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PHASE II SUMMARY OF RESULTS

Creare LLC
16 Great Hollow Road
Hanover, NH 03755

Point of Contact
Nicholas T. Kattamis
603-640-2533; ntk@creare.com

Federal Government COR
Sherry S. Borener
202-366-1666; sherry.s.borener@dot.gov

Existing inline inspection (ILI) tools and in-the-ditch measurements provide little information about strength and toughness properties. After close evaluation of available Non-Destructive Evaluation (NDE) techniques, we concluded that the most promising solution for inline and in-the-ditch inspection is through a combination of complementary techniques ("multimodal"). To address this critical, unmet need, Creare developed a hybrid tool for Inline Pipe Inspection. Our approach determines material fracture toughness through two independent techniques measuring two separate properties, which significantly increases the accuracy of the overall approach. Our multimodal approach fuses: (1) NDE through the magnetic Barkhausen noise (MBN) and (2) NDE through the attenuation of mechanical vibrations (AMV).

In Phase II, we developed our AMV and MBN techniques through extensive benchtop laboratory testing, culminating in the development of a prototype system for each modality intended for use in the field. In addition, we studied a third modality, attenuation of ultrasound (AU) to build upon our Phase I effort, but we ultimately ceased this effort due to inherent challenges that would make a robust in-the-ditch measurement infeasible.

From our laboratory tests, we found that both the AMV and MBN techniques show promise as NDE modalities to characterize material properties. MBN parameters, particularly the time shift or phase of the signal, showed a strong linear correlation to material hardness in 1045, 4140, and 4340 steel plate samples. We also observed strong trends in pipe samples from PRCI. AMV also showed a strong linear correlation to material hardness on plate samples. These data have been drafted into a paper, which we intend to submit after this contract's period of performance.

We also encountered challenges with AMV in testing on pipes due to effects of curvature and surface preparation, but we believe that these challenges can be thoroughly addressed given additional research and testing. If additional funding were available, we would focus our attention on (1) correcting the deficiencies in our AMV prototype, (2) developing the appropriate independent and multi-modal correlations for AMV and MBN for fielded pipe samples, (3) conducting field trials on pipe at PRCI to garner interest from the pipeline monitoring community, and (4) transitioning the technology to pipeline operators.

The NDE techniques developed on this effort could be leveraged for inspection of pipelines of all types. They could also be used in factories or refineries that contain lengths of pipe that pose a risk due to age and wear from service. Steel mills and heat treating facilities could also leverage this technology to quickly scan for hardness as part of their material certification process.