ATTACHMENT 1

TECHNICAL EVALUATION REPORT

MASONRY WALL DESIGN

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT UNITS 1 AND 2

NRC DOCKET NO. 50-325, 50-324

NRC TAC NO. 42876, 42877

NRC CONTRACT NO. NRC-03-81-130

FRC PROJECT C5506

FRC ASSIGNMENT 6

FRC TASK 245

Prepared by

Franklin Research Center
20th and Race Street
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Author: A. K. Le, V. N. Con

FRC Group Leader: V. N. Con

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: N. C. Chokshi

November 16, 1984

FRANKLIN RESEARCH CENTER
DIVISION OF ARVIN/CALSPAN

20th and Race Streets, Phila., Pa. 19103 (215) 448-1000

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Prepared by:	Reviewed by:	Approved by:
A. K. Le	Vu Ngoc Con	Vu Ngoc Con (For S. Carfagno)
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CONTENTS

FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

1. INTRODUCTION

1.1 PURPOSE OF REVIEW

The purpose of this review is to provide technical evaluations of Licensee responses to IE Bulletin 80-11 [1]* with respect to compliance with the Nuclear Regulatory Commission (NRC) masonry wall criteria. In addition, if a licensee has planned repair work on masonry walls, the planned methods and procedures are to be reviewed for acceptability.

1.2 GENERIC ISSUE BACKGROUND

In the course of conducting inspections at the Trojan Nuclear Plant, Portland General Electric Company determined that some concrete masonry walls did not have adequate structural strength. Further investigation indicated that the problem resulted from errors in engineering judgment, a lack of established procedures and procedural details, and inadequate design criteria. Because of the implication of similar deficiencies at other operating plants, the NRC issued IE Bulletin 80-11 on May 8, 1980.

IE Bulletin 80-11 required licensees to identify plant masonry walls and their intended functions. Licensees were also required to present reevaluation criteria for the masonry walls with the analyses to justify those criteria. If modifications were proposed, licensees were to state the methods and schedules for the modifications.

1.3 PLANT-SPECIFIC BACKGROUND

In response to IE Bulletin 80-11, the Carolina Power and Light Company (CP&L) provided the NRC with documents [2, 3, 4, 5] describing the status of masonry walls at the Brunswick Steam Electric Plant Units 1 and 2. The information in these documents was reviewed, and a request for additional information was sent to the Licensee [6] to which the Licensee responded [7].

* Numbers in brackets indicate references, which are cited in Section 5.

Additional questions [8] were sent to the Licensee, to which it has also responded [9].

The Licensee identified 87 masonry walls as safety-related for both Units 1 and 2. Fourteen are unreinforced walls and 18 are multiple-wythe walls.

The masonry walls at the Brunswick plant function as partitions, fire protection, or radiation shields. There is no safety-related piping attached to or supported from concrete masonry walls at the Brunswick plant. Light equipment, such as control panels, junction boxes, and light fixtures, is attached to walls throughout the plant.

Masonry wall types and materials for the Brunswick plant are given below.

Wall Types:

Safety-related walls	87
Walls requiring modifications	10
Walls being evaluated for possible modifications	17

Wall Functions: partition, radiation shielding, fire protection

Construction Materials:

Mortar for Unit Masonry	C270 Type M
Masonry Units	
Hollow load-bearing partitions and walls	C90 Grade N-I C129
Solid units	C145 Grade N-I
Reinforcement	ASTM 615-68 Grade 60 for sizes No. 6 to No. 11, and Grade 40 for smaller sizes.
Wire for Reinforcement	Standard Dur-O-Wal galvanized spaced at every second course

2. EVALUATION CRITERIA

The basic documents used for guidance in this review were the criteria developed by the Structural Geotechnical Engineering Branch (SGEB) of the NRC (attached as Appendix A to this report), the Uniform Building Code [10], and ACI 531-79 [11].

In general, the materials, testing, analysis, design, construction, and inspection of safety-related concrete masonry walls should conform to the SGEB criteria. For operating plants, the loads and load combinations for qualifying the masonry walls should conform to the appropriate specifications in the Final Safety Analysis Report (FSAR) for the plant. Allowable stresses are specified in Reference 11 and the appropriate increase factors for abnormal and extreme environmental loads are given in the SGEB criteria (Appendix A).

3. TECHNICAL EVALUATION

This evaluation is based on the Licensee's earlier responses [2, 3, 4, 5] and subsequent responses [7, 9] to the requests for additional information [6, 8]. The Licensee's criteria [3] were evaluated with regard to design and analysis methods, loads and load combinations, allowable stresses, construction specifications, and materials. The Licensee's response to the request for additional information was also reviewed.

3.1 EVALUATION OF LICENSEE'S CRITERIA

The Licensee reevaluated the masonry walls using the following criteria:

- Allowable stresses are consistent with ACI 531-79.
- Load combinations are according to the FSAR.
- The working stress design method is used.
- The following damping values were used:

  Unreinforced Walls

  2% - Operating basis earthquake (OBE)

  4% - Safe shutdown earthquake (SSE)

  Reinforced Walls

  4% - OBE
  7% - SSE

- The walls are modeled as beams or plates.
- The typical analytical procedure is summarized below:
  - determine wall boundary conditions
  - calculate the wall's fundamental frequency
  - calculate the seismic inertia load
  - compare computed stresses with allowables.

Other than those areas identified in Section 4, the Licensee's criteria have been reviewed and found to be technically adequate and in compliance with the SGEB criteria. The review of the Licensee's response to the request for additional information follows.

Question 1

Indicate whether the walls have stack bond or running bond. If any stack bond wall exists, provide sample calculations to obtain moment and shear stress of a typical wall.

Response 1

The Licensee confirmed that there are no stack bond walls at the Brunswick plant; all walls have running bond construction.

The Licensee's response has resolved the concern on stack bond construction at the Brunswick plant.

Question 2

Indicate how frequency variations due to uncertainties in mass, materials, and other parameters were considered.

Response 2

The Licensee indicated that the frequency variations due to uncertainties in mass, material, and other parameters were accounted for by varying the modulus of elasticity, Em, between 1000 f'm and 600 f'm for hollow masonry and between 1200 f'm and 800 f'm for solid or grouted masonry.

