Oak Ridge National Laboratory

Engineering

Standard Operating Procedure

NUMBER: SOP-ENG-D.03

REVISON: 0

DATE: APRIL 16, 1999

DESIGN ANALYSIS AND CALCULATIONS

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Date Printed:_________________________ Verifier:__________________________

I. PURPOSE

To define the process for preparing design analyses and calculations for Oak Ridge National Laboratory (ORNL) by it's Engineering Division, subcontractors, and architect-engineers to assure safe, reliable, and cost-effective designs in support of drawings, specifications, and other engineering documents.

II. DEFINITION

Design Analyses and Calculations: A documented process for examination of reference requirements; identification of bases, concepts, and alternatives; and selection and use of mathematical computer program or other analytical processes to solve and devise parameters/solutions for designs.

III. REQUIREMENTS

A. General

1. Analyses and calculations shall be sufficiently detailed as to purpose, methods,

assumptions, design input, references, and units so that a person technically qualified in this subject can review and understand the documentation and verify the adequacy of the results without recourse to the originator.

2. Analyses and calculations should include justification and explanations of factors used in establishing the size, capacity, and type of equipment, process, and structure in the design. Typical discipline specific calculations generated are listed in Appendix A.

3. Alternate design verification analyses shall be documented in accordance with this procedure.

4. Calculation revisions are made and approved in accordance with this procedure.

5. Graded Approach

a) A graded approach should be utilized when performing analyses/calculations.

b)Graded Approach is a process by which the level of analysis, documentation, and actions are commensurate with some or all of the following factors:

1) The relative importance to safety, safeguards, and security;
2) The magnitude of any hazard involved;
3) The life cycle stage of a facility;
4) The programmatic mission of a facility;
5) The particular characteristics of a facility;
6) The economic impact; and
7) Any other relevant factor.

c) The intent of the graded approach is to permit the flexibility to implement activities and processes, as appropriate, to comply with the requirements (including safety) for the individual facilities.

d) The graded approach, when used for a nuclear facility, does not eliminate any nuclear safety requirements. Whenever a graded approach is applied in meeting a nuclear safety requirement, the bases for selecting an action pursuant to the graded approach shall be documented (per references A and B) and the nuclear facility's Design Authority shall approve the selected graded approach.

B. Format

1. Analyses and calculations should be made on standard forms such as a General Design and Computation Sheets, UCN-4032A, computer output sheets, or other comparable forms. The form must have a place for identification of title, date, page, designer, and checker. Calculations may be handwritten, typed, or computer generated and must be clear and legible. If an attachment is sequentially numbered by itself with the first page noting the total number of pages contained with the attachment, the calculation number and calculation revision level need only be placed on the first page of the attachment.

2. The calculation should generally follow the outline:

a) Introduction and objectives
b) Design input (Work Smart Standards, SRD, design criteria, etc.) and references used
c) Include the complete identification and the version of any software used
d) Assumptions
e) Analyses and/or calculations:
   1) Include discussion of method of analysis used
   2) Computer software used to originate or verify design solutions for nuclear criticality analysis/calculations or anything safety related shall be verified/validated or the status of the software validation should be identified and documented prior to use [Reference B].
   3) Verification/validation of non-criticality/non-safety related software should be based on the graded approach according to cost considerations.
f) Conclusions and recommendations

3. The Design Analysis and Calculation Cover Sheet form (Figure 1, form ORNL-229) provides complete reference to discipline, project number, title, building, area, equipment, and/or system, along with approval signatures and revision records. The Cover Sheet form is to be placed on the front of each calculation. Design Analysis and Calculation (DAC) numbers are to be obtained from the ORNL Engineering Design Information System (EDIS).

4. The DAC can be placed in a binder (Figure 3) with other project related DACs. A DAC Binder Contents form (Figure 2, form ORNL-230) is placed in the front of each binder when the binder contains more than one DAC. A binder title block is shown in Figure 4.

