ISO 9001:2000

CRT LABORATORIES, INC.
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www.crtlabs.com • e-mail: crtlabs@crtlabs.com
ASTM Physical & Mechanical • Chemical-Thermal Analysis • IAPMO Cell Class
Geosynthetic Materials • Plumbing & Faucet Assemblies • Resin & Finished Product Testing

TEST REPORT

Public Service Commission (ND)
600 E. Boulevard Avenue, Department 408
Bismarck, ND 58505-0480
Tel: (701) 328-2401 / Fax: (701) 328-2133
ATTN: Darrell Nitschke / Alan Moch

LWR NO.: 17936 DATE: April 29, 2009

BACKGROUND: The customer submitted one assembly for failure analysis. The sample was delivered on 02/02/2009 via Excel Energy courier. Visual inspection was performed on 02/02/2009 and no "visual" defects were noted. Testing in accordance with CRT approved test protocol dated 11/21/2008, in addition to advance check # 51355318 received on 02/03/2009.

CRT order entry log date: 02/03/2009 / **Report due date:** 04/29/2009

CRT Notes: Excel Energy and opposing expert arrived on 03/25/2009 to witness slicing the assembly down the axis of the tubing, which was approved by Alan Moch on 03/25/2009 (approximately 10 A.M.) via telecom

Product ID: Fargo Gas Riser with approximately 3ft pigtail with an in-line PE coupling fused to Century PE tan tubing

PREPARATION:
Conditioning – ASTM D 618, 40 hours in a standard laboratory environment
CNC & Machining – CRT / ASTM methods
Nitrogen (N_2) – ASTM D 3418

TEST PROCEDURES: **Pinhole Leak Scope:**
Fiber-optic, Stereo-zoom Microscopic – CRT methods (Forensic Engineering)
Double-scan Thermal Analyses (DSC) – Differential-scanning Calorimetry – ASTM D 3418 / CRT methods (50°C thru 300°C)
Fourier-transform Infrared Microspectroscopy (FT-IR) – CRT methods
Fractology – Forensic Engineering
Melt Flow Rate (g/10 min) – ASTM D 1238 (190°C / 2.16Kg.)

Courtesy testing: **Alternate** – Dimensions per ASTM D 2513-08b(09) (Table-2)

TEST PROCEDURES: **Fusion Bead Scope:**
SEM-EDS (X-ray) – Forensic Engineering
Tensile Bead properties @ 23°C (Strip Tensiles) – CRT / ASTM / CRT modified methods
Double-scan Thermal Analyses, N_2 (DSC) – Differential-scanning Calorimetry – ASTM D 3418/CRT methods (50°C through 300°C @ 10°C/min)
Fourier-transform Infrared Microspectroscopy (FT-IR) – CRT methods
Fractology – Forensic Engineering

Specimen Retain: BB (30-day retain only unless otherwise specified)

CRT LABORATORIES, INC.
UL Approved-Registered / UL-ISO 9001:2000 Certified – ISO-IEC 17025 Compliant

Ken A. Le Jeune
COO / Laboratory Director

Jeffrey A. Blackford
Senior Laboratory Manager

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Final Laboratory Report on Riser

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A3135
Committed to Quality

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FOR: Public Service Commission (ND)
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Tel: (701) 328-2401 / Fax: (701) 328-2133
ATTN: Darrell Nitschke / Alan Moch

LWR NO.: 17936 DATE: April 29, 2009

TABLE 1

SCOPE: Failure analysis

SAMPLE ID: Fargo Gas Riser w/approximately 3ft pigtail with an in-line PE coupling fused to Century PE Tan Tubing

TEST RESULTS: The final results of testing are shown below, along with other attached data. In addition, Forensic Engineering report shall be sent by hard copy to Mr. Darrell Nitscke (Executive Secretary).

Fiber-optic analysis: Forensic Engineering report shall be sent directly to the client via hard copy.