As a result of modulus of elasticity variation, the wall's frequency will vary accordingly and the peak acceleration from the amplified response spectra can be selected.

The Licensee's response is adequate and in compliance with the SGEB criteria.

Question 3

Describe how in-plane interstory drift was considered.

Response 3

The Licensee indicated that the in-plane interstory drift was considered by comparing the in-plane strain induced in the wall to the in-plane strain limits. For unconfined walls, this limit is 0.0001, and for confined walls bounded on top and bottom or bounded on three sides, the following formula was applied:

$$\alpha = \frac{1 + (B/H)^2}{2000\ B/H}$$

where B = wall width and H = height.

For confined walls at this plant, the smallest value for B/H is 0.667, which results in α = 0.001 and α will be smaller if B/H becomes larger. The value of α = 0.001 has been judged to be acceptable in other plants. The Licensee stated that all masonry walls at the Brunswick plant respond within the above limit. As has been observed in other plants, the above formula was proposed based on a number of available test data and it is judged to be adequate and satisfactory.

Request 4

Indicate if cracking of sections was given proper consideration in the analysis.

Response 4

The Licensee indicated that cracking is not permitted in unreinforced masonry walls. For reinforced masonry walls, cracking was properly accounted for in both frequency and strength calculations. Frequency variations which account for cracking were considered by calculating the effective moment of inertia of a cracked masonry wall. Cracking was accounted for in strength calculations by assuming the masonry takes no tension (for reinforced masonry).

The Licensee's response is satisfactory and in compliance with the SGEB criteria.

Question 5

Indicate whether the block pullout was considered in the evaluation. If yes, provide sample calculations of block pullout analysis.

Response 5

The Licensee stated that block pullout was considered in the evaluation of masonry walls. The sample calculation was provided for an 8-in single wythe wall.

The pullout strength was found to be 6200 lb for unreinforced block and 51,000 lb for reinforced block. There were no attachment supports to individual blocks with loading in excess of the pullout strength.

The Licensee stated that field surveys of the various attachments to the masonry walls at the Brunswick plant were reviewed. The Licensee concluded that there were no attachment supports to individual blocks with loading in excess of the pullout strength.

The Licensee's response is adequate and in compliance with the SGEB criteria.

Question 6

a. In Reference 3, the Licensee indicated that loads and load combinations are based on the NRC Standard Review Plan for the elastic design method. The Licensee is requested to clarify whether they are consistent with the Plant Final Safety Analysis Report (FSAR). If any deviations exist, justification should be given.

b. With reference to load combinations, the Licensee is requested to provide justification for the stress factors of 1.5 for dead plus live plus abnormal temperature loads and 1.1 for dead plus live plus DBE seismic plus abnormal temperature loads.

c. In Reference 3, the Licensee indicated that impulsive and impactive loads were considered. Describe types of these loads (pipe rupture, missile impact, etc.). Also, provide a sample calculation illustrating how these loads were treated in the analysis.

Response 6

a. With regard to loads and load combinations, the Licensee confirmed that the load combinations are consistent with those in the Plant Final Safety Analysis Report (FSAR).

b. With regard to the stress factors, the Licensee indicated that the increases were included in the criteria because thermal loads are secondary and self-relieving in nature. Stress increases are normally taken in design for load equations involving temperature. The masonry walls evaluated in this program were not subjected to postulated temperature gradients through the thickness. Therefore, the wall would not experience thermal-induced flexural or shear stresses.

c. With regard to walls subjected to impact loads, the Licensee indicated that the impact loads are applicable to masonry walls which separate the diesel generators in the diesel generator building. These walls are reinforced. Each side of the masonry walls is protected by a 1/4-in steel plate attached by through bolting with 3/4-in diameter bolts. The following are commitments related to potential missiles generated by the air receivers that exist in each of the diesel generator rooms between the steel plate protected masonry walls.

Case 1 - A 2-in diameter plug of weight 1.38 lb which becomes loose and is propelled by exhausting air.

Case 2 - The air receiver is punctured and becomes a jet-propelled missile.

Case 3 - The air receiver explodes into fragments. A fragment is idealized as a 2-in-diameter circular disc.

The sample calcualtion for case 1 was illustrated. The Licensee stated that this was the most severe missile impact case and enveloped that associated with case 3. For case 2, a puncture in the most severe location was postulated and the Licensee stated that attachment and supports of the air receivers were adequate to prevent impact on the masonry walls. Therefore, no impact calculations were performed for case 2.

The sample calculation indicated that a penetration thickness of 0.12 in is less than the thickness provided by the steel plate which is 0.25 in. The overall stability of the wall, which is subject to the same postulated missile as case 1, was checked by comparing the calculated ductility ratio with the allowable ductility ratio. The calculated ductility ratio of the wall was found to be 3.7, which is smaller than the allowable ratio of 10.

The Licensee's response is judged to be adequate.

Question 7

Show, by sample calculation, how the effect of higher modes of vibration was considered in the analysis.

Response 7

The Licensee referred to a study contained in the "Recommended Guideline for the Reassessment of Safety Related Masonry Walls," dated October 6, 1980 and prepared by Owners and Engineering Firms Informal Group on Concrete Masonry Walls, and stated that this study demonstrates that the first mode contributes to over 99% of the total flexural response. The Licensee also stated that similar results are expected for shear at the boundary; therefore, higher modes were not accounted for in the calculation of stresses. Moreover, the peak accelerations were assumed to exist uniformly over the entire wall.

The Licensee's resonse is adequate and in compliance with the SGEB criteria.

Question 8

Indicate whether the construction practice for the masonry walls at the Brunswick plant was in conformance with the provisions specified for the special inspection category in ACI 521-79 [8]. If not, explain and justify the use of allowable stresses.

Response 8

With regard to the construction practice, the Licensee indicated that a daily inspection by the superintendents for the subcontractor, contractor, and owner was performed during the construction of the masonry walls.

The allowable stresses used in the design of the masonry walls at the Brunswick plant were those normally for masonry work at the time the plant was constructed.

