January 27, 2006

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: WATTS BAR NUCLEAR PLANT, UNIT 1 - RELIEF REQUEST 1-RR-07 ON THE USE OF ASME CODE CASE N-597-1 TO EVALUATE PIPE WALL THINNING (TAC NO. MC6512)

Dear Mr. Singer:

In a letter dated March 25, 2005 (ADAMS Accession No. ML050970082), Tennessee Valley Authority (the licensee), pursuant to Title 10 of the *Code of Federal Regulations* Section 50.55a(a)(3)(i), requested relief from the American Society of Mechanical Engineers (ASME) Code, Section XI, requirements to repair or replace an ASME Class 2 low alloy steel piping elbow associated with the main feedwater system at its Watts Bar Nuclear Power Plant (WBN), Unit 1. Instead, the licensee proposed to use the provisions of ASME Code Case N-597-1, "Requirements for Analytical Evaluation of Pipe Wall Thinning, Section XI, Division 1," to analytically evaluate the potential pipe wall thinning.

As discussed in the enclosed evaluation, the Nuclear Regulatory Commission staff has concluded that, pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternative provides an acceptable level of quality and safety and is, therefore, authorized for the duration of the current operating Cycle 7 for WBN, Unit 1. All other ASME Code Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA by BMozafari for/
Michael L. Marshall, Jr., Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosure: As stated

cc: See next page

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WATTS BAR NUCLEAR PLANT

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EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TENNESSEE VALLEY AUTHORITY

RELIEF REQUEST TO USE CODE CASE N-597-1 TO ANALYTICALLY EVALUATE

PIPE WALL THINNING OF ASME CLASS 2 CARBON STEEL MAIN FEEDWATER PIPING

WATTS BAR NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-390

1.0 INTRODUCTION

By letter dated March 25, 2005 (ADAMS Accession No. ML050970082), Tennessee Valley Authority (TVA, the licensee), pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), requested relief from the American Society of Mechanical Engineering (ASME) Code Section XI requirements to repair or replace an ASME Class 2 low alloy steel piping elbow associated with the main feedwater system at Watts Bar Nuclear Plant (WBN), Unit 1. As an alternative, the licensee proposed to use the provisions of ASME Code Case N-597-1, "Requirements for Analytical Evaluation of Pipe Wall Thinning, Section XI, Division 1," to analytically evaluate the effect of potential pipe wall thinning in an elbow on the structural integrity of the system under the Faulted Condition loading, which included Check Valve Slam (CVS) waterhammer and Safe Shutdown Earthquake (SSE) seismic loading. The potential pipe wall thinning was projected to take place by the WBN CHECWORKS program.

During implementation of WBN's Unit 1 Cycle 6 Refueling Outage (RFO) Flow Accelerated Corrosion (FAC) Program, ultrasonic examination (UT) detected wall thinning in an ASME Code Class 2 main feedwater piping elbow at the steam generator Loop 2 inlet nozzle. Currently, the thickness is greater than the ASME Code required minimum wall thickness t_{min}. Based on UT thickness measurements and the predicted wear rate, it was determined that the predicted wall thickness t_p will fall below the required minimum wall thickness t_{min} 13 months after startup from the RFO. The other three steam generator elbows to the inlet nozzles were ultrasonically examined and were found acceptable.

Specifically, the UT examination of the elbow found the current minimum measured wall thickness t_{meas} to be 0.635 inches in Row 2 on the upstream end of the elbow. This is the same location as the Cycle 5 RFO minimum measured wall thickness t_{meas} of 0.639 inches. Using an estimated wall thinning rate of 0.0197 inches/year (which includes a 10-percent safety factor), the predicted wall thickness t_p at the Cycle 7 RFO is calculated to be 0.605 inches. The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1 Paragraph -3622.1(a)(1) is 0.613 inches. As noted, the predicted wall thickness t_p of 0.605 inches will fall below the minimum wall thickness t_{min} of 0.613 inches, but will be greater than 90 percent of the minimum wall thickness t_{min} as allowed by the provision of Code Case N-597-1.