	Sample-1 (Pinhole Leak scope)	**Sample-2 (Fusion Bead scope)**
	N/A	SEM-EDS (X-ray) See attached SEM photos
Tensile Strip @ 23°C	2,110 – 2,249 Yield Psi	2,518 – 2,457 Yield Psi
Avg.:	2,180 Psi / 15 MPa	2,487 Psi / 17.1 MPa
Tensile Strip @ 23°C	27.2% – 31.9% Yield Elongation	21.6% – 21.4% Yield Elongation
Avg.:	29.6%	21.5%
Tensile Strip @ 23°C	82.93 – 90.10 Peak Pounds	87.59 – 82.70 Peak Pounds
Avg.:	86lbs (tubing only)	85lbs (bead to coupling only)
Differential-scanning (DSC)	127.3°C peak melt temperature Typical for PE base materials No foreign material detected	128.6°C peak melt temperature Typical for PE base materials No foreign material detected
Crystallinity % (PP)	27.2	33
Heat of Fusion (PP)	85.6 J/g	98.8 J/g
Maximum induction point (degradation)	253.0°C (good quality)	245°C (decent quality)
Fourier-transform Infrared (FT-IR)	Polyethylene (identical to sample-2)	Polyethylene (identical to sample-1)
Contamination:	No foreign material detected	No foreign material detected
Melt Flow Rate (g/10 min)	0.354 – 0.348 – 0.348	N/A
Avg.:	0.35 g/10 min	N/A
Std. Dev.:	0.003465	N/A
	Fractional melt base (indicative to HDPE for Tubing)	N/A
Dimensionals:	0.003465	N/A
(ASTM D 2513-08b)	O.D. (0.621" – 0.629")	N/A
Avg.:	0.625" / Pass	N/A
	Wall Thickness (0.090" – 0.099")	N/A
Avg.:	0.091" / Pass	N/A

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April 29, 2009
File Number 209077

CRT Laboratories
1680 N. Main
Orange, CA 92867

Attn.: Mr. Ken Le Jeune

RE: Plastic welds
Laboratory Work Request 17936

BACKGROUND

It was reported that a plastic tube had failed at a welded joint after several decades of service in a gas meter. We were requested to examine a portion of the tube to determine the cause of its failure and to visually evaluate an associated plastic weld.

EXAMINATION AND ANALYSIS

The submitted materials consisted of two sections of plastic welds, each at a lap joint in which a tube had been inserted into a fitting. Both the tubes and fittings were reportedly constructed of high density polyethylene. The larger of the received items was a longitudinal half section of a fitting end and approximately four inch length of tubing. The other, smaller received item was a longitudinal half section of a fitting end containing the failed end of the joined tube. The mating side of this failure – the tube length beyond the fitting end – was not received for examination.

Both items were inspected with the aid of a binocular microscope. Although the weld bead on the end of the larger section fitting appeared somewhat irregular, the fusion between the fitting and tube at the cross section appeared sound. There was no visual evidence of any lack of

fusion, entrapped foreign material or voids. Because the length of this lap joint substantially exceeded the wall thickness of the tube, it was anticipated that a tensile overload of these materials would result in a fracture through the tube, while leaving the welded joint intact.

The welded joint of the failed item appeared similarly sound, with two exceptions. The cross section displayed a lack of fusion for a length of approximately 0.03 inch at the end of the fitting, although there was no evidence that this feature had contributed to the crack in the tube. More significantly, the fracture surface at this weld exhibited a cavity containing approximately eight particles of apparent sand. Chevron marks and radiating patterns on the fracture surface indicated that the crack had originated at the inboard edge of this cavity. These features revealed that this void had served as a stress concentrator that contributed to the failure.

Other features suggested that the joint had experienced a relatively high load or stress at the time of the failure. The fracture surfaces displayed no evidence of joint having been weakened during service. There was no evidence of environmental stress cracking, progressive craze cracking or fatigue cracking. Although the originally fabricated joint had been weakened by the presence of entrapped debris, the final cracking from that site appeared to occur as a single, sudden event.

Although the received section did not contain the entire crack surface, the received crack pattern suggested that the joint had experienced a bending load – with tensile stress being concentrated at one side of the tube – at the time of failure. Also, the cavity did not appear to be centered at the middle of the crack. This suggested that although the cavity served as a crack initiation site, the overall tube had been highly stressed in bending at the time of failure.

