

## 10.491 Integrated Chemical Engineering

### Process Design Team Final Report

#### THE DESIGN REPORT

The design report represents the culmination of the work of the design engineer. Its importance can hardly be overemphasized because the acceptance of its conclusions and recommendations by management depends so strongly on the impression it makes. An excellent plant design is not very useful if its presentation fails to convince management that the project should be undertaken. Therefore the design report should be written with the reader in mind. It should convince the reader that

- The work was done well.
- The conclusions and recommendations are reasonable and valid.

To this end the report should

- Present conclusions and recommendations clearly and convincingly;
- Justify properly major decision such as the flowsheet selection;
- Describe accurately and clearly (these are not the same) the development of ideas and the methods employed in arriving at the final design.

Since the reader is so important, the writer must consider

- Who will read the report? Why?
- What are the responsibilities of the reader?
- How much background information does the reader have?
- What is his/her technical competence?

#### A PROCEDURE FOR PREPARING THE REPORT

1. Define the subject matter, scope of the work, and intended audience. Try to envision what each of these needs in the report.
2. Prepare a checklist for the report.
3. Prepare an outline, listing actual headings and subheadings. Under each subdivision list the topics to be discussed.
4. Expand the outline in one or more steps. Write a sentence or two under each subdivision summarizing the ideas or information to be discussed.
5. Write the first draft. Do not pay too much attention to grammar or style – concentrate on saying what needs to be said.
6. Revise and polish the first draft. If possible lay it aside for a few days, then review it again and polish. If time is short, have someone other than the author criticize the writing.
7. Get report typed, PROOF READ, and check all details carefully. Note: you most likely will run out of time, so be forewarned and prepare a schedule at the onset providing ample time to assemble the report. Don't cut short the time for the report unless absolutely necessary.

## OUTLINE OF THE REPORT

LETTER OF TRANSMITTAL – This cover letter indicates the purpose and reports the results specifically requested. Address it to the commissioner of the report.

TITLE PAGE – Title of the report; addresses; authors; organization; date.

ABSTRACT – A clear, concise statement of essential findings and results, along with conclusions and recommendations. A single page should suffice.

TABLE OF CONTENTS – Headings, subheadings, list of figures and titles, appendices, page numbers.

### BODY

1. Introduction – a discussion of the subject of the report and why it was done.

2. Background – a survey of relevant literature.

Details of references mentioned in the Discussion should be reported here, but confine mention of the current work to the Discussion.

3. Discussion – a description of the design.

Address the technical reader in this section. The goal is to justify major decisions, and convey how the authors arrived at the design and an understanding of the principles on which the process is based. Organization of this section depends on the particular process, but should include

- Basis of design: a precise statement of the problem, including feed compositions, product specifications, available utilities.
- Alternatives considered. Why were other processes rejected? How did you select your flowsheet structure? Simple sketches for this section are helpful.
- A brief description of proposed process with a qualitative flowsheet.
- Assumptions, limitations of the design, possible sources of error.
- Discussion of major equipment or sections of the process and the technical considerations which led to its selection and configuration.
- Graphs, drawings, and tables necessary to understand the discussion. Place non-essential material in an appendix. Insert each figure as near as possible to the text in which it is first mentioned. Constant flipping of pages makes for difficult reading. Also, present your heat exchanger network in a separate figure.
- Analysis of economics of the process. Include cost diagrams, pie charts and include a simple sensitivity analysis.

4. The Design – a compilation of the facts.

4.1 Flowsheet – a complete quantitative flowsheet drawn on a single large page. Include heat duties of exchangers. Label all streams and equipment.

4.2 Material and energy balances (stream information table) – Report for each stream its temperature, pressure, competent flow rates, total flow rate, and vapor fraction. Every stream must have a separate entry in the table. Streams differing only in pressure, temperature, or vapor fraction should appear in adjacent columns: only the changed quantities need to appear for the downstream entries. Include utilities and make-up streams. The stream information table must

reside on a single page, and should include the scale-up factor and units used for pressure, temperature, etc. If possible, place the stream table on the same page as the flowsheet.