WBN is currently in the first 10-year inservice inspection interval. The 1989 Edition of the ASME Code, Section XI with no Addenda governs the current repair and replacement activities at this plant.

Use of Code Case N-597-1 was previously requested by TVA for this same component following the Cycle 5 RFO, and was approved in Nuclear Regulatory Commission's (NRC's) "Safety Evaluation of Request for Relief 1-RR-05 (TAC No. MC1580)," dated August 27, 2004 (ML042430029).

2.0 REGULATORY EVALUATION

As specified in 10 CFR 50.55a(g), inservice inspection (ISI) of nuclear power plant components shall be performed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code (Code), Section XI, except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i).

Pursuant to 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Title 10 CFR 50.55a(g)(5)(iii) states that if the licensee has determined that conformance with certain code requirements is impractical for its facility, the licensee shall notify the Commission and submit, as specified in §50.4, information to support the determinations.

2.1 Licensee's Evaluation

Summary:

During implementation of WBN's Unit 1 Cycle 6 RFO FAC Program, UT detected wall thinning in an ASME Code Class 2 main feedwater piping elbow at the steam generator Loop 2, inlet nozzle. The FAC Program identifier for this component is grid 103BE252. Currently, the thickness is greater than the required minimum wall thickness t_{min}. Based on UT thickness measurements, predicted wear rate, and analytical analysis, it was determined that the predicted wall thickness t_p will fall below the required minimum wall thickness t_{min}, 13 months after startup from the RFO. However, analysis demonstrates the elbow meets the alternative evaluation criteria of ASME Code Case N-597-1, Section -3600. This condition was reported in WBN's Corrective Action Program, as Problem Evaluation Report (PER) 77658. The other three steam generator elbows to the inlet nozzles were ultrasonically examined and were found acceptable.

Use of the code case was requested for this same component following the Cycle 5 RFO and was approved by letter to TVA dated August 27, 2004, "Safety Evaluation of Request for Relief 1-RR-05 on the Use of Code Case N-597-1 to Evaluate Pipe Wall Thinning at Watts Bar Nuclear Power Plant, Unit 1"(ML042430029). The safety evaluation requires additional relief for continued operation until the end of Cycle 7 and the relief request is to meet the following condition: *The licensee must demonstrate that the structural integrity and safety of the degraded elbow will be ensured by performing a stress analysis, using the set of ultrasonic testing data recorded during the Cycle 6 RFO and projected to the end of Cycle 7. The stress*

analysis should be based on the licensing basis methodology that was approved by the staff in the resolution of Watts Bar Outstanding Issue 20(a), "Feedwater Check Valve Slam," and documented in Supplement No. 13 of NUREG-0847, "Watts Bar Safety Evaluation Report," in accordance with the provisions of Code Case N-597-1 for piping stress analysis.

The Cycle 6 RFO FAC Program UT of the elbow found the current minimum measured wall thickness t_{meas} to be 0.635 inches in Row 2 on the upstream end of the elbow. This is the same location as the Cycle 5 RFO minimum measured wall thickness t_{meas} of 0.639 inches. Using an estimated wall thinning rate of 0.0197 inches/year (which includes a 10-percent safety factor), the predicted wall thickness t_p at the Cycle 7 RFO is calculated to be 0.605 inches.

The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1 Paragraph -3622.1(a)(1) is 0.613 inches. This equation is essentially the same equation for calculating the minimum wall thickness based upon the allowable hoop stresses. As noted, the predicted wall thickness t_p of 0.605 inches will fall below the minimum wall thickness t_{min} of 0.613 inches but will be greater than 90 percent of the minimum wall thickness t_{min} as allowed by the provision of the Code Case. Thus, TVA is requesting review and approval for application of the Code Case N-597-1 as allowed by the conditions of Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1, Revision 13." Application of the Code Case provides an acceptable level of quality and safety for this application.

