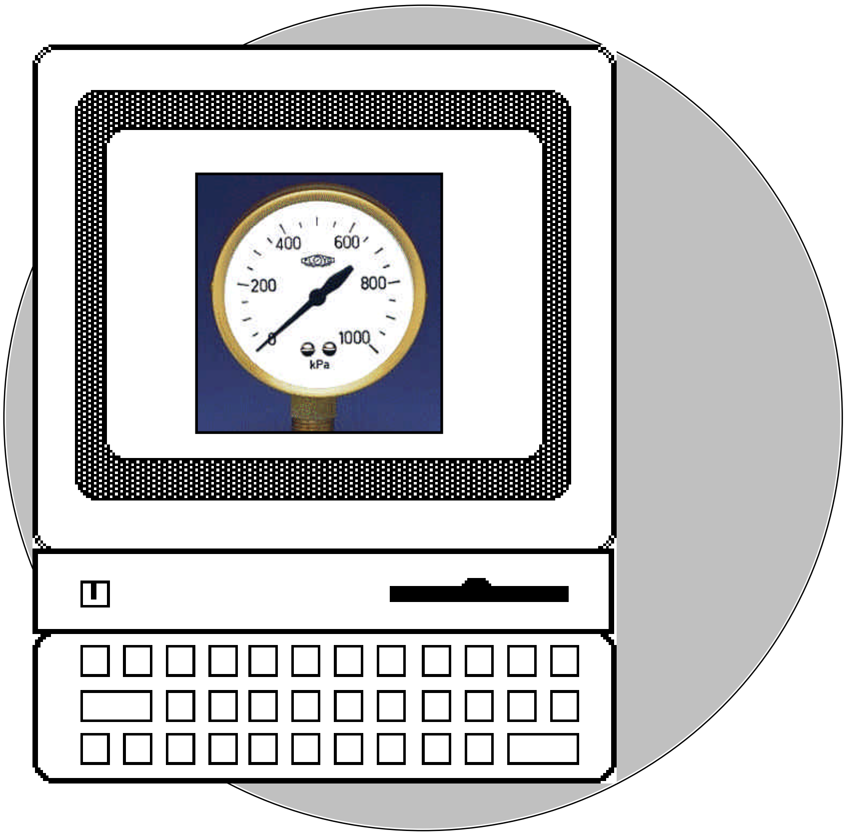
Locally Made Equipment for Teaching & Research in Agricultural Engineering

PRACTICAL RESEARCH, TESTING AND REPORT WRITING

Manual No. 8



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LOCALLY MADE EQUIPMENT FOR TEACHING AND RESEARCH IN AGRICULTURAL ENGINEERING

LIST OF TITLES IN THE SERIES

SERIES PREFACE

This manual is one of a series written to make available designs of basic equipment intended to be made by institutions for their own use in teaching and research in agricultural engineering and associated technologies. They are directed at the study of the functional performance of various machines and items of equipment and particularly at the important elements which determine that performance.

As well as providing drawings showing the main dimensions of the equipment, the manuals also include basic theory, design considerations, and techniques for their calibration and use. The designs are based, as far as possible, on the use of industrial components. In addition to specifying part numbers and sources of supply for purchased components, the latter have also been specified, where possible, in terms of size / capacity / performance so that suitable alternatives may be used.

A range of types of transducer from simple manually read devices to more complex electronic units may be used with the designs. In this way the latter can serve a range of users and can remain in use as the level of instrumentation grows.

The designs have been provided by individuals who have had experience in their development and use. We would value comment, criticism, and suggestions for improvements.

The assistance of the Australian International Development Assistance Bureau in providing financial support for the original preparation of the material for publication is gratefully acknowledged. They were originally printed and distributed to interested people by the Editor in 1991.

They are but are now being made available to a wider readership by being republished in a slightly amended form on the ePrints Repository of the University of Melbourne and can be down loaded free of charge at: http://eprints.unimelb.edu.au/

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PRACTICAL RESEARCH, TESTING AND REPORT WRITING

SUMMARY

This manual is one of the series on locally made equipment for teaching and research in agricultural engineering and associated technologies. It is intended to provide the educational and technical background for the study of such equipment in practical work and the reporting of it by students.

