National Student Design Competition 1996

Official Revised Edition

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
345 East 47th Street, New York, New York 10017-2395

If there are any questions about the design problem, Student Chapter Advisors and design course instructors are asked to contact:

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Please read the rules on the following pages carefully before submitting a solution to AIChE.

PRODUCTION OF NON-ALCOHOLIC (NA) BEER

INTRODUCTION & STATEMENT OF THE PROBLEM

PRO-D-ZINE, INC.
1996 Hops & Brew Way
Gulfcoast, Texas 70011
November 14, 1995

TO: B. A. Designer, C. H. Engineer, W. E. Optimize

FROM: C. O. Owner

SUBJECT: NON-ALCOHOLIC BEER FOR GULF BREWING COMPANY

It's good to have all of you on board at PRO-D-ZINE. With you on staff, we now have the resources to investigate Big Boss's pet project.

Since gaining a controlling interest in Gulf Brewing, Big Boss has tried to convince the brewery managers that a non-alcoholic (NA) beer can be made economically and sold at a profit. The brewery managers, however, have resisted entry into the NA beer market, citing a study ("flawed" according to Big Boss) that concluded that the NA beer market was not lucrative, and would require too much start up investment.

Gulf Brewing CEO, Anita Brewsky, has assured Big Boss that she will fully support an economical project.

Your assignment is to define an economical project for Gulf Brewing to produce and sell non-alcoholic (NA) beer, and to determine the economic potential of Gulf Brewing's entry into the NA beer market.

Big Boss has high expectations that you will prove to the managers that it can be done.

AIChE 1996 National Student Design Competition
Production of Non-Alcoholic Beer

CONTEST PROBLEM STATEMENT OUTLINE

Big Boss is willing to accept an Internal Rate of Return (IRR) of 10% to 15%; however, Gulf Brewing may not be willing to accept a rate this low.

Big Boss believes that the economics are so favorable that a non-optimized process will be very economical; though it is important to stress that we do not do non-optimized work here. *The project you define must be economically optimum.* Any distillation system that is off the economic *Net Present Worth* (NPW) by 25%-40%, is unacceptable.

Scientific literature, and successful products developed by our major competitors, indicate that, with reasonable precautions, alcohol can be successfully removed from beer and yield a pleasing result.

Taste is key to the acceptance of a NA brew. You must select a process that produces a quality product. The process must not degrade any taste components, either from heat or from oxygenation.

Also, the study must be closely guarded. We want no potential vendors of the NA technology or any current producers of NA beer to know about our work. Therefore, there may be only minimal input from outside.

I know you are not experts in the technology of NA beer production, but I feel confident that, with literature information and your knowledge, an economical and efficient process can be defined, resulting in a competitive and profitable NA product.

Keep in mind that you are on a fast track and that Gulf Brewing will expect your Project Definition Report in about 4 weeks. I will provide further instructions as information becomes available.

C.O. Owner
Pro-D-Zine, Inc.

PRO-D-ZINE, INC.
1996 Hops & Brew Way
Gulfcoast, Texas 70811
November 15, 1995

TO: B. A. Designer, C. H. Engineer, W. E. Optimize

FROM: C. O. Owner

SUBJECT: NON-ALCOHOLIC BEER FOR GULF BREWING COMPANY

I have informed Big Boss of your start on his NA beer project, and he is pleased. Upon learning of your initial work, Big Boss met with CEO Brewsky. Their discussion resulted in a better definition of premises for the NA project.

Also, FYI -- Word is out among the brewery managers that Big Boss is very serious about the NA project! Anita Brewsky had an all-day meeting with the managers and they are convinced that the project economics must be done using the following premises:

1. The Gulf Brewery is in a sold-out[1] position.

2. The Gulf Brewery's least profitable product (Prairie Premium) returns a Before Tax Income of $5.00/BBL. The brewery managers have made it very clear to CEO Brewsky that this profit is to be properly included as an Opportunity Cost of entering the market for NA beer.

3. The Gulf Brewery managers agree that the cost of brewing the regular beer, which is the feed to the NA process, is essentially the same as the cost of brewing any of their regular beers. Except for advertising, which is addressed by the following item, the managers all agree that all other ex-Battery Limits Costs will be about the same for NA beer as for regular beer.

4. The brewery managers are concerned that the advertising cost for entering the NA beer market has not been fully appreciated. Based on the Sales Department's experience in bringing a new beer to the market, the following EXTRAORDINARY advertising costs should be included in the economic analysis:

   - YEAR 1: $350,000
   - YEAR 2: $250,000
   - YEAR 3: $150,000
   - YEAR 4: $ 90,000

5. The managers are adamantly opposed to justifying a project on the basis of an IRR of 10%/Y. CEO Brewsky has reached an agreement with the managers that the project economics will be done over a range[2] of 12% to 20%/Y.