In addition, some tests were conducted to verify the allowable strength of the walls being analyzed. See Response 9.1 for more details of the laboratory test results to verify the assumed values of masonry and mortar strength used in the analysis.

Question 9

With respect to Tables A-2 and A-3 [3], justify the use of the following increase for factored loads (the increase factors allowed in the SGEB criteria [6] are shown in parentheses):

shear in flexural members	1.5 (1.3)
tension normal to the bed joint	1.67 (1.3)
tension parallel to the bed joint	1.67 (1.3)

If the Licensee intends to use any existing test data to justify these factors, the Licensee is requested to discuss the applicability of these tests to the masonry walls at the plant to the following areas:

- o nature of loads
- o boundary conditions
- o materials used
- o size of test walls.

Response 9

The Licensee indicated that the increase factors for both flexural members and shear walls have been established based on tests for shear walls. The Licensee referred to two test programs: the first one was performed by Schneider, and the second was performed at the University of California, Berkeley. The Licensee stated that these test results were used as a comparison with the code allowables. See further details relative to this subject in Response 9.3.

Question 10

In Reference 3, the Licensee indicated that the energy balance technique and arching theory have been used to qualify some masonry walls. The NRC, at present, does not accept the application of these techniques to masonry walls in nuclear power plants in the absence of conclusive evidence to justify this application. The Licensee is requested to indicate the number of walls which have been analyzed by each of these techniques and to provide the resulting stresses and displacements.

The following areas need technical verification before any conclusion can be made about these techniques:

1. Energy Balance Technique

   o For the walls which were analyzed by using the energy balance technique, provide the technical basis to ensure that the ductile mode of failure will take place (if they fail).

   o Provide justification and test data (if available) to validate the applicability of the energy balance technique to the masonry structures at Brunswick Units 1 and 2 with particular emphasis on the following areas:

      a. nature of the load
      b. boundary conditions
      c. material strength
      d. size of test walls.

2. Arching Theory

   o Explain how the arching theory handles cyclic loading, especially when the load is reversed.

   o Provide justification and test data (if available) to validate the applicability of the arching theory to the masonry structures at Brunswick Units 1 and 2 with particular emphasis on the following areas:

      a. nature of the load
      b. boundary conditions
      c. material strength
      d. size of test walls.

   o If hinges are formed in the walls, the capability of the structures to resist in-plane shear force would be diminished, and shear failure might take place. This in-plane shear force would also reduce the out-of-plane stiffness. Explain how the effect of this phenomenon can be accurately determined.

Response 10

See Response 9.5.

Question 11

Regulatory Guide 1.61 allows 4% damping for an OBE and 7% damping for a SSE. Provide justification for using 10% damping for unreinforced walls in the arching action analysis.

Response 11

See Response 9.5.

Question 12

With reference to the multiple wythes, clarify whether the collar joint strength was used in the analysis. If so, justify the allowable stresses of the collar joint. Also, provide sample calculations illustrating the analysis of multiple-wythe walls.

Response 12

The Licensee stated that the composite action was not used in the analysis of multi-wythe walls and each wythe was assumed to act independently. Therefore, the allowable stresses in the collar joint are not applicable.

The Licensee provided sample calculations for the analysis of multiple-wythe walls as follows:

For Unit 1, the wall is 8 ft 8 in long, 16 ft 4 in high, and 2 ft 0 in thick (3 wythes at 8 in).

For Unit 2, the wall is 8 ft 8 in long, 16 ft 4 in high, and 2 ft 0 in thick (2 wythes at 12 in).

Both of these walls are at elevation 17 ft 4 in the reactor building.

For the wall considered as a single 8-in wythe with seismic acceleration of 0.28 g for OBE and 0.435 g for SSE, the calculated flexural stress and shear stresses were found to be 27 psi, and 1.3 psi, which are smaller than the allowable stresses of 75 psi and 47 psi for OBE. The calculated flexural and shear stresses for SSE were found to be 43 psi and 2 psi, which are smaller than the flexural and shear allowable stresses of 125 psi and 72 psi, respectively.

For the walls considered as a single 12-in wythe in Unit 2, with seismic accelerations of 0.127 g for OBE and 0.47 g for SSE, the calculated flexural and shear stresses were found to be 16 psi and 1.2 psi, which are smaller than the allowable stresses of 75 psi and 47 psi for OBE. The calculated flexural and shear stresses for SSE were found to be 28 psi and 2 psi, which are smaller the flexural and shear allowable streses of 125 psi and 72 psi, respectively.

The Licensee's response is adequate and in compliance with SGEB criteria.

Question 13

> Provide detailed drawings and current status of proposed repairs. Also, provide a sample calculation to illustrate that the modified walls will be qualified under the working stress design condition.

Response 13

With regard to the status of proposed repairs, the Licensee stated that some repairs have been implemented in 1983. The remaining repairs will be completed in 1984.

The Licensee provided a sample calculation for wall 4a at elevation 5 ft 0 in in the diesel generator building. The wall is reinforced filled wall, 8-in thick. Structural steel member W8 x 31 was attached to one side of the wall at 25 ft 6 in maximum spacing with two 3/4-in throughbolts at 16-in spacing. Also, restraint angles were installed on top of walls. These modifications make the wall behave as a plate.

A review of the sample calculation indicated that the calculated stresses are within the SGEB code allowable. Therefore, the Licensee's response is considered adequate and in compliance with the SGEB criteria.

Question 9.1

> With reference to the reinforcement in masonry walls, the ACI 531-79 Code [1] specifies that the minimum area of reinforcement in a wall in either direction, vertical or horizontal, shall be 0.0007 (0.07%) times the gross cross-sectional area of the wall and that the minimum total area of steel, vertical and horziontal, shall not be less than 0.002 (0.2%) times the gross cross-sectional area. In view of this, clarify whether the reinforced walls at this plant meet the above requirements. It should be noted that the horizontal reinforcement is installed to satisfy the minimum reinforcement requirement for a reinforced wall.

If joint reinforcement is used to resist tension, it should follow the working stress design method, which limits its allowable to 30 ksi. The Licensee is requested to clarify if this requirement has been satisfied. If this requirement is not satisfied, identify all affected walls along with the calculated stress value for each wall.

