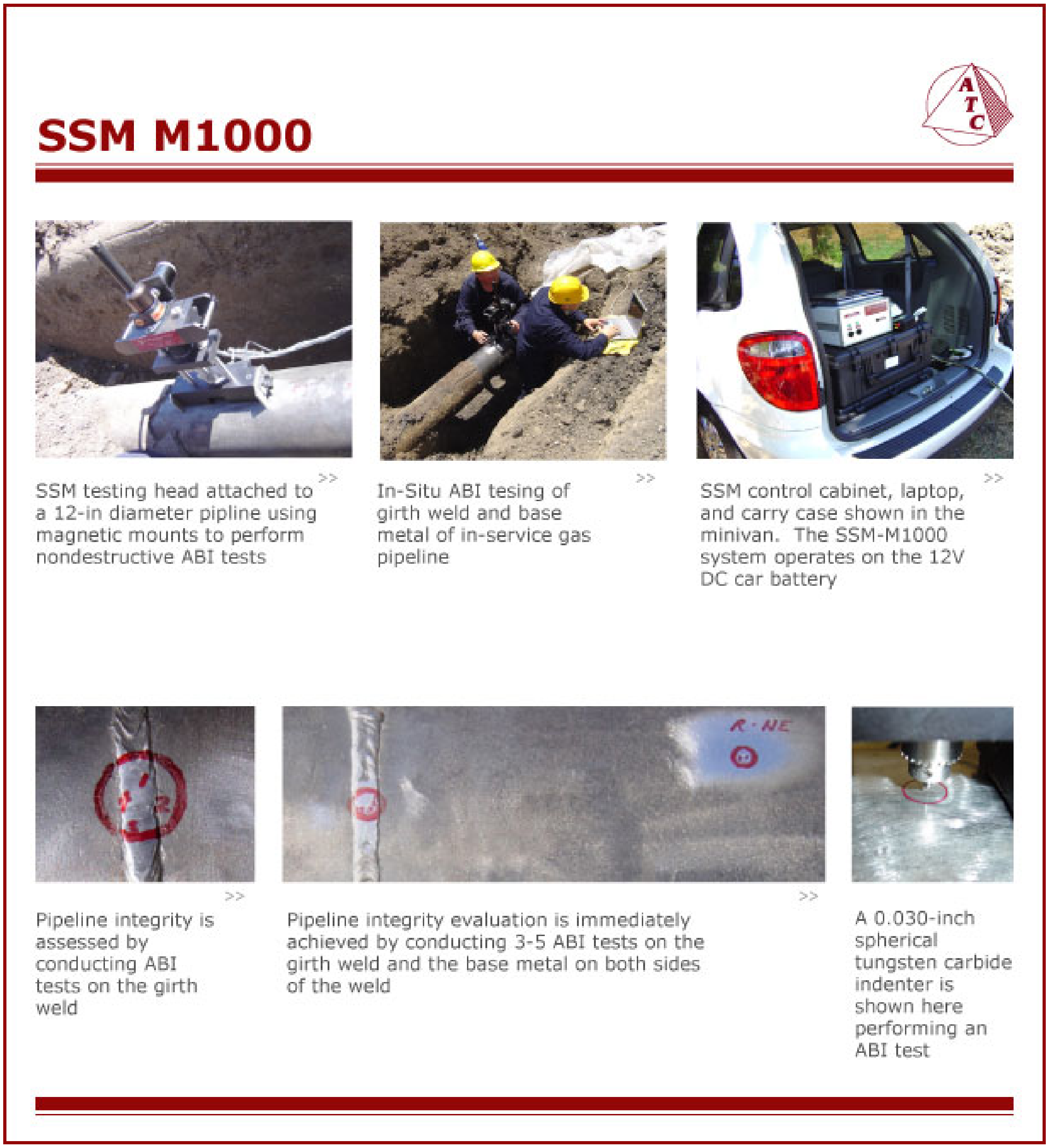
Example of ABI-Measured Tensile and Fracture Toughness Test Results that you can witness and receive at the conclusion of *In-Situ* ABI testing on your steel pipeline materials



ATC's patented Stress-Strain Microprobe® (SSM) system utilizes an innovative, nondestructive, and localized Automated Ball Indentation (ABI) test. Below are samples of ABI test data, tensile, and fracture toughness results from five (5) ABI tests conducted on a 24-inch diameter Section of X52 Pipeline Steel during the International Pipeline Conference in Houston (February 2003). All ABI tests were conducted using a 0.030-inch diameter tungsten carbide indenter.

