BKW	BKW FMB ENERGIE AG KERNKRAFTWERK MÜHLEBERG	**Prüfprotokoll** **Ultrasonic Examination**	**U-12/22** **Page 1 of 9**

	Prüfzeitpunkt: **ISI OUTAGE 2012**		Exam.Date::25-27, August, 2012	
Prüfobjekt	System: **002**		MKZ. Nr: **002 A 0001**	Wst. Gr.: Ferrit mit Plattierung
	Komponente / Abschnitt: **REAKTORDRUCKBEHÄLTER**		Prüfbereich: **See Figure 3**	
Dokumente	WP-Nummer: WP-Lfd-Nr. --	SK: **1**	Examination Type: **Base Material Examination based on ASME Section III 2010 Edition**	Detail Prüfblatt: -
	Prüfvorschrift: Rev.: **GEH-UT-728 V.0**	BPP: Lfd. Nr.: **WCP: GEH-UT-728 V0 Rev. 0** -		Zchng.-Nr.: -

Equipment

☒ Ultravision Z-Scan Version 1.2 Rev. 7 (1.2R7) ☒ GEH-I RPV ID Scanner

☒ Ultravision™ Workstation Version 1.2 Rev.7 (1.2R7)

Description and Results

2012 Reactor Pressure Vessel Base Material Exams:

Examinations were performed in the area illustrated in Figure 3 during the 2012 Outage at KKM.

Straight and angle beam examinations were performed in a 500 mm wide section of the reactor pressure vessel, located at 22° Az., extending from the flange elevation down to the shroud support plate. Limitations that were encountered in this scan area include the feedwater spargers, core spray piping, jet pump diffuser and shroud support plate.

Examination Results:

No reportable indications were found during the straight beam examinations.

No reportable indications were found during the angle beam examinations.

Geometric indications were recorded from the RPV flange, OD insulation support bracket attachments, vessel circumferential welds, shell course thickness transitions, and ID clad roll (full V path). Indications from water coupled signals from the examination scanner and entry surface noise were evaluated and determined to be non-relevant.

The 2012 examination data shows that there were no fabrication type reflectors or other adverse conditions present in the scanned areas.

Conclusions:

Calibrations, examinations, and evaluations were performed in the presence of representatives from SVTI and KKM. This examination is complete and accepted by SVTI, KKM and GEH-I and documented in GEH-I Report 6538-181058-BN1-RPVID. For examination procedures, personnel certifications and equipment certifications reference GEH-I-QA-01.

A more detailed description of the examination may be found in the following pages.

GEH-I	Prüfaufsicht	Werksachverständiger, Sachbearbeiter	SVTI
Datum: 29.Aug.2012	Visum:	Datum: 29.08.2012	Datum: 29.08.2012

[redacted]

Examination Requirements

KKM and GE Hitachi performed examinations of selected areas of the KKM Reactor Pressure Vessel base material based on the requirements of the 2010 Edition of ASME Section III. The examination was intended to confirm that the original Reactor Pressure Vessel fabrication non-destructive examinations were effective and that the base material of the KKM vessel was in the proper material condition with no fabrication related or other adverse conditions present.

The 2010 Edition of ASME Section III, NB-2542.1 requires examinations for forgings in accordance with Article 5 of Section V. The acceptance standards are defined in Section III NB-2542.2. GE Hitachi's examination techniques were developed to comply with these requirements to the extent possible with the vessels current operational status.

ASME Section V, Article 23, SA-388/SA-388M is intended for the in process examination of forgings prior to their final field assembly. For reactor pressure vessels this would have been prior to the application of clad to the inside surface.

Straight Beam Exams

ASME Section III, NB-2542.2(b) *Straight Beam Special Rule for Vessel Shell Sections* provides the acceptance standards for vessel shell forgings detected with straight beam techniques.

(1) A ring forging made to fine grain melting practice and used for vessel shell sections shall be unacceptable if the results of the straight beam radial examination show one or more reflectors producing a continuous complete loss of back reflection accompanied by continuous indications on the same plane that cannot be encompassed with a circle whose diameter is 3 in. (75 mm) or one-half of the wall thickness, whichever is greater.

(2) In addition, two or more reflectors smaller than described in (1) above shall be unacceptable unless separated by a minimum distance equal to the greatest diameter of the larger reflector or unless they may be collectively encompassed by the circle described in (1) above.

