QUARTERLY REPORT
Project WP#339: Structural Significance of Mechanical Damage

For Period Ending: November 30, 2009

Contract No: DTPH56-08-T-000011

Prepared For: United States Department of Transportation
Pipeline and Hazardous Materials Safety Administration
Office of Pipeline Safety

Prepared By:

Aaron Dinovitzer
Principal Investigator
BMT Fleet Technology Limited
311 Legget Drive
Kanata, Ontario, Canada K2K 1Z8
613 - 592 - 2830 ext 203
adinovitzer@fleetech.com

Murès Zarea, Rémi Batisse
Principal Investigators
GDF SUEZ, R&I Department
361 Ave du President Wilson
B.P. 33, 93211 Saint-Denis, France
+3-366-413-5637
mures.zarea@gdfsuez.com
remi.batisse@gdfsuez.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, Intl.
1401 Wilson Blvd., Suite 1101
Arlington, VA 22209
mpiazza@prci.org

Distribution authorized to U.S. Government Agencies only, so as to protect information not owned by the U.S. Government and protected by the recipient's "limited rights" statement, or received with the understanding that it not be routinely submitted outside the U.S. Government. Public distribution is authorized for the final section ("Public Page") of the report.

List of Activities and Deliverables

Task No.	Task	Scheduled Completion Date	Completed Date	Milestone
2	Purchase & Characterize Pipe Material	11/30/2008	Ongoing	
3	Literature Review	06/30/2009	Completed 11/30/2009	MS
4	Testing of Dents on Welds and Corrosion Features	08/30/2009	Ongoing	MS
5	Testing of Dents with Gouges	5/31/2010	Ongoing	MS
6	Demonstration of Mech. Damage Model Performance	11/30/2009	Not Yet Started	MS
7	Industry Workshop	5/31/2010	Not Yet Started	
8	Project Management and Reporting	5/31/2010	Ongoing	MS

Technical Status

Technical activities undertaken through the sixth quarter focused on the following tasks:

- Task 2: Purchase & Characterize Pipe Material
- Task 3: Literature Review
- Task 4: Testing of Dents on Welds and Corrosion Features
- Task 5: Testing of Dents with Gouges

A summary of the technical status and results to date are presented below for each tasks.

The technical group for this program has maintained close communication to ensure program coordination. Issues of concern in the program have been forwarded to PRCI and DOT for their consideration.

Task 2: Purchase & Characterize Pipe Material

There are three different pipe steels in this program:

- Pipe 1 and 2 are modern IPSCO pipes manufactured between 2005 and 2006

- Pipe 3 is intended to be older steel, either a former operating/in-service vintage pipe from one of PRCI's member companies or a manufactured pipe that replicates vintage pipe properties. The team is still establishing the source of Pipe 3.

A potential source has been identified to manufacture Pipe 3 which will represent the older/vintage pipes. The potential source will create the material with properties replicating the observed lower toughness found in the 1950's or 1960's era pipelines. The technical group for the project is evaluating the cost, schedule, and benefits of a manufactured option which would avoid the variability introduced by unknown operations (i.e., pressure cycling over time) and is coordinating the final decision with PHMSA. The team is also determining the funding necessary to purchase the material.

GDF SUEZ has received three samples of Pipe 1 and two samples of Pipe 2 all of 11.8 m in length. Pipe 1 is API X52 grade and has a 24 in. diameter and 7.9 mm wall thickness. Pipe 2 is API X70 grade. It also has a 24 in. diameter but has a wall thickness of 9.0 mm. IPSCO manufactured the pipe using the ERW process.

In the previous quarterly reports, GDF SUEZ presented material characterization results for Pipes 1 and 2:

- Tensile properties in longitudinal and transverse directions;
- Charpy V impact values in different directions at room temperature;
- Toughness J Curve;
- Pre-strain effects on toughness for Pipe 1
- Size of slip bands (Additional originally unplanned work)

In the 6th quarterly period, the technical team finalized the sensitivity study of the effect of pre-strain on toughness for Pipe 2.

Task 3: Literature Review

The literature review regarding cyclic fatigue dent assessment techniques is complete. A report summarizing the findings and demonstrating the performance of the identified assessment techniques will be available following the completion of the testing.

Task 4: Testing of Dents on Welds and Corrosion Features

BMT has commenced the final testing of girth welds interacting with dents. They have carried out a preliminary analysis of the results, including a comparison of the performance of the various specimens, and an overview of the results to date is included later on in the report (Results and Conclusions).

BMT has forwarded a draft modified test matrix summarizing the parameters of the dents interacting with metal loss, including the three proposed simulated metal loss geometries for the test samples, to the project team for comment. The project team is expected to complete its review within the next week and provide any requests for revisions. BMT will start machining the metal loss features and commence testing of the simulated corrosion in the coming quarter.

Task 5: Testing of Dents with Gouges

GDF SUEZ is in charge of the creation, characterization, burst test, and fatigue test of realistic combined defects, i.e., “dents with gouges”, and their program is described in the next table:

The defects are identified by three characters **X.Y.Z.** which are numbers:

- **X.**Y.Z.: **X** identifies the **Pipe X** material which is noted by 1, 2, or 3 in this program;

- X.**Y.**Z.: **Y** defines the **type of dent and gouge defect** characterized by its geometry notably in terms of dent depth and length, and gouge depth and length. This program is considering a maximum of three different kinds of defects per pipe material, and therefore, the value of Y can range from 1 to 3; two extreme aggression conditions are considered in this study: highly dynamic and slower aggression. The former corresponds to defect types 1 and 2 for pipe 1 (two different excavator teeth used) and type 1 for pipe 2, while the latter corresponds to type 3 for pipe 1 and type 2 for pipe 2.

- X.Y.**Z.**: **Z** is the **number of defect in the defined type of defect**. There are three similar defects per type of defect. The number 1 is for a detailed geometrical, mechanical and metallurgical in-depth defect characterization after its creation. Number 2 is a similar defect for the burst test to evaluate the defect behavior of under monotonic pressure load and number 3 is a similar defect for the fatigue test to evaluate the defect behavior under cyclic variation of the internal pressure.

In the previous quarterly reports, the following results were presented:

- Creation conditions and results for 11 defects (9 + 2 repeated ones): 1.1.1, 1.1.1b, 1.1.2, 1.1.3, 1.2.1, 1.2.1b, 1.2.2, 1.3.1*, 1.2.3, 2.1.1, 2.1.2 and 2.1.3
- Burst test conditions and results for 2 defects in Pipe 1, 1.1.2, 1.2.2 and one in Pipe 2: 2.1.2
- Fatigue test conditions and results for 2 defects in pipe 1: 1.1.3, 1.2.3
- Metallurgical Failure Investigation for 3 defects: 1.1.2, 1.1.3 and 1.2.2.

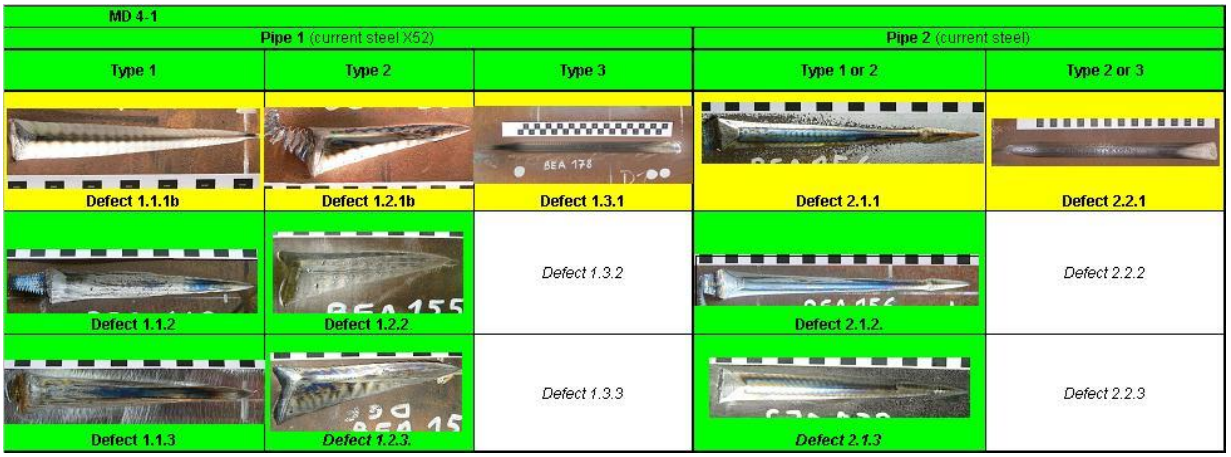
*During the fifth quarterly period, GDF SUEZ created defect 1.3.2, and intended to conduct a full-scale burst test on that test sample. Prior to the burst test, the program team recommended that internal strain gauges be placed on the internal pipe wall surface under the tooth impact area. However, because test preparation was well underway (including all welding being completed), adding internal strain gauges would require substantial effort and rework. Therefore, the team decided use this defect for destructive characterization, and it is now designated 1.3.1. to be consistent with the three character designation. Its companion defect 1.3.2 will be created in the next quarter and equipped with internal strain gauges.

