Engineering Calculations

Approved by

SPPC, 9/24/07

1.0 Purpose

This procedure provides the methods for preparing, verifying, approving, accepting, controlling, revising, and voiding engineering calculations.

2.0 Scope

This procedure applies to the generation of engineering calculations or acceptance of engineering calculations that support plant modifications to Nuclear and Safety Support Facilities, as defined in WSRC-RP-94-1268, FA00, and those engineering calculations that support Documented Safety Analysis (DSA), technical baseline documents and engineering decisions, including research and development. As used in this procedure, the term engineering calculations includes analyses and evaluations.

Refer to procedure 1.54, Manual E7 for calculations to support Commercial Industrial or Infrastructure modifications or for GS and PS calculations that support Nuclear and Safety Support facilities when the Chief Engineer has authorized the use of the Commercial Design Process (reference procedure 1.02, Manual E7).

Pressure Relief Device calculations are prepared in accordance with this procedure and Engineering Standard 15061, Manual WSRC-TM-95-1.

This procedure does not apply to calculations that support day-to-day operations and maintenance activities:

- when the calculation is generated as part of step-by-step instructions of an approved procedure
- when providing technical support and the calculation does not meet the criteria of a preliminary or confirmed calculation (e.g., to determine the weight of a component prior to transporting, to determine the amount of chemical needed to neutralize a spill, etc.)

The provisions of this procedure apply to members of the Performing Entity for management and operations at Savannah River Site (SRS), and to subcontractors performing work for any member of the Performing Entity when required by subcontract or applicable law.

3.0 Terms and Definitions

Refer to the WSRC E7 Glossary.

4.0 Responsibilities

4.1 Originator

- Determining the type of engineering calculation required
- Preparing the engineering calculation
- Ensuring application of quality assurance requirements when preparing calculations (see Attachment 8.6, procedure 2.25, Manual E7)
- Obtaining calculation identification numbers
- Resolving Verifier and Checker comments
- Signing and dating the calculation to indicate the Originator and date of completion
- Ensuring the calculations are generated, verified, accepted, approved, and filed in accordance with this procedure
- Ensuring input data and assumptions are applicable for the intended use and are adequately referenced and/or justified to provide traceability during technical review
- Ensuring conclusions clearly state whether calculation results meet/do not meet objectives
- Ensuring calculations, within the scope of procedure 1.40, Manual E7, are reviewed and accepted by a Registered Professional Engineer (RPE) in the state of South Carolina

4.2 Verifier or Checker

- Providing an independent review of the calculation contents in accordance with Manual E7, Procedure 2.60
- Signing and dating the calculation to attest that the document is technically accurate and valid for use in the intended specified application(s), is legible and complete, incorporates outstanding comments, and complies with this procedure

4.3 Responsible Manager

- Ensuring the calculation is prepared and reviewed by qualified personnel
- Ensuring this procedure is followed for all engineering calculations
- Signing and dating the type 1 calculations to indicate the above two bullets have been accomplished
- Ensuring that proper disposition of preliminary calculation open items are made prior to closure of the modification/task or issuance of a confirmed calculation

4.4 Design Authority

- Assessing the impact of calculations to the facility DSA and technical baseline documents, including discovered errors
- Initiating appropriate corrective action based upon the results of the assessment of errors
- Providing documented inputs to calculations as requested by the document originator
- Ensuring the input data, assumptions, and results, documented in the calculation, are consistent with the facility design and operation
- Ensuring recommendations are formally tracked (e.g., STAR, facility schedule, etc.)

4.5 Safety Basis Regulatory Authority

- Assisting the Design Authority in assessing the impact of calculations to the facility DSA and technical baseline documents, including discovered errors

5.0 Procedure

Engineering calculations are written records documenting an analytical or computational thought process used to support an engineering justification or to support the design or operation of a structure, system, or component (SSC). Engineering calculations are completed, checked, reviewed, and approved prior to using their results.

Excluding signatures, engineering calculations are produced in pencil or ink, including colors, and will be legible, reproducible, and complete (e.g., all relevant documents are either attached or referenced). Colors will not be used as the only means of conveying essential information.

