E&I
ENGINEERING & INSPECTIONS
UNLIMITED, INC.

Non-Destructive Evaluation
on
Headers, Water and Steam Drums
On the S.S. Norway
for
National Transportation Safety Board
June 26, 2003

5455 NORTH FEDERAL HIGHWAY • SUITE I • BOCA RATON, FLORIDA 33487 • (561) 241-0303 • FAX (561) 241-0349

ENGINEERING & INSPECTIONS
UNLIMITED, INC.

National Transportation Safety Board

S. S. Norway

Headers, Water Drums, and Steam Drum in Boilers 21, 22, & 24

Final Magnetic Particle and Ultrasonic Crack Sizing Examination

June 26, 2003

Report # FS-03-239

William Rossey Jr.
Materials Engineer

Brian Curtis
Lead Investigator

3125 Jupiter Park Circle, Suite 3 • Jupiter, FL 33458 • Tel: (561) 741-3031 • Fax: (561) 741-3797
Web: www.enginsp.com

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Subject: S. S. Norway – Final Examination of Headers, Water Drums, and Steam Drum

On June 23, 2003 Engineering & Inspections Unlimited arrived on the S. S. Norway at the Port of Miami to perform Ultrasonic Sizing Examinations.

SCOPE

The original scope of this examination was to perform Ultrasonic Sizing examinations of welds in the headers and water drums of boilers 21, 22 and 24 aboard the S. S. Norway for condition assessment following the failure of welds in the header of boiler 23 on May 25, 2003. It was apparent that repairs of the welds in the headers of boilers 22 and 23 had been performed at some point in the past. The purpose of this examination is to identify any cracking present in these pressure vessel components. After beginning the ultrasonic examination it was decided to 'screen' the welds for the presence of cracks utilizing fluorescent magnetic particle examination techniques to reduce the time needed to complete the examinations. Then ultrasonic sizing examination was performed on selected weld areas to determine crack depth. During the second day of examinations, it was determined that entry into the steam drum would be possible, so the steam drum of boiler 22 was chosen for examination as representative of the group.

EXAMINATION RESULTS

The Fluorescent Magnetic Particle examination was performed in accordance with E & I Examination Procedure MT-102, Rev. 0 and located cracks in the welds of headers 21, 22, & 24, and in the welds of water drums 22 & 24. No cracking was observed in water drum 21 or steam drum 22. The lengths and locations of these cracks are shown in the individual component slides located later in this report.

The Ultrasonic Sizing examination was performed using a specialized technique based on EPRI's crack tip diffraction technique. This technique utilizes the ultrasonic phenomena where the tips of cracks radiate a reflected signal directly out of phase with the rest of the reflectors. This makes confirmation of signal identity definitive. The crack depth is then determined by a calibrated measurement between the tip and the base of the crack at the ID surface. The measured crack depth ranged from .010" to .250". The deepest area (.250") was located in one of the repaired areas of header 22. The specific crack depths for each weld are shown on the individual component slides.

TECHNICIANS AND CERTIFICATIONS:

Phillip Knox - ASNT Level III: UT, MT, PT, Visual (LM-1784); ACCP Professional Level III: UT, MT, PT, Visual (57878); EPRI: VT 1-4, Ultrasonic Sizing; Pressure Equipment Directive

Allan McClure – Level II: MT, PT, VT, ET, UT

Wesley Gall – Level II: MT, PT, RT; Level I: UT

Report Author

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Slide Show – Table of Contents

Header 21

Header 22

Header 24

Water Drum 21

Water Drum 22

Water Drum 24

Steam Drum 22

Ultrasonic Calibration Data

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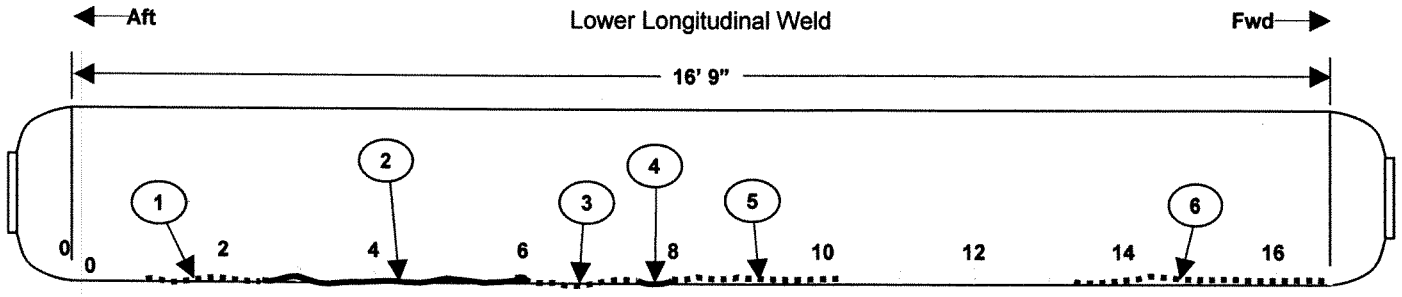
S. S. NORWAY

Header 21



Legend

Continuous Crack	———
Intermittent Crack	·····
Photo Link	⬭
Ultrasonic Link	UT

Magnetic Particle Examination Results

1.	1' thru 2'6"	Intermittent Cracks	1.5' long
2.	2'6" thru 6'	Continuous Crack	3.5' long
3.	6' thru 7'6"	Intermittent Cracks	1.5' long
4.	7'6" thru 8'	Continuous Crack	6" long
5.	8' thru 10'3"	Intermittent Cracks	2.25' long
6.	13'4" thru 16'9"	Intermittent Cracks	3'5" long

Ultrasonic Sizing Results

1. Located at 3', three overlapping cracks measuring approximately 0.040" deep.
2. Located at 7'9", single crack measuring 0.070" deep.
3. Located at 15', numerous small cracks too small to properly measure, estimate 0.010 – 0.015" deep.

Note: This header was not prepared (cleaned) for examination as well as the others examined. Some of the intermittent cracks noted might become continuous if the surface of the weld area were cleaner at the time of inspection.