This is an example of the ABI test results you will receive from us for each test location on your pipeline material (base metal, weld, and HAZ areas) to allow you to comply with the new DOT/OPS regulations when you have no documentation for the grade of your pipeline or when you have cracks and need to perform fracture mechanics analysis for fitness-for-service assessment. ATC provides SSM field-testing services to allow safe pipeline operation and to improve profitability.

For more details please visit our website: www.atc-ssm.com

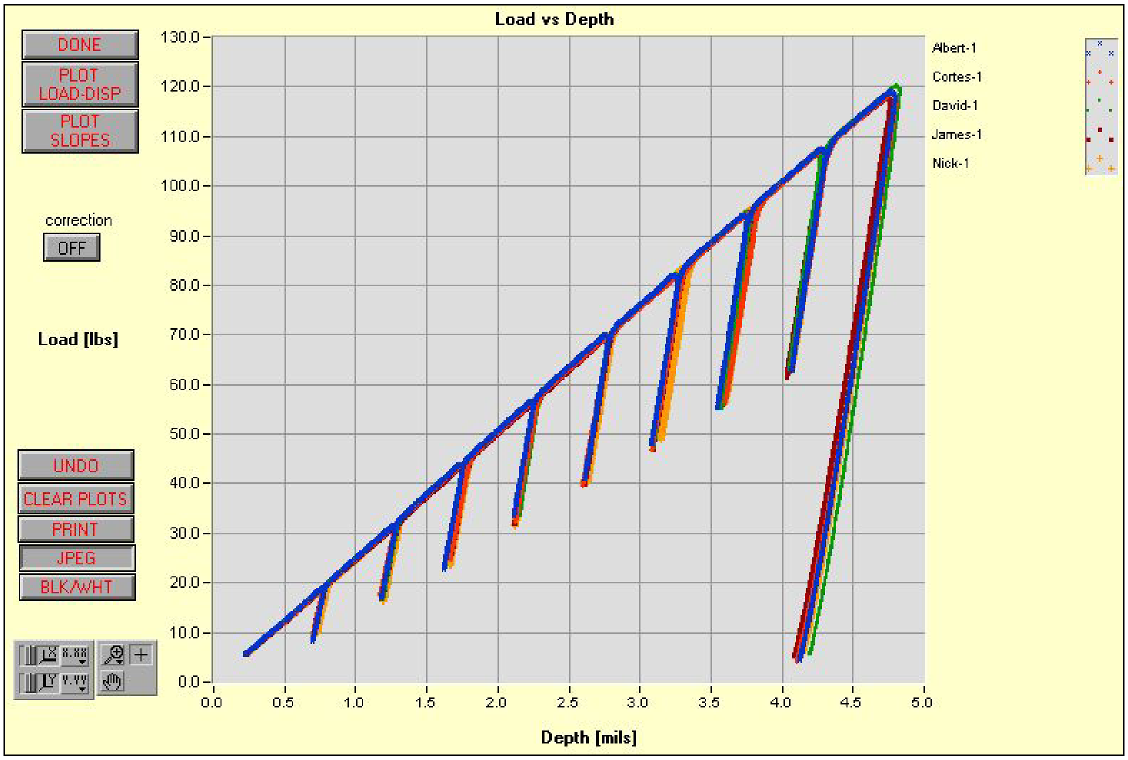


Fig. 1 Overlay of Load-Depth data from five (5) ABI tests conducted on a 24-inch diameter section of X-52 pipeline steel using a 0.030-inch diameter tungsten carbide indenter.