Note - Complete loss of back reflection is assumed when the back reflection falls below 5% full calibration screen height, reference NB-2542.2(a). Note – The reduction of a 75% FSH reflector to 5% FSH equals a 24 dB decrease in amplitude..

The straight beam examinations were performed using the techniques described in SA-388 section 8.2 *Straight-Beam Examination*. A registration level was established in addition to the techniques described in section 8.2.2.1 *Back-Reflection Technique.* [redacted]

Angle Beam Exams

ASME Section III, NB-2542.2(c) *Angle Beam Rule* provides the acceptance standards for vessel shell forgings detected with angle beam techniques.

(c) A forging shall be unacceptable if the results of angle beam examinations show one or more reflectors which produce indications exceeding in amplitude the indication from the appropriate calibration notches.

ASME Section V, Article 5, T-571.2 Forgings and Bars, provides the inspection requirements for forged materials as used at KKM.

The examinations were based on the requirements of SA-388/SA-388M. Angle beam examinations are required in both the axial and circumferential directions.

The angle beam examination was performed using the techniques described in SA-388 section 8.3 *Angle Beam Techniques – Rings and Hollow Forgings*: The normal practice for the examination of ring forgings is to machine calibration notches in the actual component for use as the calibration standard. GE Hitachi used the 25 mm long ID and OD notches in KKM's ASME basic calibration block (Figure 1) as a substitute for the calibration reflectors specified in SA-388 section 8.3.3 due to KKM being operational.

A registration level was established in addition to the techniques described in section 8.3.3. [redacted]

[redacted]

Deviations from Fabrication Examinations

The following deviations from the original Section III examination requirements for the angle beam examination were made.

(1) The vessel is clad with stainless steel to a nominal thickness of 4 mm. The original examination would have been performed in the non-clad as forged or machined surface.
(2) The calibration block is 148 mm in thickness. The original calibration material or actual component thickness was 100 mm or 120 mm in thickness.
(3) The calibration block is flat and the original calibration reflectors would have been oriented in both the axial and circumferential axis.

GE Hitachi's position is that these deviations from the SA-388 requirements did not adversely affect the intended examination based on the following.

(1) The examination system recorded the entire A-scan information without any threshold applied. All reflectors present were recorded and available for review. The influence of the clad material was compensated for in analysis by applying software controlled gain. Additionally the vessel clad condition is a design condition that cannot be changed in service.
(2) The use of a calibration block thicker than the material to be inspected resulted in an equal or slightly more sensitive examination.
(3) Calibration block curvature is addressed in ASME Section 5, Article 4, J-433(e) *Welds in Materials Greater than 20 in. (500 mm).* Which states "...Alternatively, a flat basic calibration block may be used provided the minimum convex, concave, and compound curvature radius to be examined is greater than the critical radius determined by Appendix A." Note – The reference to Appendix A is in error the correct reference is Appendix G. Material curvature is a non-critical factor on materials greater than 20 in. in diameter provided certain conditions have been met in accordance with Section V, Appendix G. These conditions only apply to convex surface materials and the flat block is acceptable for use.

Invessel Examination

GE Hitachi inspected an area 500 mm wide centered on the 22° Azimuth of the vessel. The examination was performed from the full accessible length of the vessel extending from the flange surface to the shroud support plate reference Figure 3. This examination area passes through all five shell courses of the vessel and represents all fluence conditions experienced by the vessel in service. Scanning of this length was limited due to the feedwater spargers, core spray piping, jet pump diffusers and shroud support plate.

Straight Beam Examination

The straight beam examination was performed using four (4) 0° longitudinal wave search units. The 0° search units were located in all four extremities of the search unit package, reference Figure 2. This provides for the maximum amount of coverage with a significant amount of overlap. Most areas were examined by all four search units. Reference Figure 4 for an example of a straight beam analysis display.

During the analysis of the straight beam data coupling efficiency was verified by evaluating the back wall reflection response. The back wall reflection was affected by the as welded clad inside surface of the vessel and average variations in the back wall of 6 dB were observed which is an expected condition. Loss of back wall reflection was observed where the OD surface was not parallel to the ID surface which is an expected condition. These areas are located where the thicknesses of the vessel changes and also at the vessel flange.

