been reported as one defect.

## 8.3 Comments on Height sizing

The TOFD technique gives an accurate height sizing within the stated tolerances of  $\pm 5$ mm, except defect 14. Due to satellite indications, recognition of true/intended bottom tip signals was difficult. The total measured error was 9,4mm (measured to 24,4mm instead of 15mm according to defect drawing). With a conservative judgement a bottom tip at 37,8mm was chosen, instead of 30,3mm which resulted in a bottom tip error of 9,8mm instead of 2,3mm.

## 8.4 False calls

Two false calls were reported with TANDEM set-up. Both were positioned in the area where the lack of fusion defects had been introduced.

**Table 10 Summary of false calls**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% FSH	No. Scan Lines #
	Start °/mm	Stop °/mm	Length °/mm			
45taneg	267.5/1634	271.5/1658.5	4/24.5	-33	59	12
45taneg	295/1802	299.5/1829.5	4.5/27.5	-30	26	8

## 8.5 Comments and Recommendations

The procedure fulfils the required inspection performance for detection and length sizing, even though defect 1, a 20x5 mm notch was not detected. The detection goal for a maximum acceptable defect is 30 x15mm (validation defect 20x10mm).

However, it should be noted that for several of the surface breaking defects, the amplitude response is fairly low. Without the increased inspection gain of 6dB the signal response is around reporting level.

The 45°-shear transducer does not detect any defects, and its relevance can be discussed. With the actual defect situation it is believed that this transducer is not going to add any information.

The 70°-shear transducer has been excluded due to the high noise level in the area with the lack of fusion defects. The transducer could give valuable information if the criteria for noise level was adjusted or/and the inspection gain decreased.

The TANDEM technique shows a good detection rate over the whole inspection range, from 0-60mm

The procedure does not handle the curvature of the nozzle when applying the TANDEM technique. This means that the axial position for the defect is not correct, and the projected position is in some cases outside the inspection area.

The procedure does not fulfil the required inspection performance for height sizing since defect number 14 is oversized.

The TOFD technique gives an accurate sizing within  $\pm 2\text{mm}$  for all flaws (required  $\pm 5\text{mm}$ ), except number 14. A number of satellite indications that cannot be explained as geometric or volumetric gives a bottom tip value 10mm lower than what is expected. The 'correct' bottom tip response is also present, but a 'worst case' value has been chosen.

The inspection results for location accuracy (see *Table 8*) are well inside the requirements.

There are two false calls and a significantly higher noise level in the area of 265-345°. This is the same area where the lack of fusion defects is positioned. It is highly likely that these false calls originate from the manufacturing of the weld and defects in this area. Appendix 3 includes all false calls exceeding 20% FSH in this area. The remaining weld has not given any false calls and the noise level is also lower. Moreover, the whole 360° of the weld have been inspected with TOFD PCS 20 and 40, but only the area with lack of fusion is showing satellite signals.

General comments made during inspection, and suggested improvements on the procedure can be found in Protocol T.100.440-1.



# **PART II:**

## **OUTSIDE INSPECTION OF THE CLAD TEST PIECE**

### **9 INTRODUCTION**

This part of the report documents the ultrasonic non-destructive testing results obtained from the detection performed on the ENIQ nozzle assembly 21. The inspection was carried out from the outside surface on the clad assembly at the TRC premises in 2004. The objective of the trials was to assess the detection capabilities of the proposed inspection procedure. The trials employed shear pulse-echo and Tandem technique, as detection technique.

### **10 SCOPE OF WORK**

The scope of work consisted of

- Scanning the clad test block ENIQ assembly 21 from the outer surface using the pulse echo tandem technique at a frequency of 1,5 MHz, with a focal depth of 140 mm.
- Scanning the clad test block ENIQ assembly 21 from the outer surface using the pulse echo 45° and 60° shear wave technique at a frequency of 1,5MHz.
- Analysis of the inspection data.

### **11 REFERENCE DOCUMENTS**

- Inspection procedure for the 2nd ENIQ Pilot Study, 1st Draft
- Method Of Working, MOW version 1,0
- Technical Justification for the 2nd Pilot Study, Draft for Discussion.

## 12 EQUIPMENT

### 12.1 Scanning system

The inspection was performed using the following equipment:

**Table 11 Scanning System**

Ultrasonic System	R/D Tech Tomo S/V Software version	Serial No 15297-05 1.4R7
Manipulator	Force ATS1	Serial No JRC
Drive Control Software	MCDU-02	Serial No 16497-04
Analysis Software	R/D Tech TomoView	Version 1.3R0
Pre Amplifier	Panametrics 5670	Serial No 1648
Couplant	Water	

### 12.2 Cables

**Table 12 Cables**

Item	Cable Length	Cable Type	Connector Type
1	10.0 Metres	Coax RG174 - 50Ω	Lemo 00 plug – Lemo 00 plug

### 12.3 Transducers

**Table 13 Detection and length sizing probes**

Probe Identity	Probe Type and Frequency	Crystal Size [mm]	Probe Size [mm]	Probe Function
RTD01-3	T 45° 1.5 MHz	32x25	40x40x30	Detection Length sizing
RTD01-5	T 60° 1.5 MHz	32x22	40x40x30	Detection Length sizing
RTD01-3 RTD01-4	TANDEM 1.5 MHz	32x25	40x40x30	Detection Length sizing

Note: The TANDEM configuration was set to PCS 56, achieving a focal depth of 140 mm on a flat surface.



## 12.4 Calibration blocks

50mm wide A2

Material	Carbon Steel
Radius	100 mm
Surface	Flat
Purpose	Shear transducers: delay, index, and angle

JRC-10722A

Material	Carbon Steel
Thickness	100 mm
Surface	Flat
Purpose	Shear and longitudinal sensitivity

JRC-10729A

Material	Carbon Steel
Thickness	165 mm
Surface	Flat
Purpose	TANDEM delay and sensitivity

## 12.5 Test Block

ENIQ assembly 21, drawing JRC-10692B, see appendix 1.

The test block is of ferritic material with a nozzle to shell weld, containing a total of 17 induced defects. All defects are of a longitudinal orientation with respect to the weld direction.

# 13 INSPECTION

## 13.1 Transducer Calibration and Inspection Settings

All transducers were calibrated according to the ENIQ procedure. Inspection settings as defined under appendix D in the procedure was used.

## 13.2 Sensitivity

The inspection sensitivity includes the reference/calibration sensitivity and the transfer losses between the calibration block and the inspection object. 13.3 describes the procedure to establish the transfer differences.

In cases with saturated signals, a complementary inspection scan was performed with the gain reduced to reference level. *Table 14* documents all transducers with relevant settings.

**Table 14 Sensitivity settings for detection probes**

Probe Identity	Angle	Ref. block	Reference reflector	Calibration sensitivity	Inspection sensitivity
RTD01-3	45° Shear	JRC-10729	Ø8 DAC	80% of full screen height	Calibration +6dB
RTD01-3 RTD01-4	Tandem PCS 56	JRC-10729	Ø8 at 125mm	80% of full screen height	Calibration +7,5dB
RTD01-5	60° Shear	JRC-10729	Ø8 DAC	80% of full screen height	Calibration +6dB

### 13.3 Transfer measurements

Transfer value was determined by performing a comparison (in dB) between the response from the 125 mm deep Ø8 mm SDH in calibration block JRC 10729 and the 120 mm deep Ø8 mm SDH in test sample ENIQ 21.

The largest value from the four transfer values (two SDH's, each evaluated from two sides) was added to the base/reference gain before the start of data collection.

### 13.4 Scan patterns

Scanning was performed by a bi-directional step raster pattern with a step of 0,5°.

The scan axis was defined as being perpendicular to the weld centre line and the index axis along the weld centre line.

### 13.5 Datum Convention

Co-ordinate system specified in the ENIQ procedure was slightly modified to correspond to the defect drawing JRC 10692 (appendix 1), so that the circumferential reading was comparable without mirroring the index axis position.

## 14 EVALUATION

Evaluation was done according to the ENIQ procedure with evaluation criteria as below. An indication must exceed reference level on three consecutive scan-lines to be reported.

**Table 15 Evaluation criteria**

Transducer type	Evaluation criteria
Shear wave probes	20% of reference level = 16% of full screen height

## 15 SUMMARY OF RESULTS

A summary of the results, following the evaluation criteria according to the ENIQ procedure, can be found in *Table 16*. Detailed results from each flaw and transducer can be found in appendix 3.

**Table 16 Summary of results**

DEFECT NUMBER		POSITION In mm	LENG TH In mm	HEIGHT In mm	Defect tilt and skew Transducer and % of FSH
Flaw 1	Real	69-89	20	5(7-12)	Tilt 0° Skew 0°
	Measured	67-101	34		
Flaw 2	Real	167-187	20	5(0-5)	Tilt 0° Skew 0°
	Measured	177-202	25		
Flaw 3	Real	255-275	20	5(0-5)	Tilt 10° Skew 5°
	Measured	250-272	22		
Flaw 4	Real	365-405	40	10(0-10)	Tilt 10° Skew 0°
	Measured	376-421	45		
Flaw 5	Real	481-521	40	10(0-10)	Tilt 0° Skew 0°
	Measured	489-531	42		
Flaw 6	Real	599-659	60	15(0-15)	Tilt 0° Skew 5°
	Measured	602-660	58		
Flaw 7	Real	733-793	60	15(0-15)	Tilt 20° Skew 5°
	Measured	733-794	61		
Flaw 8	Real	870-890	20	5(7-12)	Tilt 10° Skew 5°
	Measured	-	-		
Flaw 9	Real	970-1010	40	10(7-17)	Tilt 4° Skew 0°
	Measured	962-1011	49		
Flaw 10	Real	1016-1156	40	10(7-17)	Tilt 20° Skew 5°
	Measured	1121-1161	40		
Flaw 11	Real	1259-1319	60	15(7-22)	Tilt 10° Skew 0°
	Measured	1274-1329	55		
Flaw 12	Real	1424-1484	60	15(7-22)	Tilt 0° Skew 5°
	Measured	1429-1488	58		
Flaw 13	Real	1570-1590	20	10(10-20)	Tilt 4° Skew 0°
	Measured	1561-1594	33		
Flaw 14	Real	1698-1728	30	15(20-35)	Tilt 4° Skew 0°
	Measured	1695-1738	43		
Flaw 15	Real	1845-1875	30	15(30-45)	Tilt 4° Skew 0°
	Measured	1820-1857	37		
Flaw 16	Real	1979-2029	50	5(10-15)	Tilt 4° Skew 0°
	Measured	1973-2031	58		
Flaw 17	Real	2138-2198	60	5(15-17)	Tilt 4° Skew 0°
	Measured	2147-2196	49		

### 15.1 Comments on the detection results

- For defect number 2, 3, 4, 5, 6 and 7. The given position stated on the drawing JRC-100692B seems to be inaccurate, and should be confirmed by the manufacturer

- Defect number 8 was not detected by any of the three techniques applied
- A large number of 'false calls' was noted, originating both from the clad interface and the weld volume.
- The defect position in 'Y' (noted in the report forms in app.2) give a rather large error due to a number of reasons: long ultrasonic sound paths, the curvature of the object will affect both the incident angle and the Y-arm positioning.