IV. PROCESS

A. The designer:

1. Identifies hazards, mitigating standards, design inputs, and assumptions needed for calculation development.

2. Develops the analysis/calculation in accordance with this procedure.

3. Determines the appropriate level of reviews.

5. Resolves comments by the verifier, the reviewers, and supervision.

6. Compiles DAC, reserves DAC number in EDIS and obtains all required signatures.

7. Forwards the approved analysis/calculation original to the Project Engineer for submittal to ORNL Records Management, as appropriate.

B. The verifier/checker:

1. Checks the technical analysis/calculation/support documentation including drawings in accordance with requirements in this procedure and the requirements of SOP-ENG-D.04, Design Verification

2. Signs DAC Cover Sheet

C. The supervisor or design management:

1. Assures that the analyses and calculations are generated and checked by qualified engineers and designers in accordance with procedures and to the appropriate degree of detail.

2. Assures that the computer software used for design analysis and calculations has been verified for accuracy and the verification documented, as required by this procedure.

3. Reviews analysis and calculation approach to assure conformance with project requirements.

4. Assures resolution of discipline interface problems.

5. Signs DAC Cover Sheet.

D. Project Engineer

1. Forwards the approved analysis/calculation original to ORNL Records Management

V. REFERENCES

A. 10 CFR 830, Nuclear Safety Management

B. ORNL-QA-P02, ORNL Nuclear Quality Assurance Program

C. SOP-ENG-D.04, Design Verification

FIGURES

Figure 1 - Design Analysis and Calculations (DAC) Cover Sheet form
Figure 2 - Design Analysis and Calculations (DAC) Binder Contents form
Figure 3 - Typical DAC Binder
Figure 4 - Binder Title Block

VII. APPENDIX

Appendix A - Typical Discipline Design Analysis Calculations

Prepared by: [signature] Engineering Design Manager   Approved by: [signature] Director, ORNL Engineering

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OAK RIDGE NATIONAL LABORATORY
DESIGN ANALYSIS AND CALCULATIONS - (DAC)
COVER SHEET

PROJECT TITLE		**ACCOUNT NUMBER/ESO**
CALCULATION TITLE		**DAC - NUMBER**
PE	**PJ**	**RED**
SUPERVISOR/DESIGN MANAGER	**DESIGNERS (CONTRIBUTING)**	**BUILDING/AREA**

Applies to Project - WBS / Items / Systems:

Reports / Dwgs. / Rev. No.:

	SIGNATURE / DATE			
	REV. 0	**REV. 1**	**REV. 2**	**REV. 3**
Designer				
Verifier/Checker				
RED				
Supervisor/Design Mgr.				
PE				
Other				

PAGE NO.	**CONTENTS DESCRIPTION (List Attachments)**

ORNL-229

Figure 1

OAK RIDGE NATIONAL LABORATORY
DESIGN ANALYSIS AND CALCULATIONS - (DAC)
BINDER CONTENTS

PROJECT TITLE		
PROJECT ENGINEER		ACCOUNT NUMBER/ESO
RED	BUILDING(S) / AREA	

DAC No.	TITLE

Upon Completion Forward For Signature/Date To:		
DESIGNER/RED	VERIFIER	SUPERVISOR/DESIGN MANAGER
PE	PJ	RECEIVED ORNL ENG. RECORDS - RC

