SKBF TEKNISK
KBS RAPPORT

83-32

Feasibility study of detection of defects in thick welded copper

Tekniska Röntgencentralen AB
Stockholm, Sweden April 1983

SVENSK KÄRNBRÄNSLEFÖRSÖRJNING AB / AVDELNING KBS

POSTADRESS: Box 5864, 102 48 Stockholm, Telefon 08-67 95 40

FEASIBILITY STUDY OF DETECTION OF DEFECTS IN THICK WELDED COPPER

Tekniska Röntgencentralen AB
Stockholm, Sweden April 1983

This report concerns a study which was conducted for SKBF/KBS. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

A list of other reports published in this series during 1983 is attached at the end of this report. Information on KBS technical reports from 1977-1978 (TR 121), 1979 (TR 79-28), 1980 (TR 80-26), 1981 (TR 81-17) and 1982 (TR 82-28) is available through SKBF/KBS.

TRC

TEKNISKA RÖNTGENCENTRALEN AB

FEASIBILITY STUDY OF DETECTION OF DEFECTS IN THICK WELDED COPPER

Tekniska Röntgencentralen AB
April 1983

SUMMARY

The report describes a feasibility study of detecting defects in welded material using focussed ultrasonic beams. The ultrasonic testing has been applied to both electron beam welded thick walled copper containers and copper containers sealed by hot isostatic pressing.

The study shows that focussed ultrasonic technique is capable of detecting small defects in thick welded copper. This is illustrated on test blocks as well as on simulated full scale welds and joints using hot isostatic pressing.

TRC

TEKNISKA RÖNTGENCENTRALEN AB

Testing and Service
Testing and Inspection
Technology

Carl-Gustaf Öhnfeldt/ewi

April 1983

FEASIBILITY STUDY OF DETECTION OF DEFECTS IN THICK WELDED COPPER

Contents

Introduction

Tekniska Röntgencentralen AB has by order from Svensk Kärnbränsle Försörjning AB (SKBF) developed a technique for ultrasonic testing of thick welded copper containers.

This copper containers are going to be used for deposit of used fuel rods.

The aim is to detect and size defects in the welded material already at the manufacturing stage, when the fuel rods are inserted and welded into the copper containers.

Description of testing method

A non-destructive testing method, with ultrasonic focused beams is used to detect defects in the welded material.

The beam from the probe is focused by a lens which is shaped due to factors as distance in material,distance in water, type of defects etc.

The probe is aimed perpendicular to the assumed defect and if a discontinuity is detected by the soundbeam, this will give a reflection that is shown on a cathode-ray-tube screen as an echo.

The distance to the defect is measured on a scale, calibrated according to sound velocity in copper.

Material that should be tested is gated with a corresponding time gate, so that all defects within the gate appear as indications on the XY-recorder which is used for recording of the defects.

Recording of defects is performed with the C-scan method. Indications within the time gate appear as white areas at the recorder-sheet.

Sensitivity for testing can be alternated by reference from different reference-defects.

Description of the project

Testing of different welded copper specimens has been carried out at the following different steps.

1. Testing on Electronic Beam Welded (EBW) copperblock from Sciaky-France, with focused immersion ultrasonic technique. Report dated 1982-09-02.

   Enclosed as appendix 1.

2. Testing on copper container Robertsfors 1 with manual ultrasonic technique. Report dated 1982-12-06.

   Enclosed as appendix 2.

3. Testing on cutout of copper container Robertsfors 1, with focused immersion technique.

   Result enclosed as appendix 3.

4. Testing on copper container Robertsfors 2 with manual ultrasonic technique. Report dated 1983-05-11.

   Enclosed as appendix 4.

5. Testing on EBW copperblock from welding Institute GB with focused immersion ultrasonic technique.

   Result enclosed as appendix 5.

Equipment used in the test

In all the tests a puls-echo flaw-detecter Krautkrämer USIP 11 or similar has been used. For the immersion tests two different lenses have been calculated and manufactured. The first lens is designed for soundpath in material of 100 mm, and the second for 35 - 50 mm soundpath. Focus distance can be modified by changeing the water distance. A XY-recorder syncronized with scanning movement along and across the specimen, has been used.

For positioning of the probe at a certain distance and for performing the test a TRC fabricated manipulator has been used.

Testblocks have been immerged in a watertank and positioned along the scanning direction of a TRC-manipulator. The sensitivity level in all mechanised tests is at least comparable with flat-bottom hole Ø 2 mm.

Manufactoring of testblocks

To be able to compare indications found during testing reference defects with different shapes and differents depths have been placed in the test specimens.

Reference defects as flatbottom holes Ø 2 and Ø 4 mm and also side drilled holes Ø 2 mm have been used.

For detailed information see appendix 1 drawing SP 30186, appendix 3 drawing SP 30200 and appendix 5 drawing SP 30201.

Results and comments on results

1. Testing according to earlier described step 1 showed that focused ultrasonic technique is capable of detecting small defects in thick welded copper.

   On C-scan registration sheet, appendix 1, one clearly see indications from flatbottom holes Ø 2 mm. Lower to the right on "Registrering 2:2" one can also see indications from defects which later at a destructive examination where verified. The report from the destructive examination is enclosed as appendix 6.

2. At the test performed on copper container Robertsfors 1, several indications were found. This was a test to see if manufacturing conditions were satisfied. Manual testing is not so accurate as mechanised examination and is also difficult to register with good reliability.

3. Later when mechanised examination was performed it was verified that this sample showed big discrepancies. As can be seen in appendix 3 zone 1 is indicated as a large defect. In zone 2 one indication of major size was found.

4. A new test was carried out a new copper container no 2 at Robertsfors. In this test no indications was found exceeding the reference level, see appendix 4.

5. In the test specimen from Welding Institute - Great Britain a clear indication from the hole for the lifting lug can be seen. Also a major defect close to the side of the specimen can be seen. This is shown at the lower part to the right of registration sheet in appendix 5. Further more some small indications where registered.

Proposal for testing method and equipment for further tests on copper containers

With experience from the tests one can clearly see that ultrasonic testing immersion technique with focused probes is capable of detecting small defects in thick welded copper.

The copper containers should also, for good coupling with the probe, be placed in a watertank. An automatic system for scanning and recording could with great advantage be used. This will make inspection easier. Similar systems is used frequently by TRC when performing inspections at the nuclear power plants.

Appendix 1: Testing on electronic beam welded (EBW) copperblock from Sciaky-France, with focused immersion ultrasonic technique

Appendix 2: Testing on copper container Robertsfors 1 with manual ultrasonic technique

Appendix 3: Testing on cutout of copper container Robertsfors 1, with focused immersion technique

Appendix 4: Testing on copper container Robertsfors 2 with manual ultrasonic technique

Appendix 5: Testing on EBW copperblock from welding institute-GB with focused immersion ultrasonic technique

Appendix 6: Destructive examination on cutout of electron beam welded copper from Sciaky-France.

TESTING ON ELECTRONIC BEAM WELDED (EBW) COPPERBLOCK FROM SCIAKY-FRANCE, WITH FOCUSED IMMERSION ULTRASONIC TECHNIQUE

TRC
Tekniska Röntgencentralen AB
Testing and Service
C-G Öhnfeldt/ald

REPORT ON DETECTION OF DEFECTS IN WELDED COPPER USING FOCUSSED ULTRASONIC TECHNIQUE

Contents

Introduction

Tekniska Röntgencentralen AB has by order from Svensk Kärnbränsleförsörjning AB (SKBF) developed a technique for testing using ultrasonic focussed beams aiming at localizing, registrating, and sizing defects in electron-beam welded copper.

The purpose has been to localize and register defects, already at a manufacturing stage, in copper material, intended to be used as containers for final disposal of spent nuclear fuel.

Construction and manufacture of reference block

To be able to measure the sound field of the focussing ultrasonic probe, a representative reference block has been made. The block, which is of an identical copper material with weld, has been supplied by SKBF.

Representative defects for sensitivity calibration and sizing in the form of cylinder boreholes and flat bottom holes have been made in a copper block at actual sound paths. See drawing SP No 30186, enclosure 1.

Construction and manufacture of lens for testing with focussed ultrasonic beams

After having studied previously performed testings,i a with ultrasonic,it was decided to manufacture a lens for a larger planar ultrasonic probe in order to gain a narrow focussed sound field with which it is possible to penetrate the welded zone.

Due to the form of the block the lens was manufactured to produce a symmetric, point-focussed sound field at a distance of 100 mm in copper.

A holder for placing the lens on the ultrasonic probe was also manufactured.

Testing of probe

The testing of the reference block was performed as immersion testing with the block lying, alternatively standing on the end and with the ultrasonic probe directed perpendicular to the entrance surface. The testing was performed from three directions in subsequent longitudinal scans separated by 1 mm.

Equipment used

Ultrasonic Flaw-detector USIP 11

Frequency range	0,5 - 2.5 MHz
Impuls strength	1
Resolution	2
Measurement range	200 mm
Ultrasonic probe	Panametrics Ø 50 mm, 3 MHz

Focussed ultrasonic field measured with 6 dB-drop to Ø 4,4 mm.

Holder for ultrasonic probe
TRC Immersion test equipment
XY-recorder Hewlett-Packard
Polaroid-camera

Examples of registration

The registration, which is made using an XY-recorder calibrated in scale 1:1, has been chosen to be presented in C-scan. This means that the picture on the registration sheet represents a perpendicular section of the tested area.

Blank areas are reference defects and registered indications. At the bottom of registration sheet 1, enclosure 2, one can see a registration aiming at a sensitivity calibration of the equipment aginst reference defects.

The two upper registrations are scans of the welded zone with registered indications.

On registration sheet 2 one can see in addition to the sensitivity calibration a registration aiming at assessing the differences in sensitivity for two equally sized reference defects placed above, respectively below, the welded zone. The relative difference was measured to be 6dB.

Results

On the registration sheets 1:2 and 2:2 an area can be seen that repeatedly exhibits similar defect patterns. This area has on request from SKBF been cut out of the test block for destructive testing. [x)]

Complementary measurements using conventional immersion technique have confirmed the result from the testing with focussed ultrasonic beams using long sound paths.

The cut-out piece is enclosed the report in form of a rod with the measures approximately 20 x 20 x 40 mm, where the largest defects are marked with center punch marks.

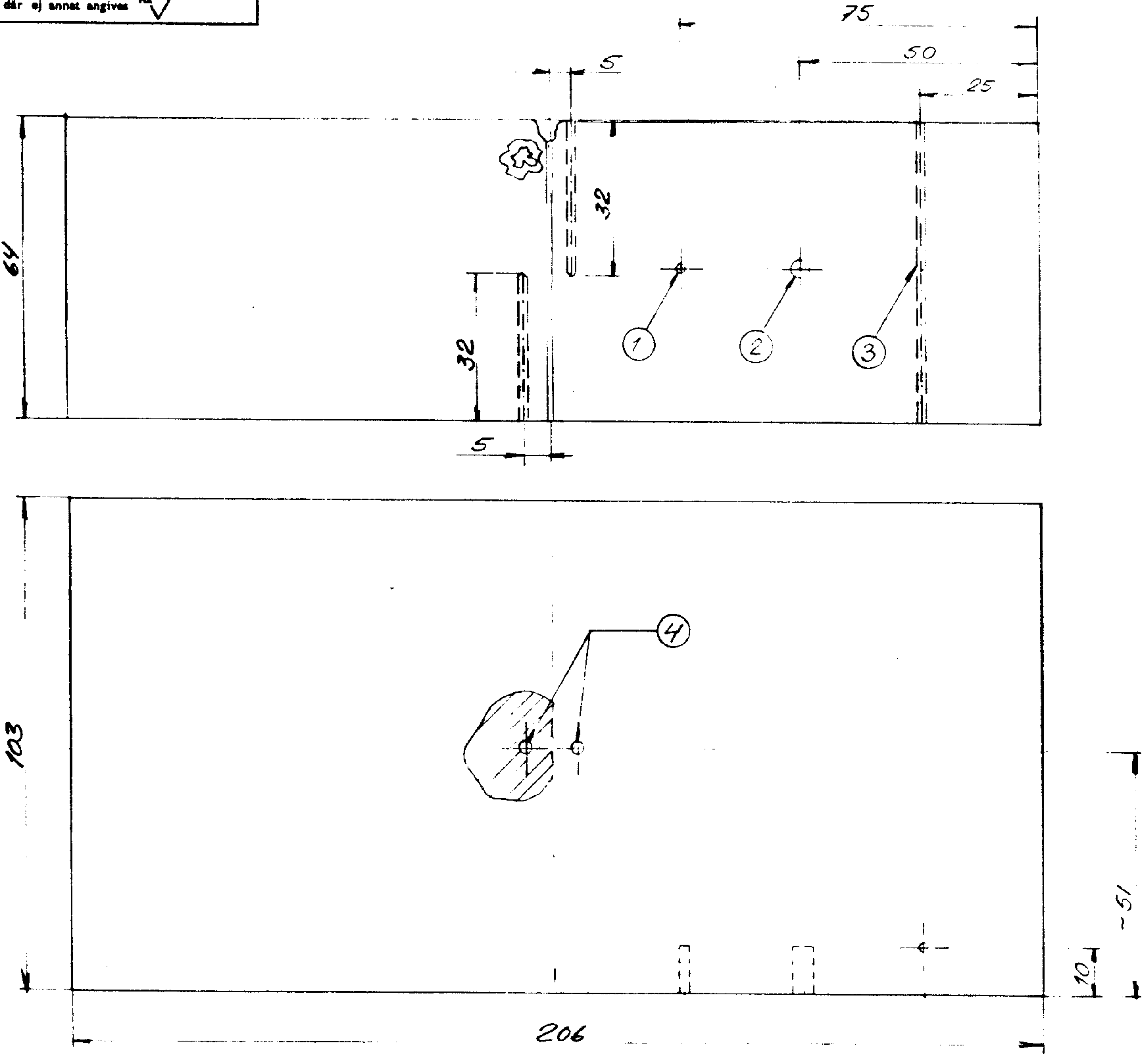
Enclosures: 1) Reference block drawing SP No 30186
2) Registration sheet C-scan no 1:2
" " " " 2:2

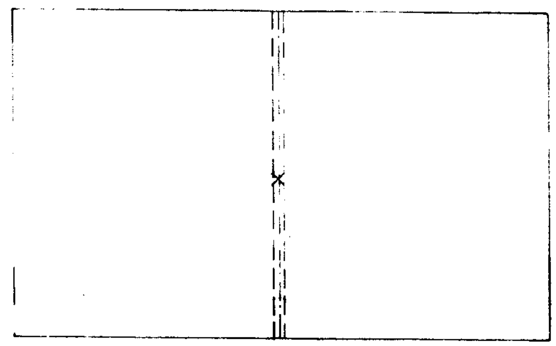
x) The results are presented in Appendix 6.