# **PART III:**

## **INSIDE INSPECTION OF THE CLAD TEST PIECE**

### **16 INTRODUCTION**

This report documents the results obtained regarding detection from the inspection performed on the clad test block ENIQ nozzle assembly 21. The inspection was carried out from the inside surface on the clad assembly at the JRC's premises in The Netherlands. The measurements were carried out in June 2005, except for the tandem technique, which was carried out in September 2005. This inspection was carried out in line with *"Inspection procedure for the 2<sup>nd</sup> ENIQ Pilot Study, Issue 3"* which covers both detection and sizing. However, based on a decision of the ENIQ TGQ only the part for detection was followed. The objective of the trials was to assess the detection capabilities of the proposed inspection procedure. The trials employed shear pulse-echo and Tandem technique, as detection technique

### **17 SCOPE OF WORK**

The scope of work consisted of

- Scanning test block ENIQ assembly 21 using the pulse echo 70° TRL technique at a frequency of 2MHz, with focus depth 8 and 12mm.
- Scanning test block ENIQ assembly 21 using the pulse echo 60° and 70° shear wave technique at a frequency of 1,5MHz.
- Scanning test block ENIQ assembly 21 using pulse echo 45° tandem technique at a frequency of 1,5 MHz, with a approximately focal depth of 40 mm.
- To analyse the obtained results relating to detection according to the inspection procedure
- To analyse the obtained results relating to detection at higher sensitivity levels than specified in the inspection procedure (see 20.3)

## 18 REFERENCE DOCUMENTS

- ENIQ.PILOT2 (04) 4 – Inspection procedure for the 2nd ENIQ pilot study - Draft  
3. Date: 17-03-2004

## 19 EQUIPMENT

### 19.1 Scanning system

**Table 17 Scanning system**

Ultrasonic System	R/D Tech Tomo S/V Software version	Serial No 15297-05 1.4R7
Manipulator	Force	
Drive Control Software	McdU-02	Serial No 16497-04
Analysis Software	R/D Tech TomoView	Version 2.2R9
Couplant	Water	

### 19.2 Cables

**Table 18 Cables**

Item	Cable Length	Cable Type	Connector Type
1	10.0 Metres	Coax RG174 - 50Ω	Lemo 00 plug – Lemo 00 plug
2	10.0 Metres	Coax RG174 - 50Ω	Lemo 00 plug – Lemo 00 plug

### 19.3 Transducers

**Table 19 Detection probes (FD = focal depth)**

Probe Identity	Probe Type	Freq [MHz]	Crystal Size [mm]	Probe Size [mm]	Probe Function
RTD01-9	TRL 70°	2.0	2x (25x15) FD.12mm	40x40x30	Detection
RTD01-10	TRL 70°	2.0	2x (Ø18) FD 8mm	40x40x30	Detection
RTD01-5	T 60°	1.5	32x22	40x40x30	Detection
RTD01-7	T 70°	1.5	32x18	40x40x30	Detection
RTD01-3 RTD01-4	T 45° TANDEM	1.5	32x25	40x40x30	Detection

## 19.4 Calibration blocks

50mm wide A2

Material	Carbon Steel
Radius	100 mm
Surface	Flat
Purpose	Shear transducers: delay, index, and angle

50mm wide A1

Material	Carbon Steel
Radius	25/50 mm
Surface	Flat
Purpose	Longitudinal transducers: delay, index, and angle

JRC-10722A

Material	Carbon Steel
Thickness	100 mm
Surface	Flat
Purpose	Shear and longitudinal sensitivity

JRC-10729A

Material	Carbon Steel
Thickness	165 mm
Surface	Flat
Purpose	TANDEM delay and sensitivity

## 19.5 Component to be inspected

ENIQ assembly 21, drawing JRC-10692B, see appendix 1. The test assembly contains 17 intended defects.

# 20 INSPECTION

## 20.1 Equipment Calibration

A comprehensive self-test routine was performed and evaluated in accordance with the inspection procedure (see 18) before and after the inspection. The recorded data files are stored together with the inspection data.

## 20.2 Transducer Calibration and Inspection Settings

All transducers were calibrated according to the ENIQ procedure. Inspection settings as defined under appendix D in the procedure was used.

## 20.3 Sensitivity

The inspection procedure requires that gain shall be added to the inspection sensitivity to compensate for the cladding. However, due to lack of information regarding the gain needed, no gain compensation was added to the inspection sensitivity. Instead, recordings were carried out at a number of different sensitivities in order to have data, which would compensate for the damping in the cladding.

In cases with saturated signals, a complementary inspection scan was performed with the gain reduced to reference level. Table 4 documents all relevant calibration reflectors, settings and inspection sensitivities.

**Table 20 Sensitivity settings for detection probes**

Probe Identity	Angle	Cal. block	Cal. reflector	Cal. Sensitivity	Inspection sensitivity
RTD01-9	70° TRL FD12	JRC- 10722	Ø3,2 at 10mm	80% of FSH	1) Cal + TM <sup>#1</sup> 2) Cal + TM <sup>#1</sup> + 6 dB
RTD01-10	70° TRL FD8	JRC- 10722	Ø3,2 at 5mm	80% of FSH	1) Cal + TM <sup>#1</sup> 2) Cal + TM <sup>#1</sup> + 6 dB
RTD01-5	T 60°	JRC- 10722	Ø6,4 at 35mm	80% of FSH	1) Cal + TM <sup>#1</sup> 2) Cal + TM <sup>#1</sup> + 9 dB
RTD01-7	T 70°	JRC- 10722	Ø6,4 at 35mm	80% of FSH	1) Cal + TM <sup>#1</sup> - 6 dB 2) Cal + TM <sup>#1</sup> + 6 dB
RTD01-3 RTD01-4	45° Tandem	JRC- 10729	Ø8 at 40mm	80% of FSH	1) Cal + TM <sup>#1</sup> 2) Cal + TM <sup>#1</sup> + 9 dB 3) Cal + TM <sup>#1</sup> + 15 dB

<sup>#1</sup> TM = Transfer Measurement (see 20.4)

A general 6 dB (TM) was added to all the detection transducers. See also chapter 5.3, regarding transfer measurements.

## 20.4 Transfer measurements

It is not possible to make transfer measurements for the clad component as no clad calibration block exists.. Consequently the transfer measurements from the unclad block were used.

These measurements were performed using the two 45° transducers, comparing signal amplitudes from the calibration block JRC-10729A and the unclad ENIQ assembly 21. The nozzle base material did not show any divergences, but for the weld material a difference of 4 to 6dB was measured, compared with the calibration block. The measurements were performed in a 'static mode', it is assumed that in a 'dynamic mode' (i.e. scanning) there would also be a measurable difference in the base material, due to the rougher surface on the nozzle.

As for the inspection of the unclad ENIQ assembly 21 a transfer measurement factor TM of + 6 dB was added to all inspection sensitivities, see Table 20.

## 20.5 Scan patterns

The scan axis was defined as being perpendicular to the weld centre line and the index axis along the weld centre line. Scanning was performed using a series of bi-directional stepped raster patterns with a step of 0,5° in circumferential direction which equals just over 3 mm at the weld centre line.

## 20.6 Datum Convention

Co-ordinates are specified in the ENIQ procedure



## 21 EVALUATION

### 21.1 Detection according to procedure

Evaluation of detection was done according to the ENIQ procedure with evaluation criteria as below.

**Table 21 Procedure evaluation criteria**

Transducer type	Evaluation criteria
Shear wave probes	25% of reference level = 20% of full screen height
Longitudinal probes	50% of reference level = 40% of full screen height

An indication must exceed reference level on three consecutive scan-lines to be reported.

### 21.2 Detection of signals outside procedure

The inspection data is also evaluated for signals below the inspection procedure evaluation criteria in order to allow comparison with modelling results.

### 21.3 Unintended defects / false calls

As the main objective of the inspection was to get as much information from the intended defects as possible - at different sensitivity levels in order to compare with results from modelling - signals from unintended defects / false calls have not been examined.

### 21.4 Length and height sizing

No length and height sizing has been performed.

## 22 DEFECTS TO BE DETECTED

According to the Technical Justification, the maximum acceptable defect is 30 mm x 15 mm. The validation defect is one that must be detected with a high degree of confidence and which, when account is taken of the maximum uncertainty in the measured size, does not exceed the maximum acceptable defect size. The validation defect size is 20 mm in length and 10 mm in height.

## 23 SUMMARY OF RESULTS

A summary of the results can be found in Table 22. Detailed results from each flaw and transducer can be found in appendix 2.

### 23.1 Comments on the detection results

#### 70°-TRL probes, inspection range 0-20 mm in depth

All defects positioned in the inspection range of the transducers have been detected, except defect 1, 2 and 3. These three defects are all PISC type-A notches with a size of 20 mm x 5 mm. For defect 1 a signal was detected below the evaluation criteria of the inspection procedure.

#### 60°-shear wave probe, inspection range 20-60 mm in depth

Two defects were fully in the inspection range for the 60° shear wave transducer, defect 14 and 15. Only defect 14 was detected, with amplitude just above the procedure reporting level (- 12 dB).

#### 70°-shear wave probe, inspection range 20-60 mm in depth

Two defects were in the inspection range for the 70° shear wave transducer, defect 14 and 15. Both defects were detected within the evaluation criteria of the procedure

#### TANDEM set-up, inspection range 20-60 mm in depth

The procedure states an inspection range of 20 to 60 mm for the TANDEM. However, since the technique cannot give any position in depth, the inspection range will more or less depend on chosen focus depth and the size of the sound-beam field. Only defects 13, 14, 15 and 17 were detected within the evaluation criteria of the procedure.