ORNL-230

Figure 2

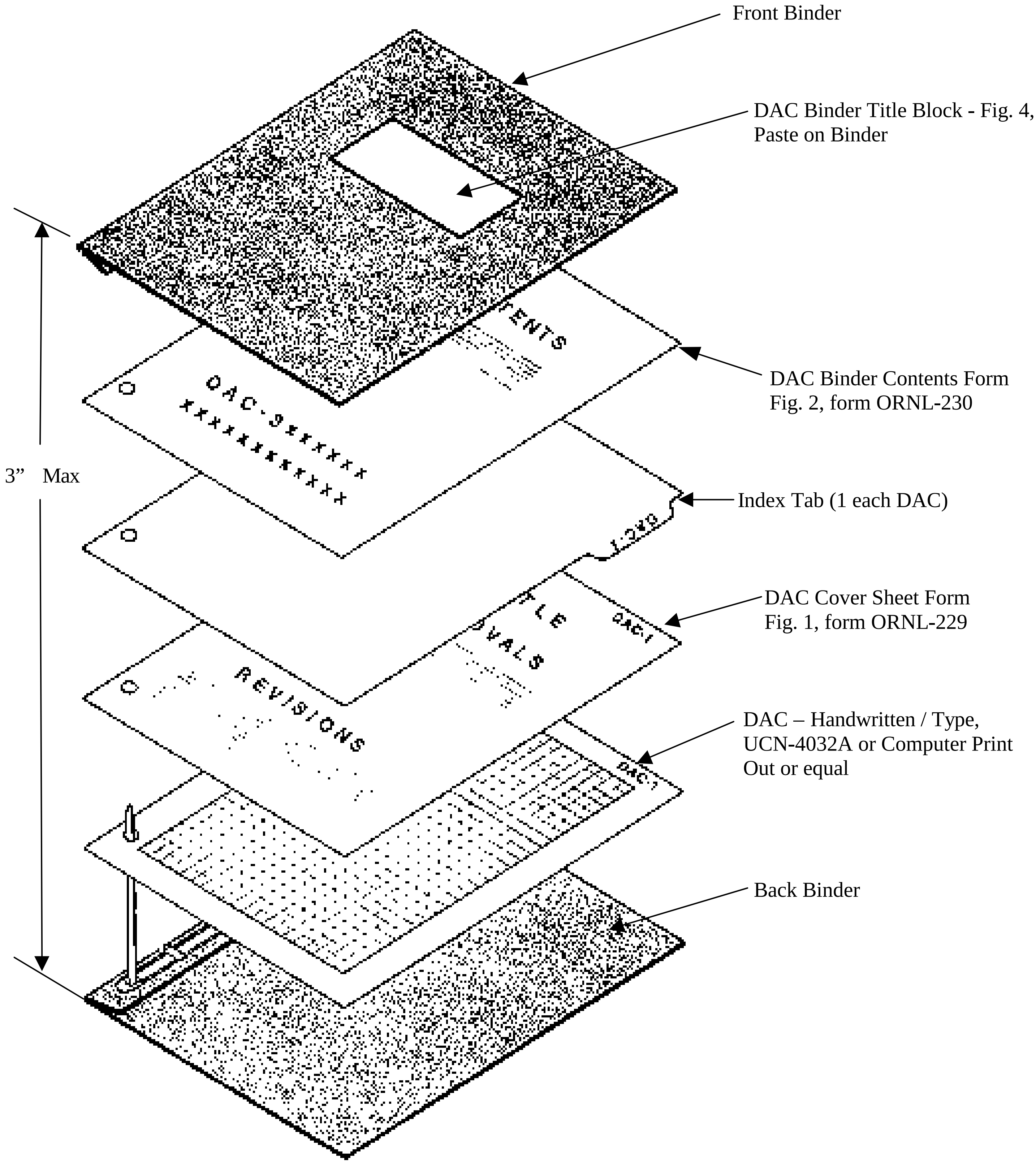

Fig. 3
Binder Contents for Design Analysis and Calculations

Binder Title Block

<table>
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<tr><td colspan="4">PROJECT TITLE / WBS</td></tr>
<tr><td colspan="2">DESIGNER</td><td>VERIFIER</td><td>DESIGN MGMT.</td></tr>
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NUMBERS</td><td colspan="3"></td></tr>
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</table>

Figure 4

Appendix A

Typical Discipline Design Analysis Calculations

Architectural:

1. Facility space requirements with regard to numbers, groupings, relationships, circulation, service, etc.
2. Life safety codes and handicapped accessibility.
3. Occupancy calculations for efficiency ratios and net/gross comparisons.
4. Rest room requirements, fixture requirements, etc.
5. Acoustical analyses.

Civil:

1. Subsurface characteristics calculations to support geological recommendations.
2. Foundations, retaining walls, storage pads, and other site-related structures.
3. Storm sewer systems, including catch basin and manhole designs.
4. Extrapolating site contours.
5. Cut and fill calculations.
6. Drainage calculations including culvert designs.
7. Design basis floods assessments.
8. Highway and railroad construction calculations, including bridges.

