

ARTECH TESTING, L.L.C.

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Mr. Frank Zakar
Senior Metallurgist
NTSB, Materials Laboratory
490 L'Enfant Plaza East, S.W.
Washington, DC 20594

August 30, 2000

PRODUCT TESTING

Ref.: Material Analysis of a Pipe and Grease-like Sample.

FAILURE ANALYSIS

ARTECH Job File: M00069
NTSB Order No.: BENS-00-0245
NTSB Reference No.: LUCJ6344

Dear Mr. Zakar:

LITIGATION SUPPORT

Two (2) excised pieces of a 10" diameter pipe, manufactured per American Petroleum Institute Standard (API) 5L Grade 52, were received for mechanical testing and chemical analysis. The two wall pieces and details for orienting the test specimens are illustrated in Figure 1 and Attachment 1.

CHEMICAL ANALYSIS

One grease-like sample was also received for chemical analysis by FTIR.

Testing was conducted per the test protocol in Attachment 2. The test results are as follows:

ENGINEERING CONSULTING

PIPE SAMPLE

Tension Testing

Three (3) transverse tensile specimens were manufactured to API specification from the larger 11"x12" piece. The specimens had a 2" gage length, and the cross-section for the gage area was 1.5" width x 0.312" wall thickness. The cut blanks were flattened before machining. The tension test results are listed in Table 1.

MATERIALS RESEARCH

Table 1 Tension Test Results

Sample ID	0.2% Offset Yield Strength (psi)	Ultimate Tensile Strength (psi)	Elongation 2" Gage Length (%)
1	52,600	70,100	33.3
2	53,300	70,700	32.6
3	56,500	69,300	33.8

BIOMATERIALS

FOOTWEAR TESTING

All tested specimens exceeded the minimum specified yield strength of 52,000 psi for Grade 52 pipe material.

Charpy Impact Tests

Twenty (20) transverse sub-size Charpy V-notch specimens were manufactured from the 9"x6" piece of pipe as illustrated in Attachment 1. The specimens were 2/3 standard width and measured 10mm x6.67mm x55mm.

Two specimens each were tested at the listed temperatures (-100°F, -50 °F, -10 °F, 32 °F, 70 °F, 110 °F, 150 °F, and 212 °F). Three specimens were tested at 50 °F. The individual test specimens for the given test temperatures were randomly selected. The impact test results are summarized in Table 3 and ordered by increasing temperature.

Table 3 Charpy Test Results

Sample ID	Temperature (°F)	Impact Value (ft-lb)	Lateral Expansion (in)	Shear (%)
C4	-100	1.5	0.002	0
C13	-100	1.5	0.002	0
C7	-50	2.0	0.002	0
C18	-50	2.0	0.005	0
C9	-10	3.0	0.004	5
C10	-10	3.0	0.003	10
C5	32	6.5	0.014	20
C14	32	7.5	0.015	20
C2	50	11.5	0.023	40
C11	50	9.5	0.019	40
C16	50	9.5	0.019	30
C6	70	18.0	0.031	50
C15	70	18.0	0.032	60
C3	110	22.0	0.042	100
C12	110	20.0	0.040	100
C1	150	22.5	0.044	100
C17	150	22.0	0.043	100
C8	212	22.0	0.045	100
C19	212	22.0	0.045	100

Chemical Analysis

A representative specimen was removed from the 11"x12" piece for chemical analysis. The material was analyzed for carbon, manganese, phosphorus and sulfur as requested by NTSB. The results are listed in Table 2.

Table 2 Chemical Analysis

	Carbon	Manganese	Phosphorus	Sulfur
Weight Percent	0.24	1.08	0.014	0.011

GREASE-LIKE SUBSTANCE

Chemical Analysis

An unidentified grease-like substance was mounted on a 1/2" diameter carbon stub, when it was received by ARTECH. The sample was analyzed by FTIR per instructions.

