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QUARTERLY REPORT – PUBLIC PAGE

Pipeline Integrity Management for Ground Movement Hazards

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Technical Status

Activities undertaken through the eighth quarter focused on the following tasks:

Task 1: Definition of Large Ground Displacement Hazards
Task 4: Use of Pipeline Geometry Monitoring to Assess Pipeline Condition
Task 5: Hazard Mitigation Strategies
Task 6: Assembly of Overall Guidelines Document

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

Task 1: Definition of Large Ground Displacement Hazards

Technical Status
Work this quarter focused on Tasks 1.7 and 1.8.

Results and Conclusions

- Task 1.7: Obtain review comments from outside experts
- Task 1.8: Prepare final draft recommendations on hazard definition

A revised draft of recommended practices for hazard definition was distributed to three external topic area experts not involved with the draft preparation near the end of February. Review comments were received by mid-April and incorporated into a third draft (Task 1.8). The third draft (Task 1.8) was distributed to all team participants on May 5. A meeting to resolve a few open questions in the third draft will be held June 12 & 13.

Task 4: Use of Pipeline Geometry Monitoring to Assess Pipeline Condition

Technical Status
Work this quarter focused on Tasks 4.2 through 4.4. Tasks 4.2 and 4.3 are now 100% complete. Task 4.4 will be 100% complete before the end of this quarter (before June 15, 2008).

Results and Conclusions
An algorithm for deducing the extensional strain induced in laterally displaced pipelines was developed for situations where the loading is predominantly transverse and the magnitude of the maximum longitudinal strain exceeds the yield strain. The induced strain is found to depend upon the pipe curvature.

Buried pipe finite element analyses were performed for a wide variety of lateral pipeline displacement scenarios. The computed nodal curvatures were treated as surrogate measured pipeline curvatures and used in the algorithm to compute the extensional and longitudinal strains which were compared with the FEA computed strains to validate the algorithm. For most of the analysis cases considered, the algorithm-deduced strains overestimated the actual strains; i.e., the

algorithm generally provided a conservative estimate for the actual strain. The comparisons were extended to consider pipeline curvature profiles developed by running a "digital pig" over the deflected shapes from the finite element analysis models to mimic the gauged measurements made by pipeline geometry pigs. These analyses showed that the numerical differentiation of the pipeline orientation required for calculation of pigged curvature can underestimate the exact curvature, especially for short pipeline curvature features. The often favorable agreement between the deduced strain and the exact strain is the result of compensating errors; i.e., the typical over prediction by the longitudinal strain algorithm is offset by the underestimate for the curvature.

An error analysis for a central difference approximation of the curvature with a gage length equal to the pig length indicates the relative error varies as the square of the ratio of the gage length to the length of the characteristic deformation feature of interest, which in this case corresponds to length over when there is a rapid change in orientation of the pipeline. The characteristic feature length is dependent upon the abruptness of the lateral displacement—the greater the abruptness, the shorter the feature length and for the same gage length the greater the error in deducing the curvature and, hence, the longitudinal strain. For gage lengths not equal to the pig length, the relative error is proportional to the gage length. This property was exploited to provide an improved estimate for the curvature and, hence, the total longitudinal strain when the curvature was estimated using two different gage lengths.

Most geometry pig vendors provide a software package that allows for viewing and printing user selected profiles of the pipeline geometry survey data at different locations along the alignment. Given the software capabilities available for viewing and processing data from geometry pig surveys, extension of the software to include the deduced total strain calculations developed in this work should be relatively straightforward.

Task 5: Options to Mitigate Risks of Large Ground Displacement

Technical Status

Work this quarter focused on Tasks 5.7 and 5.8.

Results and Conclusions

- Task 5.7: Obtain review comments from outside experts
- Task 5.8: Resolve comments from outside experts and prepare final draft report

A revised draft of recommended practices for hazard definition was distributed to three external topic area experts not involved with the draft preparation near the end of February. Review comments were received by mid-April and incorporated into a third draft (Task 1.8). The third draft (Task 1.8) was distributed to all team participants on May 5. A meeting to resolve a few open questions in the third draft will be held June 12 & 13 in Burnaby, British Columbia.

Task 6: Prepare Overall Guidance Document

Technical Status
Work this quarter focused on Task 6.1 through 6.5.

Results and Conclusions
Work under Task 6 involved combining the results of Tasks 1 through 5 into a comprehensive guidance document. Efforts during this quarter focused on the organization of the overall document and incorporating products from Tasks 1 and 5 into the overall document organization. A first draft of the comprehensive guidance document was distributed for review and comment in Quarter 8. This first draft to be distributed was incomplete as Task 4 is scheduled to be by June 15, 2008. However, this review allows full comment on the results from Tasks 1 and 5 and a review of the proposed guidelines organization.

Plans for Future Activity

Activities in the next quarter will largely focus on Tasks 4, 6 and 7 as the other tasks are essentially complete. Planned activities for these six tasks are presented below.

Task 4: Use of Pipeline Geometry Monitoring to Assess Pipeline Condition

Technical Progress
Testing of and reporting on the deduced strain algorithm under Task 4.2 is complete. Review of and reporting on measurement considerations under Task 4.3 is complete. A full draft report under Task 4.4 will be available for review before June 15, 2008. We will now begin work on our portion of Task 6.

Task 6: Comprehensive Guidance Document

Work will continue next quarter on the following subtasks:

- Task 6.2: Distribute first draft of guidelines document and obtain review comments

A first draft of the comprehensive guidance document was distributed to all project personnel for review and comment in Quarter 8. This first draft to be distributed will be incomplete as Task 4 is scheduled to be complete by June 15, 2008. However, this review allows full comment on the results from Tasks 1 and 5 and a review of the proposed guidelines organization. Efforts to review interim reports generated under Tasks 2 and 3 were initiated in Quarter 8 and will continue in the next quarter. Revised sections of the draft guidelines that incorporate results from Tasks 2, 3, and 4 (and thus complete the first draft) will be distributed and reviewed early in the next quarter.

Meeting and Presentations
No meetings or presentations are planned.