**ENVIRONMENTAL
MANAGEMENT**

**Engineering Evaluation Report on
K-311-1 Floor Subsidence
(2008 Annual Report) at the
East Tennessee Technology Park
Oak Ridge, Tennessee**

**BECHTEL JACOBS COMPANY LLC
OAK RIDGE ENVIRONMENTAL
MANAGEMENT CLEANUP CONTRACT
WITH THE UNITED STATES
DEPARTMENT OF ENERGY**

**Engineering Evaluation Report on
K-311-1 Floor Subsidence
(2008 Annual Report) at the
East Tennessee Technology Park
Oak Ridge, Tennessee**

Date Issued—November 2008

Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
under contract DE-AC05-98OR22700
for the
U.S. DEPARTMENT OF ENERGY

APPROVALS

**Engineering Evaluation Report on
K-311-1 Floor Subsidence
(2008 Annual Report) at the
East Tennessee Technology Park
Oak Ridge, Tennessee**

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November 2008

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ACRONYMS

BJC	Bechtel Jacobs Company LLC
ETTP	East Tennessee Technology Park
SSC	Structures, Systems and Components

1. INSPECTION TEAM

The Inspection Team for this project included the following:

- K. A. King—Structural Engineer
- S. J. Baker —Structural Inspector

2. SUMMARY

The purpose of this task is to evaluate the effect of floor settlement on building structure, piping, and equipment foundations between column lines 1 and 2 and B and K of Bldg. K-311-1 (see Fig. A-1 in Appendix A) at East Tennessee Technology Park (ETTP), Oak Ridge, Tennessee. Revision 0 of this document covers the 2005 annual inspection. Revision 1 addresses the 2006 annual inspection, Revision 2 addresses the 2007 annual inspection, and Revision 3 covers the 2008 annual inspection, as indicated by the changed report title. A civil survey and visual inspection were performed. Only a representative number of points were measured during the 2008 survey. The exact location of a number of survey points in Table A-1 could not be accurately determined in the 2008 survey since these points had not been spray painted since 2003. The points measured are deemed adequate to support the conclusions of this report. Based on the survey and observations, there has been no appreciable change in the condition of the unit since the 2007 inspection. The subsidence of the floor presents concerns to the building structure due to the possible indeterminate load on the pipe gallery framing. Prior to demolition activities that involve the piping or removal of the equipment, such as vent, purge and drain and foaming, engineering involvement in the planning is necessary. The piping connected to the equipment is under stress, and actions should be implemented to relieve this stress prior to disturbing any of the equipment or associated piping. In addition, the load on the pipe gallery framing needs to be relieved prior to any activities taking place in the pipe gallery. Access to this area and the pipe gallery is not allowed until the stress is released.

3. BACKGROUND AND ISSUE/CONCERN STATEMENT

The west end of the K-311-1 building unit contains an area of inactive equipment which formerly served as a Booster Station during facility operations. The area is located between the truck alley and the exterior wall (north-south column lines 1 and 2) and between east-west column lines B and K at the cell floor level in the K-275 Building. The floor structure in this area consists of grade beams and concrete slab-on-grade. Due to settling of the soil beneath the floor and the dead load of the equipment contained in the area, the concrete slab has subsided significantly within the grade beams surrounding the former Booster Station area. This has resulted in structural damage to the concrete slab, piping, and equipment foundations.

To monitor the settlement, 34 points were selected in the area and settlement readings were taken in October 1970, May 1998, July 2000, October 2001, September 2002, July 2003, September 2006, November 2007, and October 2008 to determine the extent of settlement from its first survey in October 1970 (see Appendix A). The July 2005 inspection report concluded that the subsidence of the floor presented no immediate concerns to the building, given the status of operations and activities associated with the K-275 Building. However subsequent to that report further evaluation and inspection reveals potential loading of the pipe gallery steel framing.

4. ASSUMPTIONS

The following assumptions can be made:

- The building footings are stable and will not settle.
- Settlement readings in the "Difference Since 2003" column of Table A-1. of +/- 0.01 ft should be viewed as negligible. These can be attributed to errors associated with the accuracy of the survey equipment.
- Only a representative number of points were measured during the 2008 survey.
- The exact location of a number of survey points in Table A-1 could not be accurately determined in the 2008 survey, since these points had not been spray painted since 2003. The exact location would allow the accuracy of the survey to be within 0.01 ft (1/8 in.). However, the survey accuracy of 0.05 ft (~ 5/8 in.) that allows for comparison of previous point data to evaluate continued settlement is deemed adequate. Further painting, given the dust, industrial hygiene issues, and as low as reasonably achievable concerns, is not necessary for further monitoring.