Tol. för icke direkt toleranssatta mått enl. SMS. 715

Ytjämnhet där ej annat angives Ra

Nr	Ant.	Ändring och/eller medd.-nr	Datum	Inf.	Godk.





Defect No	Type of Defect	Diam	Length
1	Flat bottomed hole	Ø2	10
2	"-	Ø4	10
3	Cylinder borehole	Ø2	64
4	"-	Ø2	32

Det.-nr	Ant.	Benämning	Material	Mod.-nr Ämne Dimension	Anm.
		SVETSPROV	KOPPAR		

Konstr.	Ritad	Kop.	Kontr.	Stand.	Godk.	Skala	Ersätter	Ersatt av
	CGO					1:1		

TRC TEKNISKA RÖNTGENCENTRALEN AB

SKBF MANTELPROV
BRÄNSLEFÖRVARING

Dat. 1982-06-09

Ritn.-nr SP 30186

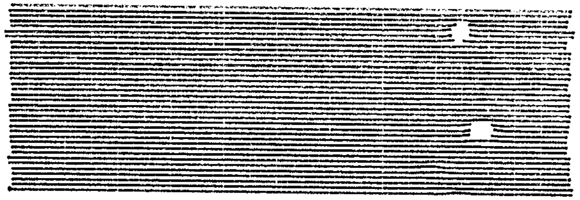
KBS -Weld test in copper intended for final storage of spent nuclear fuel

TÄBY 1982-07-07 JOJ/CGÖ

Ultra sonic flaw-detector:
USIP 11
frequency 0.5-2.5 MHz
impuls 1
resolution 2
range 200 mm

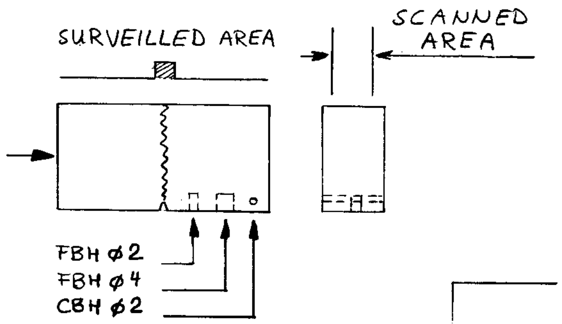
ultrasonic probe:

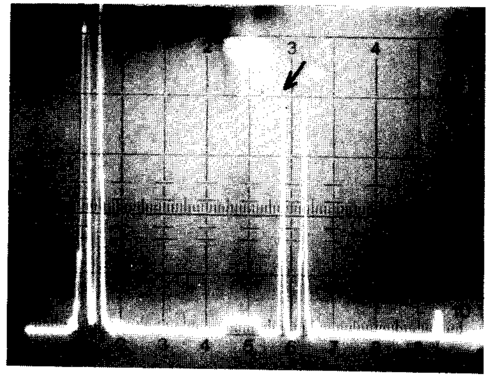
panametrics
Ø 50 3 MHz
focussed
sound beam
focussed 100 mm in Cu
focussed Ø 6dB-drop
≈4.4 mm



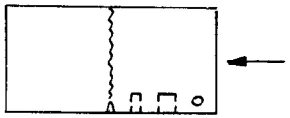
registration level=flat bottomed
hole Ø2 + 6dB

scanning from one end



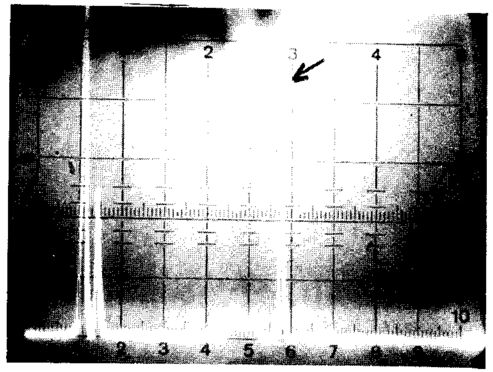


flat bottomed hole Ø2 mm 50dB

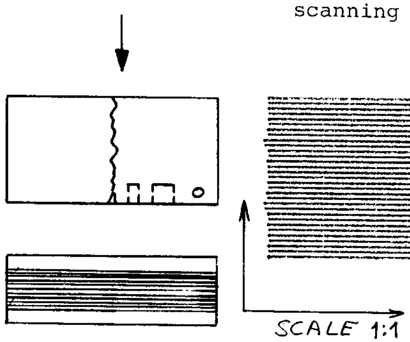


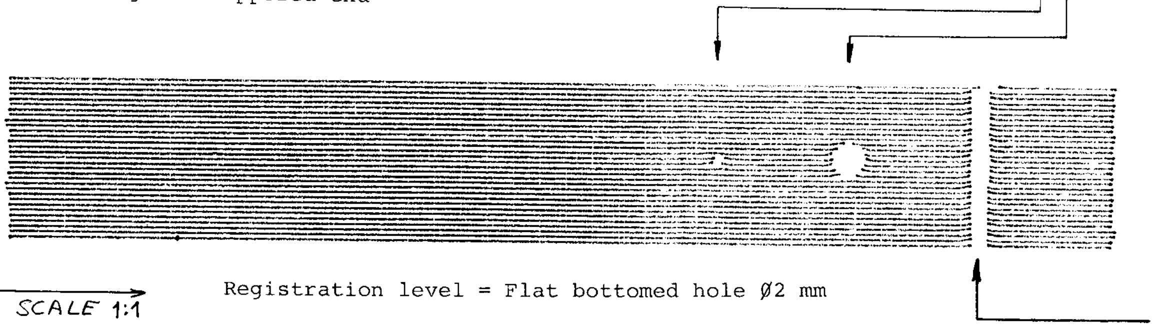
registration level =flat bottomed
hole Ø2 + 6dB

scanning from opposed end

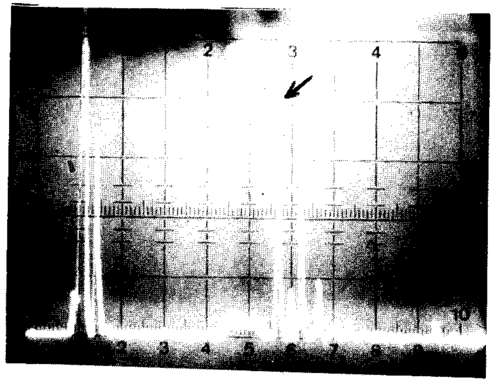


flat bottomed hole Ø4mm 40dB





Registration level = Flat bottomed hole Ø2 mm

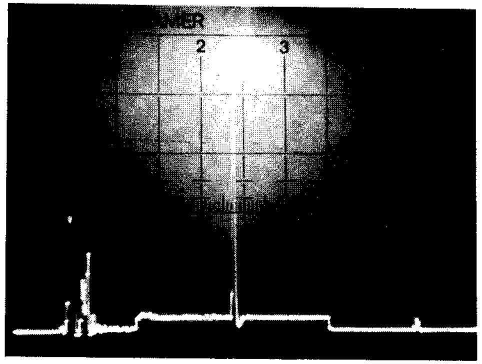


cylinder borehole Ø 2mm 44dB

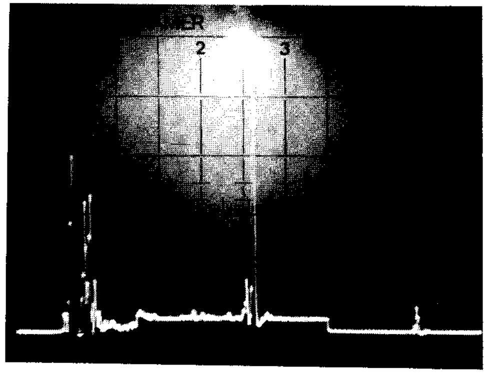
Appendix 2 Registration 1:2

TÅBY 1982-07-20 CGÖ

KBS - Weld test in copper intended for final storage of spent nuclear fuel

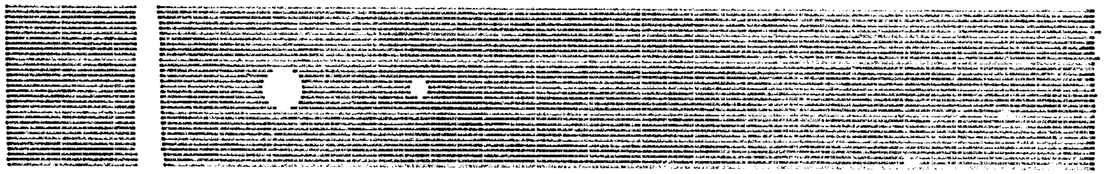


Ø2 cylinder borehole "above" weld

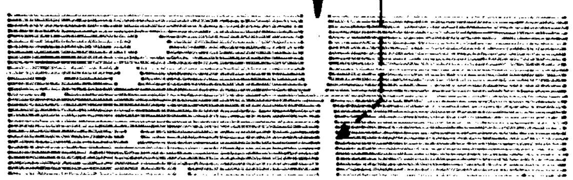


Ø2 cylinder borehole "below" weld

The relative sensitivity is 6dB lower



Registration level = Flat bottomed hole Ø2+6dB



Block standing on one end

Registration 2:2

TESTING ON COPPER CONTAINER ROBERTSFORS 1 WITH MANUAL ULTRA-SONIC TECHNIQUE

TRC
Tekniska Röntgencentralen AB
Testing and Service
Coordination and Development
Carl-Gustaf Öhnfeldt/ald

Report 1982-12-06

REPORT ON MANUAL ULTRASONIC TESTING OF COPPER CONTAINER

Contents

Introduction

Tekniska Röntgencentralen AB has by the order from Svensk Kärnbränsleförsörjning AB (SKBF) performed manual ultrasonic testing of a copper container manufactured by ASEA, Robertsfors.

Pre-investigation

Testing of the probe has been performed against a reference block manufactured in an equivalent copper material. In the reference block, reference reflectors have been made in the form of flat-bottomed holes with different diameters at different depths. Different normal beam probes have been tested against these reflectors. One of the flat-bottomed holes has also been used as a cylinder borehole, against which angle beam probes have been tested.

Equipment used

Ultrasonic flaw-detector USIP 11

Frequency range: 0.5 - 2.5 MHz
Impuls strength: 3
Resolution: 3
Measurement range: 100 mm long/trans

Ultrasonic probe

Panametric Ø 12.5 - 2.25 MHz, normal beam
" " " , angle beam probe, 45° in steel
RTD 2-crystal, 2 MHz, angular probe, 50° in steel with focussed sound beam.

Reference block in copper with flat-bottomed holes Ø 2.5 and 3.5 mm with different depths from 40-76 mm.

Polaroid camera

Test object

Testing has been performed against a copper container according to drawing ASEA-9397 626-7 (Kx3) clad with a 2.5 mm thick copper sheet.

The container was filled with simulated fuel elements and fine- grained copper powder which was sintered to a homogeneous body under high pressure and temperature.

Scope of testing

The purpose of the test was to establish if the joint between lid and cylinder was homogeneous, and also to establish if the copper sheet was joined to a cylinder.

Testing was performed from the outer surfaces of the lids and from the outer surfaces of the cylinder, see drawing "Directions of probing".

The test area was chosen randomly on an assigned half of the cylinder and lid.

Results

Local lack of bonding between copper sheet and cylinder and between sheet and lid could be established, see photograph no 13.

With normal beam probe in position 1, indications were obtained throughout the whole tested area, see photographs nos 1 and 7.