No areas of reduced back wall reflection associated with mid wall reflectors were detected. No mid wall reflectors exceeding the registration level were detected. No mid wall reflectors were observed.

[redacted]

Angle Beam Examination

The angle beam examination was performed using four (4) 45° transverse wave search units. The 45° search units were oriented with the sound beams directed in four orthogonal directions; looking up, clockwise, down and counter-clockwise (Figure 2). This provides for the maximum amount of coverage with most areas of the scanned volume being examined from four beam directions.

During the analysis of the angle beam data, coupling efficiency was verified by evaluating the inside surface clad roll reflection recorded by the full V examination. The clad roll reflection was affected by the as welded clad inside surface of the vessel resulting in characteristic patterns in the top view displays. These patterns were used to verify coupling efficiency. Reference Figure 5 for an example of an angle beam analysis display.

No reflectors associated with surface flaws were detected. No mid wall reflectors exceeding the registration level were detected.

Summary of Examination Results

Straight Beam Exams – 0° Base Material	No recordable indications were detected.
Angle Beam Exams – 45°S Looking Clockwise.	No recordable indications were detected.
Angle Beam Exams – 45°S Looking Counter Clockwise.	No recordable indications were detected.
Angle Beam Exams – 45°S Looking Up.	No recordable indications were detected.
Angle Beam Exams – 45°S Looking Down.	No recordable indications were detected.

Indications from geometric reflectors were evaluated and determined to be non-relevant.

Coverage Achieved (Figure 3)

85%	Shell Course 1 (V1 to V2)	Scanning was limited due to the shroud support plate and jet pump diffusers.
100%	Shell Course 2 (V2 to V3)	Scanning was not limited.
100%	Shell Course 3 (V3 to V4)	Scanning was not limited.
73%	Shell Course 4 (V4 to V5)	Scanning was limited due to the feedwater spargers and core spray piping.
100%	Shell Course 5 (V5 to V6)	Scanning was not limited.

[redacted]