Structural:

1. Determination of applied loadings and load combinations, including natural phenomena and design basis accidents.
2. Moment and shear distributions.
3. Stress calculations for sizing and/or evaluating structural components, including foundations.
4. Special analyses for rolling loads, thermal movement, vibrating equipment, shielding requirements, and explosion resistance.
5. Dynamic analysis of structures, systems, and components for assessing impact of design/evaluation basis earthquakes.

Engineering Mechanics:

1. Thermal and pressure stress calculations for piping systems.
2. Pressure vessels calculations.
3. Flow calculations for line sizing, pump selection, selection of relief and control valves, etc.

4. Heat transfer calculations for exchanger sizing, for cryogenic piping systems, economic analysis of insulation systems, etc.
5. Hydraulic analysis of sprinkler systems.
6. Sizing calculations for sanitary system.
7. Flow analyses of piping network systems for utilities.
8. Thermal analysis of heat conveying fluid systems.
9. Pressure / water hammer calculations.
10. Vacuum conductance calculations.

Environmental Control:

1. Heating loads
2. Cooling loads.
3. Duct static pressure loss calculations.
4. Energy conservation.
5. Equipment sizing/selection calculations.
6. Dust loading calculations for baghouse, cyclones, etc.
7. Noise level (NC or SPL), where applicable.
8. Moisture/humidity load calculations for dry rooms.
9. Testing and balancing calculations.
10. Dilution ventilation and hood exhaust calculations.
11. Control valves/damper sizing calculations.
12. Energy usage calculations.

Instrumentation:

1. Control valve sizing.
2. Flow meter sizing.
3. Control valve cavitation prediction.
4. Control valve noise.
5. Air supply capacity.
6. Electrical power supply sizing.
7. Circuit time response.
8. Equipment sizing.
9. Scale (indicating) conversion factor.
10. Analog switch settings.
11. Process variable to analog signal settings.
12. Computing system electrical circuit/load requirements.
13. Computing system heating, ventilating, and air conditioning requirements.
14. Network data/traffic flow analysis and studies.
15. Measurement and control system performance analysis.
16. Computer system alternatives analysis.
17. Calibration data.

Electrical:

1. Load analyses to determine expected power load flows, voltage regulation, reactive power

requirements, short circuit capacities (based on system component impedances) and expected equipment loadings.

2. Equipment analyses including conductor sizing, conductor pulling and bending radii, raceway size, support structure size, transformer and switchgear configuration, and motor size and performance.
3. Life-cycle costs based on energy conservation and equipment efficiency requirements.
4. Grounding and cathodic protection design requirements.
5. Lightning protection determinations.
6. Telecommunication design requirements.
7. Design basis accidents.

Process:

1. Materials and energy balances.
2. Process equipment size calculations.
3. Safe geometry for fissionable materials calculations.
4. Shielding requirements for radioactive materials calculations.
5. Concentrations and dispersion of toxic, hazardous, or radioactive materials calculations.
6. Calculations to establish likelihood of accidents, consequences of resulting hazards, and risks of these events.
7. Calculations to determine reliability, availability, and maintainability of key systems or components.
8. Human factors requirements.
9. Containment/confinement requirements.

Mechanical Engineering:

1. Structural analyses (linear or nonlinear) to determine stresses and deflections to ascertain margins of safety, structural integrity, or to optimize a design.
2. Thermal analyses (linear, nonlinear, steady state, or transient) to determine temperatures and changes of state to optimize design from a thermal standpoint or to develop thermal and/or pressure loads for structural analyses.
3. Dynamic and vibration analyses (linear, nonlinear, steady state, or transient) to determine dynamic behavior (loads, stresses, deflections).
4. Fatigue analysis.
5. Loads analyses involving pressures, thermal, and electromagnetic forces, steady state, or pulsed, and/or involving nuclear plasma heating.
6. Thermodynamic analyses using hand techniques or computer codes to determine pressures, temperatures, combustion products, densities, velocities, and/or to optimize a design.
7. Fluid mechanics analyses to determine the hydrodynamic or aerodynamic characteristics of a system or component, to determine velocities, pressures, system stability and temperatures for loads analysis or for optimizing a system or component.