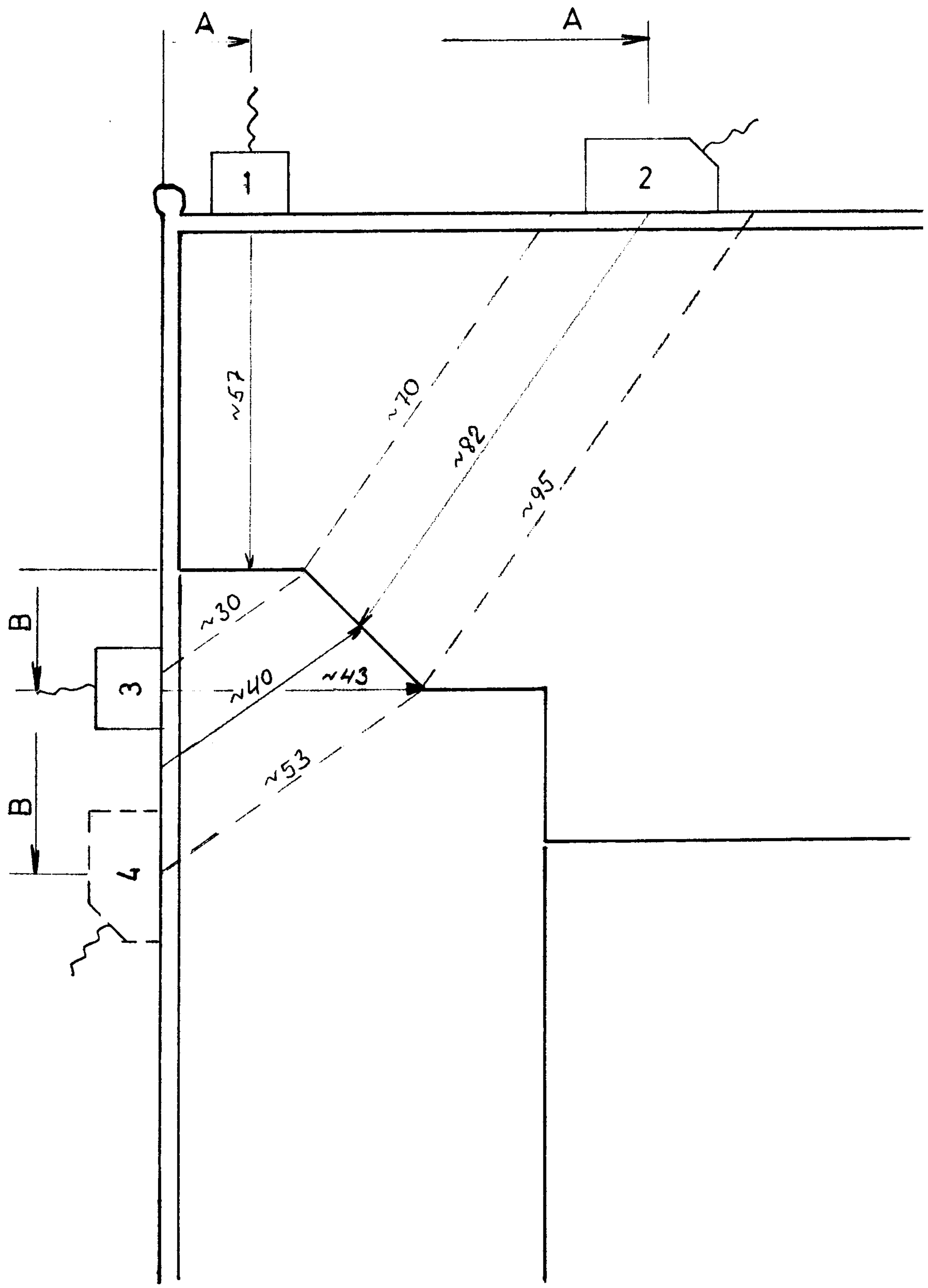
With normal beam probe in position 3, indications were obtained in randomly chosen areas, see photographs nos 3 and 9.

With angle beam probe in positions 2 and 4 indications were obtained in randomly chosen areas. See photographs nos 2, 4, 5, 6, 8, 10, 11 and 12.

See compilation of tests for further information.

SKBF - Manual ultrasonic testing of copper canister.

Directions of probing



COMPILATION OF TESTS

Photograph no	Position	Pos.	A	B	Sound path	Amplification	Comment
1	Top end	1	20		57	36	Normal beam probe
2	"	2	85		84	28	Angle beam probe (RTD)
3	Long side	3		20	36	40	Normal beam probe
4	"	3		27	34	52	Angle beam probe (Pan)
5	"	4		46	48	48	" " " "
6	"	4		40	42	24	" " " (RTD)
7	Bottom end	1	20		57	36	Normal beam probe
8	"	2	85		83	24	Angle beam probe (RTD)
9	Long side	3		20	32	46	Normal beam probe
10		3		20	30	46	Angle beam probe (Pan)
11		4		38	42	52	" " " "
12		4		32	40	24	" " " (RTD)

Photograph no 13 shows a position where the sheet-metal 2.5 mm has not been bonded to the container.

Figure appendix, Display photographs

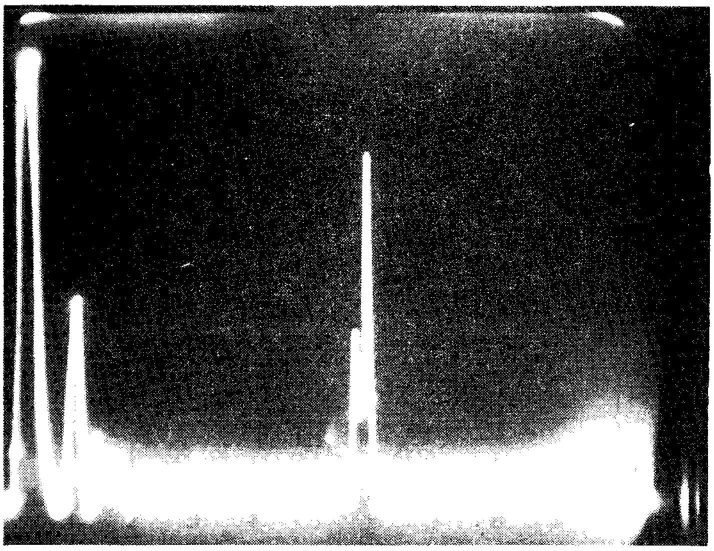


Photo no 1

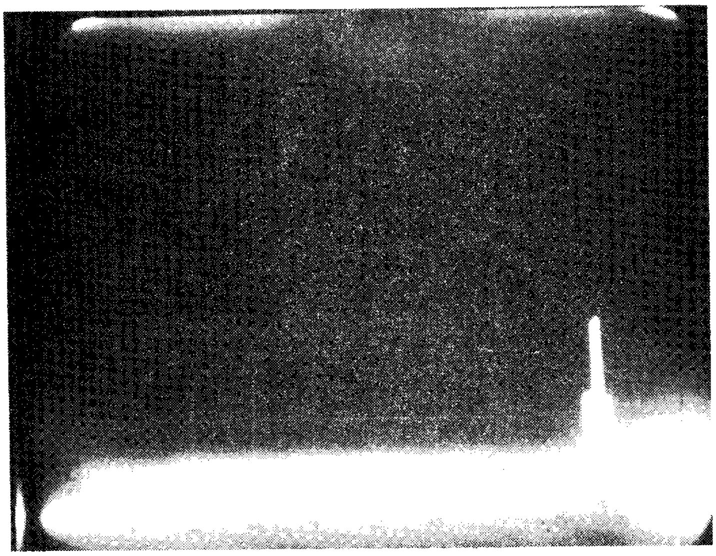


Photo No 2

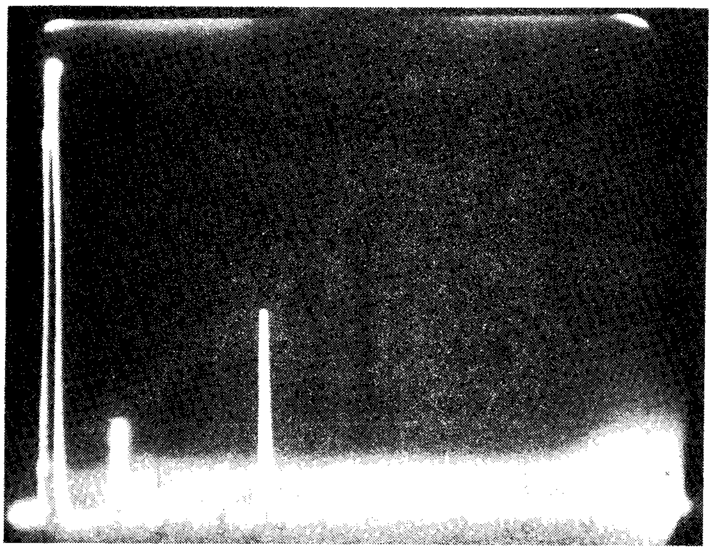


Photo no 3

TRC

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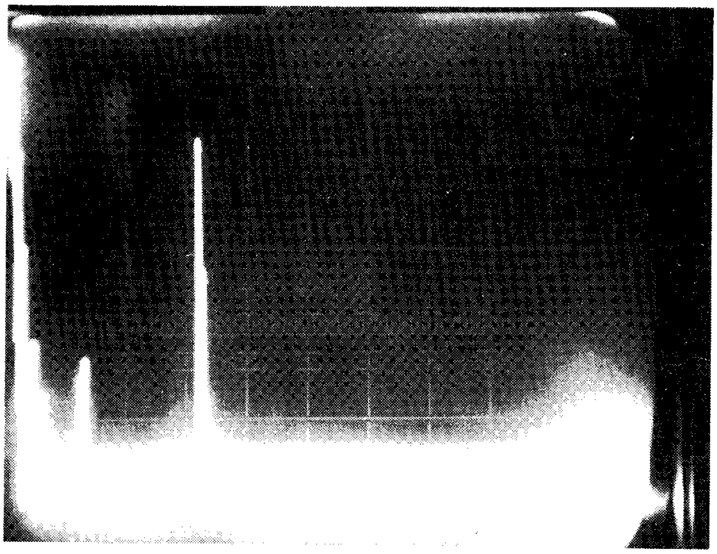
Figure appendix, Display photographs



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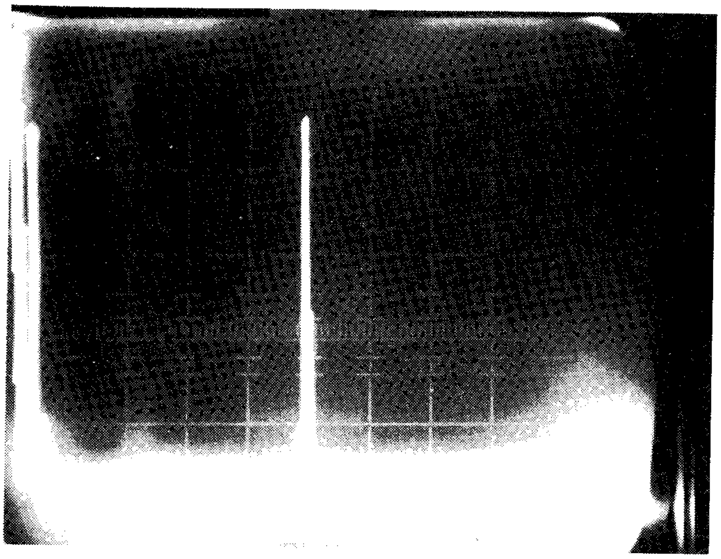

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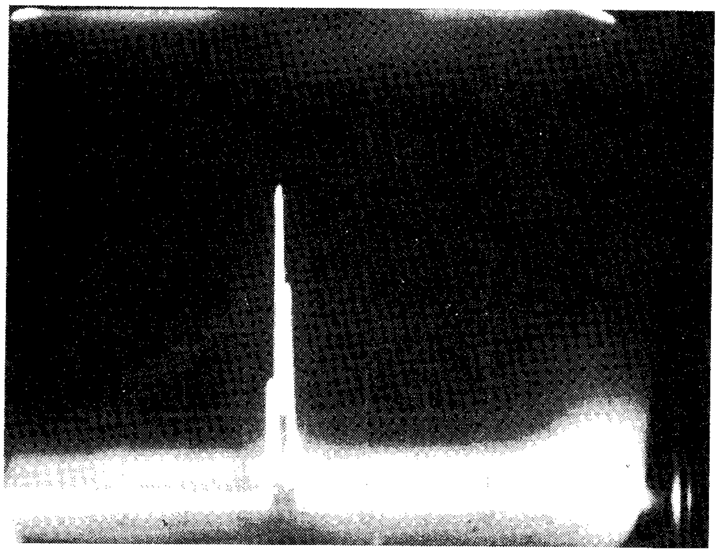