**Table 22 Summary of maximum amplitude responses**

Probe	Defect 1 (20 x 5 mm)	Defect 2 (20 x 5 mm)	Defect 3 (20 x 5 mm)	Defect 4 (40 x 10 mm)	Defect 5 (40 x 10 mm)	Defect 6 (60 x 15 mm)	Defect 7 (60 x 15 mm)	Defect 8 (20 x 5 mm)	Defect 9 (40 x 10 mm)
70 TRL FD8 NEG	- 9.1 dB	ND	ND	- 8.8 dB	- 6.8 dB	- 12.0 dB	<b><u>+ 4.5 dB</u></b>	<b><u>- 2.4 dB</u></b>	- 6.2 dB
70 TRL FD8 POS	- 8.0 dB	ND	ND	<b><u>- 0.3 dB</u></b>	<b><u>- 4.8 dB</u></b>	<b><u>- 1.6 dB</u></b>	ND	- 8.8 dB	<b><u>- 0.2 dB</u></b>
70 TRL FD12 NEG	- 6.2 dB	ND	ND	- 11.5 dB	<b><u>- 2.6 dB</u></b>	- 9.9 dB	<b><u>+ 4.8 dB</u></b>	<b>+ 1.0 dB</b>	- 6.4 dB
70 TRL FD12 POS	- 7.5 dB	ND	ND	<b><u>+ 1.4 dB</u></b>	<b><u>- 1.9 dB</u></b>	<b><u>- 1.3 dB</u></b>	- 10.4 dB	- 10.1 dB	<b><u>- 4.0 dB</u></b>
T60 NEG									
T60 POS									
T70 NEG									
T70 POS									
T45 TANDEM NEG	- 24.1 dB	ND	ND	- 24.8 dB	- 19.1 dB	- 14.7 dB	ND	ND	- 26.3 dB

Probe	Defect 10 (40 x 10 mm)	Defect 11 (60 x 15 mm)	Defect 12 (60 x 15 mm)	Defect 13 (20 x 10 mm)	Defect 14 (30 x 15 mm)	Defect 15 (30 x 15 mm)	Defect 16 (50 x 5 mm)	Defect 17 (60 x 5 mm)
70 TRL FD8 NEG	<b><u>- 5.5 dB</u></b>	- 7.7 dB	- 10.7 dB	- 7.9 dB	ND	ND	<b><u>- 0.9 dB</u></b>	- 10.5 dB
70 TRL FD8 POS	<b><u>+ 6.1 dB</u></b>	<b>+ 1.9 dB</b>	<b><u>- 2.1 dB</u></b>	<b><u>- 0.2 dB</u></b>	ND	ND	<b><u>- 3.5 dB</u></b>	- 11.9 dB
70 TRL FD12 NEG	- 7.7 dB	- 6.2 dB	- 15.7 dB	- 8.2 dB	- 10.1 dB	ND	<b><u>- 3.2 dB</u></b>	- 7.0 dB
70 TRL FD12 POS	<b><u>+ 7.9 dB</u></b>	<b>- 0.8 dB</b>	- 8.1 dB	<b><u>+ 3.7 dB</u></b>	<b><u>- 4.4 dB</u></b>	<b><u>- 4.6 dB</u></b>	<b><u>- 4.8 dB</u></b>	<b><u>- 6.0 dB</u></b>
T60 NEG					- 17.2 dB	- 13.6 dB	<b><u>- 7.2 dB</u></b>	-12.3 dB
T60 POS					<b>- 11.5 dB</b>	- 17.0 dB	ND	ND
T70 NEG					ND	<b><u>- 6.7 dB</u></b>	<b><u>- 5.4 dB</u></b>	<b><u>- 7.5 dB</u></b>
T70 POS					<b><u>- 9.1 dB</u></b>	- 15.0 dB	<b><u>- 10.1 dB</u></b>	- 14.1 dB
T45 TANDEM NEG	ND	- 23.9 dB	- 17.4 dB	<b><u>- 11.2 dB</u></b>	<b><u>+ 4.1 dB</u></b>	<b><u>- 5.3 dB</u></b>	- 16.9 dB	<b><u>- 11.4 dB</u></b>

ND: No Detection

**Bold Underline:** Detection within the procedure criteria (TRL: Ref level + 6 dB, Shear: Ref level + 12 dB)

Other numbers Detection under procedure evaluation criteria

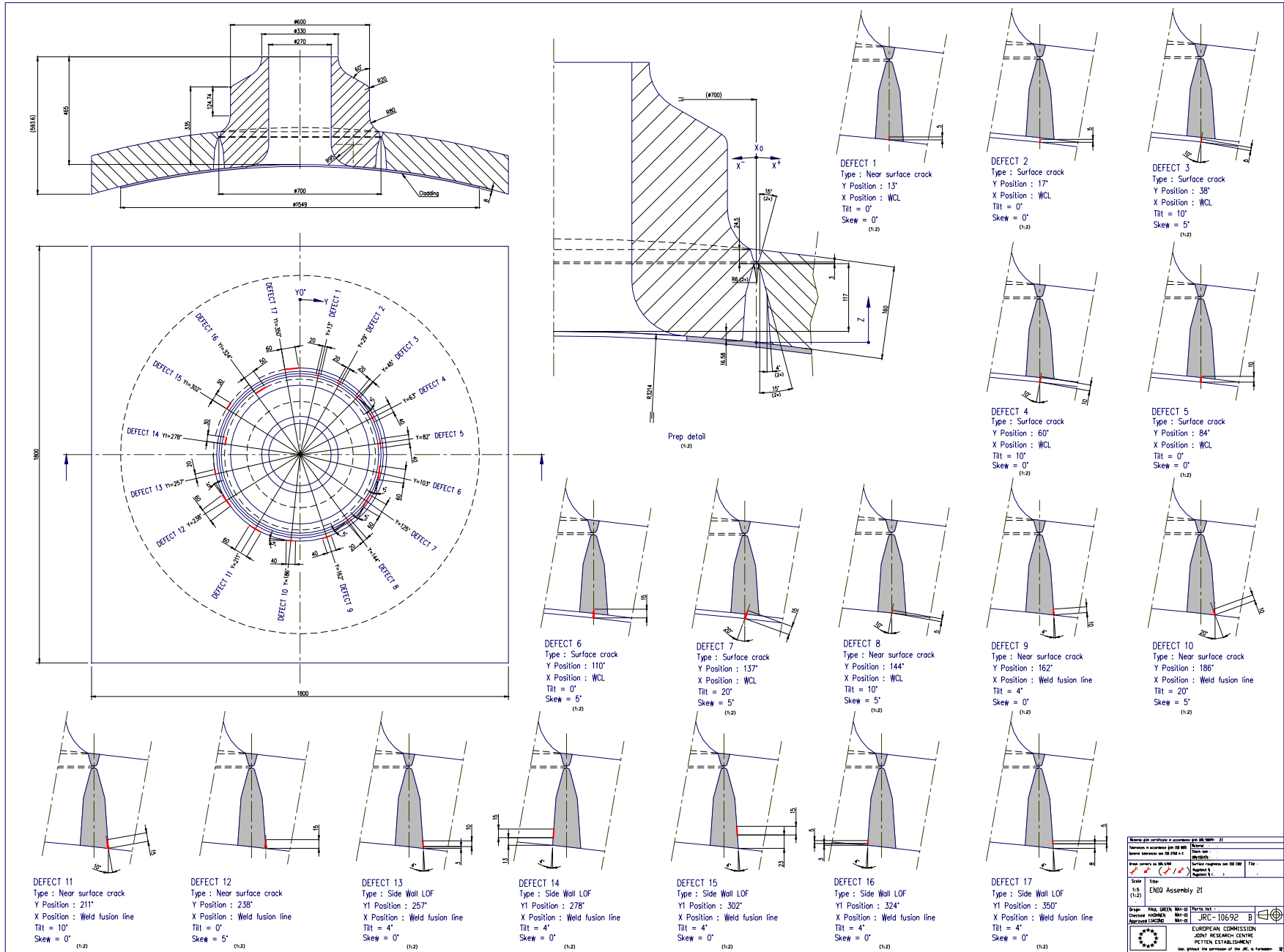


# **APPENDICIES**



## **APPENDIX 1**

**Drawing JRC-10692 B, ENIQ Assembly 21**





## **APPENDIX 2**

### **TABULATED RESULTS FOR THE INSIDE INSPECTION OF THE UN-CLAD TEST PIECE**

**FLAW 1**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
1	11.36/69.4	14.64/89.4	3.28/20.0	0	0	5.0	0	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	11/67.2	14/85.5	3/18.3	1	47	13/19	2	-	6.5	20
Eniq2170trl8pos01	11.5/70	14/85.5	2.5/15.5	2	36	13.5/-18	0	-	7.1	17.5
Eniq2170trl12neg01	12.5/76	14/85.5	1.5/9.5	1	37	13/16	0	-	5.5	24
Eniq2170trl12pos01	12/73	14/85.5	2/12.5	2	37	13/-13	0	-	5.6	23
Eniq2145tanneg01	10.5/64	15.5/95	5/31	-17	19	14.5/121	1	-	-	15

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs01	11.3/69	14/85.5	2.5/16.5	1.5	-	3.79/5.4	13/79	Lat. @ 3.29μs
Eniq2140pcs01	11.4/69.6	14.4/88	3/18.4	2	-	7.0/5.1	12.9/78.8	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).

## Circumferential cursor positions at where depth measurements were obtained.

**FLAW 8**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
8	142.36/869.6	145.64/889.6	3.28/20.0	0	0	5.0	10	5	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	141.5/864.4	144/880	2.5/15.6	0.5	+100	-	8	-	6.0	<28
Eniq2170trl8neg02*	142/867	144/880	2/13	1	65	143.5/16	4	-	5.6	25
Eniq2170trl12neg01	142/867	145.5/883	2.5/15.3	2	85	143.5/16	5	-	5.0	31
Eniq2145taneg01	140.5/858	145.5/889	5/31	-19.5	17	144.5/121	1	-	-	14

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs01	141.7/865.6	144.4/882	2.7/16.4	1.5	-	3.76/5.3	143.1/874	Lat. @ 3.31μs
Eniq2140pcs01	141.7/865.6	144.7/883.9	3/18.3	4	-	7.06/5.8	143.2/874.8	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).  
 ## Circumferential cursor positions at where depth measurements were obtained.  
 \* Scan performed @ reference to 80% fsh only i.e. no +6dB correction.