Indicate if there is any wall that has only joint reinforcement (horizontal reinforcement), no vertical reinforcement, and may have been qualified using the tensile resistance of the joint reinforcement. It should be noted that the NRC, at present, does not approve the use of joint reinforcement to qualify this type of wall. Indicate all walls belonging to this category.

Response 9.1

With regard to the minimum area of reinforcement, the Licensee confirmed that the reinforced walls at the Brunswick plant meet the requirements of ACI 531-79 with regard to the minimum area of reinforcement.

The Licensee also clarified that horizontal joint reinforcing was not used to resist tension in evaluating masonry walls; therefore, no walls were qualified using the tensile resistance of the joint reinforcing.

The Licensee's response is satisfactory and in compliance with the SGEB criteria.

Question 9.2

Regarding Response 8 of Reference 2, please provide laboratory test results to verify the assumed values of masonry and mortar strength used in the analysis.

Response 9.2

With regard to the test results of masonry blocks, the Licensee referred to tests performed by Pittsburgh Testing Laboratory for the two-core hollow load bearing block and the 100% solid block. The test results for the two-core hollow load-bearing block indicated an average strength of 1520 psi compared with the ASTM C90-70 compressive strength of 1000 psi.

The Licensee stated that no tests were performed on the mortar; however, the plant's Specification (9527-01-29-1) required that the mortar adhere to

Type of Stress	Factor
Axial or Flexural Compression[1]	2.5
Bearing	2.5
Reinforcement stress except shear	2.0 but not to exceed 0.9 fy
Shear reinforcement and/or bolts	1.5
Masonry tension parallel to bed joint	1.5
Shear carried by masonry	1.3
Masonry tension perpendicular to bed joint	
for reinforced masonry	0
for unreinforced masonry[2]	1.3

Notes

(1) When anchor bolts are used, design should prevent facial spalling of masonry unit.

(2) See 3(c).

4. Design and Analysis Considerations

(a) The analysis should follow established principles of engineering mechanics and take into account sound engineering practices.

(b) Assumptions and modeling techniques used shall give proper considerations to boundary conditions, cracking of sections, if any, and the dynamic behavior of masonry walls.

(c) Damping values to be used for dynamic analysis shall be those for reinforced concrete given in Regulatory Guide 1.61.

(d) In general, for operating plants, the seismic analysis and Category I structural requirements of FSAR shall apply. For other plants, corresponding SRP requirements shall apply. The seismic analysis shall account for the variations and uncertainties in mass, materials, and other pertinent parameters used.

(e) The analysis should consider both in-plane and out-of-plane loads.

(f) Interstory drift effects should be considered.

the following ASTM Standards: ASTM C91, ASTM C144, ASTM C270, ASTM C476, and ASTM C780.

The Licensee's response is considered adequate.

Question 9.3

> With respect to the increase factors for load combinations containing SSE or accident load case [2], please identify all walls that would not be qualified if the SGEB criteria [3] were to be used. The Licensee is advised to explain all conservative measures (if any) used in the analysis to justify a higher increase factor.

Response 9.3

The Licensee stated that all walls qualify when the SGEB criteria is used, except walls 8a and 8b in the reactor building, which are unreinforced 4-ft-thick multiple-wythe walls. Walls 8a and 8b would not be qualified if the SGEB criteria were to be used on a single 8-in wythe; however, they do qualify when evaluated as a single 4-ft section. It is noted that the strength of the collar joint was specified as 8 psi (shear and tension) for the OBE case and 12 psi for the SSE case. Based on tests results performed at the Trojan nuclear plant, the values are judged to be conservative.

The Licensee's response satisfies the SGEB criteria.

Question 9.4

> With regard to wall modifications, the Licensee indicated that some fixes have been designed to be implemented in 1983 and that the design for the remaining fixes will be completed in 1984 and detailed drawings are not available [2]. Please provide the following information:
>
> a. Total number of walls to be fixed
> b. General description of the types of fixing
> c. Schedule for completion of wall repairs
> d. Detailed drawings.

Response 9.4

The Licensee indicated that 10 walls which were qualified by the arching action theory and energy balance technique will be modified to meet SGEB code requirements. In addition, the Licensee is currently evaluating 17 additional walls for which a determination as to the necessity of a fix has not yet been made. The implementation of any necessary repairs for any additional walls resulting from evaluation of the 17 walls will be scheduled when and if such repairs are ascertained to be required. The types of modifications to be implemented include the addition of steel plasters, a steel grading restraining wall, and steel angles installed at the boundary.

Because the Licensee has made a commitment to modify walls so that they are in compliance with the SGEB criteria, this change should be acceptable.

Question 9.5

With regard to the nonlinear analysis technique (energy balance technique and arching action theory), please note the following information:

a. Arching Action: The NRC position on this issue states that the use of the arching action theory to qualify unreinforced masonry walls is not acceptable; these walls should be repaired so that they can be qualified based on the SGEB criteria [3]. (The NRC position is attached.)

b. Energy Balance Technique: The NRC is currently preparing a position statement regarding this technique, which will be forwarded to the Licensee in the near future.

Response 9.5

See Response 9.4.

3.2 EVALUATION OF LICENSEE'S APPROACH TO WALL MODIFICATIONS

As indicated in Section 3.1, the modifications include the addition of steel pilasters, a steel grading restraining wall, and steel angles installed at the boundary. The sample calculation of a modified wall has been reviewed and proved that it satisfies the SGEB criteria.

4. CONCLUSIONS

A detailed study was performed to provide a technical evaluation of the masonry walls at the Brunswick Steam Electric Plant Units 1 and 2. Review of the Licensee's criteria and additional information provided by the Licensee led to the conclusions given below.

The criteria used for reevaluation of the masonry walls, along with the additional information provided by the Licensee, indicate that the Licensee's criteria are in compliance with the SGEB criteria.

Section 3.2 indicated that 10 walls have been modified, and 17 walls are still being reevaluated. Any additional modifications which determined to be necessary will be implemented. The Licensee's approach to wall modification is judged to be satisfactory, and the modified walls were verified through sample calculations to be structurally adequate and in compliance with the SGEB criteria.