4.3 Equipment list and specifications.

4.4 Economic information – include as appropriate:

- Capital investment
- Utilities summary
- Manufacturing cost
- Estimate of Annual Earnings and Return
- Net Present Value

5. Conclusions- itemized and concisely stated. No arguments should appear here, and all items must be supported and explained in prior sections.
6. Recommendations for Future Work -- The recommendations for future work are especially important. Because of the short time available for the project you will not have been able to address all the potentially interesting/relevant topics. In practice another team might take over the detailed design and it is important that you help them come up to speed as quickly as possible by identifying important remaining issues.
7. Flowsheet – a complete quantitative flowsheet drawn on a single large page. Include heat duties of exchangers. Label all streams and equipment.
8. Nomenclature – symbols and units.
9. References – format of *AIChE J.*

## APPENDIX

- A. Calculations – include an index. Include a complete calculation for every major piece of equipment. For minor or frequently-occurring, similar equipment such as heat exchangers and compressors, a single representative calculation is sufficient. A complete calculation compresses a mass and energy balance, sizing, and costing. Each calculation must refer to specific equipment in the flowsheet and must represent the values which appear in the flow sheet.
- B. Derivations
- C. Auxiliary tables, figures, graphs
- D. Supplementary material

## A CHECK LIST FOR THE REPORT

### OVERALL:

1. Is it well-organized?
2. Readable?
3. Understandable by principal readers?
4. Has manuscript been edited ruthlessly?
5. Proofread by writer? Others?
6. Is pagination correct?

### ABSTRACT:

1. Are conclusions and recommendations clearly valid and well-substantiated?
2. Are they presented clearly and convincingly? Are they concise? Rambling presentations, even though accurate, are undesirable.
3. Are they supported by the rest of the report?

## BODY:

1. Is the reason for the project stated clearly?
2. Are the objectives stated clearly?
3. Is earlier work considered and described accurately?
4. Is the flowsheet selection properly justified?
5. Is the work itself described adequately?
6. Are sufficient data (not too many) included to make the report understandable and to support conclusions?
7. Are tables, graphs, etc. organized neatly and readably?
8. Are assumptions, limitations, and sources of error identified and evaluated?

## APPENDICES:

1. Are they complete?
2. Are they organized so the reader can turn readily from the main body of the report and find what he/she is looking for?

## GRADING OF THE DESIGN REPORT

Each report will be read by two teaching assistants and by the instructor. Grades and comments will be recorded on separate sheets, so the gradings will be independent. The grade of the report will be the arithmetic mean of the grades assigned by the readers. However, if the grades greatly differ, the instructor will confer in an effort to resolve the disparity.

Each section of the report will be scored on a scale of 0 to 5. The raw score will be weighted according to the importance of the section to obtain the contribution to the total grade. A section written with no major mistakes will receive a score of 3. Omissions, technical errors, and so forth lower the score; evidence of special care, insight, or clarity of exposition will increase.

The graders will assume the role of a non-technical reader when grading the Letter of Transmittal, Abstract, Introduction, Economic discussion, and Conclusion. The remaining sections will be judged from the perspective of a technically competent engineer.

The score of the Technical discussion will reflect the quality of presentation and justification of the design. The score for the Flowsheet will include an assessment of the quality of the design itself.

The criterion for evaluating the Calculations will be, "Can I (the reader) reproduce these results? Do I know the assumptions that produced them, and are the assumptions reasonable for a preliminary design?" Explanations of the Calculations belong in the Technical discussion. The Calculations need only show which numbers were used in what equations. If you used the computer, include a transcript of the dialog and indicate how you used the computed results to determine sizes and costs.

## IMPORTANT CAVEATS

This class is about process design. One of the most important features of solutions to design problems is that the answers are typically not unique - usually there is no 'correct answer' nor is the answer in the back of the book. The design process is further complicated by missing or conflicting information, ambiguous objectives, and no clear problem statement. As a result:

1. You will have to make a lot of assumptions, **document them**, understand the implications and then move on.
2. Keep to the **time limit imposed by the units allocated to this class** - the goal is to do the best that you can in the allocated time, not to exhaust yourself. Time management is critical.
3. This is a **team** effort, plan and allocate the work across all members, meet regularly and iterate the design concepts.