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QUARTERLY REPORT

Project WP#339: Structural Significance of Mechanical Damage

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Prepared For: United States Department of Transportation
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Prepared By: Aaron Dinovitzer
Principal Investigator
BMT Fleet Technology Limited
311 Legget Drive
Kanata, Ontario, Canada K2K 1Z8
adinovitzer@fleetech.com

Mures Zarea
Principal Investigator
Gaz de France
361 Ave du President Wilson
B.P. 33, 93211 Saint-Denis
mures.zarea@gazdefrance.com

Mr. Ian Wood
Team Project Manager
Electricore, Inc.
27943 Smyth Drive, Suite 105
Valencia, CA 91355
ian@electricore.org

Mark Piazza
Team Technical Coordinator
Pipeline Research Council, International
1401 Wilson Blvd., Suite 1101
Arlington, VA 22209
mpiazza@prci.org

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Background

The primary objective of the project is to establish a detailed experimental database to support the development and validation of improved burst and fatigue strength models for assessing the interaction of mechanical damage with secondary features (gouges, corrosion, and welds). The use of this data to develop and validate mechanistic models will produce reliable tools to assess a wide range of mechanical damage forms, thereby increasing safety, reducing unnecessary maintenance, and supporting the improvement of pipeline standards and codes of practice.

Progress in the Quarter

GDF SUEZ has created combined defects "Gouge in Dent" on current pipes specified API X52 and API X70 characterized by high ductility. Three similar defects have been made on a X52 pipe:

- Defect 1.1.1: The defect geometry has been measured by 3D laser process;
- Defect 1.1.2: This defect, after geometry characterization by 3D laser, has been well instrumented by different kinds of gages and submitted to burst test. After the burst, the defect (which was not the cause of pipe failure) has been investigated by metallurgical analysis;
- Defect 1.1.3: After the geometry characterization, the defect has been tested for fatigue failure by pressure variation with substantial instrumentation and gages for measuring pipe parameters and potential drop. . The defect failure was reached in about 10,000 cycles. Metallurgical investigation has been performed after the test.

Two other defects have been created - defect 1.2.1 on Pipe 1 (X52) with a deeper dent and gouge but shorter length than the previous defects, and the second defect on the Pipe 2 (X70), named defect 2.1.1, which is a long defect with moderate dent and gouge depths (respectively 1.5% and 12.5%).

The pipe 1 material has been characterized in terms of tensile properties, Charpy impact values, toughness J-Curve, and a study to assess pre-strain effect on toughness has been initiated. In addition, extra work consisting measuring the slip bands due to the strain has been done to check the theoretical formula described in a separate PRCI project (Project MD-4-3) on the expected crack depth initiated during the defect creation.

The initial investigation results show that there is no significant effect of pre-strain on toughness for a range of pre-strain below 4%. Due to the high ductility of the test pipe material, a defect with a dent depth around 1.3% and a gouge depth around 7.5% has no effect on the burst pressure of the pipe. The pipe with the defect behaves like a pipe without defect in monotonic load conditions. Nevertheless, the data record obtained by the gages during the burst test and metallurgical investigations after the test show that the defect has evolved, but not enough to be responsible for the failure. With a similar defect in the same pipe material, a fatigue test has led the defect to fail in about 10,000 cycles for a high amplitude of pressure variation. The data recorded by multiple gages around and directly on the defect seem to indicate that the initiation of propagation of initial small cracks or the crack initiation from severe microscopic surface

defects in the gouge could happen before or around 4000 cycles. The metallurgical investigation after the fatigue test show many cracks with a large distribution from 100 µm to several millimeter deep under the defect with a significant strain up to 40%.