Component:

FAC Grid 103BE252, 16-inch nominal pipe size feedwater pipe 45 degree elbow at the inlet to Loop 2 Steam Generator, ASME Code Class 2.

Code Requirement:

ASME Section XI, 1989 Edition, IWA-4300 provides a process for assessing a component for continued service after a defect has been removed. This provision stipulates that where the section thickness has been reduced below the minimum design wall thickness, the component shall be repaired. As an alternative, the component may be evaluated and accepted in accordance with the design rules of either the Construction Code or Section III.

Basis for Relief:

RG 1.147, Revision 13, conditionally accepted the use of Code Case N-597-1 subject to five conditions. Some of these conditions require NRC review and approval prior to continued use of the Code Case.

Proposed Alternative:

As an alternative to the requirements of IWA-4300, TVA proposes to use the provisions of ASME Code Case N-597-1 for analytical evaluation of FAC grid 103BE252, subject to the conditions incorporated into the acceptance of the Code Case in RG 1.147, Revision 13.

Justification for Granting of Relief:

Actual wall thickness measurements were taken by ultrasonic examination on February 27 and 28, 2005, during the Cycle 6 RFO. A copy of the examination data report is included in Enclosure 2 to the licensee's submittal (ML050970082). This is the second set of thickness measurements taken for this component. The data grid points for these measurements are established by procedure and are taken from the grid pattern on the component surface as depicted in the sketches labeled View 1, View 2, and View 3 of Enclosure 2.

The Cycle 6 RFO FAC Program UT of the elbow found the current minimum measured wall thickness t_{meas} to be 0.635 inches in Row 2 on the upstream end of the elbow. This is the same location as the Cycle 5 RFO minimum measured wall thickness t_{meas} of 0.639 inches. Using an estimated wall thinning rate of 0.0197 inches/year (which includes a 10-percent safety factor), the predicted wall thickness t_p at the Cycle 7 RFO is calculated to be 0.605 inches.

The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1 Paragraph -3622.1(a)(1) is 0.613 inches. This equation is essentially the same equation for calculating the minimum wall thickness based upon the allowable hoop stresses. As noted, the predicted wall thickness t_p of 0.605 inches will fall below the minimum wall thickness t_{min} of 0.613 inches but will be greater than 90 percent of the minimum wall thickness t_{min} as allowed by the provision of the Code Case. Thus, TVA is requesting review and approval for application of the Code Case N-597-1 as allowed by the conditions of RG 1.147, "Inservice inspection Code Case Acceptability, ASME Section XI, Division 1, Revision 13." Application of the Code Case provides an acceptable level of quality and safety for this application.

2.2 Staff Evaluation

The staff reviewed the information provided by TVA in support of its request for relief from ASME Section XI requirements to permanently repair or replace an ASME Class 2 alloy steel piping elbow at WBN. The staff evaluation of the request follows.

In Enclosure 2 to its Request for Relief, TVA addressed wall thinning by FAC in an ASME Section III Class 2 degraded elbow located in Loop 2 of the WBN, Unit 1 Main Feedwater System. The elbow is fabricated from 16-inch, Schedule 80, SA-333 Grade 6 material. For this elbow the nominal thickness t_{nom} = 0.844 inches. The evaluation of the piping was based on the application of ASME Section XI Code Case N-597-1. This Code Case was conditionally accepted by the staff as documented in RG 1.147, with conditions listed in Table 2 of the Guide.

Condition (2) for this Code Case, as listed in RG 1.147, states that: "*Components affected by FAC to which this Code Case are applied must be repaired or replaced in accordance with the construction code of record and Owner's requirements or a later NRC-approved edition of Section III of the ASME Code, prior to the value of t_p (minimum projected wall thickness) reaching the Code required minimum wall thickness, t_{min}, as specified in Paragraph -3622.1(a)(1) of this Code Case. Alternatively, the use of this Code Case is subject to NRC review and approval.*"

Based on measured wall-thickness data taken during the Cycle 5 RFO in September 2003, the minimum measured wall thickness was determined to be 0.639 inches. On the basis of wear rates computed using WBN FAC Program methods (including a 10 percent safety factor), the

minimum predicted wall thickness t_p at the end of current operating Cycle 6 (1.5 years later, or February 2005) was determined as t_p = 0.598 inches.