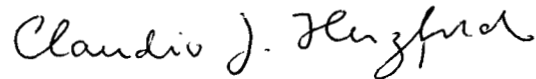
A portion of the sample was removed from the carbon stub. This excision was mixed with Potassium Bromide (KBr) using a mortar and pestle. This mixture was then compressed into a KBr "pellet", which was then analyzed using a Nicolet Model 460 Fourier Transform Infrared Spectrometer (FTIR). Due to its crystalline structure, Potassium Bromide (KBr) is "invisible" to the detector employed in FTIR. Therefore, only the sample was analyzed. Once the sample was analyzed, two reference greases were analyzed. First, a Molybdenum-Disulfide grease was examined. Next, a Lithium-based grease was analyzed. The three resulting spectra were compared to one another. This is shown in the attached FTIR spectra (FT-IR #1). Upon closer analysis of the regions from 2980 – 2800 and 1710 – 1380 wavenumbers, it was determined that the sample compound was similar to the Molybdenum grease in the high region of the spectrum (shown in FT-IR #2), but similar to the Lithium grease in the low region of the spectrum (shown in FT-IR #3). Therefore, it is not possible to conclusively identify this compound as either a Molybdenum-Disulfide or a Lithium grease using the FTIR.

Further analysis by other standard techniques is recommended for identification of the sample.

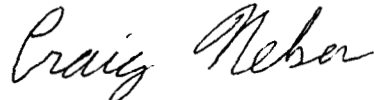
Testing was witnessed by a NTSB personnel. At all other times, the samples were under the sole custody of the NTSB personnel. Upon completion of the testing program, all tested specimens and the remaining material were returned to NTSB.

If we can be of any further assistance in this or any other matter, please do not hesitate to call.

Sincerely,
ARTECH TESTING, L.L.C.



Claudio J. Herzfeld
Test Engineer
Materials and Testing Division



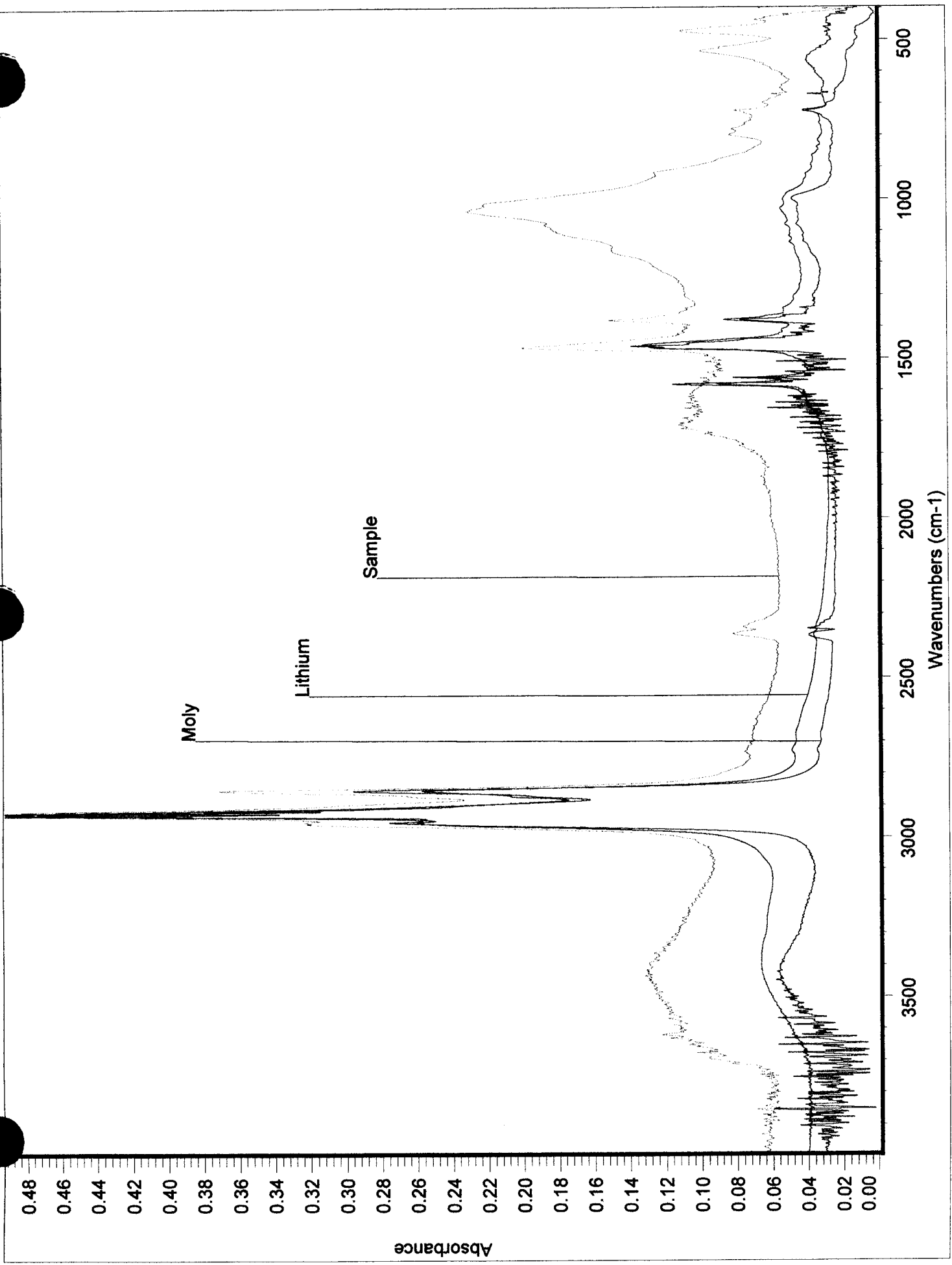
Craig Nelsen
Chemist
Chemistry Department