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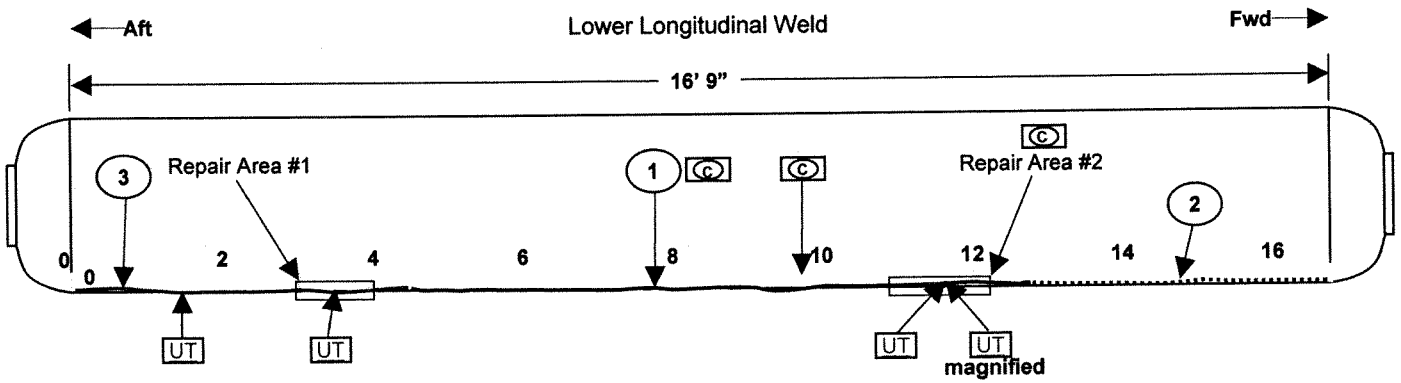
S. S. NORWAY

Header 22



Legend

No MT Examination	———
Continuous Crack	———
Intermittent Crack	.....
Photo Link	C
Ultrasonic Link	UT

Magnetic Particle Examination Results

1.	4'6" thru 12'9"	Continuous Crack	8'3" long
2.	12'9" thru 16'9"	Intermittent Cracks	4' long
3.	0' thru 4'6"	Continuous Crack	4'6" long

Note: Area 3 was not examined with Fluorescent Magnetic Particle technique due to residual ultrasonic couplant on the weld surface. However, cracks were present in this area for the full length.

Ultrasonic Sizing Results

1. **Located at 1.5', crack measuring approximately 0.040" deep.**
2. **Located at 3.5', single crack measuring 0.080" deep. This crack is in the repaired area of the weld.**
3. **Located at 7', single crack measuring 0.080" deep.**
4. **Located at 8'7", single crack measuring 0.120" deep.**
5. **Located at 11.5', single crack measuring 0.250" deep. This crack is in the repaired area of the weld.**

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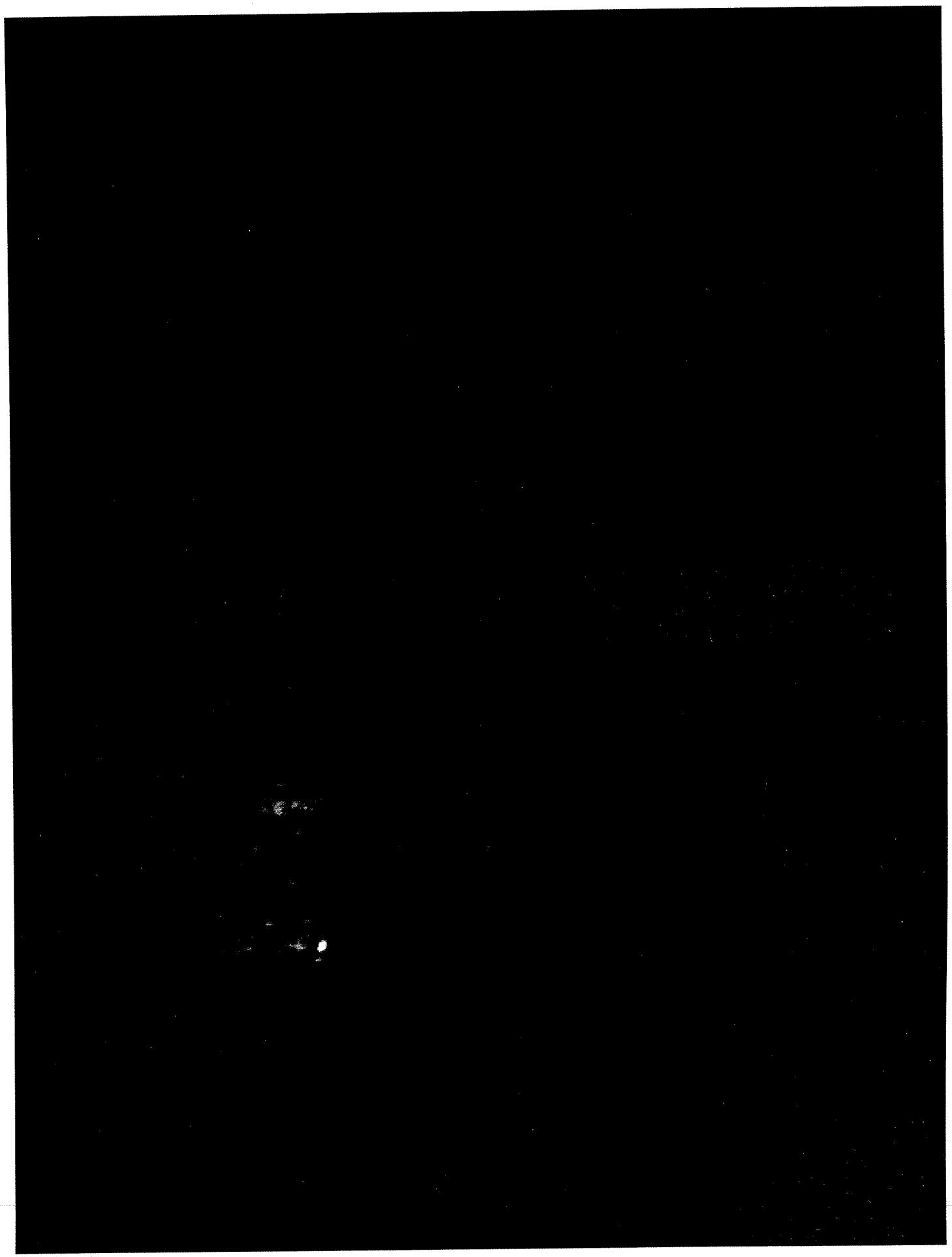

