Fire Science Laboratory

How to Develop an Experimental Plan

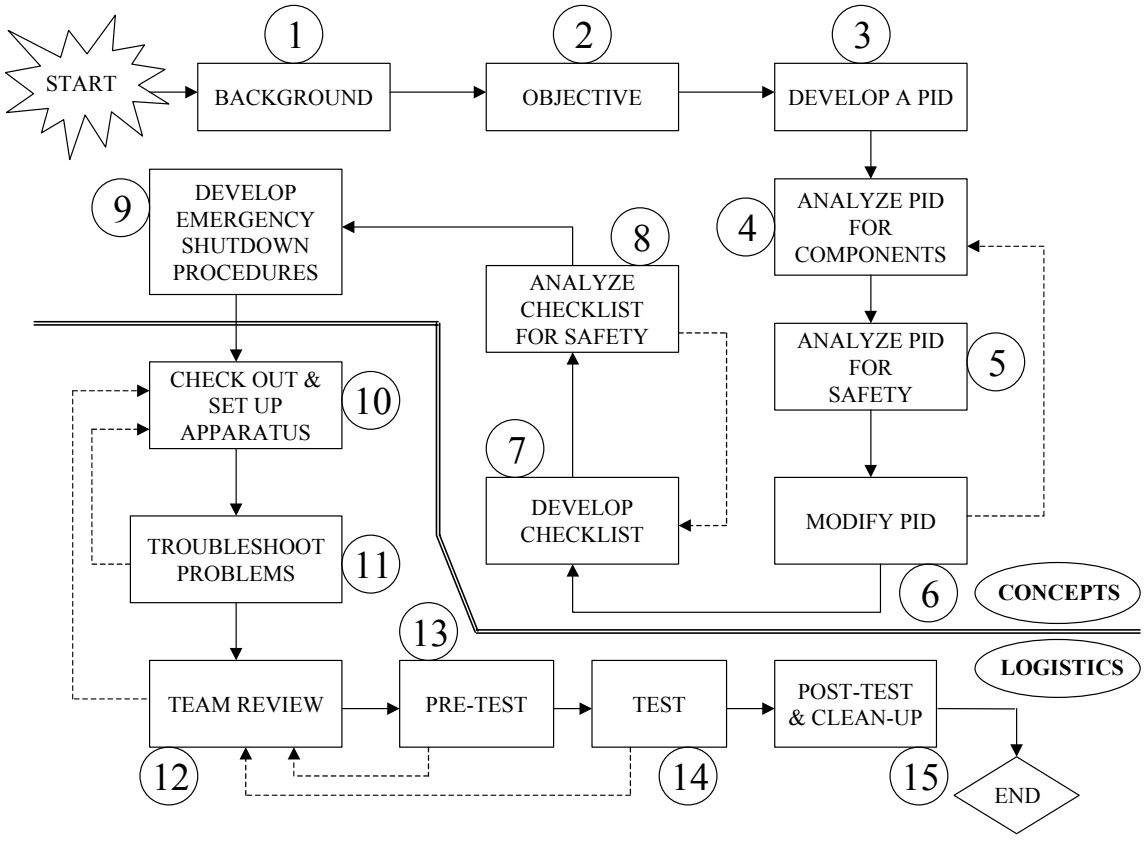
The purpose of this guideline is to help the student develop an Experimental Plan for testing. It will assist the student to understand the hazards involved and to design an appropriate and safe experiment.

The proper procedure for developing and running an experiment consist of 15 basic steps that should always be followed. The design of even very simple experiments follow these basic steps. A flowchart is presented to show these 15 basic steps and their interaction.

> *Note that steps 1 through 9 are concept and planning issues while steps 10 through 15 are logistical issues dealing with implementing the concept steps.*

Initial questions to ask yourself for each step are also included to help you understand the types of information and issues that are involved at each step. The listed questions are not all-inclusive, you should develop additional questions specific your experiment. Your advisor, the Faculty Coordinator and the lab staff are available to answer questions. See Experimental Plan Template or , Short Form for Short Tests to assist you in presenting your plan for approval.

Flow Diagram for Developing and Running an Experiment



Initial Questions for Each Step in the Flow Diagram
(Not all-inclusive. You need to develop additional questions specific to your experiment)

Steps 1 through 9 are concept issues. Thinking about and planning your experiment.