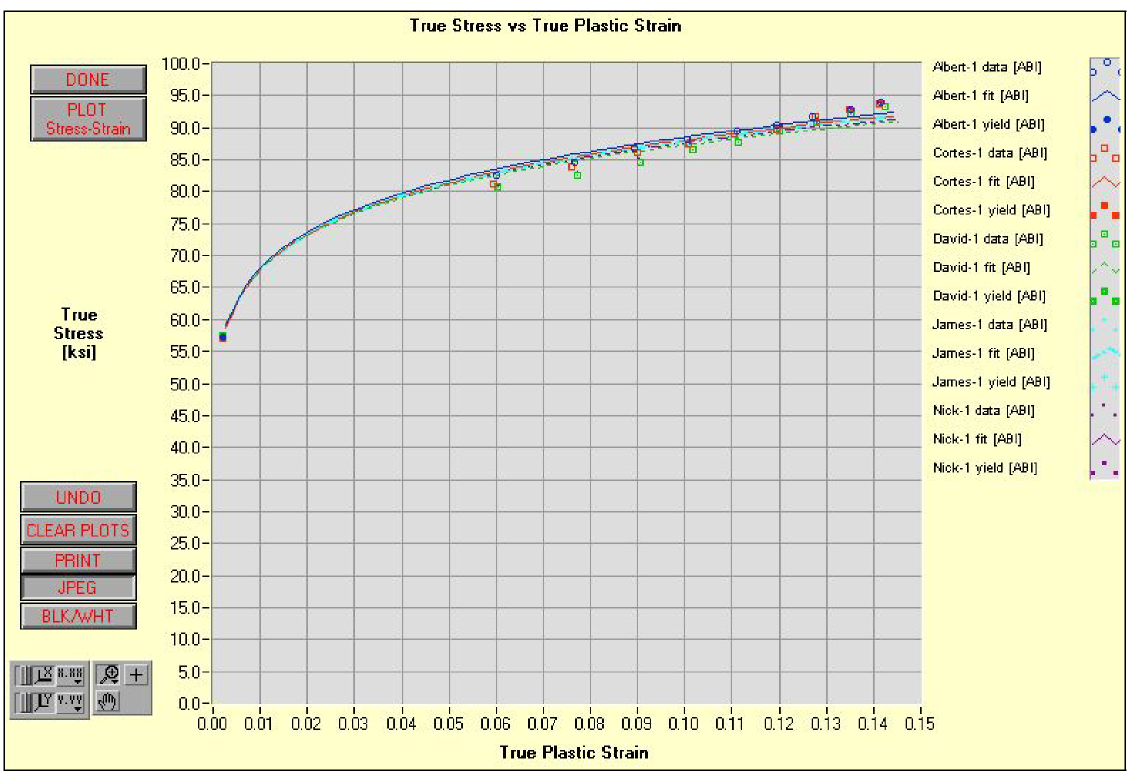


Fig. 2 Overlay of True-stress/True-plastic-strain curves from five (5) ABI tests conducted on a 24-inch diameter section of X-52 pipeline steel using a 0.030-inch diameter tungsten carbide indenter.