5. EVALUATION

5.1 STRUCTURAL EVALUATION

The total settlement through July 2003 was calculated based on the readings taken from October 1970 to July 2003 and plotted on the graphs in Appendix A.

Graphs were plotted in the 2005 report for settlements at selected points to see the pattern of subsidence of the slab, based on the readings taken in the past (see Table A-1 in Appendix A). This table tracked and documented the amounts of settlement at 34 pre-selected points on the concrete floor from 1970 to 1998, then in 2000, 2001, 2002, and 2003. The data shows that the rate of settlement at most of these locations, from 1998 to 2003, has decreased considerably. The maximum settlement recorded at any point (Point 30) between the years 2002 and 2003 was 0.48 in. Only a slight increase in settlement was noted at that point in the 2006 survey and, none in the 2007 and 2008 survey. Although there were signs of physical damage to some small-bore pipes (< 1 in.), no breakage in large-bore pipes (> 1 in.) was observed. The following points of interest were noted during the 2005 inspection/survey, with updates from the 2006, 2007, and 2008 inspections/surveys:

- The maximum settlement of 18.24 in. has occurred at Point 40, from 1970 to 1998. This point has potentially experienced additional settlement of 0.18 ft (2.1 in.) since 2003. See attached photographs (Figs. B-2 and B-3 in Appendix B).
- The next significant settlements of 9.12 in. and 10.92 in. occurred at Points 10 and 23, also from 1970 to 1998. Although Point 10 was not surveyed in 2007, Point 23 has potentially experienced additional settlement of 0.06 ft (0.72 in.) since 2003. See attached photographs (Figs. B-5 through B-18 in Appendix B).
- Of particular interest in the 2007 survey is point 15 which may have experienced 0.38 ft (4.5 in.) since 2003. Virtually no settlement was measured between 2003 and 2006 or for the 2008 survey.
- Other points of significant settlement measured during the 2007 survey are 19 (0.09 ft) and 4 (0.06 ft).
- The structural steel columns and main building framing are plumb, level, and uniform, and there are no signs of overstressing or damage to the steel framing.
- The footings for the steel columns also seem to be in good condition and show no sign of settlement, indicating that the settlement of the slab has had no significant impact on the building structure.
- The exterior elevation of the building appears to be uniform and shows no signs of deformation or damage due to the slab settlement. A minor excavation conducted in 2007 on the outside of building 311-1 revealed no drastic building foundation settlement or subgrade undermining outside of the building footing.
- There is no settlement in the footings of the building. The bottoms of footings for the building are located at El. 780 ft 0 in., and the bottoms of equipment foundations are at El. 787 ft 8 in. The equipment foundations are located in an area of old foundation, which was removed, and in proximity

to the building foundations. This has caused differential settlement due to insufficient compaction of soil, combined with the softening of soil due to water leaks.

- Some of the 2007 civil survey points may not correspond exactly to the previous locations, as these locations were last marked (spray painted) in 2003. This could result in a ± 0.05 -ft error in the survey. However, as noted above, Points 23 and 40 have potentially shown some additional settlement in the past three years.

5.2 PIPING EVALUATION

The following observations in the 2005 report remain valid for the 2008 report:

Walk-downs performed revealed deformations and/or breakages in several small-bore pipes in the vicinity of the A-Booster and B-Booster Pumps area. Because of the floor subsidence and observed damages to small-bore pipes, it was evident that all pipes, large- and small-bore, are stressed. The visible damage, mostly on small-bore pipes, includes the following:

- Deformed or broken fittings that are disengaged from pipes
- Hanger rods that are disengaged from beam attachments
- Expansion joints, in vertical pipes, that are elongated
- Floor-mounted components that are elevated off the floor and/or their supports resulting in the components' dead weights now being supported by the attached piping systems

See attached photographs (Figs. B-4 and B-19 through B-26 in Appendix B).

All of the piping systems in this area are out of service. The liquid pipelines (i.e., lube oil and coolant systems) were previously drained; therefore, only residual amounts of oil or coolant are expected to be within these systems. The nitrogen and steam systems were shut down in 2004. The process gas and dry air systems were shut down in the 1970s. The pressures in these systems are expected to be equal to the atmospheric pressure.

Further settlement of the K-311-I floor could result in the rupture of some of the piping systems. Rupture of the non-process gas systems should not cause adverse impacts to the area. However, if the process gas system piping were to rupture, radioactive contamination could migrate out of the system to the adjacent areas. The area of floor subsidence is currently barricaded and labeled as "high contamination area."