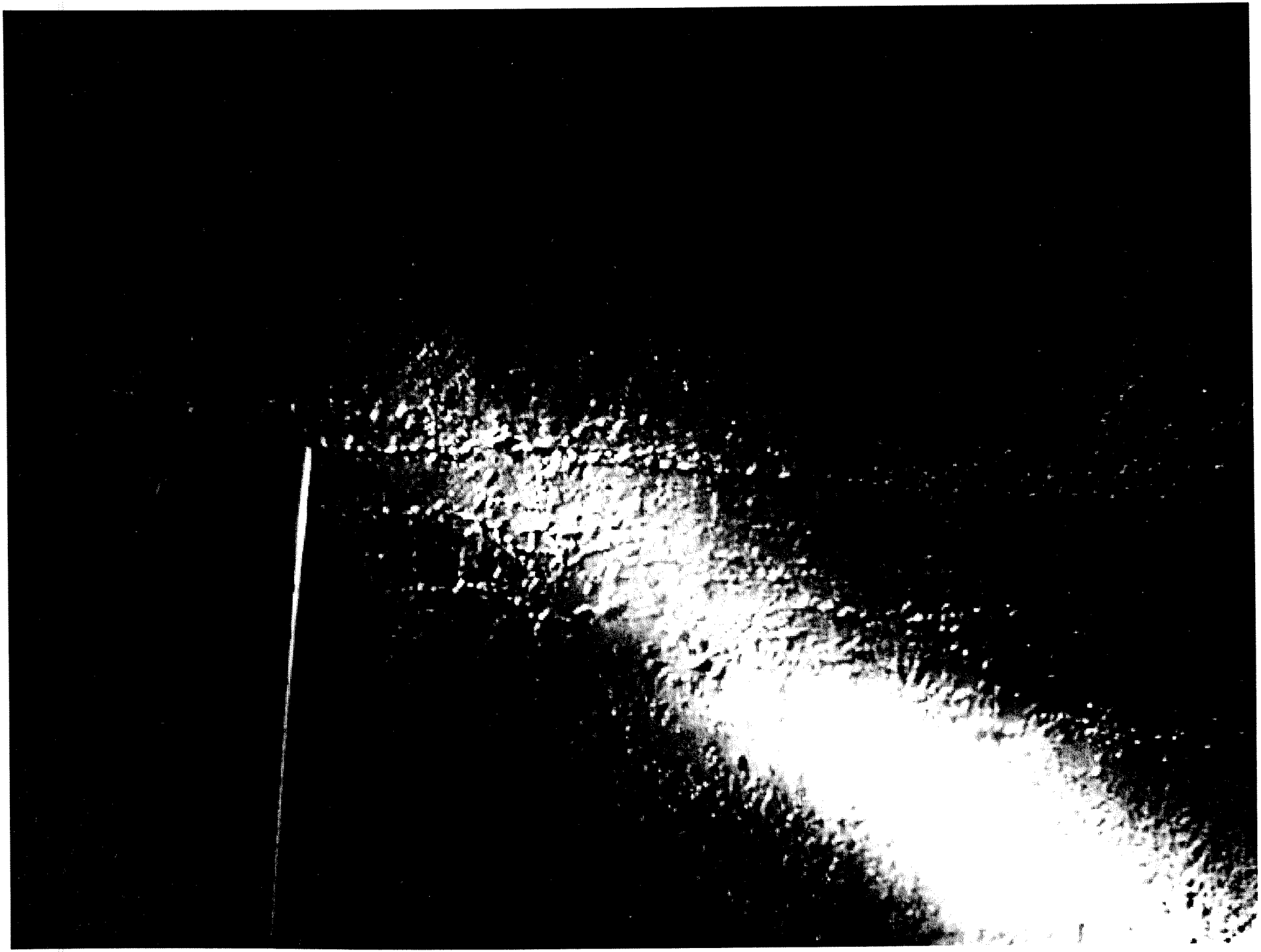

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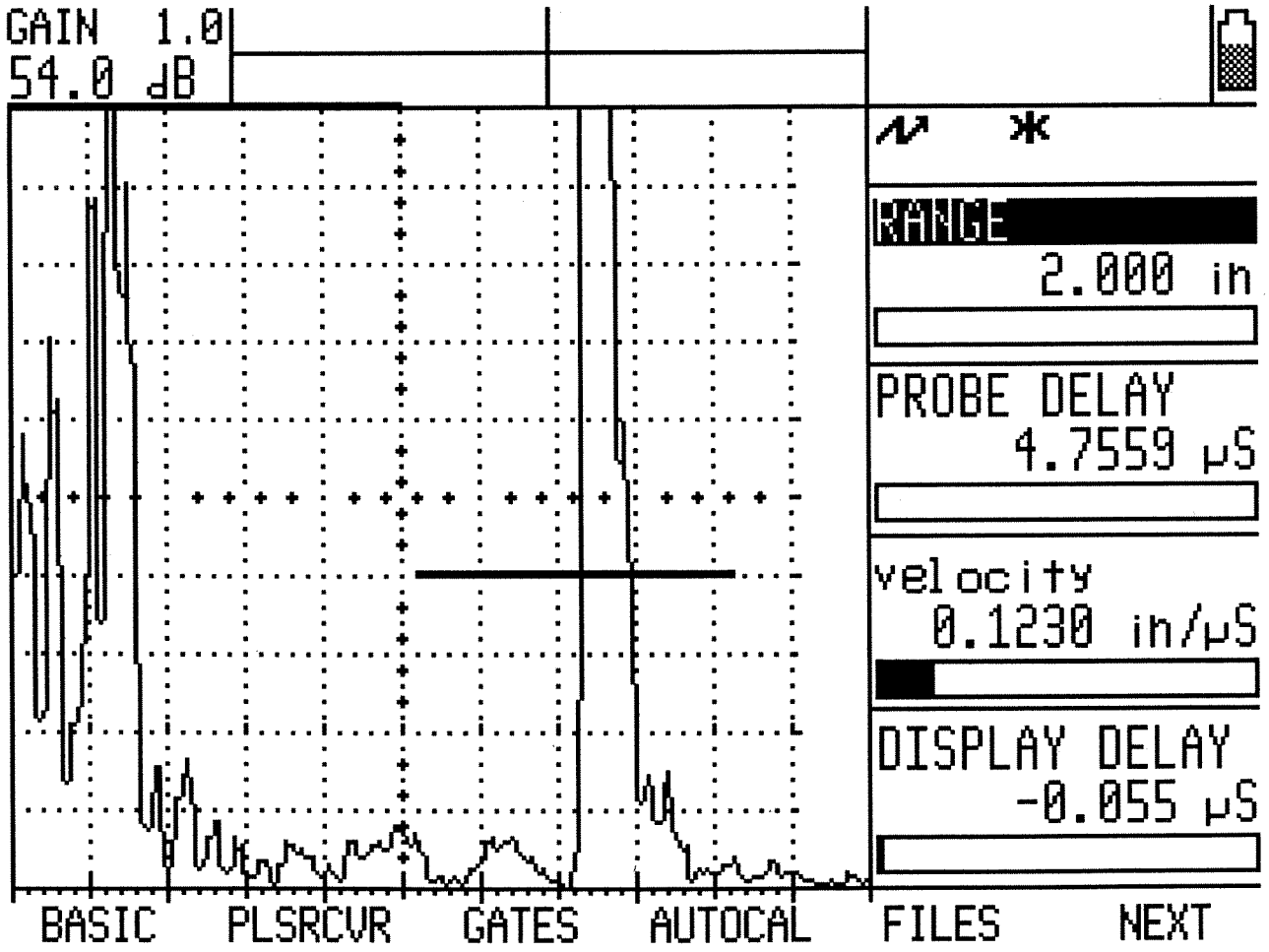
S. S. Norway – Header 22 – Ultrasonic Size on Crack #1



