EVALUATION

AGRICULTURAL MECHANIZATION

PROJECT

EGYPT

July 14, 1984

THE PRAGMA CORPORATION

815 West Broad Street
Falls Church, Virginia 22046
U.S.A.
Telex 899147 PRAGMA FSCH
Tel (703) 237-9303

ACRONYMS

AID	Agency for International Development
AMP	Agricultural Mechanization Project
ARE	Arab Republic Of Egypt
COP	Chief Of Party
FAO	Food and Agricultural Organization
GOE	Government Of Egypt
HP	Hewlet Packard
IFB	Invitation For Bid
LBI	Louis Berger International, Inc.
LL	Land Levelling
LOU	Letter of Understanding
MME	Machinery Management Extension
MOA	Ministry of Agriculture
MOI	Ministry of Irrigation
MOU	Memorandum of Understanding
PACD	Project Assistance Completion Date
PBDAC	Principal Bank for Development and Agricultural Credit
PIL	Project Implementation Letter
PM	Person Month
PP	Project Paper
R&D	Research and Development
SAO	Soil Amelioration Organization
SOW	Scope of Work
TA	Technical Assistance
UNDP	United Nations Development Programme
USAID	United States Agency for International Development

INTRODUCTION AND ACKNOWLEDGEMENTS

At the request of USAID (Cairo Mission, USAID/Washington) The Pragma Corporation was selected to conduct the mid-term evaluation of the Agricultural Mechanization Project (AMP). The team carried out its work in Egypt, from June 3 to July 15, 1984. The evaluation team wishes to express its appreciation to Drs. Sahrigi and Haddad and the project staff of the Ministry of Agriculture for their cooperation and assistance. The personnel of the many collaborating agencies who were interviewed also earned the gratitude of the team. Special thanks are due to Messrs. Lee and Radi of USAID/Cairo and to the whole T.A. team and their counterparts.

All these persons are to be commended for assisting the team during Ramadan and the holidays.

TABLE OF CONTENTS

		Page
Acronyms		i
Introduction and Acknowledgement		ii
I	EXECUTIVE SUMMARY	1
II	PROJECT BACKGROUND	11
	A. Project Physical Characteristics	13
III	EXTERNAL EVALUATION METHODOLOGY	16
	A. Primary Reasons	16
	B. Composition of the Evaluation Team	17
	C. Approach	17
	D. Methodology	18
	E. Constraints	20
	F. Schedule of Evaluation Team Activities	21
IV	EXTERNAL FACTORS	22
	A. General Project Setting	22
	B. Validity of Assumptions	23
V	INPUTS/OUTPUTS	27
	A. Inputs	27
	B. Outputs	31
	1. The Machinery Management Extension and Training Sub-Project	32
	2. Land Improvement Sub-Project	48
	3. Research and Development Sub-Project	62
	4. Planning and Evaluation Sub-Project	71
	5. Service Centers Development Sub-Project	77

VI PURPOSE 78

A. Project Focus 84

B. Project Paper Definition of Purpose 87

C. Inception Report 89

VII GOALS 91

A. Status of the Sub-Projects 92

VIII BENEFICIARIES 97

A. Direct Beneficiaries 97

B. Indirect Beneficiaries 99

IX UNPLANNED EFFECTS AND LESSONS LEARNED 101

A. Unplanned Effects 101

B. Lessons Learned 102

X CONCLUSION AND RECOMMENDATION 105

XI APPENDICES

A. Scope of Work A-1

B. Status Report on Agricultural Mechanization in Egypt B-1

C. Historical Level of Expenditure (May 31, 1984) Table 1 C-1

Level of Expenditure and Disbursement of Funds (May 31, 1984) Figures A and B C-2

D. AMP, Research Contracts D-1

Academic Training Programs, Table 1 D-2

Summary of Project Demonstration/ Training Equipment D-4

E. Publications Resulting from the Research and Development Sub-Project E-1

F. LBII, Technical Team F-1

G.	Agricultural Mechanization Reports, Technical Reports	G-1
	Activity Reports	G-2
H.	Distribution of the Service Centers and Village Workshops, Figure 1	H-1
I.	Examples of Farm Machinery Test Procedures and Data	I-1
	Suggested Minimum Description Data	I-2
J.	Relationship of Factors Affecting the Project	J-1
K.	List of Individuals Interviewed	K-1
L.	References	L-1
M.	Organization Chart of the Machinery Management and Extensions and Training Sub-Project	M-1

LIST OF TABLES AND FIGURES

		Page
A.	TEXT	
	Figure 1. Organizational Chart	12
	Figure 2. Project Area (map)	14
	Table 1. Level of Expenditure in Comparison to Budgeted Level (May 31, 1984)	28
	Table 2. Machinery Introduction Credit Fund Machineries Financed by Types and Number of Units	36
	Table 3. Machinery Introduction Credit Fund Disbursement as of April 30, 1984	37
	Table 4. Water Lifting Credit Fund Disbursement as of March 31, 1984	39
	Table 5. Population of Tractors and Agricultural Equipment pre 1000 Feddans of Cultivated Land Within the Project Area (1982)	86
	Table 6. Number of Tractors per 1000 Feddans (1978-1982)	87
B.	APPENDICES	
	Appendix C, Figures A and B Level of Expenditure and Disbursement of Funds (May 31, 1984)	C-2
	Appendix H, Figure 1 Distribution of the Service Centers and Village Workshops (map)	H-1
	Appendix M, Figure 1 Organizational Chart of the Machinery Management Extension and Training Sub-Project	M-1
	Appendix C, Table 1 Historical Level of Expenditure (May 31, 1984)	C-1
	Appendix D, Table 1 Academic Training Programs	D-2

EGYPT
AGRICULTURAL MECHANIZATION PROJECT
263-0031

I. EXECUTIVE SUMMARY

In September 1979, a grant agreement between the Government of Egypt and the Agency for International Development was signed which established the basis of funding for this project. The project was designed to build Egyptian capabilities to plan, support and carry out appropriate mechanization efforts. It is being carried out through the Agricultural Mechanization Research Institute and consists of five sub-projects:

1. Machinery management extension
2. Soil (Land) improvement
3. Service center development
4. Planning and evaluation, and
5. Research and development.

In addition, there were to be several supporting activities, such as training, assistance to small manufacturers, credit funds (i.e., water lifting fund, service center/village workshop funds) and research grants, which were carried out directly or through interaction with other organizations.

The project activities were focused on 25 selected villages in five Governorates. This area represented 41% of the total cultivated land in Egypt and was representative of the major agronomic and socioeconimic conditions within its boundaries. The budgeted cost of the project was U.S. $ 47.121 million, with the United States contributing U.S. $ 40 million (as amended)

and the Government of Egypt, U.S. $ 7.121 million in local currency.

This is the second external evaluation of this project carried out in the 45th month of operation by the Pragma Corporation.

Status of the Project

The project has been underway since September 1979, the date of signing a host country contract with Louis Berger International, Inc., for provision of technical assistance.

Inputs

The project gained momentum early 1982; the peak level of expenditure occurred in 1983 and continued in 1984. Over 75% of expenditures for commodities and 68% for technical assistance occurred during the 1982-83 period. The best performance is observed on the water lifting Credit Fund, followed by the service tender village workshop fund. Research funds experienced a slow start up and a decline in the rate of disbursement in 1983 which contributed about 485 person months; this is about 68% of the total planned input. The project has completed its T.A. team of 13 members. At the present time about 700 GOE personnel have been recruited by the AMP which constitute the total level of input as planned. Management, the USAID project officer, and the T.A. team deserve the credit for most of the recent project accomplishments.

Sub-Projects' Status

1. Machinery Management Extension

The purpose of this sub-project was to design a mechanization extension program that could serve as a model for establishing an equivalent component within the extension service.

Some of the major achievements to date have been:

- Fifty-one mechanization extension specialists selected, trained and appointed;
- 383 items of farming machinery were in operation as of June 1984, and 939 are being ordered for 1984-85;
- 1382 demonstrations/short courses given to 12,868 trainees (farmers and staff) and 1663 planned for an estimated 12,500 for 1984-85;
- 4 MOA staff members are completing MSC programs and 2 more are being processed;
- 26 farmer/leaders and 42 staff were sent on short-term technical trainings;
- A project extension information unit was established with basic photo and video tape equipment; it produced 10,000 posters, 120,000 extension folders, 18 television programs, 15,000 slides and 20 video tapes;
- A mechanized farming system was established on a Government farm where workshop and mechanized farming methods are taught;
- By the sub-project's technical support, over 200 pieces of equipment for a total of L.E. 636,000 have been

financed through the Public Bank for Development of Agricultural Credit (PBDAC);

- Technical support was also provided to PBDAC for disbursement of over 1.9 million L.E. to farmers for the purchase of water lifting equipment (1414 loans).

2. Land Improvement Sub-Project

Under the project a new division in the Executive Authority for Land Improvement projects was planned to be established to provide sub-soiling, drainage and land levelling services. The project in cooperation with the Soil Amelioration Organization would have supplied the necessary farm machinery, trained personnel and advisors.

Land levelling has been selected as a primary activity for land improvement and laser equipment as the instrument for precision levelling on a commercial scale. A total of 15 technicians received training, 37 tractors, and 26 laser units and other equipment were purchased and applied to the field activities. The sub-project should be able to complete precision levelling of 1000 feddans by the end of 1984.

3. Research and Development Sub-Project

The sub-project has a proposed budget of over 3 million dollars and is designed to support research in Egyptian institutions and funding of a farm mechanization Research and Development center. The staff includes sixteen professionals, twenty support personnel and two advisors. The sub-project's major achievements

to date have been:

- Refurbishing of the Agricultural Mechanization Institute Test Center
- Conducting tillage tests
- Modification and testing of four pieces of machinery
- Development of a prototype thresher
- Processing of nine applied research grants
- Conducting several in-country training programs
- Carrying out Egyptian-American collaborative research

4. Planning and Evaluation Sub-Project

The planning and evalution unit was designed to institutionalize an effective planning, implementation, and monitoring body for national agricultural mechanization programs. This unit consists of three advisors who are led by the Chief of Party.

The sub-project's activities were concentrated mainly on:

- Conducting five surveys (farm management, base line, water lifting cost, wheat planting and rice harvesting)
- Preparation of 22 technical reports that included economic studies, social studies, and specific activity evaluation reports
- Training of Egyptian counterparts primarily in data collection, compilation, and analysis
- Preparation of implementation plans, procedural guidelines and three letters of understanding for disbursement of loans

- Setting up of a small computer hardware unit (H.P. 85 and 86 for data processing)

5. Service Center Development Sub-Project

This sub-project was designed to address the basic repair and maintenance needs of the agricultural mechanization program in Egypt.

As originally designed, a total of $5 million of the loan fund was allocated for disbursement to the private sector for service center and village workshop development through PBDAC.

So far, the requests for funds for six service centers have been approved by the bank (L.E. 1,064,718), with five more applications under review. The amount of committed funds, as of May 7, 1984, totaled L.E. 639,200.

A total of 23 workshop loans are completed, 5 approved by the bank but not processed, 40 loans are under bank investigations and 16 are being reviewed by the project.

Beneficiaries

By the completion date, this project should be able to reach about 25,000 farmers through demonstration and training courses.

- The project provided off-shore training for 26 key farmers and 42 staff members and in-country training for 51 mechanization specialists

- The water lifting fund with its eminent success, assisted some 10,000 farmers in replacing the animal-drawn Sakias with motor driven pumps
- The university community through involvement in conducting agricultural machinery design and development research directly benefit from the project and finally
- The service center/village workshop fund and the machinery introduction fund will indirectly benefit more than 24,000 farmers within the project area.

Conclusions

The evaluation team's general findings are that:

- In the last two years the project has shown an accelerated progress toward achieving its goals.
- The project will achieve its objectives if additional time for extension of selected activities are allowed. (No additional funds are necessary, since the project has only expended 37% of its total allocated funds.)
- The project, due to a slow start at the early stages of implementation, is behind the schedule if measured by the project paper implementation plan.
- The direct and indirect effects of the project measured through beneficiaries are impressive.
- The project will contribute to the goal of increasing production and incomes within the project area if additional extension is allowed.

Recommendations

Some of the important ongoing project activities are not expected to be completed by the end of the project. This applies especially to the following activities:

a) Those which are time consuming (e.g., off-shore academic training);

b) Those programs which were too extensive to accomplish during the time frame proposed (e.g., completing demonstrations, training of trained mechanics/operators in all 25 villages) and;

c) Those components which are essential but could not be accomplished, such as the training of research support staff on the use of specific testing equipment (in-country training which must be carried out after the equipment has arrived) and continuation of the off-shore academic training.

1. Since available funds to cover these activities will still be available, USAID should consider extending those components that take a longer time to implement.

2. If the project activities are extended and follow the path as recommended by the team, priority should be given to organizational structure and project monitoring. For this purpose, services of short term consultants can be utilized. Organizational structure, interaction of the projects' departments, divisions and personnel along with scopes of work should be prepared. Efficient systems of management data collection and analysis, and a brief format for quarterly reporting of project activities should be prepared.

3. In the remaining time, the project should focus on clarifying the future institutional responsibilities for the activities it has initiated. To insure the continuity of those activities that cannot be transferred to the Agricultural Mechanization Research Institute, (i.e., those involved in the disbursement of credit funds) available AMP trained staff and personnel should gradually be transferred to appropriate positions.

4. Priority should be given to the custom clearance, assembly, and distribution of the large number of equipment items scheduled to arrive in the next six-month's period. Outside support assistance may be needed to assist in equipment assembly.

5. The characteristics of the soils (soil survey) provide important information for technical decisions involving land improvement and mechanized tillage. To the extent feasible, the project should consider the importance of the soil data.

6. The effectiveness of the three revolving funds (service center village workshops, machinery introduction and water lifting) can be further facilitated and improved by modifying the letters of understanding to provide for continuation of loan disbursements and to shorten the loan-making process. Credit fund disbursement involving the project's agricultural mechanization loan approval, processing, and monitoring would be further improved by involving other banks in the process.

7. The water lift fund should be replenished as soon as possible. The success of the fund disbursement is sufficient justification for such action.

8. An immediate review of the legal documents to assess omissions and needed requirements could be helpful. Appropriate amendments allowing line items adjustments should be prepared and approved by all parties.

9. An internal evaluation during December 1984 will be helpful to assess the total project progress and assist in identifying those items needing action before project termination and preparation of the End of Project Status.

10. A simple semi-annual review of project financial data broken by sub-project should be prepared. This should be carried through the life of the project and will provide the management with a clear picture on actual flow of funds in relation to sub-projects' activities and progress. The study can begin from the inception of the project and should include projected pipeline and actual level of expenditures.

II PROJECT BACKGROUND

The Agricultural Mechanization Project (AMP) is a five-year undertaking designed to provide assistance to GOE to institutionalize an appropriate planning and implementation system for the development of mechanization programs. The project is carried out by an agricultural mechanization unit established within the Ministry of Agriculture (MOA) under the direct supervision of the Minister (see AMP organization chart figure 1).

The project consists of five sub-projects as follows:

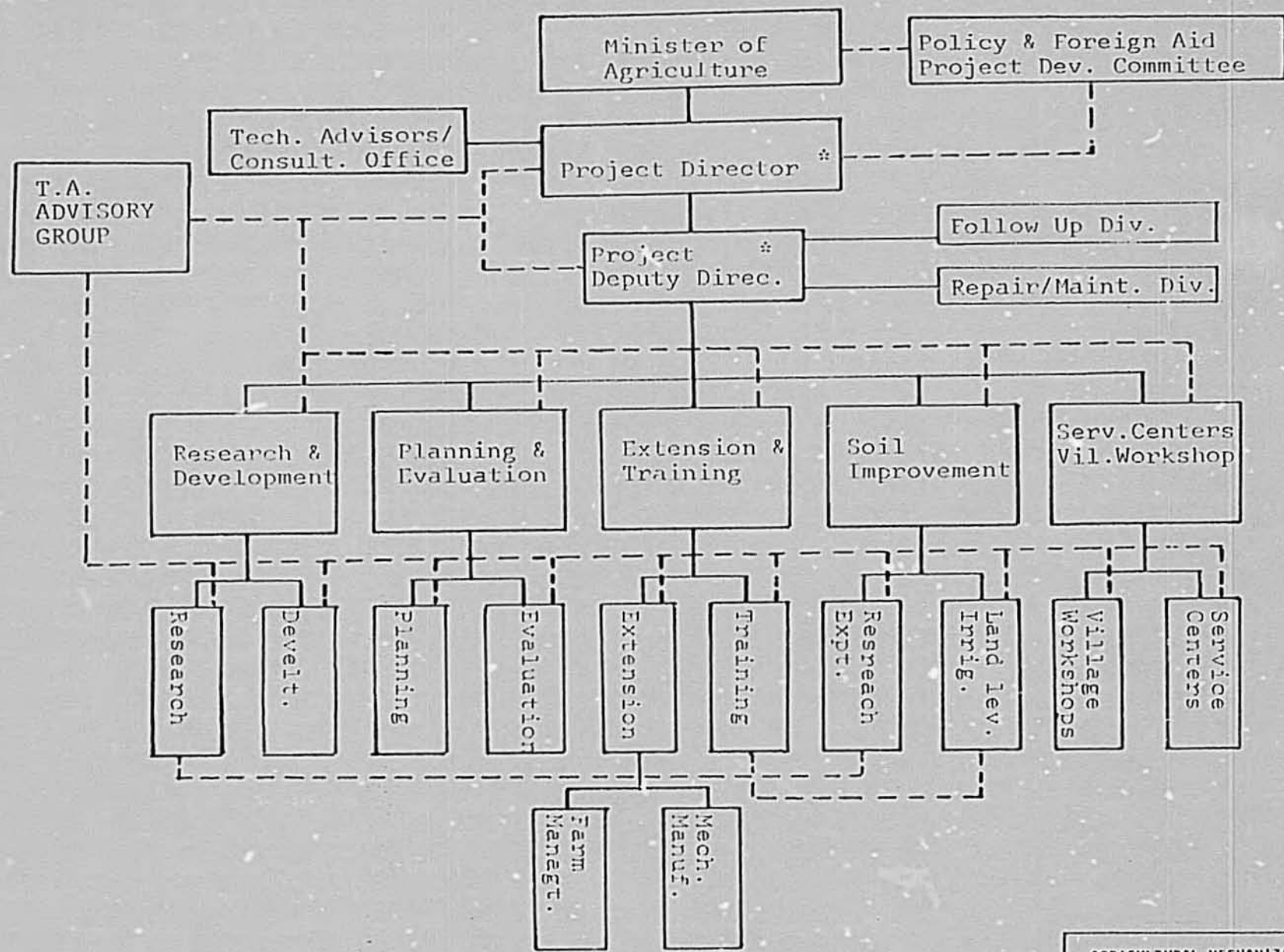
1. Machinery management extension
2. Soil (land) improvement
3. Research and development
4. Planning and evaluation
5. Service center development

In addition, there were to be several supporting activities, such as training, credit and research funds.

A project director, a deputy director, five sub-project directors and a team of 13 expatriate advisors form the core of the management and advisory group. Each member of the technical assistant group provides advisory services to at least one Egyptian counterpart. The project director has full authority in implementation of the project within the confines of MOA and USAID rules and regulations as they apply to this project. As appears in the project paper (P.P.), the intent of the project is both to build general capabilities to meet demands for services and information, and to affect demand growth through extension, planning, research, training and funding mechanisms. In the

Figure 1

AGRICULTURAL MECHANIZATION PROJECT ORGANIZATIONAL CHART



* Also director and deputy director for the Agricultural Mechanization Research Institute which supervises implementation of four other foreign aid projects in inter related fields of agricultural mechanization. (Source:Dr.A. Sahrigi)

AGRICULTURAL MECHANIZATION PROJECT
EXTERNAL EVALUATION
JULY 1984

THE PRAGMA CORPORATION

process, the growing tendency to allow farmers to set the pace and scope of mechanization will be strenghtened. Part of the strategy is thus to maximize private sector provision of mechanization services.

A. Project Physical Characteristics

Project implementation activities were primarily kept within the boundaries of five Governorates:

1. Beheira
2. Gharbiya
3. Qaliubiya
4. Sharkiya
5. Minya

A total of 25 villages were selected as project areas within these Governorates (figure 2). Nine villages outside the project area were used for control. Outside organizational support and involvement included:

- Universities and other institutions for conducting research and development,
- The Principal Bank for Development and Agricultural Credit (PBDAC),
- Research and development centers and stations,
- Other Agricultural Mechanization Projects in Egypt.

The area covered by the five Governorates (2,148,000 feddans) represents 41% of the total cultivated land in Egypt.

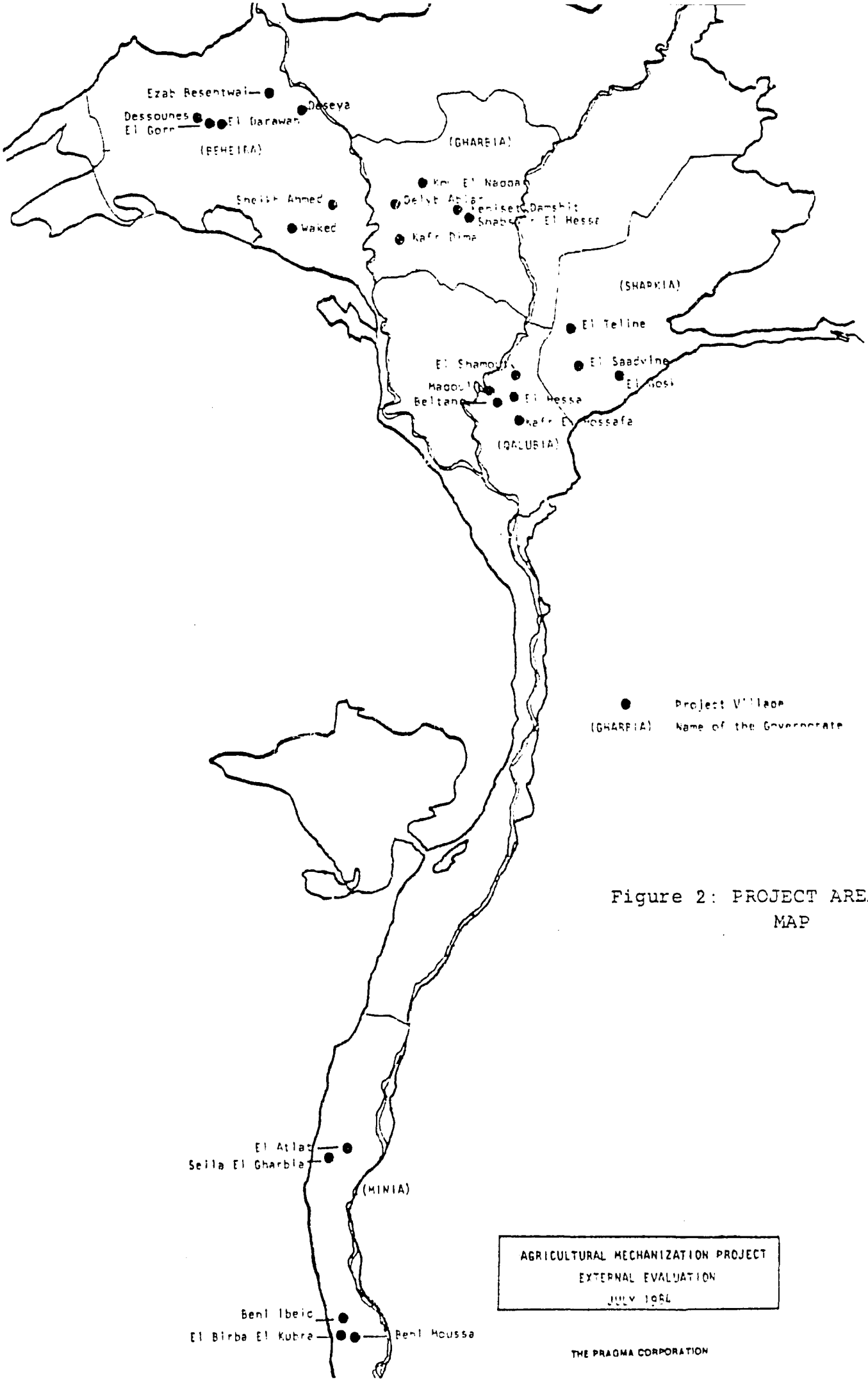


Figure 2: PROJECT AREA MAP

Projects Dates

In September 1979, under the auspices of the Foreign Assistance Act of 1961, as amended, the Agency for International Development (AID) signed an agreement with the Government of Egypt through which a total of 40 million U.S. dollars (as amended in November, 1979) was granted for implementation of the project. On September 15, 1980, MOA signed a five-year contract for provision of a technical assistance advisory group with the Louis Berger International Incorporated (LBII). Signing of this contract initiated actual implementation of the project.

III. EXTERNAL EVALUATION METHODOLOGY

A. Primary Reasons

The external evaluation of the Agricultural Mechanization Project (AMP), which was scheduled for the first quarter of 1982, was designed to examine "the implementation status of each component, identifying issues and problems as necessary" and to determine "the overall effect of the project." Since the project was in its early stages of implementation, this initial evaluation was delayed until February, 1983. The resulting evaluation report "was not considered adequate to assess overall project progress or to identify possible problems and solutions. Since the report was considered inadequate, a supplementary evaluation, reflecting an additional year of implementation, was requested. The request was granted and the report presented here is the result.

The primary reasons for the external evaluation are:

1) to provide assessment of:

- progress in achieving the project's output to date,
- the status and progress in overall coordination among the sub-projects, and make recommendations for improvement,
- the project's potential to affect the private sector, farmers' income, demand for labor and agricultural productivity;

2) to document and comment on:

- the extent of progress made in achieving the project purpose,
- the project's impact on farmers and rural dwellers, and to analyze the project's impact on agricultural mechanization in Egypt and recommend necessary actions for an efficient implementation during the remaining life of the project." (The scope of work for the evaluation is presented in Appendix A).

B. Composition of the Evaluation Team

Dr. Mohammad Fatoorehchie
Team Leader / Economist

Dr. Anacleto G. Apodaca
Agricultural Extension and Training Specialist

Dr. Wifredo De Rafols
Agronomist

Dr. John E. Dixon
Agricultural Engineer

C. Approach

The approach in meeting the scope of work was, first to review the project at the planning and design level (pre implementation) by studying the project paper, the grant agreement and the work plans. This was followed by making field visits, interviewing various people, and by reviewing project documentation and activities from initial implementation through current status and operation. The third step in the approach was to identify accomplishments, problems, and constraints based on the above

gathered information. In the fourth step, the expertise of the evaluation team and the team's experience was used in identification and analysis of accomplishments and constraints. This analysis suggested the reasons for the progress and discrepancies in the course of project implementation. The whole approach culminated with the team formulating conclusions and recommendations based on their findings. In preparing their report the team followed the outline for the Project Evaluation Summary. (PES).

D. Methodology

Several evaluation techniques were employed during the course of study. These include but were not limited to:

1. Conference sessions with personnel from the Ministry of Agriculture (MOA), Ministry of Irrigation, Principal Bank for Development and Agricultural Credit (PBDAC) and officials responsible for direct or indirect collaboration between the project and their respective organizations.
2. On-site visits to the sub-projects operations sites in five governorates.
3. Conferences with MOA and Louis Berger International personnel working in various capacities of project management and operation.
4. Review of published reports, specifically the activity reports, working papers, contract documents, operating procedures, memorandums of understanding (MOU), the

project paper (PP), the grant agreement, project implementation letters (PIL), and invitations for bid (IFB).

5. Review of the management style being used in planning, operation, and internal evaluation of the project.

6. Discussions with officials of other agricultural mechanization projects and operations personnel directly or indirectly involved with the project or sub-project operations. These discussions included people from other donor organizations.

7. Visits with the USAID/Cairo officials and personnel to clarify findings on delays, release of funds, and procedural inefficiencies.

8. Visits to several workshops, service centers and agricultural machinery and equipment showrooms. Team members discussed project effectiveness, problems and potentials as they affect the private sector.

9. A visit to the machinery research and development (R&D) center in Alexandria, and conferences with University of Alexandria personnel. Project impact, research goals, problems, and results potential were discussed with the University project principal investigator, University officials and the research director, among others.

10. In-field visits to several villages. Team members discussed and investigated project caused mechanization on farming operations and possible changes in the farmers' lifestyle and farming practices as affected

by the project.

11. Visits with banking officials at the national and governorate level. The project's activities, as they affect the banking system and their clients, were discussed.

12. Comparative analysis and trend and progress review techniques were used based on observations, review of documents and the evaluators' past experience. These items formed the foundation of this evaluation study.

Lists of organizations, sites visited, key individuals interviewed and a list of references appear in Appendices K and L respectively.

E. Constraints

The evaluation team had to function under several constraints which affected its performance. Chief among these was the very limited time originally allowed for evaluating such a large and complex project, including the writing of the report and its discussion with both USAID and MOA representatives. In addition, the timing was unfortunate because the team's arrival coincided with Ramadan (June 3rd) and the accompanying changes in office hours and absence of the staff during the critical last week of the team's visit. The team is very grateful to the project and USAID staff for interrupting their holidays to assist in completing the evaluation.

F. Schedule of Evaluation Team Activities

June 3	Arrival in Egypt (Cairo)
June 4	Briefing, orientation, preparation of the team's workplan
June 5-10	Interviews; Cairo
June 11-13	Field trip to Minia Governorate
June 14	Field trip to Qalubia and Sharkiya Governorates
June 15	Interviews Cairo
June 16-17	Field trip to Gharbiya and Beheira Governorates and Alexandria
June 18-26	Interviews, report preparation
June 27	Joint meeting with MOA and USAID staff to review findings, conclusions, and recommendations
June 28-July 3	Incorporation of comments and completion of report
July 4	Delivery of first draft to USAID and MOA
July 5	Revisions to rough draft
July 6	Departure of specialists
July 6-12	Report finalized for delivery to USAID and MOA
July 12-14	Printing, binding and shipment of final report.

IV. EXTERNAL FACTORS

A. General Report Setting

1. Social economic conditions in project areas

There have not been any major changes in socio-economic conditions in the project area. It is interesting to note that according to the AMP village profile, working paper No. 6, there are some important characteristics, such as: There were 22,779 landholders on 37,029 parcels of land; the majority of the villages have between 2,000 and 10,000 inhabitants with an average of 6,000; the cultivated area of each project village ranges from 485 to 3,815 feddans.

2. Status of national agricultural mechanization

Agricultural mechanization seems to have gained importance since the project began. The MOA activities have been brought under a single director in the Agricultural Mechanization Institute. He is also Director of the AMP, as well as having the responsibility of other mechanization projects. In addition to those under the Director's control, there are several projects from other donors which have agricultural machinery components. (See Figure 1).

"The MOA has issued, for the first time, a five year plan for mechanization that describes the following areas as the most promising for production increases through mechanization:

a. Better seedbed preparation

b. More timely planting

c. Precision levelling operations

d. Replacement of animal drawn sakia with motor-driven pumps

e. More diversified used of tractors

f. Placement of thresher-winnowers and mechanical grain harvesters.

The plan concludes that in order to achieve progress in these areas, equipment constraints and support system deficiencies must be addressed. The plan is designed to address equipment shortages, introduce new techniques, establish a countrywide network of service and repair centers, and train mechanics."[1] This excerpt is quoted because its objectives are so similar to those of the AMP and it may be assumed that the project influence is evident.

3. Other donor projects on agricultural mechanization

A number of other donors are carrying out related projects or have plans for them. (See appendix B).

B. Validity of Assumptions

As explained earlier, the implicit assumption of the PP of a global approach was rejected. Due to fund limitation (U.S. $40 M), the pilot approach to implementation of the AMP is more appropriate. During the following analysis, the pilot approach to implementation of the project is considered as an implicit assumption. The validity of the PP assumptions are examined and appropriate explanations given.

---

[1]USAID States Report on Agricultural Mechanization in Egypt.

1. <u>At the goal level:</u>

- "GOE policies encourage agricultural production." This assumption as applied to the implementation of the AMP remains valid.
- "Higher production translates into higher farm incomes."

  If prices of the input and output move together, this assumption remains valid.

2. <u>At the sub-goal level</u>:

- "Relative prices of labor and equipment do not discourage farm mechanization."

  A preliminary review of project findings and available data suggests that some degree of substitution between capital and labor exists. The elasticity of possible changes should be investigated further by a study utilizing production economic models. The planning and evaluation sub-project can carry out the analysis in early Summer, 1985. This study should test the degree and magnitude of substitution between capital and labor in response to price changes. In our view, the assumption should remain valid for changes in relative prices of labor, irrespective of the change in the prices of equipment.

3. <u>At the purpose level:</u>

- "GOE provides necessary resources." Although the provision of necessary resources by GOE on numerous occasions faced some problems, quantity and magnitude have not caused significant obstacles in implementation of the project. This assumption is valid.

- "GOE is serious in commitment to turn over certain responsibilities to the private sector."

  GOE has done a commendable job in disposing the services of PBDAC for disbursement of funds to the private sector. On several other issues, attempts have been made to encourage involvement of the private sector in agricultural mechanization.

  This assumption is valid.

4. <u>At the output and input level:</u>

- "AID/GOE resources necessary for implementation of the project are available."

  Other than the issue as discussed in No. 3, above, the project received full AID/GOE support.

  The assumption is valid.

- "Contracting and commodity procurement proceed according to implementation plan."

  As discussed earlier, the designed implementation

plan as it appears in the PP underestimates the actual time needed for procurement.

Therefore one of the assumptions, that of the time required for contracting and commodity procurement as it applies to inputs is invalid.

Availability of AID/GOE resource remains as a valid assumption.

V. INPUTS / OUTPUTS

A. INPUTS

The total level of funding of 40 million dollars for implementation of the AMP includes 21.2 million dollars of U.S. $ equivalent in local currency and 18.8 million dollars in foreign currency.

As of May 31, the total expended amount reached 26% on foreign currency (U.S. $4.966 million) and 45% on local currency (L.E. 9.643 million).

The team was informed of a noticeable level of expenditure which will possibly appear in the end of June financial statement. In our estimate, this item will amount to about 5% of the above expended amount.

The projected level of expenditure up to June 1, 1984 is 30 million dollars which is equivalent to 75% of the total allocated funds. The level of expenditure by line items differed from one activity to another.

Table 1 briefly presents the planned level of expenditure in comparison to total budget and the corresponding percentage of expenditures by line item.

Table 1 Level of Expenditure in Comparison to Bucgeted Level
May 31,1984

U.S.$ 1,000

Item	Planned U.S.Dollars	Expended To Date U.S.Dollars	Expenditure % Percentage
1. Technical Assistance	8,726	4,713	54
2. Commodities	13,133	3,379	26
3. Training	3,023	693	23
4. Research Funds	3,005	208	7
5. Special studies and evaluations	943	22	2
6. Other costs	100	28	2
7. Facilities	70	--	0
8. Loan funds	11,000	5,566	51
T O T A L	40,000	14,609	37 Avg.

Source: Activity Reports - Projects Financial Data.

All activities, in terms of expenditure level, are behind schedule. Those that require immediate attention and mobilization of resources are:

1. Evaluation and special studies
2. Training
3. Research study funds

A review of pipeline (allocated and acted upon) expenditure and actual activities by the project shows that other line items, such as commodities and loan funds, are receiving adequate attention and therefore are not treated as critical activities. Evaluation, as mentioned earlier, requires attention by the management, since its activities are considerably behind schedule.

A review of time series data on level of expenditure is a simple but effective indicator of the history of implementation during the life of the project. As is depicted in Figures A and B and Table 1 Appendix C, the project gained momentum toward the end of 1981, the peak level of expenditure occured in 1983 and continued in 1984.

The best performance is observed on the water lifting Credit Fund followed by the service center village workshop fund. Over 75% of the expenditures for commodities and 68% for technical assistance occurred during the 1982-1983 period.

Research funds experienced a slow start up and a decline in the rate of disbursement in 1983. The decline may be attributed to the development of cumbersome grant approval and release processes adopted by universities and MOA. These requirements had a dampening effect on flow and approval of proposals from

the university community.

The attention and influence of the AMP management is needed to alleviate these obstacles.

The technical assistance team has contributed about 485 person months (PM), which is about 68% of total planned T.A. input of 713 PM.

The project has completed its T.A. team of 13 members. At the present time the evaluation advisor's position is vacant. An immediate replacement for this position is necessary.

The MME extension sub-project held 1382 demonstrations and short courses for 12,868 farmers, tractor operators and staff. For 1984-85, 1660 demonstrations/short courses for an estimated 12,500 trainees are planned. Twenty-six farmer/leaders and staff members (69% of the planned participants) were sent on off-shore short-term training, with 31 more planned for 1984-85. Four MOA staff member (14%) are completing MSC degree programs abroad and 2 more (7%) are being processed for departure. Twenty-two more are scheduled to go in 1984-85, although not enough time remains in the project to complete the two-year program. An extension has been requested from USAID; this may require continuation of certain project activities.

At the present time about 700 GOE personnel have been recruited by the AMP, which constitutes the total level of input as planned. Although training of these personnel is underway, the suitability and quality of the program should receive appropriate attention from the management.

B. OUTPUTS

As described in the background (Chapter II) the project consists of five sub-projects:

1. Machinery Management Extension and Training;
2. Land Improvement;
3. Research and Development;
4. Service Center Development; and
5. Planning and Evaluation.

In addition, there were to be several supporting activities:

1. Training (in country and abroad), which was later added to the Machinery Management Extension Sub-Project (MME);
2. Water Lifting Equipment Credit Fund;
3. Service Center Credit Fund;
4. Machine Introduction Credit Fund;
5. Research Grants.

These supporting activities are discussed in Chapter V Section A (Inputs).