1. Understand the background.

    a) Why am I doing this project?
    b) What has been done before?
    c) What problems did they encounter?
    d) How can I avoid these problems?

2. Describe the objective.

    a) What is the data to be obtained?
    b) What is the scope?
    c) How involved do I want to get?
    d) What additional data could be obtained at the same time for future use?

3. Develop a process flow and instrumentation diagram (PID) i.e., a drawing of your apparatus with descriptions of how the various components interact.

    a) Describe the activities I need to do in order to achieve the objective.
    b) What is the approach?
    c) What steps need to be done?
    d) In what order?
    e) What steps depend on others?
    f) How do the steps fit together?
    g) What is the overall interaction?

4. Analyze PID for components needed.

    a) What equipment will I need to set-up and run the activity?
    b) What equipment will I need to shut down the activity?
    c) What about waste disposal?
    d) Do I need special insulation? Wiring? Fittings? Gages? Tube? Pipe? ect?
    e) Where will I run the experiment? Do I need a hood? A large space of floor? ect?

5. Analyze PID for safety issues (chemical, material, equipment or operational).

    a) What are the chemicals and materials needed?
    b) How will I store them, handle them and use them?
    c) What does the MSDS say? Other references and sources?
    d) What are the hazards of using these components, chemicals and equipment?
    e) Where do I get this information?
    f) What Protective Personal Equipment will protect me and others from these hazards?

6. Modify PID as required. Understand failure possibilities.

    a) Do I need to add components to achieve objective?
    b) How can each component fail? What will happen if that component fails?
    c) What can I do to minimize the risk of component or system failure?
    d) Does the PID need to flow differently to reduce failure possibility?

GO BACK TO STEP 4
REPEAT STEPS 4-6 AS MANY TIMES AS REQUIRED UNTIL ALL SAFETY ISSUES RELATING TO THE PID HAVE BEEN ADDRESSED !!!

7. Develop a checklist. Include a pre-test, test and post-test. The checklist is to be used during testing so you don't forget any steps.

    e) What are the pre-test startup procedures?
    f) What are the operating procedures?
    g) Am I collecting all the required data?
    h) What are the shutdown procedures?
    i) How do all the steps flow together?

8. Analyze checklist for safety issues (this is to insure all issues from PID are addressed in your SOP and checklist).

    a) How will I inform others of what I am doing?
    b) What are my "trouble" indicators during the pre-test phase and run phase?
    c) How many people are needed to run this experiment?
    d) What is each team members' assignment?

GO BACK TO STEP 7
REPEAT STEPS 7 & 8 AS MANY TIMES AS REQUIRED UNTIL ALL SAFETY ISSUES RELATING TO THE CHECKLIST HAVE BEEN ADDRESSED !!!

9. Develop emergency shutdown procedures.

    a) At what point am I venturing into an unsafe situation?
    b) What is a definition of an emergency or shut down situation?
    c) How do I safely shut down the experiment without causing more problems?
    e) What are any special conditions to be avoided?
    f) How do I know if I've reached them?
    g) What can I use to monitor conditions?
    d) What safety equipment could I need? Where is it located? How do I use it?

Steps 10 through 15 are logistical issues dealing with the actual set-up and running of your experiment.

10. Check out and set up apparatus.

    a) Have I scheduled time with the lab staff?
    b) Have I signed-in?
    c) Do I have all the components I need?
    d) Have I put it together correctly? Do I have any leaks? Do all components work properly?
    e) Am I blocking any paths of travel?
    f) Have I had the physical set-up checked out by the lab staff?

11. Troubleshoot problems.

    a) Do each of my components work separately?
    b) Did I follow the Troubleshooting Guidelines?

GO BACK TO STEP 10
REPEAT STEPS 10 & 11 AS MANY TIMES AS REQUIRED UNTIL ALL COMPONENTS WORK PROPERLY SEPARATELY AND AS A SYSTEM !!!

12. Team review of test.

    a) Do all members of the team know what is going on?
    b) Does everyone agree that it is safe?
    c) Does everyone agree that it will obtain the information needed?
    d) Does everyone understand their assigned role?
    e) Does everyone know the “trouble” indicators?
    f) Is everyone clear on the emergency shutdown procedures?