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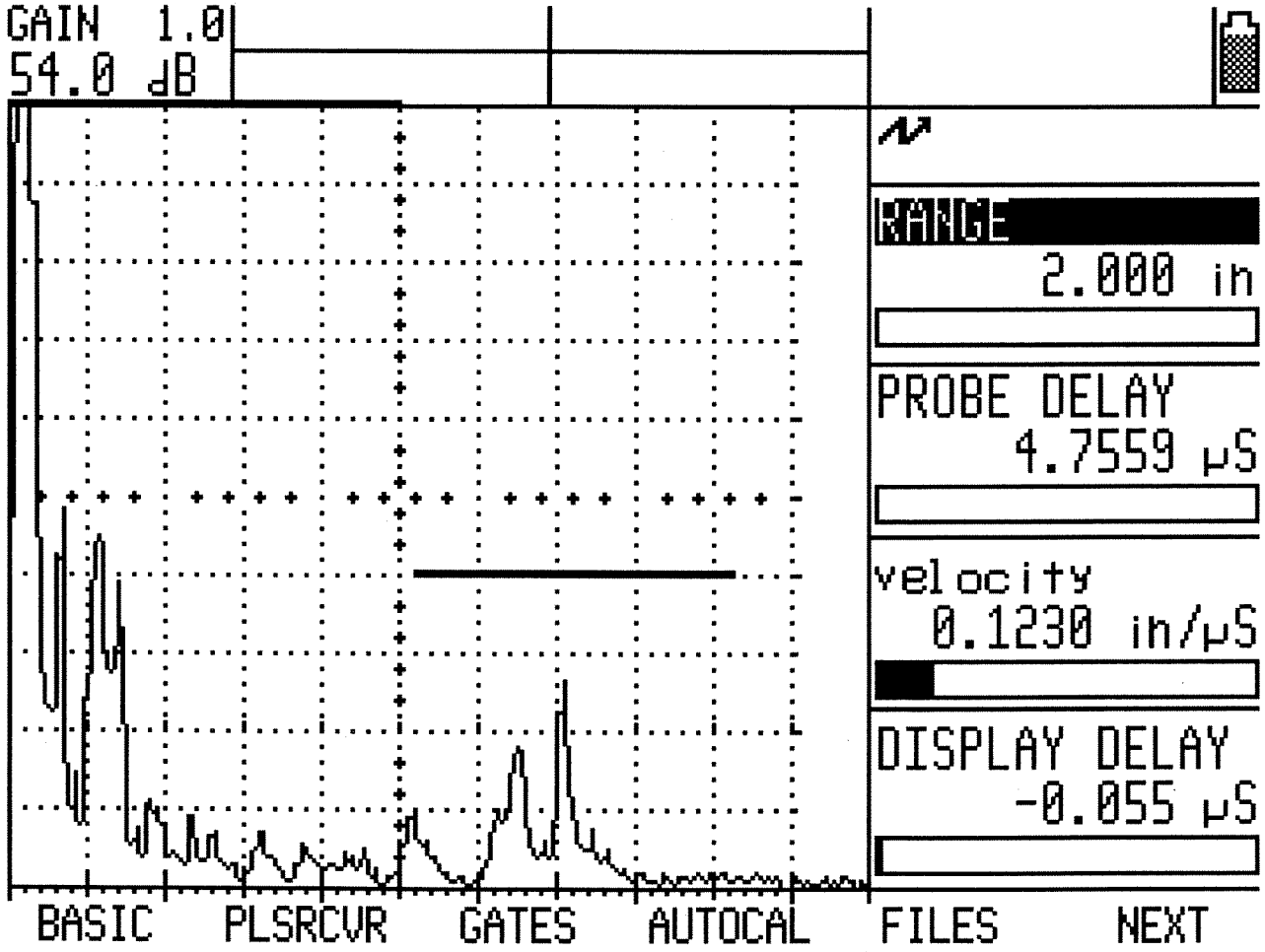
S. S. Norway – Header 22 – Ultrasonic Size on Crack #2