The objectives of practical research work and testing in agricultural engineering are presented, together with a discussion of the various types of experimental arrangement that are used for complete machines and test rigs. The types of performance test that are frequently undertaken and the significance of the experimental conditions are considered.

The main features of practical work reports are presented in Appendix 1 in a form that may handed out and kept for reference by students.

Key words*: Equipment, teaching, research, agricultural engineering, testing, performance, practical work, report writing.*

'Be doers of the word and not hearers only . . . .' The Bible: James 1:22

1.0 INTRODUCTION

Practical research and testing (hereafter termed practical work), comprising experimental laboratory and field work, is a common feature of many engineering and science courses. It is included because much professional work is of this type and the reporting of it, in technical papers and reports, is a major activity of workers in these fields.

Such practical work is meant to simulate the kind of research, investigation and testing that they will undertake during their employment. The topics may be different, but the principles of experimentation, analysis and reporting are the same.

Experiences in practical work should therefore be based on a series of exercises, graded in complexity from "set" laboratory type experiments, where the routine is more or less fixed, to "open-ended" research projects, where both the relevant factors and the methodology are not defined.

It is important that students be encouraged to make maximum use of these experiences to learn practical aspects of the construction and operation of the equipment being studied and to develop their own understanding of various experimental techniques.

As noted above, reporting of technical investigations is an essential part of professional work and practical work reports provide an opportunity for students to learn and to practise these skills. Reports should be written so that the reader, knowing nothing about the particular project, obtains a clear picture of it, including the results and the conclusions. Students should be warned to guard against the subconscious idea that the reader (professor, lecturer, tutor) already knows about the subject of the report and does not need to be told again.

Professionals are often required to work on their own and will, to a large extent, be judged by the standard of their work as revealed in their written reports. It is therefore necessary for students to develop, under the rigorous but caring scrutiny of teaching staff, a clear understanding of their work and a careful and critical attitude to the reporting of it .

2.0 OBJECTIVES OF PRACTICAL WORK

The general objectives of practical work may be set out as follows:

(a) Assist in teaching by:

- providing first-hand, close-range examination of equipment - see, touch and learn;
- reinforcement of explanations - what others have said is seen to be valid in our experience, with our equipment, in our environment;
- verification of theoretical models - experiments confirm theoretical predictions.

(b) Demonstrate experimental techniques through:

- illustration of the variability of operational conditions - constant forces, flows, etc. are only approximations to the real world; dynamics may be important;
- demonstrating measuring techniques - use of rigs, transducers, instruments;
- use of statistical analysis - variability may mask the effect being measured;
- interpretation of data - as much as, but no more than, is justified.

(c) Provide experience in technical reporting through:

- technical writing - precision in language is the key;
- presentation of results - in graphs, tables and equations;
- critical evaluation of work - through conclusions and recommendations.

(d) Provide the basis for assessment and credit:

- continuous assessment - the basis for learning and improvement;
- credit towards the final result in the course.

3.0 PRACTICAL WORK IN AGRICULTURAL ENGINEERING

3.1 Experimental Arrangements

The study of agricultural machines and equipment (hereafter referred to as machines) may be considered in various ways.

3.1.1 Testing of complete machines

The study of complete machines, as used by the farmer in the field, is usually of the research or survey type. It shows the performance of the complete machine, but it is usually not the best way to gain a detailed understanding of the principles on which the machine and its various components operate.

3.1.2 Testing with rigs

For the study of particular processes or components, it is frequently convenient and often necessary, to isolate the component that is of interest and build it into a measuring 'rig'. Hence it is possible to study it alone under controlled, or at least partly controlled, conditions. In doing this, facilities are set up to drive the component and to take the appropriate measurements. It may be done indoors or outdoors, as appropriate.