Based on measured wall-thickness data taken during the Cycle 6 RFO in February 2005, the minimum measured wall thickness was determined to be 0.635 inches (not as predicted t_p = 0.598 inches). On the basis of wear rates computed using WBN FAC Program methods (including a 10 percent safety factor), the current minimum predicted wall thickness t_p at the time of the Cycle 7 RFO (1.5 years after Cycle 6 RFO) is t_p = 0.605 inches.

The Code required minimum wall thickness t_{min} was determined to be 0.613 inches. Since this value falls between the minimum measured wall thickness during Cycle 6 RFO and the predicted Cycle 6 RFO minimum wall thickness, the licensee determined, based on the computed wear rate, that the wall thickness will reach the Code-required minimum wall thickness t_{min} 13 months into the current operating cycle, (i.e., sometime in April 2006). This would potentially constitute a deviation from the licensing basis of the plant and thus require plant shutdown to repair or replace the degraded elbow. Therefore, TVA requested relief from the ASME Code requirements so that plant operation can continue until the end of current operating Cycle 7.

Subsection -3221 of Code Case N-597-1, “Acceptance by Examination,” states that piping items whose examination and evaluation results reveal that t_p meets the acceptance standards of Section -3500 or the Construction Code are acceptable for continued service.

Paragraph -3500(a)(1) of Section -3500, “Wall Thickness Acceptance Standards,” states that for straight pipe and elbows purchased to a nominal pipe specification with an allowable wall thickness under-tolerance of 12 percent, t_p shall not be less than $0.875t_{nom}$. For this elbow, $0.875t_{nom}$ = 0.739 inches, which is greater than both the current measured minimum wall thickness and the predicted minimum wall thickness t_p. The acceptance criterion by examination was, therefore, not met. When this criterion cannot be met, Subsection -3221 states that alternative acceptance standards stated in Subsections -3222, -3223, and -3224 may be used.

Subsection -3223 of Code Case N-597-1, “Acceptance by Engineering Evaluation,” states that for Class 2 and 3 piping, an acceptable evaluation method and criteria are provided in Section -3600, “Analytical Evaluation for Class 2 and Class 3 Piping Items.” Subsection -3610, “General Requirements,” states that: *(a) analytical evaluations shall be conducted in accordance with the Construction Code. Later Code Editions and Addenda may be used. Use of later Code Editions and Addenda shall be reviewed for acceptability to the regulatory and enforcement authorities having jurisdiction at the plant site, (b) analytical evaluations shall be conducted using the predicted wall thickness t_p at the next examination of the piping item, (c) a piping item is acceptable for continued service if the minimum pipe wall thickness, branch reinforcement requirements, and piping stress criteria of the Construction Code used in the evaluation are met for all specified loading conditions, and (d) as an alternative to item (c), butt welded pipe, elbow, branch connection, and reducer piping items may be evaluated in accordance with Section -3620, “Evaluation of Pipe, Elbows, Branch Connections and Reducers.”*

The general requirements stated in Subsection -3621 of Section -3620 state the following:

(a) the evaluation shall meet the requirements of Subsection -3622 and Paragraph -3622.1, (b) for a branch connection or tee, the region within the limits of reinforcement defined in the Construction Code shall meet the requirements of Subsection -3624, and (c) evaluations shall be conducted using the appropriate piping equations, loadings, load combinations, allowable material properties, and other acceptance standards from the Construction Code used in the evaluation, except as specifically modified by this Case. Paragraph -3622.1(a), "Evaluation for Minimum Wall Thickness," of Subsection -3622, "Thickness Evaluation," also states that, *"except as provided in Paragraph -3622.1(b), the value of t_p shall not be less than 90 percent of the minimum wall thickness of the piping item, t_{min}, required for design pressure, defined in the Construction Code used in the evaluation, exclusive of any additional corrosion allowance."* Based on the Code required minimum wall thickness t_{min} for this elbow of 0.613 inches, the licensee determined that 90 percent of t_{min} is 0.552 inches. The staff finds that TVA has shown that the predicted minimum wall thickness is less than t_{min} but greater than $0.9t_{min}$, and therefore meets the criterion in this section.

The feedwater system was initially designed and qualified to ASME Code Class 2 piping. As a result of the discovery for potential CVS waterhammer loading, following a postulated pipe rupture at the main header in the Turbine Building, the NRC staff identified Outstanding Issue 20(a), "Feedwater Check Valve Slam," in NUREG-0847, Watts Bar Safety Evaluation Report, Supplement No. 6, dated April 1991. The issue was the qualification of the feedwater piping system inside containment, from the check valves to the steam generator nozzles, to Level D service limits when subjected to the faulted condition load combination of CVS waterhammer and SSE loading.

To qualify the Class 2 system for licensing under combined CVS and SSE loading, the licensee performed a dynamic, elastic-plastic analysis, using the computer program ANSYS. The as-built nominal wall thickness (t_{nom} = 0.844 inches) and as-built support configuration values were used as input. In conjunction with this analysis, the licensee also invoked the Level D Service (faulted condition) stress limits for pressure boundary integrity stated in ASME Section III Appendix F (1980 Edition through Winter 1982 Addenda, or a later Edition) for plastic analysis. Although the limits of Appendix F specified in the 1980 Edition were valid only for qualification of ASME Class 1 piping, the staff approved the application of these limits for qualification of this Class 2 system. These limits are significantly higher than the faulted conditions limits specified for Class 2 piping. During the initial licensing review for WBN, the NRC staff reviewed the ANSYS analysis and found it acceptable. The staff also approved the application of Class 1 limits for the qualification of Class 2 piping. These findings and the resolution of Licensing Issue 20(a) were documented in NUREG-0847, "Watts Bar Safety Evaluation Report," Supplement No. 13, dated April 1994.

The NRC's safety evaluation in its letter to TVA dated August 27, 2004, "Safety Evaluation of Request for Relief 1-RR-05 on the Use of Code Case N–597-1 to Evaluate Pipe Wall Thinning at Watts Bar Nuclear Power Plant, Unit 1" (ML042430029), indicated that the following condition would have to be met, if TVA intended to request subsequent relief and approval at RFO Cycle 6 for application of the provisions of Code Case N–597-1 to this component to the end of Cycle 7: *The licensee must demonstrate that the structural integrity and safety of the degraded elbow will be ensured by performing a stress analysis, using the set of ultrasonic testing data recorded during the Cycle 6 RFO and projected to the end of Cycle 7. The stress analysis should be based on the licensing basis methodology that was approved by the staff in the resolution of Watts Bar Outstanding Issue 20(a), "Feedwater Check Valve Slam," and*

documented in Supplement No. 13 of NUREG-0847, "Watts Bar Safety Evaluation Report," in accordance with the provisions of Code Case –597-1 for piping stress analysis.

As stated above, the RFO Cycle 6 FAC Program ultrasonic examination of the elbow found the current minimum measured wall thickness t_{meas} to be 0.635 inches in Row 2 on the upstream end of the elbow. This is the same location as the RFO Cycle 5 minimum measured wall thickness t_{meas} of 0.639 inches. Using an estimated wall thinning rate of 0.0197 inches/year (which includes a 10-percent safety factor), the predicted wall thickness t_p at the RFO Cycle 7 RFO is calculated to be 0.605 inches.