GO BACK TO STEP 10
REPEAT STEPS 10-12 AS MANY TIMES AS REQUIRED UNTIL ALL TEAM MEMBERS UNDERSTAND AND ARE COMFORTABLE WITH WHAT IS GOING !!!

13. Pre-Test

    a) Have I informed everyone in the area of my imminent plans to test?
    b) Am I following the checklist?
    c) Is everything looking ok to proceed to testing phase?

GO BACK TO STEP 12
REPEAT STEPS 12 & 13 AS MANY TIMES AS REQUIRED
UNTIL YOU ARE READY TO PROCEED TO TESTING PHASE !!!

14. Test.

a) Am I following the checklist?
b) Did I analyze the results for match to predicted calculations?
c) Does the data look valid and reasonable? Does it make sense?

GO BACK TO STEP 12
REVIEW YOUR DATA AND INSURE IT IS VALID BEFORE GOING ONTO ANOTHER TEST !!! INVESTIGATE AND FIX ANY OBSERVED PROBLEMS !!!

15. Post test/clean-up.

a) Shut down according to pre-planned procedures.
b) Insure everything is cool and off before leaving area. Clean up and put away tools and equipment.
c) Have I signed-out.

Helpful References (all available in the Fire Science Lab)

1. Hazardous Chemicals Desk Reference
2. Safety in Academic Chemistry Laboratories
3. Prudent Practices in the Laboratory
4. Laboratory Safety Pocket Handbook
   4a. page 125, Electrical Safety
   4b. page 177, How to Read and Understand a MSDS
   4c. page 171, Selection Criteria for Protection Devices
   4d. page 94, Hazards of Compressed Gas
   4e. page 137, Emergencies
   4f. page 67, Standard Methods of Prevention
5. Safety in the Academic Chemistry Laboratory
6. Hazardous Chemicals Desk Reference
7. Matheson General Regulator Instruction Handbook
8. Matheson Guide to Safe Handling of Compressed Gas
9. Gas Data Book
10. The Pocket Reference
    10a. page 339, Plumbing and Pipe
    10b. page 109, Electrical
    10c. page 257, Glues, Solvents, Paints and Finishes
    10d. page 385, Tools

11. Safety Notes (many topics)
12. Cone SOP
13. LIFT SOP
14. LODS SOP
15. Smoke Chamber SOP
16. Natural Gas Line SOP

17. Temperature Measurement in Engineering, Volume 1
18. Temperature Measurement in Engineering, Volume 2
19. Flow Measurement
20. Fundamentals of Temperature, Pressure and Flow Measurement
21. Handbook of Transducers
22. NFPA Handbook
23. SFPE Handbook
24. Materials Handbook
25. Sprinkler Handbook
26. Marks Standard Handbook for Mechanical Engineers
27. Handbook of Math and Physics

28. Tech and Application Notes (many topics)
29. Equipment Stock List
30. Gas Stock List
31. Tool Stock List
32. NFPA Codes
33. ASTM Codes

34. Websites
    - 31a. Lab Safety Supply webpage, www.labsafety.com
    - 31b. OSHA webpage, www.osha.com
    - 31c Vermont SIRI MSDS online webpage, www.hazard.com/msds
    - 31d NIOSH webpage, www.cdc.gov/niosh/homepage.html
    - 31e NFPA Chemical Hazard Labels, www.orcbs.msu.edu/chemical/nfpa/nfpa.html
    - 31f Thomas register of Companies, www.thomasregister.com
    - 31g Omega, www.omega.com
    - 31h National Instruments, www.natinstr.com
    - 31i Society of Fire Protection Engineers, www.sfpa.org
    - 31j National Fire Protection Association, www.nfpa.org
    - 31k. Factory Mutual, www.factorymutual.com
    - 31l National Institute of Standards and Technology, www.nist.gov
    - 31m. ANSI, www.ansi.org
    - 31n Environmental and Occupational Safety Office, www.wpi.edu/Admin/Safety
    - 31o Chemical Hygiene Plan, www.wpi.edu/Admin/Depts/Safety/Laboratory/hygiene.html
    - 31p. Haz Waste Policy, www.wpi.edu/Admin/Depts/Safety/Laboratory/hazardous.html
    - 31q. Golden Rules, www.wpi.edu/Admin/Depts/Safety/Laboratory/saferules.html
    - 31r. Federal Register 29 CFR Part 1910, www.counterpoint.com