Although the individual sub-projects are carrying out their own programs, they are mutually supportive, and coordinated by the sub-project directors and activity managers at project headquarters. In addition, there is some area coordination at the Governorate level. The technical assistance advisors are distributed within the sub-project activities according to their specialization under a Team Leader who works directly with the Project Director and Project Coordinator. (Chapter V Section A, Inputs).

Because of the coordination and the fact that the sub-projects can be considered an output of the AMP as a whole, this chapter has been organized to describe the sub-project activities.

The development of the sub-project and supporting activities are described in the following pages.

1. The Machinery Management Extension and Training (MME) Sub-Project: Objectives

As stated in the project paper, "through the project it [the sub-project] is proposed to assist the Ministry of Agriculture in establishing a meaningful farm machinery extension program. Emphasis will be on tillage and seedbed preparation, farm operations, maintenance and repair of equipment, water-lifting, implement selection, assistance to small manufacturers, and cost and return evaluation." In addition, the program would introduce modest numbers of selected new equipment items, provide technical assistance and credit funds. Finally, training programs for extension staff, farmer-owners and operators of equipment, service center staff and small manufacturers would be developed. The project was also to establish a training support group to plan both in-country and overseas training mechanization.

Purpose of Sub-Project (MME)

The purpose of this sub-project, as stated in the 1982 MME Annual Report was to design a mechanization extension program that could serve as a model for establishing an equivalent component within the extension service with appropriate linkages

to the Under-Secretary for Engineering Affairs.

MME Sub-Project Organization and Inputs

In the Inception Report, the central core of the project was to be the research and development, and the machinery management extension sub-projects. In June, 1982, training was placed under the MME sub-project. Field operations were concentrated in 23 randomly-selected villages in five Governorates; two additional villages were added at a later time, one of which was used for pre-testing field recommendations.

The sub-project is presently divided into seven units:

1. Rural agriculture mechanization information
2. Demonstration/training system (mechanized farming)
3. Field extension on Machinery Management
4. Machinery introduction fund
5. Demonstration of and training in equipment maintenance
6. Land improvement extension, and
7. Training unit (in-country and off-shore).

Of the 73 technical staff, 51 are field mechanization extension specialists who report to their area extension officers but work directly with project regional coordinators in the five Governorates. (see Appendix M Figure 1).

The first mechanization extension program (1982-83) for the project villages, compiled by 23 agricultural mechanization specialists, contains a wealth of basic information. It lists

as important initial constraints:

a) The inadequacy of skilled technicians, maintenance workshops, agricultural machinery and farm roads;

b) The small and scattered land holdings, with irrigation and drainage difficulties, and;

c) Economic constraints: i.e. costly production inputs, pricing issues and marketing problems, and high wages due to seasonal labor scarcity.

Achievements of sub-projects

Some of the major achievements to date have been:

- Fifty one mechanization extension specialists selected, trained and appointed;
- 383 items of farming machinery in operation as of June 84; and 939 ordered for 1984-85;
- 1382 demonstrations/short courses given to 12868 trainees (farmers and staff) and 1663 planned for an estimated 12,500 for 1984-85;
- 4 MOA staff members completing MSc programs and 2 more being processed;
- 26 farmer/leaders and 42 staff sent on short-term technical training;
- 31 more farmer/leaders and staff to be sent on short observation trips abroad in 1984/85;
- A project extension information unit established with basic photo and video tape equipment; it produced 10,000 posters, 120,000 extension folders, 18 television

programs, 15,000 slides and 20 video tapes;

A mechanized farming system established on a Government farm where workshop and mechanized farming methods are taught.

Machinery Introduction Fund

In August 1982, the letter of understanding, LOU, for machinery introduction credit fund was signed and later approved by USAID. This letter identified the fund's geographical distribution priorities, loan recipient's selection criteria by category, and defined the responsibilities of AMP in providing technical assistance and PBDAC in administration of the fund.

A technical committee, comprised of the technical advisors and project members, oversees and facilitates the loan approval process from the technical stand point.

The loan application process involves these major steps:

a) Technical appraisal for the bank's guarantee and/or credit review.

b) Preparation of a loan feasibility analysis.

USAID has approved a total of 2 million dollars of credit funds (1,663,360 L.E.) for this purpose. Purchase of over 200 pieces of equipment for a total of L.E. 636,008 has been financed through this fund.

Tables 2 and 3 provide detailed information on the machinery introduction funds's disbursement and distribution by type of machinery.

Table 2 Machinery Introduction credit fund, machineries financed by types and No. of units

Type	Number
Cultivator	26
Loader	4
Backhoe	42
Mower	78
Spray unit	2
Threshing machine	5
Winowing machine	1
Land lever (drag scraper)	32
Manure fork	1
Ditcher	1
Agricultural trailer	5
Planter	4
Thresher	7
Disk harrow	4

Source: Project Documents

Table 3 Machinery Introduction credit fund disbursement as of April 30, 1984

Location (Governorate)	Amount L.E.
Beheira	313,789
Gharbiya	111,299
Qalubiya	38,862
Sharkiya	135,198
Meniya	6,350
Dakahelia	30,510
T O T A L	636,008

Source: Project Documents

Water Lifting Credit Fund

Another fund designed by the PP, the Water Lifting Credit Fund, was designated for this sub-project. The planning and evaluation sub-project was assigned the responsibility of starting both the water-lifting and service center credit funds. The PBDAC was identified as the banking institution which would be responsible for administering the credit loan funds.

The loan application process involves 2 major steps:

1. Credit review and reputation of the applicant.
2. Review of land ownership and or tenancy records.

Up to April 1984, USAID has approved a total of three million dollars (2,495,040 L.E.) in credit funds for this purpose. A total of 1414 loans have been disbursed by PBDAC, for a total of 1,938,472 L.E. About 5,000 pumps have been financed through this fund.

Table 4 provides detailed information on water lifting credit fund disbursement.

Assistance to Small Manufacturers

This small unit in MME has had no stable success in promoting the design, development and testing of equipment to be manufactured locally. They have achieved the following:

a. A system for admistration and technical testing of certain types of equipment was established.
b. Various papers on assistance to small manufacturers of agricultural equipment were published.

Table 4 Water Lifting Credit Fund
Disbursement as of March 31, 1984

Location (Governorate)	No of Loans Disbursed	Amount L.E.
Beheira	541	606,635
Gharbiya	386	509,846
Qalubiya	192	232,818
Sharkiya	58	67,173
Meniya	237	522,000
T O T A L	1414	1,938,472

Source: Project Documents.

c. Project management has written memoranda on this matter to the Minister who has obtained cabinet approval.

d. There is an on-going coordinated inter-ministerial effort ongoing to process these agricultural implements involving the Ministries of Agriculture, Industry and Military Works. For example, Kuapcalil sprayers have been produced for years by the Ministry of Military Works prior to the project. Now AMP is stimulating production of the thresher, after testing 9 units in the field, (design, specifictions, standards, and even jigs were developed); 25 have been ordered from four public companies[1].

e. Most important, the Egyptian personnel (engineers, technicians, and mechanics) have been trained in local maufacturing techniques. On their own initiative they have developed a potato planter and are working on other items or equipment, aided by the technical assistance local maufacturers.

The proposal of the Project Management level is to interest the private sector in maufacturing agricultural equipment once the public companies have produced the first proto-types, so that an improvement in quality and quantity can be achieved. The end result of the project's activities in this respect has been to carry out all the steps up to establishing the demand for the threshers, which is the most important step in obtaining

---

[1]Behera Co. (5), Pyramid Centers (5), Ronsteel industry (10), Ministry of Industry on Military Works Ministry (5).

the participation of small manufacturers. This process can be duplicated with other items of equipment.

To carry out these activities, which are of such far-reaching magnitude, it may be advisable to consider a whole new project.

Coordination with other sub-projects

It has been mentioned that the Machinery Management Extension and Training sub-project is the field operations arm for the project. To carry this out, the other sub-projects have coordinated and channelled their activities through this one. This is especially true of the Land Improvement sub-project with its impressive laser land levelling activities. The other sub-projects generally did not have funds available for their field activities and had to rely on those of the MME.

Important Problems Solved

The major issues were:

1. An initial absence of a coordinating mechanism at the field level to insure the sub-projects' integration has been largely overcome through selection and training of field supervisors and activity managers. Selection of area coordinators would have been more effective,in the opinion of the evaluation team.

2. Having to initiate field extension programs without sufficient equipment, transport, machinery, training, storage facilities, and trained mechanization personnel constituted a major obstacle which has been overcome.

3. At a critical time, when the need for equipment was greatest, the shortage of trained administrative staff to manage the complex and time consuming commodity procurement process created a problem for several months.

4. Spare parts availability, although guaranteed by dealers, did not materialize, and this deficiency had to be handled through belated spare parts procurement.

5. Competing pressures between rigorous English proficiency requirements for long term participant training and the project's daily requirements impeded the selection of trainees. Management wisely decided to increase the number of counterpart personnel to the technical assistance specialists.

The project paper assumed that existing in-country facilities would be adequate and available to meet project training needs. Project management obtained training center facilities from external sources, but these were not always sufficient nor adequate. Had the original project design included a mechanization training center, the project's notable training accomplishments would have been even more impressive.

MME Outputs

1. Organization of a functioning machinery management extension unit in the five Governorates, with 51 mechanization specialists and the basic field equipment for demonstrations which will have reached about 25,000 farmers by the project completion date.

2. An unusually high adoption rate for the agricultural mechanization practices when they were properly pre-tested, demonstrated and made available on time (N.B. timeliness is a critical factor in double cropping systems under these conditions).

3. Some specific items of equipment, such as silagemower for cotton stalk removal, mower-binder, new type of chisel plow, drag scraper, seed drill, disc plow and backhoe for ditch cleaning, have been widely accepted in the project areas. Better cotton stalk removal and grain threshing methods are under study, with a new thresher design being tested for mass production.

4. Field training for:

51 mechanization extension specialists;

12,868 farmers and staff with an additional 12,500 to be trained in 1984/85;

68 farmer leaders and staff on off-shore technical training programs;

Academic training in process for 6 staff members planning for the MSc degree to support future project operations, 18 more whom were originally planned for, but could not be sent due to time limitations.

Important Issues Remaining

There are several important activities which the project will have to carry out, in the remaining 14 months. They involve:

1. Arrangements for continuation of the machinery management extension activities after project completion date:

- The majority of project villages have not established

equipment, maintenance and repair facilities.

- Provision is being made for the reception, assembly, and utilization (training of staff and demonstration) of 939 items of equipment now on order, which will be added to the 383 pieces now in the villages. This can be accomplished within the remaining time period if the special steps now planned are taken.

  In discussing these problems with project management, it has been explained that the Agricultural Mechanization Research Institute, as part of the Agricultural Research Center, would be the main implementing agency for solving these transition problems. The new MOA extension service started in January 1983 is continuing to be implemented.

2. The mission's concurence with the management decision to phase out extension activities at the Gabel Asphar farm because of the following reasons:

- The farm is an experiment to find ways of utilizing sewage and drainage water for crop production on desert land. Until now, the results have neither been proven nor tested, which is a basic requirement for extension demonstration.
- The farm is on new land with large areas neither representative of the Delta nor of small land holding mechanization.

The location, equipment, accomodation and other facilities are unsuitable for a training center, especially at university level. In addition, there may be a possibility of contamination from the use of the sewage water.

3. Improving extension work by evaluating the performance of the field extension staff has begun. The 51 field mechanization specialists require additional training if they are to function as true specialists assisting in the supervision and training of other extension agents. The individual performance of these key field men has to be evaluated periodically to ensure that their contact with the farmers and the public in general are satisfactory. It may become necessary to provide special assistance to some, or to affect transfers to other work in a few extreme cases. At present, incentive pay may be reduced and penalties imposed. This supervision is being carried out for the whole project by the follow-up unit.

4. Activity reports showing that farmers in some villages outside the project area have adopted machinery more readily than those in the project villages. The mission concurs with the management decision for phasing out extension activities in those villages where negative reactions are encountered, concentrating on working with the most open-minded farmers and letting the stubborn ones learn by observing the success of their neighbors who cooperated with the program.

Conclusions on MME Sub-Project

The agricultural machinery management extension sub-project was successful in establishing a practical field extension system for agricultural machinery using demonstration field equipment and will have trained about 25,000[2] farmers in addition to 73 project and MOA staff by the completion date. Its water lifting credit fund was eminently successful, has been expanded and is starting to produce funds for its own continuation. The information unit produced thousands of posters and pamphlets, several video-tapes for field use, radio and television programs and other materials. A mechanized farm and work shop was established and is training staff on mechanized farming, machinery operation and repair, and spare parts inventory systems. These achievements demonstrate that an effective agricultural mechanization extension program is being established especially in the areas where active extension units operate.

[2]Agricultural mechanization Project Village Profiles working paper No. 6 December, 1982. The total number of land holders is estimated at 22,779, so that by projection completion, most farmers in the project area will have attended one short/training course.

RECOMMENDATIONS

1. Priority needs to be given to the establishment of village facilities with sufficient maintenance, administrative and support staff.
2. Equal priority should be given to the reception, assembly, and distribution of the large number of equipment items scheduled to arrive in the next year.
3. Additional time is required for completing the off-shore training of the 22 candidates remaining. The evaluation team recommends an extension of time for this activity.
4. Support for small manufacturers is required as this is a complicated process and a new project may be advisable.

2. Land Improvement Sub-Project

Introduction

Some relevant information for this sub-project has been selected from various reports:

In the Project Paper, it is stated: "Under the project a new division in the Executive Authority for Land Improvement Projects will be established to provide sub-soiling, drainage and land levelling services" and;

"The shift to perennial irrigation without adequate drainage has led to a higher water table, increasing soil salinity and alkalinity, sub-soil compaction and hard-pan formation." Alternative solutions to these problems also are mentioned in the Project Paper: periodic sub-soiling, gypsum treatment, land-levelling, and various forms of drainage. The Project Paper says, " The overall responsibility for all types of land improvement in Egypt rests with the MOA, Soil Amelioration Organization (SAO)" and notes, the SAO conducts, sub-soiling, clearing of drainage canals and makes gypsum treatments.

Another paragraph from the Project Paper states: "On the equipment front the picture is far different. The SAO has only a fraction of the machinery required to provide adequate sub-soiling coverage nationwide. For land-levelling the SAO has only a few scrappers not really suitable for the work required."

The "proposed activity," was directed towards a coordination between the Agricultural Mechanization Project (AMP) and the SAO. In it, the AMP would supply the necessary farm machinery with trained personnel and advisors, and SAO, would provide

its "energetic and well qualified leadership," technical personnel, 10 research laboratories, etc. to provide the data base.

Other concerns addressed in the Project Paper included nationalizing water use and maintaining soil resources. According to the above paragraphs SAO, was well equipped to perform a soil survey, and to delivery the data base to AMP, so that the specific operations for soil improvement could begin.

Soils Data Base

According to the Project Paper a detailed soil survey was completed in 1973. The evaluating team was advised that detailed soil surveys and maps were available. Due to the time constraints imposed on the evaluation, however, we were unable to review this material. It is recognized from the AMP activity reports that mechanical and chemical soil analyses are important components of the planning data base. The importance of these data is also stressed in Dr. Garrett's report.

In order to determine the type, size and number of equipment items needed to carry out the land development improvement program, topographical, soil, and sociological surveys were listed as integral parts of the AMP project. The topographical survey for the farms included in the project as well as a sociological survey have been done.

An analysis of the situation after reading the working paper, memoranda, the activity reports of the AMP, and making a number of interviews with related personnel in and out of the project has revealed, in essence, the following factors

in approximate chronological order:

a) The Soil Improvement Director of the LBI technical team arrived in July, 1981, leaving he project in December, 1983.

b) A section of the SAO (AMP - Research component of Land Improvement) was integrated into FAO-UNDP project in July, 1981, becoming operational in July, 1982. During the period 1982-1983, eight pilot farms were selected for soil analysis, mapping, etc. Data collection will continue until 1985. Data collected from these pilot farms, as well as from the FAO-UNDP project, after being statistically analyzed, will form the data base. By then, the statistical data analysis can be finished by the Amelioration and Development of Deteriorated Soil Project. (FAO-UNDP, EGY/79/020).

The SAO - FAO project has a laboratory with most of the essential equipment to carry out physical and chemical soil analyses. This laboratory is small and inadequate for what needs to be done throughout Egypt. The farmer cannot produce better crop yields if the extension is not able to advise him on how to manage his farm, because the soil characteristics are unknown. Continuing development efforts to strengthen the soil analysis capability, as recommended in the Garrett report, would be useful.

Technically speaking, the specific type, as well as models, of farm machinery to be used will depend on the soil characteristics.

Land levelling effectiveness depends on the thorough knowledge of soils, especially when using such sophisticated equipment as a laser system. The aerable layer as well as the sub-soil is usually thoroughly studied before levelling the land. The main purpose of this operation is for irrigation.

Egyptian soils engineers and the Soils Improvement Advisor in AMP, who have a strong background in soils and irrigation, were aware of the importance of having the data base. Consequently, they have made preliminary soil surveys for the pilot areas where the farm machinery and levelling was to be demonstrated to the farmers. The T.A. was able to locate some aerial photographs taken in 1966, at 1:50,000 scale, which is too small for a detailed soil map. More recent aerial photographs would be useful for this project, as well as other projects within the agricultural sector.

a. Land Levelling

Summary

Land levelling (LL) has been selected as a primary activity for land improvement. With LL, irrigation efficiency will increase, and also surface drainage can be improved. The AMP has selected laser levelling equipment for precision LL on a commercial basis. Precision LL risks are the sole responsibility of AMP and MOA, which under-wrote the costs by providing it as a free service during the testing period. Most of the LL has been carried out in Minia Governorate. Farmer participation has been passive thus far, although a recent change in attitude is taking place.

the Minia Governorate, and will expand to other areas of the country.

The modern system of levelling is relatively new in Egypt, and its use has been very restricted. The SAO has 2 units and the Egyptian Major Cereals Improvement Project has 3 units, which are used only for State Farms. The Spectraphysics Company, which is the local distributor, is using some equipment as demonstration units. The main concern for the AMP is training and extension, encouraging the private sector to take over.

Although Laser equipment in Egypt has been technically very successful, the costs and benefits are not certain. More economic data will be gathered from field experience.

The LL is to be carried out in Minia, Assiout, Beni Suef, Gabel Asfar and Fayoum, where the soils and water problems have become serious. The average estimated size of the basins is about 70 feddan. Other technical criteria for their selection were soil salinity and alkalinity, levelling problems, weeds, and drainage. Finally, for scheduling of work purposes, the fields should be free of crops.

According to the advisory personnel involved in the Land Improvement sub-project, the following points define the limitations of the investigation:

1. The participation of farmers in planning and implementing LL activities.
2. The difficulty in levelling a number of continuous plots at the same time and problems associated with determining the original plot boundaries.

Previous Page Blank

3. The problems associated with moving top soil across neighboring plots while levelling, and the demands of farmers for compensation.
4. The role of extension in LL.
5. The impact of LL on planting techniques and the incidence and effectiveness of longer furrow time.
6. The impact of LL on irrigation time.
7. The impact of LL on crop yields.
8. The existance of and need for an accurate data base for assessing the costs and benefits of laser equipment for precision LL.

Methodology

This sub-project follows, in general terms, the methodology described in the "Inception Report," Section IV, Page 28.

The selection of villages for LL is based on technical parameters obtained from a topographical survey, as well as a visual reconnaissance. The soils reports supplied by AMP - SAO will be very helpful for expanded activities.

External Factors

According to the Activity Report No. 11 October - December 1983, Page 99, a number of tractors and laser units were still awaiting clearance from customs. The clearance process sometimes seems to have been an external factor that, due to technicalities (i.e. receiving wrong Bills of Lading from manufactures), delayed somewhat the reception of the equipment by the AMP.

The equipment was cleared at the beginning of 1984, in time to start the operations before the spring planting. During the evaluation team visit to Minia, the four LL Laser units were working under normal conditions.

The equipment consists of 3 tractors (85 H.P.) with scrappers and laser equipment (one transmitter), plus one more tractor with a chisel plow. The 85 H.P. tractor with scrapper, in an average texture soil does the levelling in 3 hours/feddan. This average performance assumes that 40 to 70 M^3 of soil are moved in the field.

Inputs

a) Training

The training of personnel started in October - November, 1982 after a survey was done at the Sugar Cane Company in Upper Egypt, on about 2 basins with a total area of 150 feddan. The people were trained for LL. By February, 1983, an engineer and 12 more people were trained. Three courses with field instruction in Minia were given, starting on November 12, 1983 and ending on February 16, 1984. In total, 15 people were trained. Eight Egyptians were assigned as counterparts to LL the operation and two T.A's were selected for a 2-3 year assignment.

b) Equipment

The total equipment for LL operation includes: Three motor vehicles, 37 tractors, 26 laser units, 3 laser

transmitters, 8 chisel plows, 3 sub-soilers, 1 mule board plow and 2 excavators.

Outputs

With all the above mentioned equipment, in coordination with MOA and MOI, about 1000 feddan will be levelled by the end of 1984. A great number of beneficiaries will be reached. Besides the training of operators and mechanics, future levelling equipment will be acquired by the private sector. Some cooperatives are requesting the help of the AMP in order to obtain credit to purchase the equipment. The farmers realize the good results and future benefits of this modern technology.

As has been mentioned elsewhere in this report, the cost analysis is in progress. More data gathering is necessary. In the most recent work some preliminary estimates indicate a cost range of L.E. 190 to L.E. 250/ feddan, including ditching.

Purpose

According to the Project Paper, page 7, the purpose of the AMP is to "build the Egyptian capabilities to plan, support and carry out appropriate mechanization efforts" ... "and to provide needed services and inputs to rural producers when and where needed at reasonable prices" .... " programs and support services contributing to increasing production and farmer's incomes." With the LL program recently initiated, data and information gathering still is in progress, because the equipment arrived but a few months ago. The experience of the past few

weeks shows that the farmers are overcoming their traditional attitude of being reluctant to accept modern changes. Some cooperatives are willing to purchase new equipment. This is an index of accomplishment.

Goal

"To improve the soil resources" (see Project Paper). There is enough evidence with LL systems that in most soils, conditions for irrigation and farming are improved. Irrigation becomes more efficient, less labor is required by the farmer, there is more uniformity in the seed germination and therefore more assurances to obtain higher yields. All these conditions are implicitly mentioned in the Project Paper.

Conclusion And Recommendations

LL has been a technical success. More information has to be gathered to establish a data base in order to have a scale of cost benefit ratios versus technical parameters.

It is considered of paramount importance that a well supplied Service Center, like the one already built in Minia, be fully operational in the nearby villages. Spare parts, whenever possible, should be available at the Service Centers. Downtime is an important cost item. The logistic maintenance and service of the equipment will help to lower the operational costs, which at present seems to be a constraint, at least at the assessment level. It is strongly recommended that more Service Centers,

fully equipped, with spare parts and testing equipment be built in the main farm mechanization areas.

b. Land Improvement Research

The research is considered one of the most important components for a successful mechanized agriculture. Provision for land improvement research could not be found in the Project Paper, although it is mentioned in the Project Paper Annex VI. The research is oriented towards machinery improvement, but not land improvement, page 11 of the same Appendix mentioned.

"Research Priorities." In the first paragraph the research output falls into two categories:

"That designed to develop and test specific types of equipment, and that designed to answer basic questions about the impact of mechanization."

The Project Paper Study Team recommended as priorities eleven research subjects, with freedom for the researchers to choose specific projects. Most of these research subjects were covered by the AMP staff and the TA members. There were already 25 working papers, included in the Annex on bibliography of this evaluation report under the "Technical Reports" heading. The last of this report was published in May, 1984.

Examples of AMP Research

The following two reports are an example of the research work done by the AMP staff, TA members and associates:

A. Working paper No. 13 deals with a "Survey on the Suitability of Egyptian Soils for Mechanized Agriculture" by Albert C. Trouse and Ahmed El Araby.

Before the operation started it was reported that soil measurements were taken: "Bulk density, moisture content, resistance to penetration of a drop type cone penetrometer, profiles of the soil surface before tillage, after tillage and a profile of the depth of tillage by removing all disturbed soil" (see pages 29-30 of the same report). The operation variables consisted of draft, forward speed and wheel slip. Apparently only approximate dynamometer readings were carried out, because an appropriate dynamometer was not available.

The Nobaria area was selected in order to test the equipment in a sandy and/or calcareous soil. Since apparently no data base on soils was available, the expert had to do some preliminary testing.

Another experiment was done with Maize on calcareous soil, at the National Training Center in Ganaclis.

Recommendations on R&D

From all the above plus Dr. Garrett's report, the following recommendations are suggested:

The research component of the AMP should be strengthened considerably. As a lesson to be learned for future projects, research on soils and farm machinery testing should proceed all other operations. The data base obtained from research should be very valuable for a sound and efficient planning for

expanding mechanization and production improvement.

Considering the importance of ecological effects on plant growth and physiological development, the climate, soil and water components must be thoroughly investigated. The experiments already started by AMP under the supervision of SAO constitute a beginning for further expansion.

Research on all three components are considered the main pillars for a successful mechanized agricultural development.

Adequate planning, in order to obtain the data base on the ecological components, deserves top consideration. Contacts and cooperation can be organized through the existing link with the Soil and Water Research Institute, which already has existing soil testing facilities spread all over the country.

The AMP should take the necessary steps in order to make use of all available testing facilities from the SWRI. In addition, well as we strongly recommend establishing soil analysis capabilities, as was reported by Dr. Garrett for the AMRI.

We highly recommend that funds be made available in order to obtain that fundamental research component for the AMP.

Only by the knowledge of the parameters involved in those components, would there be transfer of a sound advise to farmers through extension services.

According to the report of Dr. Roger E. Garrett (Agricultural Mechanization Institute, August, 1983, AID Project No. 263-0031), on page 13, in the Crop Production Section, it is suggested that. "A soil scientist would be of great service to the Irrigation, Drainage and Soil Improvement Department." Dr. Garrett did

not include this position in the recommendations, but on page 23 recommends that "basic chemical analysis equipment for solid test, water quality test, etc. be combined in a chemical laboratory." The evaluation team strongly concurs with Dr. Garrett's opinion.

3. RESEARCH AND DEVELOPMENT SUB-PROJECT

Background

The project paper which was prepared in 1979 presented the project purpose as " -- to plan support and carry out appropriate mechanization efforts." When discussing the research and development (R&D) sub-project, it proposed funding a farm mechanization research and development center, and capitalizing a fund to support research in Egyptian institutions. A research personnel exchange including graduate study was also proposed. The center was to conduct research and coordinate research funding. The sub-project was to be " -- a focal point for farm equipment research and a source of information for continuing changes in and evaluation of farm equipment use in Egypt --." To carry out these activities the project paper proposed a budget of $ 3,876,000.

The R&D center was to be located at the Tractor Testing Station at Alexandria, which had adequate space but needed up-grading to make the facility operational. The center was to identify research priorities and conduct field and laboratory investigations to further agricultural mechanization, serve as a machinery testing station, and disseminate research and testing results. Technical advisors were to be provided through USAID funds to assist with this and related work.

The applied research fund was set at one million dollars. It was to be administered by the R&D center with the help of a five person evaluation committee appointed by the project director.

The committee would assist in establishing research priorities and awarding grants for research work. Several research topics were suggested in the project paper. The research exchange with Egyptian-American collaboration, was to involve about 15 Egyptian graduate students in U.S. Universities. Provision was also provided for U.S. student study in Egypt. Professors from the USA and from Egypt were to be provided travel funds to work with their students in the host country, whether it be in Egypt or the U.S.A.

The work plan (Inception Report) prepared by the project contractor and dated August, 1981 made some suggestions to be considered when implementing the sub-project. The report emphasized the research was to be applied and problem-oriented, noted the results were to be fed to extension, and mentioned a "training sub-project". When reviewing the financial support for the sub-project it was recommended one million dollars be added to the applied research fund. In was further recommended that the collaborative research activity should be transferred to the "training sub-project," and the $ 205,000 funding for it should be used for instrumentation training. Also included in the report was a time schedule chart for the sub-project activities.

Accomplishments

The R&D sub-project has made several accomplishments toward meeting its objectives. Among them is the refurbishing of the Agricultural Mechanization Institute Test Center (tractor testing

station) at Alexandria, including the establishment of a machine workshop. Several tillage tests were conducted, and it was found chisel plows and other minimum tillage methods provided adequate primary tillage for three different soils in Egypt. Primary and secondary tillage test procedures, along with root-crop digging and maize-shelling test procedures, were developed. Among the in-house research results were tillages tests with peanuts, cotton, and maize, digging tests for potatoes, and planting tests for maize. Modifications and tests were carried out for a grain harvesting pick-up reel, two imported mower/binders, and spraying equipment. A proto-type thresher was developed.

Details of the development were present in a paper by Sahrigi, Berky & Garrett. (See MME sub-project, also). The R&D advisory committee was formed and numerous proposals were considered for supporting research outside of the Institute. Nine grants have been made to investigators in four Egyptian Universities, the Sugar Crop Research Institute, the Cotton Research Institute, and the Sugar and Distilling Co. (See Appendix D). More than LE 449,000 has been committed for this work. Several qualified persons have been identified and sent for formal training in the USA, and several more are awaiting final approval by USAID (see Table 1 Appendix D). In addition, several in-country training programs for R&D personnel have cooperated with the extension/training sub-project. In carrying out research, the technical assistant for the project has met with the R&D advisory committee. Five papers have been identified that resulted from the internal research and development, and there have been other research

oriented papers resulting from the project. (See Appendix E).

When comparing the accomplishments with the objectives of the R&D sub-project, it can be noted that: a Farm Mechanization Research and Development Center is physically in place, but some equipment for the center has yet to be received and installed. The Applied Research Fund has been established with an advisory committee to review research proposals for grant distribution; grants have been made and funds are available for more grants. The Egyptian-American Collaborative Research has been carried to the extent that Egyptian personnel have entered Universities in the USA for graduate study, while others identified for such study have yet to begin off-shore graduate work.

Constraints

The project paper neither foresaw nor allowed for the procedural delays resulting from such things as poor documentation by equipment suppliers in meeting USAID and GOE requirements and the interaction of the various regulations. These problems delayed getting materials and equipment for the project. Project personnel have worked to overcome these constraints and most of the research equipment is expected to be received by January, 1985. Since there will be a relatively short period after the equipment is received, the time available under the project for setting up the equipment and training people to use it is quite limited. The distance between the Test Center at Alexandria and the project office in Cairo could create logistic and communications delays, but the project personnel have been able to carry out sub-project

objectives through radio communication and weekly visits by appropriate personnel. Providing the inputs to overcome constraints of these and related types is a positive factor in maintaining the morale of MOA personnel. Carrying out inhouse research was done in the areas of Noubaria with light soils on new land, Sakha with heavy clays, and Beheira in cooperation with an extension village. The Horticultural Research station next to the test center is to make land available. A machinery evaluation program, as stated in the objectives, has been established on a limited basis, with the testing equipment forthcoming and Dr. Garrett's report as guidance. (Early part of 1985).

The complicated process for screening tractors and implements, taking into consideration the H.P. consumption, cost, maintenance, availability of the spare parts, etc., can be simplified by the use of desk top computers; logically, the data must be updated periodically. This is in support of the findings in Dr. Hamdy's report (computer/data acquisition system).

Beneficiaries

The principle beneficiaries of this sub-project have been the principle investigators and institutions receiving research grants. The results from the internal research will no doubt be helpful to people working in the agricultural sector, but these benefits will not be immediate. The most important problem solved from this work and which can have immediate benefit is the knowledge that minimum tillage, e.g. the use of a chisel plow, provides adequate primary tillage on several soils, thus

eliminating the need for tillage requiring more power (AMP working paper No.13). The finding that primary tillage can be done satisfactorily with minimum tillage suggests minimum tillage systems may be appropriate for Egypt. Such systems combine tillage, planting, fertilization and pesticide treatment into one operation. Satisfactory preliminary work of this type has been done with lintels in the Small Farmer Production Project (SFPP).

Input/Output Comparison

The project paper lists inputs for the R&D sub-project as those from USAID and those from GOE. USAID was to provide technical advisory staff, commodities, research funds, collaborative research funds, building renovation funds, and some vehicle operating funds. The technical advisors have been provided as noted in the Appendix F. Procedures and progress towards filling vacant advisory positions seem to be well in place. Commodities such as vehicles, shop equipment, prototypes for testing and some research equipment have been received. Additional commodities are scheduled to be received during January, 1985. Training has been provided, as noted from the Appendix D Table 1. Collaborative research has been limited to that associated with offshore training. Research funds have been dispersed, as noted in the Appendix D. The building renovation funds were not used to refurbish the Test Center at Alexandria; the work to make the offices habitable was financed by the GOE. Thus the inputs from USAID into the R&D sub-project have flowed through

all suggested channels except for reconstruction. USAID funds are still available for R&D sub-project inputs, and there is evidence that a large share of the remaining funds will be spent before the project terminates, but it is very doubtful that all funds in all categories will be spent. The inputs listed for the GOE included staff, facilities and operating cost. Sixteen professional staff and twenty support staff were listed. Facilities for the Agricultural Mechanization Research Institute Test Center, which has been and is operating, have been provided.

Conclusions and Recommendations

Since money will most likely still be available in the project on the termination date, extending project activities to provide for research equipment set-up and personnel training may be worth considering, even if it requires shifting budget line items. If construction funds are still available, new AMP building facilities may want to be considered. Extension of these activities would also allow those people in the USA, and those planning for USA training, to complete their university degree. All parties are encouraged to promote and expedite training requests for R&D sub-project personnel, especially facility observation training involving testing facility operation. Such training could be of special value in the beginning of 1985, when the testing equipment is expected to arrive. Although internal research of the type carried out to-date is laudable and should be continued, information giving the operating characteristics of agricultural machinery in Egypt is more important

at this time in its development. Results from tests of this type could be helpful to those people needing to approve bank loan applications for farm machinery. Establishing a testing system, including a method of disseminating the results and making tests, is the important thing. The results, which are to be available to anyone through testing station reports for sale to the general public and filed in all university and other technical libraries, need to provide complete technical information about each machine tested. The reports could give such information as a general description of the machine (manufacturer, model number, physical dimensions, weight, manufacturer's stated function, draft requirements for Egyptian soils, effectiveness of operation (e.g. seeding rate, seed distribution, consistency of seed placement, fertilizer distribution, etc.) and other characteristics that are dependent upon the specific machine. Example test procedures with related information are presented in the Appendix I. The tests need to provide information only; the institute need not approve a machine and likewise it need not disapprove a machine. During each test it would be best to have a representative of the machinery manufacturer at the station to assist the test engineers with machine operation and adjustment. Charging the manufacturer or importer for making a test may be worth considering. Furthermore, since not all of the equipment intended for the R&D sub-project has arrived, extension of the project activities to enhance the machinery testing program may be appropriate. The reasoning for continuing the activities complements the activity extension suggested above. During this time period

it is advised that machinery testing be emphasized, with the goal of establishing a testing system and making evaluation tests. Technical assistance for setting up the test equipment and training engineers and technicians in the use of the equipment and test procedures probably can be done best by hiring experts with testing experience on a temporary (TDY) basis.

4. PLANNING AND EVALUATION SUB-PROJECT

This component was primarily designed to complement the ongoing MOA studies for agricultural mechanization planning. Prior to project mobilization as identified in the project paper, almost all studies were short-term and designed to address specific projects or program needs. Systematic socio-economic studies and evaluations were seldom prepared, and no steady flow of information was available, for ongoing and past activities.

The planning and evaluation unit was designed to institutionalize an effective planning, implementation, and monitoring body for national Agricultural Mechanization Programs. This unit was envisioned as consisting of three advisors to be led by the Chief of Party (COP). The sub-project set out to provide:

- Implementation plans for the project and other MOA mechanization activities.
- Lending procedures and loan criteria for the service center, water lifting credit funds and machinery introduction credit funds.
- Assistance to Egyptian counterparts and staff involved in the planning and implementation of survey and data collection activities necessary for the assessment of this project and other mechanization programs in Egypt.
- Assistance to MOA personnel involved in the planning and implementation of effective and socio-culturally feasible programs.

- A data base for project activities and mechanization efforts in general.
- An information collecting system to monitor project implementation.
- Economic and social analysis for the projects effect on agricultural mechanization in Egypt.
- Advise to the Undersecretary for Engineering Affairs.
- A link between agricultural mechanization projects and the universities.
- A comprehensive data collection system on a time series basis for the evaluation of the project.
- Financial analysis of project activities.
- A feasibility study of small scale manufacturing of farm equipments (to be conducted during 1981).

The first member of the team started the sub-project activities in September 1980; he was later joined by the evaluation advisor, who arrived in December 1980. In the early stages of implementation the team, led by the COP, primarily concentrated on establishing systems for identification of data and information needs, and the initiation of a farm management and village survey. After drafting the work plan (August, 1981), a new schedule was drawn, as outlined by the inception report, identifying the major areas and studies for the sub-project. They included:

- Three surveys at project sites.
    1. Collection of information data (initial project survey) (November 81 - March 82).

2. Mechanization impact survey (April 83 - July 83).

3. Mechanization impact survey (February - April 85).

- Accuracy assessment of the area survey by participant observation on a continual basis.
- Farm management studies (June 81 - February 83).
- Initiation of the water lifting and service center funds (July 82).
- Cost-benefit analysis through the life of the project.
- Quarterly internal evaluation reports.

Input/Output Comparison

Since 1980, the sub-project has expended by 2,301,105 Egyptian Pounds and 19,500 U.S. Dollars. For the same time period, the technical assistance level of effort reached a total of 84 man months.