**FLAW 9**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
9	158.73/969.6	165.3/1009.6	6.55/40.0	+FF (+25)	0	10.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	158/965	164/1002	6/37	24	37	159.5/40	0	-	6.0	18
Eniq2170trl8pos01	158.5/968	164/1002	5.5/34	23	71.5	163.5/5	11	-	6.7	23.5
Eniq2170trl12neg01	159/971	165/1008	6/37	24	23	159.5/37	0	-	4.7	19
Eniq2170trl12pos01	163/996*	164.5/1005	1.5/9	20	57	164/5	2	-	5.7	29
Eniq2145taneg01	160/977.4	165.7/1012	5.7/34.6	-2.4	32	162.5/138	12	-	-	20

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs01	158.4/968	164.1/1002.4	5.7/34.4	24	-	4.62/9.5	161.4/986	Lat. @ 3.31μs
Eniq2140pcs01	158.7/969.4	164.4/1004.3	5.7/34.9	25	-	7.58/10.0	161.7/987.8	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).  
 ## Circumferential cursor positions at where depth measurements were obtained.  
 \* Low signal amplitude @ start of flaw hence short length recorded from -6dB measurement.

**FLAW 10**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
10	182.7/1016.2	189.2/1156.2	6.55/40.0	+FF (+25)	0	10.0	20	5	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	184/1124	188/1148	4/24	24	17	186/42	0	-	6.4	12.5
Eniq2170trl8pos01	183/1117.9	187/1142	4/24.1	21.5	+100	-	13	-	7.1	<28
Eniq2170trl8pos02*	183.5/1121	187/1142	3.5/21	21	62	185/1	6	-	7.5	28
Eniq2170trl12neg01	183/1118	187.5/1145	4.5/27	21	13	185.5/43	0	-	8.0	16
Eniq2170trl12pos01	183.5/1121	187.5/1145.4	4/24.4	22	+100	-	12	-	5.8	<28
Eniq2170trl12pos02*	184/1124	188/1148	4/24.4	23	55	185.5/7	5	-	5.9	27

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs01	182.3/1113.6	188/1148.4	5.7/34.8	24	-	4.56/9.2	185.5/1133	Lat. @ 3.31μs
Eniq2140pcs01	182.8/1116.7	188.5/1151.5	5.7/34.8	24	-	7.5/9.4	185.8/1135	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).

## Circumferential cursor positions at where depth measurements were obtained.

\* Scan performed @ reference to 80% fsh only i.e. no +6dB correction.

**FLAW 11**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
11	206.9/1263.9	215.9/1318.9	9.82/60.0	+FF (+25)	0	15.0	10	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	205.5/1255	214.5/1310	9/55	30	32	210.5/46	0	-	6.0	17
Eniq2170trl8pos01	208.5/1274	214.5/1310	6/36	24	87.8	210.5/-2	13	-	9.4	27
Eniq2170trl12neg01	209.5/1280	214.5/1310	5/30	25	26	210.5/61	0	-	13.2	22
Eniq2170trl12pos01	206.5/1261	215.5/1316	9/55	24	69	208/-22	18	-	16.7	29
Eniq2145tanneg01	208/1270.6	213.5/1304	5.5/33.4	4	20	210/143	4	-	-	19

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs02	206.4/1261	214.8/1312	8.4/51	27	-	5.51/13	210.7/1287	Lat. @ 3.31μs
Eniq2140pcs01	206.1/1259	214.8/1312	8.8/53	28	-	8.58/15.5	210.4/1285.3	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).  
 ## Circumferential cursor positions at where depth measurements were obtained.

**FLAW 12**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
12	233.1/1423.9	242.9/1483.8	9.82/60.0	+FF (+25)	0	15.0	0	5	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	232.5/1420.3	241.5/1475	9/55	31	48	240.5/53	3	-	8.0	20
Eniq2170trl8pos01	233/1423	238.5/1457	5.5/34	26	55.4	236/8	4	-	6.5	23
Eniq2170trl12neg01	233/1423	241/1472	8/49	30	35	240.5/47	0	-	6.1	23.5
Eniq2170trl12pos01	233/1423	240.5/1469	7.5/46	28	46	233.5/19	1	-	3.3	25
Eniq2145tanneg01	232/1417	240/1466	8/49	0	37	238.5/136	6	-	-	24

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs02	232.7/1421.5	241.7/1476.5	9/55	26	-	5.56/13.2	237.6/1451.5	Lat. @ 3.31μs
Eniq2140pcs01	232.9/1422.7	241.3/1474	8.4/51.3	28	-	8.6/15.6	237.1/1448.4	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).  
 ## Circumferential cursor positions at where depth measurements were obtained.

**FLAW 13**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
13	257/1569.9	260.3/1590.1	3.27/20.0	+FF (+25)	3.0	13.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	255.5/1561	258.5/1579	3/18	23	21	257/40	0	-	6.0	13
Eniq2170trl8pos01	255.5/1560.8	259/1582.1	3.5/21.3	21.5	+100	-	9	-	8.4	<28
Eniq2170trl8pos02*	256.5/1567	259.5/1585	3/18	23	82	258.5/0	7	-	8.2	26
Eniq2170trl12neg01	256/1564	258.5/1579	2.5/15	20	30	258/57	0	-	13.5	23.5
Eniq2170trl12pos01	255.5/1560.8	259.5/1585.2	4/24.4	22.5	+100	-	10	6.4	16.6	<28
Eniq2170trl12pos02*	256.5/1567	259.5/1585	3/18	22	72	258/5 & -24	6	6.3	16.6	29
Eniq2145taneg01	255.5/1560.8	258.5/1579	3/18.2	-3	44	257.5/136	8	-	-	24

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs02☐	255.8/1562.6	258.8/1580.9	3/18.3	22	3.51/3.4	-	257.6/1573.6	Lat. @ 3.31μs
Eniq2140pcs01☐☐	255.3/1559.5	258.6/1579.7	3.3/20.2	22	-	8.5/15.1	257.4/1572.4	Lat. @ 6.78μs

**Comments:**

- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).
- ## Circumferential cursor positions at where depth measurements were obtained.
- \* Scan performed @ reference to 80% fsh only i.e. no +6dB correction.
- ☐ Top tip in lateral wave depth estimated.
- ☐☐ Tip identification difficult satellite indications present (phases used to identify btm tip response).



**FLAW 14**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
14	278/1698.2	282.9/1728.1	4.91/30	-FF (-25)	13.0	28.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8pos01	279/1704	283.5/1732	4.5/28	-15	46	280.5/-45	2	10.9	-	22
Eniq2170trl12neg01	278.5/1701	284/1735	5.5/34	-20	22	283/26	0	16.7	-	9
Eniq2170trl12pos01	279/1704	284/1735	5/31	-17	70	282.5/-52	10	12.6	-	21
Eniq2160neg01	279.5/1707	284/1735	4.5/27	-18	27	282.5/40	8	-	32.9	15.5
Eniq2160pos01	278/1698.2	284.5/1738	6.5/40	-17	29	282/-42&-68	13	14.3	29.3	17
Eniq2145taneg01	276.5/1689	285.5/1744	9/55	-33	+100	-	21	-	-	<28
Eniq2145taneg03*	278/1698	284.5/1738	6.5/40	-33	79	282/116	18	-	-	24

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs02	279.2/1705.5	284.9/1740.4	5.7/34.9	-21	5.61/13.4	-	282.7/1727	Lat. @ 3.31μs
Eniq2140pcs01	278.5/1701.3	285.1/1741.6	6.6/40.3	-18	8.28/14.0	-	282.7/1727	Lat. @ 6.78μs
Eniq2170pcs01	-	-	-	-20	-	15.51/30.1	281.6/1720	Lat. @ 11.69μs
"	"	"	"	"	"	17.23/37.3	"	"
Eniq21110pcs03	-	-	-	-22	-	21.29/30.3	282.2/1723.9	Lat. @ 18.64μs
"	"	"	"	"	"	22.63/37.8	"	"

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).

## Circumferential cursor positions at where depth measurements were obtained.

\* Scan performed @ reference to 80% fsh -3dB correction.

▣ Possible alternative tip measurements due to satellite indications.

▣▣ Tip identification difficult satellite indications present (phases used to identify btm tip response).

**FLAW 15**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
15	302/1844.8	306.9/1874.7	4.91/30	+FF (+25)	23.0	38.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl12pos01	300.5/1836	305/1863	4.5/27	23	54	302/-24	8	17.1	-	18
Eniq2160pos01	299.5/1829	305/1863	5.5/34	20	28	301.5/-45	6	-	38.0	15
Eniq2145taneg01	300/1832.6	305.5/1866.2	5.5/33.6	9.5	+100	-	16	-	-	<28
Eniq2145taneg02*	301/1839	305/1863	4/24	12	85	303.4/166	13	-	-	31

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2170pcs01	-	-	-	22	13.91/22.2	17.54/38.6	302.8/1850 top tip	Lat. @ 11.69μs
"	"	"	"	"	"	"	303.3/1853 btm	"
Eniq21110pcs04	-	-	-	21	20.06/21.8	22.74/38.8	304.4/1859 top tip	Lat. @ 18.64μs
"	"	"	"	"	"	"	303.8/1856 btm	"

**Comments:**

- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).
- ## Circumferential cursor positions at where depth measurements were obtained.
- \* Scan performed @ reference to 80% fsh only i.e. no +6dB correction.
- Different circumferential positions used for top and bottom tip identification.
- Tip identification difficult satellite indications present (phases used to identify btm tip response).

**FLAW 16**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
16	324/1979.2	332.2/2029.2	8.2/50	-FF (-25)	3.0	8.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	323/1973	332/2028	9/55	-20	45	328.5/6	2	-	9.3	13
Eniq2170trl8pos01	324/1979.2	334.5/2043	10.5/64	-20	38	331.5/-44	0	-	8.5	14
Eniq2170trl12neg01	323.5/1976	332.5/2031	9/55	-18	45	325/19	0	-	13.3	12
Eniq2170trl12pos01	324/1979.2	334.5/2043	10.5/64	-18	44	333.5/-59	3	-	15.4	11
Eniq2145tanneg01	325.5/1988	332.5/2031	7/43	-39	65	328.1/102	19	-	-	29

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs03□/□□	320.9/1960.3	323.3/1974.9	2.4/14.6	-21	3.54/3.7	-	322.1/1967.6	Lat. @ 3.31μs
Eniq2140pcs01□/□□	320.2/1956	342.9/2094.7	22.7/138.7	-19	Lat. Disturbance	7.43/9.0	326.5/1994.5	Lat. @ 6.78μs

**Comments:**

- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).
- ## Circumferential cursor positions at where depth measurements were obtained.
- Top tip in lateral wave depth estimated.
- Tip identification difficult in a blind situation due to satellite indications.