CONCLUSIONS

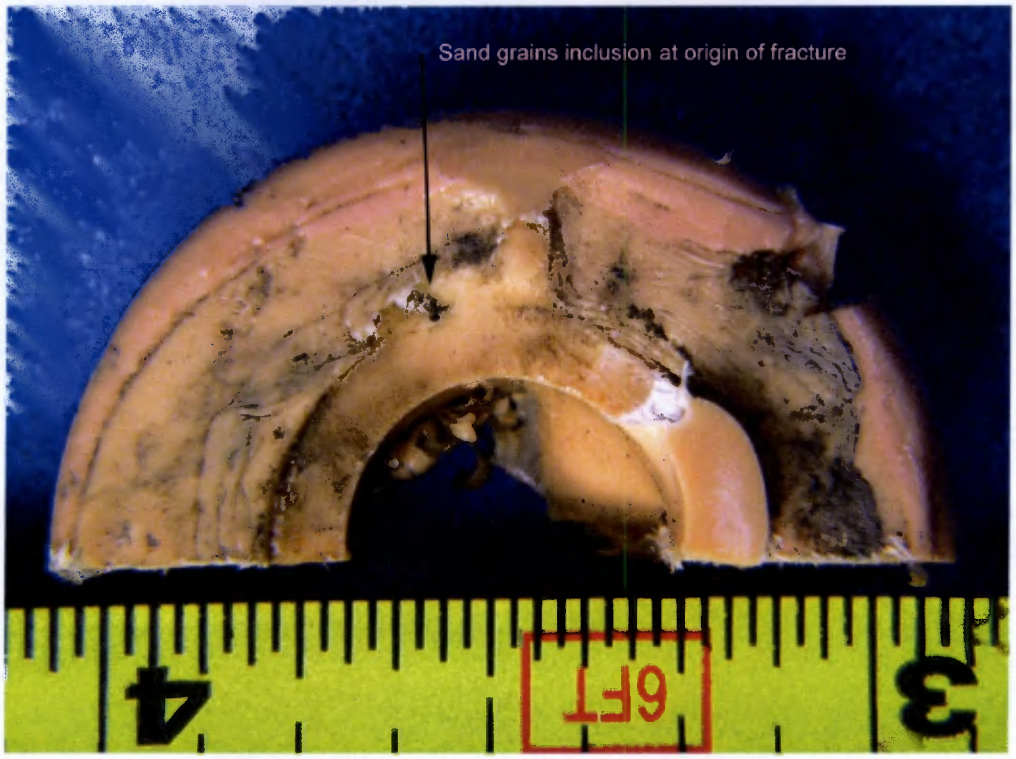
The welded joint at the cross section of the larger received item appeared to be sound.

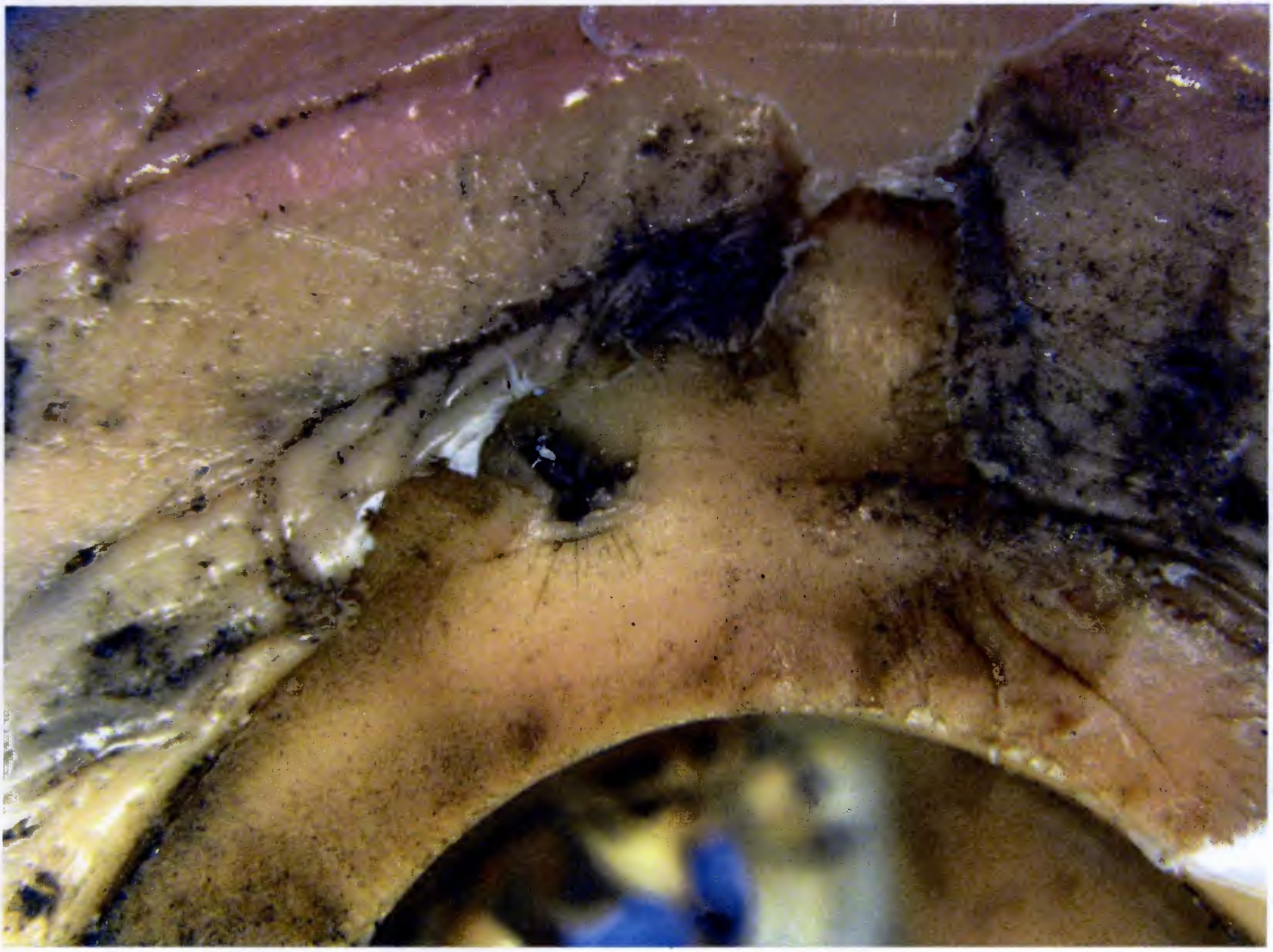
The failure of the cracked tube was attributed to the combination of a cavity formed by debris entrapped at the time of welding that served as a stress concentrator and a relatively high bending load at the time of failure.