5.1 Determination of Calculation Type

The Originator makes an initial determination of the required type of the calculation (type 1 or type 2):

Type 1 calculations are engineering calculations that are intended to be issued and controlled as independent documents (i.e., stand-alone documents). A type 1 calculation is statused as one of the following:

preliminary calculation – calculations made for estimates of performance, costs or scale which are not performed with the intent of being directly incorporated in final design documents. They may include calculations to be incorporated in cost studies, or bid specifications, or as estimates in reports to regulatory agencies.

Preliminary calculations may form the basis for preliminary safety analysis, or preliminary design work, or for issue of drawings or specifications for construction or procurement when only preliminary data is available (e.g., data supplied on similar equipment manufactured for other modifications, designer's or supplier's knowledge of similar systems, etc). Such calculations will be revised to assume the status of confirmed calculations when confirmed data is available. Design and analysis work performed based on preliminary calculations will be reviewed and revised as necessary if the results of confirmed calculations differ from the preliminary results. (Note: See 11Q, 1.01 if a Preliminary DSA is involved.)

confirmed calculation – calculations that form the basis for preliminary safety analysis, drawings, specifications, or other design or safety basis documents that are used to construct or operate the facility, provide the design basis or DSA for an operating facility, or for modifications to an operating facility. These calculations may be revised due to changes in design criteria, methods or other reasons.

Type 2 calculations are intended to be approved as part of, other documentation (i.e., not intended to be stand-alone). Type 2 calculations are used to support the engineering justification for conclusions contained in engineering documents (e.g., Design Change

Forms, Design Change Packages, Non-Conformance Reports, Drawings, Specifications, safety basis documents, etc.).
Type 2 calculations may also be used to document (generally in controlled Lab Books) computations used in Research and Development that have not been identified as required to support a configuration controlled structure, system or component or its technical baseline.

5.2 Type 1 Calculations

5.2.1 Initiation

5.2.1.1 Originator prepares a calculation and Calculation Cover Sheet (OSR 45-24).

Each sheet of the type 1 calculation, including attachments and appendices, includes the following. OSR 19-260, Calculation Continuation Sheet, is available for use as needed.

- Sequential sheet number
- Calculation number
- Revision identifier

Calculation numbers are assigned in accordance with procedure 1.20, Manual E7.

5.2.1.2 The body of the calculation (starting with sheet 2) contains the following sections. (The items that are required are specified as "required" on an item by item basis below.)

Table of Contents – (Required if the calculation contains attachments or appendices.) Generally needed for larger calculations.

Summary Sheet or Summary Calculation (Roadmap) – When a single calculation is split into multiple subordinate calculations to support complex tasks (e.g., a facility structural analysis or Master Calculation), include a summary sheet in each subordinate calculation that describes the relationship between the subordinate calculations. This information may also be included in a separate summary calculation that is referenced on the coversheet of each subordinate calculation.

Open Items - (Required for preliminary calculations.) Identifies items that require resolution prior to the calculation being issued as confirmed. Each Open Item entry should clearly identify the subject and the reason(s) for being designated an Open Item (e.g., preliminary, unverifiable, etc.). Open Items are prohibited in confirmed calculations, although a subsection with this title may be present to make it clear to the user that there are no current open items.

References - A listing of references will be included as applicable. Examples of references include drawings, reports, manuals, publications, codes and standards. Each reference entry will contain the document name and if applicable, the document number. The revision number or publication date will be provided, if available. Identify the reference where it is used in the body of the calculation. Refer to Manual 11Q, Procedure 1.01, Attachment 7 for additional information pertaining to references supporting Safety Basis documents. A reference section is not necessary for calculations performed for submittal to outside regulatory authorities (e.g., permit calculations).

Inputs and Assumptions – (Required) Number and individually list all inputs and assumptions in this section with reference to the source and/or justification. Inputs and assumptions should be clearly identifiable at the point of use within the calculation. The intent is to identify attributes that need to be properly procured, tested, installed, configuration managed, protected, etc. for the facility operation to be consistent with the calculation basis.