Rigs of this kind have many advantages over the use of complete field machines because they enable the worker to:

- examine the components at close range and to easily observe their operation under 'stationary' conditions;
- achieve a basic understanding of the operation and to determine which are the major variables determining the functional performance;
- repeat tests in the knowledge that results from all tests will be comparable because the conditions are at least partly controlled and the variation in results that arise from the natural variability of the field are eliminated or reduced.
- change the operating conditions in the knowledge that the results will reflect these changes only and not other hidden ones;
- repeat tests, irrespective of the weather or field conditions (for indoor tests).

The disadvantage of these tests is that the results are somewhat artificial. They do not exactly represent the operation and performance of the component as it occurs in the actual machine in the field, but that of it operating in somewhat ideal conditions.

Two kinds of rig may be identified:

(a) Those that are used to study an actual machine or a component of a machine. For example, in this series of designs, the Spray Calibration and Distribution Rig (Manual No 4) is of this type. It is designed to allow fitting and evaluation of various spray nozzles in a laboratory test.

(b) Those that are built to study a process. Here we may idealize and simplify the machine and so enable the rig to be used to determine theoretical parameters or to check theoretical predictions. The Grain Drying Rig (Manual No 7) is of this type. It is not intended to directly show the performance of any particular dryer. Rather it is to provide a means to understand the grain drying process, as a process in isolation, as far as possible, from a particular mechanical configuration. As such, it is able to provide a verification of the grain drying theory. It is intended that a commercial dryer would be designed on the basis of that theory and extensions of it.

The use of rigs for teaching and research, as described above, leads to a basic understanding of the process. When combined with overall field testing, a full exploration of operation and performance of the machine can be obtained.

3.2 Types of Performance Test

Two aspects of the performance of agricultural machines and equipment, that are of interest to the agricultural engineer, may be identified.

3.2.1 Functional performance

In the study of agricultural machinery, an understanding of the 'function', 'purpose' or 'objective' of the operation of these machines is required. This is, in effect, a study of the output of the machine, i.e. of what the machine is achieving in terms of a previously defined function.

The engineer asks, in effect:

- What is the function of this machine (or this component of the machine)?
- What are the appropriate parameters to represent its functional performance, i.e. what will represent how well it has achieved its function?
- How can we measure these parameters?
- How does this performance vary with the adjustments that are available to the user/operator?

Functional performance tests are designed to answer these questions.

3.2.2 Energy performance

In the study of agricultural machinery, the energy or forces involved are also of interest. This is, in effect, a study of the input to the machine in terms of parameters such as force, energy, power, fuel consumption, etc.

The engineer asks, in effect:

- What are the appropriate parameters to represent energy performance?
- How can we measure these parameters?
- How does this performance vary with the adjustments that are available to the user/operator?

Energy performance tests are designed to answer these questions.

3.2.3 Other performance measures

Other measures of performance, such as those associated with the life of the structure, the wear of the mechanism or the ergonomics of the operation, may also be identified. These are more specialized fields and are not considered in this series. It is assumed that they are such as to provide constant conditions, while the functional and energy performance are measured.

The use of the equipment provided in this series is intended to form the basis of a series of practical exercises for students studying and, in particular, measuring the functional and / or energy performance of various machines.

3.3 Experimental Conditions

As noted above, the objective of the use of rigs testing agricultural machines is to keep the operating conditions constant. The degree to which this is achieved is often an inverse function of the extent to which the natural operating conditions are simulated. For example, for rigs which are purely mechanical systems (and avoid the use of natural materials such as soil), the control is usually excellent, but the closeness to normal operating conditions less so.

Consider again, for example, the Spray Calibration and Distribution Rig (Manual No 4). The pressure settings can be repeated accurately from test to test; the effect of wind is negligible if the test is run indoors. However, the rig only allows the performance of the nozzle at the macro-level of distribution to be determined. The distribution at the intermediate and micro-scale (less than the width of the patternator trays - 50 mm) and the effect of the actual target surface on the distribution cannot be determined.

Other rigs use natural materials (such as seed or soil) in an indoor test. The simulation of the actual process is better than in purely mechanical systems, but control and repeatability are worse.

Consider again, for example, the Crop Drying Rig (Manual No. 7). Here an actual agricultural product is used as the test material and care must be taken when conducting and repeating experiments that this material (such as the seed size) and the test conditions (such as the bulk density of the bed) are as near identical as possible for every test where one variable has been changed, for example air velocity.