5. REFERENCES

1. IE Bulletin 80-11
   Masonry Wall Design
   NRC, 08-May-80

2. B. J. Furr
   Letter to J. P. O'Reilly, NRC. Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - Response to IE Bulletin 80-11 (Attached)
   Carolina Power & Light Co., July 7, 1980
   NO-80-1009

3. B. J. Furr
   Letter to J. P. O'Reilly, NRC. Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - Response to IE Bulletin 80-11 (180-Day Response) (Attached)
   Carolina Power & Light Co., November 5, 1980
   NO-80-1632

4. B. J. Furr
   Letter to J. P. O'Reilly, NRC. Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - Supplemental Response to IE Bulletin 80-11
   Carolina Power & Light Co., November 25, 1980
   NO-80-1746

5. B. J. Furr
   Letter to J. P. O'Reilly, NRC. Subject: Br[illegible] Steam Electric Plant, Unit Nos. 1 and 2 - Supplemental Respo[illegible] IE Bulletin 80-11
   Carolina Power & Light Co., December 9, 1980
   NO-80-1739

6. D. B. Vassallo, NRC
   Letter to S. R. Zimmerman, CP&L
   Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - IE Bulletin 80-11, Masonry Design - Request for Additional Information
   August 2, 1982

7. S. R. Zimmerman, CP&L
   Letter to D. B. Vassallo, NRC
   Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - IE Bulletin 80-11, Masonry Design - Response to Request for Additional Information
   July 29, 1983

8. D. B. Vassallo, NRC
   Letter to S. R. Zimmerman, CP&L
   Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - IE Bulletin 80-11, Masonry Design - Request for Additional Information
   February 21, 1984

9. A. B. Cutter, CP&L
Letter to D. B. Vassallo, NRC
Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2 - IE Bulletin 80-11, Masonry Design - Request for Additional Information
April 27, 1984

10. Uniform Building Code
International Conference of Building Officials, 1979

11. Building Code Requirements for Concrete Masonry Structures
Detroit: American Concrete Institute, 1979
ACI 531-79 and ACI 531-R-79

12. NCMA - Specification for the Design a[illegible] [illegible]struction of Load Bearing Concrete

APPENDIX A

SGEB CRITERIA FOR SAFETY-RELATED MASONRY WALL EVALUATION
(DEVELOPED BY THE STRUCTURAL AND GEOTECHNICAL ENGINEERING BRANCH
[SGEB] OF THE NRC)

CONTENTS

1. General Requirements

The materials, testing, analysis, design, construction, and inspection related to the design and construction of safety-related concrete masonry walls should conform to the applicable requirements contained in Uniform Building Code - 1979, unless specified otherwise, by the provisions in this criteria.

The use of other standards or codes, such as ACI-531, ATC-3, or NCMA, is also acceptable. However, when the provisions of these codes are less conservative than the corresponding provisions of the criteria, their use should be justified on a case-by-case basis.

In new construction, no unreinforced masonry walls will be permitted. For operating plants, existing unreinforced walls will be evaluated by the provisions of these criteria. Plants which are applying for an operating license and which have already built unreinforced masonry walls will be evaluated on a case-by-case basis.

2. Loads and Load Combinations

The loads and load combinations shall include consideration of normal loads, severe environmental loads, extreme environmental loads, and abnormal loads. Specifically, for operating plants, the load combinations provided in the plant's FSAR shall govern. For operating license applications, the following load combinations shall apply (for definition of load terms, see SRP Section 3.8.4II-3).

(a) Service Load Conditions

(1) D + L

(2) D + L + E

(3) D + L + W

If thermal stresses due to T_o and R_o are present, they should be included in the above combinations as follows:

(1a) $D + L + T_o + R_o$

(2a) $D + L + T_o + R_o + E$

(3a) $D + L + T_o + R_o + W$

Check load combination for controlling condition for maximum 'L' and for no 'L'.

(b) Extreme Environmental, Abnormal, Abnormal/Severe Environmental, and Abnormal/Extreme Environmental Conditions

(4) $D + L + T_o + R_o + E$

(5) $D + L + T_o + R_o + W_t$

(6) $D + L + T_a + R_a + 1.5\ P_a$

(7) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E$

(8) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0\ E'$

In combinations (6), (7), and (8) the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (5), (7), and (8) and the corresponding structural acceptance criteria should be satisfied first without the tornado missile load in (5) and without Y_r, Y_j, and Y_m in (7) and (8). When considereing these loads, local section strength capacities may be exceeded under these concentrated loads, provided there will be no loss of function of any safety-related system.

Both cases of L having its full value or being completely absent should be checked.

3. Allowable Stresses

Allowable stresses provided in ACI-531-79, as supplemented by the following modifications/exceptions, shall apply.

(a) When wind or seismic loads (OBE) are considered in the loading combinations, no increase in the allowable stresses is permitted.

(b) Use of allowable stresses corresponding to special inspection category shall be substantiated by demonstration of compliance with the inspection requirements of the SEB criteria.

(c) When tension perpendicular to bed joints is used in qualifying the unreinforced masonry walls, the allowable value will be justified by test program or other means pertinent to the plant and loading conditions. For reinforced masonry walls, all the tensile stresses will be resisted by reinforcement.

(d) For load conditions which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions, the allowable working stress may be multiplied by the factors shown in the following table:

Type of Stress	Factor
Axial or Flexural Compression[1]	2.5
Bearing	2.5
Reinforcement stress except shear	2.0 but not to exceed 0.9 fy
Shear reinforcement and/or bolts	1.5
Masonry tension parallel to bed joint	1.5
Shear carried by masonry	1.3
Masonry tension perpendicular to bed joint	
for reinforced masonry	0
for unreinforced masonry[2]	1.3

Notes

(1) When anchor bolts are used, design should prevent facial spalling of masonry unit.

(2) See 3(c).

4. Design and Analysis Considerations

(a) The analysis should follow established principles of engineering mechanics and take into account sound engineering practices.

(b) Assumptions and modeling techniques used shall give proper considerations to boundary conditions, cracking of sections, if any, and the dynamic behavior of masonry walls.