Analytical Methods and Computations - (Required) A clear, step-by-step description of method of solution, numerical computations (including identification of units used), and identification of the source or derivation of all equations that are not common usage (including computer codes used). For spreadsheet computations, describe, in the body of the calculation, the equations used or reference a printout of the equations used and attach the printout to the calculation. The explanation of the calculation method and the computations themselves should be succinct yet detailed enough to permit a qualified Verifier/Checker to perform the technical review with minimal interpretation or clarification of the facts presented. Include assumptions, as applicable, pertaining to the limitations of the calculation methodology.

Results - (Required) A description of the results obtained.

Conclusion - (Required) Clearly state whether the results meet/do not meet the objective for which the calculation was performed (e.g., This calculation concludes the maximum structural capacity is for a wind velocity of 117 mph. This DOES NOT meet the required design basis wind velocity of 178 mph.) Include recommendations, as applicable, in the Conclusion section of the calculation and ensure they are formally tracked (e.g., STAR, facility schedule, etc.). For example, a recommendation may be to perform additional analysis to more clearly validate the objective.

Attachments and appendices - include additional information, as needed, such as copies of references, memos, or pages of manuals, computer code output sheets, computation spreadsheet, worksheets showing/explaining equations used, input transmittals, etc.

Sufficient input information will be included to allow all of the analyses to be repeated. If microfiche or other forms of documentation (other than paper copy) are used, they will be acceptable to records management, uniquely identified with the calculation number, indicate unambiguously the extent of the information in the documentation, and be compatible for the storage period required. The paper copy will describe all other forms used and the method to retrieve the information if stored separately.

5.2.1.3 Originator determines the calculation status (preliminary or confirmed).

For preliminary calculations, the revision identifier is an alpha character, with the initial issue being "Revision A". For confirmed calculations, the revision identifier is a numeric character, with the initial issue being "Revision 0".

5.2.1.4 Originator signs and dates the cover sheet of the calculation signifying that the calculation is accurate and complete consistent with the identified status of the calculation.

5.2.2 Review and Approval

Originator forwards the calculation to the Verifier or Checker. The Verifier or Checker must be sufficiently independent of the calculation production (e.g., did not participate in the detailed development) in accordance with procedure 2.60, Manual E7.

5.2.2.1 Verification and Checking

Verification or checking is performed in accordance with procedure 2.60, Manual E7. In addition, the Verifier or Checker reviews the calculation:

- for technical accuracy, legibility, completeness, and procedural compliance, including logic of the calculation document, adequate explanation of assumptions, adequate referencing of inputs, computations, and clarity of presentation of conclusions (e.g., clearly states if results meet/do not meet objectives).
- to ensure that all inputs/assumptions and recommendations are brought forward and included in the appropriate sections of the calculation as described in Section 5.2.1.2.
- to confirm that all directly used engineering calculation references are themselves confirmed.

The Verifier or Checker refers to Section 5.4 of this procedure if software is used.

The Verifier or Checker enters the Verification/Checking method, signs, and dates the cover sheet (OSR 45-24) to indicate that all findings and comments have been resolved with the Originator and that the calculation is technically correct, valid for use in the intended specified applications, and complies with this procedure. The Originator gives the calculation to the Responsible Manager.

5.2.2.2 Design Authority Review and Approval

Design Authority signature is required to be documented on the Calculation Cover Sheet for either case listed below. (Note: Originator consults Facility Safety Bases Regulatory Authority or Design Authority to determine DSA/technical baseline impact if needed.)

(1) when the calculation is used to support a DSA or technical baseline document, that is not part of a Plant Modification subjected to a Technical Review in accordance with procedure 2.60, Manual E7. Design Authority evaluates the impact of the calculation upon the facility documents and obtains assistance from the Safety Basis Regulatory Authority (SBRA) as needed. The evaluation includes an Unreviewed Safety Questions (USQ) Screening if required per procedure 1.05, Manual 11Q. Design Authority signature on the Calculation Cover Sheet indicates satisfactory completion of the evaluation and review, approval, and acceptance of the calculation.

(2) when the calculation has been prepared by a Technical Agency (reference Technical Agency Contact List) and is not approved by the Design Authority as part of another document or procedure (e.g., Technical Report, Studies, etc.). Design Authority signature indicates review, approval, and acceptability of the calculation inputs, assumptions, and conclusions for the targeted facility. The evaluation includes a USQ screening if required per procedure 1.05, Manual 11Q.