Other devices in this series are intended to act as a load for power units such as tractors and animals (see Manuals 2.1 and 2.2). Here the emphasis is on control, adjustment and measurement of the load. In this instance, the validity of the test is more related to the operating conditions of the power unit (duration of test, feed (animal), surface, fuel (tractor) etc.) than to the characteristics of the loading device.

Where possible, experiments should be run with one variable being changed at a time. The range of values for the variables should, in general, coincide with that which is experienced in the field.

4.0 REPORTS

The preparation of reports is an essential part of the work of many engineers. Students should therefore gain practice at it as part of their practical work programme. The important features of such reports are listed and discussed in Appendix 1. These may handed out and kept for reference by students.

5.0 BIBLIOGRAPHY

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Tuve, G.L. and Dumholdt, L.C. (1966): Engineering Experimentation (McGraw-Hill), 644 pp.

Ray, M.S. (1988): Engineering Experimentation: Ideas, Techniques and Presentation (McGraw-Hill) 330 pp.

APPENDIX 1

NOTES ON THE PREPARATION OF PRACTICAL RESEARCH REPORTS

The following are the important features of reports on practical research and testing.

1. Summary

All reports should include a summary. The purpose of this is to quickly inform the reader about the work and to allow them to decide whether it is of interest to them or not. It should state briefly what was done, the results obtained and the significant conclusions.

2. Objectives

This should state clearly, in general terms, the objectives of the work. The conclusions will be expressed in terms of these objectives.

3. Equipment

A list of the equipment that has been used should be provided. This should be such as would enable someone else to repeat the work, if necessary.

4. Method

The method should be expressed in general terms; it is not desirable to write a detailed description of every action. Again, it should be such as would enable the work to be repeated if necessary.

The language should be in the past tense, passive voice; for example: "The machine was operated at. . . ." The use of personal pronouns such as "I" or "we" should be avoided.

5. Results

The original data should be recorded on a tabular sheet prepared before the experimental work begins. Special readings, such as initial conditions, no-load, maximum load, etc., and abnormal conditions should be noted. The latter may help in interpreting the results when they are being evaluated.

In planning tests involving field work (such as tillage), it is, of course, desirable to find an area of land that is as uniform as possible. However, it is also usually necessary, due to the natural variations in field conditions, to do at least three runs for each test setting. In more formal research, it is necessary to prepare an experimental plan to enable recognised statistical techniques to be used for the analysis of the results. In these, consultations with a statistician <u>before</u> the testing work commences may be appropriate.

During a test, it is useful to plot the major results as the test progresses. This allows the test to be monitored; any readings that appear to be spurious will appear as a discontinuity. They can be checked by repeating that test before the test settings are altered. Points of special interest may also be investigated more closely.

6. Calculations

Calculations are a crucial part of the analysis of any practical work; they are the place where many mistakes are made. These can best be avoided by developing a systematic process that involves a single tabulation of a width sufficient for all the results and the values to be calculated. This would show, from left to right, the original data, any conversions necessary, the major derived values and, if they are different, any values to be plotted. The calculations are then made down the first column of the tabulation, then the second, etc., successively from left to right. If a computer spread-sheet is used, the same logic applies. However where an algorithim is used it is useful to check this by some other means.