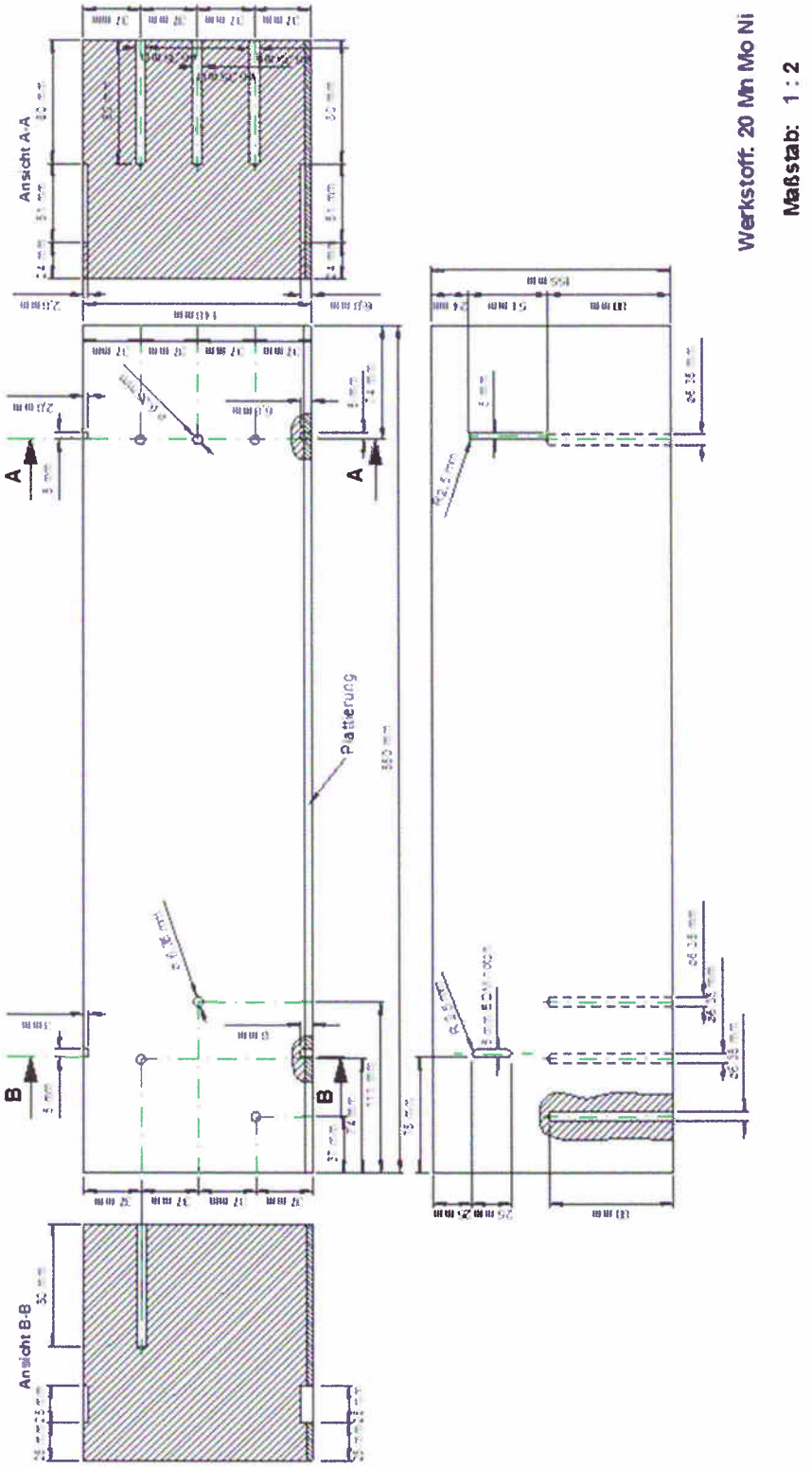

Figure 1 – KKM ASME Basic Calibration Block

[redacted]