Design Authority signature is not required to be documented on the Calculation Cover Sheet if the calculation supports a plant modification. In this case, Design Authority review, approval, and acceptance of the calculation is documented as part of the Technical Review in accordance with procedure 2.60, Manual E7.

5.2.2.3 Responsible Manager Approval

The Responsible Manager signs and dates the cover sheet indicating that the Originator and the Verifier or Checker are qualified to perform the work and that the correct procedures have been followed. The Responsible Manager returns the calculation to the Originator.

5.2.3 Transmittal to Document Control

The Originator forwards the calculation to Document Control in accordance with procedure 1.20, Manual E7. As a minimum, the following information is transmitted:

- Project or task identification
- Calculation number
- Revision status
- Calculation status (preliminary or confirmed)
- Calculation title
- Originator
- Keywords
- Computer software and version number
- PDF of the complete calculation

5.2.4 Revising Issued Calculations

When revising calculations, the Originator ensures:

- they are starting with the latest, approved revision
- the inputs and assumptions are still valid
- the documents supporting the calculation inputs and assumptions are still valid
- any other documents impacted by the revision are identified, evaluated, and revised accordingly

5.2.4.1 Revising the Total Calculation

- Revise the cover sheet and all pages to indicate the next revision number and date
- In the Revision Description block on the cover sheet, provide a concise description of the revision to ensure that the significance of the revision is understood
- Place a change bar in the right margin of each line in which a content change occurs
- Place a change bar in the right margin of each line containing new content
- Renumber pages to reflect the new page count
- Do not place change bars by existing content that is shifted due to deletion, addition or replacement of other content

5.2.4.2 Revising Individual Pages

Revisions may be accomplished by revising calculation pages as follows:

- The cover sheet is revised to reflect the correct number of sheets and next revision number. The sheets revised, added, deleted or voided are identified in the Summary of Revision block.

Note: It is acceptable for the Cover Sheet block to refer to a sheet or sheets in the document that specify this detail.

- If additional information is required within the body of a calculation, additional sheets may be added. The added sheet(s) are numbered and identified with the new revision number. These sheets will be identified with alpha suffixes (e.g., 4A, 4B, etc. Starting with A going to Z, AA to ZZ, AAA to ZZZ . . .)
- When a sheet identified with an alpha suffix is added, a note will be added to the previous sheet to indicate that new sheets follow and the total extent of the number of sheets added is clearly indicated.
- Revisions within a calculation sheet are identified by a change bar in the right hand margin adjacent to the revised material. The revision number or letter of the sheet is changed to the new revision identifier of the document.
- Correction tape, whiteout, or other materials are not to be used to make changes. Changes are made by scribing a single line through the information, adding new information, then initialing and dating next to the change. For multiple line changes, all lines are scribed and the Originator may either date each line or draw a box or enclosure around all affected lines initialing along the box or enclosure.
- Calculation sheets may be voided. If a revised calculation sheet is to be substituted for an existing sheet, the revised sheet is identified with the next revision number or letter and a bar along the entire right margin. The original sheet is left in place with the word VOID marked in large letters on the sheet covering the majority of the text. The date is placed on the voided sheet by writing, "voided (date)" on the sheet.

5.2.4.3 Revisions due to Discovered Errors

If revisions are being made in response to errors discovered in the issued revision, and the issued revision is not voided in its entirety, then all sheets of the issued revision must be corrected by the Originator and reviewed by the Verifier or Checker to eliminate any incorrect information resulting from the discovered error.

Errors discovered in issued calculations are evaluated for impact and resolved in accordance with this procedure and other applicable procedures (e.g., Manual 1Q, QAP 15-1; Manual 1B, MRP 4.23; Manual 11Q, Procedure 1.05).

5.2.4.4 Review and Approval

Review and approval are performed in accordance with step 5.2.2 of this procedure. The Verifier or Checker signs and dates each revised or added sheet and the cover sheet or only the cover sheet if the total calculation is revised. The Responsible Manager signs and dates the cover sheet. The Originator forwards the revision to Document Control in accordance with step 5.2.3.