(c) Damping values to be used for dynamic analysis shall be those for reinforced concrete given in Regulatory Guide 1.61.

(d) In general, for operating plants, the seismic analysis and Category I structural requirements of FSAR shall apply. For other plants, corresponding SRP requirements shall apply. The seismic analysis shall account for the variations and uncertainties in mass, materials, and other pertinent parameters used.

(e) The analysis should consider both in-plane and out-of-plane loads.

(f) Interstory drift effects should be considered.

(g) In new construction, grout in concrete masonry walls, whenever used, shall be compacted by vibration.

(h) For masonry shear walls, the minimum reinforcement requirements of ACI-531 shall apply.

(i) Special constructions (e.g., multiwythe, composite) or other items not covered by the code shall be reviewed on a case-by-case basis for their acceptance.

(j) Licensees or applicants shall submit QA/QC information, if available, for staff's review.

In the event QA/QC information is not available, a field survey and a test program reviewed and approved by the staff shall be implemented to ascertain the conformance of masonry construction to design drawings and specifications (e.g., rebar and grouting).

(k) For masonry walls requiring protection from spalling and scabbing due to accident pipe reaction (Y_r), jet impingement (Y_j), and missile impact (Y_m), the requirements similar to those of SRP 3.5.3 shall apply. However, actual review will be conducted on a case-by-case basis.

5. References

(a) Uniform Building Code - 1979 Edition.

(b) Building Code Requirements for Concrete Masonry Structures ACI-531-79 and Commentary ACI-531R-79.

(c) Tentative Provisions for the Development of Seismic Regulations for Buildings - Applied Technology Council ATC 3-06.

(d) Specification for the Design and Construction of Load-Bearing Concrete Masonry - NCMA August, 1979.

(e) Trojan Nuclear Plant Concrete Masonry Design Criteria Safety Evaluation Report Supplement - November, 1980.

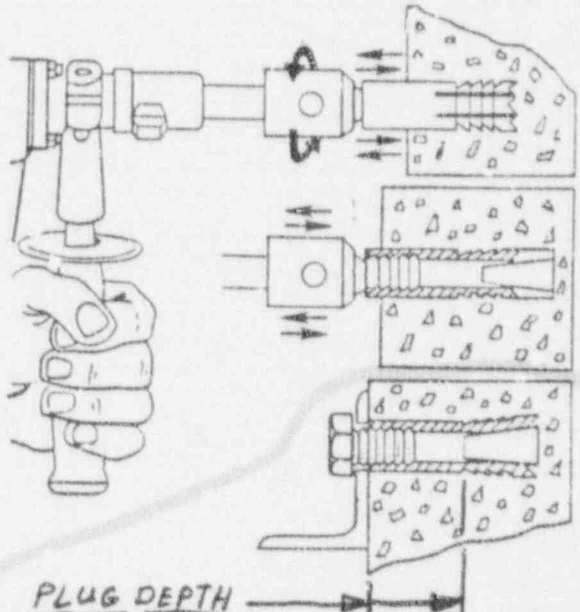
ATTACHMENT 6

QUESTION 10 RESPONSE
Sketch of Self Drilling Anchors

self-drilling anchors

- *Drills its own hole, eliminating costly carbide bits.*
- *Assures accurate hole size every time.*
- *Installs fast with both the 700 and the 747 Roto Stop hammers.*
- *Economical solution to heavy-duty anchoring requirements.*

Self-Drilling Anchors provide their own case-hardened steel drill for every hole. Installation with RED HEAD Roto Stop Hammers creates one of the fastest, simplest and most economical anchoring systems in the world . . . especially for overhead applications.



1. **DRILL HOLE**, remove anchor and clean out hole. Place red plug in anchor.
2. **EXPAND ANCHOR** by reinserting anchor in hole and driving until flush. Snap off cone.
3. **BOLT** object to complete installation.

Safe working loads for single installations under static loading should not exceed 25% of the ultimate load capacity. For information on other conditions, contact your nearest factory representative.

For complete installation information see instructions packed in every box of anchors.

Snap off type

For installation with electric or air impact hammers.

Cat. No.	Bolt Size	Depth In Concrete	Thread Depth	Outside Diameter	Pullout LBS.	Shear LBS.
					★ Ultimate Load Capacity in 3500 PSI stone aggregate concrete (reduce 30% for structural light-weight aggregate concrete)	
• S-14	1/4"	1 1/32"	3/8"	[illegible]/16"	3670	1335
• S-16	5/16"	1 5/16"	15/32"	15/32"	4060	2030
• S-38	3/8"	1 17/32"	9/16"	9/16"	5670	3370
• S-12	1/2"	2 1/32"	13/16"	11/16"	8500	6720
• S-58	5/8"	2 15/32"	15/16"	27/32"	11,700	11,900
• S-34	3/4"	3 1/4"	1 1/32"	1"	16,200	16,200
• S-78	7/8"	3 11/16"	1 13/32"	1 1/8"	17,850	18,450

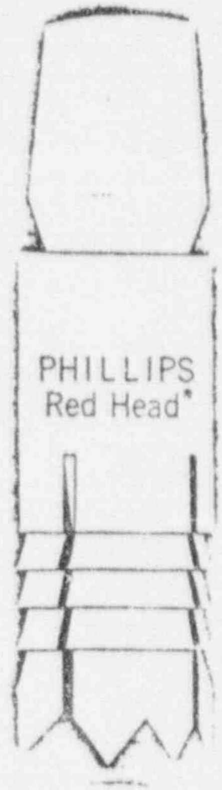
Flush type

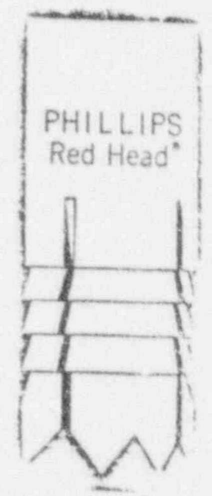
For hand installation with FH-300 series flush holders. (See P. 17)