The sub-project concentrated mainly on:

1. Conducting five surveys, (farm management base line, water lifting cost, wheat planting and rice harvesting).
2. Preparation of 22 technical reports that included: economic studies, social studies, and specific activity evaluation reports. (See Appendix G).
3. Training of Egyptian counterparts primarily in data collection, compilation and analysis.

4. Preparation of implementation plans, procedural guidelines and three letters of understanding for disbursement of loans.

5. Setting up of a small computer hardware unit. (H.P. 85 and 86 for data processing).

Although there were considerable accomplishments in the 3 1/2 year life span of this component, some deviations between achievements and planned activities exist. The delay in arrival and early departure of the evaluation advisor (December 81 - June 84), drafting of the workplans, and the absence of an internal evaluation of the project, are the major causes responsible for these deviations.

WORK SCHEDULE

The inception report primarily shifted the main focus of the project from a national to a localized approach. The data collection, analyses, and economic studies prepared by the sub-project were designed to review and analyze the implementation of the project as well as raise issues which might affect its development. The strategy for the pilot approach had its merits as it applies to other sub-projects and implementation. The shift in emphasis has departed significantly from the sub-project Goals and Purposes of the Project Paper. The Project Paper implies the development and integration of a sectoral approach to mechanization planning.

Due to size limitations of the advisory team, the sub-project probably should not handle planning studies at the sectoral

level. In our view, the sub-project should fully concentrate on organizational setup activities, evaluation studies and carrying out the necessary data collection programs. The completion of the team in December, 1980 and late preparation of the inception report comprised another obstacle in development of this project. Until August of 1981, as no work plans had been yet developed, the team primarily focused on preparatory work in support of other sub-projects start-up, and was not able to provide the management with appropriate and timely support.

No overall internal evaluation to date has taken place. Periodic appraisal of objectives and progress of the sub-project was the most effective management tool that the project paper and the work plan had envisioned.

Such an evaluation, in our view, would have been helpful to the management in making the necessary adjustments in implementation of this and other sub-projects.

RECOMMENDATIONS

During the remainder of the life of the project, this sub-project should fully concentrate on studies and activities that are directly related to AMP. Management support with data needs for organizational setup and monitoring of project implementation should receive high priorities. Periodic internal evaluation as envisioned by the inception report must be conducted. A management information system with a focus on monitoring of project implementation should be established.

- The feasibility study of small scale manufacturing of farm equipments must be conducted.
- A thorough review of survey questionnaires must be made. The evaluation team has some concern about the practicality of the survey questionnaires which seem complicated. In our view, the design relies heavily on the level of expertise of the enumerators who may not necessarily have adequate training and background.

5. SERVICE CENTER DEVELOPMENT SUB-PROJECT

Service center and village workshop funds

Introduction

Information in the Project Paper (late seventies) indicates 7% of the total tractors were inoperable, the down time of broken tractors averaged 3-6 months, and large dealerships only operated small workshops, normally located in larger cities. Absence of adequate maintenance and repair facilities in rural areas, lack of proper tools, equipment, and skilled mechanics, and inadequate spare part inventories prompted the design of the service center development sub-project. The agricultural mechanization project focused on these issues and initiated financing of a service dealer and workshop network. This system was designed to address the basic repair and maintenance needs of the Agricultural Mechanization Program in Egypt.

As originally designed, a total of $ 5 million of the loan fund was allocated for disbursement to the private sector for service center development. The funds were to be released in three tranches and were primarily allocated to provide financial assistance in setting up easily accessible service centers and workshops. The sub-project, designated "machinery service" in the Project Paper, objectives were: 1- to provide loans to qualified private operators for the development of a capability to service farm machinery promptly and reliably and to supply spare parts --"2- " to plan and implement a program to rehabilitate tractors", and 3- to focus on the establishment of area and local repair centers".

CONDITIONS

The loans were to be disbursed to qualified private operators for the development of service centers and small workshops. At the beginning, a ceiling of LE 150,000 for service centers and LE 30,000 for small workshops was established. A local bank was to be selected for carrying out the loan disbursement activities on a long term basis throughout the project area. Loan terms, conditions and qualifying criteria were planned to be prepared by the AMP expatriates. A target of 20 major service centers and 50-70 small workshops was established.

ORGANIZATION

A two-person team of expatriates was proposed to develop:

- a program of repair and maintenance for the private sector and cooperatives for MOA
- standards and performance monitoring criteria for repairs and,
- focus on establishment of a service centers and local workshops network.

In setting up the disbursement criteria for funds, these experts were to be assisted by the planning/financial specialist from the planning and evaluation sub-project.

FUNDS DISBURSEMENT

In April, 1981, the service center development advisor joined the project. In his initial 7 months, the advisor conducted interviews and informal market surveys. He has also assisted

the planning and evaluation sub-project to determine the terms and conditions of the service centers and village workshop credit fund. Agreement between MOA and PBDAC on the terms of the first letter of understanding (LOU) was reached and approved by USAID in December 1981.

The LOU, identified the recipient selection guidelines and the loan terms and conditions for different groups of borrowers, and set up the administrative procedures and responsibilities of the bank and AMP. In October 19th 82, the loan limit was raised from 150,000 LE to 250,000 LE for service centers and from 30.000 LE to 50.000 for the village workshops.

The loan application process involves four major steps.

1. Evaluation of the applicant's ability to run his unit efficiently from a technical point of view. Responsibility for this step is invested in AMP.
2. Pre-qualification for the bank's credit review. This step involves acquiring land registration records and obtaining permission from several ministries, including: agriculture, health, irrigation, transportation; and the new buildings authority.
3. Applicant's credit worthiness review at the PBDAC.
4. Review of the applicant's eligibility for the loan and his/her capability in meeting the requirements.

The first payment for a service center was made in February 1983, and the center is expected to be operational by the July 1984.

So far, the requests for funds for six service centers have been approved by the bank (1,064,718 LE), with five more

applications under review. The total amount of committed funds, as of May 7,1984, totaled 639,200 LE. The first village workshop loan was completed in January 1983, 14 months after the completion of the LOUs, for a total of 12,636 LE. Since January 1983 and through May 1984, 23 loans have been approved and processed by the bank, with a total commitment of 535,089 LE.-

Most of the completed loans are scattered in Minia, Gharbia and Beheira Governorates (Fig.1. Appx H.) The banks in Qalubia and Sharkia have not approved any loans yet. The main problems related to the loan approval process and inadequacy of the system will be treated later. A total of 45 applications for a total of 1,125,500 LE await bank approval or final action. Five loans for a total of 101,000 LE have been already approved but await processing. Of the remainder, (40), 16 loans, representing a total of 380,000 LE are being investigated by the project.

All loan funds for the sub-project are considered "in the pipeline" with about 17% expended, 10% under project review and 73% under bank review. There have been 23 workshop loans completed, 5 approved by the bank but not processed, 40 loan are under bank investigation and 16 are being reviewed by the project. The AMP has met its objective of making the loan fund available to further provide service and maintenance to farm machineries and is continuing to assist clients in obtaining loan approval from the bank. The service centers and village workshops are dispersed and thus serve many areas (Figure 1 Appendix H). It has been observed that the originally estimated

impact (service) area of 10 to 15 km. has been greater than anticipated.

The personnel involved in this sub-project have had to overcome some constraints in meeting their objectives. For example, the bank processing has been slow but this might be expected when a new program is introduced, i.e., the soft-loan characteristics of the fund were not fully understood. Land registration was another required item taking a long time to solve all of the related problems. Initially, there was reluctance to accept a private sector program sponsored by a government organization. Again, as those involved found there was no catch if then to participated, the loans moved ahead. The original interest rate impeded, progress but was solved by lowering it. At the current time, the sub-project is progressing smoothly and the banks are processing workshop loans at a higher speed.

The service center sub-project obligated all of the budgeted loan funds, and has assisted in the processing of the loans for the set up or enhancement of eleven service centers and 84 workshops. While the number of service centers is 55% of the goal; the number of workshops is 20% over. Since this sub-project is having reasonable success, transferring funds from other sub-projects with an uncommitted balance when necessary, may be worth considering.

The sub-project experienced a successful result in capturing the private sector's demand for the service center/village workshop funds. The momentum generated by the sub-project activities should be extended to other potential non project areas. Results

achieved by the project provide sufficient justification for such action.

VI. PURPOSE

"The project purpose is to build Egyptian capabilities to plan, support and carry out appropriate mechanization efforts. Simply stated, this means developing ARE abilities to effectively choose and implement mechanization efforts that provide needed services and inputs to rural producers when and where needed and at reasonable prices. The substantative measure of successful project achievement will be well-formulated and effectively-implemented farm equipment projects, programs and support services contributing to increasing production and farmer's incomes."

"The purpose will be attained through the initiation of activities to fill gaps in the current range of mechanization analysis and support efforts and the strengthening of on-going programs to reach more individuals with additional information and services. The ultimate result will be a comprehensive program of planned, inter-linked and mutually complementary parts capable of providing the farmer with the support he needs to produce his crops more efficiently."

To help in the discussion of shortfall causes in terms of the casual linkage between outputs and purpose or external factors it is well to identify the various factors influencing the project and their inter-relationship.

Some of the factors can be controlled by the project management and some cannot. Other factors can be established at the beginning of the project but cannot be changed easily during the project. The factors were placed in various groups according to their

influence upon the project:

1. Controllable input
2. Non controllable input
3. Environmental
4. Design
5. Management control
6. Undesirable output
7. Desired output and
8. Management constraint factors

The relationship of this factors are presented in Appendix J.

Some of the causes of short falls are described in the following paragraph:

Project Focus: Global vs. Pilot

Until late, the focus and extent of project concentration remained unclear. As the project paper implies but does not explicitly state. The AMP and its activities would appear to be global, while the inception report and the sub-project work plans implicitly suggest the pilot approach. Villages in 5 Governorates were selected and the majority of activities were contained within the boundaries of the selected areas. The evaluation team is unaware of any documents that officially provides acceptance or approval of a switch in scope of activities from a global to a pilot design.

Early estimates for implementation of agricultural mechanization at the national level show an investment need of over 600 million dollars. Due to limitation of funds and the precedence set by the project in previous years, acceptance of project activities

at the pilot level, with the exception of planning and evaluation studies, should receive general acceptance. Given the amount of funds available, in our view, the pilot approach in implementation of the project is the most appropriate of the two alternatives. The planning and evaluation sub-project shall clarify the issue obtain necessary documentation and formalize agreements.

Project Area Based On Random Selection of Villages

As explained earlier the implementation of AMP was a three step procedure.

First, five Governorates, with 41% of the cultivated land-holdings and the majority of agricultural production in Egypt, were identified. The population of Tractors and Agricultural equipment in the project area prior to project mobilization approximated the average national holdings. The mechanical horse power available for irrigation showed lower than average holdings (see Table 5).

Table 5: Population of tractors and agricultural equipment per 1000 feddans of cultivated land within the project area (1982).

Coverage	Tractors	Plows	Pesticide Sprayers	Machines	Agricultural Trainers	Mechanical Power for Irrigation H.P.
National Avg.	7.30	6.80	2.40	1.50	3.37	163.9
Project Avg.	7.48	7.32	2.86	1.66	4.08	122.26

Source: Complied from Arab Republic of Egypt, Ministry of Agriculture, Agricultural Mechanization Project, Egyptian Agricultural Mechanization Five Year Plan, 82/83-86/1987.

Based on the type of soil, those districts with different types of soil were kept as the sampling population. Out of 11 districts the planning and evaluation sub-project randomly selected 23 project villages, with two villages added. The selection of 2 additional villages by the project was not based on statistical reasoning: other justifications were presented to the team. The evaluation team raises the possibility of statistical and technical basis in this selection. Utilizing available non-project data and information, which are also the bases of the AMP's planning and design activities, some issues are raised, such as the rate of increase in number of tractors per 1000 feddan in the project area, prior to the project.

Table 6: Number of Tractors per 1000 feddans

(1978-1982)

	1978	1982	Estimated Annual % Rate of change during 1978-1982	Ratio of Increase (Annual)
National Aver.	4.1	7.30	% 15.6	1
Project Aver.	2.8	7.48	% 33.4	2.14

Source: ERA 2000 feasibility Study, P.P.x 1
Egyptian Agricultural Mechanization Five Year Development Plan
P.P. 5,45.
Project paper; Annex X Page 1.

Although the project areas show a close approximation to the national average in number of tractors and equipment in static terms, the rate of change at Governorate level shows an upward statistical bias. The annual rate of change for tractors in the project Governorates for the period of 1978 to 1982 shows more than a two to one ratio over the national average. (Table 6.)

B. <u>The Project Paper Definition of Purpose</u>

The Project Paper is an excellent planning document that has its own merits; it is thorough in general, and treats most of the agricultural mechanization issues adequately. Today, five years after its completion, we are in a better position to judge the validity of its assumptions and applicability of its plans of action.

The Project Paper is an ambitious document. As originally designed, it identifies problems and actions at a national level, but underestimates the level of investment required to carry

out all of the activities.

The Project Paper also has some built in deficiencies:

The natural slow process of setting up the system in the early stages of a project of this size is an integral part of schedule planning. The Project Paper does not adequately bring this issue under consideration.

2. The bureaucratic inefficiencies present in most multi-system undertakings, such as the interaction of AMP with MOA, USAID and PDBAC, are also not considered.

3. The structure of the project, as formulated in the Project Paper, shows research and extension being implemented concurrently, in overview, given the inadequacy of mechanization research data, this assumption introduces a serious implementation problem. Extension cannot properly proceed unless there is an appropriate technology developed from a research base.

4. The treatment of credit loan funds requirement and disbursement procedures, for the start up of a system, suffers from numerous inadequacies.

5. The severe underestimation of the required level of funding, for a project on mechanization for the whole country.

These issues render the Project Paper's suggested purpose and schedule of activities, as originally written, almost impossible to achieve; this explains the modifications that were made during implementation, such as those included in the inception report.

C. Inception Report

In a contractual agreement between MOA and LBI, the contractor prepares a work plan to describe the proposed strategies to accomplish its responsibilities under the AMP. This work plan (inception report) was prepared and presented to MOA by March 1981. This implementation proposal (inception report) deviates from the Project Paper, it implicitly assumes that the approach of project implementation is a pilot undertaking rather than that of a project with parameters directly addressing the issues on a national (global) level. The implemented plan did not, in numerous instances, necessarily agree with the guidelines in the Project Paper.

The content of the inception report suffers from a few discrepancies.

1. The implicit organization of the implementation system over-emphasizes documentation and paperwork, which in the opinion of the evaluation team, was excessive and could have been done without imposing a drain on the technical assistants' efforts.

   In the course of administering the plan of action, the team observed excessive management requirements in terms of report preparation; this style of management imposed an indirect drain of expertise from field activities report preparations and office work.

2. The inception report falls short of discussing the global vs. pilot approach issue directly. The vagueness inherited by the Project Paper was not adequately treated in the

inception report. The closest attempt by the inception report to expose the issue came in the following:

"The project itself can be viewed as a sub-system within a larger system of national scope to which the outputs of the system relate." (Inception Report, Page 5)

Treatment of the service center sub-project was inadequate and numerous issues related to administration, transfer and disbursement of funds were not addressed.

VII. GOALS

The project is designed to contribute to two major goals: increased agricultural production, and higher farm incomes, which are in harmony with the GOE objectives and the AID's strategy. Direct project contributions are planned to result from:

1. improved soil resources;
2. promotion and better use of equipment;
3. introduction of new equipment;
4. raising of livestock productivity;
5. improved planning and establishment of a more effective institution.

The Project Paper also identifies sub-goals such as provision of adequate power to agricultural operations for Egyptian farmers.

Although the project has passed a time span of over 45 months, the total time should not be considered its effective life. Level of expenditure is a good indicator in support of this observation (26% for U.S. Dollars and L.E. 45% equivalent as of May 31, 1984). During the first two years of project implementation, most efforts and resources were devoted to setting up the organization for training the staff and preliminary testing of machines and techniques; it was in 1983 that the sub-projects gained momentum.

If the project receives an extension for some selected activities and follows the course as recommended by the evaluation team, it would be able to further contribute to the goal of increased agricultural production and increase farmers' level of income in the project area. At this stage, it is too early

to determine the socio-economic impact of the project. The planning and evaluation sub-project should launch an impact study at the project area level when the actual expenditure level passes 3/4 of allocated funds.

A. STATUS OF SUB-PROJECTS

Machinery Management Extension and Training

The Machinery Management Extension and Training sub-project's goals cannot be separated from those of the whole project because the field extension units comprised the delivery system to the farmers; in addition, training of staff is a support activity for the whole project. The sub-project made excellent progress in establishing the system and achieved successful extension work in most areas. The total number of farmers trained in short courses exceeded expectations and is noteworthy. The results (adoption rates) were very high for several machines and techniques demonstrated. The off-shore training effort was not wholly carried out, but this may still be done if selected project activities continue by means of an extension period. This is true of the 22 candidates for academic training to the MSC level, who would continue working in their specialties when they returned. The short-term Technical Training (off-shore) can be carried out in the coming 15 months; careful selection of the candidates is required because of the important future role these trainees will play.

Introduction of New Equipment

Through dispersion of the machinery introduction fund, over 200 pieces of equipment for a total of L.E. 636,008 have reached the farmers in the project area (see Tables 2 and 3). Considering the late start of the fund (August 1982), the present level of disbursement (over 38%) is judged as a better than average performance. The MME sub-project reported unusually high adoption rates for the machines demonstrated, in view of the fact that most farmers only own about one and a half feddan, and therefore cannot usually finance their purchase (for further detail see the section under Outputs)

Raising of Livestock Productivity

Introduction of over 10,000 pumps through water lifting credit fund may indirectly contribute to livestock productivity. Studies, such as Era 2000, provide estimated indices on the level of increase of milk and meat as a result of livestock replacement with pumps. Although the evaluation team has difficulty in accepting these indices, in our view the contribution of the fund with its excellent performance constitutes a significant achievement.

Improved Planning/Effective Institution

This component was primarily designed to institutionalize an effective planning, implementation and monitoring body for national agricultural mechanization programs. The planning and evaluation unit reached its full level of staffing by early

1981, and has launched several technical studies, surveys and established the foundation for two distinct planning and evaluation units.

The planning activities, with only a few exceptions such as provisions for organizational set up and assistance in preparation of management information systems, are on schedule. The evaluation activities have slightly deviated from the planned schedule. Activities, especially those for the development of a monitoring system, overall internal evaluation, and impact studies should receive high priority.

Land Improvement Sub-Project

This sub-project started to be effective as soon as the bulk of the equipment became available. The field personnel, tractor drivers and mechanics, after several training courses were ready by the time the equipment arrived. Greater progress could have been achieved if the land levelling equipment had arrived earlier in 1983, but the funds available were utilized for other types of equipment which had priority.

The land levelling operation as a technique has proven highly successful. However, more soil research is necessary to do the operation in a more effective and economic manner.

More data and information has to be gathered in order to be able to advise the farmers on this aspect of this operation.

A previous calculation of production costs related to specific crops, soil conditions, earth volumes to be moved, irrigation scheduling, etc. has to be made in order to see if levelling

is advisable.

The sub-soiling operations, different types of drainage, gypsum applications, fertilizer distribution, trace element balance, etc. are all a function of soil characteristics and its pedological behavior towards irrigation. After the soil data base is known, the above operations can proceed effectively.

Research and Development Sub-Project

The R & D sub-project has goals of making the Agricultural Mechanization Research Institute the focal point for farm equipment research, a source of information for the evaluation of farm equipment, and, in cooperation with the MME sub-project, the strengthening of farm machinery manufacturing in Egypt. The sub-project has carried out and published the results from research done within the institute. Through the research grant fund, grants to other institutions have been made in a systematic manner for agricultural mechanization research. A demonstration of machinery development involving a potential manufacturer has been initiated, using a systematic approach for development of mass produced farm machinery.

Service Center and Workshop Development Sub-Project

This sub-project was designed to address the basic repair and maintenance needs of the Agricultural Mechanization Program in Egypt. A loan of U.S. $5 million dollars was allocated for disbursement to the private sector for service center and village workshop development. A target for establishment of 20 area

service centers and 50-70 village workshops was set.

The service-center/village-workshop sub-project has had an excellent performance in terms of market demand, investigation, and fund disbursement to the private sector. If the sub-project follows the path as prescribed by the evaluation team, it will surpass its set goal. (See Chapter V-Section 5). If the project is extended, the following activities should receive priorities.

Draft a new LOU with contingencies (such as annual inflation rate, and complete transfer of responsibility for technical review to AMP) that would secure loan activities beyond the contractor's termination date. To initiate competition within the banking system, involving other banks in the loan disbursement process should seriously be considered.

An organization setup for identification of potential clients, preparation of feasibility studies and provision to assist the loan process by banks should be established.

In cooperation with PBDAC, manuals for the sub-project staff and their counterparts at the PBDAC should be prepared. Needed manuals involve preparation of loan application, technical data collection and analysis, feasibility analysis, and loan evaluation. These manuals can significantly enhance the loan process activities.

Intensive courses in the loan promotion process, disbursement and evaluation should also be considered.

VIII. BENEFICIARIES

A. Direct Beneficiaries

By the completion date this project will have reached about 25,000 farmers through the demonstrations and field training courses. This is a significant number, who will have been directly trained or participated in the field demonstrations, especially since the project area covered about 24,000 farmers (in total). It is understood that the short course is only a start in training farmers, but the contact for future transfer of technology has been established. The extension demonstrations were supported, or grew out of, the other sub-projects. The machinery management extension and training sub-project was the vehicle for promoting and channeling the benefits from all the sub-projects to the farmers and their families.

The same applies to the training function which became a part of the MME sub-project. One of the most effective aids to project development was the training of 26 key farmers by sending them to other countries, such as the Philippines and Thailand, to actually see the equipment and cultural practices in action and to talk to farmers like themselves, who were involved. When those key farmers returned they had in most cases, become ardent supporters and promoters of the project activities. The additional 31 farmers/leaders and staff members to be sent during the coming year should provide an additional boost to the project.

The 51 mechanization specialists being trained by the project and the 42 staff members who were sent on short-term technical

training were also direct beneficiaries of the project. The mechanization specialists, in reality, have much to learn before they can function as true extension specialists, but they are carrying out their functions satisfactorily in the field. Their major contribution will come when they become capable of supervising and training the extension agents.

The staff members who participated in the short-term training also profited by seeing the technology in action in the countries visited. An additional number of staff members will be included in the next group, which is to be sent during 1984-85.

The water lifting equipment credit fund has been eminently successful, assisting some 10,000 farmers in replacing the animal-drawn Sakias with motor-driven pumps. The benefits of this equipment are so evident and necessary that the demand far exceeds the available funds; it is now a simple financing operation to be carried forward by the agricultural banks.

Recipients of the machinery introduction credit fund are another group of direct beneficiaries. By adopting more efficient machineries and equipment, their efficiency and level of income is enhanced.

1. Service Center and Workshop Operators

As has been described in Chapter V Outputs, this fund addressed one of the major problems in mechanization in the rural areas. Through the credit fund, which has as a target assisting the establishment of 20 major service centers and 50-70 small workshops. This network should suffice as a complement to existing facilities in the project areas in addition to serving

as pilots, and will indirectly benefit the 24,000 farmers living there.

2. Local Manufacturers

One machinery manufacturer is working with the project Agricultural Machinery Testing Center in Alexandria on the development of a thresher. The demand for machines which are being introduced cannot be estimated at this time, but judging from the farmers' prompt acceptance of them, it should prove to be significant.

3. Universities

The university community, in particular faculty members, are direct beneficiaries of the project. Through participation in advisory committees on several sub-projects and conducting agricultural machinery design and development research, they directly interact with project activities.

B. Indirect Beneficiaries

1. Rural Population

The farm families in rural areas, through the 18 television programs,[1] more than 100,000 extension publications, demonstration signs and other information, have been made aware of the Agricultural Mechanization Project which is assisting in the Mechanization of Agriculture. By means of the BDAC and other advertising in newspapers, the existence of special funds for acquiring water lifting pumps and the machines being introduced

[1]Black and white television sets are among the electrical appliances which have accomplished the rural electrification program which covers most of the cultivated areas in Egypt.

has also been disseminated to the rural areas. The demand for these machines and services is beginning to stimulate private individuals to enter custom work and provide the service of expensive machinery on a fee basis, particularly combine threshers, and backhoes for ditch cleaning.

2. Egyptian Agriculture

The final effects of this project upon the country's agriculture will be perceived in future years through the work of the Agricultural Mechanization Research Institute which is continuing the majority of the project activities after its completion date. The Institute is successfully beginning the rationalization process for the selection and use of farm tractors, assisting in improving their repair, operation, maintenance, and continuing to introduce appropriate machinery which is needed. This will be a great step forward in the mechanization of Egyptian agriculture, contributing significantly to the goals of increased production and higher farm incomes.

IX. UNPLANNED EFFECTS AND LESSONS LEARNED

A. Unplanned Effects

The project has experienced some unplanned changes which the evaluation team considers important enough to mention and they are:

1. Appointment of a new director which occurred in February 1982, introduced an effective management ideology and a momentum toward full implementation of the project. This change, brought in by the director, took some time before its momentum was felt, as is normal with every change in administration; once the staff became adjusted to the change, the work progressed normally and is accelerating. Management deserves the credit for most of the recent project's accomplishments.

2. The adjustments in implementation of the project to compensate for design shortfalls. As described in Chapter IV under "External Factors," unforeseen circumstances such as the need to create the "Machinery Introduction Fund" and the importation of commodities required concentrated management input. The latter was contrary to the expectation that the tractors would be readily available through the participation of the private sector. These adjustments made the management to rightfully

devote part of its limited resources to accommodate such changes.

B. Lessons Learned

The experience and knowledge gained through 45 months of project implementation provide us with a good understanding of the cause and effect issues as they apply to the AMP. In the following, an attempt was made to cast light on some design matters which in our view were important.

1. This project should have been prepared with one main objective: To assist the host country Government in devising ways and means for carrying out the goals stipulated in the Project Paper and supporting them with the necessary training, equipment and supplies financing and facilities to carry out the work. The necessary basic research work should have begun one or two years before implementation. No provision for purchase of parts for machineries was envisioned.

2. For effective extension work, such projects should be concentrated in a small area which is well communicated and representative of the main agricultural situation where activities can be tested and the basic staff trained. A strong extension

organization from the beginning to direct and supervise the field staff is a basic requirement.

3. Soil and water management should be supported by an accurate and strong data base for the design of the future farm mechanization programs. For this purpose, remote sensing techniques and interactive computer graphics system and a well equipped laboratory recommended.

4. The people working as a part of the project are best equipped to tell what the project has done and what external factors have impeded project progress. Because of this, a document briefly outlining these items and prepared by the project would make the evaluation process more effective, efficient and creditable. Ideally the evaluation team should have this paper and all the basic documents ready upon arrival.

5. The establishment of practical training centers that would function in cooperation with agricultural universities would be a welcome complement to the development of agricultural mechanization in Egypt.

6. Evaluation missions, such as this one, on large projects require a minimum of eight weeks in order to complete the work and the report in the host country.

7. The complicated process for screening tractors and implements, taking into consideration the H.P. consumption, cost, maintenance, availability of spare parts, etc. can be simplified by the use of desk top computers; logically, the data must be updated periodically.

X. CONCLUSION AND RECOMMENDATION

1. The sub-projects' development had a slow start at the beginning, but at later stages gained momentum toward reaching their planned objectives. Basic staff has been trained and the equipment have arrived or are being processed at this point.

The technical assistance team is competent and has been very effective in achieving project goals. Large number of field demonstrations and short courses have been carried out and are presently ongoing; the results are equally impressive, with very high adoption rates of the recommendations and the successful introduction of various machines and techniques.

- Several technical, economic and evaluation studies have been produced.

- PEDAC received over 6 million dollars of funds for disbursement, out of which over 3.5 million dollars has been approved by the bank and is being disbursed.

- The land improvement was achieved by the laser land levelling techniques which recently received acceptance by the farmers.

- Institutions outside of the project are receiving research grants and results from project research are being published. The specific accomplishments of the individual research

projects have been described and discussed in the Chapter V.

- Some of the important ongoing project activities are not expected to a completed by the end of the project for the reasons previously explained. This applies especially to the following activities:
  - a) Those which are time consuming (e.g. off-shore academic training);
  - b) Those programs which were too extensive to accomplish during the time frame proposed (e.g. completing demonstrations, and training of mechanics/operators in all 25 villages) - and;
  - c) Those components which are essential but could not be accomplished, such as the training of research support staff on the use of specific testing equipment, in-country training - which must be carried out after the equipment has arrived, and continuation of the off-shore academic training.

Since available funds to cover these activities will still be available, the evaluation team proposes that those activities be extended.

2. In the remaining time, the project should focus on clarifying the future institutional responsibilities for the activities it has initiated. To insure the continuity of those activities

that can not be transferred to the Agricultural Mechanization Research Institute, (i.e. those involved in the disbursement of credit funds) available AMP trained staff and personnel should gradually be transferred to appropriate positions.

3. Priority should be given to the customs clearance, assembly, and distribution of the large number of equipment items scheduled to arrive in the next six months period. Outside support may be needed to assist in equipment assembly.

4. The characteristics of the soils (soil survey) provides important information for technical decisions involving land improvement and mechanized tillage. Such information is needed for current and future demonstration villages.

5. The effectiveness of the three revolving funds (service center village workshops, machinery introduction, and water lifting can be further facilitated by modifying the LOU's to provide for continuation of loan disbursements and to shorten the loan making process. Credit fund disbursement involving agricultural mechanization loan approval, processing, and monitoring would be further improved by involving other banks in the process.

6. The water-lift fund should be replenished as soon as possible. The success of the fu disbursement is sufficient justification for such action.

7. An immediate review of the legal documents to assess commissions and needed requirements could be helpful. Appropriate amendments allowing line-items adjustments should be prepared and approved by all parties involved.

8. An internal evaluation during ~~December,~~ 1984 will be helpful to assess the total project progress and assist in identifying those items needing action before project termination and preparation of the EOPS.

9. If the project activities are extended and follow the path as recommended by the team priority should be given to organizational set up review. For this purpose, services of short term consultants can be utilized. Organizational structure, interaction, of projects' departments, divisions and personnel along with scopes of work should be prepared. Efficient systems of management data collection and analysis, and a brief format for quarterly reporting of project activities should be prepared.

10. A simple semi-annual review of project financial data, broken down by sub-project should be prepared. This should be carried through the life of the project and would provide the management with a clear picture of actual flow of funds in relation to sub-project's activities and progress. The study can begin with the inception of the project and should include projected pipeline and actual level of expenditures.

APPENDIX A

SCOPE OF WORK

Agricultural Mechanization Project (Project No. 263-0031)

OBJECTIVE

The objective of this work order is to assist USAID/Cairo in evaluating the above project.

STATEMENT OF WORK

The Contractor shall be responsible for the following:

1. Assess the progress to date in achieving each of the project outputs as envisioned in the project design. (Are they advancing at the pace anticipated? Are the inputs provided sufficient and necessary to achieve the outputs adequately and in a timely fashion? Are each of the outputs reaching their expected objectives?)

2. Assess the extent and nature of coordination between the various project outputs. (Are they progressing at compatible rates? Does the work of one facilitate and/or complement the work of the others? If not, why not?) Where appropriate, recommend actions that may be necessary to improve the coordination between the outputs.

3. Document the extent to which progress has been made in achieving the project purpose. (Has the project contributed to improved Egyptian capabilities to plan, support and carry out appropriate mechanization efforts? Are the agricultural mechanization needs nation-wide being identified and addressed more effectively, efficiently and comprehensively as a result of this project? Are previous gaps in the range of mechanization analysis and support efforts being filled? To what extent is progress at the purpose level attributable to output achievements to date?)

109

4. Comment on the extent to which achievements at the project purpose level are affecting farmers and rural dwellers. (Are improved equipment and techniques reaching farmers? Are they using them appropriately?With what effect on productivity, income, employment? Are local entrepreneurs perceiving new mechanization?)

5. Analyse the impact of this project within the broader context of agricultural mechanization in Egypt. (What are the effects on the progress and impact of this project on other donors' efforts in this area? What are the effects on this project of GOE actions and policies regarding agricultural mechanization?)

6. Assess the project's effect on the private sector

7. Recommend any necessary actions to be taken in the remaining life of project to ensure improved performance and enhanced impact.

8. Follow the Project Evaluation Summary guidelines in preparing the evaluation.

Basic methodoloty for all USAID/Cairo evaluation relies predominantly on informal interviews and site visits by the team. Interviews will be primarly with Ministry of Agriculture Staff, Egyptian Project Cheif Investigators, USAID staff involved in project implementation and project beneficiaries in selected rural areas of Egypt. These interviews are to be qualitative in nature (i.e., statistics are not compiled) and are to be used in combination with the first hand observations of the project's activities in the team's preparation of its evaluation report. In other words, USAID/Cairo expects the team to rely on its expertise and experience to analyze and convey an overall on its expertise and experience to analyse and convey an overall sense of the project's progress and impact based on what it sees and hears in a relatively short short and constrained time frame

110

Status Report on Agricultural Mechanization in Egypt

The following is a summary of ongoing activities of other doners, the GOE, non-Governmental actors, and USAID in agricultural mechanization.

Total Stock and Supply of Machinery

According to a Ministry of Agriculture survey in 1982, a total of 38,639 tractors in the 50-65 horsepower range were available in Egypt, an average of 7.3 tractors for every 1000 feddans. Based on data published in March 1983, the total population of other agricultural machines includes 21,799 fixed pumps, 39,281 mobile pumps, and 18,184 threshers. Imports of tractors and related implements has increased from 1500 units in 1973 to about 4000 units in 1982. The bulk of agricultural implements are produced and 65% are locally assembled.

About 75% of tractors are owned by private individuals, 11% by cooperatives, and 14% by the public sector.

GOE Activity

In the past, GEO mechanization efforts have included imports of a wide variety of machines, local assemply of tractors, and production of various implements primarily through the public sector companies. The banking system has facilitated the procedures and conditions for providing loans to farmers for agricultural equipment.

A number of public sector companies produce farm machinery and tools for the domestic market. Nasr Automotive Company (NASCO) in Helwan is responsible for tractor production. The current level of production is about 3000 units a year. The Beheira Company in Alexandria accounts for 80% of total production of farm implements such as ploughs, land levelers, threshers,

and trailers. The Helwan and Shoubra Diesel Companies, public sector comapnies under the same management, machine and assemble diesel engines using local materials. Demand for chisel plows is met through a number of private and public sector firms and many small workshops.

In addition, various GOE entities import agricultural machinery. For example, the MOA and MOI have imported U.S.$ 13,107,154 worth of pumps, spare parts, trucks, motors, and related commodities under USAID's CIP since 1975.

The MOA has issued, for the first time, a five year plan for mechanization that describes the following areas as the most promising for production increases through mechanization:

1. better seedbed preparation;
2. more timely planting;
3) precision leveling operations;
4) replacement of animal drawn sakia with motor-driven pumps;
5) more diversified use of tractors;
6) placement of thresher-winnowers and mechanical grain harvesters into general use. The plan concludes that in order to achieve progress in these areas equipment constraints and support system deficiencies must be addressed. The plan is designed to address equipment shortages, introduce new techniques, establish a countrywide network of service and repair centers, and train mechanics.

However, the funding source(s) for the plan is not clear. The projected total cost of the plan is L.E. 693 million, while the MOA has access to only L.E. 43 million. Mechanization is not stated as an agricultural sector objective or

principal sector project in the National Five Year Plan. Only six mechanization projects (out of a total of 79 in agriculture) with a total value of L.E. 47.6 are listed in the National Five Year Plan Detailed Description of Projects. Presumably, this funding gap could be met by the private sector, but the MOA is unclear as to how this will be achieved. The constraints to an increased private sector role in agricultural mechanization, such as the ceiling set on imports by the MOA procurement committee, have not been addressed.

Donor Activity

A. IBRD

Agricultural Development Project

A multi-faceted project whose aim is to increase production in Menoufia and Sohag through:

1) Improved extension
2) credit;
3) cooperative
4) mechanization

The project is importing a variety of agricultural machines for two experimental farms in order to evaluate the impact of mechanization on a pilot basis. Total cost amounts to U.S.$ 32 million and L.E 13.648 million from July 1978 to December 1983. IBRD has agreed to continue financing the various agricultural development and mechanization activities in Menoufia during CY 1984.

Third Education Project

A training project that includes the upgrading of two existing farm mechanization centers located in the Delta and training in farm mechanization in three other multi-purpose centers. Training programs range in length from 1 to 3 months and technical assistance is provided by expatriate experts. Total cost is U.S.$40.1 million and L.E. 11.74 million.

113

National Mechanization Program

The GOE has requested U.S.$ 200 in IBRD financing for the first stage of a national agricultural mechanization system. According to the MOA the program is designed to establish 150 specialized mechanization stations to address the rural labor shortage and increase productivity. The program will also include the establishment of agricultural cooperative societies to provide loans at 8% interest for farmers to finance mechanization costs. Training will also be provided. An IBRD mission is expected in Egypt in the next two months for discussions on the matter.

B. JAPANESE

Rice Mechanization Pilot Project - Kafr El Sheikh

The Japanese Agency for International Cooperation has granted Kafr El-Sheikh Governorate U.S.$ 5 million to finance the application of agricultural mechanizationa over 2000 feddans cultivated with rice. A similar effort has been initiated in Dakahlia.

Improvement of Sugar Cane Production in Aswan Governorate

The project provides a loan for procurement of equipment to improve sugar cane production in Aswan. The project will introduce machinery in stages through its various components: soil preparation, canal cleaning, road maitenance, field practices, repair and maintenance facilities, and a training center. A commitment of U.S$ 13 million was made in January 1981.

Rice Crop Mechanization Project

A U.S.$ 5.7 million grant to construct and equip a mechanization center, training dormitory and workshop.