This report presents:

- The effect of pre-strain on toughness for Pipe 2
- Defect creation and characterization of defect 2.2.1
- Fatigue test results of defect 2.1.3 and metallurgical investigation after failure

The table below summarizes the progress of the task on “Dent and Gouge” defects for the entire program. The background color in the table represents:

- White: Defects not yet created
- Yellow: Defects already created but not yet characterized/investigated or submitted to either Burst or Fatigue tests
- Green: Defects created and tests completed



Business Status

The project remains well coordinated with the pipeline industry through the PRCI partnership on the project.

Funds Expended

		Federal Funding			Cost Share Funding			
Item # per MS	**Task # Task Description**	**Budget**	**Expended (Actuals) This Quarter**	**Expended (Actuals) to Date**	**Budget**	**Expended (Actuals) This Quarter**	**Expended (Actuals) to Date**	**% Task Work Completed**
1	Project Kick Off Meeting and Subcontracting	$9,335	$0	$9,335	$831	$0	$831	100%
2	Purchase & Characterize Pipe Material	$34,674	$0	$19,567	$96,108	$16,149	$16,149	70%
3	Literature Review	$11,549	$0	$11,549	$8,669	$2,114	$8,669	100%
4	Testing of Dents on Welds & Corrosion Features	$188,507	$0	$157,363	$599,631	$0	$541,282	65%
5	Testing of Dents with Gouges	$150,020	$1,500	$150,020	$254,403	$0	$192,461	60%
6	Demonstration of Mechanical Damage Model Performance	$22,008	$0	$0	$10,930	$0	$5,530	0%
7	Industry Workshop	$12,030	$0	$0	$4,325	$0	$0	0%
8	Project Management and Reporting	$73,694	$7,336	$46,072	$43,959	$4,242	$25,451	On-going
	GRAND TOTAL	**$501,818**	**$8,836**	**$393,906**	**$1,018,856**	**$22,505**	**$790,373**	

Schedule

The project is generally on schedule, but as discussed in prior reports, Task 5-Testing of Dents with Gouges is impacted by the shutdown of the neutron diffraction facility at Chalk River. This delay impedes the detailed characterization of defects of Index 1. Note, the analysis of the defect samples using neutron diffraction was not included in the original scope of work and was added to the program on a voluntary, no-cost basis.
Finally, the team expects to receive approval for a contract modification in the next quarterly period to support the procurement of manufactured vintage pipe for the DOT sponsored tests .

Payable Milestones

Task status for this period is:

Task No.	Task	Status	Scheduled Completion Date	Payable Milestone (Item No)
1	Project Kick Off Meeting and Subcontracting	100% Complete	8/31/2008	
2	Purchase & Characterize Pipe Material	70% Complete	11/30/2008	2*
3	Literature Review – effect of pre-strain and dent-gouge defect from field feed-back	100% Complete	11/30/2008	3*
4	Testing of Dents on Welds and Corrosion Features	65% Complete	11/30/2009	
5	Testing of Dents with Gouges	60 % Complete	5/31/2010	24
6	Demonstration of Mech. Damage Model Performance	0% Complete	5/31/2010	
7	Industry Workshop	0% Complete	5/31/2010	
8	Project Management and Reporting	On-Going	5/31/2010	26

*Only PRCI cash cost sharing was expended for these tasks. No federal funds were used this quarter.

Results and Conclusions

A summary of the results are:

- Task 2 - The team found very little influence of pre-strain in the range 0% to 10% on the toughness of Pipe 2 which was the similar result found for Pipe 1.
- Task 3 - The literature review regarding cyclic fatigue dent assessment techniques is complete
- Task 4 - Several general trends were identified through comparison of the cyclic fatigue lives available to date (for plain dents and dents interacting with welds). The trends help to relate the effects of the various parameters on both the residual dent depth and the resulting fatigue lives.
- Task 5 - Testing dents with gouges: Creation with a slower aggression and then first characterization of defect 2.2.1., similar to defect 1.3.1, a deep dent and shallow gouge in Pipe 2. It reached around 4.5% dent depth and a gouge depth of about 0.2%. Such a deep

dent in the ~X80 pipe required an internal pressure during defect creation of 20 bars.

- Task 5 - Defect 2.1.3 on Pipe 2 was submitted to a fatigue test, followed by a metallurgical investigation of the fatigue failure. Failure was observed around 17,600 cycles, with a maximum pressure of 128 bars.

Task 2: Material Characterization – Pre-strain effect on toughness of Pipe 2

The team did not find any significant effect of pre-strain on toughness J-Curve in the range of 0% to 10% pre-strain for Pipe 2 (Figure 1). The toughness of one specimen with pre-strain of 10% was higher than the others with the same pre-strain. After some investigation, the team found that the fracture surface of this one specimen had a large split not found on the other specimens. This split could provide resistance to crack growth.

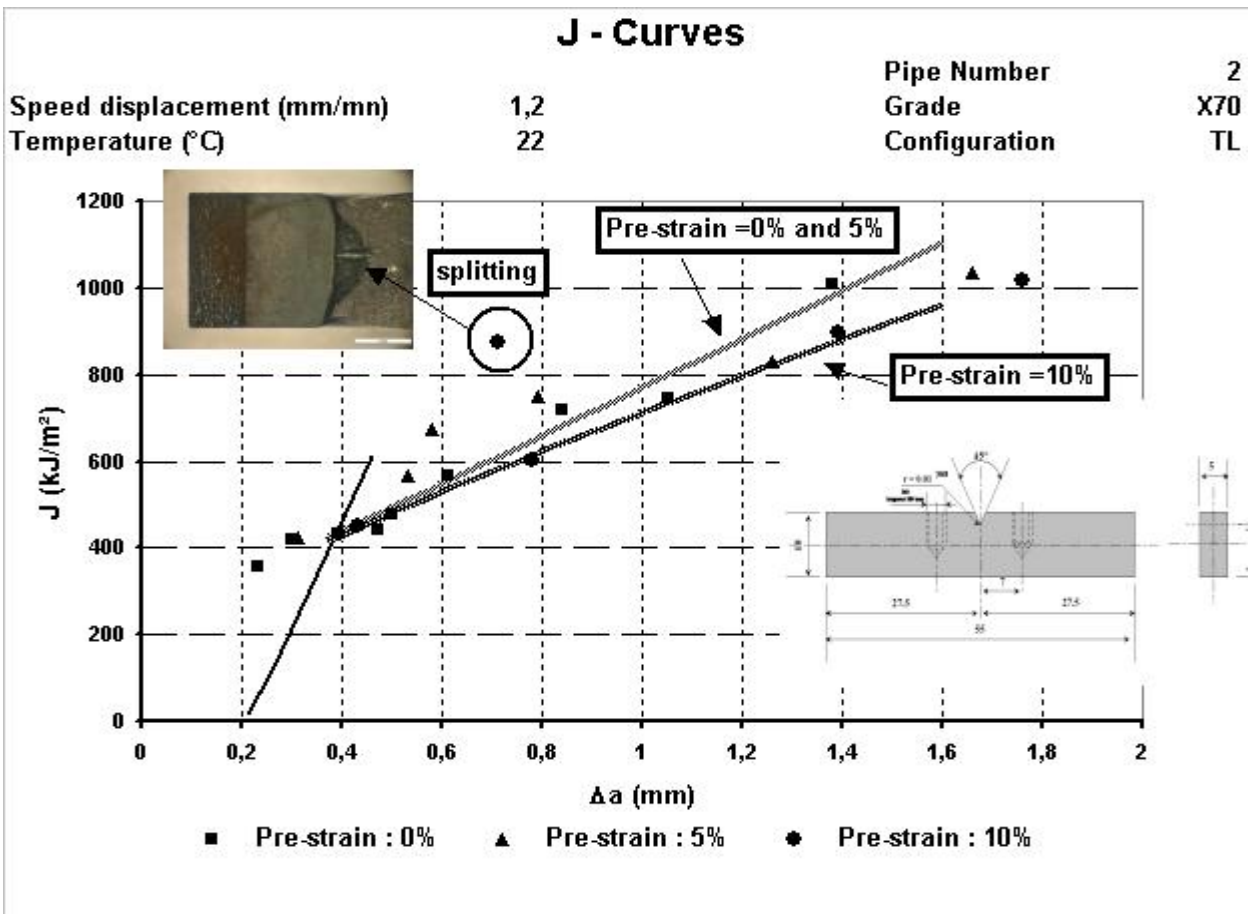


Figure 1: Pre-strain effect on toughness J-Curve for Pipe 2

The critical toughness values J_{1C} for Pipe 2 are 430 kJ/m², 431 kJ/m² and 418 kJ/m² respectively for pre-strains 0%, 5% and 10%.