6. AUTHORIZATION BASIS – SAFETY BASIS COMPLIANCE

Per Technical Safety Requirements for the East Tennessee Technology Park K-275 and K-277 Facilities, Rev. 3D, Sect. 5.6, Procedures and Programs, Sect. 5.6.2.5, Initial Testing, In-Service Surveillance, and Maintenance Program states: “The Initial Testing, In-Service Surveillance, and Maintenance program ensures that safety Structures, Systems and Components (SSCs) (including Design Features (DFs) subject to degradation) perform their intended functions. The maintenance program is developed and implemented to ensure that maintenance activities are conducted to preserve and restore the availability, operability and reliability of the plant SSCs important to operation of the FACILITY and control and CALIBRATION of Measuring and Testing Equipment (M&TE).” The first bulleted item states: “The Initial Testing, In-Service Surveillance, and Maintenance Program shall establish a requirement to provide scheduled structural evaluations in the K-275/K-277 BUILDINGS.” In compliance, this inspection has been performed to status the condition of the K-311-1 building floor located between the truck alley and the exterior wall (north-south column lines 1 and 2) and between east-west column lines B and K at the cell floor level in the K-275 Building.

6.1 RECOMMENDATIONS

- Do not place additional loads in the subsidence area without engineering approval.
- Maintain the posting on the exterior of the building, “Digging Requires Facility Manager Approval,” 10 ft from the building along column line B to K.
- Any work inside the subsidence area requires engineering evaluation.
- Special engineering evaluation and planning should be performed before decontamination and decommissioning activities take place that could cause disturbances or additional loading on the slab or equipment. This includes vent, purge and drain, foaming, or work in the truck alley piping that is connected to the booster station.
- Discontinue annual monitoring when the stored energy offered by suspended equipment and piping has been removed.

6.2 CONCLUSIONS

- The foundations for the building frame are stable, and there is no indication of any settlement.
- Additional settlement in the area since last measured in 2003 is very minor, with the exception of Points 15, 23 and 40 as noted in Table A-1. Points 4, 5, 7, 15, 19, and 24 have settlements that are noted as approximately ½ in. or greater, but uncertainty in the survey locations could account for this difference in elevation measurements. Measurement of the points during the 2005 inspection was deemed unnecessary, since the graphs of settlement through 2003 show an extreme decline in the amount of settlement. The survey measurements were taken in 2008 to evaluate any additional potential of settlement. Since the locations of the past surveys have not been marked since 2003, the 2006 survey location may have been taken in an area up-slope or down-slope of the exact point, resulting in a survey delta of ± 0.05 ft.

7. REFERENCES

Engineering Evaluation Report on K-311-1 Floor Subsidence (2007 Annual Report) at the East Tennessee Technology Park, Oak Ridge, Tennessee, BJC/OR-2345/R2, November 2007

Engineering Evaluation Report on K-311-1 Floor Subsidence (2006 Annual Report) at the East Tennessee Technology Park, Oak Ridge, Tennessee, BJC/OR-2345/R1, November 2006

Engineering Evaluation Report on K-311-1 Floor Subsidence at the East Tennessee Technology Park, Oak Ridge, Tennessee, BJC/OR-2345, October 2005.

Facility Management, Surveillance, Inspection and Testing, Annual Inspection Report for the K-311-1 Floor Subsidence Survey and Evaluation, prepared by American Technologies, Inc., August 2003.

Technical Safety Requirements for the East Tennessee Technology Park K-275 and K-277 Facilities, TSR-ET-K25/K27-0002, Rev. 3D, Bechtel Jacobs Company LLC, June 2005.

K-275 Structural Drawings:

1. AWS-8169-0
2. AWS-8170-0
3. 311-1-A-20-AA
4. 311-1-A-20-BA
5. 311-1-A-20-CA
6. 311-1-A-40-BA
7. 311-A-1-A-40-ZA-2

K-275 Mechanical Drawings:

1. AWP-7831
2. AWP-7850-1
3. AWP-8073
4. AWP-8074-1
5. AWP-8119
6. AWS-8170-0
7. 300-M-19-GA311-M-05-DA

APPENDIX A.
TABLE OF SETTLEMENT ELEVATIONS
(FROM ATI REPORT) AND 2006 REPORT
K-311-1 FLOOR SUBSIDENCE SURVEY AREA SKETCH
(FROM ATI REPORT), AND SETTLEMENT GRAPHS