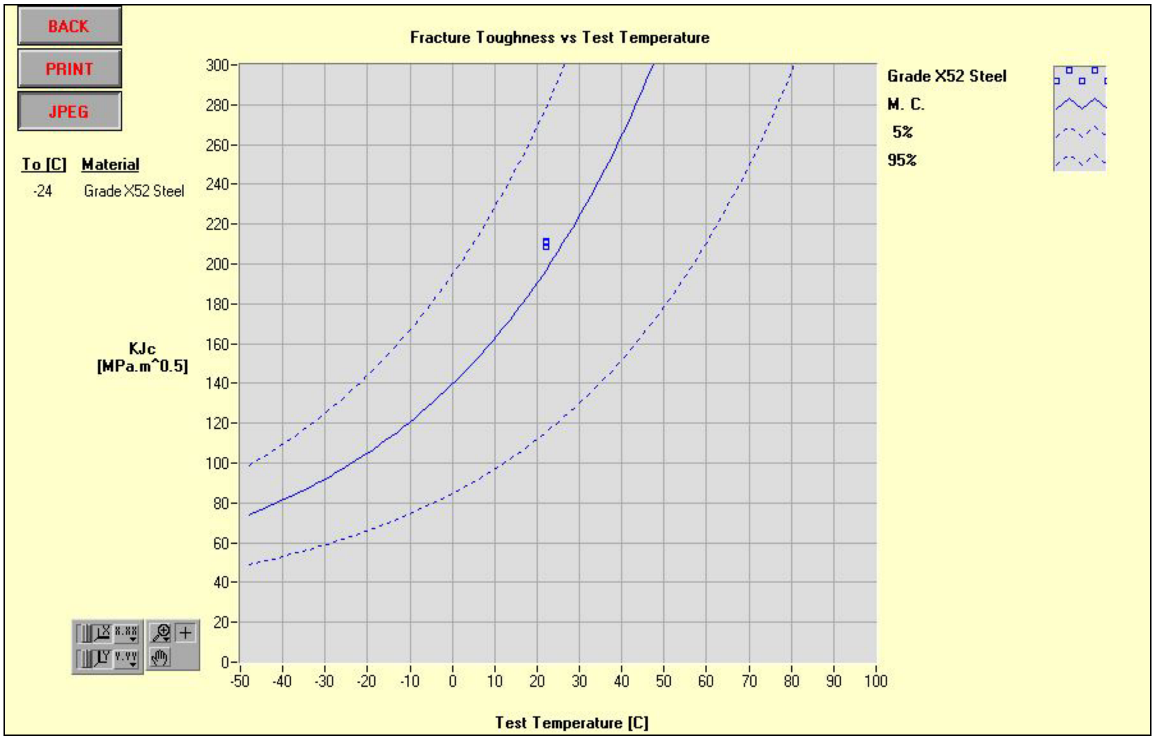


Fig. 3 Fracture toughness master curve from five ABI (5) ABI tests conducted on a 24-inch diameter section of X-52 pipeline steel using a 0.030-inch diameter tungsten carbide indenter. The reference temperature determined from the ABI tests (-24°C) is defined as the temperature at a median fracture toughness level of 100 MPa√m (ASTM Standard E 1921). The 95% and 5% confidence limit curves are shown in dotted curves. **[Note: Although we perform ABI tests at a single ambient temperature, the universal shape of the master curve, with fracture toughness decreasing with decreasing temperature, allows the determination of fracture toughness of the pipe base metal or weld at other operating temperatures such as those in cold or artic winters]**.

Table 1 Summary of ABI-measured tensile, BHN, and fracture toughness properties from five (5) ABI tests conducted on a 24-inch diameter section of X-52 pipeline steel using a 0.030-inch (0.76-mm) diameter tungsten carbide indenter.

Test	Yield Strength [ksi]	Strength Coefficient, (K) [ksi]	Strain Hardening Exponent (n)	Estimated UTS [ksi]	Ratio Yield to UTS	Calculated UTS [ksi]	Calculated Uniform Ductility [%]	ABI Hardness (030G)	Fracture Toughness [ksi.in^0.5]
Albert-1	57.2	115.1	0.114	80.2	0.71	80.3	11.5	187	192.5
Cortes-1	57.0	114.5	0.114	79.8	0.71	79.9	11.5	186	191.5
David-1	57.4	112.2	0.109	78.9	0.73	79.0	11.4	187	189.7
James-1	57.0	114.1	0.113	79.6	0.72	79.7	11.5	186	191.6
Nick-1	57.6	113.2	0.111	79.5	0.72	79.5	11.4	187	191.7
Average	57.2	113.8	0.112	79.6	0.72	79.7	11.5	187	191.4
S.D.	0.2	1.0	0.002	0.4	0.01	0.4	0.05	0.5	0.9

S.D. = Standard Deviation

It should be noted that in a blind study (witnessed by three engineers from Columbia Gas, Exponent, and ANR Pipeline Company, and included pipeline steels with various grades manufactured 1931 though 1978) the ABI-measured tensile results were compared against those from destructive tension tests of pipeline coupon specimens. The ABI results were found to be equivalent and more repeatable and have been accepted by the DOT OPS (see Ref. 1 and the attached review signed by the DOT Secretary). The ABI-measured fracture toughness results produced equivalent average values with greater consistency (hence, a smaller standard deviation) than the destructive test results. The ABI results were considered a success story by the DOE (see Ref. 2 which is also downloadable from DOE website). Both references are downloadable from: www.atc-ssm.com.