Task 4: Testing of Dents on Welds and Corrosion Features

A summary of the results of the testing of plain dents and dents interacting with welds is

presented in Table 1 below. The table includes the results of the twelve plain dent specimens tested as part of the first phase of the test program.

Table 1: Summary of Plain Dents and Dents Interacting with Welds

Specimen #	Pipe	Nominal Indenter Diameter (in)	Initial Dent Depth (%)	Dent Condition	Interacting with	Initial Pressure Cycle (%SMYS)	Second Pressure Cycle (%SMYS)	Cyclic Pressure Range (%SMYS)	Weld Seam Location	Corrosion Patch	Initial Dent Depth (%OD)	Dent Depth After 2nd Cycle (%OD)	Final Dent Dpeth (%OD)	Cycles to Failure
1	A	2	5	R	Plain	100%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	5.56%	6948
2	A	2	5	R	Plain	100%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	5.51%	38685
3	B	4	10	R	Plain	100%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	9.01%	6886
4	B	4	10	R	Plain	100%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	8.28%	16234
5	B	4	10	R	Plain	80%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	9.84%	2531
6	B	4	10	R	Plain	80%	80%	10%-80%	N.A.	N.A.	N.A.	N.A.	9.84%	3359
7	A	2	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.21%	1.47%	2.63%	21103
8	A	2	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.88%	2.71%	2.48%	28211
9	A	2	15	U	Plain	80%	80%	10%-80%	N.A.	N.A.	5.89%	3.25%	3.28%	6825
10	A	2	15	U	Plain	80%	80%	10%-80%	N.A.	N.A.	5.76%	2.96%	2.69%	9116
11	A	4	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	7.99%	2.73%	2.55%	15063
12	A	4	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	6.00%	1.90%	2.28%	27575
13	B	2	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.81%	2.80%	2.17%	13262
14	B	2	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.74%	2.42%	2.21%	15065
15	B	2	15	U	Plain	80%	80%	10%-80%	N.A.	N.A.	5.52%	2.97%	2.21%	4035
16	B	2	15	U	Plain	80%	80%	10%-80%	N.A.	N.A.	5.63%	2.99%	2.22%	4684
17	B	4	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.41%	1.88%	1.56%	11415
18	B	4	15	U	Plain	100%	80%	10%-80%	N.A.	N.A.	5.32%	1.83%	1.69%	15949
19	A	2	5	R	Long Seam	100%	80%	10%-80%	2" Offset	N.A.	1.56%	1.30%	1.56%	32282
20	A	2	5	R	Long Seam	100%	80%	10%-80%	2" Offset	N.A.	1.17%	1.43%	1.56%	24919
21	A	2	5	R	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				67000
22A	A	4	10	R	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				
23	B	4	10	R	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.	N.A.	N.A.		12722
24	B	4	10	R	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.	N.A.	N.A.		16278
25	A	2	15	U	Girth Weld	100%	80%	10%-80%	C.L.	N.A.	6.28%	2.77%	2.77%	19063
27	A	2	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				18633
28	A	2	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				16107
29	A	4	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				14400
31	B	2	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.	6.03%	2.68%	2.55%	9890
32	B	2	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.	5.97%	2.71%	2.51%	9506
33	B	4	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				9386
34	B	4	15	U	Girth Weld	100%	80%	10%-80%	2" Offset	N.A.				9871
35	B	4	15	U	Girth Weld	100%	80%	10%-80%	C.L.	N.A.				**Running**
36	B	4	15	U	Girth Weld	100%	80%	10%-80%	C.L.	N.A.				15568

A variety of comparisons of the results is presented in Figures 2 to 6.

Figure 2 presents the ratio of the fatigue lives for all of the duplicate specimens conducted to date. As shown, aside from specimens 1-2 and 3-4, the ratio of fatigue lives ranges from a low of 1.04 to a maximum of 1.83, indicating that there is good repeatability in the specimen results.

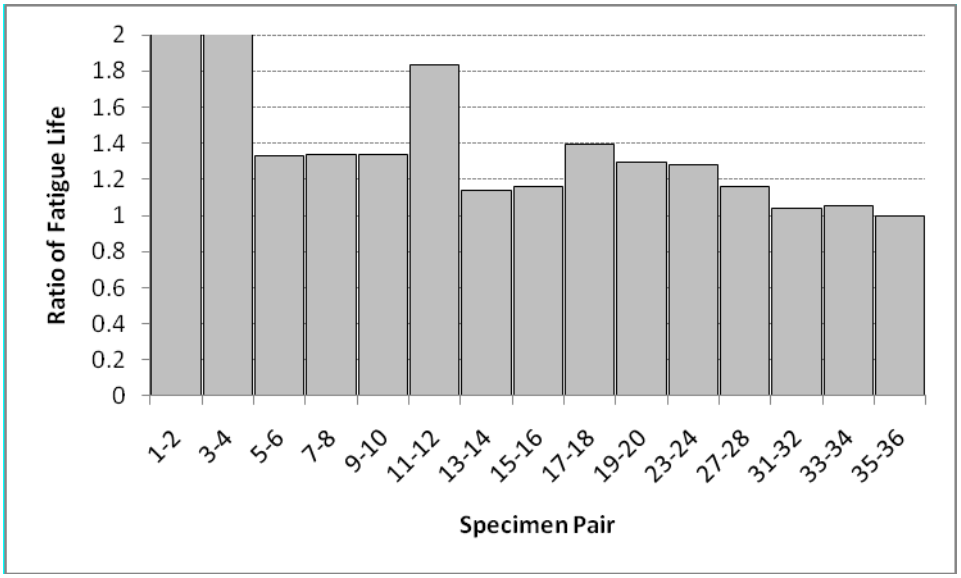


Figure 2: Ratio of Fatigue Lives for Duplicate Specimen Pairs

Figure 3 presents the effect of a number of the major parameters considered in the experimental program in terms of the ratio of the average fatigue lives for the group of specimens. The results indicate the general sensitivity of the fatigue lives to the various parameters. For example the first two bars on the right of the plot indicate the fatigue lives of the specimens seeing 100% SMYS (specified minimum yield strength) is approximately 3.5 times the lives of the specimens seeing only 80% of SMYS.

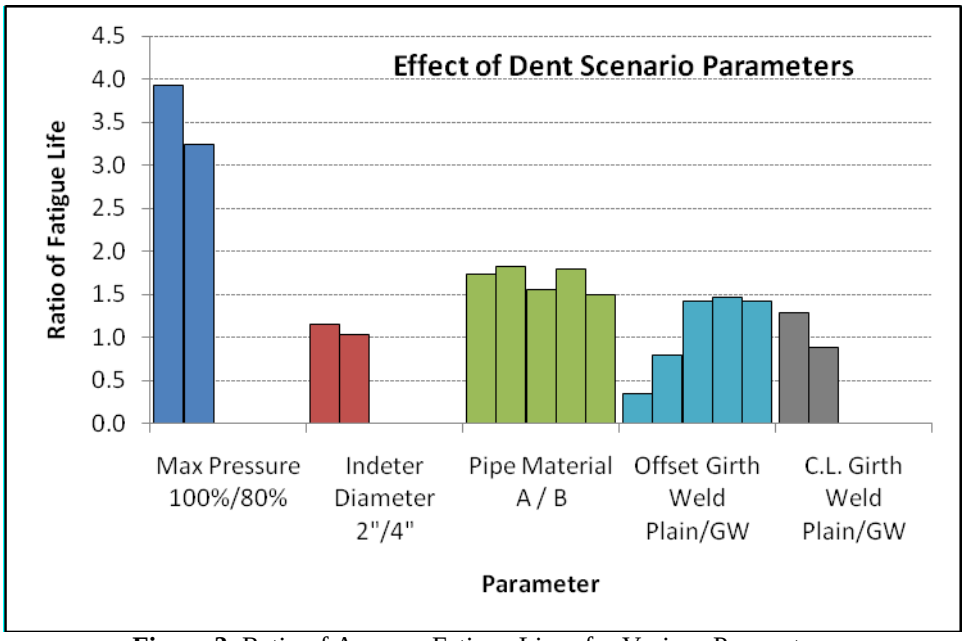


Figure 3: Ratio of Average Fatigue Lives for Various Parameters

Figure 4 presents and compares the rebounded dent depth following the removal of the indenter (i.e., elastic rebound) for unrestrained dents versus the initial applied dent depth of 15% OD. As shown, the rebounded dent depths range from 5.2% to 6.2% of OD, with one outliner at 8.0%.