114

Food Production Increase Project

A U.S.$ 8.8 million grant committed in November 1981 for fertilizer, agricultural machinery, and equipment to increase food production. Phase II provides machinery for the Agricultural Machinery Hire Service Station Project.

Agricultural Mechanization Projects

The Japanese are discussing the extension of a loan worth U.S.$ 20 million for mechanization projects. The proposal includes the establishment of a leading mechanization station and construction of four assisting stations to provide training for the workers of the main station. This project is still being discussed with the Japanese by the MOA.

C. Catholic Relief Services

Ten Horse Power Agricultural Series

A USAID-funded project for development, testing, and local manufacture of appropriate agriculture machines for Egypt's small farmers. Since its inception in 1977 the project has introduced several machines: a 10 HP multi-crop thresher/winnower, reaper, tiller, and corn husker/sheller. The proposed Phase III for U.S.$ 7.9 million will further develop and introduce the machines produced under the earlier phase, increase local manufacture, and expand activities in the Middle East Region.

D. UNDP/FAO

Improved Farming System for the Nile Valley

The project is conducting a testing and demonstration program in Naway Village in Minia Governorate with the FAO as the executing agency for the UNDP. The project is experimenting with the most suitable methods of providing mechanization services to small farm holdings with particular reference to viable multi-farm use of machinery and the determination of reasonable service charges. Total funding for Phase I (1978-81) amounted to U.S.$ 829,000 from UNDP and L.E. 2,369,000 from the GOE. Phase II (1982-85) will be funded by U.S.$ 1,300,000 from UNDP and L.E. 948,000 from the GOE.

115

E. ILO

Agricultural Machinery Training Centers

The project established training programs in tractor operations and agro-mechanics in several existing training centers. A reconditioning program for agricultural machinery and a survey of mechanization in various countries by MDA officials will be sponsored. Total cost of the activity is U.S.$ 506,550 from the ILO with a GOE contribution of L.E. 756,800 for the 1981-1984 period.

F. ITALY/FAO

Improved Farming Systems in Ismailia Governorate

This is an Italian-funded project implmentated by FAO to improve agricultural rotation, mechanization, fertilization and irrigation in Ismailia. The project, similar to the UNDP-funded farming systems activity in the Nile Valley, has total cost of U.S.$1,261,125.

F. FEDERAL REPUBLIC OF GERMANY

Training Center for Agricultural Mechanization, Maamoura

The project is designed to provide training in the use, application, maintenance, and repair of farm amchinery to operators, farmers, instructors, extension agents workshop personnel, and students. The German Government will provide technical assistance, supply equipment, improve buildings, and provide scholarships for additional training at an estimated cost of U.S.$ 3 million.

H. RUMANIA

Rental Service Centers

An agreement has been made to establish 61 rental service centers for agricultural tractors and farm machinery within zones established by the MDA. Rumania will provide the equipment for the centers that will provide tractor services to farmers and perform a maintenance and repair function.

116.

I. UNITED STATES

Small Scale Agricultural Activities

This activity is designed to make appropriate technological modifications to existing cultural practices and introduce simple improved variations to on-farm methods in order to assist small farmers with cost-saving devices that will reduce labor costs and improve yields. This is being accomplished through a series of low-cost sub-projects totalling U.S.$1.7 million from 1979 to 1984.

USAID's Major Cereals and Rice Proejcts also have mechanizaton components that involve applied research in mechanization alternatives. These activities are a part of the project's efforts to increase production of specific crops.

Non-Governmental Actitivity

The private sector is involved in trade and production of implements. Private sector dealers can import a variety of tractor types and quantities up to a ceiling set by the MOA. An attempt has been made to standardize machinery through the MOA procurement committee which must approve all machinery imports. The MOA is in the process of issuing specifications and standars for agricultural machinery. Some private sector firms are involved in the assembly of imported engines. Some private sector firms are involved in the assembly of imported engines. The Tanta Motor Company and the Sallam Plant are privately-owned plants producing varibus implements such as chisel ploughs, threshers, trailers and irrigation pumps. The Tanta Motor Company also imports tractors and power tillers. All of the Sallam Plant's work is done on contract and no stock of finished items is kept.

Source : USAID/Cairo

117

Appendix C
Table 1

AGRICULTURAL MECHANIZATION PROJECT
HISTORICAL LEVEL OF EXPENDITURE
MAY 31, 1984
(1000 $/LE)

LOCAL CURRENCY (US.$ EQUIVALENT)

Line Item	Budget		June/80		Dec/81		Dec/82		Dec/83		May/84	
	$	LE	$	LE	$	LE	$	LE	$	LE	$	LE
1. Tech. Assistance	6,424	2,302	394	74	495	243	1,221	353	1,330	314	198	91
2. Commodities	9,133	4,000	122	-	80	-	183	1,323	356	697	29	589
3. Training	2,023	1,000	-	-	-	-	9	196	265	153	70	-
4. Research Fund	1,005	2,000	-	-	-	-	186	-	6	16	-	-
5. Special Studies/ Evaluation	215	728	-	-	-	-	-	-	12	-	10	-
6. Vehicle Operating Expenses	-	100	-	-	-	-	-	-	-	28	-	-
7. Facilities	-	70	-	-	-	-	-	-	-	-	-	-
8. Credit Funds :												
a. Service Center/ Village Workshop	-	5,000	-	-	-	-	-	66	-	540	-	960
b. Water lifting	-	3,000	-	-	-	-	-	406	-	1,404	-	2,190
c. Machine Introduction	-	2,000	-	-	-	-	-	-	-	-	-	-
d. Uncommitted	-	1,000	-	-	-	-	-	-	-	-	-	-
TOTAL	18,800	21,200	516	74	575	243	1,599	2,344	1,969	3,152	307	3,830

Source: Project finanical documents - AMP activity reports.

AGRICULTURAL MECHANIZATION PROJECT
LEVEL OF EXPENDITURE & DISBURSEMENT
OF FUNDS.(May 31, 1984)

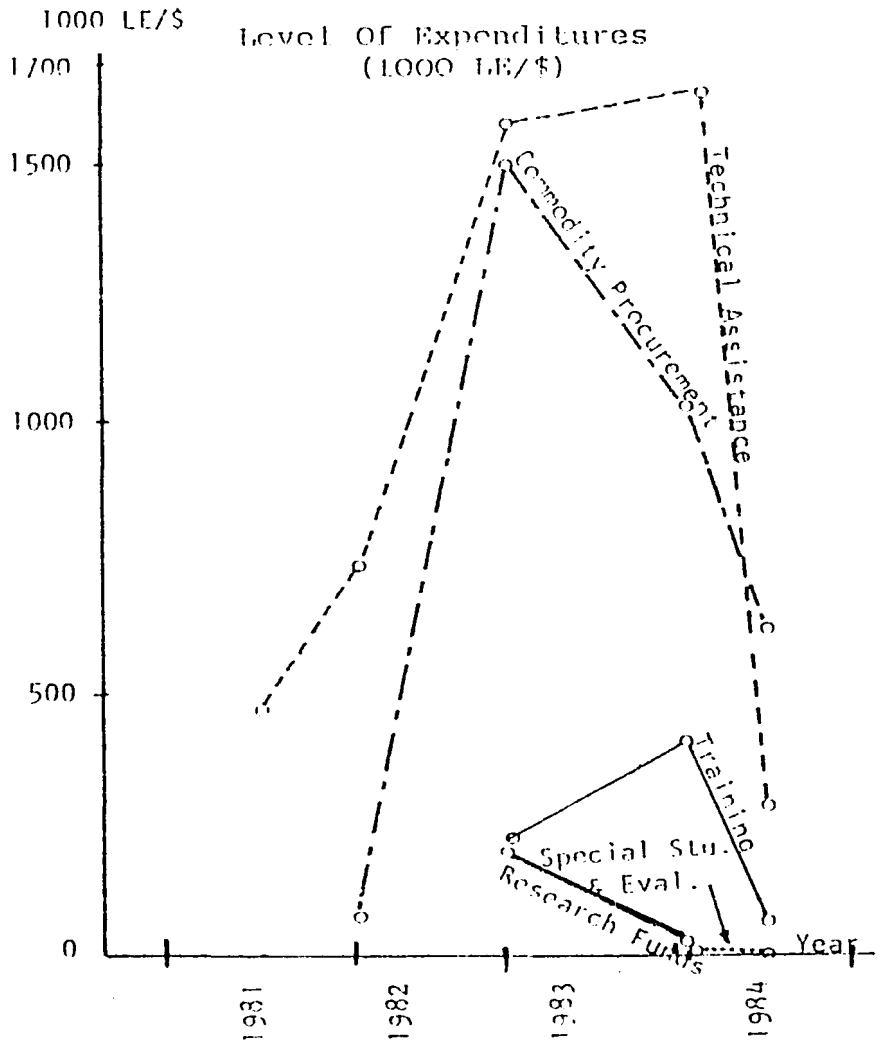


Figure A

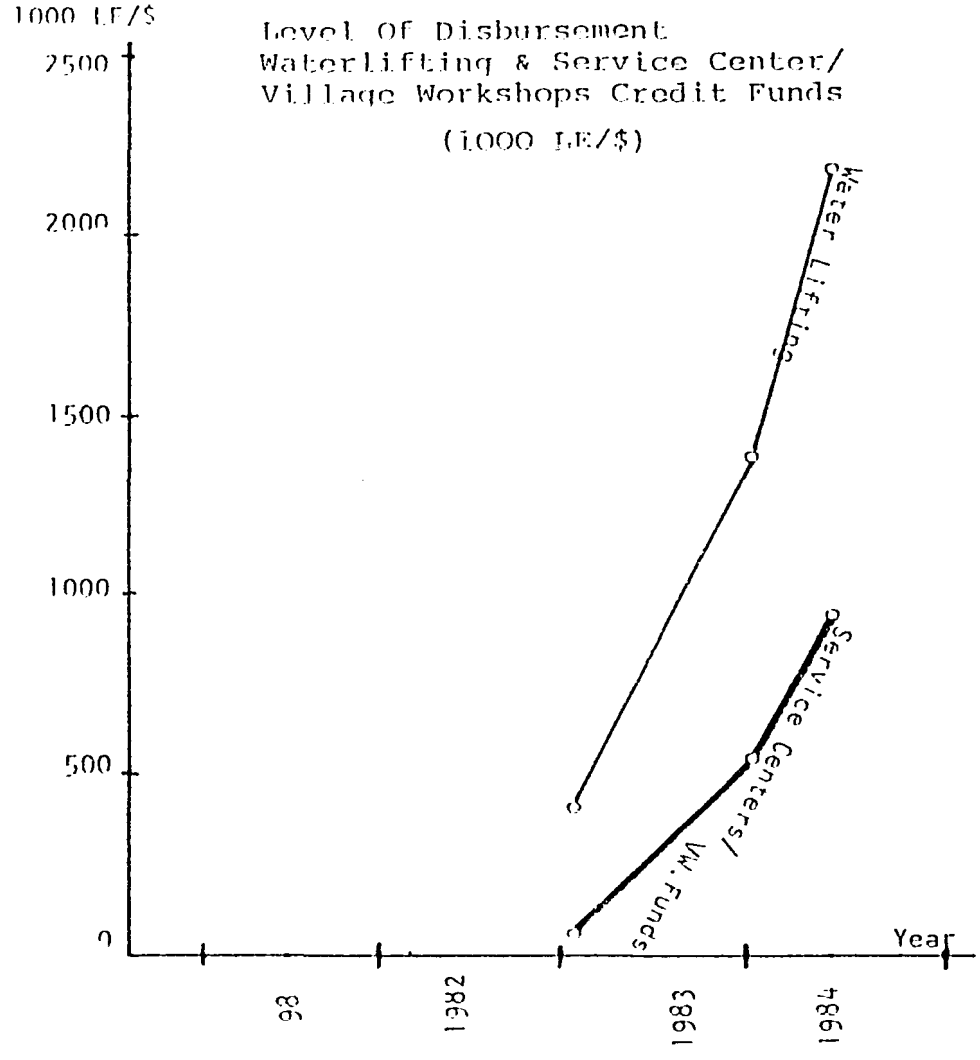


Figure B

SOURCE: ACTIVITY REPORTS - PROJECT FINANCIAL DOCUMENTS.

119

Agricultural Mechanization Projects Research Contracts

	Research Budget L.E.	Amount Advanced L.E.
1. Alexandria University		
a. Seed bed preparation	49,779	18,000
b. Development of Grain Harvesting system	67,080	18,164
c. Grain drill development and parts type manufacturing	42,768	18,000
2. Mansoura University		
Mechanization of cotton production in the Nile Valley	46,306	25,000
3. Sugar and Distilling Co.		
Mechanization of sugar cane	85,704	25,000
4. Cotton Research Insitute		
Development of planting system efficient use of row crop seeds	74,879	29,974
5. Azhar University		
Development of small suction cotton picking unit	32,195	8,000
6. Menoufia University		
Cotton stalk pulling machine	50,424	32,640
7. Sugar Crop Research Institute		
Evaluation of mechanization handling and loading of sugar-cane in Egypt	35,140	16,000
T O T A L	484,293	181,778

Source : Project documents.

Table 1 Agricultural Mechanization Project:
Academic Training Programs
15 September 1985 - 15 September 1986

No	Degree	Program Course Title	Training Plan No.	Duration	Estimated Cost U.S.$
		PROGRAMS IN-PROGRESS			
1	MS	Agricultural Economics	3PE1A	Aug 83-Jan 85	0
2	MS	Agricultural Economics	3PE1B	Jan 84-Aug 86	14800
3	MS	Agricultural Economics	3PE1C	Mar 84-Aug 86	14800
4	MS	Agricultural Economics	3MR11	Jan 84-Jan 86	11100
		PROGRAMS PROJECTED			
5	MA	Agricultural Education	3T1.1	Sept 84-Sept 86	23600
6	MS	Soil Science	2RD4	Sept 84-Sept 86	23600
7	MS	Soil Science	3S113	Sept 84-Sept 86	23600
8	MA	Rural Sociology	2PE8	Sept 84-Aug 86	23600
9	MS	Computer Programing	3PE9	Sept 84-Aug 86	23600
10	MS	Agricultural Village	4MR11	Sept 84-Aug 86	23600
		PLANNING			
11	MS	Agricultural Engineering	2RD3	Sept 84-Aug 86	23600
		TECHNOLOGY			
12	MS	Development Manufacturing	3RM12	Sept 84-Aug 86	23600
13	MS	Agricultural Mechanization	2EX45.1	Sept 84-Aug 86	23600
14	MS	Agricultural Mechanization	2EX45.2	Sept 84-Aug 86	23600
15	MS	Agricultural Mechanization	3RM17	Sept 84-Aug 86	23600

121

No	Degree	Program Course Title	Training Plan No.	Duration	Estimated Cost U.S.$
16	MS	Agricultural Mechanization EXTENSION	2EX45.3	Sept 84-Aug 86	23600
17	MS	Agricultural Engineering POWER/MACHINERY	3RM15	Sept 84-Aug 86	23600
18	MS	Agricultural Engineering POWER/MACHINERY	3RM16	Sept 84-Aug 86	23600
19	MS	Agricultural Engineering POWER/MACHINERY	4RM12	Sept 84-Aug 86	23600
20	MS	Agricultural Engineering PEST CONTROL	4RM13	Sept 84-Aug 86	23600
21	MS	Agricultural Engineering POST HARVEST	4RM14	Sept 84-Aug 86	23600
22	MS	Agricultural Engineering Irrigation	3S11	Sept 84-Aug 86	23600
		T O T A L			465500

Source : Project documents.

122

Agricultural Mechanization Project

Summary of

Project Demonstration/Training Equipment

Type of Equipment	Number of Units	
	On-Site June 1984	Total Units by September 1985
A. General equipment	75	341
B. Seed bed preparation	77	293
C. Planning	52	185
D. Cultivation	7	52
E. Fertilization	1	18
F. Insect/weed control	1	57
G. Harvesting	72	160
H. Post-harvesting	14	53
I. Maintenance (plus spare parts for all units)	84	163
T O T A L	383	1322

Source: AMP files.

Publications Resulting from the R&D Sub-project

- Sahrigi, Ahmed El, Zakaria El Hadded, and Richard K. Berky. Farm Machinery Manufacturing: A system approach. Second PADAC '83 Int'l Conference: Dept. of Production Eng., Univ. of Alexandria. 27-29 December, 1983. (English and Arabic)

- Haddad, A. A. El and S. F. Ahmed. A Semi-automatic Potato Planter: Design and Development of a prototype. Second PADAC '83 Int'l conference: Dept. of Production Eng. Univ. of Alexandria. 27-29 December, 1983. (English and Arabic)

- Trouse, Albert C. Jr. and Ahmed El Araby. A Survey of the Suitability of Egyptian Soils for Mechanized Agriculture. Working paper No. 13 Agricultural Mechanization Project USAID Project No. 263 -0031, Ministry of Agriculture, Cairo, Egypt, March, 1983. (English)

- Reaves, Carl A., Project Research Investigations: Tillage experiments with cotton, maize and peanuts. Working paper No. 14, Agricultural Mechanization Project, USAID project No. 263-0031, Ministry of Agriculture, Cairo, Egypt, January 1984. (English).

- El-Sahrigi, Ahmed, R. L. Berky and R.E. Garrett. Machinery Manufacturing Introduction to promote mechanization of Egyptian Agriculture. ASAE Paper No. 84-5003. American Society of Agricultural Engineers. St. Joseph, MI. USA. June, 1984.

- Gaiser, David W. Jr. A Systems Approach to Agricultural Mechanization Development in Egypt. ASAE Paper No. 82-5538, American Society of Agricultural Engineers, St. Joseph, MI. USA. June, 1982.

- Gaiser, David W. Jr. and Steven Shepley. Simulation Model for Evaluating Cropping Intensity and Mechanization Impact, ASAE. Paper No. 84-5001, American Society of Agricultural Engineers, St. Joseph, MI. USA June, 1984.

APPENDIX F

LBII TECHNICAL TEAM
Titles, Names, Planned and Actual Activity Dates

Title/Names	Start:Planned/Actual	End:Planned/Actual
1. Team Leader and Project Technical Dir.	October 4, 1980	September 1985
Dr.David W.Gaiser	October 4, 1980	(Current)
2. Planning and Financial Advisor	September 15, 1980	September 1985
Mr.Steven C.Shepley	September 1980	(Current)
3. Research Admin..Tech Director	November 3, 1980	November 1, 1984
Dr.Carl A.Reaves	November 3, 1980	December 31,1984
Ongoing research field) survey on 3 threshers)	April 28, 1984	(Current)
(Carl A.Reaves(TDY)		
4. Evaluation Advisor	December 1980	September 1985
Dr.Peter Reiss	December 1980	June 6, 1984
(Open, new candidate proposed)		
5. Agric.Extension Technical Director	January 15, 1981	August 1,1983
Mr.Edward Constein	February 2,1981	July 1,1982
Mr.Roger Engstrom	January 1, 1983	August 1,1983(Extended)
6. Farm Management Advisor	April 15, 1981	May 15,83- May 15,1984
Mr.Gordon Stringer	April 15, 1981	November 1,1983
Mr Roger Engstrom	November 1,1983	*Current(July 1984)
7. Machinery Development Advisor	May 1,1981	September 1,1984
Mr.Raymond Beebe	April 15, 1981	December 31,1982
Mr.Allison Blanshine	October 15,1983	(Current)

125

8. Small Manufacturer Advisor.	September 1, 1981	September 1,1984
Mr.Richard Berkey	February 3,1982	(Current) Extended
9. Agricultural Eng.Education Specialist and Coordinator of Extension/Training	August 1,1981	October 1983-September 1984
Mr.Fredrick Schantz Mr.Roger Engstrom	September 9,1981 July 1,1984	September 9,1983 September 1,1985
10 Service Center Development Advisor	May 1,1981	June 1,1985
Mr.Graham Sparrow	April 9,1981	(Current(19 April 1985)
11 Equipment Repair Advisor	May 1,1981	June 1,1985
Mr.Robert Snyder	May 7, 1981	Current(May 7,85)
12 Soil Improvement Director	June 1,1981	September 1,1985
Mr.Erroll Coles Mr.Fred Hodgson (5 mo extended 1 yr. this fall)	July 13,1981 May 10,1984	December 31,1983 Current/10 Oct.84
13. Irrigation Engineer/ Agronomist	June 1,1981	September 1,1985
Mr.James McClung	April 1,1982	Current(April 1,85
14 Water Lift.Extension Specialist	July 1,1981	September 1985

(Position scratched and added to soil improvement director,No 12)

---

* Mr.R.Engstrom will continue his duties as the coordinator of extension training with some responsibilities under No.5(if the extension is approved.)

Source: Dr. David Gaiser, Chief of Party-AMP.

126

APPENDIX G

AGRICULTURAL MECHANIZATION REPORTS

I. TECHNICAL REPORTS

1. Working paper No. 1 "Agricultural cooperative tractor cost survey in Behera and Gharbia Governorates (April 1982).

2. Economic use optimization of tractor power in selected land improvement operations. (April 1982).

3. The state of Agricultural Mechanization in Egypt results or a survey (June 1982).

4. Wroking paper No. 2 "Analysis of comparative water lifting cost in lower Egypt (July 1982).

5. Working paper No. 3 "Comparative societal and on farm cost of irrigation water lifting in A.R.E. (September 1982).

6. Working paper No. 4 basin survey Minia Governorate results of the preliminary survey (October 1982).

7. Working paper No. 5 a methodology for evaluation economic and financial costs of tractor operations in A.R.E. (December 1982).

8. Agricultural Mechanization project vaillages profile (December 1982).

9. "Agricultural Mechanization cost model" (February 1983).

10. Working paper No. 7 "Reduction Maize loss through optimizing the date of planting simulation model and economic analysis" (April 1983).

11. Working paper No. 8 Mechanization extension in Egypt in Agriculture (April 1983).

12. Agricultural Mechanization and labor, a look at the demand and supply sides (April 1983).

13. "Opportunity cost in Animal labor in Egyptin Irrigation Agriculture" (June 1983).

14. Farm management study methodology - "crop enterprise budget and mechanization impact on long ber-seen production (August 1983).

15. Mechanization extension program for project villages (1982-83) (August 1983).

16. Agricultural mechanization institute "A plan for prototype production" (August 1983).

17. "Partial economic analysis for mechanized wheat production in selected project villages" (September 1983).

18. Egyptian agricultural mechanization five years development plan 1982/1983 1986/1987 (October 1983).

19. Agricultural mechanization "Computer data acquisition systems" (November 1983).

20. "Improving rice grain yields and income through cropping calandar optimization and mechanized harvesting methods simulation model and economic Egyptian conditions.

21. Agricultural machinery management suitable for Egyptian conditions (February 1984).

22. Egyptian cotton production economics and farmer response to Governornment price intervention and meat import policies (April 1984).

23. Perspectives on Agricultural mechanization in Egypt (May 1984).

II. ACTIVITY REPORTS

Eleven (11) quarterly actitivity reports covering the period: 15 September 1980 - 31 December 1983.

A. Annexes within activity reports. (Selected papers)

1. Working paper, land improvement demonstration basin construction program (June 1982).

2. Economic of cutting stalks with silages mowers (December 9, 1982).

3. Working paper basin surveys: Minia Governorate (December 1982).

128

4. The reactions of farmers to a small Italian wheat harvester (March 1983).

5. Farmers' perceptions of changing agricultural conditions and the role of extension in Minia Governorate (March 1983).

6. Tests of primary and secondary tilage test procedures (June 1983).

7. An evaluation of the water lift loan fund (June 1983).

8. Machinery demonstration evaluation series No. 1: silage mowers (June 1983).

9. Machinery demonstration evaluation series No. 2: wheat cultivation: grain drills, mower-binders, and combines.

10. Egyptian Reasearch and Development Needs, September, 1983-December, 1988, (Dec. 1983).

11. Computer/Data Acquisition System for the Agricultural Mechanization Research Institute. (December 1983)

Appendix H

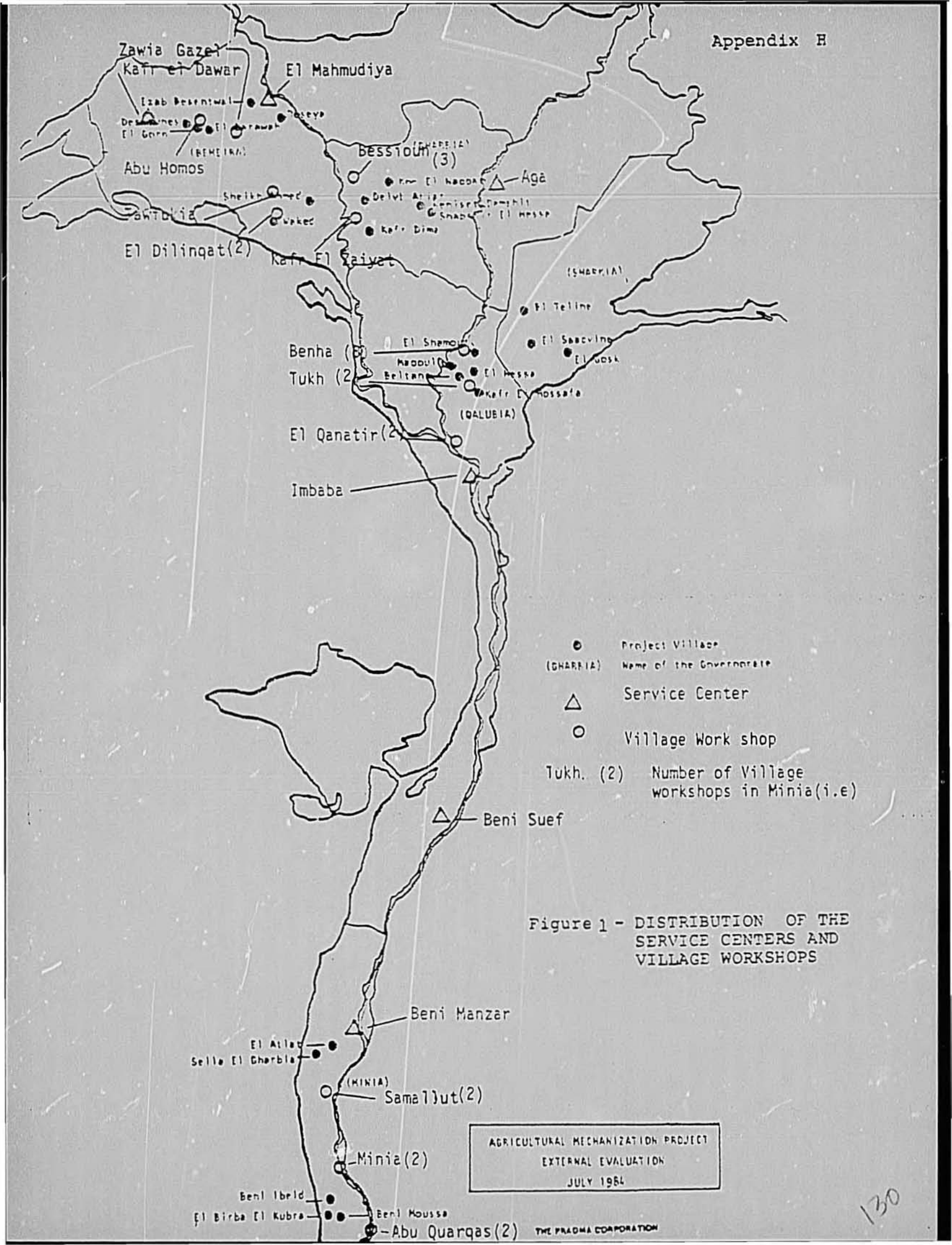


Figure 1 - DISTRIBUTION OF THE SERVICE CENTERS AND VILLAGE WORKSHOPS

AGRICULTURAL MECHANIZATION PROJECT
EXTERNAL EVALUATION
JULY 1984

Examples of farm machinery test procedures and data

Contents | Page

1.	Suggested minimum descriptive data	I-1
2.	Agricultural tractor test code	I-2
3.	Rol-over protective structure (ROPS) for Wheeled Agricultural Tractors	I-3
4.	Brake test procedures and brake performance criteria for agricultural equipment	I-4
5.	Test procedure for determining the load carry ability of farm wagon running gear	I-5
6.	Test procedures for measuring deposits and airborne spray from ground swath sprayers	I-6
7.	Test procedure for dry fertilizer spreaders	I-7
8.	Terminology for combines and grain harvesting	I-8
9.	Combine capacity test procedure	I-9
10.	Terminology and definitions for agricultural chemical applications	I-10

Suggested Minimum Description Data

The following type of data is probably needed as a part of the report for each machine tested. Because of the variability of farm machinery and its function, it may be necessary to supplement the list with machine-specific information.

1. Manufactures name and address
2. Importers name and address (if appropriate)
3. General description of machine:

   a) Machine model No.
   b) Manufactures stated size and rating
   c. Machine's principle function(s)
   d. Physical dimensions of machine
   e. Machine operating weight (full, empty)

4. Description of repairs and adjustments made during the test(s)
5. Date(s) of test
6. Basic weather data on test dates

   a) Temperature range
   b) Relative humidity range
   c) Barometric pressure
   d) General Conditions (sunny, cloudy, rain, etc.)

7. Test site location(s)
8. Remarks (comments by tests personnel which may help explain test results or limitations)
9. Name of people responsible for making the test

AGRICULTURAL TRACTOR TEST CODE

Original Agricultural Wheel-Type Tractor Test Code approved in 1937; revised in 1945, 1956, 1957; rewritten and adopted as Agricultural Tractor Test Code in 1959; revised 1962. ASAE-SAE liaison responsibility established June 1964. SAE revisions adopted December 1964, December 1967, December 1972; reconfirmed December 1977; SAE revisions adopted March 1981.

Purpose. The purpose of this Standard is to define test conditions, give a description of the tests to be made, specify data to be obtained, show formulas and calculations, define terms, and establish a uniform method of reporting so that performance data obtained on various makes and models of tractors tested in accordance with this Standard, will be comparable regardless of where the test is made. It is obvious, because of the many present day tractor models available in a number of types with numerous items of special or optional equipment, that the scope of this Standard must be limited to obtaining and reporting only the most significant of widely used performance data.

Outline of Code

Section 1—Test Conditions

Section 2—Detailed Description of Test Procedure
2.1 Preparation of tractor for performance runs
2.2 Mechanical power outlet performance
2.2.1 Maximum power-fuel consumption
2.2.2 Varying power-fuel consumption
2.2.3 Power at standard power take-off speed—(This run is made only when the engine speed at SAE and ASAE standard power take-off speed does not correspond to the engine speed at the maximum power run [paragraph 2.2.1].)
2.3 Drawbar performance
2.3.1 Maximum drawbar power
2.3.2 Varying drawbar power-fuel consumption, including sound level at operator station
2.3.3 Drawbar pull versus travel speed
2.3.4 Exterior sound level

Section 3—Final Inspection

Section 4—Calculations and Formulas

Section 5—Definition of Terms

Section 6—Uniform Method of Publishing Results

SECTION 1—TEST CONDITIONS

1.1 The tractor tested shall represent a production model in all respects. The tractor manufacturer shall supply the tractor when a certified test report is desired. The manufacturer shall supply a list of technical specifications of the tractor's construction giving detailed information regarding the powerplant, transmission, final drive, miscellaneous special and optional equipment, center of gravity of tractor with operator, machine clearance circles, and turning radii with and without brakes. The manufacturer shall also supply printed information covering all operating and servicing instructions necessary for the satisfactory operation of the tractor. All specifications shall be subject to verification.

1.1.1 The tractor manufacturer shall appoint an official representative to be present during certification runs. It shall be the duty of the manufacturer's representative to make all decisions where permissible choices or company policy are concerned. He shall also prepare the tractor for test, operate it during limber-up, make any adjustments required, and at conclusion of the test, prepare tractor for final inspection and reassemble after inspection.

1.1.2 The tractor shall be equipped with the most frequently installed items of optional equipment; however, the manufacturer should ascertain the optional equipment requirements of the specific test station, when tests are to be made for certification. Power consuming accessories shall be disconnected only if it is practical for the operator to do so as a normal farming practice. Any equipment on the tractor shall be complete and operable. The equipment shall be such that it does not interfere with the conduct of the test.

1.1.3 The tractor shall be operated as recommended by the manufacturer. Tracks or wheel and tire equipment, adjustments, servicing operations, and selection of fuel and types of lubricants shall conform to instructions printed in the published information delivered with the tractor.

1.1.4 Commercially available fuel shall be used providing it meets the manufacturer's specifications.

1.1.5 Commercially available lubricants shall be used providing they meet the manufacturer's specifications.

1.1.6 Where choices of adjustments or operating conditions are made by the manufacturer, the guide in making such choices should be the suitability for general operation.

1.1.7 Unless otherwise specified, controls that are easily manipulated from tractor seat may be used to secure optimum performance during runs.

1.1.8 The maximum drawbar hitch-point height shall be established in accordance with paragraph 4.3 as defined under Section 4.

1.1.9 Drive wheel or track slippage shall be calculated as shown under Section 4, and shall not exceed 15 percent for tractors equipped with pneumatic tires or 7 percent for tractors equipped with steel lugs or tracks.

1.2 All measurements shall be obtained with instruments and test equipment having an accuracy representative of good laboratory practice. Power at the mechanical power outlet shall be measured by means of a dynamometer. The laboratory fuel supply shall be arranged so that the fuel pressure at the carburetor or the fuel transfer pump is equivalent to that which exists when the tractor fuel tank is half full. The equipment should be arranged so that the fuel temperature is comparable to that which exists in normal operation of the tractor when fuel is taken from the tractor fuel tank.

1.2.1 Laboratory air temperature shall be 23 ± 7 C (73 ± 13 F) dry bulb, and readings shall be taken at a sufficient distance from the tractor to record actual ambient temperature. The test area shall be well ventilated. Engine exhaust gas shall be discharged from the test area. If an auxiliary laboratory exhaust stack is used, it shall be of such design that it does not change the engine performance. Laboratory atmospheric pressure shall not be less than 96.6 kPa (28.6 in. Hg).

1.2.2 The test tractor shall be equipped with track or tire and wheel equipment regularly supplied to the trade. Additional mass may be added as ballast if the manufacturer regularly supplies it for sale. When liquid ballast is used in tires, the inflation pressure shall be determined at the same height as the valve with the valve in the lowest position. Individual tire inflation pressures shall be in accordance with the manufacturer's instructions, and at these pressures, the tire load including the mass of a 75 kg (165 lb) operator on the tractor seat shall not exceed the limitation of ASAE Standard ASAE S295, Agricultural Tractor Tire Loadings, Torque Factors and Inflation Pressures. Because the traction coefficient of a tire changes with wear, the tread bar height of the test tire prior to the start of run 2.3.1 shall be not less than 65 percent of that of a new tire. To establish tread bar height, the tire shall be mounted and inflated as for the runs covered in paragraph 2.3.1. The height of the tire tread bars shall be measured by use of a 3-point gage. The gage shall be placed astride of the tread bar and perpendicular to the direction of the tread bar as close to the tire center line as possible. Two legs of the gage shall be positioned at the base of the tread bar (at the point of tangency between the tire carcass and the radius joining the tread bar to the carcass). The third point of the gage shall be in the center of the tread bar. The tread bar height shall be the difference in elevation between the two outside legs of

Best Available Document

133

the gage and the center point. The tread bar height measured in this manner shall be taken for a minimum of four equally spaced locations around the periphery of the tire. The results of these measurements shall be averaged and compared to similar data on a new tire of the same make, size, and type.

1.3 The drawbar test course shall be a hard surface on which data can readily be reproduced. It shall be constructed according to modern highway construction standards and of sufficient strength to withstand the heaviest tractor. The drawbar test runway or runways shall be straight, level, and not less than 91.4 m (300 ft) long with the approach of such length that speed and pull can be stabilized before entering the runway. For tractors equipped with rubber tires, the recommended surface materials of the drawbar test course are, in the order of preference:

1.3.1 **Concrete.** The runway or runways of the drawbar test course shall have a minimum of expansion joints. The surface shall have a uniform gritty texture with a corrugated appearance. This type of finish is also known as a "belted" finish.

1.3.2 **Bituminous.** These materials are generally known as tarmacadam or asphaltic concrete.

1.3.3 **Earth.** Test courses having earthen surfaces shall be well-packed and substantially free of loose material. This requires a soil that will adhere together when properly prepared and maintained. Suitable maintenance equipment shall be provided for grading, applying water, and packing both the subsurface and the surface. The use of this type of surface is discouraged for testing tractors equipped with pneumatic tires. For tractors having steel lugs or tracks, the test course should be earth as described in paragraph 1.3.3.

1.4 All information published in the test report shall represent the performance of a complete tractor. Power measurements shall be taken as delivered to the test equipment from a mechanical power outlet, if available, and from the drawbar.

1.4.1 The test report shall accurately define the tractor type and list all items of special or optional equipment used during the run.

1.5 For official certification, the Test Station shall provide facilities and personnel to conduct the performance runs, record all data, prepare, certify, and publish the report.

1.6 Until satisfactory correction formulas are developed for all tractors only observed data will be published. However, the necessary wet- and dry-bulb air temperatures and barometric pressure are recorded and published so that correction formulas may be applied.

SECTION 2—DETAILED DESCRIPTION OF TEST PROCEDURE

2.1 Preparation of tractor for performance runs

2.1.1 The purpose of these preparatory runs is to stabilize the tractor performance for the later runs by operating the tractor to remove stiffness, check its condition, and make permissible adjustments to assure normal operation.