The ABI technique has two major advantages over destructive tests of specimens machined from coupon samples, namely, being localized and practically nondestructive. The **ABI is a multi-axial mechanical test** that is considered nondestructive because it does not remove any material and leaves a shallow/smooth spherical depression (i.e., no sharp edges or stress-concentration sites). Furthermore, it introduces a compressive residual stress that retards crack initiation, similar to a single shot peen. The nondestructive and in-situ capabilities of the ABI technique make it attractive to measure the tensile and fracture toughness properties of base metal, girth welds, and HAZs of pipelines without service interruption and to detect any hydrogen embrittlement on coupon samples or on in-service pipelines to monitor their structural integrity. Additional pipeline applications are described in References 3-4.

References:

1. Haggag, F. M., "Nondestructive Determination of Yield Strength and Stress-Strain Curves of In-Service Transmission Pipelines Using Innovative Stress-Strain Microprobe® Technology," *ATC/DOT/990901*, Sept. 1999.

2. Haggag, F. M., "Nondestructive and Localized Measurements of Stress-Strain Curves and Fracture Toughness of Ferritic Steels at Various Temperatures Using Innovative Stress-Strain Microprobe® Technology," DOE-SBIR Phase II final report *DOE/ER/82115-2*, under grant number DE-FG02-96ER82115, 1999.

3. Haggag, F. M., and Phillips, L. D., "Innovative Nondestructive Method Determines Fracture Toughness of In-Service Pipelines:" Proceedings of the International Pipeline Conference, IPC04-0345, Calgary, Canada, Oct. 2004.

4. Haggag, F. M., and Phillips, L. D., "Integrating Automated Ball Indentation with ASME B31G Code to Assess Remaining Integrity of Corroded Pipelines," Proceedings of the International Pipeline Conference, IPC04-0357, Calgary, Canada, Oct. 2004.

990924-060

THE SECRETARY OF TRANSPORTATION

WASHINGTON, D.C. 20590

December 13 , 1999

The Honorable Zach Wamp
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressman Wamp:

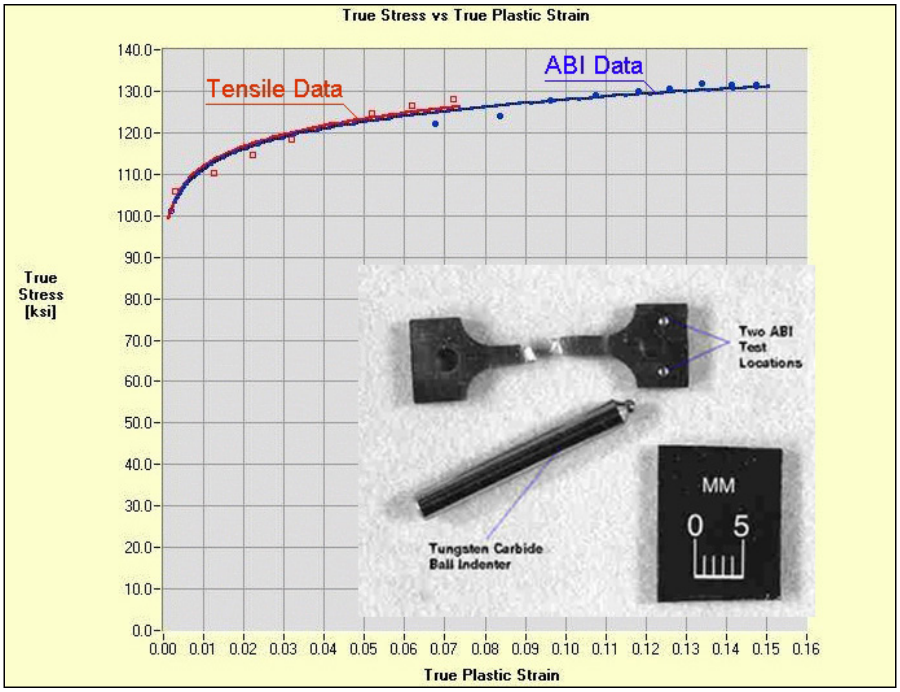
Thank you for your letter and report forwarded on behalf of Dr. Fahmy M. Haggag regarding Stress-Strain Microprobe™ (SSM) technology. Dr. Haggag's report has been forwarded to the Research and Special Programs Administration (RSPA) for review.