**FLAW 17**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
17	350/2138	359.8/2197.9	9.8/60	+FF (+25)	8.0	13.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8neg01	349.5/2135	359/2193	9.5/58	17	49	350.5/39	2	-	7.9	22
Eniq2170trl8pos01	350/2138	359.5/2196	9.5/58	19	54	355/-4	3	-	8.5	23.5
Eniq2170trl12neg01	350/2138	359/2193	9/55	17	41	351.5/50	0	-	12.0	26
Eniq2170trl12pos01	350.5/2141	359.5/2196	9/55	20	90	357/-19	19	-	14.4	28
Eniq2145tanneg01	350.5/2141	359/2193	8.5/52	2	84	357/145	22	-	-	31

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs03	349.5/2135	360/2199	10.5/66	18	4.07/7.0	-	359.2/2194	Lat. @ 3.31μs
Eniq2140pcs01	349.6/2135.6	359.5/2196	9.9/60.4	21	Lat. Disturbance	8.2/13.6	355.6/2172.2	Lat. @ 6.78μs

**Comments:**

# Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).  
 ## Circumferential cursor positions at where depth measurements were obtained.

**ADDITONAL ANALYSIS OF DEFECT 14 AND 15.**

**FLAW 14**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
14	278/1698.2	282.9/1728.1	4.91/30	-FF (-25)	13.0	28.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl8pos01	279/1704	283.5/1732	4.5/28	-15	46	280.5/-45	2	10.9	-	22
Eniq2170trl12neg01	278.5/1701	284/1735	5.5/34	-20	22	283/26	0	16.7	-	9
Eniq2170trl12pos01	279/1704	284/1735	5/31	-17	70	282.5/-52	10	12.6	-	21
Eniq2170neg01	277/1692	283.5/1732	6.5/40	-19	55	282/58	19#		28.3	10
Eniq2170pos01	279/1704	284/1735	5/31	-16	82	282/-52	16#	13.0		12
Eniq2160neg01	279.5/1707	284/1735	4.5/27	-18	27	282.5/40	8	-	32.9	15.5
Eniq2160pos01	278/1698.2	284.5/1738	6.5/40	-17	29	282/-42&-68	13	14.3	29.3	17
Eniq2145taneg01	276.5/1689	285.5/1744	9/55	-33	+100	-	21	-	-	<28
Eniq2145taneg03*	278/1698	284.5/1738	6.5/40	-33	79	282/116	18	-	-	24

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2120pcs02□□	279.2/1705.5	284.9/1740.4	5.7/34.9	-21	5.61/13.4	-	282.7/1727	Lat. @ 3.31μs
Eniq2140pcs01□□	278.5/1701.3	285.1/1741.6	6.6/40.3	-18	8.28/14.0	-	282.7/1727	Lat. @ 6.78μs
Eniq2170pcs01□□	-	-	-	-20	-	15.51/30.1	281.6/1720	Lat. @ 11.69μs
"	"	"	"	"	"	17.23/37.3□	"	"
Eniq21110pcs03□□	-	-	-	-22	-	21.29/30.3	282.2/1723.9	Lat. @ 18.64μs
"	"	"	"	"	"	22.63/37.8□	"	"

**Comments:**

- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).
- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL) down to noise level (21% fsh for pos and 17% fsh for neg)
- ## Circumferential cursor positions at where depth measurements were obtained.
- \* Scan performed @ reference to 80% fsh -3dB correction.
- Possible alternative tip measurements due to satellite indications.
- Tip identification difficult satellite indications present (phases used to identify btm tip response).

**FLAW 14**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
14	278/1698.2	282.9/1728.1	4.91/30	-FF (-25)	13.0	28.0	4	0	

**DEFECT LENGTH SIZING SUMMARY TABLE**

File Name	Circ Pos (x)			Circ Pos / Length (x) Error			Comments
	Start °/mm	Stop °/mm	Length °/mm	Start °/mm	Stop °/mm	Length °/mm	
Eniq2145tanneg01	276.5/1689	285.5/1744	9/55	-1.5/-9.2	+2.6/+15.9	+4.09/25	

**DEFECT HEIGHT SIZING/Y POSITION SUMMARY TABLE**

File Name	(y) Pos. mm	(y) Pos. Error mm	Tip Pos.		Tip Pos. Error		Comments
			Top mm	Btm mm	Top mm	Btm mm	
Eniq2120pcs02	-21	4	13.4	-	+0.4	-	
Eniq21110pcs03	-22	4	-	37.8	-	+9.8	

**FLAW 15**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
15	302/1844.8	306.9/1874.7	4.91/30	+FF (+25)	23.0	38.0	4	0	

**DETECTION**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2170trl12pos01	300.5/1836	305/1863	4.5/27	23	54	302/-24	8	17.1	-	18
Eniq2160pos01	299.5/1829	305/1863	5.5/34	20	28	301.5/-45	6	-	38.0	15
Eniq2170neg01	300.5/1836	305/1863	4.5/27.5	22	41	303/142	11	25.0	44.0	9
Eniq2170pos02*	300.5/1836	305/1863	4.5/27.5	18	60	303/-76	12	-	-	12
Eniq2145tanneg01	300/1832.6	305.5/1866.2	5.5/33.6	9.5	+100	-	16	-	-	<28
Eniq2145tanneg02*	301/1839	305/1863	4/24	12	85	303.4/166	13	-	-	31

**SIZING**

File Name	Circ Pos (x)			(y) Pos. mm	Tip Pos.		Circ Pos (x) °/mm ##	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top μs/mm	Btm μs/mm		
Eniq2170pcs01☐☐	-	-	-	22	13.91/22.2	17.54/38.6	302.8/1850 top tip	Lat. @ 11.69μs
"	"	"	"	"	"	"	303.3/1853 btm ☐	"
Eniq21110pcs04☐☐	-	-	-	21	20.06/21.8	22.74/38.8	304.4/1859 top tip	Lat. @ 18.64μs
"	"	"	"	"	"	"	303.8/1856 btm ☐	"

**Comments:**

- # Number of consecutive scan lines above reporting threshold (16% fsh shear/40% fsh TRL).
- ## Circumferential cursor positions at where depth measurements were obtained.
- \* Scan performed @ reference to 80% fsh only i.e. no +6dB correction.
- ☐ Different circumferential positions used for top and bottom tip identification.
- ☐☐ Tip identification difficult satellite indications present (phases used to identify btm tip response).



**FLAW 15**

**INTENDED FLAW DIMENSIONS/POSITIONS**

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
15	302/1844.8	306.9/1874.7	4.91/30	+FF (+25)	23.0	38.0	4	0	

**DEFECT LENGTH SIZING SUMMARY TABLE**

File Name	Circ Pos (x)			Circ Pos / Length (x) Error			Comments
	Start °/mm	Stop °/mm	Length °/mm	Start °/mm	Stop °/mm	Length °/mm	
Eniq2160pos01	299.5/1829	305/1863	5.5/34	-2.5/-15.8	-1.9/-11.7	+0.59/+4.0	

**DEFECT HEIGHT SIZING/Y POSITION SUMMARY TABLE**

File Name	(y) Pos. mm	(y) Pos. Error mm	Tip Pos.		Tip Pos. Error		Comments
			Top mm	Btm mm	Top mm	Btm mm	
Eniq21110pcs04	21	-4	21.8	38.8	-1.2	+0.8	

## **FALSE CALLS**

**UNINTENDED FLAWS / FALSE CALLS**

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
Eniq2145tanneg01	267.5/1634	271.5/1658.5	4/24.5	-33	59	270/119	12	-	-	16
Eniq2170trl8pos01	285.5/1744	287.5/1756	2/12	27	20	287/7	3	-	7.2	10.5
Eniq2145tanneg01	295/1802	299.5/1829.5	4.5/27.5	-30	26	296.6/117	8	-	-	21
Eniq2170trl8pos01	320.5/1957.8	322.5/1970	2/12.2	-14	19.5	321/-40	3	-	9.4	9
Eniq2170trl8neg01	340/2076.9	342/2089.2	2/12.3	-24	24	341.5/0	3	-	8.8	13
Eniq2170trl12pos01	342/2089.2	343.5/2098	1.5/9.2	23	34	343/-23	3	-	16.8	20.5



## **APPENDIX 3**

### **TABULATED RESULTS FOR THE OUTSIDE INSPECTION OF THE CLAD TEST PIECE**

# FLAW 1

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
1	11.36/69.4	14.64/89.4	3.28/20.0	0	155.0	160.0	0	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	12.5/76.4	15.0/91.6	2.5/15.3	-2.0	97.5	14.0/85.5	12	-	164.5	14.0
ENIQ_04_60_sh_03	11.0/67.2	16.0/97.7	5.0/30.5	+3.0	31.3	13.5/82.5	6	-	156.4	11.0
ENIQ_04_45_56tan_01	11.5/70.3	16.5/100.8	5.0/30.5	-12.0	46.3	14.0/85.5	7	-	-	15.0

### Comments:

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 2

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
2	27.36/167.1	30.64/187.2	3.28/20.0	0.0	163.0	168.0	0	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	30.0/183.3	33.0/201.6	3.0/18.3	+5.0	42.2	31.5/192.4	6.0	-	170.3	8.0
ENIQ_04_60_sh_03	29.0/177.2	31.5/192.4	2.5/15.3	+18.0	47.4	30.5/186.3	6.0	-	172.0	11.0
ENIQ_04_45_56tan_01	-	-	-	-	-	-	-	-	-	-

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.

# FLAW 3

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
3	41.72/254.9	45.0/274.9	3.28/20.0	0.0	163.0	168.0	10	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	41.0/250.5	44.5/271.8	3.5/21.4	+26.0	28.2	43.0/262.7	5.0	-	168.3	6.0
ENIQ_04_60_sh_03	-	-	-	-	-	-	-	-	-	-
ENIQ_04_45_56tan_01	-	-	-	-	-	-	-	-	-	-

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.