2.1.2 The tractor shall be limbered up in accordance with the manufacturer's recommendations. Limber-up shall be accomplished with approximately the same mass as will be used for the maximum drawbar power runs. Minor adjustments are permissible during and at the end of this run. Adjustments shall be limited to those which conform to the published instructions supplied with the tractor. The recording of hours of operation for the entire test shall begin with the start of this run. Prior to the start of this run, the engine crankcase shall be drained and refilled with new oil of the type and viscosity recommended by the manufacturer as stated in the published information delivered with the tractor. The oil used to fill the crankcase, any oil added or withdrawn during the test, and the oil drained from the crankcase at the conclusion of the test shall be weighed and specific gravity taken, in order that the total volume of oil used during the entire test can be determined. Specific gravity data are to be obtained at or converted to 15.15 C (60.60 F). Prior to the start of this run, the transmission and other oil reservoirs on the tractor shall be filled with lubricants of the type and viscosity recommended by the manufacturer.

2.2 Mechanical power outlet performance

2.2.1 Maximum power—fuel consumption

2.2.1.1 The purpose of this run is to determine the maximum power as delivered through a mechanical power outlet to a dynamometer at the manufacturer's specified engine or mechanical power outlet speed; and to record the corresponding fuel consumption.

NOTE: This power can be measured through a belt pulley, power take-off shaft, or any other mechanical power outlet depending upon limitations of test equipment.

2.2.1.2 During the preparation for this run, the manufacturer shall establish fuel settings and ignition or injection timing, which shall remain unchanged throughout the test. The governor and the position of the manually operated governor control shall be adjusted to provide the high idle engine or power outlet speed specified by the manufacturer for maximum power operation.

2.2.1.3 Data recorded at intervals of no more than 10 min shall include engine crankshaft revolutions per minute, dynamometer revolutions per minute, mechanical power outlet shaft revolutions per minute, coolant temperature, wet- and dry-bulb air temperatures, fuel consumed, and dynamometer torque. Speeds of engine, mechanical power outlet, and dynamometer shall be taken simultaneously. The coolant temperature shall be taken in the radiator top tank. The barometric pressure shall be recorded at the beginning of the run and at 1 h intervals thereafter. The duration of the run shall be a minimum of 2 h continuous operation.

NOTE: In order to determine belt slippage, simultaneous determinations of the revolutions of both drive and driven pulleys shall be taken at no-load for a minimum of 1000 revolutions of the drive pulley with the belt tension used for this run. Belt slippage shall be calculated as shown under Section 4. Belt tension shall be adjusted for optimum power and remain unchanged throughout run. Usually optimum power is obtained with approximately 1 percent slippage.

2.2.2 Varying power—fuel consumption

2.2.2.1 The purpose of this run is to determine fuel consumption and speed when power is varied.

2.2.2.2 All adjustments shall be the same as in paragraph 2.2.1.2.

2.2.2.3 Data recorded shall be the same as in paragraph 2.2.1.3. The duration of the run shall be for 2 h of continuous operation.

2.2.2.4 The run shall consist of six power settings, each to be run for a period of 20 min in the following order:

(a) 85 percent of dynamometer torque obtained at maximum power, run 2.2.1.

(b) Zero dynamometer torque.

(c) One-half of 85 percent of dynamometer torque obtained at maximum power, run 2.2.1.

(d) Dynamometer torque at maximum power.

(e) One-quarter of 85 percent of dynamometer torque obtained at maximum power, run 2.2.1.

(f) Three-quarters of 85 percent of dynamometer torque obtained at maximum power, run 2.2.1.

NOTE: These percentages represent long and continuous past practice and are necessary to maintain continuity in procedure and meaning of the results.

2.2.3 Power at standard power take-off speeds

(This run is made only when the engine speed at maximum power does not correspond to the engine speed at SAE and ASAE standard power take-off speeds, as specified in ASAE Standard S203, Rear Power Take-Off for Agricultural Tractors.)

2.2.3.1 The purpose of this run is to determine power at the standard power take-off speed or speeds, and to record the corresponding fuel consumption.

2.2.3.2 All adjustments shall be the same as in paragraph 2.2.1.2.

2.2.3.3 Data recorded shall be the same as in paragraph 2.2.1.3. The duration of each run shall be a minimum of 1 h of continuous operation.

2.3 Drawbar performance

2.3.1 Maximum drawbar power

2.3.1.1 The purpose of this run is to determine the maximum power in not more than 12 forward gears or 12 travel speeds as selected by the manufacturer. The maximum travel speed shall not exceed the safety limitations of track or test equipment.

2.3.1.2 All engine adjustments shall be the same as in paragraph 2.2.1.2 unless the manufacturer specifies a different engine revolutions per minute for drawbar operation than for mechanical power outlet operation, run 2.2.1. In this case, the position of the manually operated governor control shall be adjusted to provide the maximum high idle engine or power outlet

134

revolutions per minute specified by the manufacturer for drawbar operation. The tractor tire and wheel or track equipment shall conform to the manufacturer's recommendations. Ballast added shall meet requirements specified under paragraph 1.2.2 of Section 1. The tractor shall be weighed with operator and ballast (if ballast is used) after tractor has been properly serviced, fuel tank and radiator filled, and all test equipment in place. For wheel type tractors, the total weight of the tractor, the weight on the front wheels, and the weight on the rear wheels shall be recorded and reported with and without ballast, but including a 75 k. (165 lb) operator. In the interest of steering control and to obtain more uniform results, the maximum drawbar hitch point height shall be established in accordance with paragraph 4.3 as defined under Section 4. Preliminary drawbar runs at maximum drawbar pull shall be made to establish maximum hitch point height. The height as related to the tractor shall remain unchanged throughout all drawbar tests. The effective circumference of the drive wheels or tracks shall be determined by driving the tractor over the drawbar test runway or runways and counting the revolutions of each drive wheel or track. The tractor shall be driven at low speed, without drawbar pull, and with all ballast in place (if ballast is used). Drive wheel or track slippage is calculated as shown under Section 4. If drive member slippage is excessive, the drawbar pull shall be reduced until slippage does not exceed 15 percent for tractors equipped with pneumatic tires and 7 percent for tractors equipped with steel lugs or tracks. Where there are two or more travel speeds in which maximum power shall be limited by drive member slippage, only one travel speed shall be checked.

2.3.1.3 Data recorded shall include: Average drawbar pull and engine crankshaft revolutions per minute maintained over test runway or runways, drive member revolutions to traverse the test runway or runways, time to traverse the test runway or runways, engine coolant temperature, wet- and dry-bulb air temperatures, and barometric pressure. Test results reported are recommended to be an average of two or more suitable runs over the drawbar test runway or runways. Two suitable runs would be those in which test conditions are stabilized, and during which the average travel speed for the two runs is within 1 percent of each other.

2.3.2 Varying drawbar power, fuel consumption, and sound level at operator station

2.3.2.1 The purpose is threefold: First, to determine fuel consumption with the tractor operating at maximum available power, at 75 percent of the drawbar pull obtained at maximum power in run 2.3.1, and at 50 percent of the drawbar pull obtained at maximum power in run 2.3.1. Second, to determine the sound level at the operator's station under these load conditions. Third, to determine whether the tractor will maintain a preselected drawbar power output for 10 h and to measure fuel consumed during the run.

2.3.2.2 Except for the run specified under paragraph 2.3.2.4d, all engine adjustments and other items shall be the same as in paragraph 2.3.1.2. The gear or travel speed shall be selected by the manufacturer within the speed range normally used in agricultural operations. All runs shall be of sufficient duration to assure accuracy of data.

2.3.2.3 Data recorded shall be the same as obtained in paragraph 2.3.1.3 with two exceptions as follows:

(a) The drawbar pull shall be the average determined from draft data taken over the complete circuit of the drawbar test course.

(b) Sound level measurements at the operator's station are added.

The sound level measurements at the operator's station shall be conducted according to the instrumentation and procedure specified in Society of Automotive Engineers Standard J919, Operator Sound Level Measurement Procedure for Powered Mobile Construction Machinery—Singular Type Test. The load conditions for these measurements will be those described in paragraph 2.3.2.4 of this code instead of the load conditions described in SAE Standard J919, Operator Sound Level Measurement Procedure for Powered Mobile Construction Machinery—Singular Type Test, paragraph 3.3.

2.3.2.4 Fuel consumption runs and measurement of sound level at the operator's station shall be made with the tractor operating as follows:

(a) At maximum available power, which is the maximum sustained power the tractor is capable of delivering at the drawbar for a predetermined length of time.

(b) At 75 percent of the drawbar pull obtained in run 2.3.1.

(c) At 50 percent of the drawbar pull obtained in run 2.3.1.

(d) At reduced engine speed, where both engine and travel speed ratio are adjusted to produce the pull and travel speed recorded under 2.3.2.4c.

NOTE: For tractors equipped with torque multiplier with "lockout," the four runs shall be made in both torque-multiplier drive and with the torque multiplier in "lockout."

2.3.3 Drawbar pull versus travel speed

2.3.3.1 The purpose of this run is to determine the drawbar pull-travel speed characteristic, or "lugging" ability, of the tractor in the gear or transmission setting selected in run 2.3.2.

2.3.3.2 All adjustments and other items shall be the same as in paragraph 2.3.1.2. (It would be desirable to make this run immediately after the maximum drawbar power run has been made in run 2.3.1 in the gear or at the travel speed selected for run 2.3.2.) Drive member slippage shall not exceed 15 percent for tractors equipped with pneumatic tires or 7 percent for tractors equipped with steel lugs or tracks.

2.3.3.3 Data recorded shall be the same as paragraph 2.3.1.3.

2.3.3.4 A series of runs shall be made starting at maximum power. In each succeeding run, the necessary drawbar pull shall be applied to the tractor to reduce the drive member speed in increments of approximately 10 percent, using drive member speed at maximum power as 100 percent. A sufficient number of runs shall be made to establish speed at which maximum drawbar pull is obtained, or speed at which maximum drawbar pull is limited by drive member slippage or cooling capacity of torque multiplier when tractor is equipped with torque multiplier.

NOTES:

A. For tractors equipped with torque multiplier and "lockout," runs shall be made in both torque multiplier drive and with torque multiplier in "lockout."

B. For tractors equipped with an automatic powershifting fixed ratio transmission, the same procedure shall be followed except that the test shall be terminated at the first automatic shift.

C. For tractors equipped with transmissions having infinitely variable engine-to-final drive ratios under the control of the operator, no runs are required. Actual drawbar pull, drawbar power, and speed obtained in run 2.3.1 shall be published.

2.3.4 Exterior sound level. The exterior sound level measurements will be conducted according to the instrumentation and procedures specified in SAE J1008, Exterior Sound Level Measurement Procedure for Self-Propelled Agricultural Field Equipment.

SECTION 3—FINAL INSPECTION

3.1 The purpose of the final inspection is to check some of the most significant items of the manufacturer's tractor specifications against the tractor tested, and to inspect the condition of some of the most critical tractor parts. It is suggested that the check of specifications include bore and stroke, valve lift, valve sizes, compression ratio and carburetor size.

SECTION 4—CALCULATIONS AND FORMULAS

4.1 Drive wheel or track slippage

$$\text{Percent slip} = 100\left(\frac{R-r}{R}\right)$$

R = total drive wheel revolution count to traverse the drawbar runway under load

r = total drive wheel revolution count to traverse the drawbar test runway under no-load

4.2 Belt Slippage

$$\text{Percent belt slip} = 100\left(\frac{RN-n}{RN}\right)$$

135

$$R = \frac{\text{Driven pulley revolutions with no-load}}{\text{Drive pulley revolutions with no-load}}$$

N = drive pulley rpm with load
n = driven pulley rpm with load

4.3 Stability Factor

$$\text{Stability factor } K = \frac{Fw \times Wb}{P \times h}$$

Fw = static front end weight
Wb = wheelbase
P = maximum drawbar pull parallel to ground
h = height of static line of pull perpendicular to ground
K = 1.25 (minimum)—may be more

SECTION 5—DEFINITION OF TERMS

5.1 **Agricultural tractor** is a vehicle designed and advertised to pull, propel, and supply power to operate machinery used in agricultural operations.

5.2 **Ballast** is any substance that is added to or removed from the tractor for the purpose of changing traction or stability. It may be added or removed at the will of the operator, and its presence is not always essential for operation of the complete tractor. Mounted equipment may be used as ballast.

5.3 **Spark ignition engine** is an internal combustion engine in which the ignition of the air-fuel mixture is accomplished by a spark inside the combustion chamber but generated from a source outside the combustion chamber. The mixing of the fuel and air in conventional spark ignition engines occurs before compression, the fuel metering being accomplished by a carburetor or similar device. The control on the amount of air-fuel mixture admitted to the cylinders is usually secured by means of a throttle valve in accordance with power requirements.

5.3.1 **Compression ignition engine** is an internal combustion engine in which the ignition of the air-fuel mixture is accomplished by the heat of compression. The initial mixing of the fuel and air in the conventional compression ignition engine occurs near the end of the compression stroke, the fuel being metered into the combustion chamber by means of a suitable fuel metering mechanism, with the quantity varied in accordance with power requirements.

5.3.2 **Rated speed of the engine** is the speed in revolutions per minute specified by the tractor manufacturer for continuous operation at maximum power for a particular operation. There may be one or more speeds specified. For example, there may be different rated speeds for operation at the mechanical power outlet, at the power take-off shaft, and at the drawbar.

5.3.3 **High idle engine or power outlet speed** is the high idle speed in revolutions per minute, sometimes called maximum no-load speed, necessary to provide the required full load speed, sometimes called rated speed, for maximum power at the mechanical power outlet, power take-off shaft, or drawbar.

5.4 **Selective gear fixed ratio transmission** is a transmission of such design that the ratio of engine speed to final drive member speed can be changed but with interruption of power to the final drive members.

5.4.1 **Torque multiplier** is a mechanism capable of automatically multiplying the engine torque. In this case, the increased torque produces a corresponding increase in drawbar pull.

NOTE. The torque converter falls into this classification.

5.4.2 **Torque multiplier lockout** is a means by which the torque multiplier can be made inoperative.

5.4.3 **Automatic power shifting fixed ratio transmission** is of such a design that it automatically shifts from one fixed ratio to another.

5.4.4 **Operator controlled power shifting fixed ratio transmission**

5.4.4.1 **Full range.** This type of transmission is of such design that the operator can change from any fixed ratio to any other fixed ratio with the tractor under power.

5.4.4.2 **Partial range.** This type of transmission is of such a design that the operator can change from certain fixed ratios to other fixed ratios with the tractor under power.

5.4.5 **Infinitely variable transmission.** This type of transmission is of such design that the operator can infinitely vary the ratio between engine and final drive members throughout part or all of the speed range of the tractor. This type of transmission includes electrical, hydrostatic, friction, and any other devices.

5.5 **Mechanical power outlet** is any outlet through which the tractor engine power can be delivered to a dynamometer, such as a belt pulley, power take-off shaft, or any other shaft or outlet.

5.5.1 **Maximum power at the mechanical power outlet** is the average maximum sustained power the tractor delivers to a dynamometer through a mechanical power outlet with adjustments as specified by the manufacturer.

5.5.2 **Power at standard power take-off speeds** is the power the tractor delivers to a dynamometer through a mechanical power outlet at SAE and ASAE standard power take-off speed or speeds.

5.6 **Maximum drawbar power** is the maximum power the tractor is capable of delivering at the drawbar on the test runway or runways.

5.7 **Maximum available drawbar power** is the average maximum sustained power the tractor delivers at the drawbar during several complete circuits of the drawbar test course. Power shall be determined from the average drawbar pull obtained over two or more complete circuits of the drawbar test course and the average travel speed concurrently obtained on the test runway or runways.

5.8 **Specific fuel consumption** is the ratio between the mass of fuel consumed per unit of time and the corresponding measured power. Distinction should be made between specific fuel consumption based on the power obtained at a mechanical power outlet and that based on the power obtained at the drawbar.

5.9 **Specific volumetric consumption** is the ratio between the measured power and the corresponding volume of fuel consumed per unit of time. Distinction should be made between specific volumetric consumption based on the power obtained at mechanical power outlet and that based on the power obtained at the drawbar.

5.10 **Drawbar pull versus travel speed** is sometimes referred to as the "lugging" ability of the tractor. This shows the ability of the tractor to produce increased drawbar pull with the corresponding reduction in travel speed.

SECTION 6—UNIFORM METHOD OF PUBLISHING RESULTS

All information shall be published in either the SI units [Systeme Internationale, See ASAE Standard EP285, Use of SI (Metric) Units] and U.S. customary units, or SI units only. The following shows that information shall be published in the certified report, how it is obtained, and how it shall be published.

6.1 **Mechanical power outlet performance**

6.1.1 **Maximum power-fuel consumption at the mechanical power outlet.** Power, engine and/or power outlet revolutions per minute, coolant temperature, wet- and dry-bulb air temperatures, and barometric pressure shall be the average for the run. The rate of fuel consumption shall be reported in L/h (gal/h). Specific fuel consumption shall be determined on the basis of average power developed and fuel consumed during the run, and shall be reported as kg/kW·h (lb/hp·h). Specific volumetric consumption shall be reported as kW·h/L (hp·h/gal).

6.1.2 **Varying power-fuel consumption at the mechanical power outlet.** Power, engine and/or power outlet revolutions per minute, coolant temperature, and wet- and dry-bulb air temperatures shall be averaged for each run. The rate of fuel consumption shall be reported in L/h (gal/h) for each run. Specific fuel consumption shall be determined on the basis of the average power developed and fuel consumed during each run, and shall be reported as kg/kW·h (lb/hp·h). Specific volumetric consumption shall be reported as kW·h/L (hp·h/gal). The last, or seventh, line in the tabulation shall be a summary of the six runs determined as follows: Power, engine and/or mechanical power outlet revolutions per minute, coolant temperature, wet- and dry-bulb temperatures, and barometric pressure shall be the average of the six runs. The rate of fuel consumption shall be reported in L/h (gal/h) for the run. Specific fuel consumption shall be determined on the basis of the average power developed and fuel consumed during the run, and shall be reported as kg/kW·h (lb/hp·h). Specific volumetric consumption shall be reported as kW·h/L (hp·h/gal).

6.1.3 **Power at standard power take-off speeds.** Power, engine and/or power outlet revolutions per minute, coolant temperature, wet- and dry-bulb air temperatures, and barometric pressure shall be the average for the run. The rate of fuel consumption shall be reported in L/h (gal/h). Specific fuel consumption shall be determined on the basis of average power developed and fuel consumed during the run, and shall be reported as kg/kW·h (lb/hp·h).

Specific volumetric consumption shall be reported as kW·h/L (hp·h/gal).

6.2 **Drawbar performance**

6.2.1 **Maximum drawbar power.** For each forward gear or travel speed tested, power, drawbar pull, travel speed, engine revolutions per minute, percent drive member slippage, coolant temperature, wet- and dry-bulb air temperatures, and barometric pressure shall be reported as an average from two or more suitable runs as described in paragraph 2.3.1.3.

6.2.2 **Varying drawbar power-fuel consumption.** Power, drawbar pull, travel speed, engine revolutions per minute, percent drive member slippage, coolant temperature, wet- and dry-bulb air temperatures, and barometric pressure shall be reported as an average from data obtained during each run. The rate of fuel consumption shall be reported in L/h (gal/h). Specific fuel consumption shall be determined on the basis of the average power developed and fuel consumed during each run, and shall be reported as kg/kW·h (lb/hp·h). Specific volumetric consumption shall be reported as kW·h/L (hp·h/gal). Sound level at the operator's station shall be reported in dB(A) as specified in SAE Standard J919, Operator Sound Level Measurement Procedure for Powered Mobile Construction Machinery—Singular Type Test.

6.2.3 **Drawbar pull versus travel speed.** Information published shall be drawbar pull, drawbar power, travel speed, engine revolutions per minute, and percent drive member slippage.

6.2.4 Exterior sound level shall be reported in dB(A) as specified in SAE J1008, Exterior Sound Level Measurement Procedure for Self-Propelled Agricultural Field Equipment.

6.3 **Fuel**

Type ..... Grade .....

Specific Gravity at, or Converted to, 15/15 C (60/60F) .....

Octane No. Motor ..... Research .....

Cetane No. .....

6.4 **Engine oil**

SAE Viscosity No. ..... API Service Classification .....

Transmission and Final Drive Lubricant: SAE No. .....

Type ..... Oil to Engine ..... gal(L) Oil from Engine ..... gal(L)

6.5 **Total hours of operation** .....

6.6 Any parts replaced or repaired during the entire test shall be listed in the published report.

Cited Standards:

ASAE S295, Agricultural Tractor Tire Loadings, Torque Factors, and Inflation Pressures

ASAE EP285, Use of SI (Metric) Units

SAE J919, Operator Sound Level Measurement Procedure for Powered Mobile Construction Machinery—Singular Type Test

SAE J1008, Exterior Sound Level Measurement Procedure for Self-Propelled Agricultural Field Equipment

Best Available Document

137

ASAE Standard: ASAE S383 (SAE J1194)

ROLL-OVER PROTECTIVE STRUCTURES (ROPS) FOR WHEELED AGRICULTURAL TRACTORS

Supersedes S305, Operator Protection for Wheel Type Agricultural Tractors, adopted August 1967; S336, Protective Frame for Agricultural Tractors—Test Procedures and Performance Requirements, adopted August 1967, and S336, Protective Enclosures for Agricultural Tractors—Test Procedures and Performance Requirements, adopted February 1970. Proposed by the Engineering Policy Committee of Farm and Industrial Equipment Institute, approved by the Power and Machinery Division Standards Committee, adopted by ASAE March 197[illegible], reconfirmed December 1981.

SECTION 1—PURPOSE

1.1 The purpose of this Standard is to establish the test and performance requirements of a roll-over protective structure (ROPS) designed for wheel-type agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental upsets. All self-propelled implements are excluded.

SECTION 2—SCOPE

2.1 Fulfillment of the intended purpose requires testing as follows:

2.1.1 A laboratory test, under repeatable and controlled loading, to permit analysis of the ROPS for compliance with the performance requirements of this Standard. Either the static test as described in paragraph 6.1 or the dynamic test as described in paragraph 6.2 shall be conducted.

2.1.2 A crush test to verify the effectiveness of the deformed ROPS in supporting the tractor in an upset attitude.

2.1.3 A field upset test under reasonably controlled conditions, both to the rear and side, to verify the effectiveness of the protective system under actual dynamic conditions. (See paragraph 6.4.1 for requirements for the omission of this test.)

2.1.4 In addition to the laboratory and field loading requirements, there is a temperature-material requirement. (See paragraph 7.1.2.)

2.2 The test procedures and performance requirements outlined in this Standard are based on currently available engineering data.

SECTION 3—DEFINITIONS

3.1 An agricultural tractor, for purposes of this Standard, is defined as a 2 or 4-wheel drive type machine of more than 15 kW (20 hp) net engine power as defined by Society of Automotive Engineers Standard J816, Engine Test Code—Spark Ignition and Diesel, designed primarily to provide the tractive power to pull, push, carry, propel, and/or provide power to implements designed primarily for agricultural usage.

3.2 The tractor mass is defined as the maximum gross machine mass determined by the manufacturer or a minimum ratio of mass to maximum power take-off power at rated engine speed of 67 kg/kW (110 lb/hp), whichever is greater. The mass includes the ROPS, all fuels, and other components required for normal use. (When power take-off power is not available, use 95 percent of net engine flywheel power.)

3.3 A roll-over protective structure (ROPS) is a cab or frame for the protection of operators of wheeled agricultural tractors to minimize the possibility of serious operator injury resulting from accidental upsets. The protective structure is characterized by providing space for the clearance zone inside the envelope of the structure or within a space bounded by a series of straight lines from the outer edge of the structure to any part of the tractor that might come in contact with flat ground and is capable of supporting the tractor in that position if the tractor overturns. (See Figs. 1, 2 and 3 for typical configurations.)

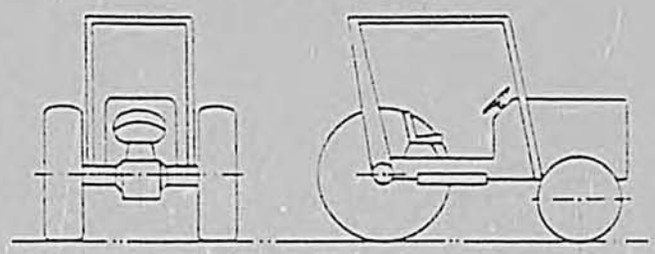


FIG. 1—TRACTOR WITH TYPICAL 2 POST ROPS

3.4 Seat reference point (SRP in Figs. 4, 5 and 6) is that point where a vertical line tangent to the most forward point at the longitudinal seat centerline of the seat back and a horizontal line tangent to the highest point of the seat cushion intersect in the longitudinal seat centerline section. The SRP is determined with the seat unloaded and adjusted to the highest and most rearward position provided for seated operation of the tractor.

SECTION 4—GENERAL REQUIREMENTS

4.1 Batteries, fuel tanks, oil reservoirs, and coolant systems shall be constructed and located or sealed to reduce the possibility of spillage that might be injurious to the operator in the event of upset.

4.2 All sharp edges and corners at the operator's station shall be appropriately treated to minimize operator injury in the event of upset.

4.3 Glazing shall conform to SAE J674, Safety Glazing Materials—Motor Vehicles.

4.4 Two or more operator exits shall be provided and positioned to reduce the possibility of all exits being blocked by the same accident.

4.5 Rear input energy tests (static, dynamic, or field upset) need not be performed on ROPS applied to tractors having four driven wheels and where the static vertical force reaction at the front wheels is greater than the static vertical force reaction at the rear wheels since this type of tractor is not prone to rearward upset.

4.6 The tractor mass used shall be that of the heaviest tractor model on which the ROPS is to be used.

4.7 New ROPS and mounting connections of the same design shall be used for conducting the tests as described in the static (par. 6.1), the dynamic (par. 6.2), or the field upset procedures (par. 6.4).

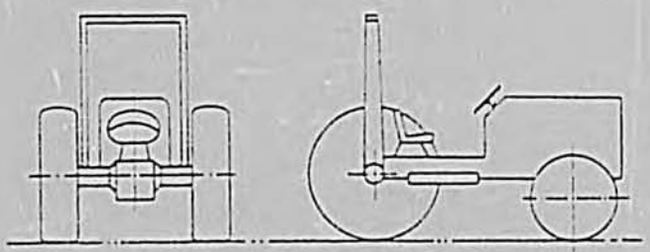


FIG. 2—TRACTOR WITH TYPICAL 4 POST ROPS

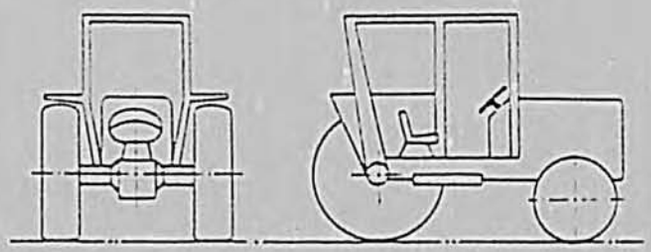


FIG. 3—TRACTOR WITH TYPICAL ROPS ENCLOSURES

178

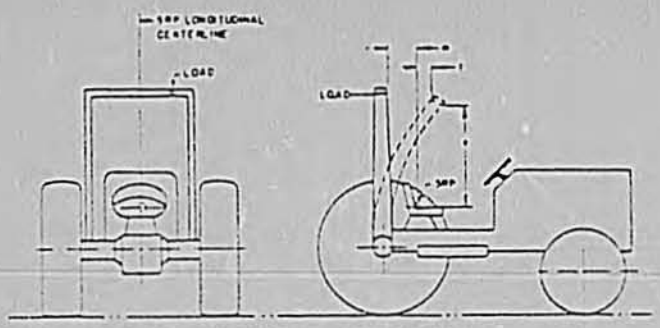


FIG. 4—TYPICAL REAR LOAD APPLICATION

4.8 In case of an offset seat, the ROPS loading shall be on the side with the least space between the centerline of the seat and the protective structure.

4.9 Accuracy of measurement:

MEASUREMENT	ACCURACY
Deflections of enclosure	: 5% of deflection measured
Tractor mass	: 5% of mass measured
Force applied to frame	: 5% of force measured
Dimensions of critical zone	: 12.7 mm (0.5 in.)

4.10 Where movable or normally removable portions of the ROPS add to structural strength, they shall be placed in configurations that contribute least to the structural strength during the test.

4.11 If an overhead weather shield is available as an optional attachment to the protective structure, it may be in place during tests, provided it does not contribute to the strength of the protective structure.

4.12 If an overhead falling object protective cover is available as an optional attachment to the protective structure, it may be in place during tests, provided it does not contribute to the strength of the protective structure.

4.13 No repairs or adjustments shall be made during the tests.

4.14 The protective structure shall meet the performance requirements established in Section 7.

SECTION 5—SEAT AND SEAT BELT REQUIREMENTS

5.1 ROPS equipped tractors shall be fitted with seat belt assemblies (Type 1) conforming to SAE J4c, Motor Vehicle Seat Belt Assemblies, except as noted hereafter.

5.2 Where a suspended seat is used, the seat belt shall be fastened to the movable portion of the seat to accommodate the ride motion of the operator.

5.3 The seat belt anchorage shall be capable of withstanding a static tensile force of 4446 N (100 lbf) at 45 degrees to the horizontal equally divided between the anchorages. The seat mounting shall be capable of withstanding this force plus a force equal to four times the force of gravity on the mass of all applicable seat components applied 45 degrees to the horizontal in a forward and upward direction. In addition, the seat mounting shall be capable of withstanding 2224 N (500 lbf) belt force plus two times the force of gravity on the mass of all applicable seat components both applied at 45 degrees to the horizontal in an upward and rearward direction. Floor and seat deformation is acceptable provided there is no structural failure or release of the seat adjuster mechanism or other locking device. The seat adjuster or locking device need not be operable after application of the test load.

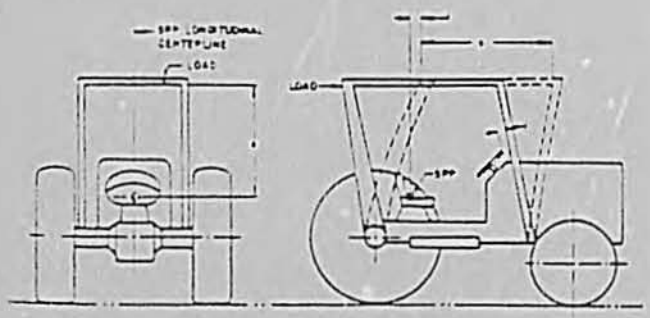


FIG. 5—TYPICAL REAR LOAD APPLICATION

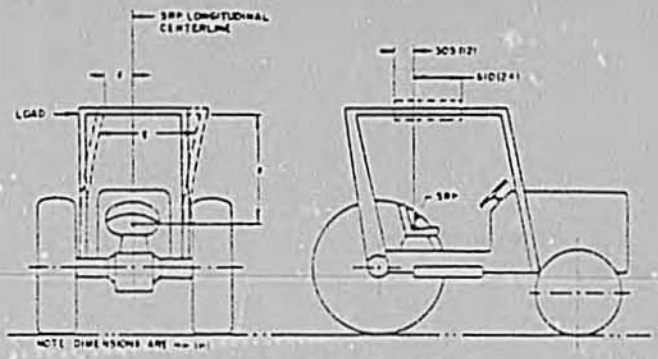


FIG. 6—TYPICAL SIDE LOAD APPLICATION

SECTION 6—TEST PROCEDURES

6.1 **Static test** (optional to paragraph 6.2)

6.1.1 **Test conditions**

6.1.1.1 The ROPS mounting base shall be the tractor chassis or the equivalent for which the ROPS is designed to assure the integrity of the entire system.

6.1.1.2 The ROPS shall be instrumented with the necessary equipment to obtain the required load deflection data at the location and direction specified in Figs. 4, 5 and 6. The measuring devices shall be located to record the force and deflection at the point of and along the line of loading. Load and deflection points shall be plotted in increments of deflection no greater than 13 mm (0.5 in.). The rate of application of deflection (load) shall be such that it can be considered static.

6.1.2 **Definition of terms**

M = tractor mass as defined in paragraphs 3.2 and 4.6
Units: M in kg
M' in lb

E_u = energy input to be absorbed during side loading
$E_u = 980 - 1.2\,M$ units: J and kg
$E_u = 8676 - 4.8\,M'$ units: in.-lbf and lb

E_r = energy input to be absorbed during rear loading
$E_r = 1.4\,M$ units: J and kg
$E_r = 5.64\,M'$ units: in.-lbf and lb

F = static load
Units: F in N
F' in lbf

D = deflection under F
Units: D in mm
D' in inches

F-D = static force deflection curve

E_s = strain energy absorbed by the structure
E_s = area under F-D curve
Units: E_s in J
E_s' in in.-lb

6.1.3 **Static test procedures**

6.1.3.1 Apply the rear load per Figs. 4 or 5 and record F and D simultaneously. Rear load application shall be uniformly distributed along a projected dimension no greater than 686 mm (27 in.) and an area no greater than 0.1032 m² (160 in.²) normal to the direction of load application. The load shall be applied to the upper extremity of the ROPS at the point which is midway between the center of the ROPS and the inside of the ROPS upright. If no structural cross member exists at the rear of the ROPS, a substitute test beam which does not add strength to the ROPS may be utilized to complete this test procedure. (See paragraph 6.4.1.1 if field upset is omitted.) Stop the test when (a) the strain energy absorbed by the structure is equal to or greater than the required input energy E_r (paragraph 6.1.2); or (b) deflection of the structure exceeds the allowable deflection (paragraph 7.1.1).

6.1.3.2 Using data obtained in paragraph 6.1.3.1, construct the F-D curve as shown typically in Fig. 8 and calculate E_s.

6.1.3.3 Apply the side load as shown in Fig. 6 and record F and D simultaneously. Static side load application shall be uniformly distributed along a projected dimension no greater than 686 mm (27 in.) and an area no greater than 0.1032 m² (160 in.²) normal to the direction of load application. Side load

139

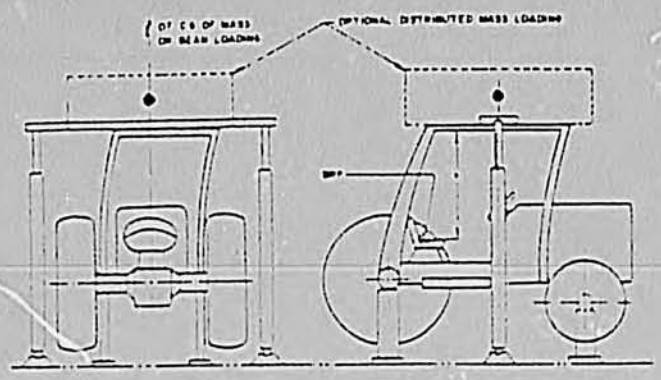


FIG 7—TYPICAL METHOD OF LOAD APPLICATION FOR CRUSH TEST

application shall be at a 90 degree angle to the centerline of the vehicle. The center of side load application shall be located between a distance 610 mm (24 in.) forward, and a distance 305 mm (12 in.) rearward of the seat reference point to best utilize the structural strength (See Fig. 6). If the ROPS is a one or two post design, the side load shall be applied in line with the upper cross member. This side load shall be applied to the longitudinal side farthest from the point of rear load application. (See paragraph 6.4.1.1 if field upset is omitted). Stop the test when (a) the strain energy absorbed by the structure is equal to or greater than the required input energy E_r (paragraph 6.1.2); or (b) deflection of the structure exceeds the allowable deflection (paragraph 7.1.1).

6.1.3.4 Using data obtained in paragraph 6.1.3.3 construct the F-D curve as shown typically in Fig. 8 and calculate E_a.

6.2 Dynamic test (optional to paragraph 6.1)

6.2.1 Test conditions

6.2.1.1 The tractor shall be ballasted to achieve the mass as specified in paragraph 3.2 so that the static vertical force reaction at the front wheels shall be at least 33 percent of the static vertical force reaction at the rear wheels. The wheel tread setting, where adjustable, shall be at the position nearest to halfway between the minimum and maximum settings obtainable on the tractor. Where only two settings are obtainable, the minimum setting shall be used provided the tires do not interfere with structure deflection. The tires shall have no liquid ballast and shall be inflated to the maximum operating pressure recommended by the manufacturer.

6.2.1.2 The dynamic loading shall be produced by use of a 2000 kg (4410 lb) mass acting as a pendulum. The impact face of the mass shall be 686 ± 25 x 686 ± 25 mm (27 ± 1 x 27 ± 1 in.) and shall be constructed so that its center of gravity is within 25 mm (1 in.) of its geometric center. The mass shall be suspended from a pivot point 5.5 to 6.7 m (18 to 22 ft) above the point of impact on the ROPS and shall be conveniently and safely adjustable for height. (See Fig. 9).