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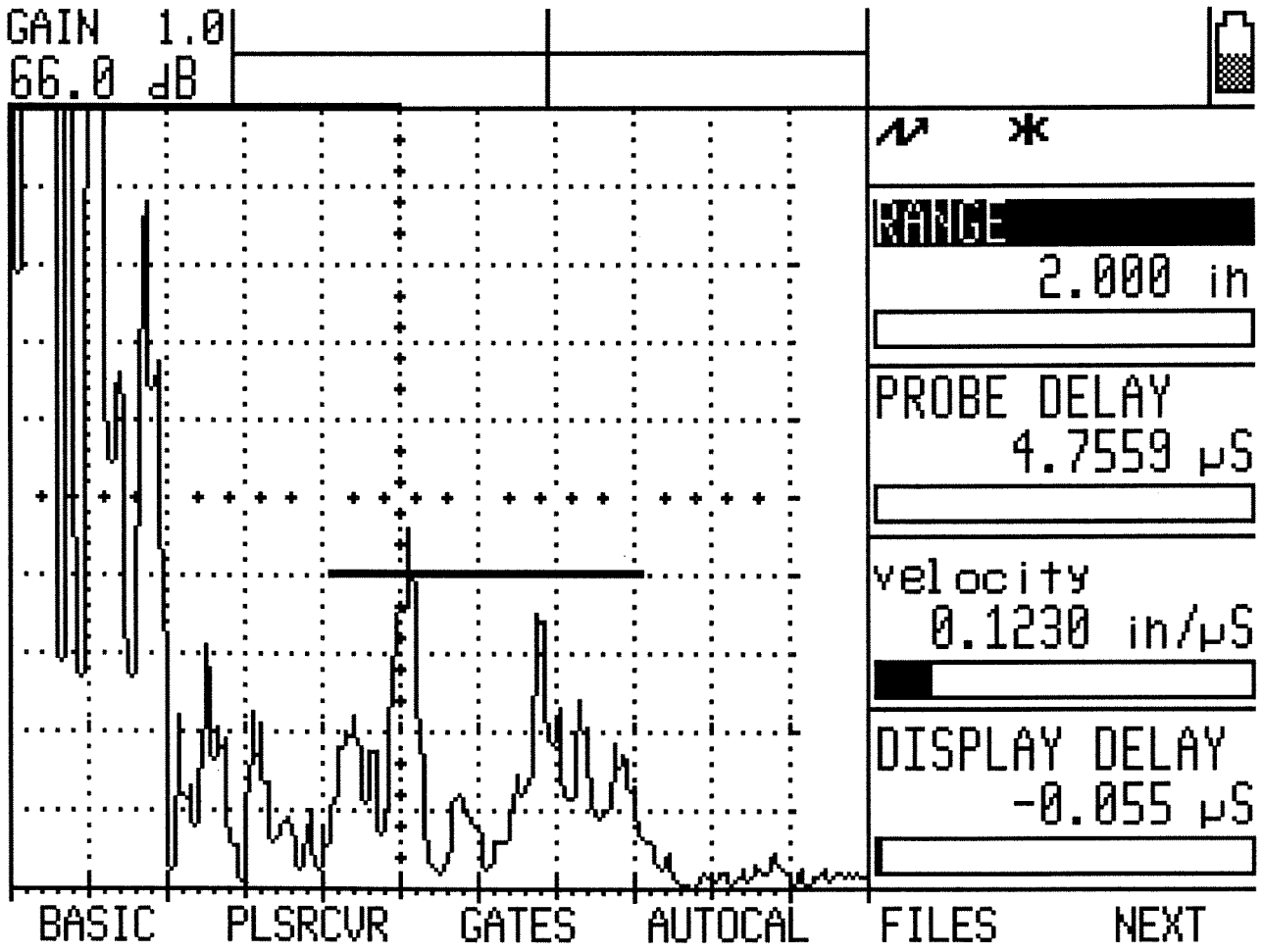
S. S. Norway – Header 22 – Ultrasonic Size on Crack #5



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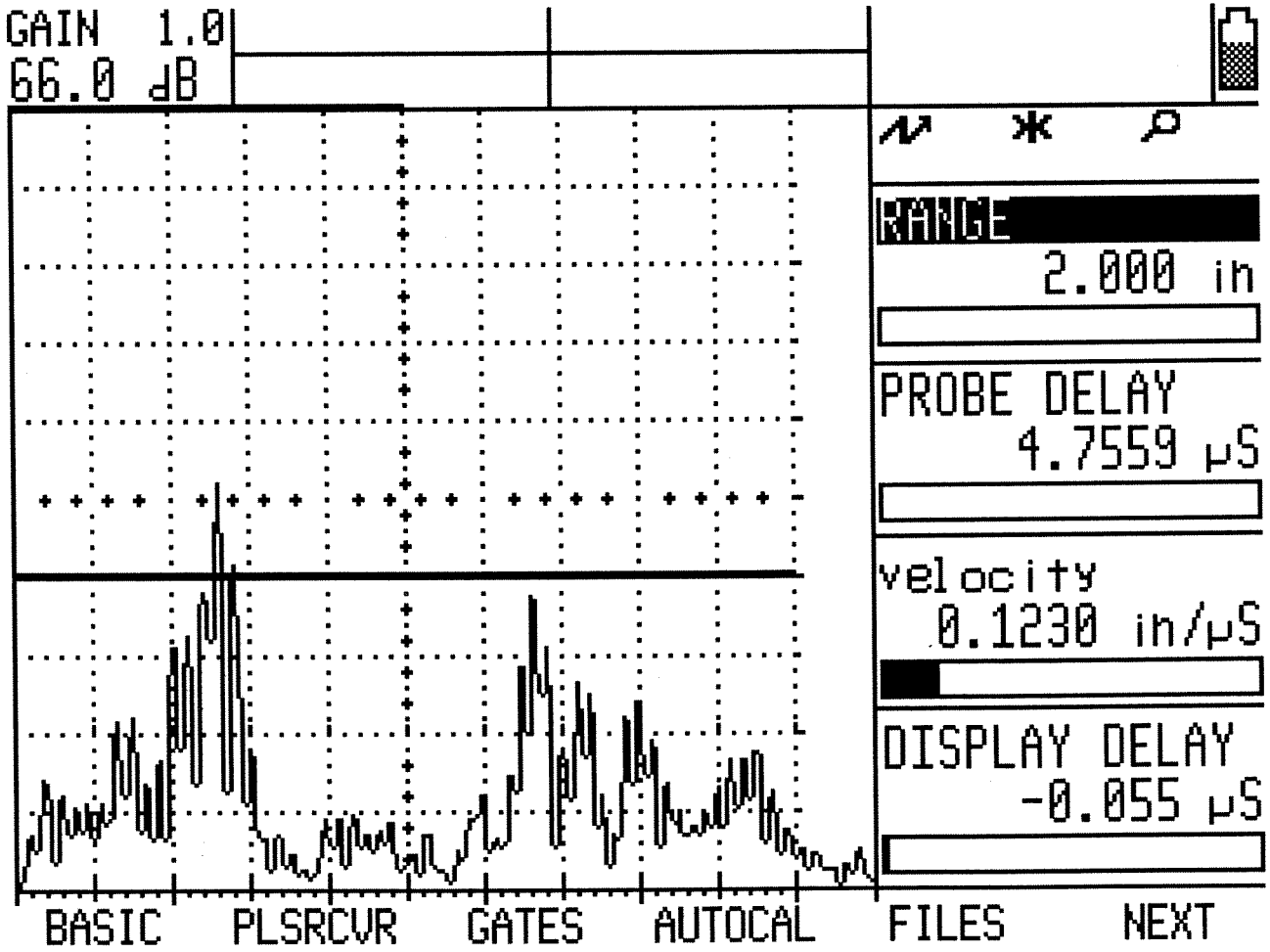
S. S. Norway – Header 22 – Ultrasonic Size on Crack #5