Photo no 6

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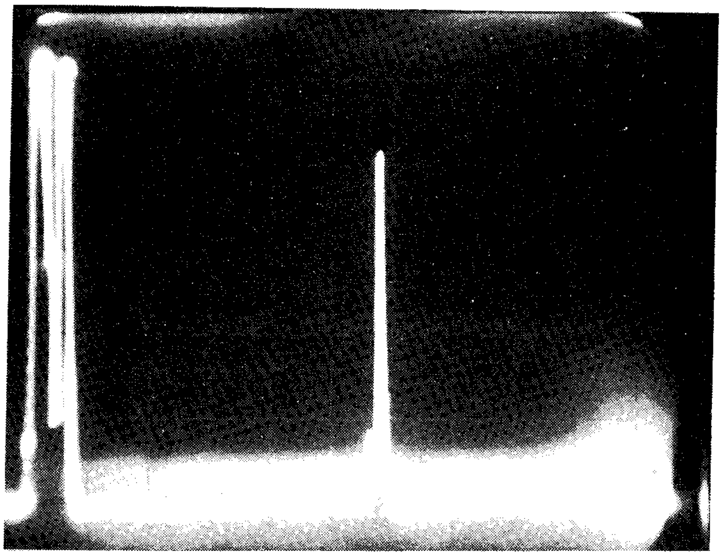
Figure appendix, Display photographs



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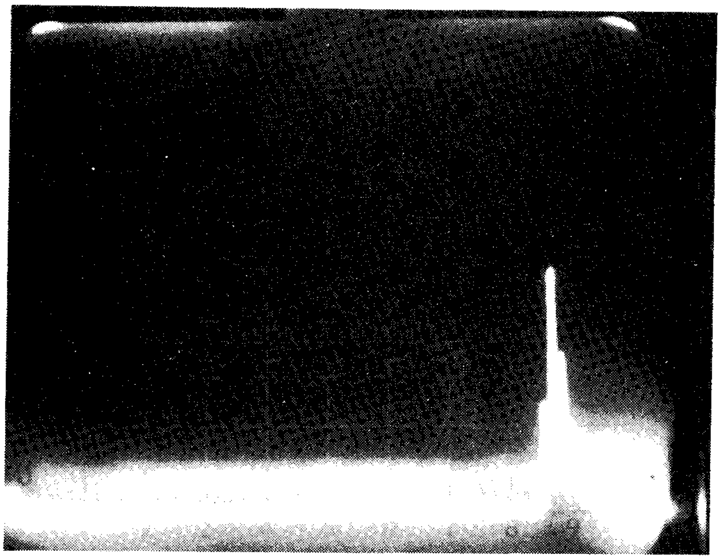

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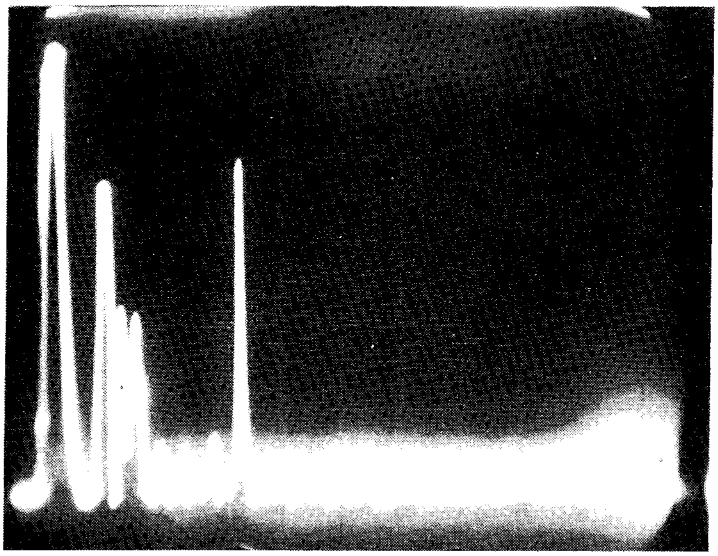