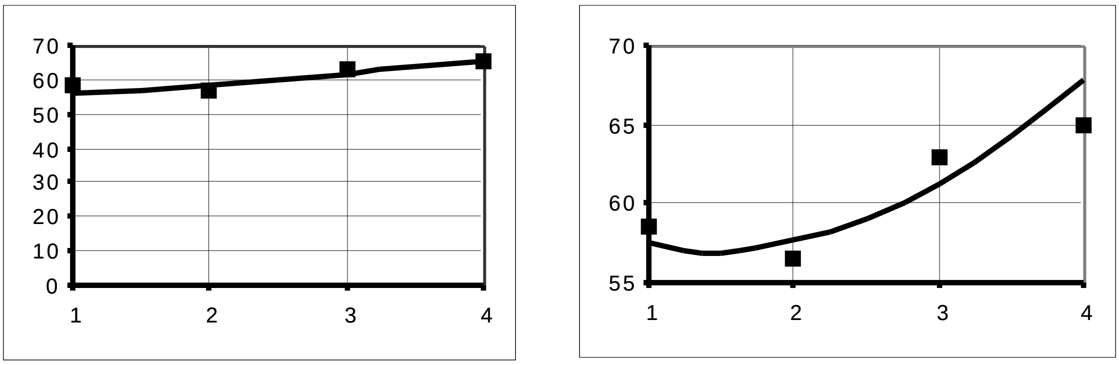
7. Graphs

Graphs represent a visual form of the results; they should be plotted wherever such a representation is a useful aid to their interpretation and discussion. Graphs also form a basis for interpretation by the reader; hence the actual points, as calculated, should be shown. This allows the reader to judge the form of the graph (the regression) and the fit of the data (the correlation). Only in more complex situations should statistical analysis be used to determine the regression equation and to calculate the correlation coefficient.

Each graph sheet should have a title and all relevant conditions should be stated. Axes should be labeled and scales marked; scales of 1 unit = 1, 2, 4, 5, 10, etc. should be used. Different graphs may be plotted in the same sheet, but points should be identified by means of different shapes. Where possible, graphs should be identified directly rather than by means of a legend.

There are well established conventions in each discipline for which variables should be plotted on which axes; these should be followed. Where such conventions are not available, it is usual to plot the 'independent', 'chosen' or the most fundamental variable in the horizontal axis. The 'dependent' or 'derived' variable is plotted on the vertical axis.

For graphs with linear scales (not logarithmic), it is usually best to plot the dependent variable from a zero base, as shown in Figure 1(a). This reduces the possibility of drawing of unwarranted conclusions about the variables, as might occur if the graph is plotted as in Figure 1(b). It may of course be that there is a curvilinear relationship between the variables shown. However there is too much 'variability' or 'error' in the readings to be confident of this. One might be encouraged to assume such a relationship if there were other grounds (eg, theoretical) for thinking so. Further testing with better control over the experimental conditions would be necessary to increase ones confidence in this conclusion.



(a) **(b)**

Figure 1: Correct (a) and incorrect (b) methods of plotting graphs

8. Discussion

This is perhaps the most important part of the report as it represents the writer's own thinking about the work. Where appropriate the discussion should include the following:

(i) A general discussion of the form of the results and a justification of the trends in terms of the process that they represent or of theory. For example in Figure 1 above, if the non-linear result is proposed, then some justification, (perhaps theoretical) ought to be offered.

(ii) A discussion of any departure from theory or from the ideal and the reasons for this.

(iii) A comparison of the results with published work. These may be actual values or be expressed in terms of coefficients, efficiencies, or 'specific' values.

(iv) An analysis and discussion of any errors associated with the work. Again in Figure 1 it appears that the variability in the results masks any non-linear variability that may exist.

9. Conclusions

Conclusions represent the logical outcome of the work . They should be expressed in terms of the original objectives, as expressed in (2) above and include all (but no more) than may realistically be concluded from the results.

10. References

Only references to published work actually quoted should be given. They should be arranged alphabetically, without numbering.

The citation in the report should consist of the name of the author and the year of publication, as follows:

- " . . . according to Halley (1686). . . .", or
- " . . . shown by an earlier study (Halley, 1686)."

For joint authors, the citation would read ". . . Halley and Smith (1686) . . ." or ". . . Halley et al. (1686) . . ."

In the reference list, each reference must be complete and in the following form:

- For an article: author(s), year, title of article, title of journal (underlined), volume number, page(s) cited.
- For a book: author(s), year, title of book (underlined), publisher (in brackets), page(s) cited.

11. Acknowledgements

Any special help with the work should be acknowledged in a simple manner.

12. Presentation

The quality of the presentation (whether hand written or typed) will be judged by the reader according to:

- legibility
- completeness
- accuracy
- precision and appropriateness in language
- consistency of style

A careful attitude in these matters will reveal an interest by the writer in his / her work and inspire confidence in the reader that will not be misplaced !.