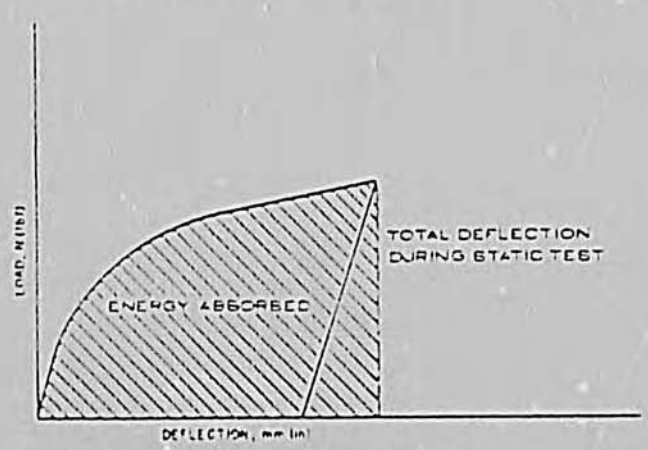


FIG. 8—FORCE DEFLECTION (F-D) CURVE

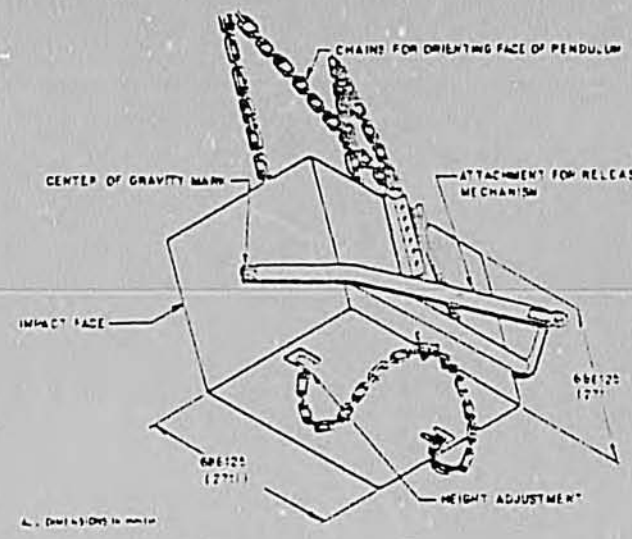


FIG 9—PENDULUM

6.2.1.3 For each phase of testing, the tractor shall be restrained from moving when the dynamic load is applied. The restraining members shall have strength no less than and elasticity no greater than that of a 12.7 mm (0.50 in.) diameter steel cable. Points of attaching restraining members shall be located an appropriate distance behind the rear axle and in front of the front axle to provide 15 to 30 degree angle between a restraining cable and the horizontal. For the impact from the rear, the restraining cables shall be located in the plane in which the center of gravity of the pendulum will swing or, alternatively, two sets of symmetrically located cables may be used at convenient lateral locations on the tractor. For the impact from the side, restraining cables shall be used as shown in Figs. 10 and 11.

6.2.1.4 The restraining cable(s) shall be tightened to provide tire deflection of 6 to 8 percent of nominal tire section width. After the tractor is properly restrained, a beam no smaller than 150 x 150 mm (6 x 6 in.) in cross section shall be driven tightly against the appropriate wheels and clamped. For the test to the side, an additional beam of sufficient strength to prevent rim displacement shall be placed as a prop against the wheel rim nearest the operator's station on the side opposite the pendulum impact and shall be secured to the base so it is held tightly against the wheel rim during impact. The length of this beam shall be chosen so that it is at an angle of 25 to 40 degrees to the horizontal when it is positioned against the wheel rim. (Figs. 10 and 11).

6.2.1.5 Means shall be provided for indicating the maximum instantaneous deflection relative to the SRP and parallel to the vertical plane of the pendulum swing. A simple friction device is illustrated in Fig. 13.

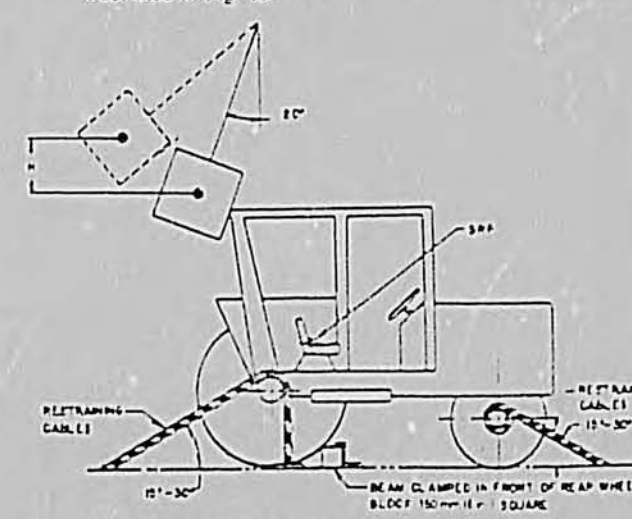


FIG. 10—TYPICAL REAR IMPACT APPLICATION

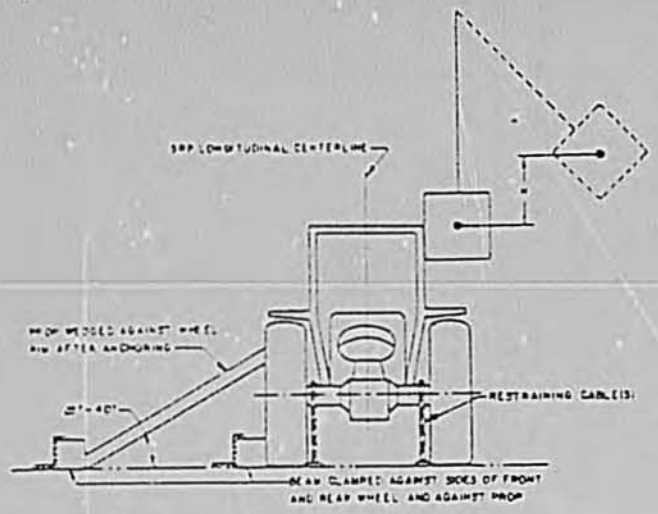


FIG. 11—TYPICAL SIDE IMPACT APPLICATION

6.2.1.6 If any cables, props, or blocking shift or break during the test, the test shall be repeated.

6.2.2 **Definition of terms**

M = tractor mass as defined in paragraphs 3.2 and 4.6
Units: M in kg
M in lb

H = vertical height of the pendulum mass
Units: H in mm
H in inches

The pendulum mass shall be 2000 kg (4410 lb).

The pendulum mass shall be pulled back so that the height of its center of gravity above the point of impact is as follows:

H = 125 + 0.107 M Units: mm and kg

H = 4.92 + 0.0019 M Units: inches and lb

6.2.3 **Dynamic test procedures**

6.2.3.1 The ROPS shall be evaluated by imposing dynamic loading from the rear, followed by a load to the side on the same ROPS. The pendulum swinging from the height determined by paragraph 6.2.2 imposes the dynamic load. The position of the pendulum shall be selected so that the initial point of impact on the ROPS shall be in line with the arc of travel of the center of gravity of the pendulum. A quick release mechanism should be used but shall not influence the attitude of the pendulum.

6.2.3.2 **Impact at rear.** The tractor shall be properly restrained per paragraphs 6.2.1.3 and 6.2.1.4. The tractor shall be positioned so that the supporting chains of the pendulum are at an angle of 20 degrees to the vertical when striking the structure as shown in Fig. 10. If the angle of the cab or frame member at the point of contact is greater than 20 degrees forward of the vertical, the angle of the face of the pendulum shall be further adjusted by any convenient means so that the striking face of the pendulum and the cab or frame member are parallel. The impact shall be applied to the upper extremity of the ROPS at the point which is midway between the centerline of the

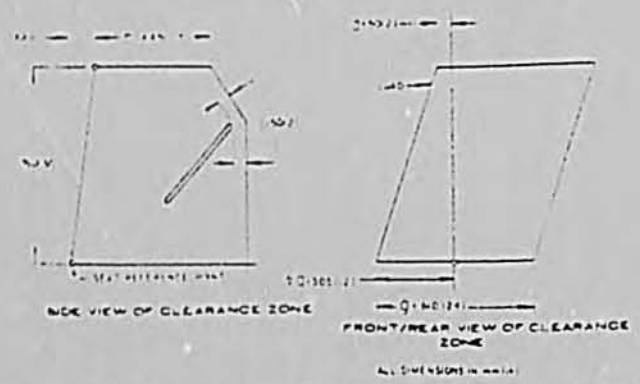


FIG. 12—PICTORIAL REPRESENTATION OF CLEARANCE ZONE

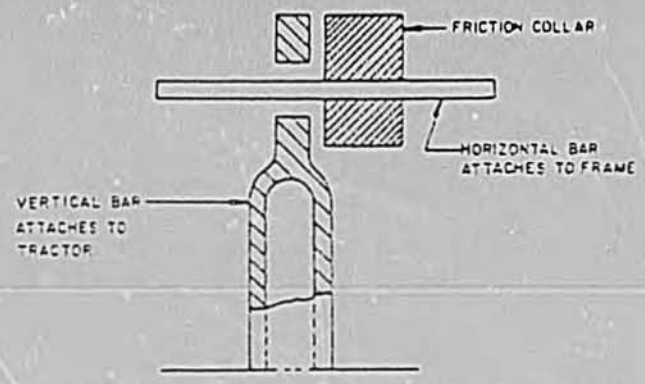


FIG. 13—TYPICAL METHOD OF MEASURING DEFLECTION

ROPS and the inside of the ROPS upright. If no structural cross member exists at the rear of the ROPS, a substitute test beam which does not add to the strength of the structure may be utilized to complete the test procedure.

6.2.3.3 **Impact at side.** The tractor shall be properly restrained as per paragraphs 6.2.1.3 and 6.2.1.4. The tractor shall be positioned so that the supporting chains of the pendulum are vertical when striking the structure as shown in Fig. 11. If the structural member at the point of impact is not vertical, the angle of the face of the pendulum shall be adjusted by any convenient means so that the striking face of the pendulum and the cab or frame member are parallel. The point of impact shall be at the upper extremity of the ROPS at a 90 degree angle to the centerline of tractor and located between a distance 610 mm (24 in.) forward, and a distance 305 mm (12 in.) rearward of the seat reference point to best utilize the structural strength. (See Figs. 6 and 11). If the ROPS is a one or two post design, the side impact shall be applied in line with the upper crossmember. The side impact shall be applied to the longitudinal side farthest from the point of rear impact.

6.3 **Crush test procedure**

6.3.1 After the ROPS has been subjected to either static or dynamic loads, the same ROPS shall be subjected to a static crush test.

6.3.2 The test load shall be 1.5 times the gravity force of the tractor mass as defined and explained in paragraph 3.2. The manner of distributing this load on the ROPS shall be such to best utilize those structural members in the fore and aft plane which will support the tractor in an upset position. The resultant of the initial crushing force or load shall be in the vertical direction and shall be in a vertical plane passing through the SRP and parallel to the longitudinal axis of the tractor (see Fig. 7). The tractor chassis shall be rigidly supported during this test.

6.4 **Field upset test**

6.4.1 **Test conditions**

6.4.1.1 The field upset test may be omitted if laboratory test (static or dynamic) results indicate compliance at an energy application of 115 percent or more of the requirements defined in paragraphs 6.1.2 or 6.2.2 and the ROPS meets the temperature-material requirements (see paragraph 7.1.2).

6.4.1.2 The tractor shall be ballasted to achieve the mass as specified in paragraph 3.2 so that the static vertical force reaction at the front wheels shall be at least 33 percent of the static vertical force reaction at the rear wheels. The wheel tread setting, where adjustable, shall be at the position nearest to halfway between the minimum and maximum settings of the shortest axles obtainable on the tractor. Where only 2 settings are obtainable, the minimum setting shall be used provided the tires do not interfere with structure deflection. The tires may have liquid ballast and shall be inflated to the maximum operating pressure recommended by the manufacturer.

6.4.1.3 The tests shall be conducted on a firm soil bank as shown in Figs. 14 and 15. The soil in the impact area shall have an average cone index in the 0 to 152 mm (0 to 6 in.) layer not less than 150. (Cone index is defined in ASAE Standard ASAE S313, Soil Cone Penetrometer, or SAE J106, Soil Type and Strength Classification.) The path of tractor travel shall be 12 ±

Best Available Document

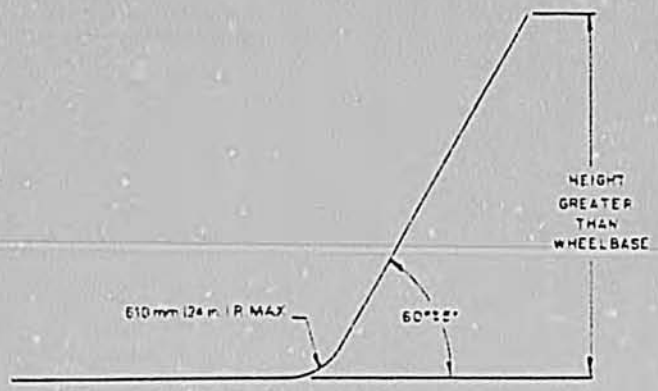


FIG. 14—TYPICAL REAR OVERTURN BANK

2 degrees to the top edge of the bank. A 457 mm (18 in.) high ramp as described and located in Fig. 15 shall be used to assist in upsetting the tractor to its side.

6.4.1.4 A means shall be provided for indicating the maximum instantaneous deflection of the structure during upset. A simple friction device is illustrated in Fig. 13.

6.4.2 **Field upset test procedures**

6.4.2.1 **Rear upset.** Rear upset shall be induced by engine power with the tractor operating in a gear to obtain 4.8 to 8.0 km/h (3 to 5 mph) at maximum governed engine rpm preferably by driving forward directly up a minimum slope of 60 ± 5 degrees as shown in Fig. 14. The engine clutch may be used to aid in inducing the upset.

6.4.2.2 **Side upset.** Side upset shall be induced by driving the tractor under its own power along the specified path of travel at a minimum speed of 16 km/h (10 mph) or at maximum tractor speed if under 16 km/h (10 mph) and over the ramp as described in paragraph 6.4.1.3. (See Fig. 15.)

SECTION 7—PERFORMANCE REQUIREMENTS

7.1 **General requirements**

7.1.1 The ROPS, overhead weather shield, overhead protection, fenders, cab sheet metal, or related ROPS parts, outside of, but near the operator area may be deformed in tests as described in paragraphs 6.1, 6.2, 6.3 or 6.4 but shall not leave sharp edges exposed to the operator or intrude on the clearance zone described by the dimensions shown in Figs. 4, 5 and 6 as follows:

- d = 50 mm (2 in.) inside of frame upright to vertical centerline of seat
- e = 760 mm (30 in.) at the longitudinal centerline
- f = no greater than 100 mm (4 in.) to rear edge of crossbar measured forward of the SRP
- g = 610 mm (24 in.) min (See Fig. 6)
- h = 445 mm (17.5 in.) min (See Fig. 5 cab or 4 post ROPS.)
- j = 50 mm (2.0 in.) measured from outer periphery of steering wheel (See Fig. 5)
- m = not greater than 305 mm (12 in.) measured from SRP to forward edge of crossbar (See Fig. 4, 1 or 2 post ROPS only)

Fig. 12 is a pictorial representation of the clearance zone.

7.1.2 The temperature material requirements will be met if the ROPS passes either of the dynamic tests (paragraphs 6.2 or 6.4) at a metal temperature of -18 °C (0 °F) or below. The temperature-material requirements will also be met if the ROPS passes either the dynamic test (paragraphs 6.2 or 6.4), or the static test (paragraph 6.1) at ambient temperature provided structural members are from material which exhibit Charpy V-notch impact strengths at -30 °C (-20 °F) shown in Table 1. Specimens are to be "longitudinal" and taken from flat stock, tubular sections, or structural sections before forming or welding for use in the ROPS. Specimens from tubular or structural sections are to be taken from the middle of the side of greatest dimension, not to include welds. There is no Charpy requirement for steel 2.6 mm (0.10 in.) or less in thickness and a maximum carbon content of 0.20 percent.

7.1.3 Fasteners used to attach the ROPS to the tractor frame and to connect structural parts of the ROPS shall be SAE grade 5 through 8 or equivalent. (Ref. SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners, and SAE J995, Mechanical and Material Requirements for Steel Nuts).

TABLE 1—MINIMUM CHARPY V-NOTCH IMPACT STRENGTHS†

Specimen Size	Impact Strength	
mm	J	ft-lb
10 x 10*	11.0	8.0
10 x 9	10.0	7.5
10 x 8	9.5	7.0
10 x 7.5*	9.5	7.0
10 x 7	9.0	6.5
10 x 6.7	8.5	6.5
10 x 6	8.0	6.0
10 x 5*	7.5	5.5
10 x 4	7.0	5.0
10 x 3.3	6.0	4.5
10 x 3	6.0	4.5
10 x 2.5*	5.5	4.0

*Indicates preferred size. Specimen size shall be no less than the largest preferred size that the material will permit.
†Reference: ASTM A 370-76, Standard Methods and Definitions for Mechanical Testing of Steel Products.

7.2 **Static test performance requirements.** The structural requirements will be met if the required rear and side energy input levels are reached or exceeded, and the dimensions of the zone of clearance in paragraph 7.1.1 are adhered to in rear and side loading.

7.3 **Dynamic test performance requirements.** The structural requirements will be met if the dimensions of the zone of clearance in paragraph 7.1.1 are adhered to in both rear and side loading.

7.4 **Crush test performance requirements.** The structural requirements will be met if the dimensions of the zone of clearance in paragraph 7.1.1 are adhered to.

7.5 **Field upset performance requirements.** The structural requirements will be met if the dimensions of the zone of clearance in paragraph 7.1.1 are adhered to in both rear and side upsets.

Cited Standards:

ASAE S313, Soil Cone Penetrometer
ASTM A370-76, Standard Methods and Definitions for Mechanical Testing of Steel Products
SAE J4c, Motor Vehicle Seat Belt Assemblies
SAE J10b, Soil Type and Strength Classification
SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J674, Safety Glazing Materials—Motor Vehicles
SAE J816, Engine Test Code—Spark Ignition and Diesel
SAE J995, Mechanical and Material Requirements for Steel Nuts

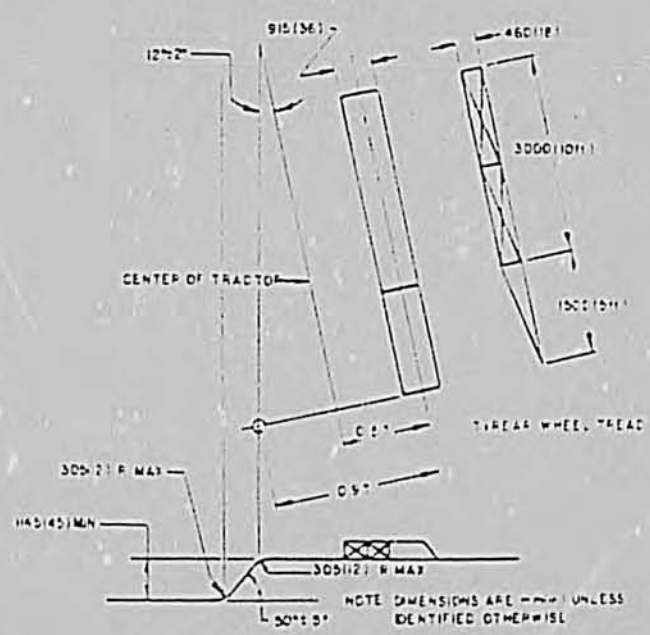


FIG. 15—SIDE OVERTURN BANK AND RAMP

142

ASAE Tentative Standard: ASAE S365.1T (*SAE J1041)

BRAKE TEST PROCEDURES AND BRAKE PERFORMANCE CRITERIA FOR AGRICULTURAL EQUIPMENT

* Corresponds in substance to previous revision S365T.

Proposed by the Engineering Committee of the Farm and Industrial Equipment Institute, approved by the ASAE Power and Machinery Division Standards Committee, adopted by ASAE, December 1973, reconfirmed for one year December 1974, December 1975, December 1976, December 1977, December 1978, December 1979, December 1980, December 1981, December 1982, revised April 1983.

SECTION 1—PURPOSE

1.1 The purpose of the Tentative Standard is to establish test procedures for measurement of brake system performance and to establish minimum performance criteria for agricultural equipment equipped with brakes.

SECTION 2—SCOPE

2.1 The test procedures and performance criteria are directed to the travel, parking, and towing of agricultural equipment that may be operated on a highway.

SECTION 3—DEFINITIONS

3.1 **Agricultural equipment:** Agricultural tractors, agricultural self-propelled material transporters, self-propelled implements, and combinations of tractors or self-propelled implements with trailed equipment designed primarily for use in agricultural operations.

3.2 **Agricultural self-propelled material transporter:** A single unit, agricultural self-propelled vehicle designed to haul agricultural material, but which may also be used to push or tow agricultural equipment.

3.3 **Agricultural tractor:** A 2- or 4-wheel drive type vehicle of more than 20 engine horsepower designed to furnish the power to pull, carry, propel, or drive implements that are designed for agriculture. All self-propelled implements are excluded.

3.4 **Brake system input force:** The sum of all forces applied by the operator to the brake system, as measured at the normal point of load application, in a line from the point of application through the operator's hip joint for foot pedal controls, or through the operator's arm-to-shoulder joint for hand-operated controls.

3.5 **Combination vehicle:** A self-propelled vehicle coupled to trailed equipment where at least one unit is equipped with brakes.

3.6 **Emergency brake system:** A brake system used for stopping a vehicle in the event of a malfunction in the operation and control of the service brake system.

3.7 **Highway:** The entire width between the boundary lines of every way publicly maintained when any part thereof is open to the use of the public for purposes of vehicular travel. (Uniform Vehicle Code published by National Committee on Uniform Traffic Laws and Ordinances.)

3.8 **Maximum vehicle weight:** The weight of the test vehicle conforming with the manufacturer's recommendations, when it is fully laden, when it is fully ballasted, or when it is equipped with either permanently mounted, semi-permanently mounted, or quickly detachable auxiliary equipment.

3.9 **Parking brake system:** A means for holding a vehicle continuously in a parked position.

3.10 **Self-propelled agricultural implement:** A vehicle designed to perform an agricultural operation without the use of a separate propelling vehicle.

3.11 **Service brake system:** The primary system used for retarding and stopping a vehicle.

3.12 **Single unit vehicle:** A self-propelled vehicle not coupled to trailed equipment.

3.13 **Stopping distance:** The distance traveled between the point at which the brake control is actuated, and the point at which the vehicle comes to a stop.

3.14 **Stopping time:** The time elapsed between the instant at which the brake control is actuated, and the instant at which the vehicle comes to a stop.

3.15 **Test vehicle:** The term used in this Standard for agricultural equipment on which brake performance tests are conducted.

3.16 **Trailed equipment:** Single or multiple implements or equipment trailing or semi-mounted on a propelling vehicle.

SECTION 4—CLASSIFICATIONS

4.1 For the purpose of this Standard, agricultural equipment is classified as follows:

CLASS A—Agricultural tractor and agricultural self-propelled material transporter.

Examples:
- Agricultural tractor
- Self-propelled bale wagon
- Self-Propelled forage wagon

CLASS B—Self-propelled equipment or combinations of trailed equipment coupled to a Class A vehicle primarily used for field work.

Examples:
- Self-propelled combines
- Self-propelled swathers
- Self-propelled cultivators
- Self-propelled balers
- Self-propelled forage harvesters
- Tractors coupled to trailed equipment

CLASS C—Combination of trailed agricultural equipment coupled to a Class A vehicle primarily used for haulage.

Examples:
- Tractors with:
  - Farm wagons
  - Fertilizer distributors
  - Nurse tank wagons
  - All other implements and combinations of agricultural equipment

SECTION 5—FACILITIES AND INSTRUMENTATION

5.1 The following facilities and instrumentation are required:

5.1.1 **Ambient temperature.** A means to measure ambient temperature within ± 5 F (± 3 C).

5.1.2 **Braking system input force.** An instrument to measure the applied force to the brake control, within an accuracy of ± 3 percent.

5.1.3 **Stopping distance.** A means of measuring the stopping distance within an accuracy of ± 1 percent.

5.1.4 **Test course.** The test course shall be straight and consist of a clean swept, level dry concrete or other specified surface of adequate length to conduct the test. The approach shall be of sufficient length, smoothness, and uniformity of grade to assure stabilized travel speed of the vehicle. The braking surface shall not have more than 1 percent slope in the direction of travel and no more than 3 percent slope at right angles to the direction of travel.

5.1.5 **Test speed.** A means of measuring the test speed within an accuracy of ± 2 percent of actual speed.

5.1.6 **Test weight.** A means for weighing wheel loads within an accuracy of ± 2.5 percent.

5.1.7 **Time to stop.** A means of measuring the stopping time within an accuracy of ± 1 percent.

5.1.8 **Tire pressure.** A means of measuring tire inflation pressure within an accuracy of ± 3 percent.

5.1.9 **Towing force.** An instrument to measure towing force (tension and compression) within an accuracy of ± 3 percent, and with a towing force indicator visible to the test vehicle operator.

113

5.1.10 **Towing vehicle.** A towing vehicle with sufficient power and weight to pull the test vehicle. The device connecting the towing vehicle to the test vehicle shall be substantially horizontal.

5.1.11 **Wind velocity.** A means of measuring wind velocity within an accuracy of ± 2 miles per hour (3.2 km/hr).

5.2 The following facilities and instrumentation are optional:

5.2.1 **Brake temperature.** A temperature measuring system shall have ± 2 percent full scale accuracy.

5.2.2 **Deceleration.** An instrument to measure maximum deceleration within an accuracy of ± 3 percent.

5.3 **Brake test report.** A typical brake test report form is shown in Fig. 1.

SECTION 6—TEST PROCEDURE FOR AGRICULTURAL EQUIPMENT CLASSIFICATIONS A, B AND C

6.1 **General**

6.1.1 Examine the test vehicle to assure compliance with the test vehicle manufacturer's specifications on brake system components, lubrication type, reservoir levels, and tires. Set all tire pressures to the maximum of test vehicle manufacturer's specifications for weight to be tested. Conduct all tests with the brake system fully operational per manufacturer's specifications and instructions. Set all power assist adjustments (pressure, etc) to minimum of manufacturer's specification range.

6.1.2 Burnish or "break in" the test vehicle brakes as specified by manufacturer or as required to establish consistent braking performance.

6.1.3 Record test vehicle weight, individual wheel load distribution, and vertical tongue load where applicable.

6.1.4 Record ambient temperature, wind velocity and wind direction with respect to the test course. The test shall not be conducted when the wind velocity exceeds 20 miles per hour (32.2 km/hr) or when the ambient temperature is below 40 F (4 C) or above 80 F (32 C) unless it can be shown that the test results will not be significantly influenced.

6.1.5 The term "cold" brakes shall mean that the temperature does not exceed 212 F (100 C) at the radial midpoint of the open edge of each brake drum or at the periphery of each brake disc. Previous to each stop, maintain drum or disc temperature of 212 F (100 C) or less.

6.1.5.1 If the drum or the disc temperature cannot be conviently measured, the vehicle manufacturer should specify an alternate point of measurement and specify a correction factor for that point.

6.1.5.2 Where it is impractical to measure the temperature of the brakes, they can be considered "cold" brakes when they have not been subjected to severe braking tests during the preceding hour, and at least 5 minutes must elapse between each stop.

6.1.6 Auxiliary retarder, variable ratio drive, or other auxiliary braking devices shall not be used in the brake tests unless they are simultaneously actuated by the brake control, or unless such retardation is automatic with normal braking procedure. Description and use of such devices shall be noted in the test report.

6.1.7 Record a description of any unusual or erratic brake performance, noise characteristic, or parts failure observed during the tests.

6.1.8 All test stops conducted must be accomplished under control without pull or swerve which would take the test vehicle out of a test lane 4 ft (1.2 m) wider than the maximum width of the test vehicle.

6.2 **Effectiveness test procedure**

6.2.1 The test vehicle brakes shall be "cold" prior to each stop.

6.2.2 Two effectiveness tests shall be carried out: (1) with the test vehicle ballasted to the maximum vehicle weight as specified in paragraph 3.8, and (2) with the test vehicle unballasted.

6.2.3 Effectiveness tests shall be conducted on the specified test course from an initial test vehicle velocity of 15 miles per hour (24.1 km/hr) or maximum test vehicle speed recommended by the manufacturer, whichever is less, to clearly define minimum stopping distance and brake input force. The foot control input force shall not exceed 200 lb (890 N). The hand controlled input force shall not exceed 88 lb (391 N).

6.2.4 Stopping distance, as specified in paragraph 3.1.3, (and maximum deceleration rate—optional), shall be measured from a stabilized travel speed with the engine not contributing to the braking effort, except as noted in paragraph 6.1.6.

6.3 **Fade and recovery test procedure**

6.3.1 Starting from a "cold" condition with the test vehicle ballasted at the maximum vehicle weight, the service brakes shall be heated by towing at a speed of 12.4 miles per hour (20 km/hr) or at 60 percent of maximum vehicle speed whichever is less, with engine clutch disengaged or transmission in neutral and with input to the service brake system sufficient to maintain a constant drawbar pull equal to 10 percent maximum vehicle test weight over a distance of 0.62 mile (1 km). Record required brake control force inputs at the beginning and end of this heating cycle.

6.3.2 Immediately disconnect the towing vehicle and repeat the effectiveness test at the maximum vehicle weight using the brake input force limits specified in paragraph 6.2.3 to demonstrate the minimum controlled stopping distance. This test shall be completed within 3 minutes of the completion of the heating cycle specified in paragraph 6.3.1.

6.3.3 After cooling the brakes to a "cold" condition, repeat the effectiveness test at the maximum vehicle weight to determine recovery characteristics.

6.4 **Wetted brake effectiveness and recovery test procedure**

6.4.1 Perform the effectiveness test at the maximum vehicle weight after flooding the test vehicle's brakes with water for a minimum of 2 minutes. This test is not applicable to fully sealed brake systems.

6.4.2 **Recovery test**

6.4.2.1 After flooding the brake facings for a minimum of 2 minutes, conduct the recovery test by towing the vehicle at 60 percent of maximum vehicle speed or 12.4 miles per hour (20 km/hr) whichever is less and with the engine not contributing to the braking effort. Brake applications at 2-minute intervals shall be run, measuring the input pedal force (within limits specified in paragraph 6.2.3) required to produce a drawbar force of 25 percent of maximum ballasted weight of test vehicle.

6.4.2.2 After drying the brakes, conduct the effectiveness test at the maximum vehicle weight to determine brake recovery characteristics.

6.5 **Emergency brake system test procedure.** Use the effectiveness test at the maximum ballasted vehicle weight to measure performance of emergency braking systems.

6.6 **Parking brake system test procedure**

6.6.1 Parking brake holding tests shall be conducted on a level test course with the transmission of the maximum ballasted test vehicle in neutral. Pull the test vehicle from rest until a towing force equal to at least 20 percent of test vehicle maximum weight is developed. If parking brake input force is applied with hand control, maximum input shall be limited to 120 lb (534 N). If foot controlled, the maximum input force shall be limited to 200 lb (890 N).

6.6.2 Repeat paragraph 6.6.1 in reverse direction.

6.6.3 Parking brake tests may be optionally conducted on a 20 percent slope.

6.6.4 If test vehicle is equipped with a positive transmission locking device (park position) rather than a parking brake, apply a drawbar pull equal to at least 20 percent of the test vehicle maximum weight in each direction. Test may be optionally conducted on a 20 percent slope.

SECTION 7—TEST PROCEDURE FOR TRAILED AGRICULTURAL EQUIPMENT WITH BRAKES

7.1 **General**

7.1.1 Connect the test vehicle to a towing vehicle in a manner representing normal usage and manufacturer's recommendation for the test vehicle. The test vehicle brake actuating system must be separate from the towing vehicle brake actuating system, unless the test vehicle is to be limited by manufacturer's recommendation to a specified towing vehicle or actuating system. A towing force indicator shall be inserted between the test vehicle and towing vehicle in such a manner that only towing forces are indicated, and no vertical weight transference is shown.

7.1.2 Perform all steps in paragraph 6.1.

7.2 **Effectiveness test procedure**

7.2.1 The test vehicle brakes shall be "cold" prior to each stop.

7.2.2 The effectiveness test shall be carried out with the test vehicle ballasted to the maximum vehicle weight specified by the manufacturer.

7.2.3 Effectiveness tests shall be conducted from an initial velocity of 15 miles per hour (24.1 km/hr) or at a maximum trailing speed recommended by the manufacturer, whichever is less.

7.2.4 The test vehicle brake input force shall be operated at suitable increasing increments in individual tests until the minimum, controlled trailed vehicle stopping distance (see paragraph 6.1.5) as determined in paragraph 7.2.5 has been achieved, or until maximum test vehicle brake control force is reached. The maximum foot control input force shall not exceed 200 lb (890 N). The maximum hand-controlled input force shall not exceed 88 lb (391 N). The towing vehicle brakes shall be applied with sufficient force to cause the towing force to be as constant and as near zero as possible (tension or compression), between test vehicle and towing vehicle.

NOTE: Towing force will be a positive compressive force for overrun type brakes.

7.2.5 Stopping distance, as specified in paragraph 3.1.3, shall be measured from a stabilized vehicle speed with the towing vehicle engine disengaged from the drive train.

7.3 **Fade and recovery test procedure.** Fade and recovery tests shall be conducted as specified in paragraph 6.3.

7.4 **Wetted brake effectiveness and recovery test procedures.** Wetted brake effectiveness and recovery tests shall be conducted as specified in paragraph 6.4.

7.5 **Emergency uncoupling brake actuation test procedure.** Conduct the maximum ballasted effectiveness test with the trailed test vehicle brakes automatically actuated by becoming uncoupled from the towing vehicle in a manner representing unintentional or accidental uncoupling at the towing vehicle drawbar.

7.6 **Parking brake test procedure.** Parking brake tests shall be conducted as specified in paragraph 6.6.

SECTION 8—MINIMUM PERFORMANCE CRITERIA

8.1 **Service brake stopping distance**

8.1.1 Minimum service brake stopping distances are shown in Table 1. Stopping distances shall be measured from an initial speed of 15 miles per hour (24.1 km/hr) or from the maximum speed recommended by the manufacturer, whichever is less.

TABLE 1—MINIMUM SERVICE BRAKE STOPPING DISTANCE

Equipment Class	Effectiveness and Recovery Tests		Fade Test	
	Feet	Meters	Feet	Meters
A	25	7.6	31	9.4
*B	50	15.2	63	19.2
*C	50	15.2	63	19.2

*The weight of the trailed equipment without brakes should not exceed the weight of the agricultural equipment used as the towing vehicle.

8.1.2 Test vehicles with primary speed retardation systems other than conventional service brakes shall meet the same stopping distance specifications given in paragraph 8.1.1.

8.2 **Parking system requirements**

8.2.1 The parking system shall hold the test vehicle stationary in both forward and reverse direction on a 20 percent slope or equivalent loading, under all conditions, up to the manufacturer's maximum vehicle weight rating.

8.2.2 The parking system, when applied, shall remain in the applied position in compliance with paragraph 8.2.1 despite any contraction of the brake parts, exhaustion of the source of energy, or leakage of any kind.

8.3 **Emergency braking system requirements.** Trailed equipment brakes applied by accidental or unintentional uncoupling (see paragraph 7.5), shall be independent of the towing vehicle and capable of holding the test trailed vehicle, weighted to manufacturer's maximum vehicle weight rating, on or against the equivalent pull of a 20 percent slope (forward or reverse) for a period of at least 15 minutes after emergency actuation. Trailed equipment brakes shall be released only by a specific action of the operator.

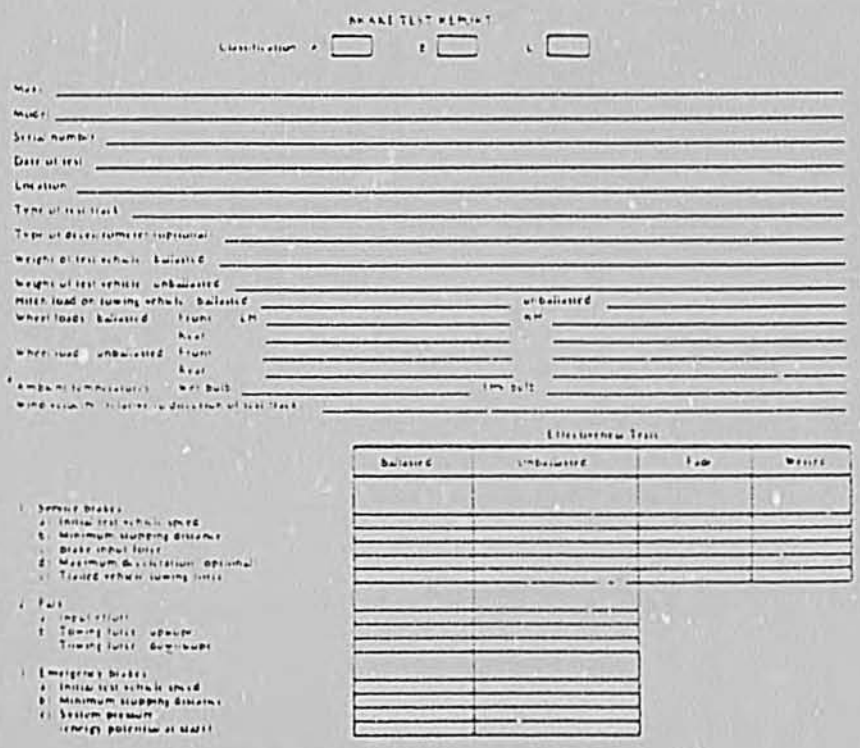


FIG. 1—TYPICAL BRAKE TEST REPORT

I.15

TEST PROCEDURE FOR DETERMINING THE LOAD CARRYING ABILITY OF FARM WAGON RUNNING GEAR

Developed by the ASAE Farm Wagon Subcommittee, approved by Power and Machinery Division Standards Committee, adopted as a Tentative Standard February 1972, reconfirmed December 1973, reclassified as a Standard, December 1974, reconfirmed December 1979.

SECTION 1—PURPOSE AND SCOPE

1.1 The Standard provides a uniform method for determining capacity ratings of farm wagon running gear. The Standard provides minimum acceptable performance criteria.

1.2 The Standard relates to farm wagon running gear having 2 or more axles. Steering means shall be auto-steer or fifth wheel type.

SECTION 2—GENERAL DESCRIPTION OF TEST

2.1 A wagon running gear is loaded with a load which is 110 percent of the load rating to be tested as outlined in Section 3. It is then run over a single ramp constructed as outlined in Section 7, in a manner described in Section 8, at a temperature not lower than 32 deg F (0 deg C). The wagon running gear is considered to pass the test for the rating indicated if it meets the criteria defined in Section 9.