Photo no 9

Figure appendix, Display photographs

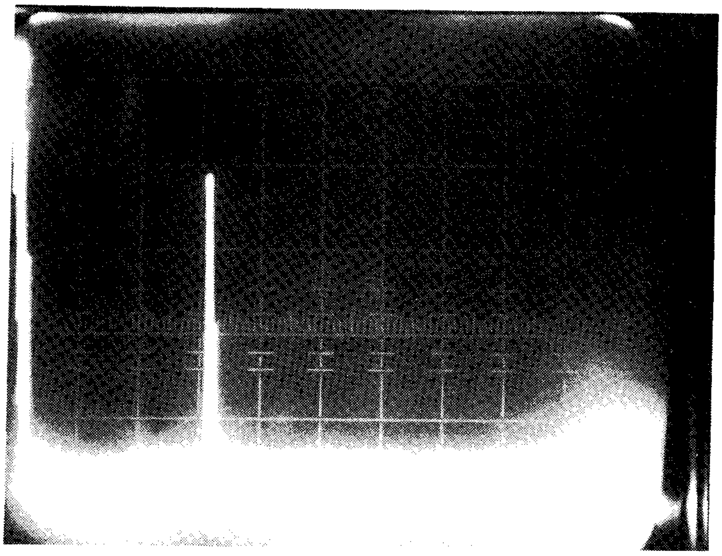


Photo no 10

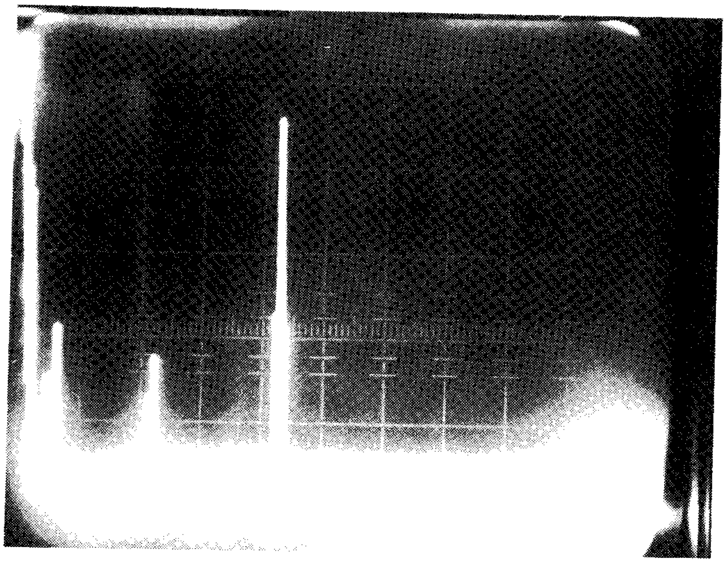


Photo no 11

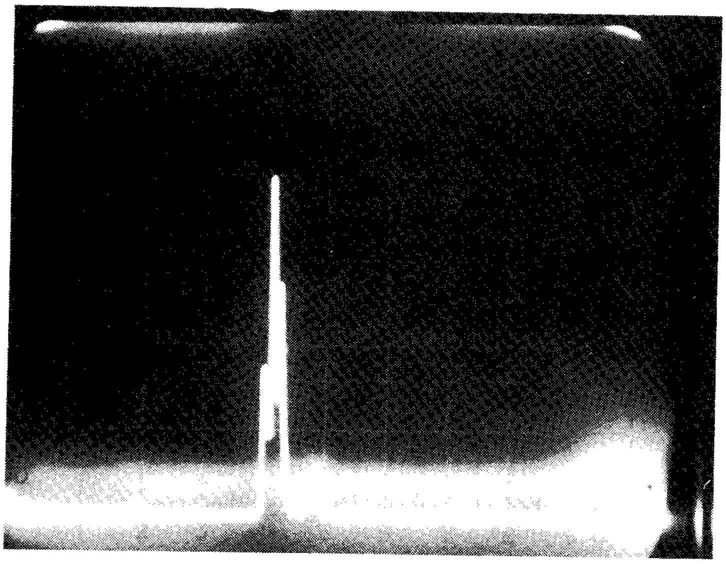


Photo no 12

Figure appendix, Display photographs

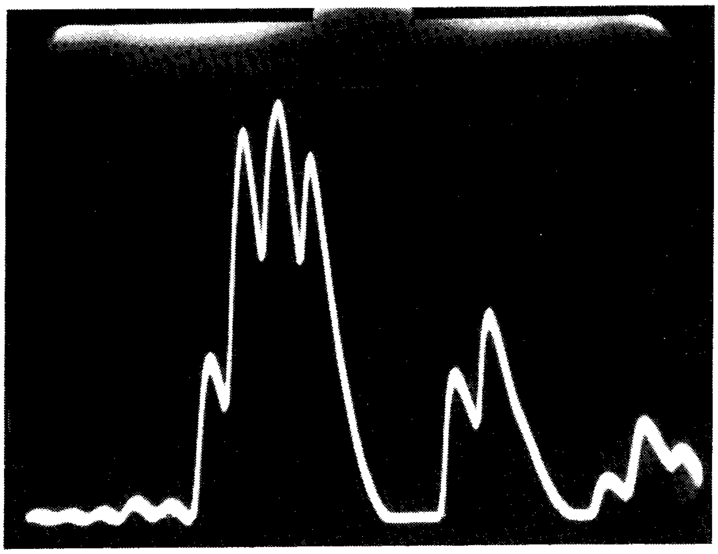


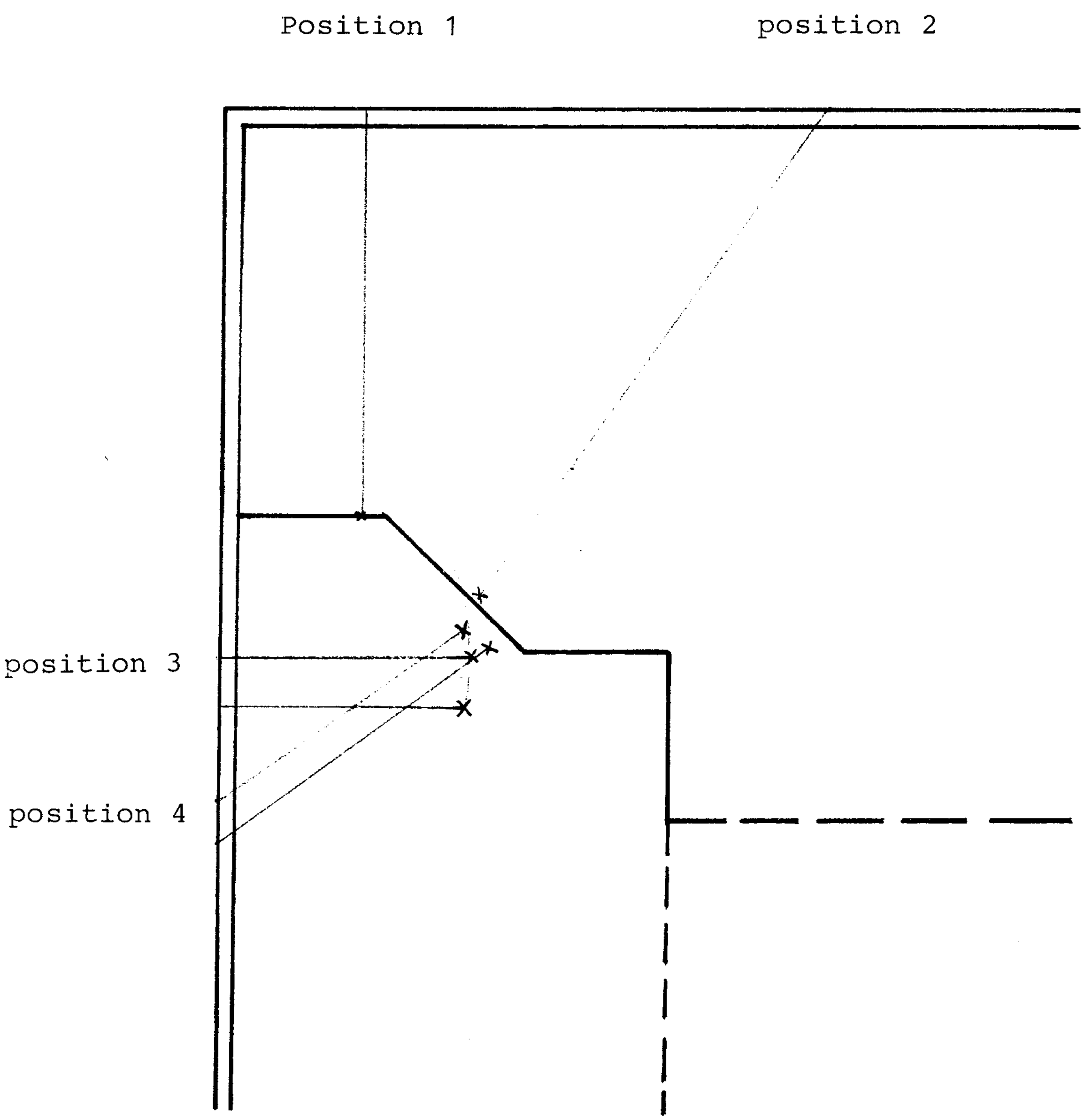
Photo no 13

SKBF - Manual ultrasonic testing of copper canister

Top end

Sound paths by recorded indications

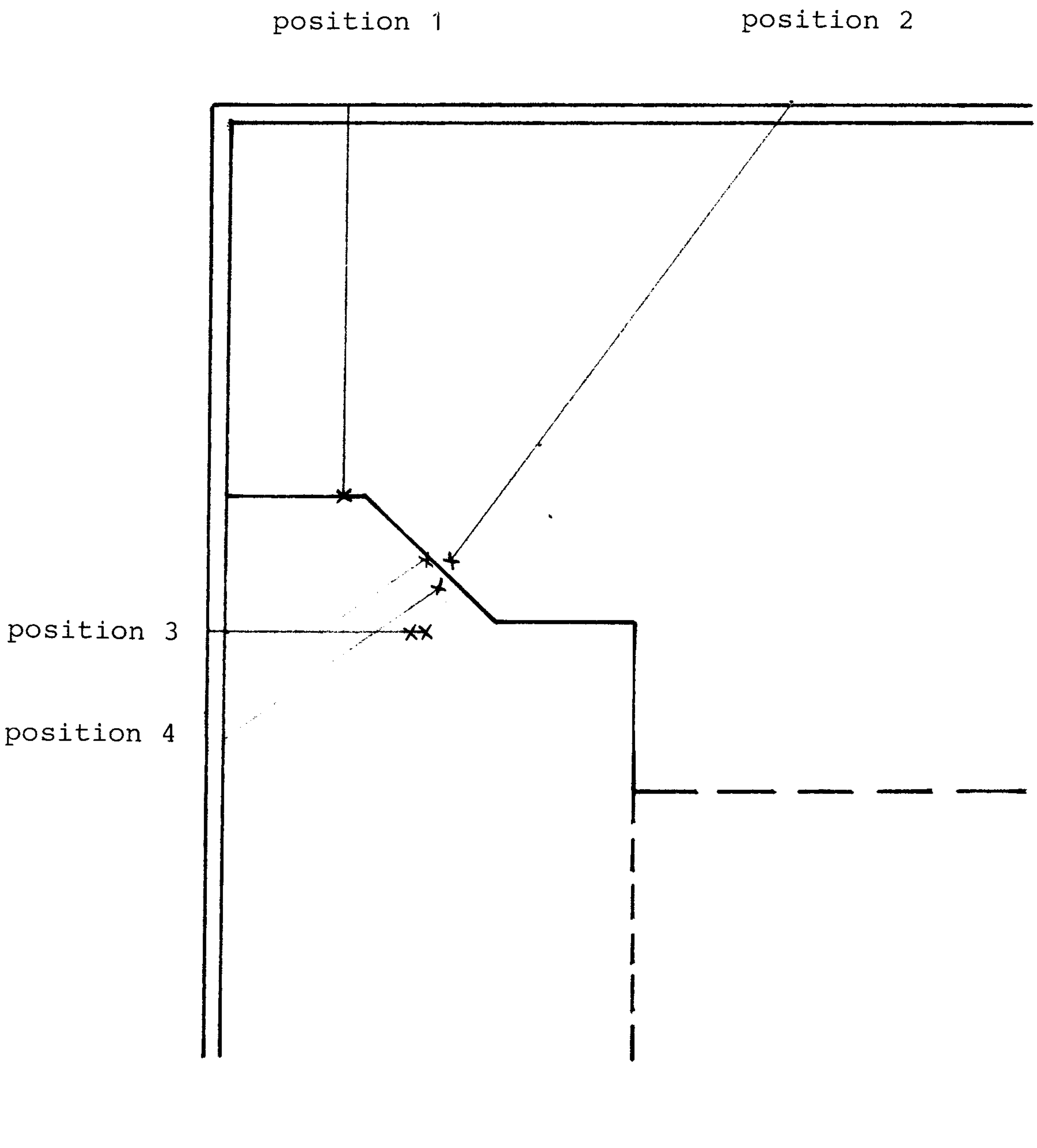
TÄBY 1982-12-03
CG ÖHNFELDT



Scale 1:1

SKBF - Manual ultrasonic testing of copper canister.
Bottom end
Sound paths by recorded indications

TÄBY 1982-12-03
C-G ÖHNFELDT

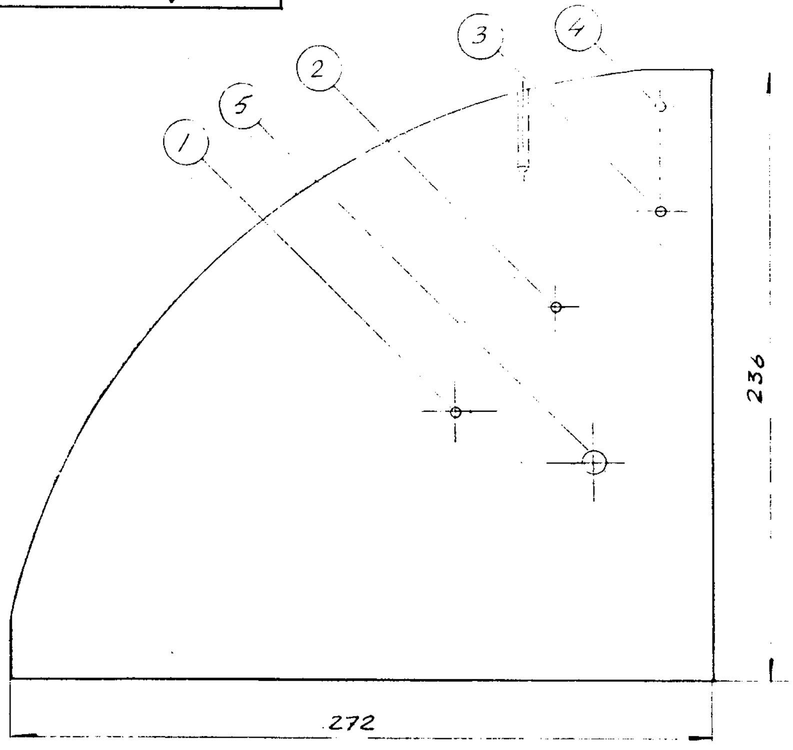


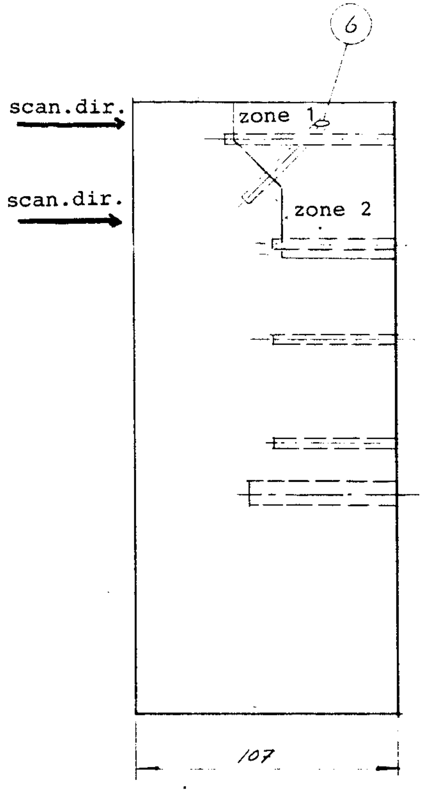
TESTING ON CUTOUT OF COPPER CONTAINER ROBERTSFORS 1, WITH FOCUSED IMMERSION TECHNIQUE

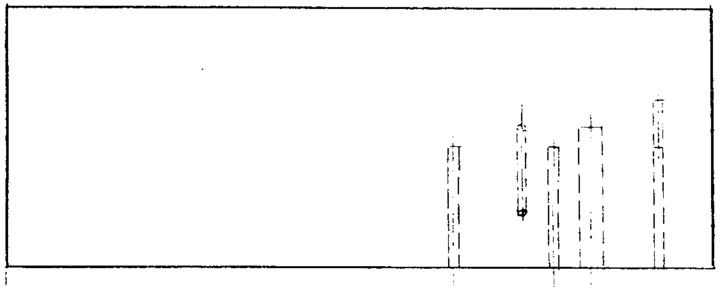
Tol. för icke direkt toleranssatta mått enl. SMS. 715

Ytjämnhet där ej annat angives Ra

Nr	Ant.	Ändring och/eller medd.-nr	Datum	Inf.	Godk.







Pos.	Designation	Diam.	Depth	Comment
1	Flat bottomed hole	3.0 mm	35 mm	From scanned end
2	"-	3.0 mm	53 mm	"-
3	"-	3.0 mm	53 mm	"-
4	"-	3.0 mm	35 mm	"-
5	"-	10.0 mm	45 mm	"-
6	"-	3.0 mm	62 mm	"-

Det.-nr	Ant.	Benämning	Material	Mod.-nr Ämne Dimension	Anm.
			kopper		

Konstr.	Ritad	Kop.	Kontr.	Stand.	Godk.	Skala	Ersätter	Ersatt av
	RGM					1:2		

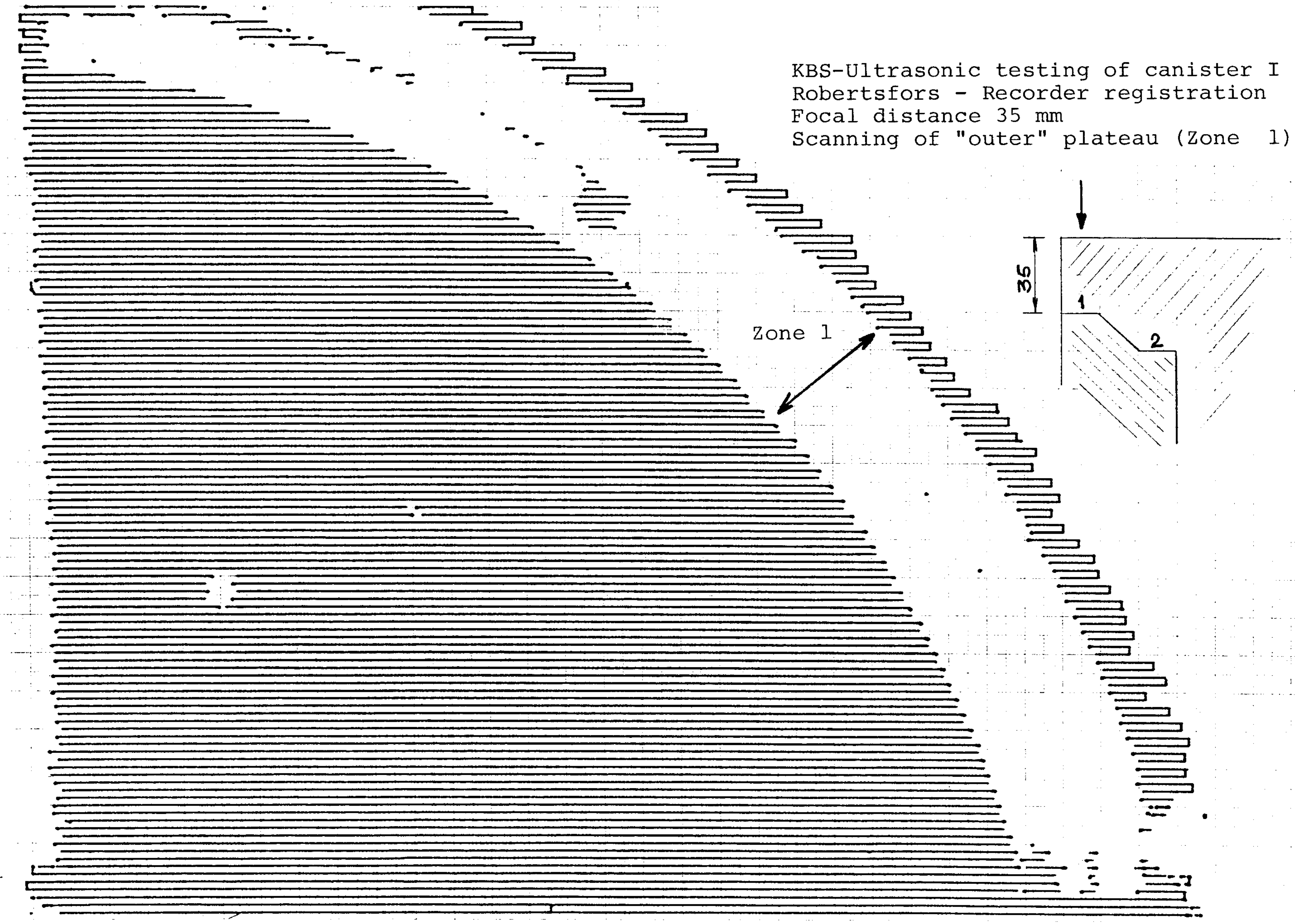
TRC
TEKNISKA RÖNTGENCENTRALEN AB

SKBF. Bränsleförvaring.
Svetsprov Robertsfors 1

Dat 830408

Ritn.-nr SP30200

KBS-Ultrasonic testing of canister I
Robertsfors - Recorder registration
Focal distance 35 mm
Scanning of "outer" plateau (Zone 1)



Scale 1:1

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TEKNISKA RÖNTGENCENTRALEN AB