Cat. No.	Bolt Size	Thread Depth	Depth In Concrete	Outside Diameter	Pullout LBS.	Shear LBS.
					★ Ultimate Load Capacity in 3500 PSI stone aggregate concrete (reduce 30% for structural light-weight aggregate concrete)	
• F-14	1/4"	11/32"	1 1/4"	7/16"	3670	1335
• F-16	5/16"	3/8"	1 7/32"	15/32"	4060	2030
• F-38	3/8"	15/32"	1 7/16"	9/16"	5670	3370
• F-12	1/2"	21/32"	1 15/16"	11/16"	8500	6720
• F-58	5/8"	7/8"	2 3/4"	27/32"	11,700	11,900
• F-34	3/4"	1 1/8"	3"	1"	16,200	16,200

★ Based on Independent Testing Laboratory tests. Report available on P. 15

Meets or exceeds U.S. Government G.S.A. Specification No. FF-S-325, Group III, Type 1 (Dated 9-10-57)





ATTACHMENT 7

QUESTION 10 RESPONSE
Tables 3 and 4 from BSEP/SP 79-22

TABLE 3

ACCEPTABLE PLUG DEPTH, SELF-DRILLING ANCHORS	
Anchor Size	Plug Depth*
3/8"	25/32"
1/2"	1 5/32"
5/8"	1 13/32"
3/4"	1 31/32"
7/8"	2 9/32"

*Plug Depth = (Anchor Length) - (Plug Length) (± 1/8")

TABLE 4

MINIMUM THREAD ENGAGEMENT, SELF-DRILLING ANCHORS	
Anchor Size	Minimum Thread Engagement
3/8"	1/4"
1/2"	3/8"
5/8"	3/8"
3/4"	1/2"
7/8"	5/8"

ATTACHMENT 8

?P&L Letter Dated July 26, 1982

FORM 22

CP&L

Carolina Power & Light Company

Brunswick Steam Electric Plant
P. O. Box 10429
Southport, NC 28461-0429

July 26, 1982

FILE: B09-13510C
SERIAL: BSEP/82-1616

Mr. James P. O'Reilly, Director
U. S. Nuclear Regulatory Commission
Region II, Suite 3100
101 Marietta Street N.W.
Atlanta, GA 303)

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-324
LICENSE NO. DPR-62
SUPPLEMENTAL RESPONSE TO IE BULLETINS 79-02,
79-07, AND 79-14

Dear Mr. O'Reilly:

In our letter (BSEP/81-0440) dated February 25, 1981, we committed to complete the Phase I and Phase II portion of the seismic reanalysis of the plant to satisfy the requirements of IE Bulletins 79-02, 79-07 and 79-14 by July 31, 1981, and March 31, 1982, respectively. This letter is to report the Phase I, or generic analysis, and Phase II, the individual analysis, have been completed in accordance with these dates.

The Phase I and Phase II programs did not include as-built evaluation of inaccessible isometrics as that work required a unit outage for access to complete. These isometrics on Unit No. 2 have been as-built and reanalyzed during the current outage. Two inaccessible isometrics in Unit No. 1 remain. These will be as-built and evaluated during this year's outage.

In the February 25, 1981, letter, we provided a list of potential problem areas and inconsistencies that were discovered during our review program, together with intended resolution and schedules. We will address the status of these areas in the same order as listed previously.

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A. Lines Originally Seismically Analyzed, But Not Included in IE Bulletin 79-07 Efforts

Upon the completion of the seismic line review, 38 isometrics remained to be analyzed. Twenty-one of these isometrics were addressed under the February 25, 1981 letter. The remaining 17 (isometrics) were analyzed under the Phase I program. There were no short-term fixes required based on this analysis. All long-term fixes associated with these isometrics have been issued and are in the process of being installed. We plan to complete the fixes associated with these isometrics on both units by the end of the next Unit No. 1 refueling outage. This outage is presently scheduled to start in September 1982. For Unit No. 2, approximately 35 inaccessible (during power operation) fixes may not be completed during the current outage, however, due to insufficient outage time. If necessary, these few remaining supports will be completed during the next available outage of sufficient duration, and no later than the end of the next Unit No. 2 refueling outage.

B. Vents, Drains, Instrument Connections

These connections were not covered by the original computer analysis so they did not fall under the scope of IE Bulletins 79-07 and 79-14. It was determined they should be evaluated to give reasonable assurance that they did not significantly affect the process piping. A generic analysis of these connections showed a negligible effect for large bore piping. The remaining small bore piping was handled by a sampling program. Approximately half of these connections were analyzed with no cases of overstress on the process pipe. It was thus concluded that no significant impact on the analysis of the parent lines existed.

C. Unanalyzed Loads Due to Valve Eccentricity

In our letter of February 25, 1982, approximately 25 motor-operated valves were cited as not having been analyzed for eccentric loadings. All but four have been evaluated based on UE&C estimated valve and operator weights and centers of gravity. Efforts to verify the assumed values with vendors have indicated that the estimated values are as accurate (± 10 percent) as any values which could be supplied by the manufacturers. Since the analyses will not be significantly affected by a 10 percent variance in weights and the vendor's estimates will not improve the accuracy of the analysis, the vendor verification program was terminated. The remaining four valves were not originally computer analyzed and, therefore, are not encompassed by IE Bulletin 79-07. However, a generic analysis was performed on these lines which verified that the piping stresses are within ANSI B31.1 limits.

D. Verification of Acceptable Containment Penetration Nozzle Loads

All penetration nozzle loads have been verified as acceptable per the requirements of IE Bulletins 79-07 and 79-14.

E. Vendor Supplied and Vendor - A/E Interface Piping

After a review of vendor documentation, we have concluded that these lines were not computer analyzed. IE Bulletins 79-07 and 79-14 thus do not apply.

F. Small Nozzle Loads on Safety-Related Components

The only lines encompassed in this category are the vent and drain lines off the HPCI, RCIC and core spray pumps, which were analyzed.

The IE Bulletin 79-14 condition has been reviewed and no short-term fixes were required. Long-term fixes are scheduled on the same basis discussed for Item A.