Showing Sizing Measurement of 0.250"



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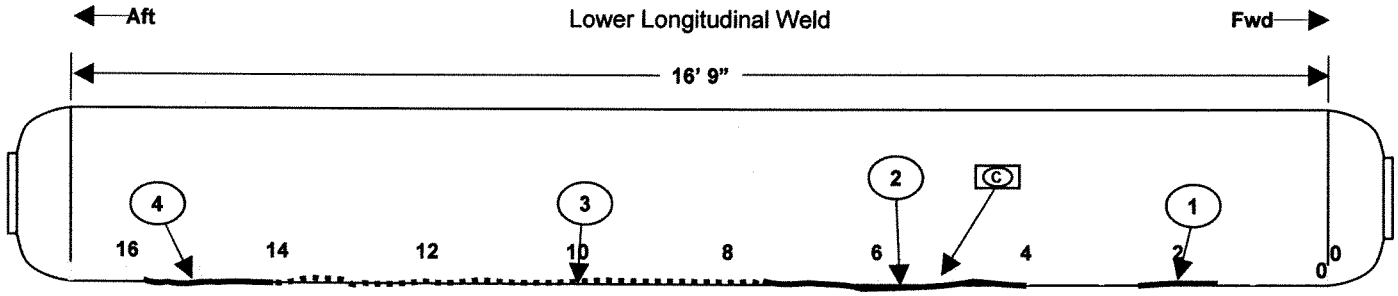
S. S. NORWAY

Header 24



Legend

Continuous Crack	———
Intermittent Crack	.....
Photo Link	C
Ultrasonic Link	UT

Magnetic Particle Examination Results

1.	1.5' thru 2.5'	Continuous Crack	1' long
2.	4' thru 7.5'	Continuous Crack	3.5' long
3.	7.5' thru 14'	Light Intermittent Cracks	6.5' long
4.	14' thru 15'9"	Continuous Crack	1'9" long

Ultrasonic Sizing Results

1. Located at 2', multiple overlapping cracks measuring 0.080 – 0.100" deep.
2. Located at 5.5', single crack measuring 0.090" deep.
3. Located at 15', single crack measuring 0.090" deep.

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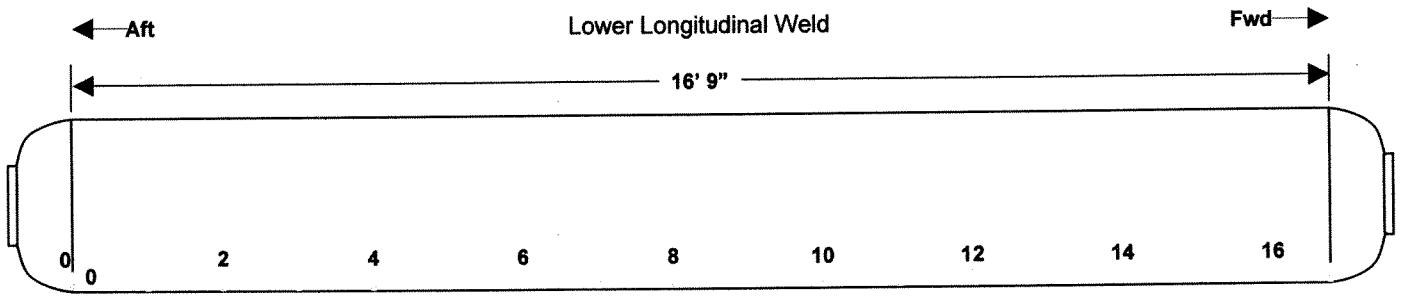
Water Drum 21



Legend

Continuous Crack	———
Intermittent Crack	·····
Photo Link	⬭
Ultrasonic Link	UT

Magnetic Particle Examination Results

There were no cracks detected in this examination.

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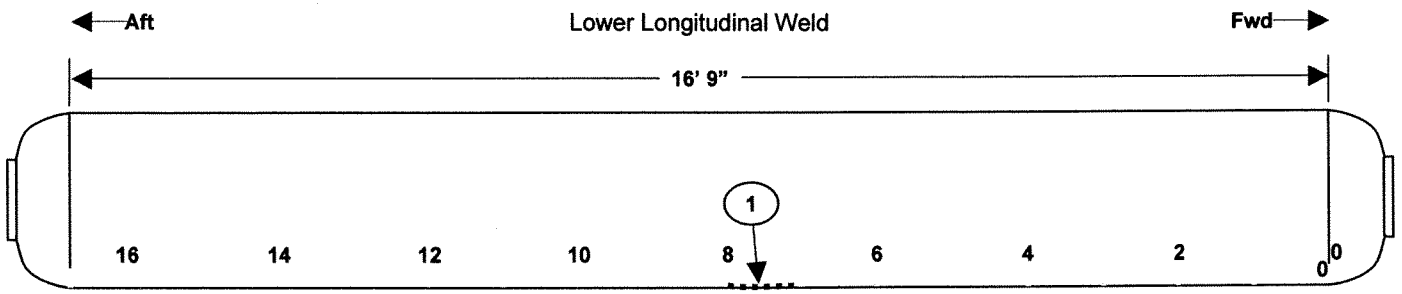
Water Drum 24



Legend

Continuous Crack	———
Intermittent Crack	·····
Photo Link	⬭
Ultrasonic Link	UT

Magnetic Particle Examination Results

1.	7' thru 8'	Intermittent Cracks	1' long

Ultrasonic Sizing Results

1. Located at 7.5', Lightly Intermittent Cracks were visible at this location with ultrasonic scanning but no separation of the crack base and tip were observed, therefore, no depth is given and it is assumed that the depth is less than 0.015"