KBS - ULTRASONIC TESTING OF CONTAINER I - ROBERTSFORS - FIGURE APPENDIX

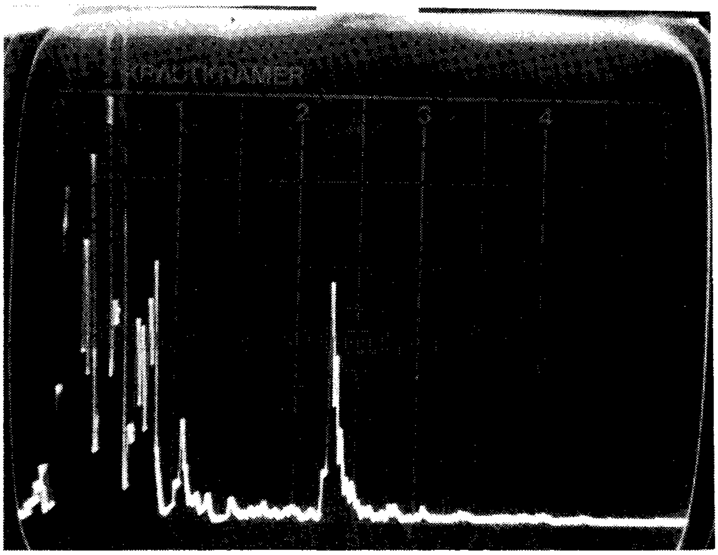


Figure 1
Flat bottomed hole Ø 10 mm
Sound distance 45 mm
Amplification 46 dB
Water distance 105 mm

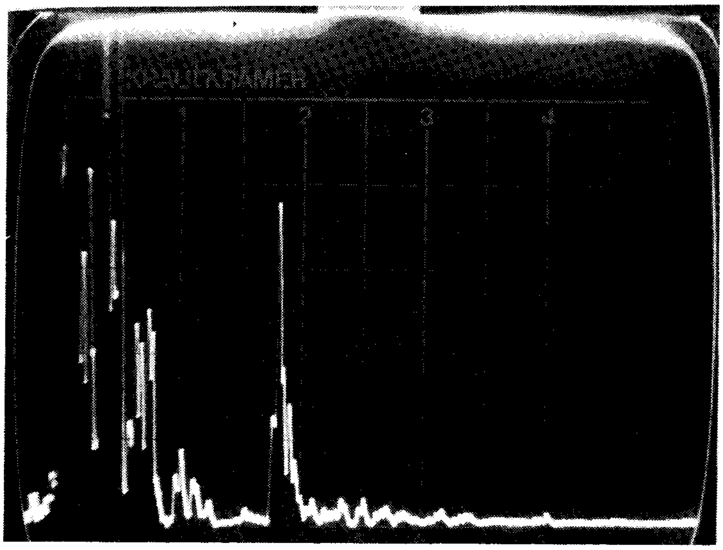


Figure 2
Flat bottomed hole Ø 3 mm
Sound distance 35 mm
Amplification 46 dB
Water distance 105 mm

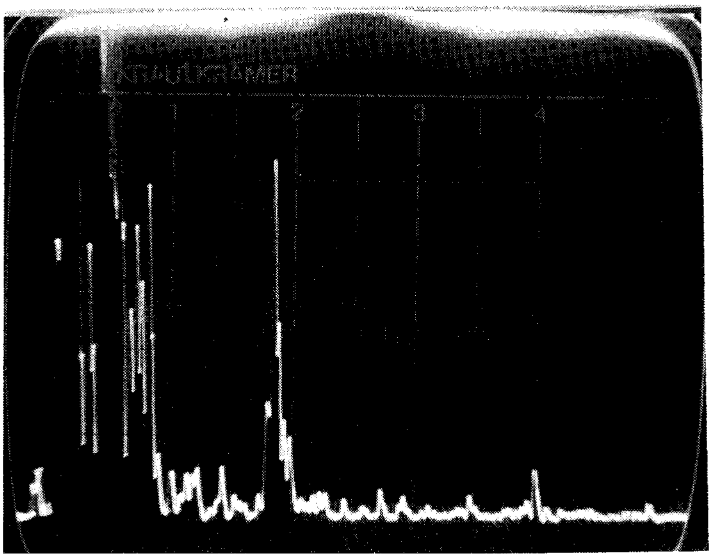
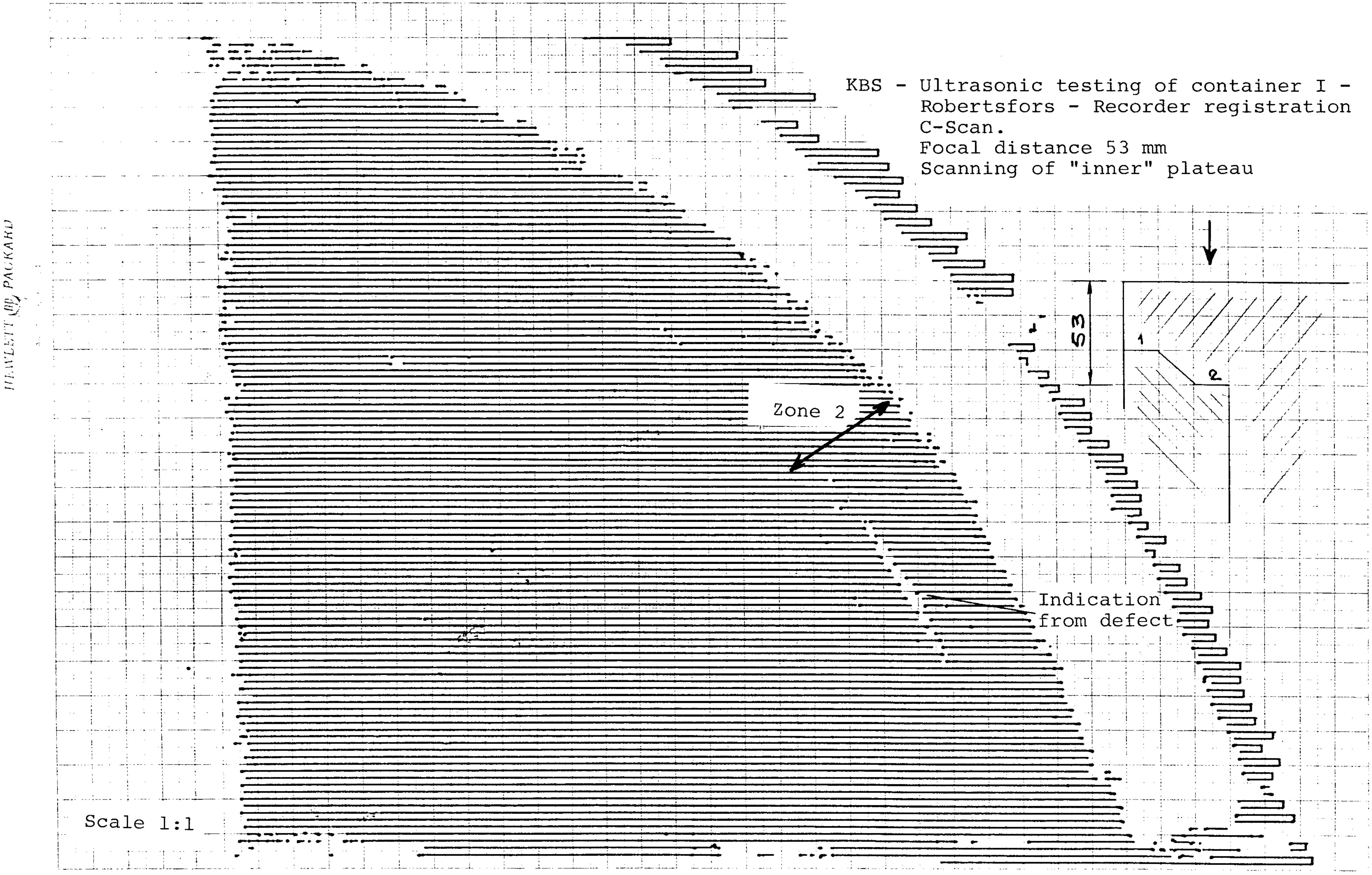


Figure 3
Indication from welded zone
Sound distance 35 mm
Amplification 46 dB
Water distance 105 mm



KBS - Ultrasonic testing of container I - Robertsfors - Recorder registration C-Scan.
Focal distance 53 mm
Scanning of "inner" plateau

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TEKNISKA RÖNTGENCENTRALEN AB

KBS - ULTRASONIC TESTING OF CONTAINER I - ROBERTSFORS - FIGURE APPENDIX

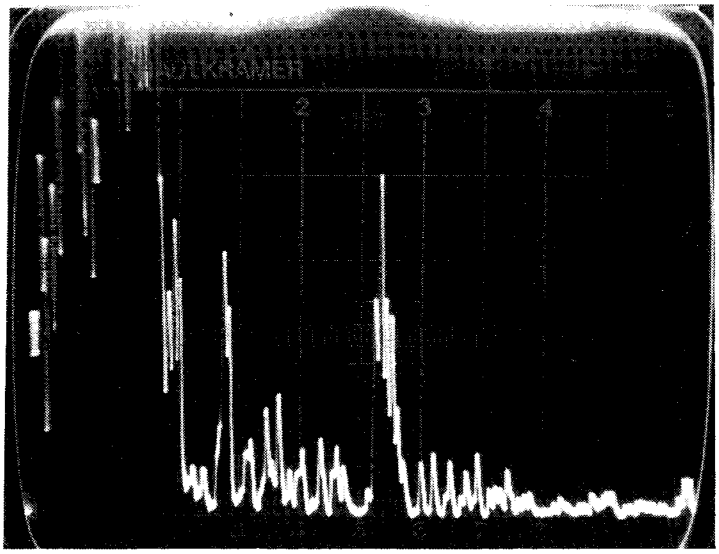


Figure 4
Flat bottomed hole Ø 3 mm
Sound distance 53 mm
Amplification 60 dB
Water distance 45 mm

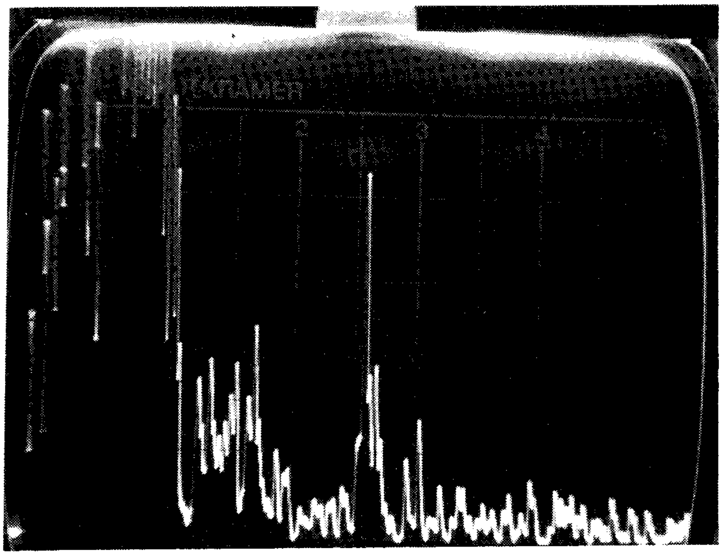


Figure 5
Indication from welded zone
Sound distance 53 mm
Amplification 60 dB
Water distance 45 mm

APPENDIX 4

TESTING ON COPPER CONTAINER ROBERTSFORS 2 WITH MANUAL ULTRASONIC TECHNIQUE

Appendix 4,

ULTRASONIC TESTING OF COPPER CONTAINER INTENDED FOR FINAL STORAGE OF SPENT NUCLEAR FUEL

1. General

By the order from Svensk Kärnbränsleförsörjning AB ultrasonic testing of the binding between container and lid/bottom has been performed on a copper container (dummy), manufactured for the purpose of gaining experience in non-destructive and destructive testing.

The testing was performed 1983-04-21 at the manufacturer, ASEA, Robertsfors.

2. Test object

The copper container was identical to the previously tested container, drawing ASEA-9397 626-7.

However, this time the pressure-tight outer shell which is necessary for the manufacturing process was made of 2 mm thick stainless steel.

Sketches showing the tested parts of the copper container are shown in figure 1.

3. Equipment

Ultrasonic flaw-detector: USM 2

Probe: Normal beam probe Ø 12.5 mm 2.25 MHz

	Angle beam probe RTD 2 MHz separate transmitter and receiver focussing to 60 mm in austenite (corresponding to 70 mm in copper)
	Crystal size: 2 15 x 25 mm each
	Angle of refraction: 60° in austenite (corresponding to 45° in Cu).
	To the angle beam probe an RTD E-tuned adapter for USM 2, 2 MHz was used.
Reference block:	Copper block with flat-bottomed holes Ø 3.5 mm at different depths; 40, 60 and 76 mm.
Couplant medium:	Ultragel II

4. Scope of testing

The binding of lid and bottom to the mantle has been tested manually using the contact technique around the full periphery.

Binding zone 1:	has been tested using normal beam probe in direction 1
Binding zone 2:	has been tested using angle beam probe in direction 3 for the lid and in direction 4 for the bottom.
Binding zone 3:	has been tested using normal beam probe in direction 1
Binding zone 4:	has been tested using normal beam probe in direction 2.

Concerning zones and directions,see figure 1.

In addition to the testing mentioned above control of the binding between lid/bottom/ mantle and the sinter mass has been performed at random.

Tests also indicated that the simulated fuel rods could easily be indicated.

5. Limitations of tests

Lid part: Due to lack of binding between the outer stainless steel cladding and the copper container the outermost part (5-10 mm)of zone 1 could not be tested. For the same reason certain parts (approx. 10%) of zone 4 could not be tested.