Table A-1. Elevations in K-311-1 (former Booster Station)*

Shot No. ^a	10/1/70 Elev. (ft)	7/18/00 Elev. (ft) ^c	10/9/01 Elev. (ft)	9/13/02 Elev. (ft)	7/31/03 Elev. (ft)	9/27/06 Elev. (ft)	11/12/07 Elev. (ft)	10/06/08 Elev. (ft)	Difference Since Latest Data (ft) ^f	Description
1	795 78	795 73	795 74	795 73	795 73	NA	NA		NA	Top of grade beam
2	795 67	795 65	795 65	795 64	795 66	NA	NA		NA	Top of grade beam
3	795 71	795 63	795 65	795 64	795 65	NA	NA		NA	Top of grade beam
4	795 28	794 58	794 55	794 50	794 47	NA	794 41	794 37	-0 04	Slab at gas cooler
5	795 45	795 2	795 21	795 21	795 21	795 17	NA	795 22	0 05	Slab at exterior wall
6	795 75	795 67	795 69	795 68	795 68	795 68	795 69		NA	Top of grade beam
7	795 41	795 11	795 15	795 14	795 13	795 09	NA		NA	Slab at gas cooler
8	795 25	794 58	794 59	794 57	794 56	NA	794 56	794 54	-0 02	Slab at pump motor
9	795 22	794 74	794 72	794 70	794 68	NA	794 73		NA	Slab at pump
10	795 26	794 52	794 52	794 50	794 50	794 49	NA	794 50	0 01	Slab at pump motor
11	795 14	794 82	794 82	794 81	794 80	NA	NA	794 91	0 09	Slab at pump
12	795 08	794 74	794 75	794 74	794 74	794 73	794 72	794 77	0 05	Slab at pump
13	795 31	794 85	794 79	794 77	794 77	794 75	794 76	794 82	0 06	Slab at pump motor
14	795 61	795 5	795 49	795 48	795 48	795 49	NA		NA	Slab at doorway
15	795 48	795 24	795 25	795 25	795 26	795 25	794 88	794 84	-0 04	Slab at pump motor
16	795 06	794 72	794 74	794 75	794 73	794 72	794 75		NA	Slab at pump
17	795 71	795 66	795 69	795 68	795 68	795 69	NA	795 70	0 01	Top of grade beam
18	795 38	794 87	794 90	794 89	794 89	794 87	794 89	794 88	-0 01	Slab at pump motor
19	795 3	795	795 02	795 01	795 02	NA	794 93		NA	Slab at pipe housing
20	795 66	795 62	795 63	795 63	795 63	795 64	795 64		NA	Slab at pipe housing
21	795 69	795 65	795 67	795 67	795 67	795 67	795 68	795 69	0 01	Top of grade beam
22	795 68	795 61	795 63	795 63	795 62	795 63	795 64	795 64	0 00	Slab at exterior wall
23	795 45	794 54	794 54	794 54	794 54	794 48	794 48	794 49	0 01	Slab at pump motor
24	795 38	794 96	795 95	794 94	794 98	794 94	794 94		NA	Slab at pump housing
25	795 71	795 68	795 69	795 69	795 70	795 70	795 69	795 71	0 02	Slab at exterior wall
26	795 62	795 32	795 35	795 34	795 34	795 34	795 34	795 27	-0 07	Slab at pump motor
27	795 52	795 19	795 21	795 20	795 19	NA	795 21	795 28	0 07	Slab at pipe housing
28	795 67	795 65	795 66	795 66	795 67	NA	NA		NA	Top of grade beam
29	795 56	795 38	795 40	795 40	795 39	795 38	795 39	795 40	0 01	Slab at pump motor
30	795 59	795 26	795 27 ^(e)	795 28	795 24	795 22	795 23	795 25	0 02	Slab at pump
31	795 56	795 19	795 21	795 20	795 19	795 20	795 21	795 20	-0 01	Slab at pipe housing
32	795 66	795 63	795 64 ^(e)	795 64	795 64	795 64	NA	795 63	-0 01	Top of grade beam
33	795 69	795 66	795 68	795 68	795 68	795 71	NA		NA	Top of grade beam
40	795 66	793 98	794 19 ^(e)	794 19	794 19	794 14	794 01	793 99	-0 02	Broken slab on grade