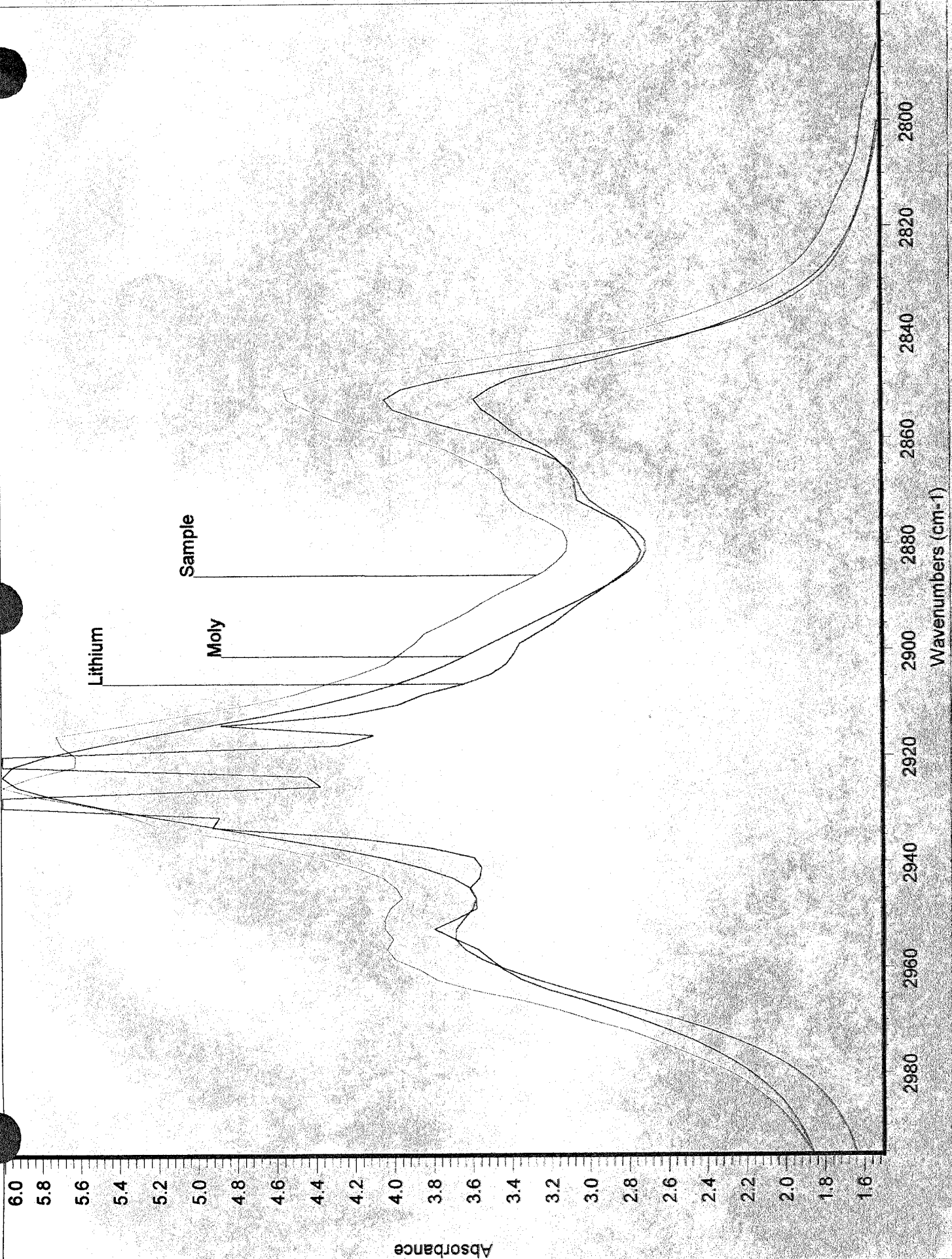


V. Sahay
Managing Engineer
Materials and Testing Division

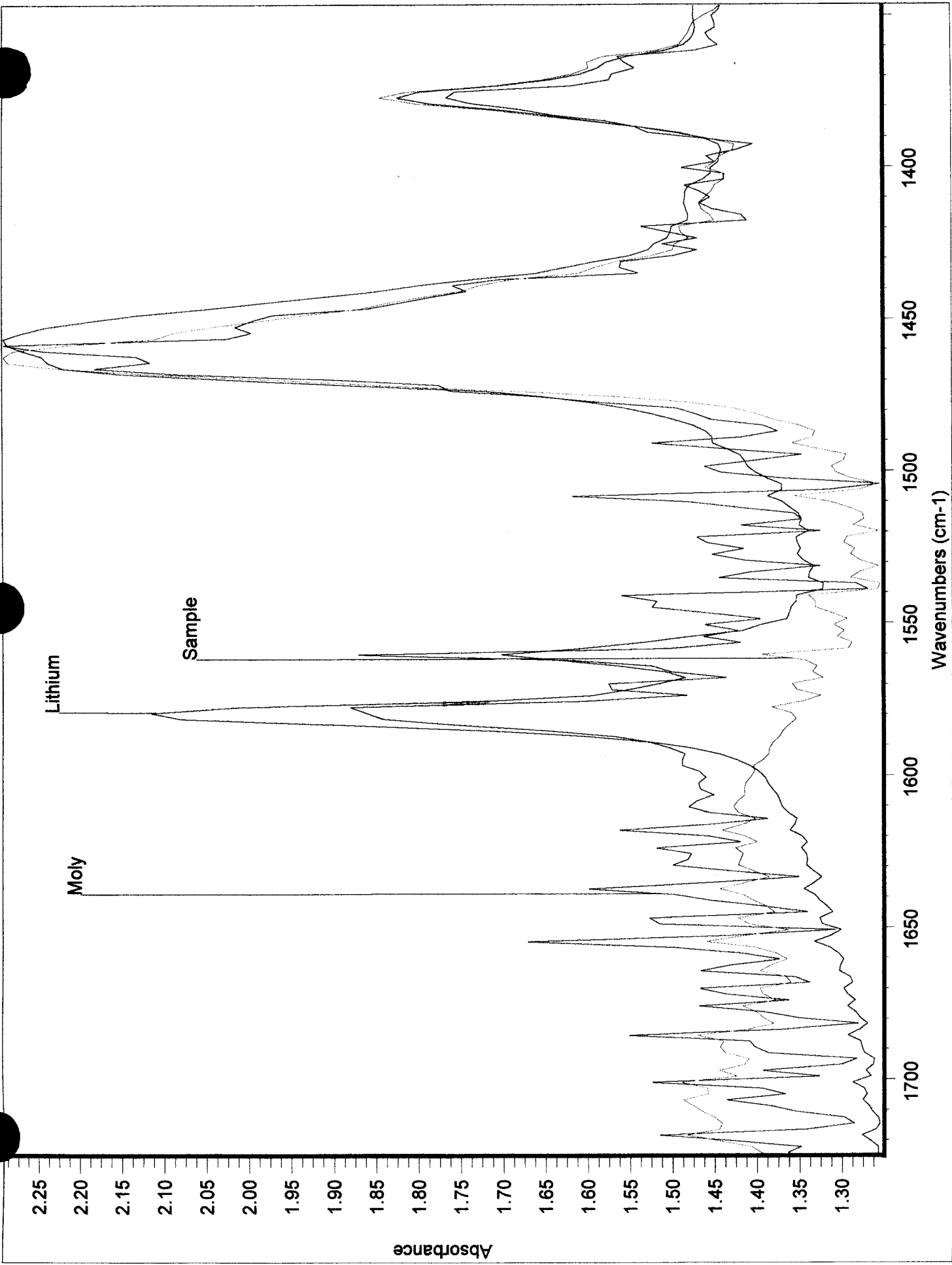


Figure 1 Pipe Pieces





FTIR # 3



National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, DC 20594

July 21, 2000

V. Sahay

Artech Testing LLC

14554 Lee Road
Chantilly, VA 20151

Dear Mr. Sahay,

The Safety Board materials laboratory is performing a failure analysis of a pipe that was manufactured per American Petroleum Institute Standard (API) 5L grade 52, 0.312 inch nominal wall thickness. Grade 52 indicates that the steel alloy has minimum yield strength of 52,000 pounds per square inch (psi).

Attached to this package are two excised pieces of the wall from the pipe. One piece measures approximately 9 inches x 6 inches and the other 11 inches x 12 inches. Included in the package is a sample of an unidentified grease-like substance. Please manufacture the test