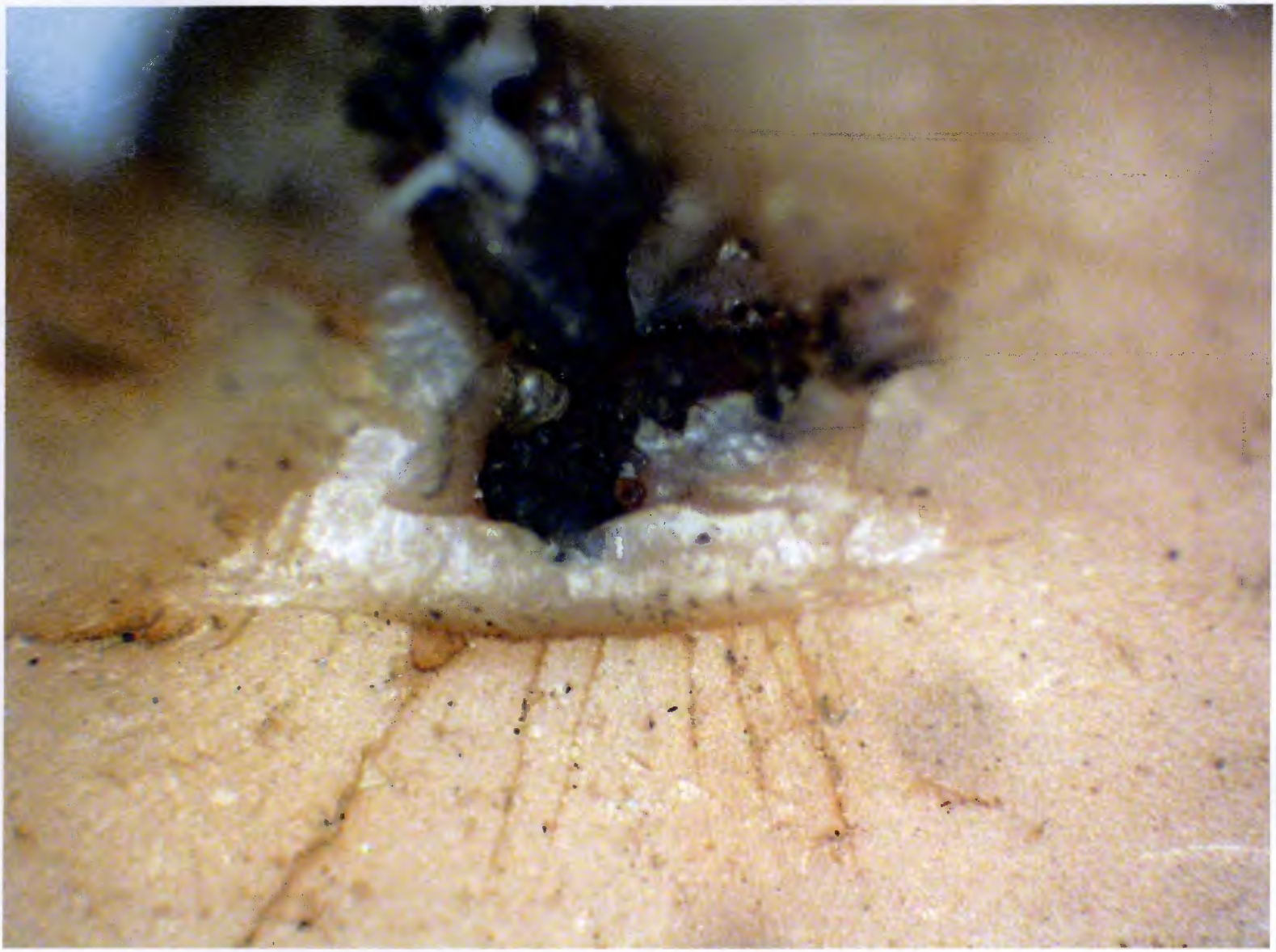
Respectfully submitted,