Bottom part: Due to lack of bonding parts (approx. 40%) of zone 4 could not be tested.

6. Amplification setting

For normal beam probing, the 3.5 mm flat-bottomed holes in the reference block were used with 6 dB amplification for transmission through the outer stainless steel cladding, as a reference reflector.

For angle beam probing, a Ø 3.5 mm cylinder borehole in the copper block at the depth of 40 mm was used with 6 dB amplification as reference reflector.

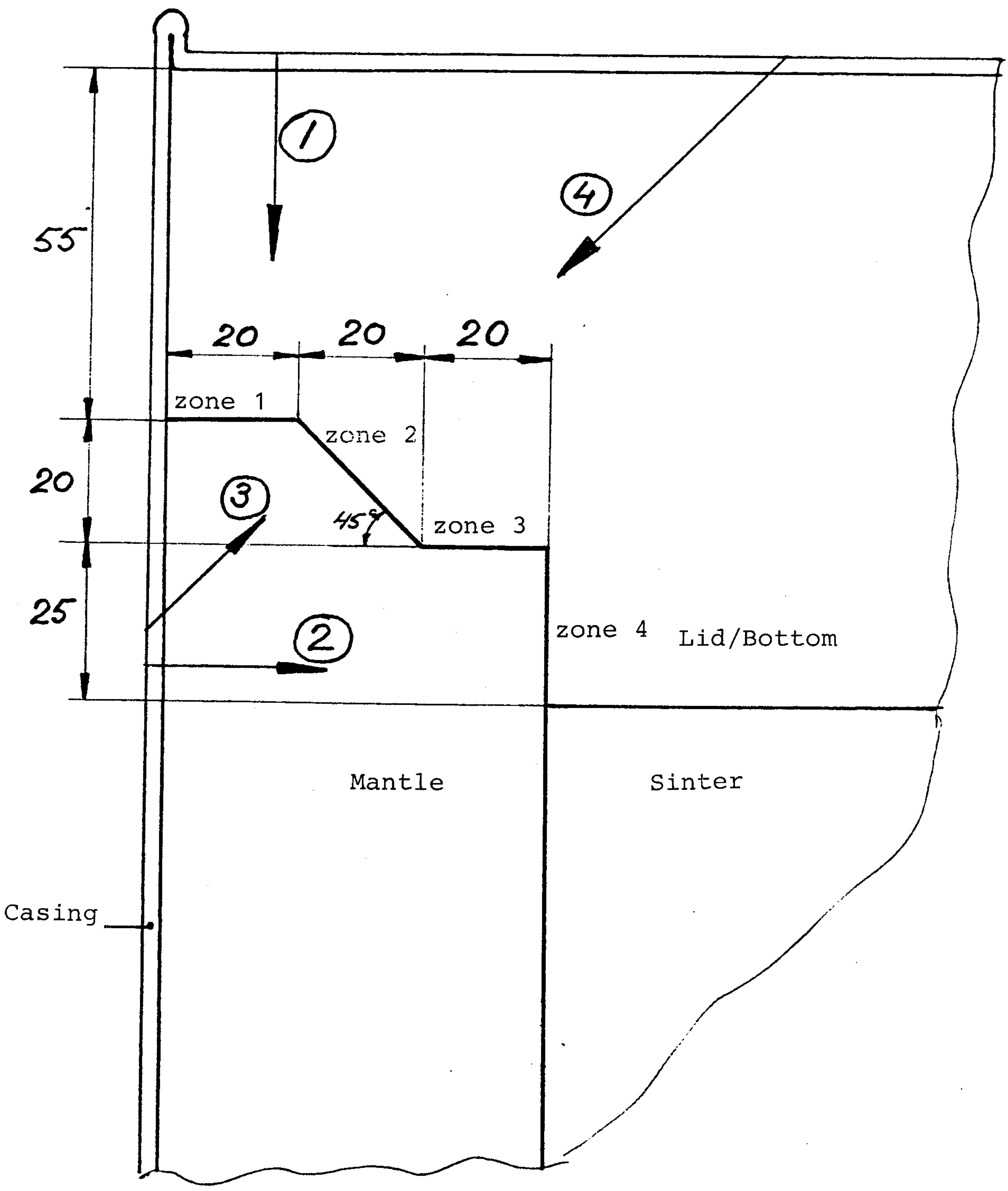
7. Results

No indications have been recorded from any of the zones 1, 2, 3 and 4 nor from the transition zones between lid/bottom/mantle and sinter mass.

Tekniska Röntgencentralen AB
Testing and Inspection Technology
Staffan Orrgård, Test Engineer

Figure 1

Division into zones and directions of sound paths



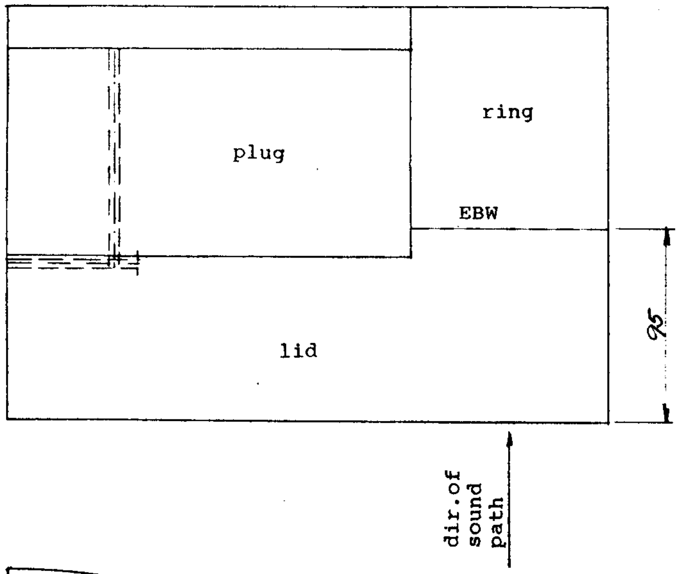
APPENDIX 5

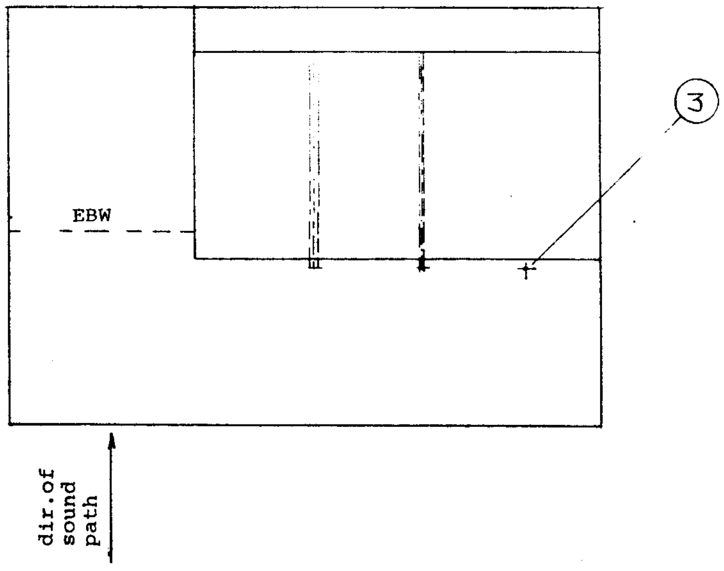
TESTING ON EBW COPPERBLOCK FROM WELDING INSTITUTE-GB WITH FOCUSED IMMERSION ULTRASONIC TECHNIQUE

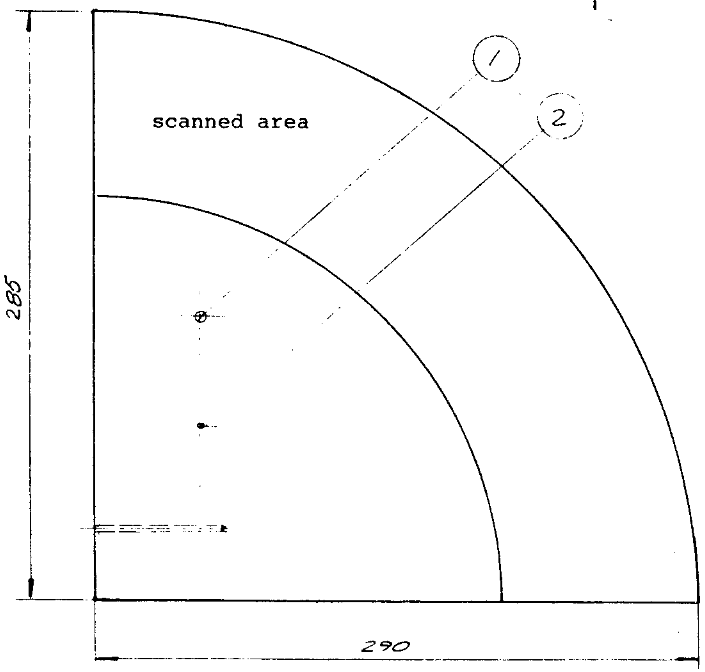
Tol. för icke direkt toleranssatta mått enl. SMS. 715

Ytjämnhet där ej annat angives Ra √

Nr	Ant.	Ändring och/eller medd.-nr	Datum	Inf.	Godk.







Pos.	Designation	Diam.	Depth	Note
1	Flat bottomed hole	4mm	105mm	from scanned side
2	" "	2mm	105mm	" " "
3	Cylinder borehole	2mm	60mm	" " "

Det.-nr	Ant.	Benämning	Material	Mod.-nr Ämne Dimension	Anm.
			Koppar		

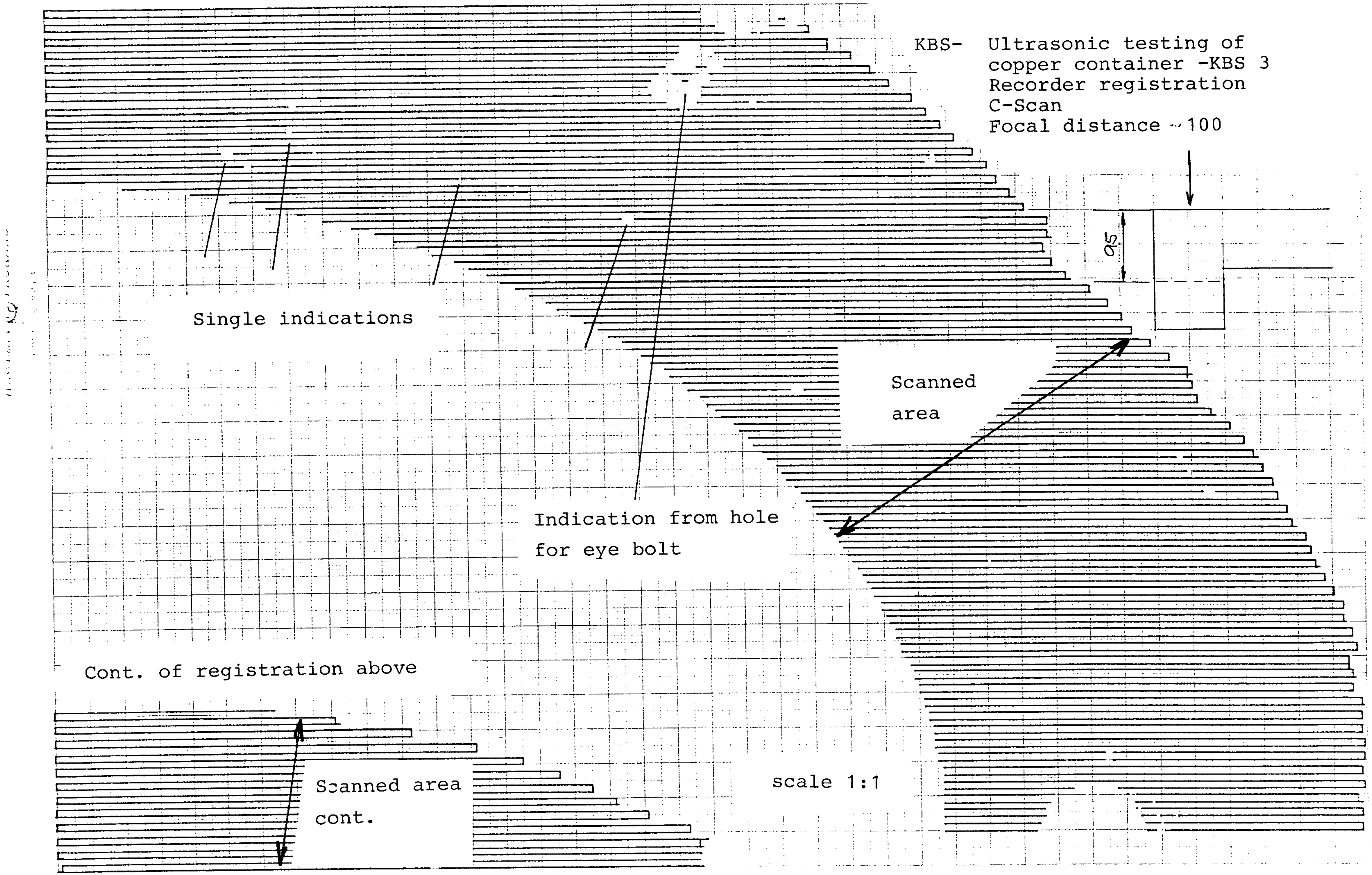
Konstr.	Ritad	Kop.	Kontr.	Stand.	Godk.	Skala	Ersätter	Ersatt av
	RGM					1:2,5		