*This table has been imported from ATI's 2003 report and is reformatted

^a See Fig. A.1 for graphical depiction of survey points

^b 1998 data has been rounded to nearest 0.01 ft

^c Actual shot locations for 1970 and 1998 surveys were not marked in the field. Locations for 2000 survey were approximated from photocopy of field sketch and notes from 1998 survey. As a result, discrepancies may exist preventing direct correlation of data obtained in 1970 and 1998 with that obtained during the 2000 survey

^d Inaccessible in 1998

^e Points 30, 32, and 40 have been remarked. Surveyors could not locate 2001 survey point mark for Points 30, 32, and 40. Therefore, the difference in elevation is not relevant

^f Survey locations from 2003 survey were marked with paint. The paint was barely visible in locations due to dust, age, and wear. As a result, discrepancies in actual locations may result in elevation differences of 0.05 ft

NA = Not Accessible or location could not be found

Fig. A-1. K-311-1 floor subsidence survey area reference sketch.

Note: This sketch and the referenced photos (in Appendix C) are imported from the 2003 report and are included here for information only. Note that Photo 5 is not available.

Fig. A-2. Point 23-Settlement in pump area.

Fig. A-3. Point 40-Settlement in pump area.

Fig. A-4. Point 7-Settlement in pump area*.

*No shot taken in 2007.

Fig. A-5. Point 8-Settlement in pump area.

Fig. A-6. Point 9-Settlement in pump area.

Fig. A-7. Point 10-Settlement in pump area*.

*No shot taken in 2007.

Fig. A-8. Point 11-Settlement in pump area*.

*No shot taken since 2003.

Fig. A-9. Point 12-Settlement in pump area.

Fig. A-10. Point 15-Settlement in pump area.

Fig. A-11. Point 16-Settlement in pump area.

Fig. A-12. Point 18-Settlement in pump area.

Fig. A-13. Point 19-Settlement in pump area.

Fig. A-14. Point 24-Settlement in pump area.

Fig. A-15. Point 26-Settlement in pump area.

Fig. A-16. Point 27-Settlement in pump area.

Fig. A-17. Point 29-Settlement in pump area.

Fig. A-18. Point 30-Settlement in pump area.

Fig. A-19. Point 31-Settlement in pump area.

Fig. A-20. Point 32-Settlement at grade beam*.

*No shot taken in 2007.

Fig. A-21. Point 3-Settlement at grade beam*.

*No shot taken since 2003.

Fig. A-22. Point 17-Settlement at grade beam*.

*No shot taken in 2007.

APPENDIX B.
2005 FIELD PHOTOS

Fig. B-1. Photo of settlement under exterior wall grade beam.

Fig. B-2. Photo of area of maximum settlement.

Fig. B-3. Photo of area of maximum settlement.

Fig. B-4. Photo of settlement under pipe supports.

Fig. B-5. Photo of area of floor slab separation.

Fig. B-6. Photo of area of floor slab settlement.

Fig. B-7. Photo of area of floor slab settlement.

Fig. B-8. Photo of example of settlement crack in floor slab.

Fig. B-9. Photo of area of floor slab separation.

Fig. B-10. Photo of example of floor slab crack.

Fig. B-11. Photo of area floor settlement.

Fig. B-12. Photo of pump area settlement.

Fig. B-13. Photo of settlement at "A" pump area.

Fig. B-14. Photo of floor settlement at "A" pump area.

Fig. B-15. Photo of floor settlement at "B" pump area.

Fig. B-16. Photo of floor settlement at grade beam.

**Floor settlement under
pipe support**

Fig. B-17. Photo of floor settlement under pipe support.

Fig. B-18. Photo of pump "A" area floor settlement.

Fig. B-19. Photo of broken pipe.

Fig. B-20. Photo of example of broken pipe.

Fig. B-21. Photo of deformed 90-degree connections.

Floor/Pedestal settled below cooler. Pipe is now supporting cooler.

Fig. B-22. Photo of floor settlement below cooler.

Fig. B-23. Photo of example of broken pipe support.

Fig. B-24. Photo of broken pipe support.

Fig. B-25. Photo of gas cooler area.

Fig. B-26. Photo of elongated expansion joints.

APPENDIX C.
FIELD REPORTS FROM ATI REPORT IN 2003

Fig. C-1. View of north edge of damaged slab showing extent of subsidence (looking northwest)*.

*Photo printed from ATI report of August 2003.

Fig. C-2. View of area above equipment (looking south)*.

*Photo printed from ATI report of August 2003.

Fig. C-3. View of damaged slab and equipment (looking south)*.

*Photo printed from ATI report of August 2003.

Fig. C-4. View of standing water and damaged slab (looking northwest)*.

*Photo printed from ATI report of August 2003.

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