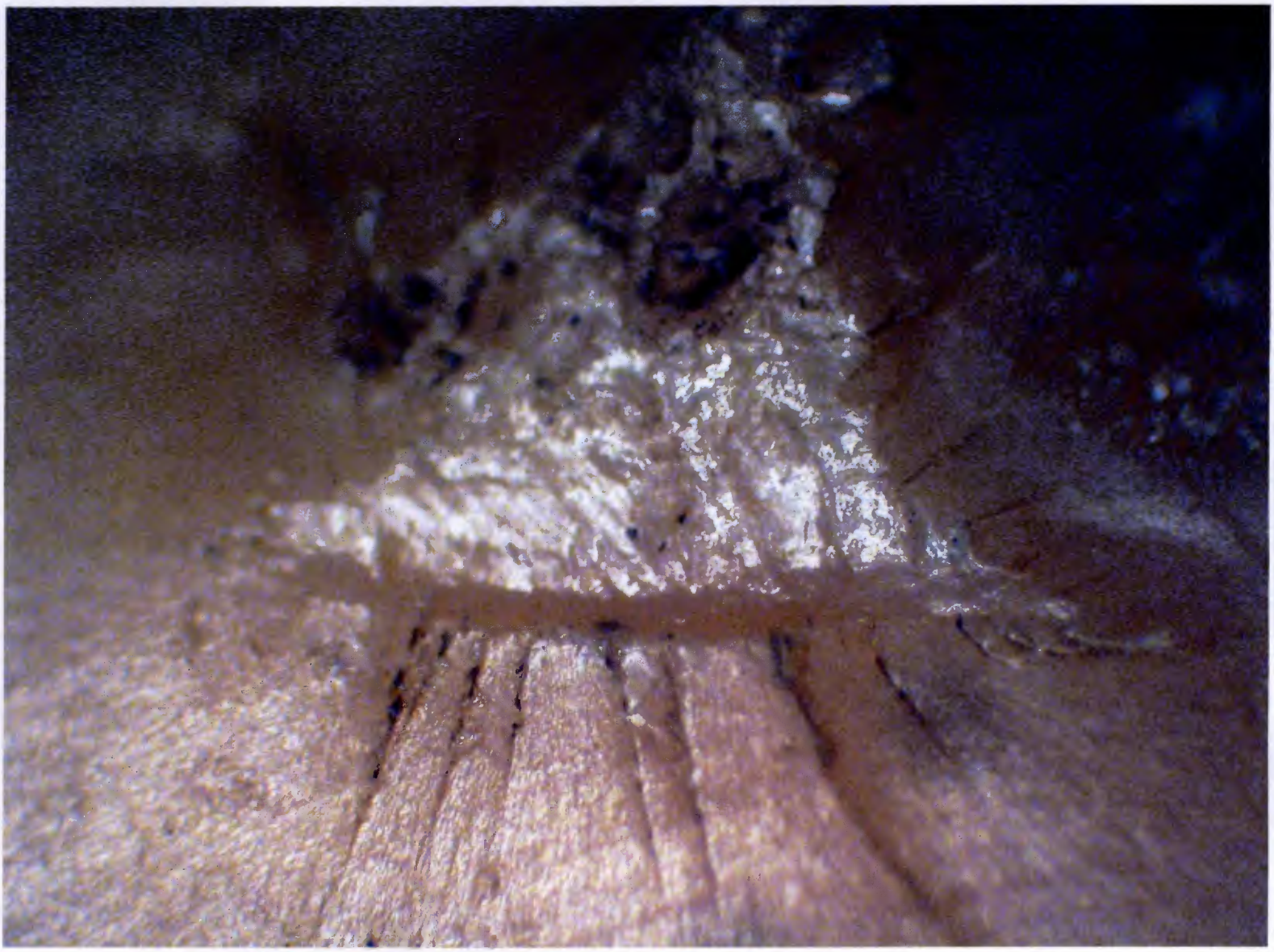
FORENSIC ENGINEERING CONSULTANTS

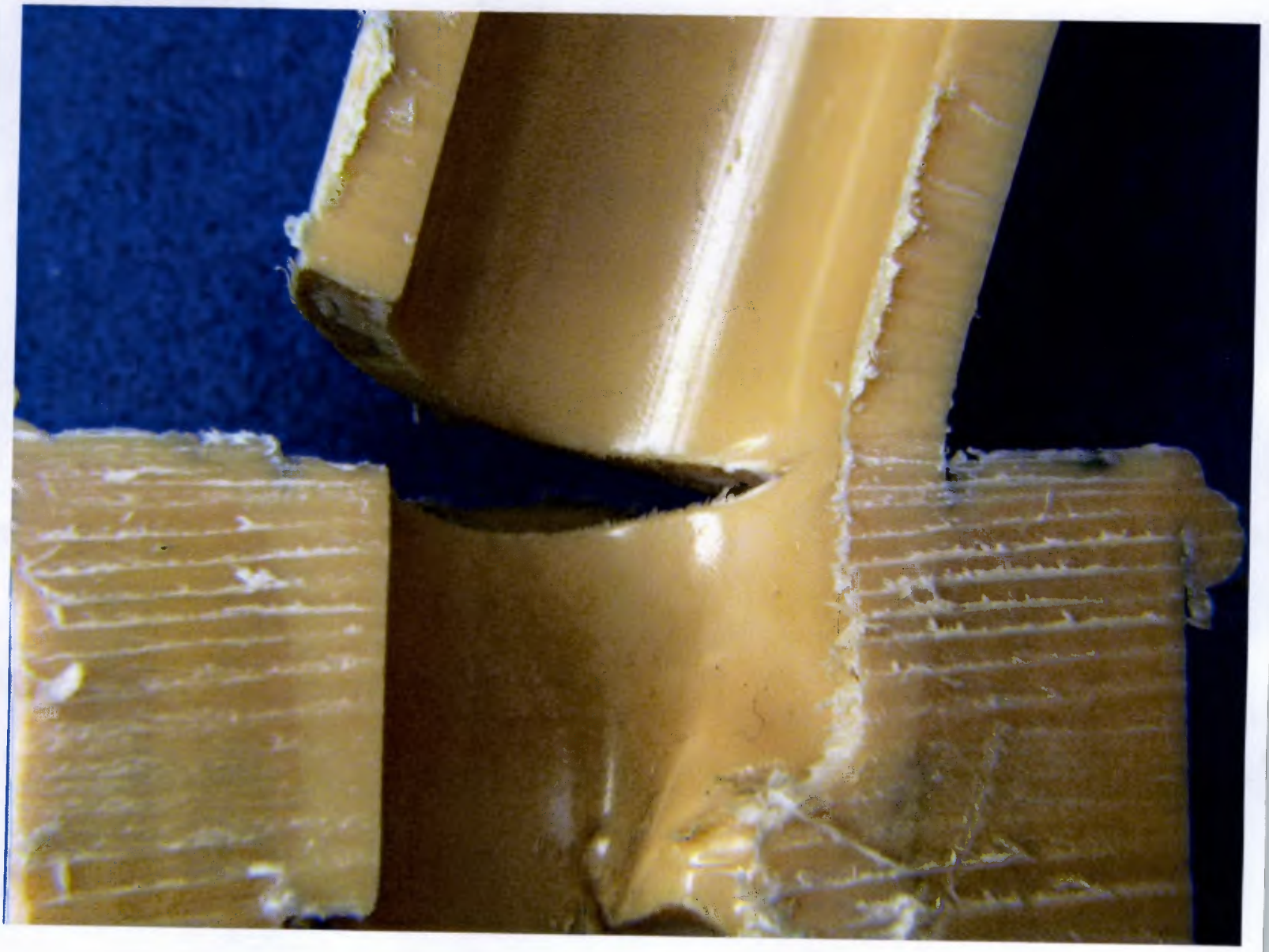
Scott Meek, B.S.
Registered Professional Engineer
Texas License No. 44413