# FLAW 4

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
4	59.73/364.8	66.28/404.9	6.55/40.0	0.0	158.0	168.0	10	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	66.5/406.2	69.0/421.5	2.5/15.3	+22.0	65.1	68.0/415.4	9.0	-	170.2	10.0
ENIQ_04_60_sh_03	61.5/375.7	69.0/421.5	7.5/45.8	+26.0	27.4	65.5/400.1	7.0	-	167.0	10.0
ENIQ_04_45_56tan_01	66.5/406.2	69.0/421.5	2.5/15.3	+7.0	33.1	67.5/412.3	4.0	-	-	10.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.

# FLAW 5

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
5			6.55/40.0	0.0	158.0	168.0	0	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	82.0/500.9	86.5/528.4	4.5/27.5	+18.0	35.2	83.5/510.1	8.0	-	168.8	7.0
ENIQ_04_60_sh_03	80.0/488.7	87.0/531.5	7.0/42.8	+33.0	26.7	82.5/504.0	10.0	-	172.1	8.0
ENIQ_04_45_56tan_01	-	-	-	-	-	-	-	-	-	-

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.

# FLAW 6

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
6			9.82/60.0	0.0	153.0	168.0	0	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	100.0/610.9	108.0/659.7	8.0/48.9	+26.0	40.9	103.5/632.3	16.0	-	173.5	8.0
ENIQ_04_60_sh_03	98.5/601.7	106.5/650.6	8.0/48.9	+21.0	35.3	104.5/638.4	14.0	-	168.8	11.0
ENIQ_04_45_56tan_01	99.5/607.8	104.0/635.3	4.5/27.5	+4.0	52.0	100.5/613.9	13.0	-	-	14.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.

# FLAW 7

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
7			9.82/60.0	0.0	153.0	168.0	20	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	120.0/733.0	130.0/794.1	10.0/61.1	+17.0	54.3	126.0/769.7	24.0	-	166.3	8.0
ENIQ_04_60_sh_03	121.5/742.2	126.5/772.7	5.0/30.5	+23.0	80.3	123.0/751.4	14.0	-	168.9	17.0
ENIQ_04_45_56tan_01	123.0/751.4	129.0/788.0	6.0/36.7	+6.0	36.2	125.5/766.6	11.0	-	-	10.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Conflicting defect start/stop positions on drawing JRC 10692 B.

# FLAW 8

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
8	140.72/859.6	144.0/879.7	3.28/20.0	0.0	155.0	160.0	10	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	-	-	-	-	-	-	-	-	-	-
ENIQ_04_60_sh_03	-	-	-	-	-	-	-	-	-	-
ENIQ_04_45_56tan_01	-	-	-	-	-	-	-	-	-	-

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).  
 Not detected by any of the three techniques applied.

# FLAW 9

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
9	158.73/969.6	165.3/1009.6	6.55/40.0	+FF (+25)	150.0	160.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	158.5/968.2	163.5/998.8	5.0/30.5	+29.0	64.1	159.5/974.3	14.0	-	165.3	10.0
ENIQ_04_60_sh_03	157.5/962.1	165.5/1011.0	8.0/48.9	+32.5	30.6	162.0/989.6	12.0	-	159.1	9.0
ENIQ_04_45_56tan_01	161.0/983.5	163.5/998.8	2.5/15.3	+10.0	53.4	162.0/989.6	7.0	-	-	12.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 10

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
10	182.7/1016.2	189.2/1156.2	6.55/40.0	+FF (+25)	150.0	160.0	20	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	-	-	-	-	-	-	-	-	-	-
ENIQ_04_60_sh_03	183.5/1120.9	190.0/1160.6	6.5/39.7	+33.0	36.0	185.5/1133.2	12.0	-	164.7	10.0
ENIQ_04_45_56tan_01	184.5/1127.1	189.0/1154.5	4.5/27.5	+21.0	50.2	186.0/1136.2	11.0	-	-	12.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 11

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
11	206.9/1263.9	215.9/1318.9	9.82/60.0	+FF (+25)	145.0	160.0	10	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	210.5/1285.9	215.5/1316.4	5.0/30.5	+43.0	84.5	213.5/1304.2	19.0	-	165.9	11.0
ENIQ_04_60_sh_03	208.5/1273.7	217.5/1328.6	9.0/55.0	+44.5	32.6	210.5/1285.9	11.0	-	163.2	10.0
ENIQ_04_45_56tan_01	210.0/1282.8	214.5/1310.3	4.5/27.5	+24.5	43.2	213.5/1304.2	9.0	-	-	14.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).



# FLAW 12

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
12	233.1/1423.9	242.9/1483.8	9.82/60.0	+FF (+25)	145.0	160.0	0	5	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	234.0/1429.4	242.5/1481.4	8.5/51.9	+56.0	53.1	240.5/1469.1	19.0	-	168.5	9.0
ENIQ_04_60_sh_03	235.5/1438.6	243.5/1487.5	8.0/48.9	+54.6	34.5	238.0/1453.9	14.0	-	162.1	10.0
ENIQ_04_45_56tan_01	235.0/1435.5	241.0/1472.2	6.0/36.7	+30.4	73.0	236.5/1444.7	18.0	-	-	18.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 13

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
13	257/1569.9	260.3/1590.1	3.27/20.0	+FF (+25)	147.0	157.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	255.5/1560.8	261.0/1594.4	5.5/33.6	+59.0	38.3	258.5/1579.1	12.0	-	172.1	8.0
ENIQ_04_60_sh_03	256.5/1566.9	261.0/1594.4	4.5/27.5	+57.6	34.7	259.0/1582.1	8.0	-	159.7	10.0
ENIQ_04_45_56tan_01	256.0/1563.8	259.0/1582.1	3.0/18.3	+31.4	+100	258.5/1579.1	10.0	-	-	+18.0
ENIQ_04_45_56tan_02	256.0/1563.8	259.0/1582.1	3.0/18.3	+27.4	62.0	257.5/1573.0	6.0	-	-	22.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 14

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
14	278/1698.2	282.9/1728.1	4.91/30	-FF (-25)	132.0	147.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	278.5/1701.3	284.5/1737.9	6.0/36.7	+4.0	33.8	280.0/1710.4	8.0	-	169.5	8.0
ENIQ_04_60_sh_03	277.5/1695.2	284.0/1734.9	6.5/39.7	+27.5	35.4	280.0/1710.4	11.0	-	176.1	11.0
ENIQ_04_45_56tan_01	277.5/1695.2	284.5/1737.9	7.0/42.8	-13.7	+100	283.0/1728.8	16.0	-	-	+18.0
ENIQ_04_45_56tan_02	278.5/1701.3	283.5/1731.8	5.0/30.5	-17.7	73.6	281.0/1716.5	14.0	-	-	24.0

Comments:  
 # Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 15

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
15	302/1844.8	306.9/1874.7	4.91/30	+FF (+25)	122.0	137.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	301.0/1838.7	303.5/1854.0	2.5/15.3	+22.0	27.7	302.5/1847.9	4.0	-	144.9	8.0
ENIQ_04_60_sh_03	299.5/1829.5	304.0/1857.0	4.5/27.5	+46.5	32.2	302.0/1844.8	8.0	-	142.7	12.0
ENIQ_04_45_56tan_01	298.0/1820.4	304.0/1857.0	6.0/36.7	+17.4	33.7	303.0/1850.9	12.0	-	-	10.0

**Comments:**  
 # Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 16

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
16	324/1979.2	332.2/2029.2	8.2/50	-FF (-25)	152.0	157.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	324.5/1982.3	332.0/2028.1	7.5/45.8	-8.0	+100	327.0/1997.5	22.0	-	166.3	+16.0
ENIQ_04_45_sh_04	325.0/1985.3	332.5/2031.1	7.5/45.8	-12.0	69.0	326.0/1991.4	16.0	-	165.7	18.0
ENIQ_04_60_sh_03	323.0/1973.1	332.5/2031.1	9.5/58.0	-24.8	42.1	327.0/1997.5	19.0	-	145.1	14.0
ENIQ_04_45_56tan_01	324.5/1982.3	328.0/2003.6	3.5/21.4	-26.7	83.7	326.5/1994.5	11.0	-	-	16.0

**Comments:**

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

# FLAW 17

## INTENDED FLAW DIMENSIONS/POSITIONS

Flaw Ident. No.	Circ Pos (x)			Axial (y) mm	Depth		Tilt °	Skew °	Comments
	Start °/mm	Stop °/mm	Length °/mm		Top Tip mm	Btm Tip mm			
17	350/2138	359.8/2197.9	9.8/60	+FF (+25)	147.0	152.0	4	0	

## DETECTION

File Name	Circ Pos (x)			(y) Pos. mm	Max. Amp.% fsh	Probe Pos @ Max. °/mm	No. Scan Lines #	Est. Depth		Signal/Noise Ratio dB's
	Start °/mm	Stop °/mm	Length °/mm					Top mm	Btm mm	
ENIQ_04_45_sh_03	351.5/2147.2	359.0/2193.0	7.5/45.8	+19.0	+100	354.5/2165.5	18.0	-	168.3	+15.0
ENIQ_04_45_sh_04	352.0/2150.3	359.0/2193.0	7.0/42.8	+20.0	58.7	353.0/2156.4	16.0	-	168.0	18.0
ENIQ_04_60_sh_03	351.5/2147.2	359.5/2196.1	8.0/48.9	+6.0	44.2	354.0/2162.5	20.0	-	145.5	12.0
ENIQ_04_45_56tan_01	349.0/2131.9	358.5/2190.0	9.5/58.0	+6.4	+100	357.5/2183.8	22.0	-	-	+18.0
ENIQ_04_45_56tan_03	351.5/2147.2	358.0/2186.9	6.5/39.7	+7.4	72.9	353.0/2156.4	19.0	-	-	24.0