SECTION 3—RATINGS AND LOADING METHODS

3.1 The ratings to be confirmed by testing shall be determined prior to testing to establish the test load. Published ratings shall be to the nearest 1000 lb or 500 kg.

3.2 The rating to be confirmed by testing shall include the weight of the wagon running gear, tires, and what they carry. For example, a wagon running gear rated for 10,000 lb (4536 kg) will weigh 10,000 lb (4536 kg) on the ground when loaded.

3.3 Wagon running gear to be tested shall be equipped with a framework for holding the load to be applied and shall be constructed:

3.3.1 To position the center of gravity of the applied load a minimum of 24 in. (610 mm) above the top of the bolster. (See Fig. 1).

3.3.2 To not reinforce the reach pole and to follow wagon running gear manufacturers' recommendations for securement to front and rear bolsters. The framework may be flexible enough to stay on the bolster throughout the test.

3.4 The applied load shall bring the weight upon the ground up to 110 percent of the rated load being tested.

3.5 Load distribution shall be equally distributed on all tires ± 5 percent.

3.6 Bow of the reach, toe-in and camber of all wheels when loaded as in paragraph 3.4 shall be measured and recorded.

SECTION 4—WAGON RUNNING GEAR AND EQUIPMENT

4.1 Wagon running gear shall be equipped as it is intended to be sold. Optional equipment that affects the load carrying ability of the wagon running gear shall be included if the wagon running gear is to be rated with this optional equipment.

4.2 **Wheel base**

4.2.1 Ratings 12,000 lb (5443 kg) and under shall be run at 96 ± 2 in. (2438 ± 51 mm).

4.2.2 Ratings over 12,000 lb (5443 kg) shall be run at 108 ± 2 in. (2743 ± 51 mm).

4.3 **Wheel track width.** The maximum setting recommended by the wagon running gear manufacturer shall be used.

4.4 **Tires and tire pressure.** Tires shall be selected in accordance with the recommended load limits and maximum inflation pressures published by the Tire and Rim Association for a maximum speed of 5 mph for implement tires and low section height implement tires used in field service. Tires shall be inflated to a cold inflation pressure adequate for carrying the loads determined in paragraph 3.5.

SECTION 5—TOWING VEHICLE

5.1 The towing vehicle shall be capable of pulling and backing the loaded farm wagon running gear over the test ramp as outlined in Section 8.

5.2 Drawbar height shall be 15 to 17 in. (381 to 432 mm) above the ground.

SECTION 6—SPEED

6.1 The wagon running gear should be pulled and backed over the test ramp at a slow speed, approximately 0.5 mph (0.8 km per hr.), to reduce the effect of impact. Faster speeds may be used, but impose high loads upon the wagon running gear.

SECTION 7—RAMP AND SURROUNDING APRON

7.1 A single ramp of durable material shall be constructed on relatively level ground to the dimensions shown in Fig. 2.

7.2 dimensions of the ramp relative to the surrounding apron shall be maintained.

SECTION 8—TEST PROCEDURE

8.1 The towing vehicle shall pull and back the loaded wagon running gear over the ramp in the following sequence as shown in Fig. 3.

8.1.1 Pull entire wagon running gear up 45 degree slope and down 30 degree slope at 90 ± 15 degree approach angle.

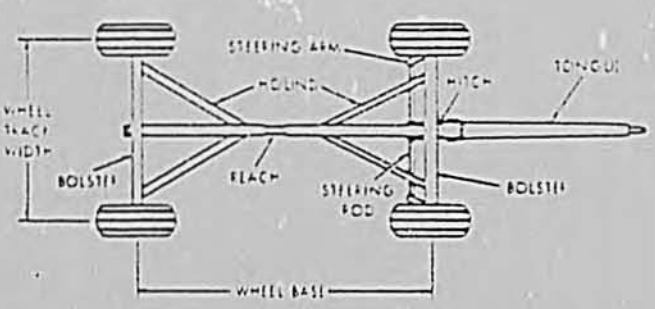


FIG. 1—NOMENCLATURE OF FARM WAGON RUNNING GEAR

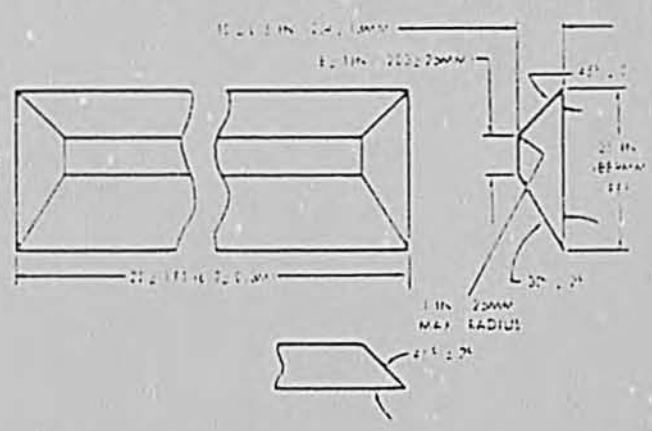


FIG. 2—TEST RAMP

8.1.2 Back entire wagon running gear up 30 degree slope and down 45 degree slope at 90 ± 15 degree approach angle.

8.1.3 Pull entire wagon running gear up 45 degree slope and down 30 degree slope at 45 ± 15 degree approach angle with right front wheel contacting ramp first.

8.1.4 Back entire wagon running gear up 30 degree slope and down 45 degree slope at 45 ± 15 degree approach angle with left rear wheel contacting ramp first.

8.1.5 Pull entire wagon running gear up 45 degree slope and down 30 degree slope at 45 ± 15 degree approach angle with left front wheel contacting ramp first.

8.1.6 Back entire wagon running gear up 30 degree slope and down 45 degree slope at 45 ± 15 degree approach angle with right rear wheel contacting ramp first.

8.1.7 Pull right wheels up end of ramp, go full length and down other end.

8.1.8 Pull left wheels up end of ramp, go full length and down other end.

8.2 The test sequence outlined in paragraph 8.1 shall be repeated 3 times for a total of 24 passes.

SECTION 9—CRITERIA FOR ACCEPTANCE

9.1 A farm wagon running gear is considered acceptable for the load rating being tested if it remains operational under the test load. The following limits shall not be exceeded after the test is completed. All measurements shall be made while the wagon running gear is still carrying the test load.

9.1.1 Bow of the reach shall be the original bow ± 1.0 in. (± 25 mm).

9.1.2 Toe-in shall not change more than 3 degrees from original toe-in.

9.1.3 Camber shall not change more than 3 degrees from original camber.

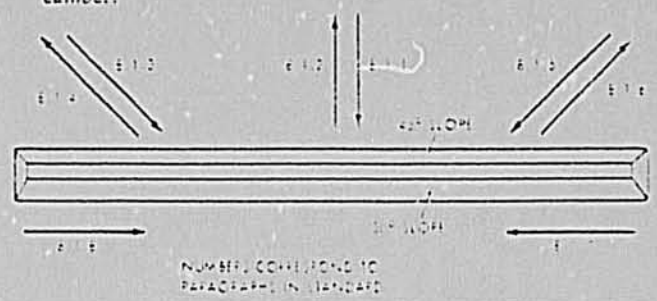


FIG. 3—TEST PROCEDURE SEQUENCE AND DIRECTIONS

147

TEST PROCEDURE FOR MEASURING DEPOSITS AND AIRBORNE SPRAY FROM GROUND SWATH SPRAYERS

Developed by the ASAE Agricultural Chemical Application Committee, approved by the Power and Machinery Division Standards Committee, adopted by ASAE June 1977, reconfirmed for one year December 1978, December 1979, December 1980, December 1981; revised and reclassified as a full Standard January 1983.

SECTION 1—PURPOSE AND SCOPE

1.1 This Standard establishes a test procedure for use in measuring and reporting in-swath and out-of-swath deposits and airborne spray from sprayers.

1.2 This Standard pertains to moving, ground sprayers applying agricultural chemicals in a swath. It does not pertain to orchard hand gun, air carrier systems, foggers, or other sprayers where the spray is not intended to be deposited in a swath on the land surface or crop canopy. It does not pertain to aerial applicators.

SECTION 2—ESSENTIAL ELEMENTS OF A TEST

2.1 A standard reference spray application, as described in paragraph 2.1.1, shall be included with each test, because it is not desirable to specify all details of this sprayer test procedure precisely. For example, it is not desirable to limit all users of this procedure to one size, composition, and placement of collectors. The standard reference application provides a basis of comparison between any two spray tests.

2.1.1 **Standard reference application for ground sprayers.** Eight flat fan nozzles rated at 0.76 L/min (0.2 gpm) at 275 kPa (40 psi) gage pressure with an 80 deg spray angle shall be used. The nozzles shall be pointed vertically downward with the fans in a plane 85 deg to the direction of travel to prevent mixing in the overlap region. The nozzle spacing shall be 50 cm (20 in.). The nozzle gage pressure shall be 300 kPa (43.5 psi). The nozzle orifice shall be approximately 50 cm (20 in.) above the land or crop surface. The speed of travel shall be 5 km/h (3.1 mile/h). The same spray liquid shall be used in the standard reference application as was used in the sprayer test except when spray carriers are being compared. The carrier for the standard reference application shall be water.

2.1.2 Through use of a dual sprayer (consisting of two independent sprayers carried on the same chassis), the standard reference application may be made simultaneously with the test being reported to insure equality of meteorological conditions. If the standard reference application is not made simultaneously with the test being reported, it shall be made when site and meteorological conditions are similar to those existing at the time of the test being reported. Site conditions include those described in paragraph 3.1. Meteorological conditions during the standard reference application shall not differ from those existing during the test being reported by more than the amounts given in Table 1.

TABLE 1—TOLERANCES ON METEOROLOGICAL FACTORS

Factor	Tolerance
Horizontal wind speed	± 10% of base* wind speed
Dry bulb temperature	± 3 °C (± 5.4 °F)
Relative humidity	± 4% of base relative humidity
	± 25% of base stability ratio

*Base refers to meteorological conditions existing at the time of the test being reported.

SECTION 3—TEST SITE AND METEOROLOGICAL CONDITIONS

3.1 The test site (see Fig. 1) shall include a sample line along which collectors shall be placed to sample spray deposits, and a spray line along which the centerline of the sprayer is operated. The sample line shall be approximately parallel to the wind direction (within ± 30 deg), and the spray line shall be perpendicular to the sample line. A sketch and a description of the test site shall be included with the test report and the sketch should include natural barriers (e.g. roads, trees, etc.). The description shall include the kind and height of crop cover on the test surface, the direction of crop rows, if any, relative to the sample line, the approximate degree of land slope both parallel to and perpendicular to the sample line, and the size and location of any wind obstructions within 0.8 km (0.5 mi) upwind of the test area. The spray line shall be at least 0.6 times as long as the sample line. The description of the test site shall also include the location, relative to the spray and sample lines, of the weather station and, if used, a tower for sampling airborne spray.

3.2 At least one weather station shall be provided for measurement of meteorological conditions and for determining stability ratio, as described in paragraph 3.3. The following meteorological conditions shall be measured and time averaged for the duration of each spray pass or 2 minutes, whichever is greater (all elevations are relative to the ground).

3.2.1 The temperature difference between 2.5 m (8.2 ft) and 10 m (32.8 ft) elevation, measured within 0.1 °C (0.18 °F). (When temperature is greater at 2.5 m than at 10 m, this difference is referred to as a temperature lapse, and shall be reported as a negative quantity.)

3.2.2 The dry bulb air temperature at 2.5 m (8.2 ft) elevation, measured within 0.1 °C (0.18 °F).

3.2.3 Either the wet bulb temperature measured within 0.2 °C (0.36 °F) or the percent relative humidity measured within 2% at 1.6 m (4.9 ft) elevation. If the wet bulb temperature is measured, the results shall be converted to relative humidity and the percent relative humidity shall be reported.

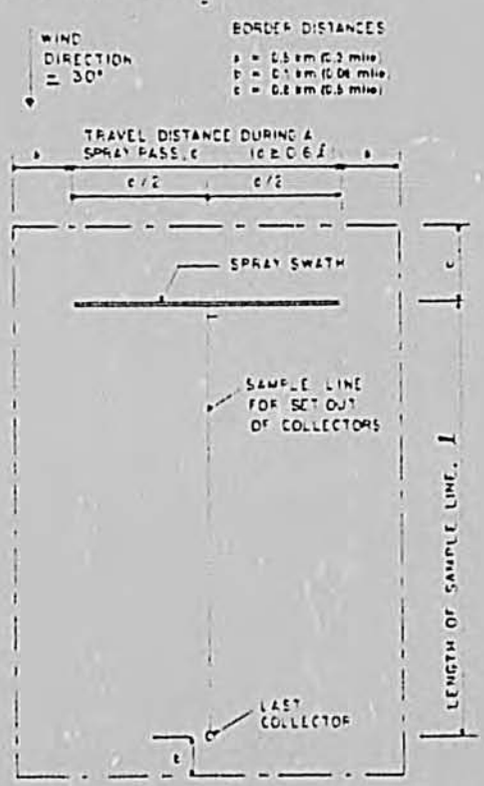


FIG. 1—TYPICAL TEST SITE CONFIGURATION

148

3.2.4 Horizontal wind speed at 5 m (16.4 ft) elevation, measured within 0.2 m/s (0.45 mile/h).

3.2.5 The vertical turbulence intensity, defined as the standard deviation of the vertical air speed divided by the average horizontal wind speed with both speeds to be measured at 2.5 m (8.2 ft) elevation. The standard deviation of the vertical air speed, σ_w, may be calculated from the following equation:

$$\sigma_w = \sqrt{\frac{1}{T}\int_0^T (W_i - W)^2\, dt}$$

where

T = averaging time as described in paragraph 3.2

W_i = instantaneous values of vertical air speed, measured within 0.1 m/s (0.22 mile/h)

W = time-averaged value of W_i

3.2.6 The mean vertical flow W shall be reported as a positive quantity if the mean flow is directed downward and as a negative quantity if the mean flow is directed upward. If the quantity σ_w is computed using numerical integration, the time increments between ordinates shall not exceed 0.5 s.

3.3 The stability ratio shall be calculated from the following equation and shall be reported as an indication of atmospheric stability:

$$SR = \frac{10(T_{10} - T_{2.5})}{U_5^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where

SR = stability ratio (°C·s²/m²)

$T_{10} - T_{2.5}$ = temperature difference between 10 m and 2.5 m elevation (°C)

U_5 = horizontal wind speed difference between 5 m elevation (m/s)

SECTION 4—SPRAY DEPOSITS

4.1 Collectors shall be provided for sampling the quantity of spray material depositing at various locations along the sample line. The size, shape, orientation, and material of the collectors, and their vertical elevation relative to the land surface of crop canopy shall be reported. If flat collectors are used, the exposed surface shall be level. Spacing of the collectors along the sample line shall be in accordance with paragraphs 4.1.1 and 4.1.2.

4.1.1 Within the intended swath area, identical collectors shall be equally spaced along the sample line beginning at the upwind edge of the intended swath and continuing to the downwind edge of the intended swath. The intended swath width and the distance from the spray line to the downwind edge of the intended swath shall be reported. The theoretical application shall be calculated as the quantity of spray per unit area in the swath if all of the spray has deposited uniformly across the intended swath width. The amount deposited on each collector in the swath shall be reported as a percentage of the theoretical application and may also be reported in quantity of spray per unit area. The theoretical application shall be reported.

4.1.2 In the area downwind from the intended swath, logarithmic spacing of the collectors along the sample line is recommended. The number of collectors and their respective distances from the spray line shall be reported. The quantity of spray deposited on each collector shall be reported as a percentage of the theoretical application and may also be reported in quantity of spray per unit area.

4.1.3 When the angle between the mean wind direction and the sample line is not zero, deposits shall be corrected to account for the greater distance the spray cloud must travel in reaching the sample line. The following procedure should be used each pass for correcting wind deviation. Using the method of least squares, the following equation should be fitted to the data:

$$\log D_k = b_{1k} + b_{2k}\, U + b_{3k}\, U^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where

D = deposit at the kth collector downwind of the spray line, expressed as a percent of the theoretical application

$$U = \log\left(\frac{X}{\cos\phi}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

X = distance from the spray line to the kth collector, measured along the sample line

ϕ = mean angle of deviation between the sample line and the wind direction during the test; the deviation should not exceed 30 deg

b_{ik} = coefficients used to obtain the best fit between the equation and the measured data.

After the equation for log D_k is established, U is replaced by X and the equation with X is used to calculate wind-corrected deposits along the sample line.

4.1.4 There are several tracers and measuring devices that can be used to measure the deposit on the collectors. Tests should be run to determine the background level of the tracer in the test area; as well as the degradation rate, if any, and recovery from the collector of the tracer being used. Test results shall be corrected to the basis of zero background, zero degradation and 100% tracer recovery.

4.2 Measurement of droplet sizes is optional. If droplet sizes are to be measured, collectors suitable for measuring the droplet size spectrum shall be provided at various locations along the sample line. The test report shall include a description of the method used for obtaining the droplet sizes, the locations of the collectors, and the following data for each collector.

4.2.1 The total number of droplets (N_t) which deposit on the collector during the spray run.

4.2.2 The percent of N_t that fall within each of a range of droplet size classes.

4.2.3 For each class, the size class limits expressed as droplet diameters in micrometers.

SECTION 5—AIRBORNE SPRAY

5.1 Portions of the spray may follow a trajectory that precludes deposition within the test area. Therefore, at least one vertical line of aspirated air samplers should be provided to detect quantities of airborne spray. The air samplers should be isokinetic for accurate measurement of spray concentration in the air. If non-isokinetic samplers are used, the air velocity through the sampler inlet shall be reported, as well as the horizontal wind speed at each sampler elevation. The vertical line of air samplers should be near the sample line, and may be coincident with the weather station described in paragraph 3.2. The uppermost air sampler should be above the top edge of the spray cloud. Samplers between the uppermost sampler and the ground should be equally spaced. The test procedure should include the capture and reporting of the amount of airborne spray reaching each sampler during the passage of the entire spray cloud. The number and type of air samplers used, and their respective heights above the ground, should also be reported.

5.2 Measurement of airborne droplet sizes is optional. If droplet sizes are to be measured, isokinetic air samplers suitable for measuring the droplet size distribution in the spray shall be interspersed with the air samplers described in paragraph 5.1. The test report shall include a description of the methods used for obtaining the droplet sizes and data for each sampler, as indicated in paragraphs 4.2.1 through 4.2.3.

SECTION 6—REPORTING OF RESULTS

6.1 A complete test report shall include the following:

6.1.1 The model, size, number, spacing and orientation of the atomizers used; the combined and individual flow rate of all atomizers, measured within 1%; all other relevant atomizer variables, such as pressure at the nozzle, spinning disc speed and diameter, etc.; the height of the atomizers above the land or crop surface; and the speed of the sprayer.

6.1.2 Type and proportion by volume of the carrier medium, the pesticide type and concentration of active ingredient and any additives contained in the spray liquid. For non-liquid pesticides or additives, the mass shall be given per unit volume of carrier medium.

6.1.3 Test site and meteorological conditions as described in Section 3—Test Site and Meteorological Conditions.

6.1.4 Spray deposits, as described in Section 4—Spray Deposits.

6.1.5 Airborne spray, as described in Section 5—Airborne Spray.

ASAE Standard ASAE S341.1

TEST PROCEDURE FOR DRY FERTILIZER SPREADERS

Developed by Fertilizer Application Subcommittee of ASAE Agricultural Chemical Application Committee; approved by Power and Machinery Division Standards Committee; adopted as Tentative Standard December 1971; reclassified as full Standard December 1972; revised March 1976; reconfirmed December 1982

SECTION 1—PURPOSE AND SCOPE

1.1 The purpose of this Standard is to establish a uniform method of determining and reporting performance data on spreaders designed to apply dry fertilizer on top of the ground. Tests performed according to this Standard make it possible to predict field performance and to compare machines.

1.2 This Standard pertains to centrifugal, venturi, and other types of broadcast spreaders designed for dry fertilizer application while operating on the soil surface. Portions of the test procedures outlined herein are suitable for determining the delivery rate of gravity or drop spreaders, however, additional tests not covered in this Standard are needed to completely evaluate the performance of gravity spreaders.

SECTION 2—TEST CONDITIONS

2.1 The fertilizer spreader to be tested shall be in good mechanical condition and shall be properly adjusted.

2.2 Tests may be conducted on a fertilizer spreader to evaluate an experimental model, to qualify a new production model, or to verify the performance of an existing production model.

2.3 The manufacturer of a new production model of a fertilizer spreader shall furnish information covering all operating and servicing instructions necessary for satisfactory operation. This information shall include typical spreading rates in kg/ha (lbm/acre or lbm/1000 ft²) for at least three divisions on the rate scale, complete specifications or product name for the material used in determining these rates, and a list of all known products for which the machine is unsuitable.

2.4 The geometric specifications shall be checked with the machine standing on an impenetrable, horizontal surface in normal operating position. Dimensions of length and width shall be measured along horizontal lines and dimensions of height along vertical lines.

2.5 The manufacturer shall be notified well in advance of any test in which his current production model will be compared with those of other manufacturers. The manufacturer shall be entitled to have his representative present during the test.

2.6 **Test materials.** The test may be conducted with a standardized material such as uniform size spherical prills, or a fertilizer product may be used. In either case a description of the material including sieve size, moisture content, bulk density, and product name shall be specified in the test report. The test material should be allowed to settle for 10 min before determining bulk density.

2.6.1 When a fertilizer product is used, it shall be a standard granular material defined as one in which 90 percent or more of the product remains on any sieve within the range of No. 7 (2.80 mm opening) to No. 16 (1.00 mm opening), and in which the largest particle passes through a sieve having an opening not larger than 2.83 times that of the sieve retaining 90 percent or more of the product, or a No. 4 sieve (4.75 mm opening), whichever is smaller. The sieves used shall conform to American National Standard Z23.1, Specifications for Wire-Cloth Sieves for Testing Purposes. The percent of material retained by each screen shall be reported.

2.6.2 When a fertilizer product is used, the moisture content shall be determined and reported on a dry weight basis.

2.6.3 When an agricultural fertilizer product is used, it shall have a bulk density of 800 to 1040 kg/m³ (50 to 65 lbm/ft³).

2.6.4 A description of the test material particle shape and surface texture shall be included in the test report.

SECTION 3—TEST PROCEDURE

3.1 **Description of the test procedure**

3.1.1 The accuracy of the test can be influenced by wind, fertilizer particle size, rate of application, ground slope, travel speed and ground roughness.

3.1.2 All test work shall be done when the wind velocity is less than 8 km/h (5 mi/h) at a height of 1 to 2 m above the ground. If a wind exists, the direction of travel shall be parallel (within plus or minus 15 deg) to the direction of the wind.

3.1.3 Tests shall be conducted on a surface having a slope of less than 2 percent. If desired, the spreaders may also be tested on a sloping surface provided all spreaders in the comparison are tested on the same slope and the degree and direction of the slope is reported.

3.1.4 If the spreader is normally used for transport as well as spreading, the spreader shall be transported at least 140 m (450 ft) at the spreading test speed before actual spreading begins. Level surface tests may be made with the spreader stationary during the test, by moving the collection trays past the spreader. If this is done, spreaders designed for transport shall be transported prior to the test.

3.2 The fertilizer spreader shall be filled the day of the test. A minimum of 10 min shall be allowed for settling before the test is conducted. If the test is not conducted within 4 h after filling, the spreader shall be emptied and refilled.

3.3 Tests shall be run with the spreader hopper or box filled and leveled to 40 to 50 percent of capacity as defined by ASAE Standard ASAE S281, Capacity Designation for Fertilizer Hoppers and Containers.

3.4 **Collection devices**

3.4.1 Width of each collecting tray (measured perpendicular to the direction of travel) shall not exceed 10 percent of the anticipated effective swath width. The length shall be equal to or greater than the width with a minimum length of 1 ft. The maximum wall thickness of the tray sides shall be 2.3 mm (0.09 in.).

3.4.2 To decrease the possibility of particles ricocheting out of the trays, each collecting tray described in paragraph 3.4.1 should be divided into smaller compartments. The maximum size of the compartments shall be 10 cm (4 in.) wide by 10 cm (4 in.) long. The depth of the compartments shall be at least 50 percent of the maximum horizontal dimension. Precautions such as covering the tray floor with soft material may be taken if the fertilizer being tested contains no small particles which may lodge in the padding.

3.4.3 Sufficient trays shall be used to provide at least 10 trays in the effective swath width. Spacing of the trays shall be uniform except that trays may be rearranged to allow passage of spreader and vehicle wheels. For broadcast spreaders, additional trays shall be spaced out on either side of the effective swath width to a distance equal to at least 50 percent of the swath width.

3.4.4 During all tests, the top of the tray shall not be over 10 cm (4 in.) above the ground level with the spreader in the normal operating position.

3.4.5 Power-take-off driven units shall be operated at the speed specified by the spreader manufacturer. If the specified speed is 540 ± 10 rpm or 1,000 ± 25 rpm (see ASAE Standard ASAE S203, Rear Power Take-Off for Agricultural Tractors) or other, it shall be noted in the test report. For truck-mounted units the spinner shall be rotated at the speed recommended by the manufacturer. For electrically driven units, supply voltage shall conform to that recommended by the manufacturer; any deviation shall be stated in the report.

150

Best Available Document

3.4.6 Relative travel speed between the spreader and the collection trays shall be in the range recommended in the manufacturer's literature, and kept constant during the collection of the test. The actual speed of the spreader and/or collection trays at which the tests were conducted shall be reported.

SECTION 4—SPREAD PATTERN TEST

4.1 **General.** Spread pattern tests indicate the degree of uniformity across the swath being spread from the ground spreader.

4.2 The spread pattern shall be determined for at least three different application rates. The actual delivery rates and the spreader settings used to achieve these rates shall be reported. All spreaders to be compared shall be tested at the same rates, if possible. Application rates of approximately 25, 50, and 75 percent of the maximum application rate for the test material used should be selected. Additional tests may be conducted and reported at other rates selected from within the manufacturer's recommended range of application rates.

4.3 Spreaders will be operated past the collecting trays in only one direction. Sufficient passes shall be made to collect a sample of at least 20 g in the trays in the heaviest portion of the spread pattern, or a minimum of five passes shall be made.

4.4 The tests shall be run using the most effective spread pattern width symmetrical about the centerline of travel. The effective pattern width shall be the distance between the points on either side of a single swath where the rate of deposit equals one-half of the effective application rate. The effective pattern width shall be determined in a manner which will give the most uniform overall application rate. The manufacturer's recommendation shall be used as a guide in determining the most effective pattern width.

4.5 The spreader tested shall be rated for uniformity of distribution. The coefficient of variation will be used to determine and express the uniformity of distribution of applications. When overlapping of swaths occur, a simulated field application of multiple adjacent swaths shall be used to compute the coefficient of variation. The simulated field distribution for each swath distribution pattern obtained in paragraph 4.2 is constructed by using the effective pattern width determined in paragraph 4.4 and accumulating the sample weights at each collection tray location. Individual replicates of the swath distribution pattern (not averages) shall be used. The method of spreading assumed, i.e., either switchback or perimeter, shall be reported.

4.6 The results of this test may also be presented graphically as shown in Fig. 1.

4.6.1 In plotting test data the vertical axis shall indicate the application rate in kg per ha (lbm per acre or lbm per 1,000 ft²) and the horizontal axis shall represent the spread width in m (ft).

4.6.2 The coefficient of variation and the setting at which it was determined shall be stated in each graph.

4.6.3 When indicating spreader overlap as shown in Fig. 1, it is necessary to report the method of spreading assumed, i.e., either switchback or perimeter, and plot the graph accordingly.

SECTION 5—CALCULATIONS AND FORMULAS

5.1 **Formulas**

5.1.1 Standard deviation = $\sqrt{\dfrac{\Sigma (X_i - \overline{X})^2}{N - 1}}$

where

X_i = the individual reading

$\overline{X}$ = mean reading = $(\Sigma X_i)/N$

N = total number of readings

5.1.2 Coefficient of variation = (standard deviation) (100) / $\overline{X}$

SECTION 6—METHOD OF REPORTING RESULTS

6.1 If the test has been conducted as described by this Standard, the test results shall be identified as follows:

6.1.1 Following each test result, place this designation:

(ASAE S341)

Example: Coefficient of Variation — 18 percent at _____ kg per hectare (ASAE S341)

6.1.2 A descriptive statement shall be included in the report to explain the coefficient of variation. For example: This 18 percent variation means that at a setting of 100 kg/ha (89 lbm/acre) the actual application rate should vary from 82 to 118 kg per ha (73 to 105 lbm/acre) 68 percent of the time.

6.1.3 The following note shall be placed on each page on which test results appear: "These results have been obtained from a test made in accordance with ASAE Standard ASAE S341."

6.2 **Description of spreader.** A short description of the spreader shall precede the dimensions. If the spreader can be adjusted to deliver one side at a time (for headlands and row-crops), this should be mentioned. Adjustable spreader variables and their settings shall be reported. The following data should be included in the description:

Type: (Spinner, blower, endless belt, etc.)
Manufacturer's name, model number, and year of manufacture: (Serial number if available)
Minimum and maximum application rates: kg per ha (lbm/acre)
Minimum and maximum output rates: kg/min (lbm/min)
Overall length: mm (in.)
Overall height: mm (in.)
Overall width: mm (in.)
Height of particle release above ground level (in operation): mm (in.)
Metering system used
Number of spinners or delivery points
Manufacturer's recommended spread width: m (ft)
Hopper capacity: m³ and kg (ft³ and lbm)
Track width (c-to-c): mm (in.)
Number of wheels

6.3 All test results shall be stated as listed under paragraph 6.1 and include the following:

Standard deviation (for each application rate)
Coefficient of variation (for each application rate)
Material tested (analysis, bulk density, moisture content)
Forward travel speed
Relative travel speed
Effective width of spread pattern
Information concerning exceptions or additions which are peculiar to this test

Cited Standards:

ASAE S203 Rear Power Take-Off for Agricultural Tractors
ASAE S251 Capacity Designation for Fertilizer Hoppers and Containers
ANSI Z23.1 Specifications for Wire-Cloth Sieves for Testing Purposes

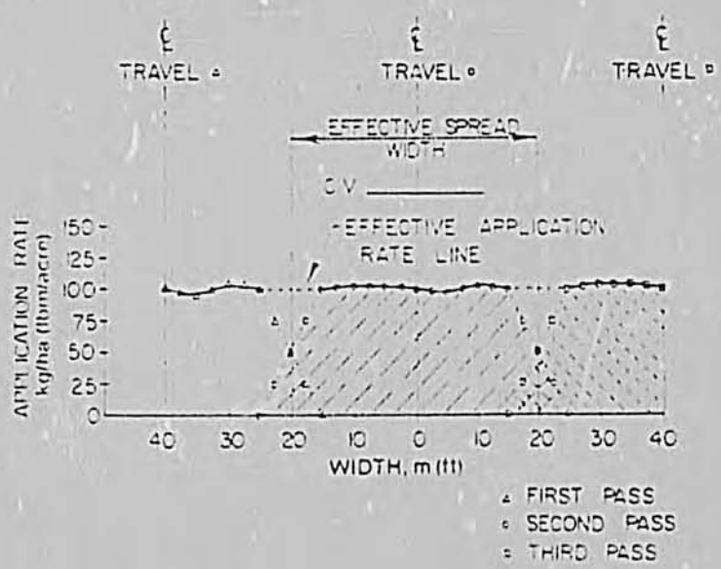


FIG. 1—GRAPHICAL PRESENTATION OF SPREAD PATTERN

TERMINOLOGY FOR COMBINES AND GRAIN HARVESTING

Developed by the ASAE Grain Harvesting Committee, approved by the Power and Machinery Division Standards Committee, adopted by ASAE as Tentative Standard February 1971; reclassified as full Standard, December 1971; reconfirmed December 1977; revised April 1981.

SECTION 1—PURPOSE AND SCOPE

1.1 The purpose of this Standard is to establish terminology pertinent to grain combine design and performance. It is intended to improve communication among engineers and researchers and to provide a basis for comparative listing of machine specifications.

SECTION 2—COMBINE COMPONENTS

2.1 **Header:** The portion of the combine comprising the mechanisms for gathering the crop.

2.1.1 **Gathering width:** The distance bewteen the center lines of the outermost divider points, expressed in meters to the nearest hundredth. Where adjustable dividers are used the maximum and minimum dimensions shall be stated.

2.1.2 **Grain header width:** The distance between the side sheets of the header measured immediately above the forward tips of the sickle sections; expressed in meters to the nearest hundredth.

2.1.3 **Maize (ear corn) header width:** The average distance between the center lines of adjacent picking units multiplied by the number of units. Where the header width is adjustable, maximum and minimum distances between center lines shall be stated, expressed in centimeters to the nearest whole centimeter. The maximum and minimum header widths shall then be expressed in meters to the nearest hundredth, and the number of picking units shall be stated.

2.2 **Cutting mechanism:** That device on the header for severing the plant stalks. May include reciprocating, rotary, continuous, scissor-type, or other mechanisms for severing.

2.2.1 **Sickle:** A cutting mechanism which uses a reciprocating cutter.

2.2.1.1 **Sickle frequency:** The number of cycles which the sickle makes in a given period of time. One cycle is the full movement of the sickle in one direction and its return to the starting point. Frequency shall be expressed in hertz.

2.2.1.2 **Sickle stroke:** The distance that a point on the sickle travels with respect to the center line of a guard in one half cycle, expressed in millimeters.

2.3 **Pickup:** A device for gathering a crop from a windrow.

2.3.1 **Pickup width:** The minimum distance including the width of the outermost conveying elements but not including the gather of flared side sheets; expressed in meters to the nearest hundredth.

2.4 **Cutting mechanism height:** The height of the forward tip of any cutting blade or sickle section above the plane on which the machine is standing, measured under the following conditions and expressed in centimeters.

2.4.1 The maximum and minimum dimensions shall be in the highest point and the lowest point to which the cutterbar can be raised or lowered with the standard lift mechanism.

2.4.2 Tire and wheel equipment shall be stated, and tires shall be inflated to the field operating pressures recommended by the combine manufacturer.

2.4.3 The plane on which the combine is standing shall be substantially level.

2.4.4 The header installed at the time of measuring shall be stated.

2.4.5 The grain tank shall be effectively empty in accordance with ASAE Standard ASAE S312, Capacity Designations for Combine Grain Tank Systems.

2.5 **Rotating threshing or separating elements**

2.5.1 **Threshing cylinder:** A rotating element, which in conjunction with a stationary element adjacent to it, is fitted primarily to promote threshing. The crop being threshed is contained between rotating and stationary elements for less than 360°.

2.5.2 **Threshing rotor:** A rotating element similar to a threshing cylinder except that the crop is contained for 360° and may pass around the rotor axis one or more times.

2.5.3 **Separating cylinder or rotor:** Defined as for threshing cylinder or rotor, except that the terms "separating" and "separated" replace "threshing" and "threshed".

2.5.4 **Rotary separator:** An alternative term for a rotary device, similar to a cylinder, which is fitted to promote separation only.

2.5.5 **Cylinder or rotor threshing or separating diameter:** The diameter of the circle generated by the outermost point of the appropriate rotating element as it rotates about its own axis (dimension D, Figs. 1, 7, and 8); expressed in millimeters.

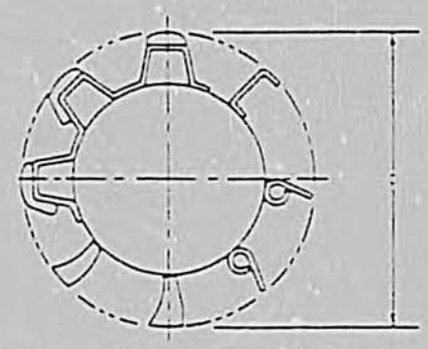


FIG. 1—CYLINDER OR ROTOR DIAMETER

2.5.6 **Cylinder or rotor threshing or separating length:** The length of the cylindrical volume generated by the outermost points of the cylinder or rotor elements, as the cylinder or rotor rotates about its own axis, and as appropriate to its threshing or separating section (dimension L, Fig. 2); expressed in millimeters.

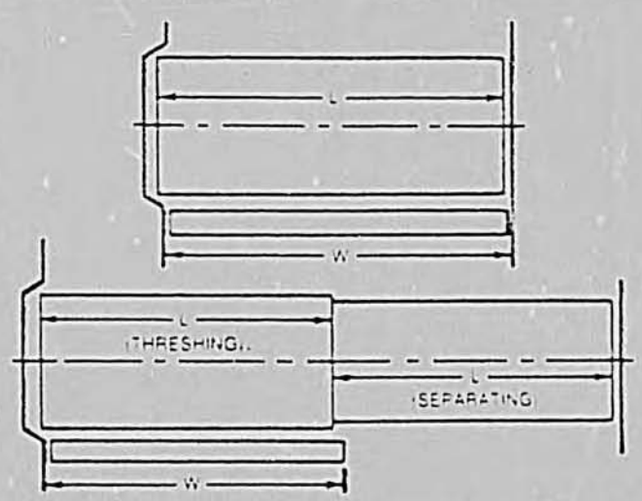


FIG. 2—CYLINDER, ROTOR, AND CONCAVE DIMENSIONS

2.5.7 Single or multiple cylinders or rotors may be disposed laterally (Fig. 3) or longitudinally (Fig. 4) within the combine. If multiple cylinders or rotors are used, the number shall be stated and the dimensions given as in Figs. 3 and 4.

