LABORATORY EXPERIMENTS & REPORTS

1/12/08

Every experiment has three parts:

1. **Preliminary THINKING and planning** --
   i.e. (a) analyzing the problem, (b) obtaining the hypothesis and criterion,
   (c) choosing the equipment, and (d) performing the detailed planning required before meaningful data can be collected and evaluated.

2. **Data handling** -- readings, calculations, and plots.

3. **Analysis of results and presentation of conclusions.**

Parts 1 and 3 are the work of an engineer. Part 2 is the responsibility of an engineer, but typically the work of a technician. Since experimental work is expensive and time consuming, your supervisor is not going to let you spend people time and money until you satisfy him in writing (a) you know what you are doing, and (b) you have produced adequate instructions so a technician could do the data handling.

Before you can schedule the actual experiment, you must submit four (4) **items = a proposal, an operating procedure, a detailed test plan, and your design-performance predictions.**

1. Proposal {this is what your boss reads and makes decisions from}

You must convince your supervisor that you can get the right results quickly and economically. Tell your supervisor everything he/she needs to know -- e.g.

a) What do you propose to do?
b) How do you intend to do it?
c) What equipment will you need? {that is not part of the identified unit}
d) How long will it take? and what will it cost? {besides your labor}
e) What results do you expect?
f) How will you know if you have the right answers?

Do not make your supervisor waste time coming back to you with additional questions. Do not waste his/her time with UNNECESSARY information; be specific, avoid both vague generalities and excessive detail. You need to be clear, complete, and brief -- typically NO MORE than ONE PAGE.

{Think of this as a summary cover memo for the other 3 items. The proposal will be read by superiors who will not take the time to read the detailed plans and calculations}

2. & 3. Procedure & Test Plan {these are what the plant operators & technicians work from}

Give itemized instructions - imperative mood, clear, complete, brief, specific, and in a logical order. Do not attempt to evade decisions by leaving them to the technician. Specify

Procedure & Test Plan continued

(1) what data are necessary, (2) how they are obtained, (3) what "on-the-spot" calculations are to be done and how they are made, (4) starting and stopping points and how many points, (5) precautions to be taken, (6) type of graphs to be made, (7) ordinates and abscissas (e.g. "plot y vs. x"), (8) "canned" calculational routines or programs, and (9) any tables, charts, or equipment instructions drawn from your appendices or other sources.

Provide a set of blank tables, each with a descriptive title that will make clear to the technician and to any other party what the table does. Each column has a heading, and it also contains the symbol and the units where appropriate. There should be space for all original data in its original form in case any check has to be made at some future date. There should also be space for any repetitive calculations that are needed "in-the-field", as well as totals, averages, etc. { Data sheets should not include space for detailed result analysis calculations done by the engineer after the experiment. }

A hazardous operations (HAZOPS) analysis must be included with the procedure. Warn the technicians of all safety hazards that may be encountered in the tests, recommended action should an accident or operating failure occur, and specify all safety equipment needed to conduct the experiment.

4. Predictions

A copy of the final result plot goes to the technicians as part of your test plan to aid them in determining if the tests are going as planned. It may also go into the methods or theory section of the main report body; or it may go into the results discussion.

The calculation procedure and result tables are for your team of engineers to support the results analysis (and for the instructor to determine if you did the predictions correctly). These details do not go to the technicians, nor into the main body of the report. They eventually go into the formal report appendices.

FORMAL Reports

Each team will have one formal report with complete appendix. The proposal, test plan, procedures, and predictions as previously submitted should be **corrected** for both English and engineering, and included as an appendix. All data should be carefully and neatly recorded and included as an appendix. Show sample calculations in another appendix.

Remember to focus results on original assignment memo objectives.

Diagnostics of operating deviations must be explicit and supported by your data.

Recommendations must be explicit and thoroughly described. { Requesting maintenance to disassemble, inspect, and fix an unsubstantiated defect is not acceptable. }

Heat Exchanger Test Plans

1/12/08

Test Plan

In addition to the operating procedure, a detailed test plan must be prepared and submitted. The test plan should include**:**

1. Manual calibration check of computer temperature data system while system is cold. [i.e. evidence to convince yourself and your 'client' that the temperature and flow measurements are all reliable.]
2. Determination of maximum obtainable flow rate in each exchanger unit and calibration check of the flow meters. Include a specific procedure on how an internal leak check is to be conducted.
3. Pre-labeled BLANK data sheets to record all information you will need to do the results analysis. In addition to all temperatures and flow rates, you need actual steam pressure reading and actual barometric pressure. Also 'bucket & stop watch' flow meter calibration data and place to calculate the resulting GPM.
4. Each unit has its own pressure gauge. How do you know they are in calibration**?** Can you devise an experiment to compare the 2 gauges for similarity in accuracy**?**
5. How do you know when you have reached steady state to collect test data**?**
6. Specify at least 6 "target" flow rates to test and a procedure for technicians to determine actual test flow rates. Start-up safely at high cooling water flow rates and work your way down towards boiling limit. Specify safe cool down, shut down procedures.
7. After you have completed the minimum sequence of tests on a unit, you should randomly repeat several of the experiments to acquire the statistical evidence to determine confidence limits on the reliability of your experimental results.
8. The technicians should plot the actual test data on your prediction plots as they conduct the tests. This will let them make 'on-the-spot' decisions about whether the data is adequate and whether each unit is operating as designed.
9. If the two exchangers do not behave the same, the technicians need to devise new tests 'on-the-spot' to determine the cause of any problems and to provide data to support the eventual conclusions AND recommendations on how to correct the problems from reoccurring.

Note -- A group of technicians will be assigned to run your operating procedure, test plan, and collect the data for you. You will analyze the data collected by the technicians; you will not be running the experiment yourself and might not even be present. You will be the 'technicians' for some other group and be running their experiment for them.

EXECUTIVE SUMMARY 'Memo' Reports

Each person is to write their own summary and engineering analysis sections. ⇒ Focus on the results necessary to satisfy the project objectives and support conclusions.

Executive Summary reports should include ONLY the following format:

1. Title page.
2. Summary = ~1 page and includes objectives and conclusions.
3. Discussion & conclusions = engineering analysis; include result tables & graphs necessary to support the written discussion. **DO NOT** include all the details and appendix material which are in the formal report; only include appendix of any unique calculational analysis you did independent of the group.
4. Recommendations = summary of recommended operating conditions and modifications necessary to achieve the requested objectives.

Note -- ORAL Reports also should present only the above topics.

ALL Reports

OK to use footnotes for literature citations if less than a dozen sources.

Engineering analysis: (Results Discussion plus Conclusions & Recommendations) This is where you convince your supervisor (and his superiors) or client that your work is (a) competent, (b) inadequate, or (c) super. It is the most important part of the experimental lab work. Analyze your experiment and results, give limits of applicability, discuss sources of errors, reach and justify conclusions, make recommendations where applicable. Make clear to the reader that you actually have the right answer to the problem presented or specific recommendations on how to get the right answer. Make it easy to include you in (a) or (c), but hopefully not (b).