### Comments:

# Number of consecutive scan lines above reporting threshold (20% fsh shear).

**DEFECT LENGTH SIZING SUMMARY TABLE**

Defect No.	Start %/mm #	Stop %/mm #	Measured Length %/mm	Stated Length %/mm	Δ Length mm	Comments
1	11.0/67.2	16.5/100.8	5.5/33.6	3.28/20.0	+13.6	
2	29.0/177.2	33.0/201.6	4.0/24.4	3.28/20.0	+4.4	
3	41.0/250.5	44.5/271.8	3.5/21.4	3.28/20.0	+1.4	
4	61.5/375.7	69.0/421.5	7.5/45.8	6.55/40.0	+5.8	
5	80.0/488.7	87.0/531.5	7.0/42.8	6.55/40.0	+2.8	
6	98.5/601.7	108.0/659.7	9.5/58.0	9.82/60.0	-2.0	
7	120.0/733.0	130.0/794.1	10.0/61.1	9.82/60.0	+1.1	
8	-	-	-	3.28/20.0	-	Not detected by any of the three techniques applied
9	157.5/962.1	165.5/1011.0	8.0/48.9	6.55/40.0	+8.9	
10	183.5/1120.9	190.0/1160.6	6.5/39.7	6.55/40.0	-0.3	
11	208.5/1273.7	217.5/1328.6	9.0/55.0	9.82/60.0	-5.0	
12	234.0/1429.4	243.5/1487.5	9.5/58.0	9.82/60.0	-2.0	
13	255.5/1560.8	261.0/1594.4	5.5/33.6	3.27/20.0	+13.6	
14	277.5/1695.2	284.5/1737.9	7.0/42.8	4.91/30.0	+12.8	
15	298.0/1820.4	304.0/1857.0	6.0/36.7	4.91/30.0	+6.7	
16	323.0/1973.1	332.5/2031.1	9.5/58.0	8.2/50.0	+8.0	
17	351.5/2147.2	359.5/2196.1	8.0/48.9	9.8/60	-11.1	

**Scan File List**

File Name	Index Pos.° (x)		Scan Pos. mm (y)		Comments
	Start	Stop	Start	Stop	
ENIQ_04_45_sh_03	0.0	363.0	50.0	280.0	Scanned at reference+DAC+6dB transfer (defects 16 and 17 saturated)
ENIQ_04_45_sh_04	310.0	363.0	50.0	280.0	Scanned at reference+DAC ie no transfer (defects 16 and 17 only)
ENIQ_04_60_sh_03	0.0	363.0	149.0	370.0	Scanned at reference+DAC+6dB transfer
ENIQ_04_45_56tan_01	0.0	363.0	62.5	280.0	Scanned at reference+DAC+7.5dB transfer (defects 13,14 and 17 saturated)
ENIQ_04_45_56tan_02	250.0	290.0	62.5	280.0	Scanned at reference+DAC ie no transfer (defects 13 and 14 only)
ENIQ_04_45_56tan_03	340.0	363.0	62.5	280.0	Scanned at reference+DAC ie no transfer (defect 17 only)





## **APPENDIX 4**

### **TABULATED RESULTS FOR THE INSIDE INSPECTION OF THE CLAD TEST PIECE**

DEFECT 1, POSITION: 13°

LENGTH: 20 mm

HEIGHT: 5 mm

TILT: 0°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	13.0	16.0	7	14.5	19	28.1	- 9.1	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	12.0	15.0	7	15.0	-20	32.0	- 8.0	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	12.5	14.5	5	13.5	41	39.4	- 6.2	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	12.5	15.5	7	14.0	-21	33.6	- 7.5	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	11.5	16	10	13.0	108.5	28.1	- 24.1	

**COMMENTS:**

DEFECT 2, POSITION: 29°

LENGTH: 20 mm

HEIGHT: 5 mm

TILT: 0°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	ND							G <sup>#1</sup> : amp=63%, Y=2.0, X=31.0
70TRL_FD8_NEG + 6dB	ND							G <sup>#1</sup> : amp>100%, Y=2.0, X=31.0
70TRL_FD8_POS	ND							G <sup>#1</sup> : amp=62.5, Y=0.0, X=30.5
70TRL_FD8_POS + 6dB	ND							G <sup>#1</sup> : amp>100%, Y=0.0, X=30.5
70TRL_FD12_NEG	ND							G <sup>#1</sup> : amp=40%, Y=0.0, X=30.0
70TRL_FD12_NEG + 6dB	ND							G <sup>#1</sup> : amp=65%, Y=0.0, X=30.0
70TRL_FD12_POS	ND							G <sup>#1</sup> : amp=15%, Y=6.0, X=30.0
70TRL_FD12_POS + 6dB	ND							G <sup>#1</sup> : amp=35%, Y=6.0, X=31.0
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:**

#1: G = Ghost indication appearing when the probe is right above the defect.

DEFECT 3, POSITION: 45°

LENGTH: 20 mm

HEIGHT: 5 mm

TILT: 10°

SKEW: 5°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	ND							G <sup>#1</sup> : amp=43%, Y=1.0, X=47.0
70TRL_FD8_NEG + 6dB	ND							G <sup>#1</sup> : amp>100%, Y=1.0, X=47.0
70TRL_FD8_POS	ND							G <sup>#1</sup> : amp=60.0, Y=0.0, X=46.5
70TRL_FD8_POS + 6dB	ND							G <sup>#1</sup> : amp>100%, Y=0.0, X=46.5
70TRL_FD12_NEG	ND							G <sup>#1</sup> : amp=20%, Y=0.0, X=46.5
70TRL_FD12_NEG + 6dB	ND							G <sup>#1</sup> : amp=45%, Y=0.0, X=46.5
70TRL_FD12_POS	ND							G <sup>#1</sup> : amp=20%, Y=5.0, X=47.0
70TRL_FD12_POS + 6dB	ND							G <sup>#1</sup> : amp=30%, Y=5.0, X=47.0
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:**

#1: G = Ghost indication appearing when the probe is right above the defect.

DEFECT 4, POSITION: 63°

LENGTH: 40 mm

HEIGHT: 10 mm

TILT: 10°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	63.5	66.5	7	64.5	10	29.1	- 8.8	G <sup>#1</sup> : amp>100%, Y=-4.0, X=65.5
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	62.5	66.5	9	65.0	-25	77.3	- 0.3	G <sup>#1</sup> : amp=50, Y=0.0, X=65
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	62.5	64.5	5	64.0	16	20.5	- 11.8	G <sup>#1</sup> : amp=70%, Y=0.0, X=64.5
70TRL_FD12_NEG + 6dB	62.0	65.0	7	64.0	8	42.5	- 11.5	G <sup>#1</sup> : amp>100%, Y=0.0, X=64.5
70TRL_FD12_POS	62.5	66.5	9	65.0	-24	94.5	+ 1.4	G <sup>#1</sup> : amp=30%, Y=6.0, X=65.5
70TRL_FD12_POS + 6dB								
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	61.5	64	6	63.0	128.6	26	- 24.8	

**COMMENTS:**

**#1: G = Ghost indication appearing when the probe is right above the defect.**

DEFECT 5, POSITION: 82°

LENGTH: 40 mm

HEIGHT: 10 mm

TILT: 0°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	82.0	85.0	7	83.5	15	36.7	- 6.8	G <sup>#1</sup> : amp>100%, Y=-2.0, X=85.0
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	82.0	84.5	6	83.0	-28	46.1	- 4.8	G <sup>#1</sup> : amp=78.0, Y=0.0, X=84.5
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	81.0	85.5	10	83.5	32	59.1	- 2.6	G <sup>#1</sup> : amp>100%, Y=0.0, X=83.5
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	81.5	85.0	10	82.5	-24	64.1	- 1.9	G <sup>#1</sup> : amp=20%, Y=5.0, X=83.5
70TRL_FD12_POS + 6dB								
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	80	83.5	8	82.5	107.5	50	- 19.1	

**COMMENTS:**

**#1: G = Ghost indication appearing when the probe is right above the defect.**

DEFECT 6, POSITION: 103°

LENGTH: 40 mm

HEIGHT: 10 mm

TILT: 0°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	100.5	108	16	104.5	18	19.7	- 12.2	G <sup>#1</sup> : amp>100%, Y=-2.0, X=107.5
70TRL_FD8_NEG + 6dB	100.0	107.5	16	104.0	21	40.2	- 12.0	
70TRL_FD8_POS	100.5	107.5	15	106.0	-28	66.9	- 1.6	G <sup>#1</sup> : amp=57.8, Y=0.0, X=106.5
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	100.0	107.5	16	105.0	38	25.5	- 9.9	G <sup>#1</sup> : amp>100%, Y=0.0, X=106
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	100.5	108	16	104.0	-32	68.7	- 1.3	G <sup>#1</sup> : amp=45%, Y=5.0, X=105.5
70TRL_FD12_POS + 6dB								
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	98.5	104.5	13	102.0	115.5	41.4	- 14.7	
45TANDEM_NEG + 15dB	100.5	107.5	15	102.0	111.5	67.5	- 16.5	

**COMMENTS:**

**#1: G = Ghost indication appearing when the probe is right above the defect.**

DEFECT 7, POSITION: 125°

LENGTH: 60 mm

HEIGHT: 15 mm

TILT: 20°

SKEW: 5°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	122.5	130.0	16	126.5	18	>100		G <sup>#1</sup> : amp=41%, Y=-2.0, X=123.5
70TRL_FD8_NEG + 6dB								
70TRL_FD8_NEG - 6dB	122.5	129.0	14	124.5	12	67.2	+ 4.5	
70TRL_FD8_POS	ND							G <sup>#1</sup> : amp=65%, Y=-6.0, X=122.5
70TRL_FD8_POS + 6dB	ND							G <sup>#1</sup> : amp>100%, Y=-6.0, X=122.5
70TRL_FD12_NEG	121.0	129.0	17	124.0	15	>100		G <sup>#1</sup> : amp=25%, Y=-8.0, X=122
70TRL_FD12_NEG + 6dB								
70TRL_FD12_NEG - 6dB	122.0	129.0	15	125.5	11	69.5	+ 4.8	G <sup>#1</sup> : amp=50%, Y=-8.0, X=122
70TRL_FD12_POS	126.0	127.0	3	126.5	-30	12.6	- 16.1	G <sup>#1</sup> : amp=60%, Y=-5.0, X=122.5
70TRL_FD12_POS + 6dB	126.0	127.0	3	126.5	-25	48.0	- 10.4	G <sup>#1</sup> : amp>100%, Y=-5.0, X=122.5
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:** #1: G = Ghost indication appearing when the probe is right above the defect.