5.2.4.5 Voiding Calculations

Entire calculations are voided by entering "ENTIRE CALCULATION VOIDED" across the majority of the text on the Calculation Cover Sheet. The Conclusion Section is revised to indicate why the calculation was voided and the revision level of the calculation is increased by one. The Originator, Verifier or Checker, and Responsible Manager sign and date the cover sheet. The Originator forwards the revision to Document Control in accordance with step 5.2.3.

5.3 Type 2 Calculations

Type 2 calculations will meet the following requirements in a manner agreed to by the Originator and Reviewer:

- The calculation and documentation will be maintained for its useful life
- The documentation will be adequate to allow a qualified, independent person to repeat the calculation and come to the same conclusion without recourse to the Originator.

5.3.1 Initiation

5.3.1.1 The Originator prepares the calculation. As a minimum, the body of the calculation includes the purpose and summary of conclusions. It may also include the applicable items identified in step 5.2.1.2 of this procedure. Type 2 calculations do not require the use of a Calculation Cover Sheet. OSR 19-189, Calculation Sheet, and OSR 19-260, Calculation Continuation Sheet, are available for use as needed.

5.3.1.2 The Originator signs and dates the calculation signifying that the calculation is accurate and complete.

5.3.2 Review, Approval and Issuance

5.3.2.1 The calculation will be verified or checked in accordance with procedure 2.60, Manual E7. The Verifier or Checker reviews the calculation for technical accuracy and procedural compliance, including logic of the calculation document, adequate explanation of assumptions, adequate referencing of inputs, computations, and clarity of presentation of results, conclusions, and recommendations. Ensure conclusions clearly state if results meet/do not meet objectives and include recommendations if applicable.

5.3.2.2 The Reviewer signs and dates the type 2 calculation in a prominent position in at least one location by printing "Checked by:" or "Verified by:" if appropriate, followed by printed name, signature, and date. This indicates that the calculation has been reviewed and all findings and comments have been resolved with the Originator.

5.3.2.3 Type 2 calculations are approved and revised in accordance with the governing procedure of the document of which they are a part. (Type 2 calculations may be numbered the same as the document in which they are included.) Type 2 calculations may be converted to type 1 and issued as independent documents by following the steps of this procedure for type 1 calculations.

5.3.2.4 Recommendations included in the calculation are formally tracked (e.g., STAR, facility schedule, etc.).

5.4 Use of Engineering Calculation Software

Engineering calculation software is not subject to the requirements of sections 5.4.1 and 5.4.2 if all of the following provisions are met. However, all engineering calculation software is subject to the error control requirements in section 5.4.3.

- The calculation Verifier/Checker independently assesses the equations or algorithms for correctness and applicability in accordance with procedure 2.60, Manual E7.
- The calculation Verifier/Checker verifies input and output values for each use by one of the design verification processes (e.g., alternate calculations) described in Manual E7. Where a calculation has numerous input and output values, the Verifier/Checker may select a representative sample of the total input and output values for review. In these cases, the Verifier/Checker must justify the values selected in the review documentation.

5.4.1 Software Management and Quality Assurance

Software used in engineering calculations will comply with all of the following:

- 1Q, QAP 20-1 Software Quality Assurance
- E7, Section 5.0, Software Engineering and Control
- Applicable provisions in this section (5.4)

5.4.2 Functional Classification of Software

Prior to using software in an engineering calculation, ensure that the software has been independently assessed for applicability and correctness for the intended use and the functional classification assigned to the software, in accordance with Manual 1Q QAP 20-1, meets or exceeds the functional classification of the subject engineering calculation.

5.4.3 Error Control

Any user suspecting that software or programmable device may contain an error is to immediately cease use of the item and notify the software owner or designee. The user, who identified the possible error, and the owner jointly determine if an error exists. The owner investigates the error and determines the impact of the error on the software functionality. The owner notifies applicable Design Authority personnel and other impacted users. Design Authority, with assistance from the SBRA as needed, assesses impacts of errors on calculations used to support DSAs and technical baseline documents. The owner, Design Authority, and impacted users determine the reporting requirements and, as appropriate, initiate non-conformance report(s), program deficiency report(s), request for corrective action report(s), or stop work order(s) in accordance with Manual 1Q.