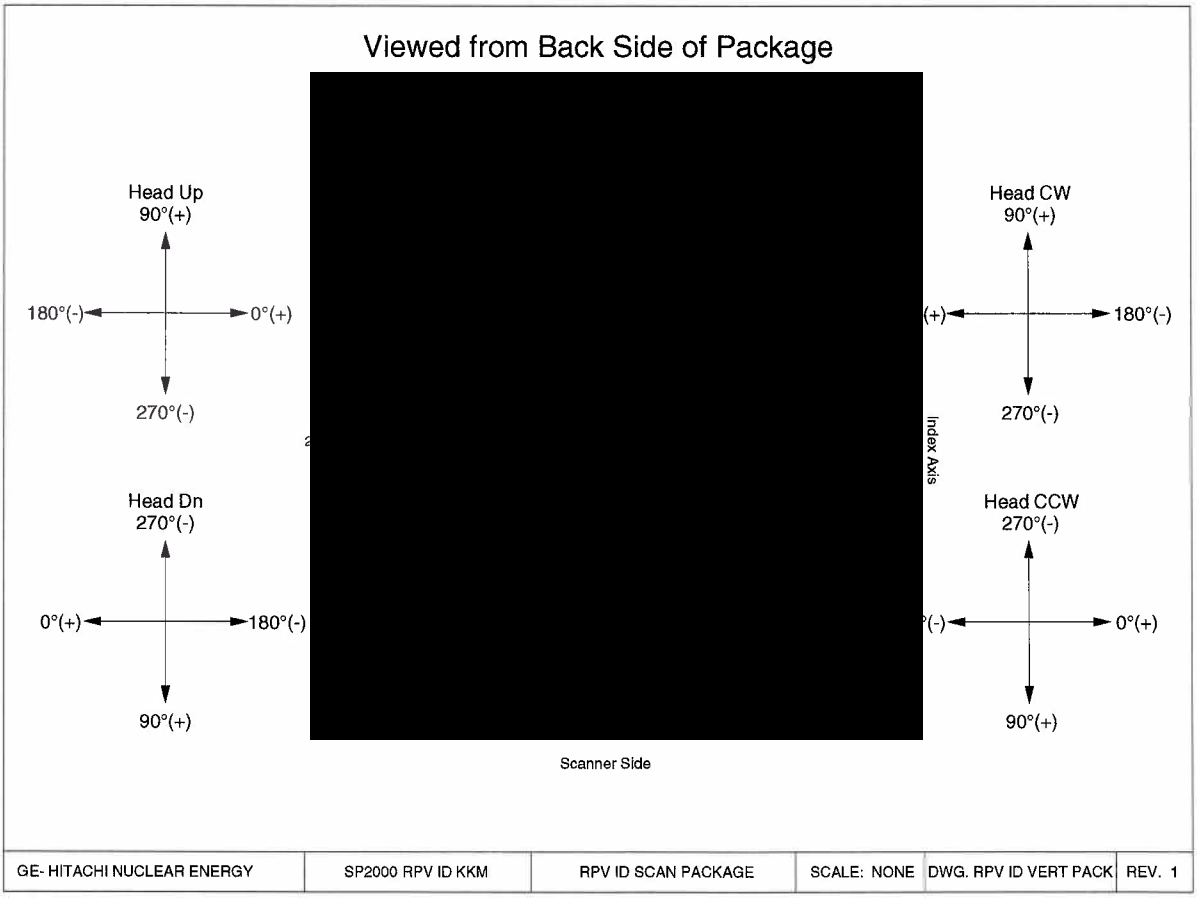

Figure 2 – RPVID Search Unit Package for KKM

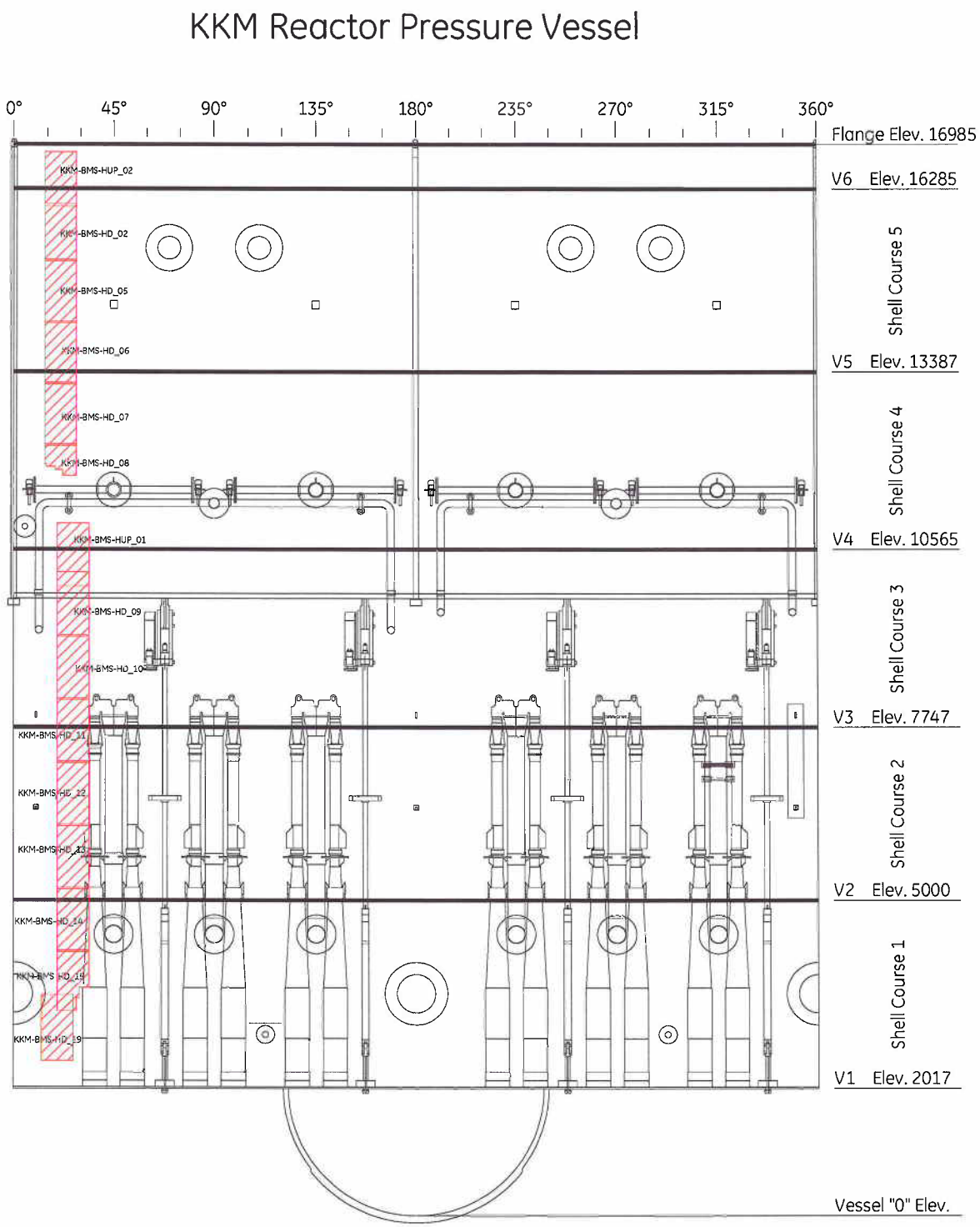