The RSPA Administrator Kelley S. Coyner has advised me that the Office of Pipeline Safety (OPS) has been following the development of SSM technology for some time. Dr. Haggag's report has been reviewed and the technology appears to be fundamentally sound for application in the pipeline industry. Although the U.S. Government is not permitted to endorse an individual product or technology, it is RSPA's policy to encourage industry to use the latest technology, materials and practices available. RSPA is interested in and plans to follow the development of SSM technology as it is applied by the pipeline industry.

Again, thank you for bringing this information to our attention. If we can be of further assistance, please contact Michael J. Frazier, Assistant Secretary for Governmental Affairs, at (202) 366-4563.

Sincerely,

Rodney E. Slater



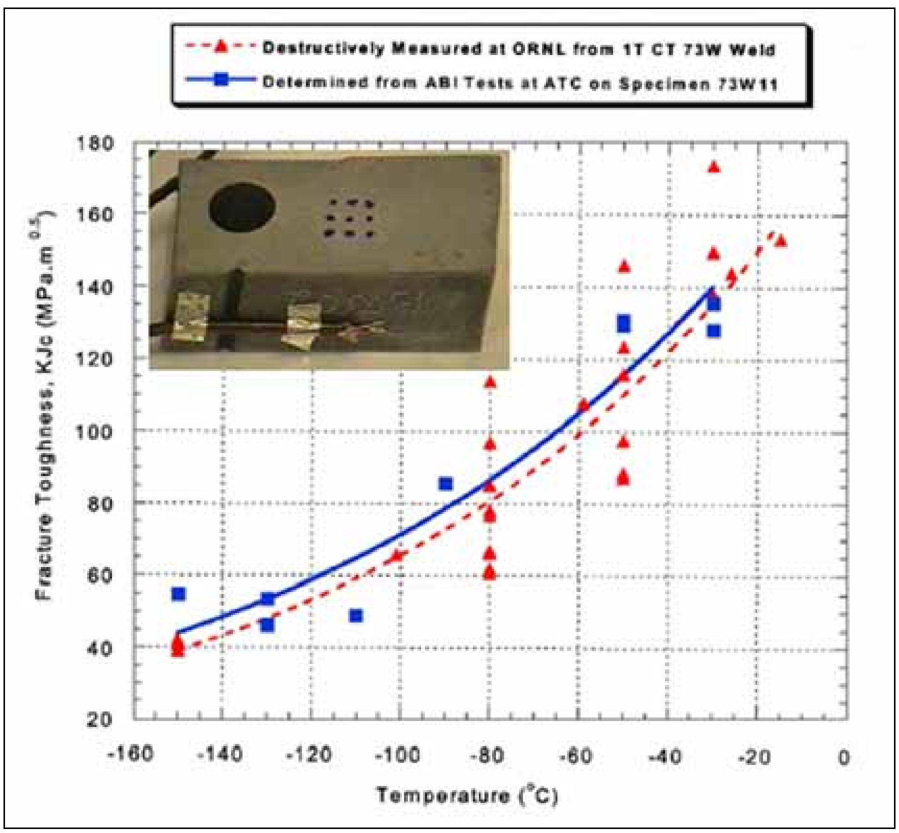


Fig. 4 The ABI-measured tensile and fracture toughness properties are in excellent agreement with those from destructive coupon specimens. Nine ABI tests were conducted on the broken half of the destructive fracture toughness specimen. Both tensile and fracture toughness properties are measured from each single ABI test in less than two (2) minutes without specimen manufacturing or interruption to structure/component service.

Fig. 5 The bench-top SSM system (Model SSM-B4000) is shown above with all optional accessories. ATC's patented SSM systems have been in use worldwide since 1991. In addition to performing the innovative ABI tests, the bench-top systems are also state-of-the-art universal testing machines with the SSM-Suite^{TM} software icons shown below.