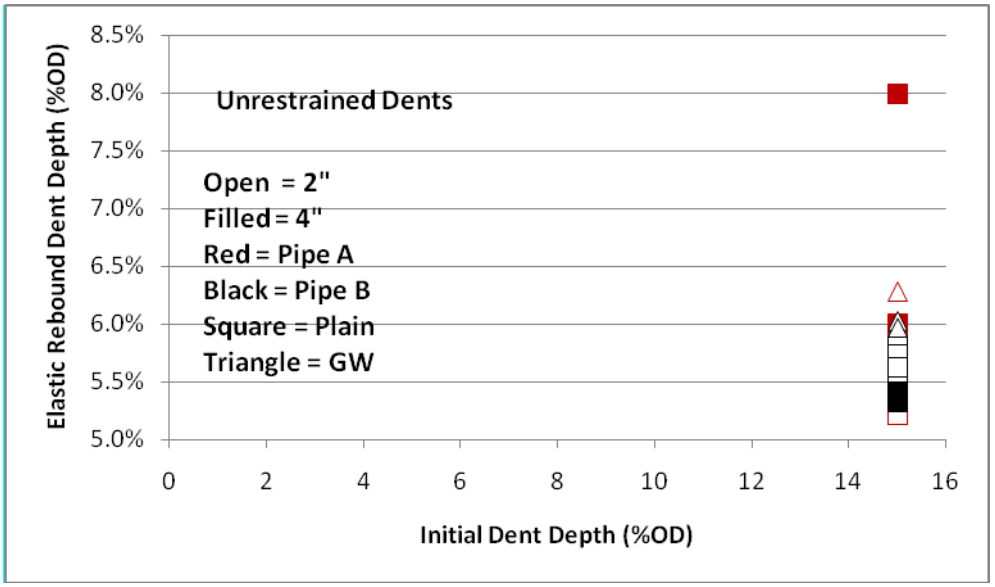


Figure 4: Rebounded Dent Depth vs Initial Dent Depth (Unrestrained Dents)

Figure 5 presents the residual dent depth after the initial 100% and 80% SMYS pressure cycles, as a function of the maximum internal pressure. The results indicate that the residual dent depths for a maximum internal pressure of 80% SMYS are deeper (3 – 3.5% OD) than those that experienced a maximum pressure of 100% SMYS (1.5-2.75% OD).

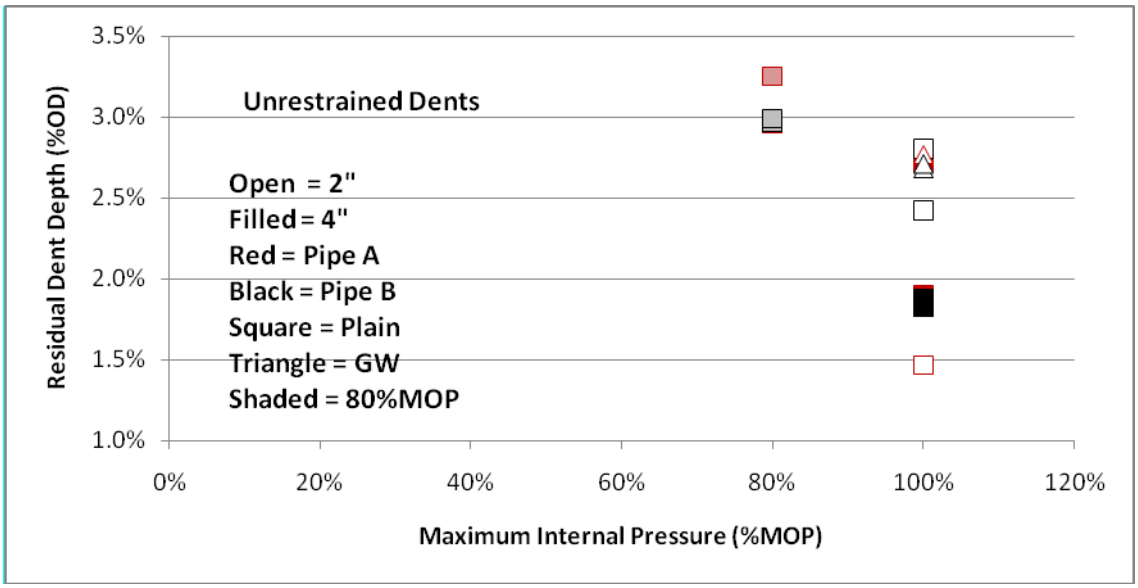


Figure 5: Residual Dent Depth vs Maximum Internal Pressure (Unrestrained Dents)

Figure 6 presents the fatigue life (in pressure cycles) versus the residual dent depth (after first maximum pressure cycle) for all of the unrestrained dents. The results indicate that with increasing residual dent depth there is a corresponding decrease in fatigue life with the shortest fatigue lives being for the deepest residual dents (for those specimens seeing a maximum internal pressure of 80%).

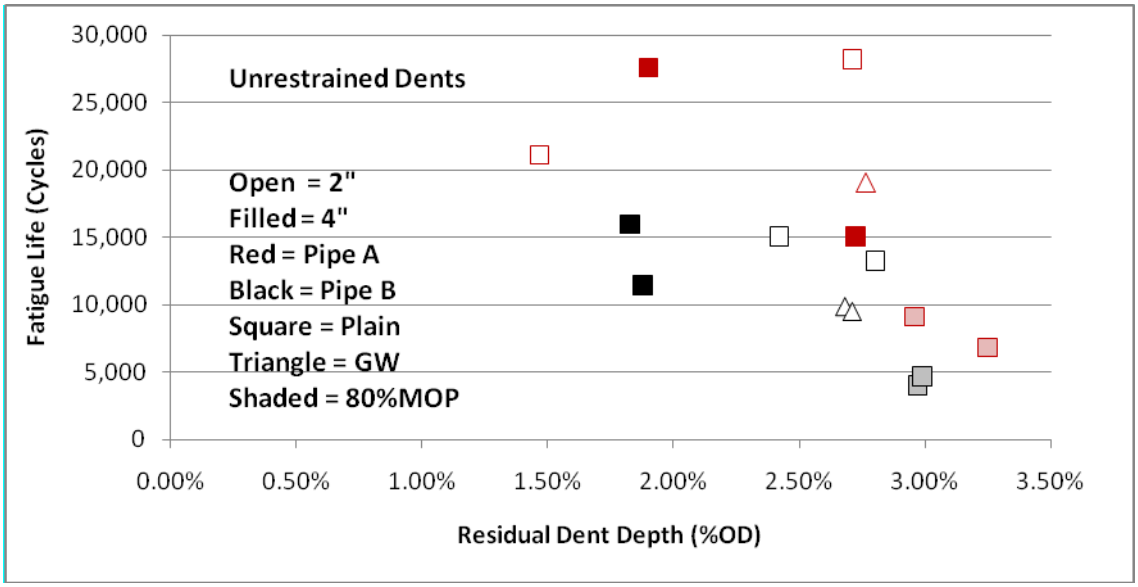


Figure 6: Fatigue Life versus Residual Dent Depth (Unrestrained Dents)

Task 5: Testing dents with gouges: Creation and characterization of defect 2.2.1.

The team created a type of Dent + Gouge defect similar to defect 1.3.1 (deep dent and shallow gouge) in Pipe 2 with a slower aggression. The defect was created under an internal pressure of 20 bar (load factor of 12% of actual yield strength) in order to ensure producing a deep dent in the very strong Pipe 2 material (almost X80 strength). Force versus displacement is plotted in **Error! Reference source not found.**.