Based on the measured Cycle 6 RFO wall thickness, the licensee performed, in support of its relief request, a stress analysis of the degraded elbow with the wall thinning predicted to occur by the end of the operating Cycle 7, in accordance with the provisions of Section -3623 of the Code Case. The licensee submitted this analysis for staff evaluation, in accordance with Condition (2) stated in Table 2 of RG 1.147 for Code Case N-597-1, and the condition requirement stated in the NRC letter.

In accordance with this requirement, the licensee provided the measured Cycle 6 RFO UT elbow thicknesses and the results of two stress analyses for staff review and evaluation. The analyses used elbow geometrical properties (such as cross-sectional area and moment of inertia) based on the average wall thickness, calculated from the projected minimum wall thicknesses at RFO Cycle 7 of the highest degraded cross-section in the elbow. One analysis consisted of an ASME Section III Class 2 elastic analysis of the degraded elbow for all load combinations that did not include CVS waterhammer loading. This analysis was shown to meet the ASME Section III Class 2 allowable stresses for piping. The highest stress ratio (maximum stress / allowable stress) was determined as 0.996 < 1.0. This analysis also meets the evaluation requirements stated in Subsection -3623.1, “Evaluation Requirements,” which require that the stress evaluation be performed using the equations required by the Construction Code.

The second stress analysis consisted of an elastic elbow analysis based on the ASME Section III Class 1 methodology. This analysis used the internal moments calculated from the ANSYS elastic-plastic piping system analysis, subject to the CVS and SSE load combination, that had previously been evaluated and approved by the staff in Supplement 13 of NUREG-0847. The highest stresses were compared against the ASME Section III Appendix F stress limits that had also previously been approved in this supplement. This approach was used as an alternative to performing an ANSYS full elastic-plastic analysis with the highest degraded wall thickness in the entire elbow. Based on this analysis, the licensee demonstrated that the primary membrane and primary membrane-plus-bending stress intensities will meet the Supplement No.13 stress limits in the Cycle 7 RFO degraded condition. The highest stress ratio (maximum stress / allowable stress) was determined as 0.967 < 1.0. The staff evaluated the licensee’s approach and concluded that, for this one-time request for relief, the analysis satisfies the intent of the methodology and the ASME Section III Appendix F stress limits accepted by the staff in Supplement No. 13 of NUREG-0847.

Based on the above evaluation, the staff finds that the licensee has provided reasonable assurance that it is unlikely that the structural integrity of the degraded elbow will be compromised prior to the Cycle 7 RFO.

3.0 CONCLUSION

Based on the above evaluation, the staff concludes that the application by the licensee of the relevant provisions of Code Case N-597-1 has provided reasonable assurance that the structural integrity and safety of the degraded elbow will be ensured for continued operation until the Cycle 7 RFO. This assurance was provided by the results of stress analyses of the degraded elbow using the set of UT data recorded during the Cycle 6 RFO and projected to the Cycle 7 RFO, in accordance with the provisions of Code Case N-597-1 for piping stress analysis, and the condition stated in the NRC Safety Evaluation dated August 27, 2004. The stress analysis that complied with this condition was based on an acceptable alternative to the licensing basis methodology, but applied the ASME Section III Appendix F stress limits that were approved by the staff in the resolution of Outstanding Issue 20(a), "Feedwater Check Valve Slam," and documented in Supplement No. 13 of NUREG-0847, "Watts Bar Safety Evaluation Report." However, the wall thickness is projected to degrade to the Code minimum wall thickness approximately 13 months into Cycle 7. The licensee will therefore be required to repair or replace the degraded elbow, in accordance with the requirements of ASME Section XI, at the Cycle 7 RFO. These requirements will be met by the licensee's commitment to replace the degraded elbow during the steam generator replacement during the Cycle 7 RFO,

In summary, pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternative provides an acceptable level of quality and safety and is, therefore, authorized for the duration of the current operating Cycle 7 for WBN, Unit 1. All other ASME Code Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principle Contributors: George Georgiev, DCI/CPNB
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Date: January 27, 2006