6. The Gulf Brewing Plant Manager has agreed that one additional operator position will be adequate for the NA process.

7. The brewery managers are understandably opposed to any changes to the brewing process. Big Boss has promised management that the normal brewing process will not be affected by the addition of the NA plant.

8. Big Boss estimates that the selling price for the NA beer will be from $3 to $5 a barrel above the selling price of Prairie Premium, but he does not want to make this argument unless the economics are poor (i.e., the NA capacity requirements are excessive to obtain a reasonable return). Do your economic analysis initially on the basis of equal netback for NA beer and Prairie Premium, but if you need to claim more netback for NA beer, then include that in your analysis. Big Boss keeps reminding us to call our local beer distributor and inquire about the prices of regular and NA beers.

P.S.: *SOME REMINDERS*

1. Consider excise taxes.
2. Don't contact O_2 with the beer.
3. Keep the "volatiles in the beer."
4. Investigate capacity vs. IRR.
5. Economically optimize the process. Maximize NPW.
6. 12% < IRR < 20%.
7. Include Opportunity Costs.
8. Do not "scorch" the beer.
9. Extraordinary advertising costs 1st 4 years.
10. Netback on NA could exceed netback on PG.
11. Be conservative in producing a quality product.

[1] This seems reasonable to Big Boss because, if current sales trends continue, additional capacity must be added at Gulf Brewing by 1999.
[2] One of the managers did mention that using the 0.6 rule for relating TCI to plant capacity seemed reasonable. All the managers seemed agreeable to accept an economic analysis done on this basis.

PRO-B-ZINE, INC.
1996 Hops & Brew Way
Gulfcoast, Texas 70011
November 16, 1995

TO: B. A. Designer, C. H. Engineer, W. E. Optimize

FROM: "Big Boss"

SUBJECT: PDZ PROJECT DEFINITION REPORT PROCEDURES AND PERTINENT REFERENCES (per C.O. Owner's request)

FINAL REPORT FORMAT

NOTE: FOR CONSISTENCY, CLARITY AND UNDERSTANDABILITY, ALL OF THE REPORT MUST BE DONE IN ENGLISH UNITS!!!!!!!!!

1. **Title Page.**
2. **Table of Contents.**
3. **Executive Summary** - Two (2) page (maximum) condensation of report.
4. **Introduction** - Orient the client to the assigned task.
5. **Summary** - Summarize the results of the analysis and summarize the conclusions and recommendations. Briefly tell what options were considered and the advantages/disadvantages of each.
6. **Conclusions** - Interpret your results. List your conclusions in decreasing order of significance.
7. **Recommendations** - Emphasize business opportunity and potential process improvements. Address product quality.
8. **Project Premises** - Itemize all pertinent process and economic premises, including (1) the overall project schedule, battery limits etc., (2) feed and product specs, (3) costs of raw materials, utilities etc., (4) selling prices of all products, (5) economic, including depreciation schedule, taxes, project life etc., (6) environmental requirements, (7) processing limitations, (8) existing brewery operation, (9) extraordinary costs, (10) labor cost, (11) product quality considerations.

9. **Process Flow Diagram (PFD)** - Include all items of process equipment; include and number all process streams;, indicate all utilities needed per individual equipment.
10. **Stream Attributes** - For each and every stream on the PFD, include on the PFD or on a separate page a Tabulation of Stream Attributes (SA's), including Stream Number, Mass Flow of Each Component, Total Mass Flow, Temperature, Pressure and Volumetric Flow Rate (GPM for liquids & CFM for gases). Proper SA's (lb/hr of each component, T, P, etc.) from a process simulator will suffice.
11. **Process Description** - Include process conditions, equipment type and size and how the process equipment is integrated to achieve process objectives. Explain the purpose of each process equipment item.
12. **Safety and Environmental** - Note and explain any special considerations. Explain and document how emission limits were achieved.
13. **Utility Summary** - Itemize each utility by user. Give yearly cost for each user and total yearly costs.
14. **Operating Cost Summary** - Itemize using the categories given in Peters and Timmerhaus, Fourth Edition, Tables 26 & 27, pages 210 & 211.
15. **Equipment Information Summary** - Itemize operating conditions and sizes of process equipment for each and every item of process equipment.
16. **Capital Estimate** - Itemize process equipment costs and itemize the overall estimate per Method C [1], page 180, or the Wroth Method [2], page 60.
17. **Economic Analysis** - Include a discussion of the economic methods and analysis. Include appropriate cash flow analysis tables. Include any graphical representations such as Required Plant Capacity vs IRR.
18. **Innovation and Optimization** - Explain and document what was done to make the process the economic optimum.
19. **Engineering Calculations** - Include all pertinent hand calculations.
20. **Computer Programs** - Include input and output files, an explanation of the model(s) used and nomenclature.
21. **Computer Process Simulation** - Include input and output files and a simulator flow chart for one set of documented process conditions for any process simulation using standard programs such as ASPEN, HYSIM OR PRO-II. NOTE: THERE MUST BE A ONE-TO-ONE CORRESPONDENCE BETWEEN STREAM NUMBERS IN THE PROCESS SIMULATION AND STREAM NUMBERS ON THE PROCESS FLOW DIAGRAM.