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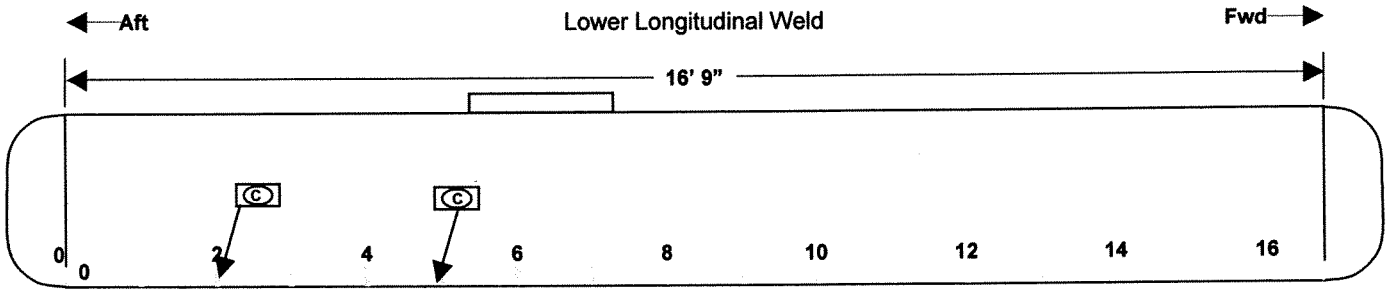
Steam Drum 22



Legend

Continuous Crack	———
Intermittent Crack	.....
Photo Link	C
Ultrasonic Link	UT

Magnetic Particle Examination Results

The weld area from 0' thru 5' was examined with Fluorescent Magnetic Particle technique with no crack indications noted.

Ultrasonic Sizing Results

The areas at 6", 1.5', & 5' were examined with ultrasonic scanning. Only geometric reflectors were noted, no cracks were detected.

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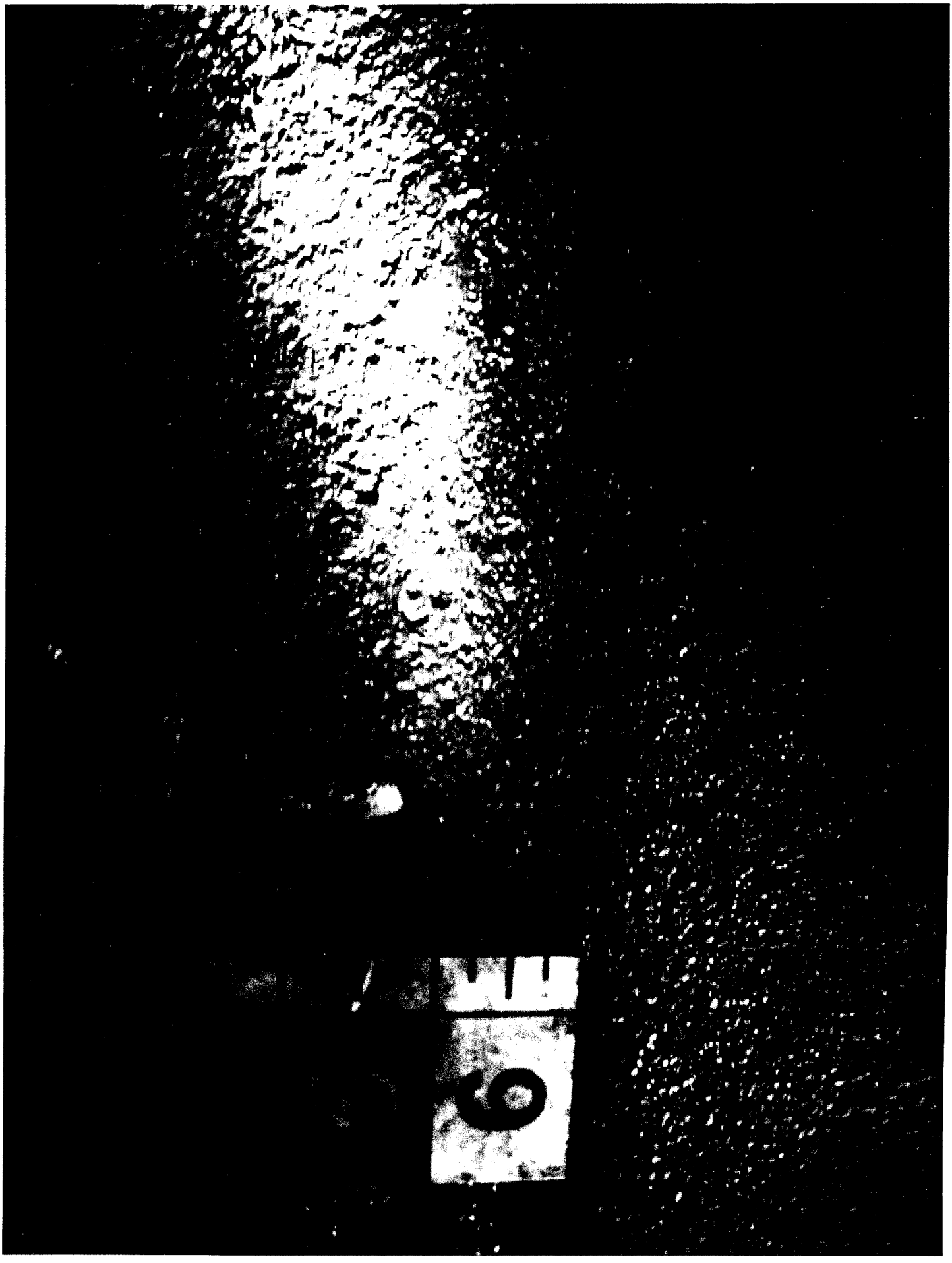