specimens and perform the test described in this letter. The orientation of the test specimens was drawn on the outside diameter of the pieces. A sketch of the excised wall pieces and details regarding the orientation of the test specimens is shown in "Attachment 1".

1. Manufacture 3 transverse tensile specimens from the wall of the pipe. Specimens will represent the full wall thickness of the pipe. According to the API specification, the transverse tensile test specimen is 1.5 inch wide in the gage area and has a 2-inch gage length. Report ultimate tensile strength (psi), yield strength (psi), and elongation (%).
2. Remove material from the 11 inches x 12 inches wall to perform chemical analysis. Report the percentage of carbon, manganese, phosphorus, and sulfur.
3. An unidentified grease-like substance was found on the surface of the pipe. It was placed by NTSB personnel on the surface of a 1/2-inch diameter carbon stub. Analyze by FTIR method and identify this substance.
4. Manufacture a total of 19 transverse subsized Charpy V-notch specimens. Each specimen will be 2/3 size and will measure 10 millimeter (mm) x 6.67mm x 55mm. Test specimens at the following temperatures:
 - 2 specimens at -100, -50, -10, 32, 70, 110, 150, and 212 degrees Fahrenheit
 - 3 specimens at 50 degrees Fahrenheit

July 21, 2000

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Report impact energy value (foot-pounds), lateral expansion (inch), and shear area on fracture surface (%).

NTSB shall retain all submitted specimens, including leftover material and tested specimens.

Please call me by telephone, (202) 314-6536, if you have questions regarding these test procedures.

Sincerely,



Frank Zakar
Senior Metallurgist
Materials Laboratory

ATTACHMENT 1.

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JULY 21, 2000
NTSB
Frank P. Zekur