CAPITAL ESTIMATE

Working Capital - Per Table 26, page 210 of [1]

Total Installed Capital

Use Method C, page 180 [1], Percentage of Delivered-Equipment cost or the Wroth Method [Ref. 2, p. 60].

Purchased Equipment Cost (Simulator results may be used.)

1. Heat Exchangers - Use Fixed-tube-sheet, Fig. 15-15, [1].
2. Distillation Columns - Figure 16-28, [1].
3. Process Vessels - Figures 14-58, [1] for large volume storage tanks.
4. Vacuum systems [3].
5. Pumps - Fig. 14-40, [1] for single stage centrifugals.
6. Freight - Use 5% of purchase price.

OPERATING COSTS

Refer to Table 27, page 210 [1]. Use Table 23, page 200 [1] for Selected Utilities and Labor.

1. Operating Labor (OL) - Estimate the number of operator positions. There are 4 operators per shift position. Labor cost, page 200, [1].
2. Direct Supervision and Clerical Labor - 17.5% of OL.
3. Utilities - Individual determination.
4. Maintenance & Repairs - 3% of Fixed Capital Investment.
5. Operating Supplies - 15% of Maintenance & Repairs.
6. Laboratory Charges - 15% of OL.
7. Patents and Royalties - As appropriate for process.
8. Local Taxes and Insurance - 3% of Fixed Capital Investment.
9. Plant Overhead - 60% OL, Supervision and Maintenance.
10. Administrative Expenses - 15% OL, Supervision and Maintenance.

ECONOMIC PREMISES

1. Cash Flow Analysis done per Table 2, page 306 & 307 [1]. Use 1/1/99 costs to do the cash flow analysis; i.e., do not inflate costs year-by-year.
2. 10 year project life.
3. Required IRR varies continuously from 12% to 20%.
4. Startup at full capacity 1/1/99.
5. Inflation prior to 1/1/99 = 2.5%/year.
6. Depreciation: 7 year MACRS. See page 287, [1].
7. Incremental Income Tax Rate: 34% Federal + 6% State.

REFERENCES

NOTE: IT IS ASSUMED THAT EVERY STUDENT HAS READY ACCESS TO THE TEXTBOOK BY PETERS & TIMMERHAUS [1] AND THAT THE INSTITUTIONAL LIBRARY WILL HAVE REFERENCES [2],[3] & [4]. MOST STUDENTS WILL NOT HAVE READY ACCESS TO THE OTHER REFERENCES. A SINGLE COPY (PER INSTITUTION) OF REFERENCES 5-12 CAN BE OBTAINED BY CONTACTING AIChE*xpress* CUSTOMER SERVICE, 1-800-242-4363.

1. Peters, M.S. & K.D. Timmerhaus, PLANT DESIGN & ECONOMICS FOR CHEMICAL ENGINEERS, 4'th Edition, McGraw-Hill, 1990.
2. Couper, J.R. & W.H. Rader, APPLIED FINANCE AND ECONOMIC ANALYSIS FOR SCIENTISTS AND ENGINEERS, Van N. Reinhold,1986.
3. Ryans, J.L. & D.L. Roper, PROCESS VACUUM SYSTEM DESIGN AND OPERATION, McGraw-Hill, 1986.
4. Gomez, J.V., "Calculating Air Leakage Values for Vacuum Systems," Chemical Engineering, p. 149, June, 1991.
5. Selections from the 1994 Annual Report of Anheuser-Busch, page R-1, attached.
6. COMPARISON OF A-B BEERS, pages R-2 thru R-6, attached.
7. Marchbanks, C., "Non- and Low-alcohol Beers: How They are Made," Brewing & Distillers Int., p. 16, December 1986, pages R-7 thru R-9, attached.
8. Siebel, R., "Non-alcoholic Beer: The Beverage of the 1990s," Brewers Digest, pages R-10 thru R-14, attached.
9. ALFA LAVAL BREWERY SYSTEMS, pages R-15 thru R-21, attached.
10. Hodgins, K.R., "De-alcoholization of Beer," pageS R-22 thru R-27, attached.
11. Hardwick, W.A., "Beer," Chapter 3, Biotechnology, Vol. 5, Verlag Chemie, Weinheim, 1983, pages R-28 thru R-60, attached.
12. Engan, S. "Beer Composition: Volatile Substances," Chapter 3 from FOOD SCIENCE AND TECHNOLOGY, A SERIES OF MONOGRAPHS, Vol. 2, Brewing Science, Academic Press, 1981, pages R-61 thru R-64, attached.