Figure 3 –Scanned Area Map for KKM RPVID Exams

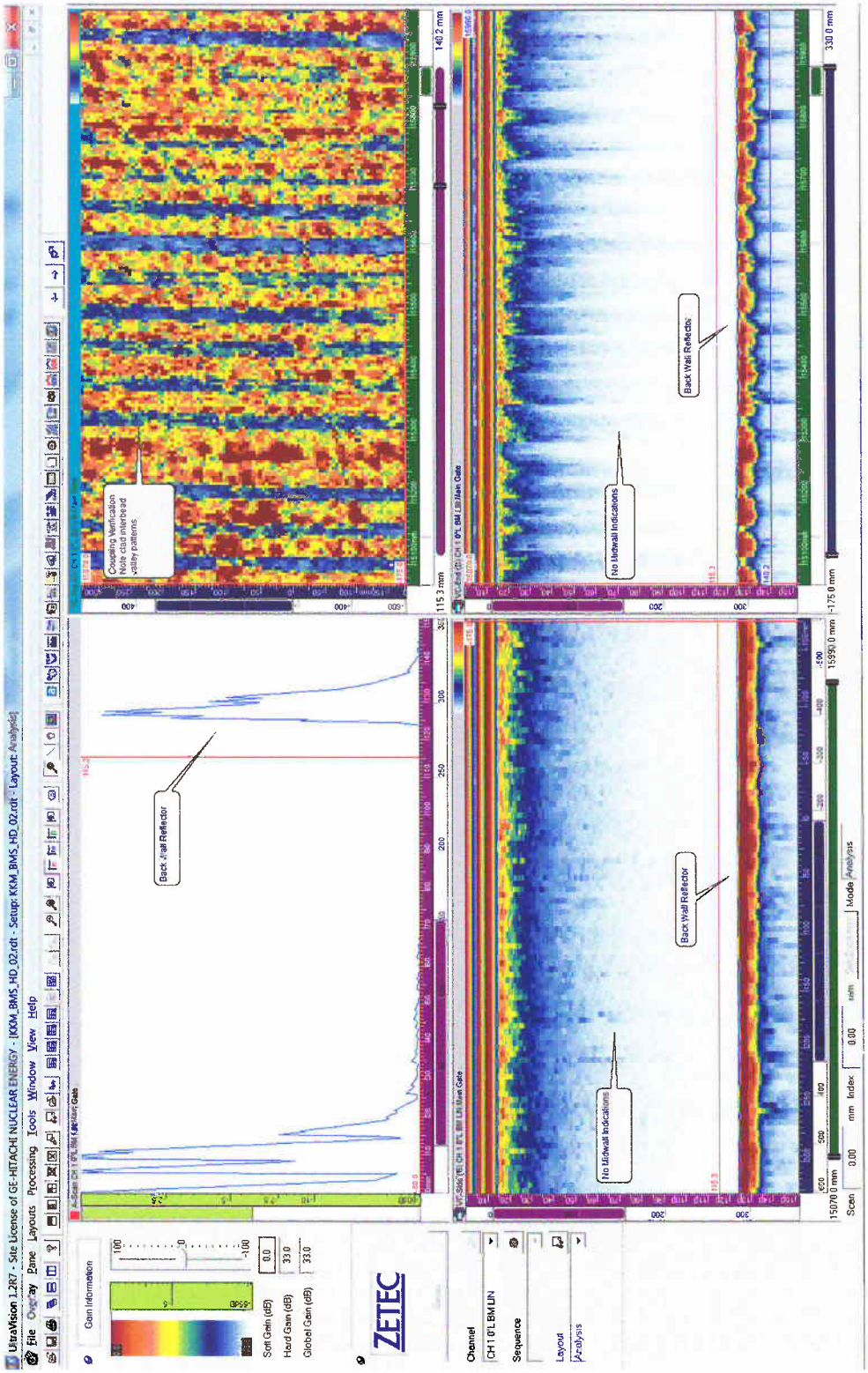

Figure 4 – Example of a Straight Beam Display