During error resolution, users are not to perform engineering calculations with the erroneous software unless a technical justification that ensures technical adequacy of such calculations is provided. The technical justification must be incorporated into the subject engineering calculation documentation.

5.5 Calculations by Others

Type 1 calculations, prepared by contractors or suppliers, that are not prepared in accordance with this procedure, must be accepted prior to using their results. Calculations prepared by contractors or suppliers are prepared according to the quality assurance requirements identified in the procurement specification or subcontract. Acceptance is in addition to the subcontractor's quality assurance requirements.

Calculations previously prepared for other projects that may be applicable to the design being developed may be used instead of developing new calculations. Evaluation and acceptance are performed in accordance with this section.

5.5.1 The Responsible Manager assigns an Originator to prepare a cover sheet and review the calculation.

5.5.2 The Originator prepares an engineering calculation including the contractor calculation documentation in accordance with this procedure. The Originator states that the purpose of the engineering calculation is to include the contractor's calculation and states how it is to be used. The Originator states the review needed and performed to use the contractor's calculation.

5.5.3 The Originator reviews the calculation to assure applicability, conformance with procedural requirements and completeness, and documents the results. If there are any discrepancies noted, the calculation will not be used until the calculation is revised.

5.6 Registered Professional Engineer

When required by state or federal law or by the Department of Energy, calculations, within the scope of procedure 1.40, Manual E7, will be sealed, signed, and dated by a Registered Professional Engineer (RPE) in the state of South Carolina.

5.7 Release to Outside Agencies

Calculations that affect the technical baseline of a facility and are to be released to an outside agency other than an Engineering Subcontractor will be reviewed by the Design Authority prior to release. The Releasing Organization forwards the calculation to the Design Authority who reviews the calculation for facility applicability. The Design Authority will indicate their concurrence by signing (or initialing) and dating the calculation in block 18. The calculation is returned to the Releasing Organization. This review is in addition to other reviews required to release information to the public (outside agency). The Releasing Organization’s Responsible Manager will concur prior to release of calculations.

6.0 Records

Type 1 calculations are QA records and are maintained in accordance with QAP 17-1, Manual 1Q. Type 2 calculations are maintained in accordance with the procedure that governs the document in which they reside. Records must contain adequate documentation to reproduce the subject engineering calculations and demonstrate that all requirements are met.

7.0 References

7.1 Conduct of Engineering and Technical Support Manual E7
- Procedure 1.02, Engineering Overview and Graded Approach
- Procedure 1.20, Engineering Document Numbering System
- Procedure 1.40, Engineering Certification of State and Federal Documents
- Procedure 1.54, Commercial Engineering Calculations
- Procedure 2.25, Functional Classifications
- Procedure 2.60, Technical Reviews

7.2 WSRC Quality Assurance Manual 1Q
- QAP 15-1, Control of Nonconforming Items
- QAP 17-1, Quality Records Management
- QAP 20-1, Software Quality Assurance

7.3 WSRC Management Requirements and Procedure Manual 1B
- Procedure MRP 4.23, Site Tracking, Analysis, and Reporting (STAR)

7.4 WSRC Facility Safety Document Manual 11Q
- Procedure 1.01, Generation, Review and Approval of Safety Documents
- Procedure 1.05, Unreviewed Safety Questions

7.5 WSRC-RP-94-1268, WSRC Nuclear and Radiological Facility List Standard/Requirements Identification Document, FA-00, Facilities Lists and Attachments

7.6 WSRC-TM-95-1, SRS Engineering Standards Manual
- 15061, Pressure Equipment Protection Requirements

7.7 Calculation Design Tools (Optional)

Design Checklists, Design Integration Desktop Instruction (DIDI-005)

Calculation Documentation When Using Mathcad™ or Excel™ Computer Programs, Design Integration Desktop Instruction (DIDI-023)

Best Practices for Generating Engineering Calculations (Reference the Conduct of Engineering web page.)

Forms

OSR 45-24, Calculation Cover Sheet
OSR 19-189, Calculation Sheet
OSR 19-260, Calculation Continuation Sheet

8.0 Attachments

None