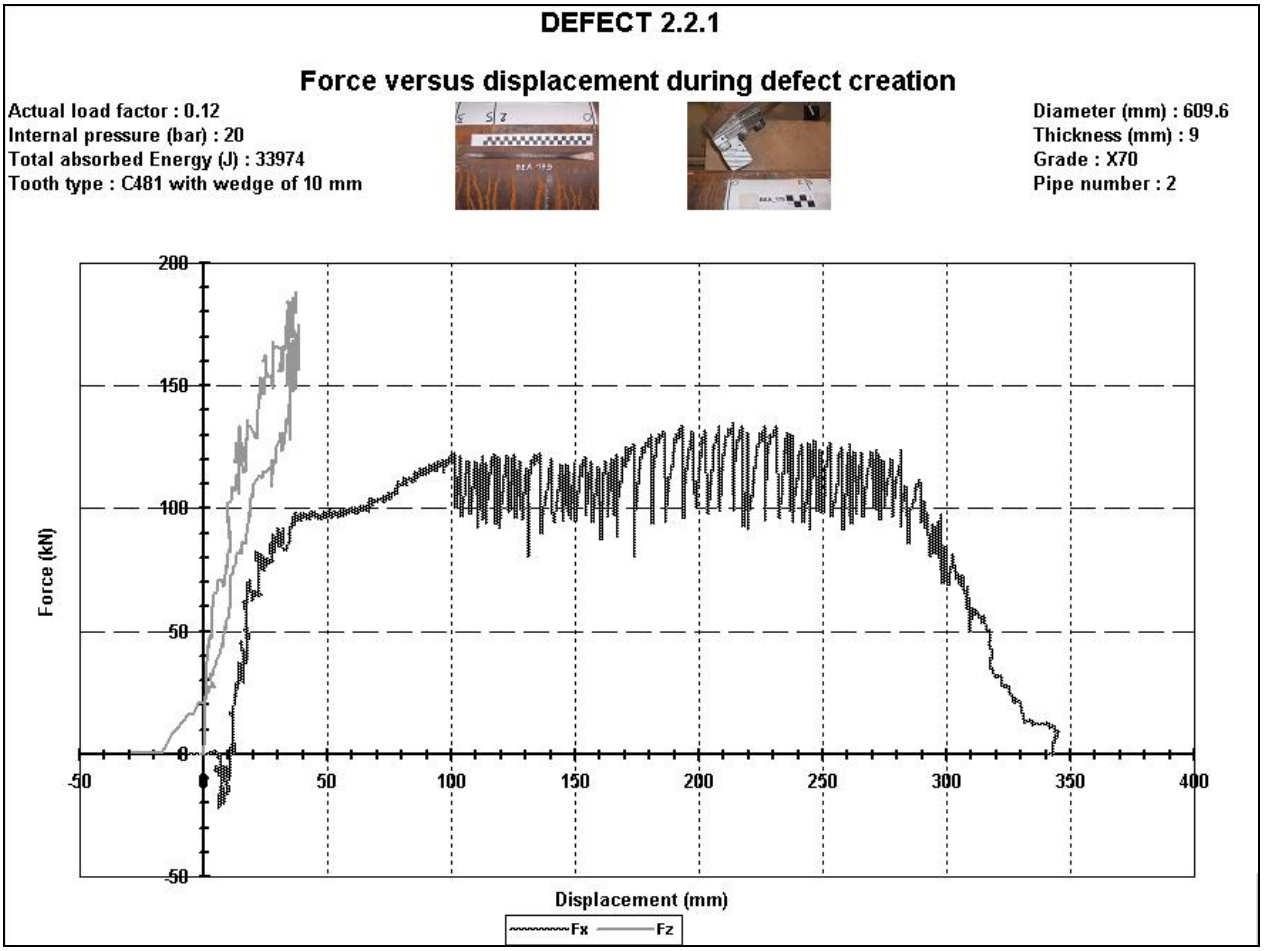


Figure 7: Force-displacement curve for creation of defect 2.2.1

Error! Reference source not found. shows a lateral view of the defect.

Figure 8: Lateral view of defect 2.2.1.

Defect 2.2.1 is more than 300mm long. The residual dent depth (pressure = 0) is around 4.5% and the gouge is very shallow (0.2% depth). Magnetic particle inspection (MPI) did not reveal the presence of cracks or micro-cracks at the bottom of the gouge (**Error! Reference source not found.**).

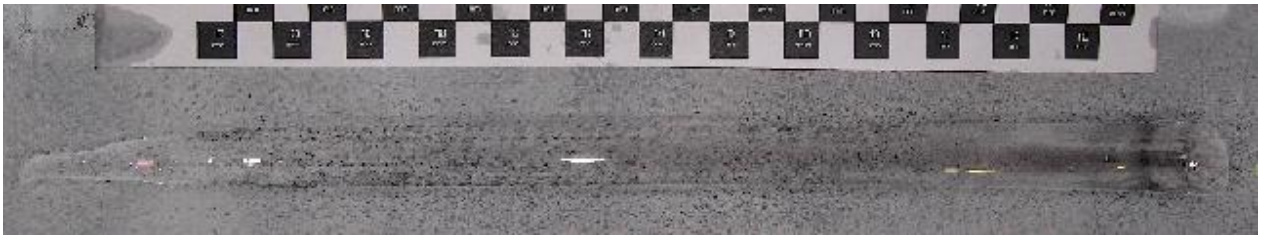


Figure 9: Defect 2.2.1 - No crack or micro-crack was indicated by magnetic particle inspection

Two-dimensional profiles in longitudinal and transverse pipe directions passing by the deepest point of defect 2.2.1 are presented in Figure 10 and 11.

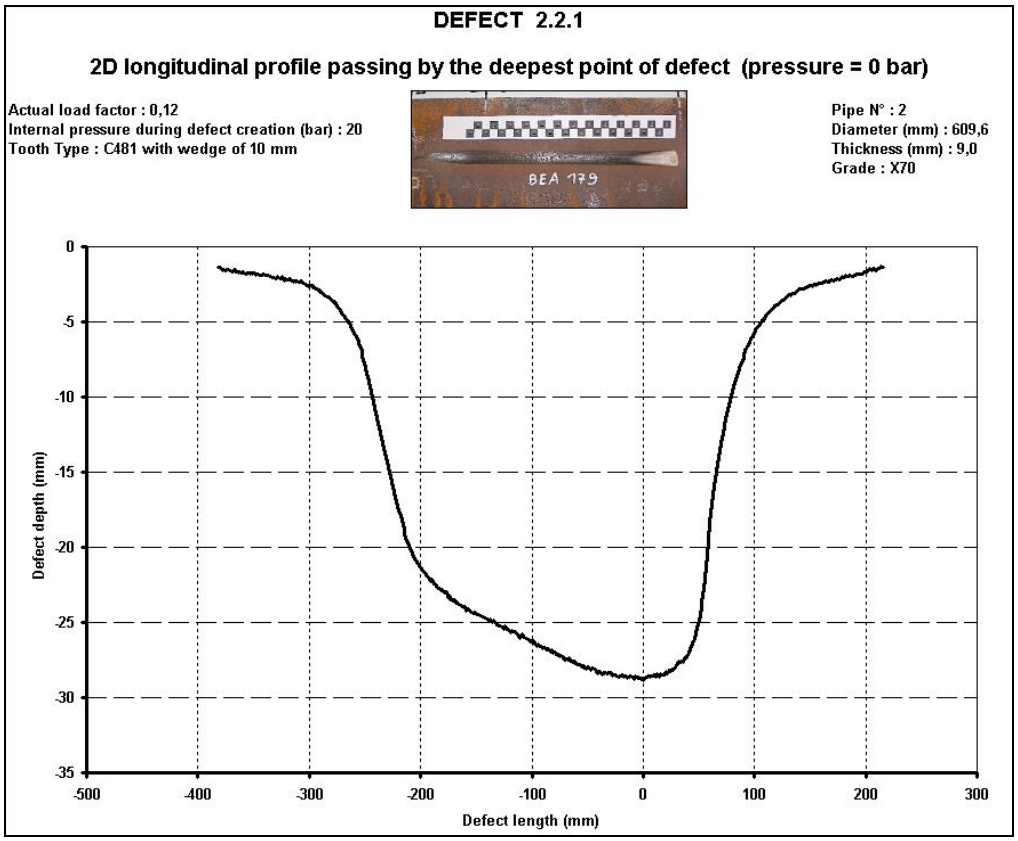


Figure 10: Defect 2.2.1 – 2D Longitudinal Profile at no pressure.