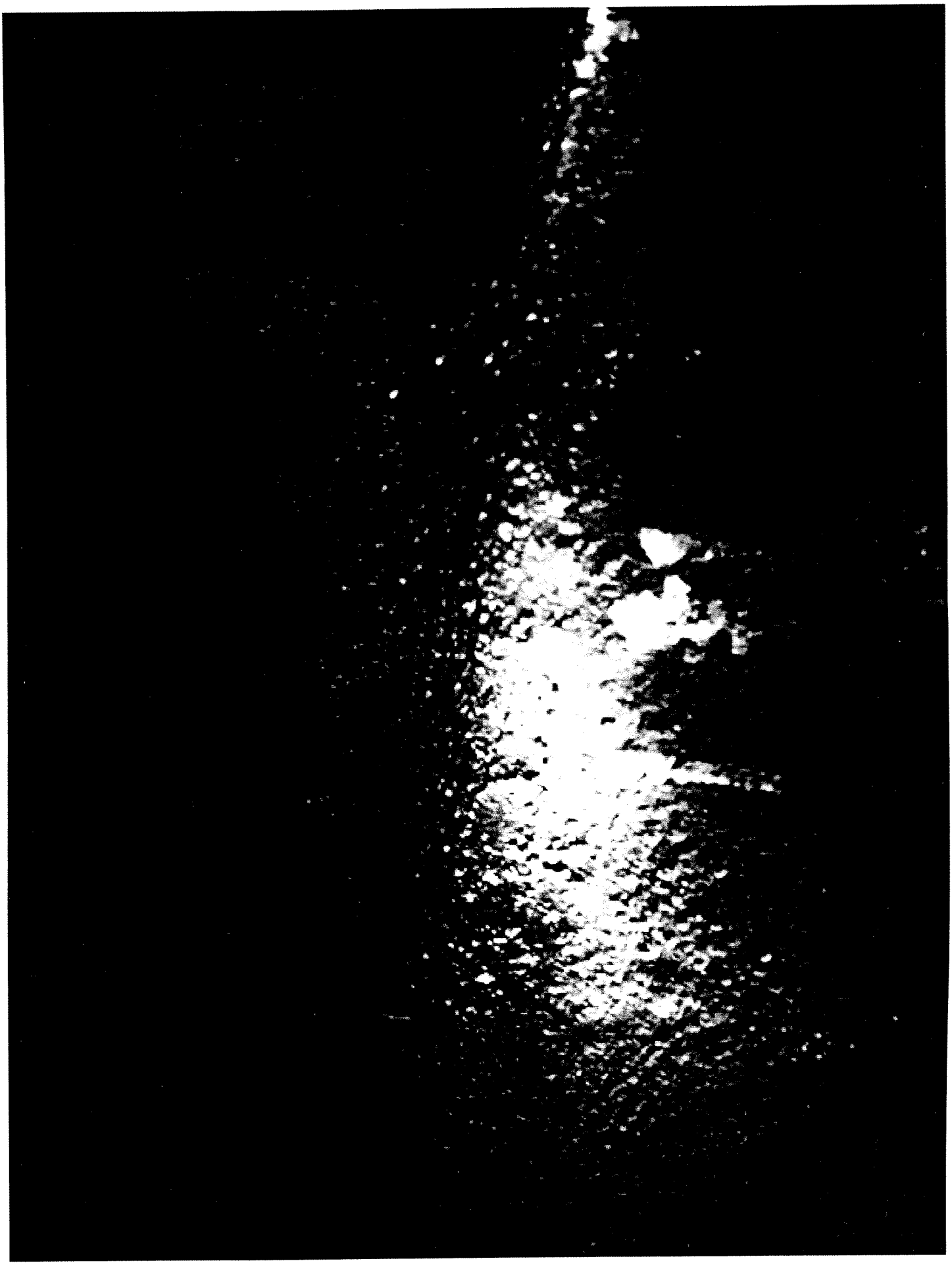

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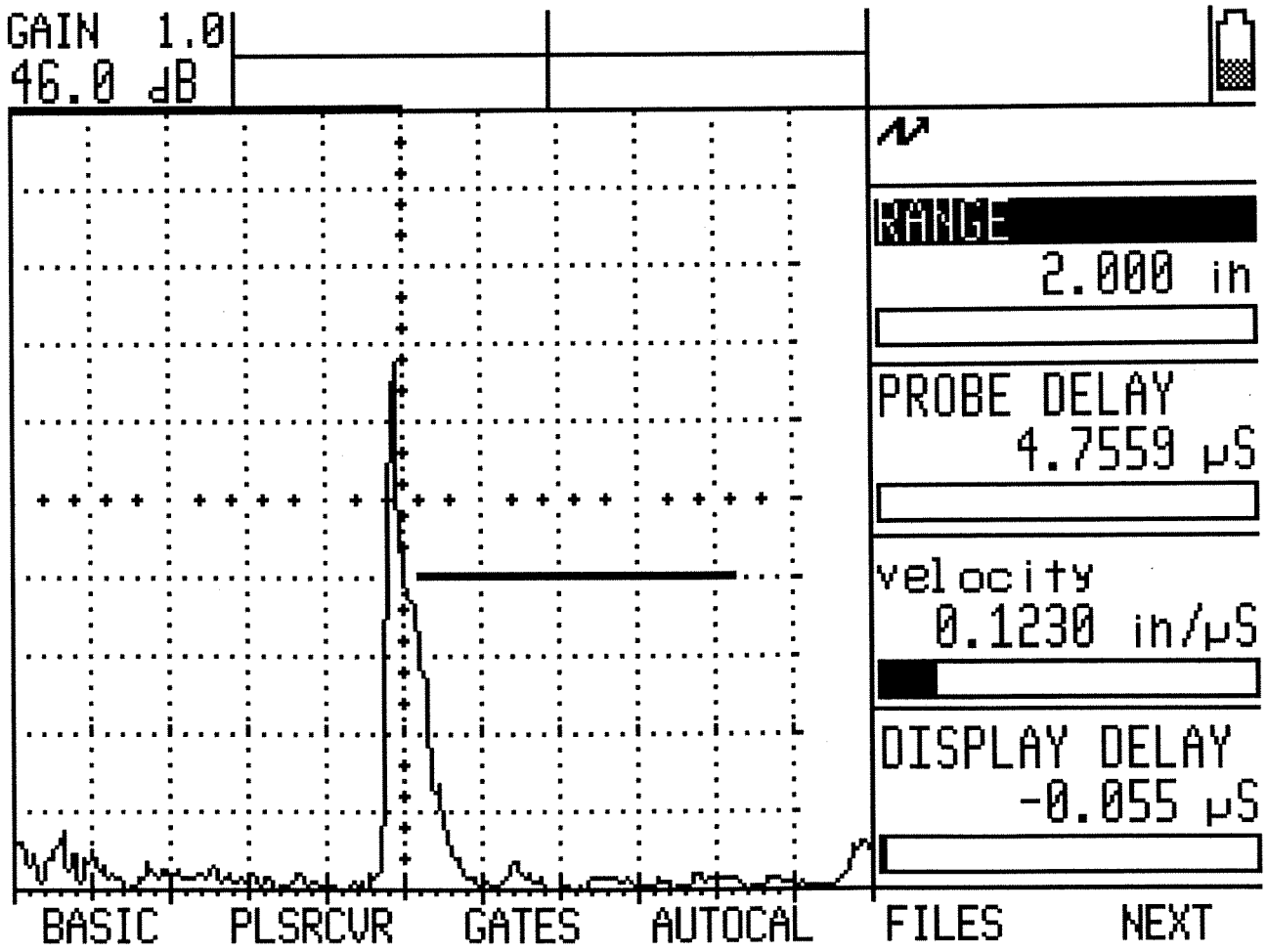
Ultrasonic Calibration for Headers on S. S. Norway using 45^0 transducer



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