TRC
TEKNISKA RÖNTGENCENTRALEN AB

SKBF, Bränsleförvaring
Welding Institute

Dat. 830410

Ritn.-nr SP 30201


KBS- Ultrasonic testing of
copper container -KBS 3
Recorder registration
C-Scan
Focal distance ~100
Ø5
Single indications
Scanned area
Indication from hole for eye bolt
Cont. of registration above
Scanned area cont.
scale 1:1

KBS - ULTRASONIC TESTING OF COPPER CONTAINER - KBS 3- FIGURE APPENDIX

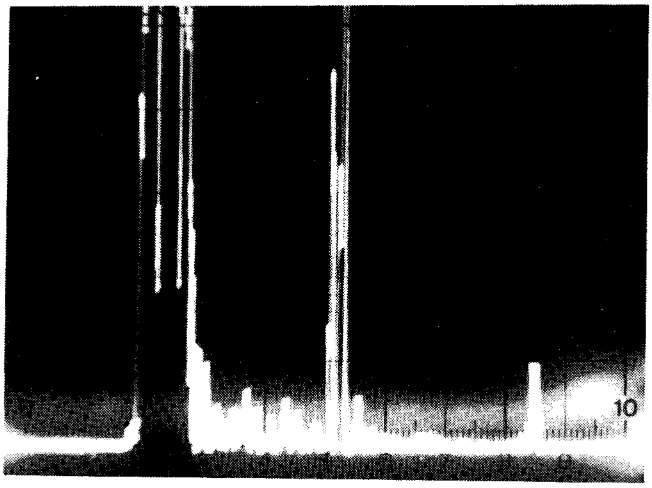


Figure 1

Flat bottomed hole Ø 2 mm
Sound distance 75 mm
Amplification 62 dB
Water distance 150 mm

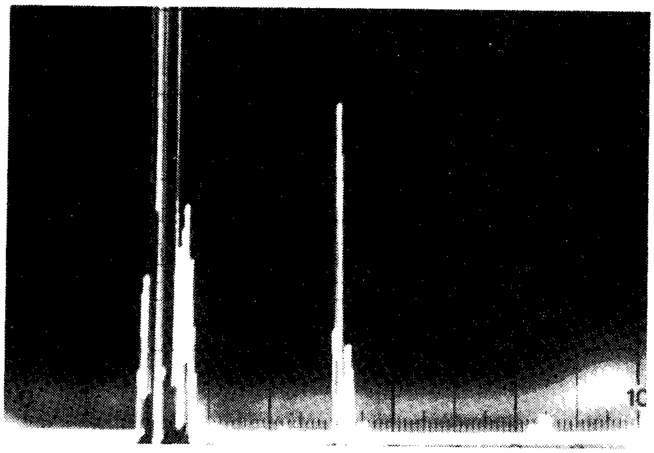


Figure 2

Flat bottomed hole Ø 4 mm
Sound distance 75 mm
Amplification 48 dB
Water distance 100 mm

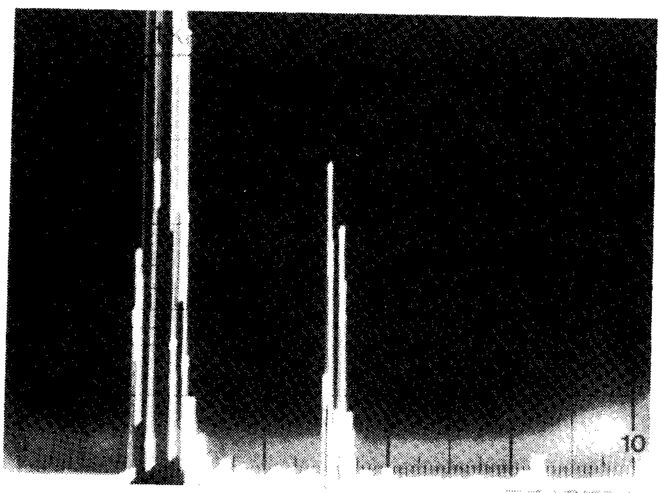


Figure 3

Cylinder bore hole Ø 2 mm
Sound path 75 mm
Amplification 56 dB
Water distance 100 mm

DESTRUCTIVE EXAMINATION ON CUTOUT OF ELECTRON BEAM WELDED COPPER FROM SCIAKY - FRANCE

In the investigation reported in Appendix 1, two defects were clearly seen during scanning from both sides. These defects are marked by A and C in Figure 2 in Appendix 1. As described in that Appendix, a small piece of the copper was cut out and sent to Gränges Metallverken for metallographic investigation. The report from Gränges Metallverken, in the form of a letter, is enclosed in this Appendix. The defects are typical for the first Sciaky weld tests.From the metallographic study it can be concluded that these defects, in one case an approx. Ø 3 mm hole and a cylinder shall defect plus small pores estimated to correspond to an approx. 2 mm defect can be clearly detected using a focussed ultra sonic technique.

Gränges Metallverken AB

Concerning Electron Beam Welds in Cu

We have finally received the results of the in a previously submitted report deleted hydrogen analysis. The following values were obtained by analyzing four different specimens according to the smelt extraction method:

	Specimen	H_2-content, ppm
a)	No 1 (see report F 2453)	0,64
b)	No 2 "	0,64
c)	Unwelded starting material for b	1,0
d)	Later received, TRC-tested material	2,2

Two figures are also enclosed, showing two section planes perpendicular to each other through ultra sonic detected and center punch marked defects in the weld in d. In the figure can be seen both some spherical gas pores, and a type of defects previously found by ASEA during their investigations, and which consist of more or less halfcylinder-shaped oxide shell porosities, (at the arrow in fig 1) and also some bigger holes (the hole in fig 1 is partly filled with a fused metal under the section plane). In the direction of the electron beam with the cylinder surface about perpendicular to the growth direction of the crystals. In the perpendicular section (fig 2) it can be seen at the edges of the fusion zone the remains of the outer parts of a defect similar to the one at the arrow in fig 1.

The width of the fusion zone is in this case considerably larger than in the previously investigated welds, 3-4 mm and 1-2 mm respectively.

Rune Carlsson

GRÄNGES METALLVERKEN

Figure 1
Section plane
⊥ direction
of the electron
beam

15X

Center punch mark

Figure 2
Section plane
∥ direction
of electron beam

15X

Center punch mark

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1977–78

TR 121

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Summaries. Stockholm, May 1979.

1979

TR 79–28

The KBS Annual Report 1979.

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The KBS Annual Report 1982.

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1983

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Trygve E Eriksen
Department of Nuclear Chemistry
The Royal Institute of Technology
Stockholm, Sweden 1983-01-19

TR 83–02

The possible effects of alfa and beta radiolysis on the matrix dissolution of spent nuclear fuel

I Grenthe
I Puigdomènech
J Bruno
Department of Inorganic Chemistry
Royal Institute of Technology
Stockholm, Sweden, January 1983

TR 83–03

Smectite alternation Proceedings of a colloquium at State University of New York at Buffalo, May 26–27, 1982

Compiled by Duwayne M Anderson
State University of New York at Buffalo
February 15, 1983

TR 83–04

Stability of bentonite gels in crystalline rock – Physical aspects

Roland Pusch
Division Soil Mechanics, Univeristy of Luleå
Luleå, Sweden, 1983-02-20

TR 83–05

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Åke Bresle
Jozef Saers
Birgit Arrhenius
Archaeological Research Laboratory
University of Stockholm
Stockholm, Sweden 1983-01-02

TR 83–06

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L A Benjamin
D Hardie
R N Parkins
University of Newcastle upon Tyne
Department of Metallurgy and engineering Materials
Newcastle upon Tyne, Great Britain, April 1983

TR 83–07

Sorption of radionuclides on geologic media – A literature survey. I: Fission Products

K Andersson
B Allard
Department of Nuclear Chemistry
Chalmers University of Technology
Göteborg, Sweden 1983-01-31

TR 83–08

Formation and properties of actinide colloids

U Olofsson
B Allard
M Bengtsson
B Torstenfelt
K Andersson
Department of Nuclear Chemistry
Chalmers University of Technology
Göteborg, Sweden 1983-01-30

TR 83–09

Complexes of actinides with naturally occurring organic substances – Literature survey

U Olofsson
B Allard
Department of Nucluear Chemistry
Chalmers University of Technology
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TR 83–10

Radilysis in nature: Evidence from the Oklo natural reactors

David B Curtis
Alexander J Gancarz
New Mexico, USA February 1983

TR 83–11
Description of recipient areas related to final storage of unreprocessed spent nuclear fuel
Björn Sundblad
Ulla Bergström
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Nyköping, Sweden 1983-02-07

TR 83–12
Calculation of activity content and related propeties in PWR and BWR fuel using ORIGEN 2
Ove Edlund
Studsvik Energiteknik AB
Nyköping, Sweden 1983-03-07

TR 83–13
Sorption and diffusion studies of Cs and I in concrete
K Andersson
B Torstenfelt
B Allard
Department of Nuclear Chemistry
Chalmers University of Technology
Göteborg, Sweden 1983-01-15

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The complexation of Eu (III) by fulvic acid
J A Marinsky
State University of New York at Buffalo
Buffalo, NY 1983-03-31

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Diffusion measurements in crystalline rocks
Kristina Skagius
Ivars Neretnieks
Royal Institute of Technology
Stockholm, Sweden 1983-03-11

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Stability of deep-sited smectite minerals in crystalline rock – chemical aspects
Roland Pusch
Division of Soil Mechanics, University of Luleå
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Analysis of groundwater from deep boreholes in Gideå
Sif Laurent
Swedish Environmental Research Institute
Stockholm, Sweden 1983-03-09

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Migration experiments in Studsvik
O Landström
Studsvik Energiteknik AB
C-E Klockars
O Persson
E-L Tullborg
S Å Larson
Swedish Geological
K Andersson
B Allard
B Torstenfelt
Chalmers University of Technology
1983-01-31

TR 83–19
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Sif Laurent
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Stockholm, Sweden 1983-03-29

TR 83–20
Encapsulation and handling of spent nuclear fuel for final disposal
1 Welded copper canisters
2 Pressed copper canisters (HIPOW)
3 BWR Channels in Concrete
B Lönnerbeg, ASEA-ATOM
H Larker, ASEA
L Ageskog, VBB
May 1983

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An analysis of the conditions of gas migration from a low-level radioactive waste repository
C Braester
Israel Institute of Technology, Haifa, Israel
R Thunvik
Royal Institute of Technology
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Calculated temperature field in and around a repository for spent nuclear fuel
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Stockholm, Sweden April 1983

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Preparation of titanates and zeolites and their uses in radioactive waste management, particularly in the treatment of spent resins
Å Hultgren, editor
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L Fälth, University of Lund
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The Swedish Corrosion Research Institute
and its reference group
Stockholm, Sweden April 1983

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Feasibility study of electron beam welding of spent nuclear fuel canisters
A Sanderson, T F Szluha, J L Turner, R H Leggatt
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The United Kingdom April 1983

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Summary Report 1983-02-01
Ronald Forsyth, Studsvik Energiteknik AB
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TR 83–27
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Trygve Eriksen
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Univerisity of Luleå
Luleå, Sweden 1983-07-01

TR 83–28
An analysis of selected parameters for the BIOPATH-program
U Bergström
A-B Wilkens
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Nyköping, Sweden 1983-06-08

TR 83–29
On the environmental impact of a repository for spent nuclear fuel
Otto Brotzen
Stockholm, Sweden april 1983

TR 83–30
Encapsulation of spent nucler fuel – Safety Analysis
ES-konsult AB
Stockholm, Sweden April 1983

TR 83–31
Final disposal of spent nuclear fuel – Standard programme for site investigations
Compiled by
Ulf Thoregren
Swedish Geological
April 1983

TR 83–32
Feasibility study of detection of defects in thick welded copper
Tekniska Röntgencentralen AB
Stockholm, Sweden April 1983

TR 83–33
The interaction of bentonite and glass with aqueous media
M Mosslehi
A Lambrosa
J A Marinsky
State University of New York
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B Allard
K Andersson
H Kipatsi
L Eliasson
U Olofsson
H Persson
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Actinide solution equilibria and solubilities in geologic systems
B Allard
Chalmers University of Technology
Göteborg, Sweden 1983-04-10

TR 83–36
Iron content and reducing capacity of granites and bentonite
B Torstenfelt
B Allard
W Johansson
T Ittner
Chalmers University of Technology
Göteborg, Sweden April 1983

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Surface migration in sorption processes
A Rasmuson
I Neretnieks
Royal Institute of Technology
Stockholm, Sweden March 1983

TR 83–38
Evaluation of some tracer tests in the granitic rock at Finnsjön
L Moreno
I Neretnieks
Royal Institute of Technology, Stockholm
C-E Klockars
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Uppsala April 1983

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Diffusion in the matrix of granitic rock Field test in the Stripa mine. Part 2
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I Neretnieks
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Stockholm, Sweden March 1983