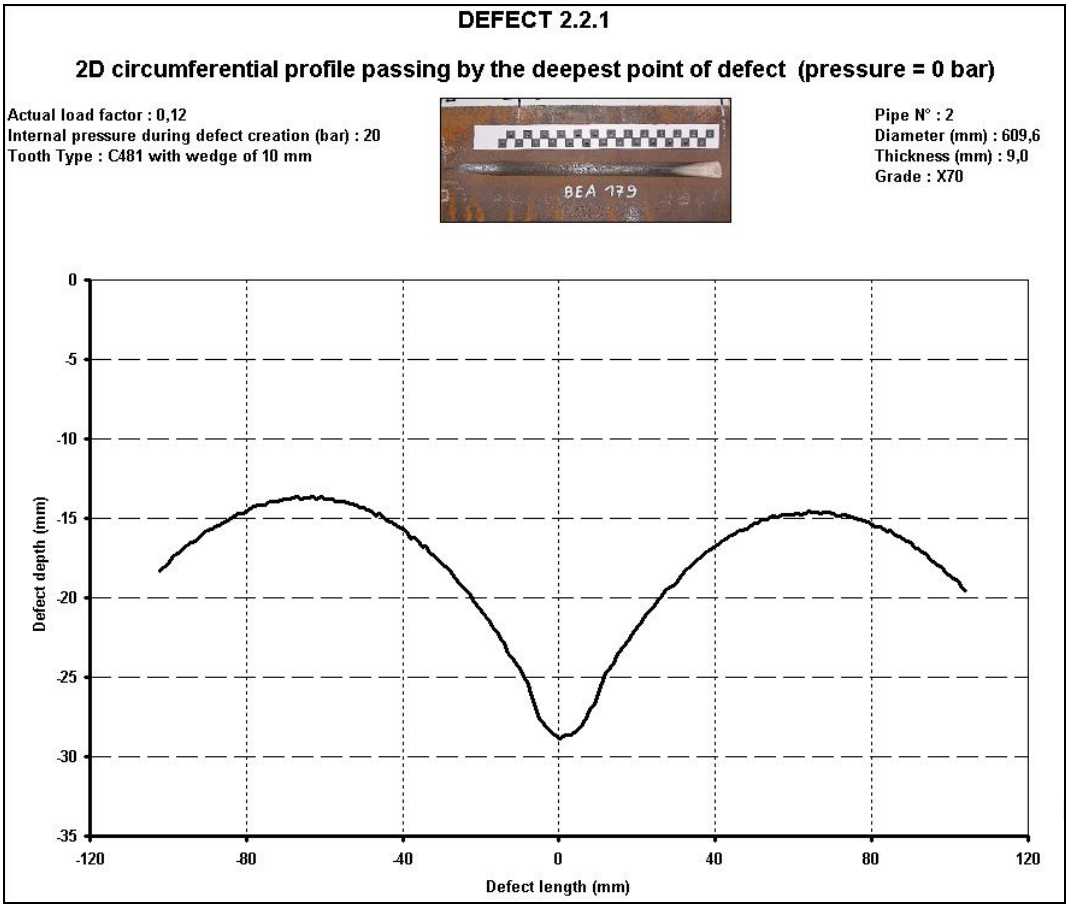


Figure 11: Defect 2.2.1 – 2D Transverse Profile at no pressure.

Task 5: Testing dents with gouges: Fatigue Failure Investigation of defect 2.1.3

Defect 2.1.3 was instrumented with the following:

- Four strain gauge rosettes along the defect (one more than initially panned)
- One transverse axial strain gauge in the defect
- Two strain gauges on the internal pipe surface wall under the defect area
- One opening clip gauge
- A potential drop
- Two vertical displacement gauges (LVDT) in the defect and one on the pipe away from defect for the reference.

In addition, two pairs of targets were placed on each side of the defect to measure the defect opening at different locations during the test via a digital SLR camera which showed the evolution in the distance between targets. Reference strain gauges and one vertical displacement gauge were also placed away from the defect on the pipe (Figure 12 and 13).

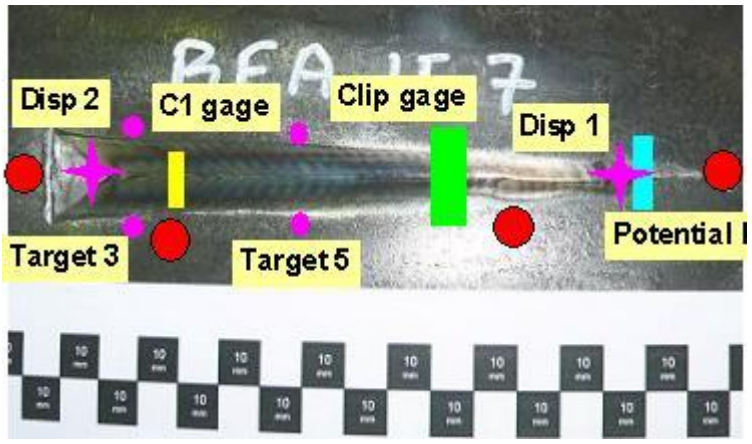


Figure 12: Instrumentation plan for the fatigue test on defect 2.1.3.

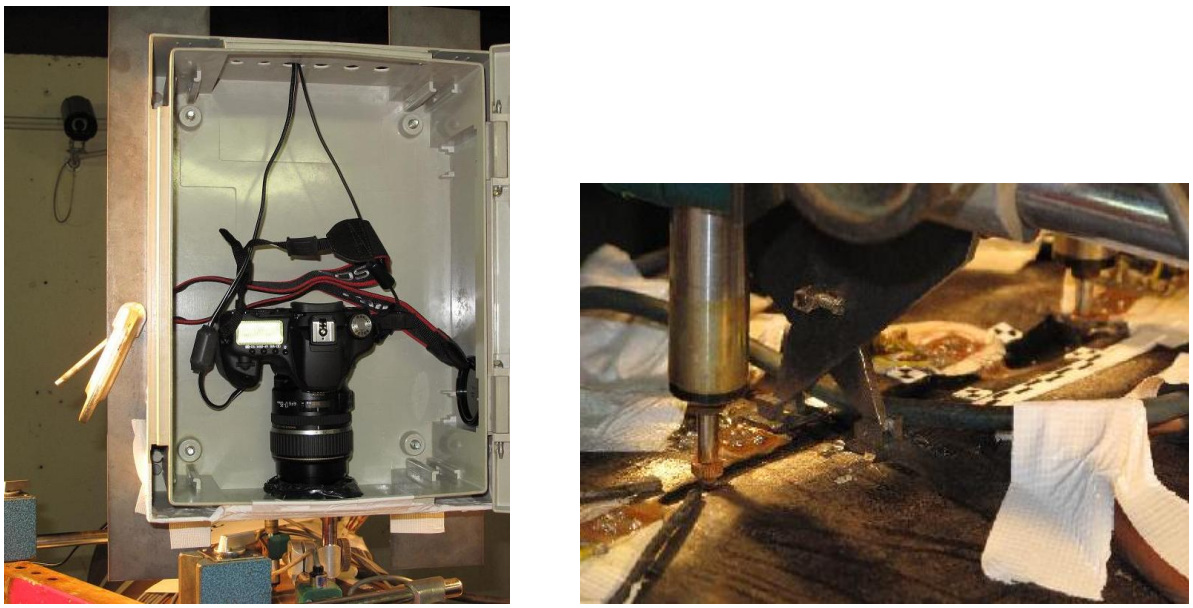


Figure 13: General view of defect 2.1.3 instrumentation and focus on camera for displacement measurement between targets.

During the fatigue test, all information from instrumentation was recorded and Figure 14 shows the evolution of distance between targets and the clip gauge opening versus the number of cycles. The maximum pressure was 128 bar corresponding to 80% of actual yield strength, as requested by DOT to reflect recent modifications to US regulations and allowances for operating pipeline systems at higher design factors.