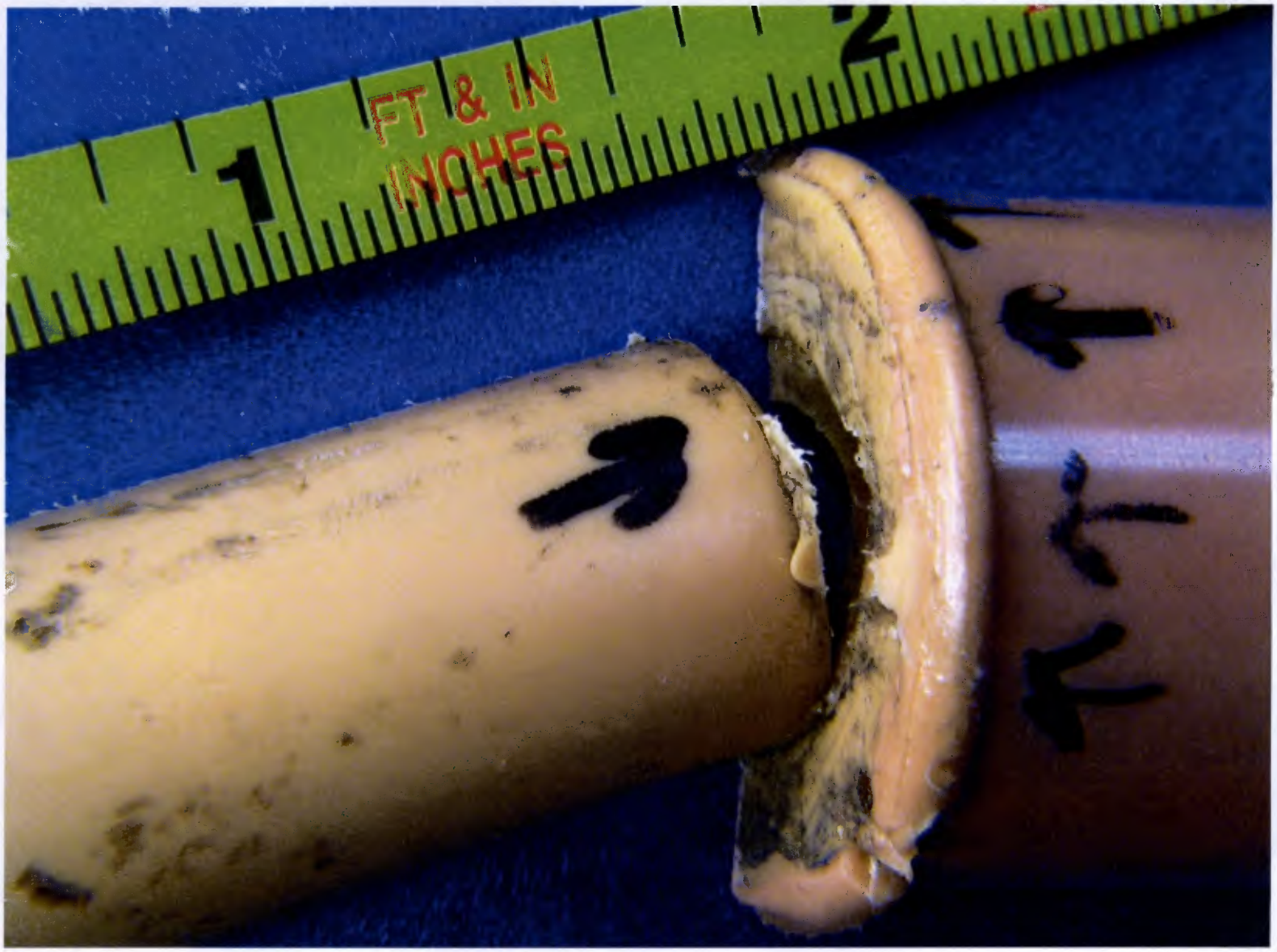

Sand grains inclusion at origin of fracture
4
6FT
3





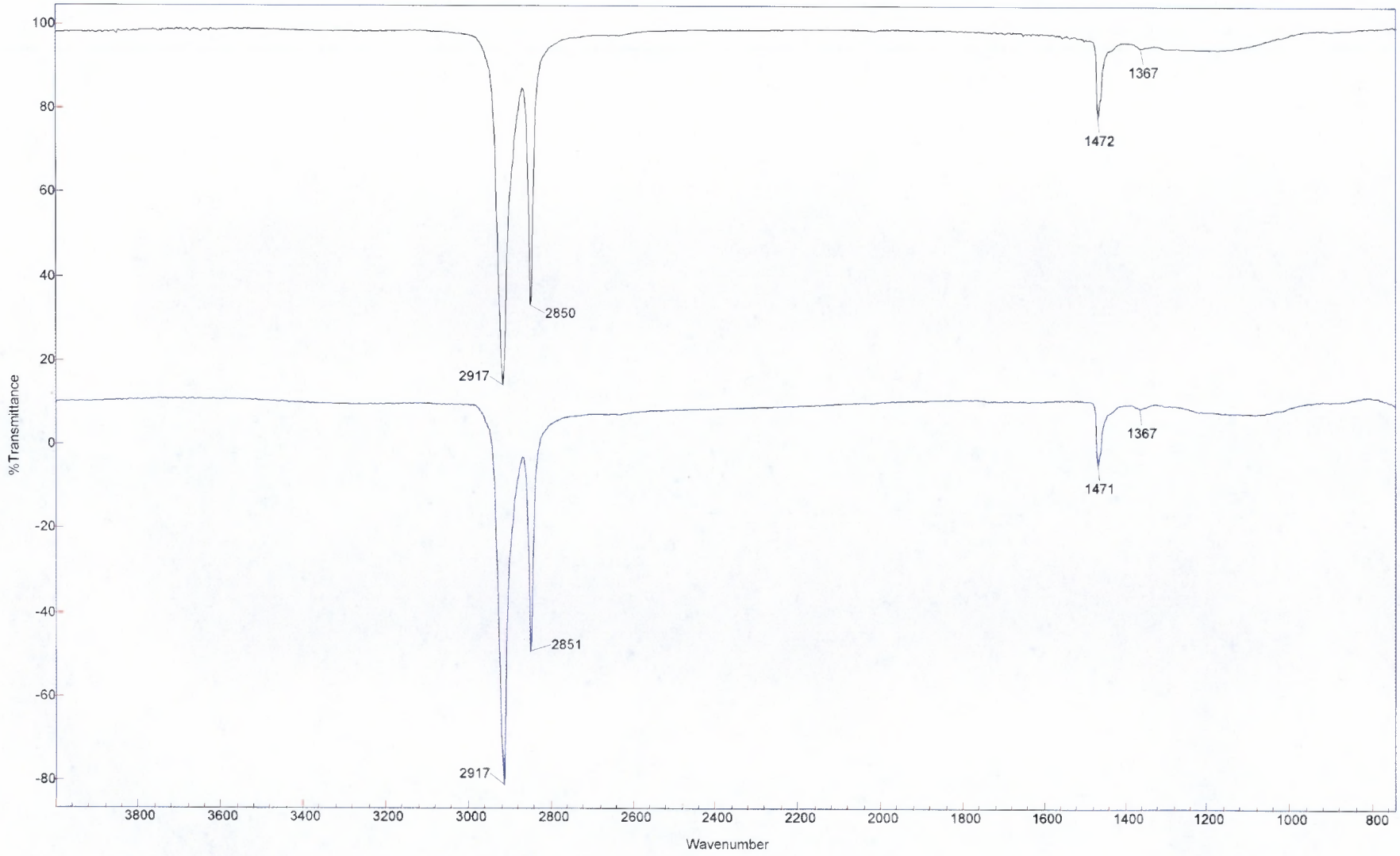





FT & IN
INCHES
1
2

fused bead area

Pinhole area



No significant differences are seen between the spectra.