from a KKM Shell Course

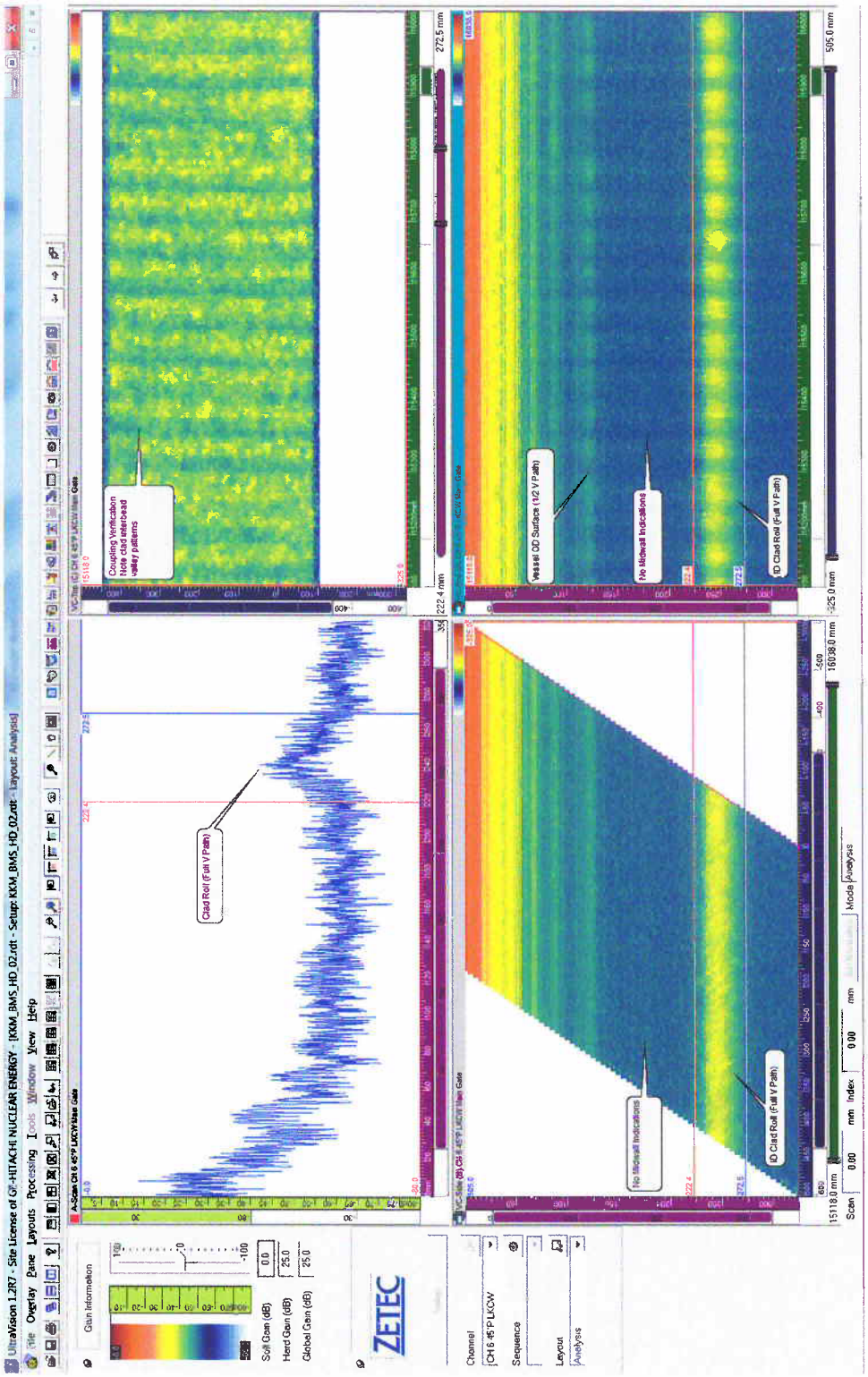

Figure 5– Example of an Angle Beam Display from a KKM Shell Course