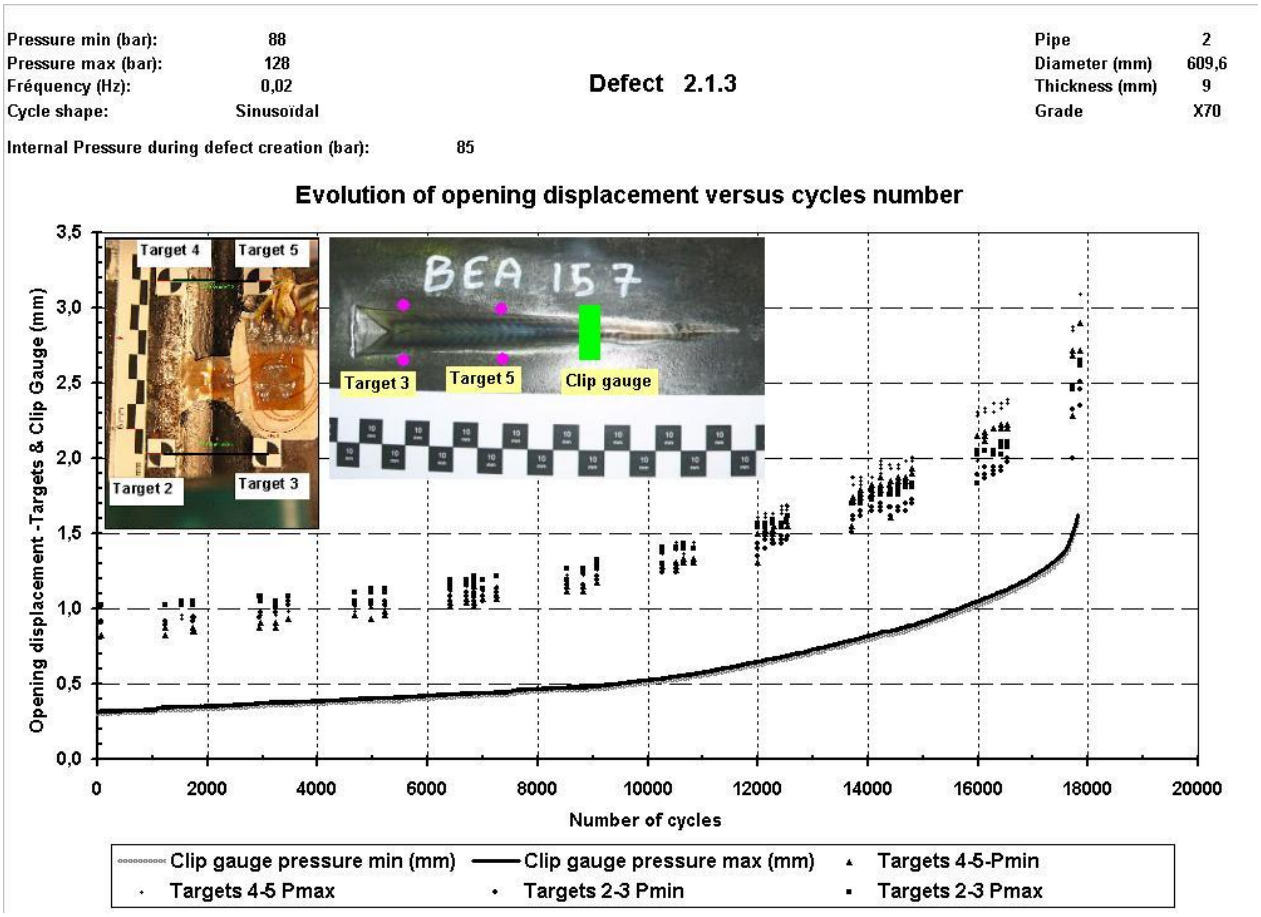


Figure 14: Evolution of defect opening versus the number of cycles.

The first water drop was observed leaking from the crack between 17,564 cycles and 17,600 cycles (Figure 15).

Figure 15: Leak in defect 2.1.3.

A metallurgical investigation was performed after fatigue failure. The defect was cut in 10 samples as shown in Figure 16.

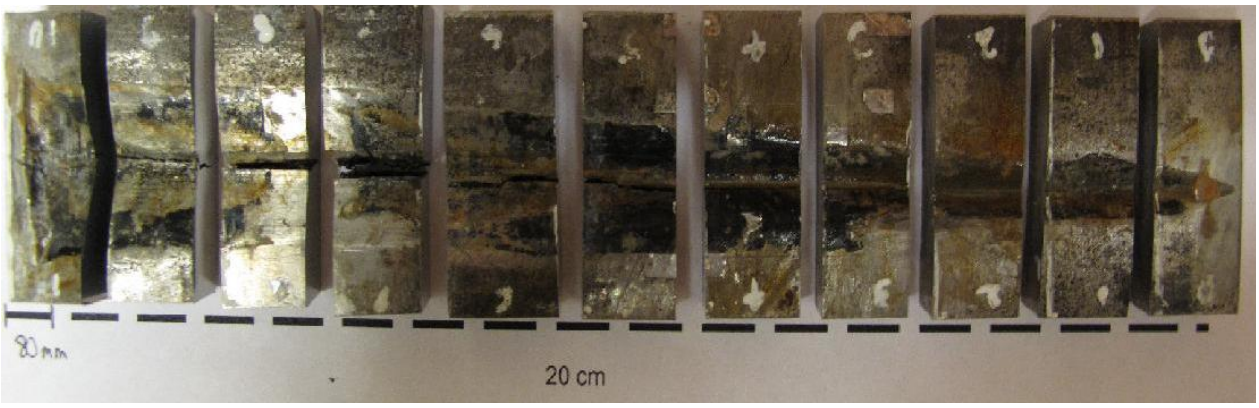


Figure 16: Defect 2.1.3 – cut in 10 pieces for metallurgical investigation. Cut No. 8 (third section from left of view above) is detailed below in Figure 17.

The researchers examined each cut under an optical microscope. As with previous defects created by highly dynamic impact with an excavator tooth, the gouge surface is covered with a hard layer in the range of 50 to 150 µm thick. This change in microstructure was due to the successive massive and very quick friction heating during the impact of the aggressive tooth, followed by an extremely fast cooling as heat was conducted away into the steel. In the hardened layer, the researchers recorded multiple micro-cracks (Figure 17).

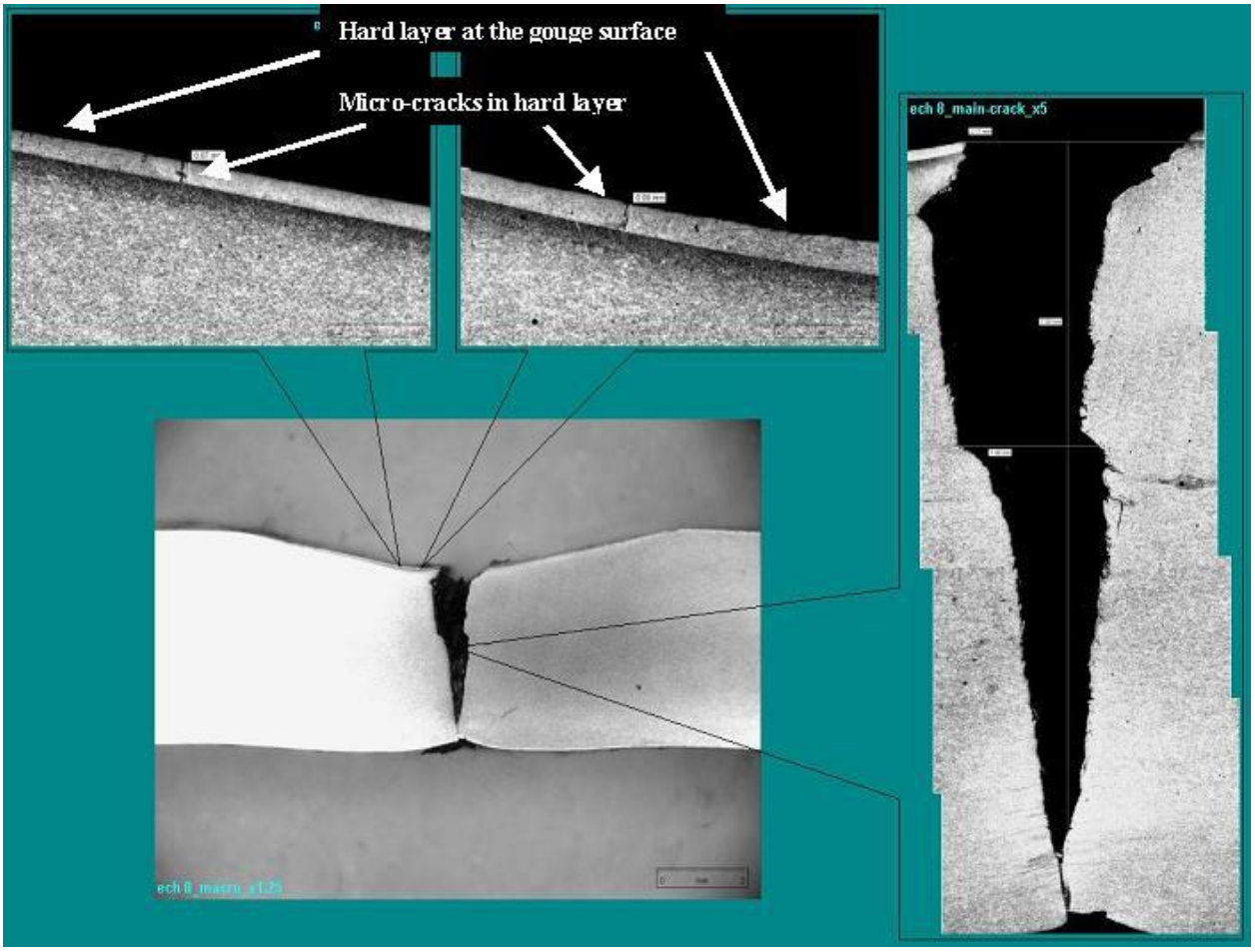


Figure 17: Metallurgical observation on cut number 8 (from Figure 16 above) - micro-cracks in hard layer and main fatigue crack

The investigators measured the depth of micro-cracks and cracks on each cut and a statistical distribution was established based on a population of 37 cracks (Figure 18). As shown on the left side of the chart in Figure 18, the depth of many of the micro-cracks is consistent with the thickness of the hardened layer. At the other end of the chart, the large crack depths on the histogram essentially correspond to the main crack that propagated by fatigue and is observed in the different cuts.