G. Seismic Requirements Inconsistencies

Only two lines under this category were found to require analysis; one is the surge line in the Diesel Fresh Water Cooling System, the other is a drain line in the Standby Liquid Control System. These lines are small and were not originally computer analyzed. Therefore, the 79-07 Bulletin is not applicable. However, in order to completely close out all outstanding items, these lines were as-built and evaluated as part of Item A.

H. CRD System Baseplate Flexure Analysis

In regard to our bulletin requirements for the CRD System supports, we stated in our February 25, 1981 letter, "Completion of baseplate flexure analysis on CRD piping not essential to safe shutdown is scheduled for completion as part of the Phase II Program." CP&L has determined that nonessential portions of the CRD System are not safety related or seismically qualified; therefore, this analysis was not required.

I. Anchor Bolt Testing

As stated in our February 25, 1981 letter, the scheduled anchor bolt testing per IEB-79-02 of all the additional supports identified for testing is now complete for Unit No. 2.

The testing of self-drilling anchors included application of a torque representing a pull out load equal to or greater than the allowable design load for the anchor. Concrete embedment and thread engagement were also measured whenever it was possible to remove the bolt/stud from the anchor. It must be noted here that this phase of test program covered many floor mounted supports employing self-drilling anchors with all thread rod studs and grout. Because of moisture conditions during plant operation several studs were found to be frozen in anchors and could not be removed for measurement of depth. All of these anchors, however, either passed the preload test or were replaced.

All supports that did not meet the test acceptance criteria were conservatively evaluated for the load values generated by IE 79-07 reanalysis effort. Repairs were made to deficient supports and the frozen studs broken during test. Rusted self-drilling anchors in service water intake structure were replaced by stainless steel wedge anchors.

A total of 163 baseplates containing 433 anchors were included under this phase of the program. All baseplates and anchor bolts were tested to the extent as was reasonably possible. The primary test verifying adequate preload was performed on 88 percent of all anchor bolts and on at least one anchor bolt on all of the baseplates except two. One of these baseplates had a seismic load of one pound and the other a safety factor of 20. These loads are sufficiently low that the satisfactory inspections of their condition when testing was attempted was adequate to assure their reliability. The preload test demonstrated the actual ability of each anchor bolt to withstand its design load. The failure rate for this test was 2.4 percent. The inability to back off the leveling nut was the predominent reason for not testing all of the anchors. A stuck leveling nut does not indicate any structural deficiency with an anchor, it just prevented any meaningful testing. The low failure rate and the extensiveness of the test program for both baseplates and anchors provides a high confidence in the ability of the existing anchor bolts to accommodate the required loads.

Tests for proper installation were performed on 59 percent of the anchor bolts. A failure rate of 1.6 percent was obtained for improper engagement and 1.6 percent for inadequate embedment. Problems with anchor bolts or studs which could not be removed (27 percent of all anchors), in addition to the previously mentioned frozen leveling nut problems (9 percent of all anchors), were the overriding reasons preventing full testing. All of the anchors with unremovable bolts or studs were successfully tested for preload, however, demonstrating the load capability of the anchors. This satisfactory demonstration and the low failure rates indicate there is no concern for inadequate embedment and engagement. In addition, 31 percent of these anchor bolts which were not fully tested were subsequently replaced for other reasons further reducing the number of not fully verified anchors.

An overall failure rate of 5.6 percent was obtained from the testing program on Unit No. 2. The extensiveness of the preload testing, the low failure rates from the tests, and the number of anchors which were replaced, leave a small opportunity for inadequate baseplates.

Anchor Bolt Testing Results Summary on Unit No. 2

Total number of baseplates	163
Number of baseplates tested	161
Total number of anchors	433
Number of anchors tested for preload	380
Number of anchors failed preload	9
Preload test failure rate	2.4%
Number of anchors not tested for preload	53
Number not tested due to frozen leveling nut	39
Number tested for other reasons	14
Number of anchors tested for embedment	254
Number of anchors with inadequate embedment	4
Embedment test failure rate	1.6%
Number of anchors not tested for embedment	179
Number not tested due to frozen leveling nut	39
Number not tested due to frozen stud	117
Number not tested for other reasons	23
Number of anchors tested for engagement	256
Number of anchors with inadequate engagement	4
Engagement test failure rate	1.6%
Number of anchors not tested for engagement	177
Number not tested due to frozen leveling nut	39
Number not tested due to frozen stud	117
Number not tested for other reasons	21
Total failure rate	5.6%

As required by IE Bulletin 79-02, CP&L has completed the test program for Unit No. 2. Unit No. 1 testing is essentially complete. The results are being tabulated and checked to assure no identified supports remain untested. During the upcoming Unit No. 1 outage scheduled to start in September 1982, any supports not yet tested in the primary containment will be tested and results transmitted to your office.

In our February 25, 1981 letter, we committed to performing a weld verification sampling program for seismic pipe supports as part of the Phase I program. We have completed this sampling program with greater than a 95 percent confidence level that the original QC inspection program was adequate. This 95 percent confidence level is consistent with that required for the IEB 79-02 sampling programs and thus we believe our pipe support welds are acceptable.

In conclusion, upon the completion of the long-term fixes discussed previously, the Pipe Stress Analysis Summary Tables will be updated to indicate completion of the field modifications. This update will signify our completion of work and compliance with the above bulletins. We anticipate this milestone will occur in mid-1983, at which time you will be notified in writing.

Very truly yours,
ORIGINAL SIGNED BY:
C. R. DIETZ
C. R. Dietz, General Manager
Brunswick Steam Electric Plant

JSB/dg

cc: Mr. R. C. DeYoung

JCB

bcc: Mr. D. L. Bensinger/File: BC/A-4
Mr. F. R. Coburn
Mr. A. B. Cutter
Dr. T. S. Elleman
Mr. B. J. Furr
Dr. J. D. E. Jeffries
Mr. I. A. Johnson
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Nuclear Operations File 13510(E)
Mr. L. H. Martin
Mr. J. A. McQueen, Jr./File: B-X-544
Mr. D. O. Myers
Mr. C. H. Moseley
Mr. R. B. Starkey, Jr.
Mr. L. V. Wagoner
Mr. J. L. Willis
Ms. M. S. Wingo