DEFECT 8, POSITION: 144°

LENGTH: 20 mm

HEIGHT: 5 mm

TILT: 10°

SKEW: 5°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	143.0	146.0	7	144.0	18	60.6	-2.4	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	143.5	144.5	3	144.0	-16	28.9	-8.8	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	142.0	145.0	7	144.0	20	89.8	+1.0	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	142.0	144.0	5	143.5	-21	25	-10.1	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:**

DEFECT 9, POSITION: 162°

LENGTH: 40 mm

HEIGHT: 10 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	160.0	165.5	12	164.0	43	39.1	- 6.2	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	159.0	165.5	14	164.5	1	78.1	- 0.2	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	159.0	164.5	12	163.5	37	38.3	- 6.4	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	159.0	165.5	14	164.5	0	50.4	- 4.0	
70TRL_FD12_POS + 6dB								
60T_NEG	161.0	165.0	9	163.5	27	43.0	- 5.4	Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	160	164	9	164.5	143.7	21.9	- 26.3	

**COMMENTS:**

DEFECT 10,

POSITION: 186°

LENGTH: 40 mm

HEIGHT: 10 mm

TILT: 20°

SKEW: 5°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	184.5	190.0	12	185.0	38	42.5	- 5.5	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	183.5	189.0	12	186.0	-2	> 100		
70TRL_FD8_POS + 6dB								
70TRL_FD8_POS - 6dB	184.0	189.0	11	185.5	0	80.5	+ 6.1	
70TRL_FD12_NEG	183.5	186.0	6	184.0	32	33.1	- 7.7	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	183.5	190.0	14	186.5	-11	> 100		
70TRL_FD12_POS + 6dB								
70TRL_FD12_POS - 6dB	183.5	190.0	14	185.5	-5	100	+ 7.9	
60T_NEG	ND							Out side inspection area for probe
60T_NEG + 9dB	ND							Out side inspection area for probe
60T_POS	ND							Out side inspection area for probe
60T_POS + 9dB	ND							Out side inspection area for probe
70T_NEG - 6dB	ND							Out side inspection area for probe
70T_NEG + 6dB	ND							Out side inspection area for probe
70T_POS - 6dB	ND							Out side inspection area for probe
70T_POS + 6dB	ND							Out side inspection area for probe
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:**

DEFECT 11,

POSITION: 211°

LENGTH: 60 mm

HEIGHT: 15 mm

TILT: 10°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	209	216.5	16	210.5	41	32.8	-7.7	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	207.5	216.0	18	207.5	-3	100	+1.9	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	208.5	215.0	14	209.0	38	39.1	-6.2	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	206.5	216.5	21	208.5	-7	72.7	-0.8	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	ND							
60T_POS	ND							
60T_POS + 9dB	ND							
70T_NEG - 6dB	ND							
70T_NEG + 6dB	ND							
70T_POS - 6dB	ND							
70T_POS + 6dB	ND							
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	209.0	211.0	5	211.0	132.6	28.8	-23.9	

**COMMENTS:**

DEFECT 12,

POSITION: 238°

LENGTH: 60 mm

HEIGHT: 15 mm

TILT: 0°

SKEW: 5°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	234.5	242.5	18	239.5	41	23.4	- 10.7	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	234.0	240.0	13	239.0	6	63	- 2.1	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	ND							
70TRL_FD12_NEG + 6dB	234.0	242.0	17	238.5	30	26.3	- 15.7	
70TRL_FD12_POS	234.5	243.0	19	240.0	-39	31.5	- 8.1	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	237.5	241.5	9	240.0	23	39.8	- 15.1	
60T_POS	ND							
60T_POS + 9dB	ND							
70T_NEG - 6dB	ND							
70T_NEG + 6dB	ND							
70T_POS - 6dB	ND							
70T_POS + 6dB	ND							
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	233.5	240.5	15	236.0	130.6	30.5	- 17.4	
45TANDEM_NEG + 15dB	234.0	241.5	16	236.0	138.6	60.2	- 17.5	

**COMMENTS:**

DEFECT 13,

POSITION: 257°

LENGTH: 20 mm

HEIGHT: 10 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	258.0	260.5	6	259.5	37	32.3	- 7.9	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	257.5	260.5	8	258.5	- 6	78	- 0.2	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	ND							
70TRL_FD12_NEG + 6dB	257.5	260.0	6	259.0	39	31.2	- 8.2	
70TRL_FD12_POS	257.0	261.0	9	260.0	- 40	> 100		
70TRL_FD12_POS + 6dB								
70TRL_FD12_POS - 6dB	257.0	262.0	11	260.0	- 39	61.1	+ 3.7	
60T_NEG	ND							
60T_NEG + 9dB	ND							
60T_POS	ND							
60T_POS + 9dB	ND							
70T_NEG - 6dB	ND							
70T_NEG + 6dB	ND							
70T_POS - 6dB	ND							
70T_POS + 6dB	ND							
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	257.0	262.5	12	258.0	149.7	62.2	- 11.2	
45TANDEM_NEG + 15dB	257.0	263.5	14	258.0	145.7	> 100		

**COMMENTS:**

DEFECT 14,

POSITION: 278°

LENGTH: 30 mm

HEIGHT: 15 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	ND							
70TRL_FD8_NEG + 6dB	ND							
70TRL_FD8_POS	ND							
70TRL_FD8_POS + 6dB	ND							
70TRL_FD12_NEG	281.5	285.0	8	282.5	18	22.7	- 10.9	
70TRL_FD12_NEG + 6dB	281.5	285.0	8	282.5	17	50	- 10.1	
70TRL_FD12_POS	281.0	287.0	13	283.5	- 72	48	- 4.4	Second signal #2
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	282.5	286.5	9	283.5	19	31.3	- 17.2	
60T_POS	ND							
60T_POS + 9dB	282.0	286.0	9	283.0	- 95	60.2	- 11.5	
70T_NEG - 6dB	ND							
70T_NEG + 6dB	ND							
70T_POS - 6dB	ND							
70T_POS + 6dB	281.0	286.5	12	282.5	- 95	56.2	- 9.1	
45TANDEM_NEG	279.5	288.0	18	284.0	103.5	> 100		
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							
45TANDEM_NEG - 6dB	279.5	288.0	18	284.0	100.5	64.1	+ 4.1	

**COMMENTS:** #2 Second tip signal visible (Ampl 58% [- 2.7 dB], Y= - 87mm, X=283.5°)

DEFECT 15,

POSITION: 302°

LENGTH: 30 mm

HEIGHT: 15 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	ND							
70TRL_FD8_NEG + 6dB	ND							
70TRL_FD8_POS	ND							
70TRL_FD8_POS + 6dB	ND							
70TRL_FD12_NEG	ND							
70TRL_FD12_NEG + 6dB	ND							
70TRL_FD12_POS	303.0	307.0	9	306.0	- 47	46.9	- 4.6	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	303.0	306.5	8	304.5	70	46.9	- 13.6	
60T_POS	ND							
60T_POS + 9dB	302.0	308.0	13	305.0	-57	32.0	- 17.0	
70T_NEG - 6dB	ND							
70T_NEG + 6dB	303.0	306.5	8	305.0	89	73.4	- 6.7	
70T_POS - 6dB	ND							
70T_POS + 6dB	302.5	304.0	4	303.5	- 76	28.3	- 15.0	
45TANDEM_NEG	300.5	309.0	18	304.5	157	43.3	- 5.3	
45TANDEM_NEG + 9dB	ND							
45TANDEM_NEG + 15dB	ND							

**COMMENTS:**



DEFECT 16,

POSITION: 324°

LENGTH: 50 mm

HEIGHT: 5 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	327.0	334.5	16	331.5	4	71.8	- 0.9	
70TRL_FD8_NEG + 6dB								
70TRL_FD8_POS	323.0	334.0	19	329.0	- 39	53.5	- 3.5	
70TRL_FD8_POS + 6dB								
70TRL_FD12_NEG	326.0	334.0	17	332.5	27	55.1	- 3.2	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	324.0	334.0	21	329.5	- 41	46.1	- 4.8	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	325.0	333.5	18	330.0	0	98	- 7.2	
60T_POS	ND							
60T_POS + 9dB	ND							
70T_NEG - 6dB	ND							
70T_NEG + 6dB	325.0	335.0	21	332.5	- 1	85.8	- 5.4	
70T_POS - 6dB	ND							
70T_POS + 6dB	328.0	332.0	9	329.0	- 62	50.0	- 10.1	
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	326.0	334.0	17	333.0	103.5	32.0	- 17.0	
45TANDEM_NEG + 15dB	325.5	334.0	18	333.0	103.5	64.1	- 16.9	

**COMMENTS:**

DEFECT 17,

POSITION: 350°

LENGTH: 60 mm

HEIGHT: 5 mm

TILT: 4°

SKEW: 0°

**DETECTION:**

File name	X Start [°]	X Stop [°]	No. Scan Lines	X Probe Pos @ max. ampl [°]	Y Probe Pos @ max ampl [mm]	Max. Amp. [% FSH]	Max. Amp. [dB]	Comment
70TRL_FD8_NEG	353.0	357.0	9	355.0	47	19.5	- 12.3	
70TRL_FD8_NEG + 6dB	352.0	356.5	10	354.0	47	47.7	- 10.5	
70TRL_FD8_POS	ND							
70TRL_FD8_POS + 6dB	351.5	359.5	17	353.0	- 10	40.6	- 11.9	
70TRL_FD12_NEG	351.0	360.0	19	352.5	54	35.9	- 7.0	
70TRL_FD12_NEG + 6dB								
70TRL_FD12_POS	352.0	360.0	17	353.5	- 26	40.2	- 6.0	
70TRL_FD12_POS + 6dB								
60T_NEG	ND							
60T_NEG + 9dB	353.0	358.0	11	355.5	49	54.7	- 12.3	
60T_POS	ND							
60T_POS + 9dB	ND							
70T_NEG - 6dB	ND							
70T_NEG + 6dB	352.0	359.0	15	355.5	59.3	67.2	- 7.5	
70T_POS - 6dB	353.0	359.5	14	353.5	- 52.3	31.5	- 14.1	
70T_POS + 6dB	353.0	359.5	14	353.5	- 53.5	> 100		
45TANDEM_NEG	ND							
45TANDEM_NEG + 9dB	351.0	360.0	19	358.5	150.7	60.9	- 11.4	
45TANDEM_NEG + 15dB								





## **European Commission**

### **EUR 22907 EN – DG JRC – Institute for Energy ULTRASONIC INSPECTION RESULTS OBTAINED IN THE ENIQ 2ND PILOT STUDY**

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#### **Abstract**

This report is a compilation of the ultrasonic non-destructive inspections results obtained on the ENIQ 21 BWR-type nozzle to shell weld mock-up. The report has been divided into three different sections

- 1) Report on inspection results obtained on the unclad mock-up
- 2) Report on inspection results obtained on the clad mock-up
- 3) Relevant appendices to these inspection reports

The first series of measurements was carried out at the premises of Westdyne TRC (Sweden) in 2002 and the second part was carried out at the JRC of the European Commissions in the Netherlands in 2005.

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