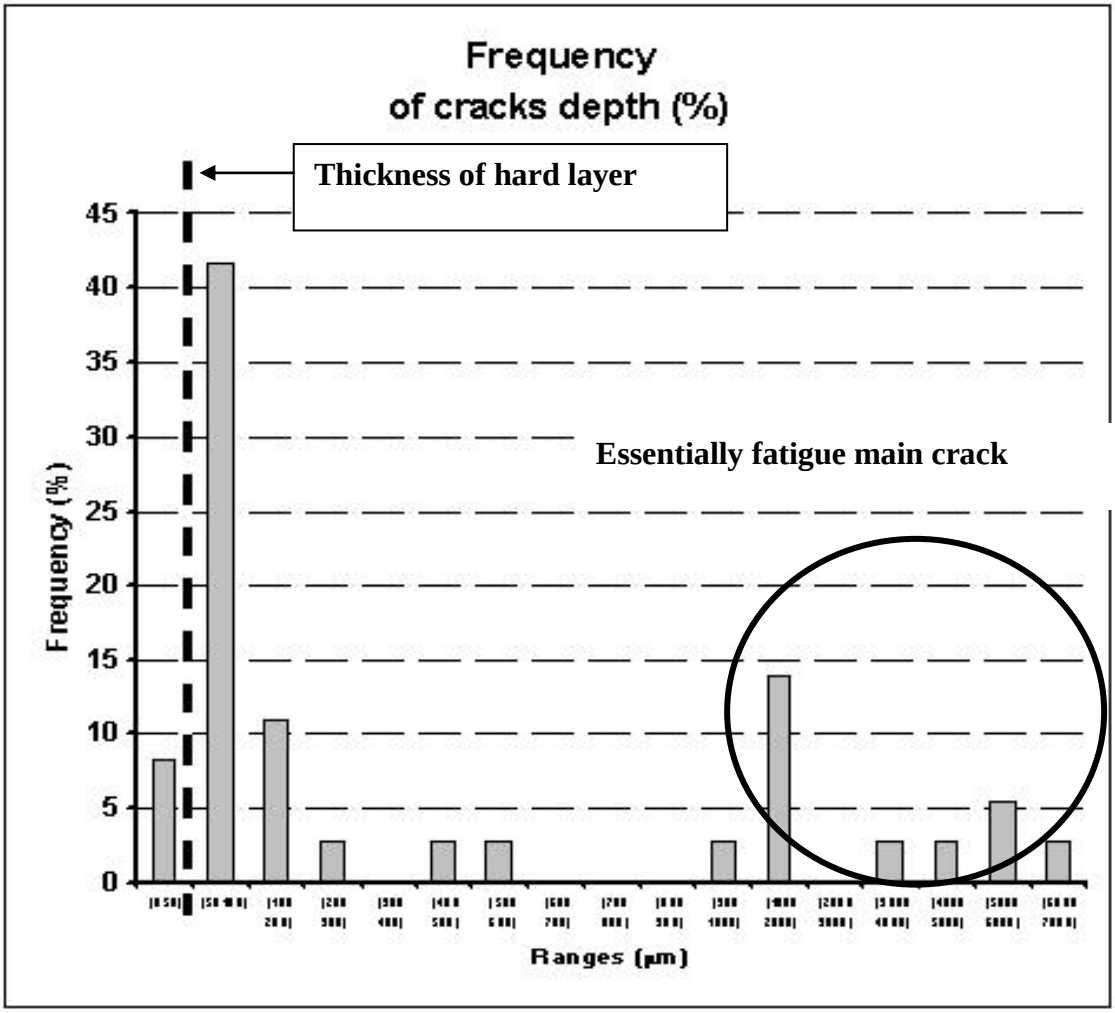


Figure 18: Distribution of crack depths sized on 10 cuts.

From the depth of the cracks on ten cuts, the team was able to create a profile of the main fatigue crack (Figure 19).

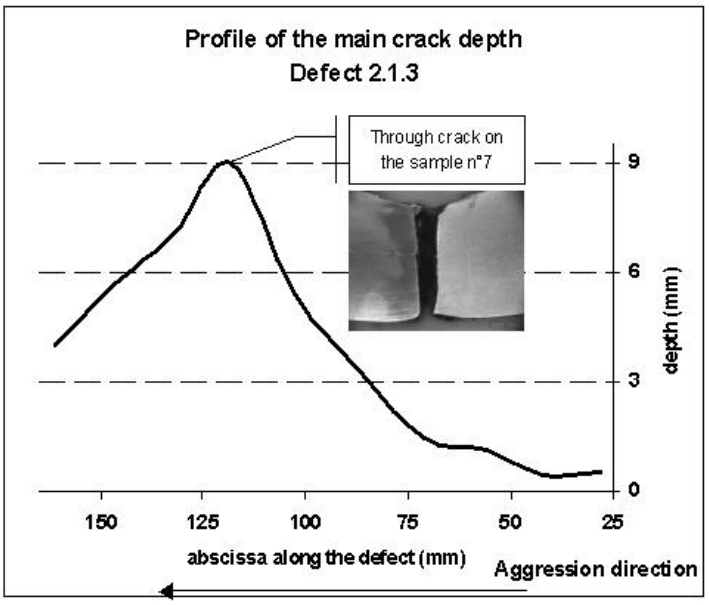


Figure 19: Profile of the front of the main fatigue crack.

Issues, Problems or Challenges

- Task 2 is slightly behind schedule due to challenges related to identifying a source for manufacturing pipe and collecting cost/schedule data for the vintage pipe. Neither task will delay the overall schedule of the project if the pipe is identified and delivered in the near future. The project team will evaluate schedule impact after confirming the period required for manufacture and delivery of the vintage pipe, and coordinate with DOT any necessary extensions to the project schedule that may be required as a result of these challenges.

- The residual stresses in defects called x.x.1 are measured on the same vessel for a given material. This process avoids wasting material by using the same vessel for different x.y.1 defects. The consequence is that the residual stress measurements and the metallurgical characterization of these already created defects will be performed at the end of the defect creation process for a given material (Pipe 1, Pipe 2, or Pipe 3).

- Demonstration of mechanical models is delayed until 2010 to include the results from the vintage pipe testing program and therefore provide for a more substantial set of data for the analysis.

- The process to mark the cracks and micro-cracks by ink injection in “dent and gouge” defects was not satisfactory. The team is developing a new or modified process.

- A number of adjustments and modifications have been made to the program to improve the outcomes and generate additional and/or more robust data. These changes have included additional tests (e.g., neutron diffraction), additional instrumentation to expand/improve the data collected during the tests, and related coordination, planning,

and management to implement the modifications. The project team is attempting to offset any cost increases associated with these changes by improvements in productivity. However, it may be necessary to request a contract modification to account to the costs and additional time needed to provide for these changes.

Plans for Future Activity

Planned activities for the project are presented below.

Task 2: Purchase & Characterize Pipe Material

GDF SUEZ will proceed to cyclic tensile tests on materials from Pipe 1 and 2 to determine the cyclic law hardening. The source (or sources) for vintage pipe material will be confirmed and the material procured. Testing on vintage pipe material will begin once the materials are delivered to the test facilities (GDF SUEZ in Saint Denis, France, and Stress Engineering Services in Houston, TX, USA).

Task 4: Testing of Dents on Welds and Corrosion Features

Full scale testing of dents on welds will be completed by the end of November 2009. Testing of dents interacting with corrosion features will start in the next quarter.

Task 5: Testing of Dents with Gouges

GDF SUEZ will launch the creation of defects 1.3.2 and 2.2.2 and perform burst tests of defects 1.3.2 and 2.2.2. The team will also develop a standard format and prepare complete reports for the tests completed to date.