AIChE National Student Design Competition 1996 -- Revised Edition

PRODUCTION OF NON-ALCOHOLIC BEER

DEADLINE FOR MAILING

Solutions must be postmarked no later than **Midnight, June 7, 1996.**

RULES OF THE CONTEST

Solutions will be graded on:
- correctness of results.
- soundness of conclusions.
- ingenuity and logic.
- accuracy of computations.
- form of presentation.

Accuracy of computations means primarily freedom from mistakes; extreme precision is not necessary.

The statement of the problem contains all the pertinent data except for those available in handbooks and literature references. The use of textbooks, handbooks, journal articles, and lecture notes is permitted. **The references cited at the end of the problem statement are critical to solving the problem.** Therefore, one copy of the entire set will be mailed with each order of 1996 National Student Design Handbooks. Advisors are encouraged to put this information on reserve for participating students, or make additional copies as necessary.

Students may use any available commercial or library computer programs in preparing their solutions. Students are warned that physical property data built into these programs may differ from data given in the problem statement. In such cases, as with data from other literature sources, values given in the problem statement are most applicable. If students use commercial or library computer programs or other solution aids, they should state it in their reports and include proper references and documentation. The problem can be solved without the use of sophisticated computer programs. Judging is based on the overall solutions, not on skills in manipulating computer programs.

The 1996 National Student Design Competition is designed to be solved either by an individual chemical engineering student working entirely alone, or a group of no more than three students working together. Solutions will be judged in two categories: individual and team.

There are other approached to using the problem, and it is expected that some Advisors will use the problem as classroom material. The following confidentiality rules therefore apply:

Students submitting solutions:
The problem may not be discussed with anyone (student, faculty, or others, in or out of class) before or during the period allowed for solutions. Discussion with faculty and students at that college or university is permitted only after complete final reports have been submitted to the Chapter Advisor.

Students not submitting solutions:
Discussion with faculty and with other students at that college or university who are not participating in the contest is permitted.

All students:
The problem may not be discussed with students or faculty from other colleges or universities, or with individuals in the same institution who are still working on the problem for the contest, until after June 7, 1996. This is particularly important in cases where neighboring institutions may be using different schedules.

RULES FOR SUBMITTING SOLUTIONS

(Failure to comply will result in solutions being returned to the appropriate Faculty Advisor for revision. Revised submissions must meet the original deadline.)

ELIGIBILITY

- ONLY AIChE NATIONAL ENROLLED, UNDERGRADUATE STUDENT MEMBERS MAY SUBMIT A SOLUTION. Non-member entries will not be considered.
- Entries may be submitted either by individuals or by teams of no more than three students. Each team member must meet all eligibility requirements.
- Each Faculty Advisor should select the best solution or solutions, not to exceed two from each category (individual and team), from his or her chapter.

TIMELINE FOR COMPLETING THE SOLUTION

- Students are allowed no more than thirty days to complete the problem. This period may be selected at the discretion of the individual advisor, but in order to be eligible for an award a solution must be post marked no later than midnight, June 7, 1996.
- THE FINISHED REPORT SHOULD BE SUBMITTED TO THE FACULTY ADVISOR WITHIN THE 30-DAY PERIOD.

REPORT FORMAT

- The report must be suitable for reproduction, that is, typewritten or computer-generated. Tables may be written in ink. Supporting calculations and other appendix material may be in pencil.
- The report should not contain any reference to the student's names or institution. Graph paper naming the institution should be avoided.

SENDING THE SOLUTION TO AIChE

- Two copies of each of the solution(s) must be sent to the below address. Original manuscript(s) must remain in the possession of the Student Chapter Advisor, or Faculty Advisor, sponsoring the student(s).
- The content of the solutions submitted to the Faculty Advisor and the AIChE office must be the same.
- Each copy must be accompanied by the enclosed ENTRY FORM giving each contestant's name, AIChE membership number, college or university, Faculty Advisor name, address, home address, home telephone number, and student chapter, lightly attached to the report. This form is used by AIChE for identification.
- **DEADLINE:** Entries must be postmarked no later than midnight, June 7, 1996.
- As soon as the winners have been notified, original manuscripts must be forwarded to the AIChE office.

SEND TO:

Awards Administrator
American Institute of Chemical Engineers
345 East 47th Street
New York, New York 10017-2395
Ph: 212-705-7478

DEADLINE: JUNE 7, 1996