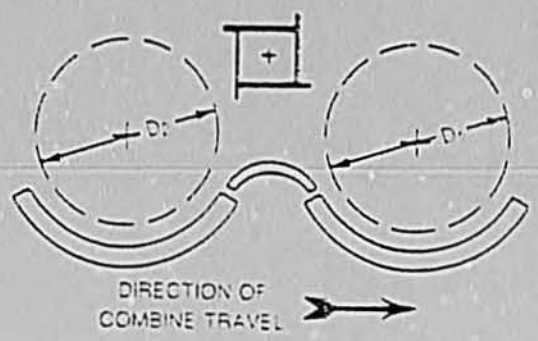


FIG. 3—LATERALLY-DISPOSED CYLINDERS OR ROTORS

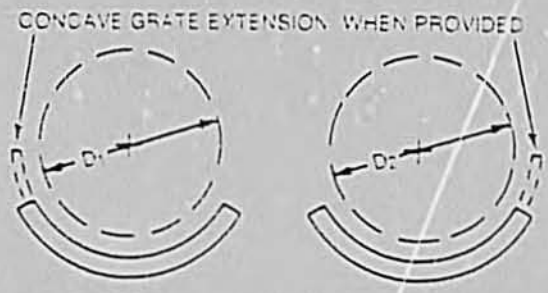


FIG. 4—LONGITUDINALLY-DISPOSED CYLINDERS OR ROTORS, VIEWED FROM REAR

2.6 **Concave:** A concave-shaped stationary element adjacent to a threshing cylinder or rotor, fitted primarily to promote threshing.

2.6.1 **Concave width or length:** The outside dimension of the concave, measured parallel to the axis of its associated threshing cylinder or rotor (dimension W, Fig. 2), expressed in millimeters.

2.6.2 **Concave arc length:** The arc length dimension including the first and last bars of the concave. This shall be measured in a plane perpendicular to the axis of its associated cylinder or rotor, and around the contour formed by the inner surfaces of the concave bars (dimension L, Fig. 5). Concave arc length shall be expressed in millimeters.

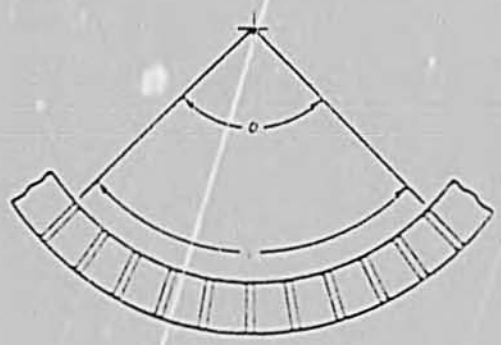


FIG. 5—CONCAVE ARC

2.6.3 **Concave arc:** A common (alternative) means of defining arc length, in degrees. It shall be measured from the outside of the first bar to the outside of the last bar, in a plane perpendicular to the axis of the associated cylinder or rotor (dimension α, Fig. 5).

NOTE: When using this means of defining the arc length of the concave, it is essential that the diameter of the associated cylinder or rotor be quoted also. See paragraph 2.5.5.

2.6.4 **Concave area:** The product of the concave width (or length) and arc length, expressed in square meters to the nearest hundredth.

2.6.5 If more than one concave is used, this shall be so stated, and the dimensions and areas shall be given separately.

2.7 **Separating grate:** A permeable element which in conjunction with a relatively-moving device adjacent to it is fitted to promote separation.

2.7.1 **Concave grate:** That portion of the concave area which is permeable for separation.

2.7.2 **Concave grate extension:** A permeable element approximately concentric with the cylinder and generally forming an extension of the concave contour, as shown in Figs. 4 and 7.

2.7.3 **Transition grate:** A permeable element to provide transition from the concave, or concave grate extension, to the next separating device.

2.7.4 **Separating grate length or width:** The outside dimension of the permeable area including frame members, measured parallel to the axis of its associated cylinder or rotor, expressed in millimeters.

2.7.5 **Separating grate arc length:** The outside dimension of the permeable area including frame members, measured in a plane perpendicular to the axis of its associated cylinder or rotor, expressed in millimeters. It may be expressed in degrees if the diameter of the associated cylinder or rotor is also quoted (See paragraphs 2.6.2 and 2.6.3).

2.7.6 **Transition grate length:** The contour length of the upper surface of the transition grate including frame members (dimension B, Fig. 7), expressed in millimeters.

2.7.7 **Concave grate area:** The product of concave grate arc length, (dimension A, Fig. 6) and concave length or width (dimension W, Fig. 2), expressed in square meters to the nearest hundredth.

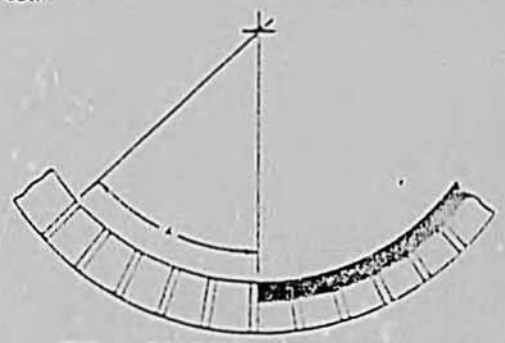


FIG. 6—CONCAVE GRATE ARC LENGTH

2.7.8 **Concave grate extension area:** The product of concave grate extension length including frame members (dimension C, Fig. 7) and the concave width or length, expressed in square meters to the nearest hundredth.

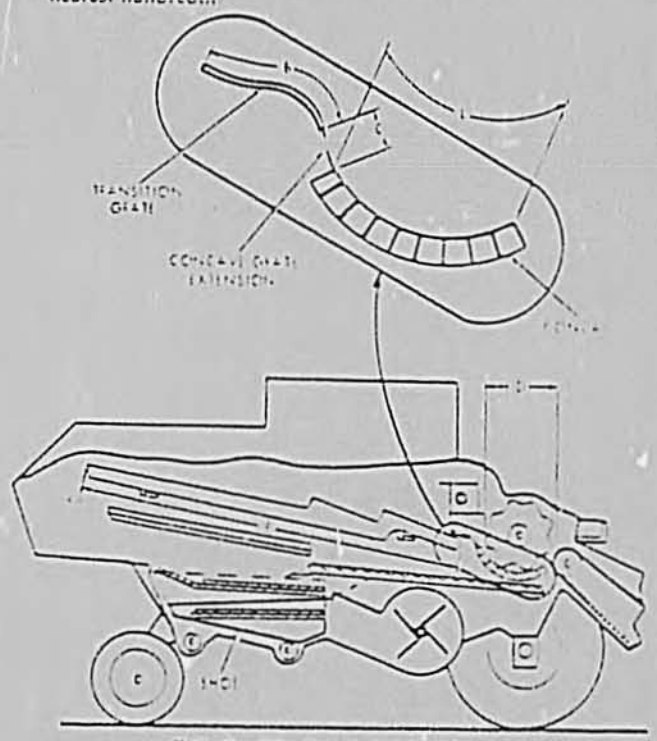


FIG. 7—COMBINE SIDE VIEW

153

2.7.9 **Transition grate area:** The product of transition grate length (dimension B, Fig. 7) and the length or width of the associated concave, expressed in square meters to the nearest hundredth.

2.7.10 **Separating grate area:** The product of separating grate length (or width) and arc length, expressed in square meters to the nearest hundredth.

2.8 **Further separation devices:**

2.8.1 **Straw walker or straw rack area:** The product of the straight length (dimension P, Figs. 7 and 8) and the inside width (dimension R, Fig. 9) of the separator side structure immediately adjacent to the straw walkers or rack, expressed in square meters to the nearest hundredth. Where walker extensions are used in the standard specifications of the machine, dimension P shall be taken with the adjustable portions fully extended, and this condition shall be stated.

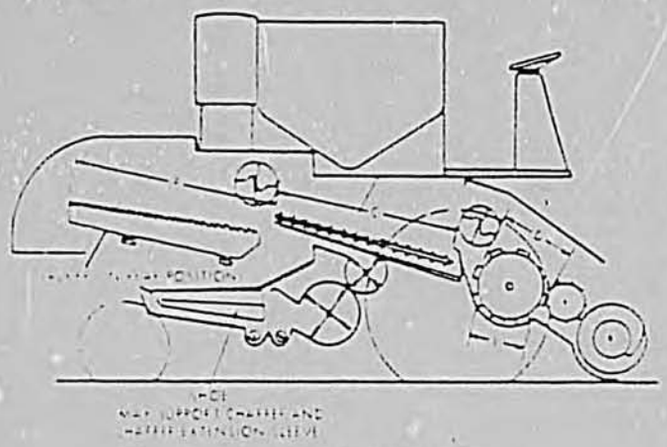


FIG. 8—COMBINE SIDE VIEW

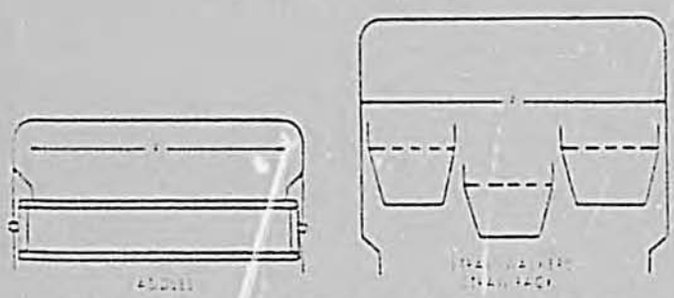


FIG. 9—WIDTH OF STRAW WALKERS AND RADDLES

2.8.2 **Straw raddle area:** The product of the raddle length (dimension C, Fig. 8) and the exposed width of the raddle (dimension R, Fig. 9), expressed in square meters to the nearest hundredth.

2.8.3 **Separating drum:** A rotating permeable drum, with its axis approximately horizontal, in which separation is promoted by the tumbling action of the crop material contained within.

2.8.4 **Separating drum area:** The product of the length and inside perimeter of the permeable area, expressed in square meters to the nearest hundredth. Drum inside diameter, expressed in millimeters, should also be stated.

2.8.5 **Auxiliary separating devices:** Means of separating, auxiliary to the main separation mechanisms, and other than those of paragraph 2.7 and its subparagraphs 2.8.1, 2.8.2, and 2.8.3.

2.9 **Shoe:** The oscillating structure shown in Figs. 7 and 8 which supports the cleaning sieve of sieves and which may also support the chaffer sieve and chaffer sieve extension.

2.10 **Cleaning areas**

2.10.1 **Sieve cleaning areas of the shoe:** The chaffer sieve, intermediate sieve, cleaning sieve, and extensions to them. The area of each shall be calculated using the outside dimensions of the permeable surface including frame members, and shall be expressed in square meters to the nearest hundredth.

2.10.2 **Pneumatic cleaning areas:** Where chaff is removed by aerodynamic means alone. These areas shall be calculated as the product of the width and depth of the air stream at the point of contact of the air with the crop material. The depth shall be measured perpendicular to the direction of the air flow. The area shall be expressed in square meters to the nearest hundredth.

2.10.3 **Other cleaning areas:** Dirt screens, recleaners, and other auxiliary cleaning devices. These areas shall be specified. Permeable surfaces and pneumatic cleaning areas shall be calculated and expressed as defined in paragraphs 2.10.1 and 2.10.2.

2.11 **Component areas:** For purposes of [illegible] specification the areas defined in paragraphs 2.6.4, 2.7.7, 2.7.8, 2.7.9, 2.7.10, 2.8.1, 2.8.2, 2.8.4, 2.10.1, 2.10.2, and 2.10.3 shall be listed individually and should not be used singly or in combination as a measure of machine performance or capacity.

2.12 **Engine power:** The corrected gross rated, brake power in accordance with Society of Automotive Engineers Standard SAE J816, Engine Test Code — Spark Ignition and Diesel, at the governed engine RPM which shall be stated. Where particular markets require the use of a different test code for determining engine power, the engine test code shall be stated.

2.13 **Engine displacement:** Engine displacement shall be expressed in liters to the nearest hundredth.

2.14 **Turning radius:** The distance from the turning center to the center of tire contact of the wheel describing the largest circle while the vehicle is executing its shortest turn without turning brakes in operation. The wheel base and guide wheel tread width shall be stated. Turning radius shall be expressed in meters to the nearest hundredth.

2.15 **Clearance radius:** The distance from the turning center to the outermost point of the combine executing its shortest turn without brakes in operation. If equipment options or attachments affect this dimension, such equipment shall be specified. The wheel base and guide wheel tread width shall be the same as in paragraph 2.14. Clearance radius shall be expressed in meters to the nearest hundredth.

2.16 **Combine weight:** The weight of the complete machine equipped for field operation. The weight shall be determined under the conditions specified in paragraphs 2.4.2, 2.4.3, 2.4.4, and 2.4.5 and the fuel tanks shall be empty. If other equipment options or attachments affect the weight, such equipment shall be specified. Combine weight shall be expressed in kilograms to the nearest 10.

2.17 **Combine length:** The overall dimension from the foremost point to the rearmost point of the combine equipped for field operation measured parallel to the longitudinal center line of the combine. The header installed shall be stated, and if other equipment options or attachments affect the length, such equipment shall be specified. Combine length shall be expressed in meters to the nearest hundredth.

2.18 **Combine height:** The vertical distance from the plane on which the combine is standing to the highest point on the combine. The height shall be measured under the conditions specified in paragraphs 2.4.2, 2.4.3, 2.4.4, and 2.4.5. The height with all components in position for transport and the height with all components in position for field operation shall be specified. Combine height shall be expressed in meters to the nearest hundredth.

2.19 **Discharge height of unloader:** The vertical distance from the plane on which the combine is standing to the lowest point of the discharge opening with the unloader in operating position as shown in Fig. 10. The height shall be measured under conditions specified in paragraphs 2.4.2, 2.4.3, 2.4.4, and 2.4.5. Discharge height shall be expressed in meters to the nearest hundredth.

2.20 **Clearance height of unloader:** The vertical distance from the plane on which the combine is standing to a point on the underside of the unloader located at a horizontal distance of one meter (3.3 ft) from the lowest point of the discharge opening as shown in Fig. 10. This height shall be measured under the conditions specified in paragraph 2.19, and expressed in meters to the nearest hundredth.

2.21 **Reach of unloader:** The horizontal distance measured perpendicular to the longitudinal center line of the combine, from the lowest point of the unloader discharge opening to the outermost point of the header on the unloader side as shown in Fig. 10. The reach shall be measured under conditions specified in paragraph 2.19, and expressed in meters to the nearest hundredth.

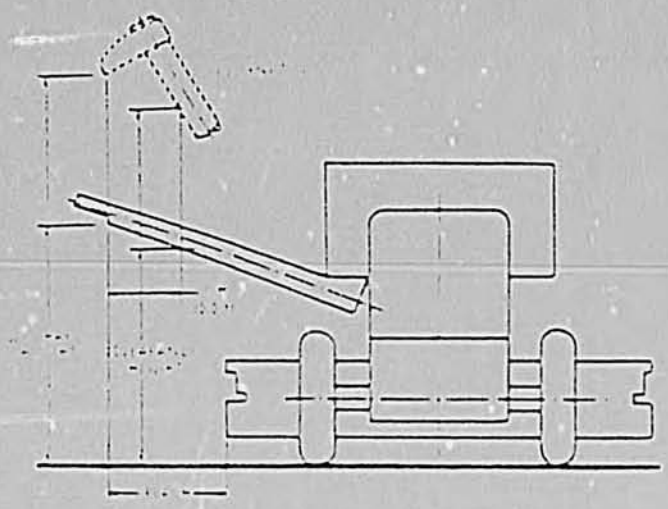


FIG. 10—GRAIN UNLOADER SPECIFICATIONS

SECTION 3—CROP TERMINOLOGY

3.1 For the purposes of this Standard, the term "grain" shall be taken as the general term of reference for the whole range of grains, seeds, legumes and fruits which are capable of being recovered from crops by a combine harvester.

3.2 **Grain damage:** For the purposes of this Standard, grain damage refers only to that attributable to the machine. It shall be expressed as the percentage by weight, to the nearest one-tenth, of damaged kernels in the sample.

3.2.1 **Visible grain damage:** Kernel damage where the seed coat appears broken to the naked eye.

3.2.2 **Invisible grain damage:** Kernel damage which requires instrumentation or special procedures for determination.

3.3 **Unthreshed heads:** Any head, pod, cob, or part of same from which all or part of the seed has not been detached.

3.4 **Returns:** The material from the grain cleaning mechanism which is recirculated for reprocessing.

3.5 **Material-other-than-grain to grain ratio:** The total weight of material-other-than-grain divided by the total weight of grain in a sample.

3.6 **Moisture content:** Moisture content of the crop shall be expressed on the wet basis. The percentage moisture content of grain and the moisture content of material-other-than-grain shall be determined from samples taken from the discharge of the combine during the test period.

3.7 **Plant length:** The length of the plant from its base at ground level to its tip when the plant is straightened, expressed in centimeters.

3.8 **Stubble length:** The length of the plant stalk attached to the ground immediately after harvesting, expressed in millimeters to the nearest 10.

SECTION 4—COMBINE PERFORMANCE

4.1 **Threshing:** The detaching of seed from the head, cob or pod.

4.2 **Separating:** The isolating of detached seed, small debris, and unthreshed material from the bulk.

4.3 **Cleaning:** The isolating of desired seed from chaff, small debris and unthreshed material.

4.4 **Sieving:** The isolating of desired seed by a mechanical device where the desired seed penetrates the device and the undesired material is carried over the device.

4.5 **Screening:** The isolating of desired seed by a mechanical device where the desired seed is carried over the device, and the undesired material penetrates the device.

4.6 **Chaffing:** Pneumatic cleaning.

4.7 **Feed rates**

4.7.1 **Grain feed rate:** The weight of grain, including processing loss, passing through the machine per unit of time, expressed in metric tons per hour.

4.7.2 **Material-other-than-grain feed rate:** The weight of material-other-than-grain passing through the machine per unit of time, expressed in metric tons per hour.

4.7.3 **Total feed rate:** The sum of grain feed rate and material-other-than-grain feed rate, expressed in metric tons per hour. The material-other-than-grain to grain ratio shall be specified.

4.8 Grain losses shall be classified according to their source and shall include all field losses attributable to the machine.

4.8.1 **Processing loss rate:** The weight per unit of time of detached grain and grain from unthreshed heads remaining in the bulk and chaff after completion of the threshing, separating and cleaning processes. Processing losses shall be expressed as a percentage of the grain feed rate.

4.8.2 **Gathering loss rate:** The weight of grain per unit of time which has been missed or dropped by the header or pickup. Gathering losses shall be expressed as a percentage of the sum of the grain feed rate and the gathering loss rate.

4.8.3 **Leakage loss:** Any involuntary loss of grain from the combine other than those described above. It shall be expressed as a percentage of the grain feed rate.

4.9 **Capacity:** The measure of the ability of a combine to perform its function of harvesting crop.

4.9.1 **Combine capacity:** The maximum sustained total feed rate at which the processing loss level, with the machine in field operation on level ground, is as stated in Table 1 below. It shall be expressed in metric tons per hour. Tests for determining capacity shall be conducted in accordance with ASAE Standard S341, Combine Capacity Test Procedure.

4.9.2 **Grain output capacity:** The maximum sustained rate of grain discharged from the combine's cleaning apparatus (including, if they are fitted, auxiliary cleaning devices as defined in paragraph 2.10.3), at which the processing loss level, with the machine in field operation on level ground, is as stated in Table 1 below. It shall be expressed in metric tons per hour.

TABLE 1—CROPS AND CONDITIONS FOR CAPACITY TESTING

Crop	Acceptable Range of Material-Other-Than-Grain to Grain Ratio	Range of Moisture Content in Percent: Grain	Range of Moisture Content in Percent: Material Other Than Grain	Processing Loss Level Percent
Wheat	0.4 – 1.5	10-20	6-25	3
Barley	0.4 – 1.5	10-20	6-25	3
Rice	1.0 – 2.4	15-24	20-60	3
Sorghum	0.4 – 0.8	10-17	15-40	3
Maize (sweet corn)	0.4 – 1.0	10-35	10-40	3
Rapeseed	1.0 – 3.0	8-20	10-30	3
Soybeans	0.4 – 1.5	10-15	10-20	3

Note: If crop and or climatic conditions do not permit test data to be obtained with the conditions listed in Table 1, the circumstances must be reported and the actual figures recorded.

Cited Standards:

ASAE S312, Capacity Designations for Combine Grain Tank Systems
SAE J816, Engine Test Code—Spark Ignition and Diesel
ASAE S341, Combine Capacity Test Procedure

I.25

155

COMBINE CAPACITY TEST PROCEDURE

Developed by the ASAE Grain Harvesting Committee, approved by the Power and Machinery Division Standards Committee, adopted by ASAE March 1979, reconfirmed for one year December 1979, reclassified as a full Standard February 1981.

SECTION 1—PURPOSE AND SCOPE

1.1 This Standard is intended to provide the basic requirements for a uniform procedure for measuring and reporting combine capacity, as defined in ASAE Standard S343, Terminology for Combines and Grain Harvesting. Because crop conditions are variable and uncontrollable, the procedure provides only for the comparative testing of one machine, or one machine configuration, relative to another, in a particular crop condition.

SECTION 2—TERMINOLOGY

2.1 **Test machine:** The subject combine or combine configuration.

2.2 **Comparison machine:** The other combine or configuration.

2.3 **Test run:** The events necessary to record a single set of measurements.

2.4 **Test:** All the events and data comprising several test runs.

2.5 **Catch:** Any material collected during a test run.

SECTION 3—SELECTION OF CROP

3.1 Capacity tests should preferably be conducted in crops and conditions listed in ASAE Standard S343, Terminology for Combines and Grain Harvesting. Where test data indicate that such requirements have not been adhered to, the reasons for departures shall be stated in the test report.

3.2 Crops used for tests shall be reasonably uniform, free of disease, weeds and other crops. They should in general be standing well. If local climatic conditions or local practices lead to different conditions typical of the locality (for instance widespread lodging or the windrowing of crops), the circumstances should be stated in the test report.

SECTION 4—MACHINES

4.1 The test machine shall be fully identified as to make, model, year and other pertinent information. The terminology and methods of measurement defined by ASAE Standard S343, Terminology for Combines and Grain Harvesting, shall be used where relevant.

4.2 The comparison machine shall be similarly identified, functionally sound and one which has been available on the open market for a continuous period of at least one year prior to the date of the test.

4.3 At the time of test, both test and comparison machines shall be in good order, and the working surfaces shall have been adequately run-in.

4.4 Immediately prior to testing, both test and comparison machines should be adjusted for optimum performance in the same piece of crop that will be used for the tests. Pretest adjustments should aim for optimum performance with harvesting conditions typical of normal practice in the relevant locality. Care should be taken to ensure that the dockage level in the clean grain sample of the test machine is similar to that of the comparison machine. Persons responsible for adjusting the machines shall be given adequate time and opportunity to do so, with regard to the time requirements of Section 6 for conduct of the test proper. They shall also be responsible for deciding when the optimum adjustments have been attained.

4.5 No adjustment of the threshing, separating, or cleaning mechanisms shall be permitted during the test.

SECTION 5—COLLECTION OF SAMPLES

5.1 Apparatus for catching crop material discharged from the combine shall be built and operated so that:

5.1.1 The whole of the effluent from the machine is caught during the catch period.

5.1.2 The grain catch may be delayed after initiation of material-other-than-grain (mog) catch to compensate for the time the grain spends in the conveyor. This circumstance must be reported.

5.1.3 Catches are started and stopped without interrupting combine mechanisms or forward travel.

5.1.4 The apparatus does not significantly interfere with the combine's normal operation, for instance, with the flow of air from the cleaning mechanism.

5.1.5 Catches are taken from the points of normal discharge from the combine's separating and primary cleaning mechanisms at the normal rate of discharge. Conveyor-type apparatus for improving the accessibility of the catch points is permitted, but must be such as to cause no change in the condition of the crop material as discharged from the combine.

5.1.6 Samples of grain for analysis can be taken by passing a container through the stream of grain at the catching point during or immediately after taking the main catch. Storage containers shall be completely filled, and air-tight.

SECTION 6—TEST PROCEDURE

6.1 Prior to each catch period, the combine shall operate for such distance as the test supervisor may deem necessary to ensure that conditions have become stabilized throughout the relevant mechanisms.

6.2 During this period and during the catching periods, the full gathering width of the header shall be utilized. If the crop is windrowed, the windrow(s) should preferably be symmetrical and shall be picked up wholly and smoothly to ensure flow of crop across substantially the full width of the thresher.

6.3 Field speed and compensatory header adjustments shall be made only between test runs.

6.4 Field speeds for test runs should be selected to start below the speed used during the pre-test adjustment period and should be carried high enough to perceptibly indicate that maximum feasible feed rate has been reached. The limiting factor on feed rate such as engine overload, feeding difficulty, etc., should be noted and recorded in the test report.

6.5 The time of day selected for the test shall be when crop conditions are most stable, usually the several hours after noon. Comparative tests shall be conducted as closely as possible to the same time and location in the field. Differing circumstances should be reported.

6.6 The catch period should preferably be at least 5 seconds.

6.7 A test shall consist of at least 5 test runs and preferably not less than [illegible]

6.8 The test supervisor may discard attempted test runs at the time of test if in his judgment there is obvious reason to do so, e.g., functional failure, detrimental foreign objects entering machine, overfilling or spillage from catch receptacle, etc. Otherwise the results of all test runs made shall be entered on the test report, and comments shall be included on any unusual circumstance.

6.9 Samples for grain analysis shall be at least three in number, taken throughout the test period, and of not less than 1000 cm³ (60 in.³) volume.

6.10 Straw samples for moisture testing shall be at least three in number and taken throughout the test period. They should be taken from the straw discharged immediately after the end of the catch period and stored in completely-filled, air-tight containers until analyzed. Requirements are similar with regard to straw moisture measurements made by portable meter.

156

SECTION 7—PROCESSING OF CATCHES

7.1 Separating and cleaning should be as fully mechanized as practicable to ensure consistency. Feeding of crop should aim for relatively low feed rates, to retain at least 99 percent of the free grain contained in the samples before processing. Manual sorting of cleaned grain should be minimized.

7.2 In the event that USDA grade No. 2 grain or seed standards are not met, the sample should be evaluated by USDA standard techniques.

SECTION 8—TEST REPORTING

8.1 The test file should include all original data and measurements recorded for both test and comparison machines. These data shall include the following:

8.1.1 Location of test site.

8.1.2 Date and time of starting and stopping tests.

8.1.3 Combine and header identifications.

8.1.4 Crop, variety, crop conditions, and a reasonable estimate of average yield.

8.1.5 Combine settings and adjustments, particularly those relevant to the crop-handling mechanisms.

8.1.6 Details from the test runs recorded as follows:

8.1.6.1 Duration in seconds to nearest 0.1 second.

8.1.6.2 Field speed in kilometers per hour to the nearest 0.1 km/h (0.1 mph).

8.1.6.3 Grain catch in kilograms to nearest 0.2 kg (0.5 lb).

8.1.6.4 Separator mechanism catch in kilograms to nearest 0.05 kg (0.1 lb).

8.1.6.5 Cleaning mechanism catch in kilograms to nearest 0.05 kg (0.1 lb).

8.1.6.6 Free grain from separator in kilograms to nearest 0.005 kg (0.01 lb) up to 2 kg (5 lb) and to nearest 0.05 kg (0.1 lb) thereafter.

8.1.6.7 Free grain weight from cleaning mechanism in kilograms to nearest 0.005 kg (0.01 lb) up to 2 kg (5 lb) and to the nearest 0.05 kg (0.1 lb) thereafter.

8.1.6.8 Grain weight from rethreshed mop catches in kilograms to nearest 0.005 kg (0.01 lb) up to 2 kg (5 lb) and to the nearest 0.05 kg (0.1 lb) thereafter.

8.1.7 Moisture content of grain and straw samples expressed on the wet basis to the nearest whole percentage, and method of measurement.

8.1.8 Sample constituents if required by paragraph 7.2.

8.2 The report shall include sections in which the test supervisor shall record details specified above together with notes of unusual changes in weather or other conditions during the tests, and general comments on the performance of the machines and the conduct of the tests.

SECTION 9—CALCULATIONS

9.1 Calculations for each test run on each machine shall include these items as defined in ASAE Standard S343, Terminology for Combines and Grain Harvesting:

9.1.1 The total feed rate, mop feed rate and grain feed rate in metric tons per hour (lb/min).

9.1.2 The processing losses recorded to the nearest 0.1 percent.

9.1.3 The mop/grain ratio for the comp. and the mean value from all runs, for each machine.

9.1.4 The mean moisture contents of the grain and mop samples.

9.2 The resulting calculations shall be tabulated in the test report.

SECTION 10—PRESENTATION OF RESULTS

10.1 Graphs with linear scales are preferred for presentation of processing loss results, with total feed rate, mop feed rate or grain feed rate specified as the horizontal coordinate and percentage loss as the vertical coordinate. The data points for each test run shall be plotted on the graphs.

10.2 The capacity of each machine shall be the feed rate level at which the loss curve intersects the specified level of loss, as defined in ASAE Standard S343, Terminology for Combines and Grain Harvesting.

Cited Standard:

ASAE S343, Terminology for Combines and Grain Harvesting

I.27

157

TERMINOLOGY AND DEFINITIONS FOR AGRICULTURAL CHEMICAL APPLICATION

Developed by the ASAE Agricultural Chemical Application Committee, approved by the Power and Machinery Division Standards Committee, adopted by ASAE December 1969, reconfirmed December 1974, revised March 1983.

SECTION 1—PURPOSE AND SCOPE

1.1 The purpose of this Standard is to establish uniformity in terms used in the field of agricultural chemical application. Terms are adopted from related fields where applicable.

1.2 The terms are appropriate to any agricultural chemical application. Units in parentheses following a definition are meant as typical and are not exhaustive of all units available for the term.

SECTION 2—GENERAL CHEMICAL TERMS AND CHARACTERISTIC MEASUREMENTS

2.1 **Air flow rate:** The flow rate of air in a jet, expressed in volume per relevant unit (ft^3/min, m^3/s, m^3/tree).

2.2 **Application rate:** The amount of any material applied per unit treated.

2.2.1 **Active chemical rate:** The amount of active ingredient applied per unit treated, expressed in terms of mass per relevant unit treated. (For area treatment, kg/ha, lb/acre, or oz/1000 ft of row; for space application, mg/m^3, or oz/1000 ft^3; for individual units, kg/plant or animal.)

2.2.2 **Formulation rate:** The amount of chemical formulation applied per unit treated, expressed in terms of mass or volume per relevant unit treated. (For area treatment, kg/ha, lb/acre, or oz/1000 ft of row; for space application, mg/m^3, or oz/1000 ft^3; for individual units, kg/plant or animal.)

2.2.3 **Spray rate:** The amount of spray liquid applied to a unit receiving treatment, expressed in volume per unit treated. (For area treatment, L/ha, or gal/acre; for space treatment, mL/m^3, or oz/1000 ft^3; for individual units, L/plant, mL/animal, or gal/tree.)

2.3 **Carrier:** A gas, liquid, or solid used to propel or transport a chemical.

2.4 **Concentration:** Amount of the active ingredient contained in the chemical formulation expressed as a percent or mass per relevant unit basis.

2.5 $\overline{D}_{pq}$, **Mean droplet diameter:** $\overline{D}_{pq}$ is represented by:

$$\overline{D}^{(p-q)} = \frac{\Sigma D_i^p}{\Sigma D_i^q}$$

where

D_i = the diameter of the ith particle, ΣD_i^0 is the total number of drops in the sample.

Thus:

$\overline{D}_{10}$ = arithmetic mean diameter
$\overline{D}_{20}$ = surface mean diameter
$\overline{D}_{30}$ = volume mean diameter
$\overline{D}_{32}$ = Sauter mean diameter
$\overline{D}_{43}$ = mean diameter over volume

2.6 D_{x0}, **Median droplet diameter:** For cumulative distributions, D_{x0}, where x is V, A, L, or N, are diameters such that the fraction (f) of the total of volume, surface area, length of diameter, or number of drops respectively, is in drops of smaller diameter. Thus:

D_{V0} = volume median diameter
D_{A0} = area median diameter
D_{L0} = length median diameter
D_{N0} = number median diameter

Also, D_{V10} and D_{V90} = diameter of drop such that 10 percent and 90 percent respectively, of the liquid volume is in drops of smaller diameter.

2.7 **Deposit rate:** The amount of any material deposited per unit area.

2.7.1 **Active chemical deposit rate:** The amount of active ingredient deposited per unit area.

2.7.2 **Formulation deposit rate:** The amount of formulation deposited per unit area.

2.7.3 **Spray deposit rate:** The amount of spray liquid deposited per unit area.

2.7.4 **Mean deposit rate:** The average amount of deposit over the entire spray swath.

2.7.5 **Effective spray deposit rate:** The mean deposit from center to center of adjoining swaths.

2.8 **Diluent:** A gas, liquid, or solid used to reduce the concentration of active ingredient in a formulation or to reduce the concentration of a formulation for application.

2.9 **Drift:** The movement of chemicals outside the intended target by air mass transport or diffusion.

2.9.1 **Particle drift deposits:** The deposition of chemical particles outside the intended target.

2.9.2 **Airborne drift:** The dispersion of chemical particles to the atmosphere outside the intended target.

2.9.3 **Vapor drift:** The dispersion of vaporized chemical to the atmosphere and areas surrounding the target area during and following application.

2.10 **Droplet size characterization:** Classification of sprays.

2.10.1 **Aerosols:** Distribution of droplets with $D_{V0} \leq 50$ μm.

2.10.2 **Mists:** Distribution of droplets with 50 μm $< D_{V0} \leq$ 100 μm.

2.10.3 **Fine sprays:** Distribution of droplets with 100 μm $< D_{V0} \leq$ 400 μm.

2.10.4 **Coarse sprays:** Distribution of droplets with $D_{V0} >$ 400 μm.

2.11 **Formulation:** The form in which a chemical is offered for sale to the user, and includes both the active and inert ingredients.

2.12 **Sprayed width per nozzle:** The effective width sprayed by a single nozzle. For broadcast spraying it is the nozzle spacing. For band spraying it is the band width. For row crop spraying it is the number of nozzles per row divided by the row width.

2.13 **Swath, effective width:** The center to center distance between overlapping broadcast applications.

SECTION 3—TYPES OF APPLICATION

3.1 **Band application:** Distribution of a chemical in parallel bands leaving the area between bands free of chemicals.

3.2 **Basal application:** Application of a chemical to the base of a tree in a circle around the trunk, or by injection into slashes or cuts.

3.3 **Baseboard application:** Application to a building on the lower portion of the inside walls.

3.4 **Broadcast application:** Application of a chemical over the entire area to be treated.

158

3.5 **Crack and crevice application:** Application in a building by a means which projects the material into cracks and crevices which are inaccessible to the normal inhabitants of the building.

3.6 **Dip application:** Application by direct immersion.

3.7 **Directed application:** Application of a chemical to a specific area such as a row, bed, or at the base of plants.

3.8 **Foliar application:** Application of a chemical to the stems, fruit, leaves, needles, or blades of a plant.

3.9 **Pour on application:** Application by pouring a chemical onto the target.

3.10 **Saturation application:** Application of a chemical with a sufficient volume of solution that it begins to flow from the plant or animal.

3.11 **Space application:** Dispersion of liquid or dry particles in an air space in such a manner that target pests are exposed to the chemical.

3.12 **Spot treatment:** Application of a chemical to a small restricted area, usually to control the spread of a pest.

3.13 **Soil injection:** Mechanical placement of a chemical beneath the soil surface with a minimum of mixing or stirring of the soil, as with an injection blade or knife.

SECTION 4—APPLICATION APPARATUS

4.1 **Air carrier system:** A sprayer apparatus consisting of a pressure source and controls for the spray liquid and a blower with suitable ducts to produce an air jet in which spray nozzles are located. Air from the blower carries the spray for a distance for deposition on the target being treated.

4.2 **Boom sprayer:** A sprayer apparatus consisting of a pressure source and controls, and specifically employing an over-the-crop (or vertical for tree and vine crops) boom with atomizers (hydraulic, rotary, or other) arranged to provide uniform coverage of the treated surfaces.

4.3 **Bucket pump sprayer:** A sprayer apparatus consisting of a manually operated pump which may be held or mounted in a bucket containing the spray solution. The pump is connected to an atomizing device which forms and distributes the spray.

4.4 **Cold aerosol:** Any device which produces a liquid dispersion by mechanical means having a volume diameter less than 50 um.

4.5 **Compressed air sprayer:** A sprayer apparatus that uses air to pressurize the liquid or to siphon liquid from the container and an atomization device which forms and distributes the spray.

4.6 **Granular applicator:** An apparatus consisting of a hopper, a metering device and a device for spreading or placing the granules in the target area.

4.7 **High clearance sprayer:** An apparatus consisting of the components of a boom sprayer mounted on a self-propelled vehicle whose frame is constructed to permit the vehicle to pass over plants with minimal damage.

4.8 **Hose end sprayer:** An apparatus designed to be attached to standard garden hose, consisting of a hand-held container for spray mixture with an integral metering head through which water from the garden hose flows. The metering head utilizes water pressure, siphon effect, or some other water powered means to meter the spray mixture into the water stream which is then atomized.

4.9 **Knapsack sprayer:** A sprayer apparatus carried on the operator's back, consisting of a spray solution tank, pressure source, and an atomizing device which forms and distributes the spray. Spray pressure is supplied by lever operated manual or engine powered pumps or a compressed air tank. Some knapsack sprayers have air carrier blowers to distribute the spray.

4.10 **Slide pump sprayer:** A sprayer consisting of a telescoping pump operated by both hands. On the outlet end of the pump is mounted a spray nozzle. On the inlet of the pump is attached a line leading to a container containing the spray solution.

4.11 **Spray attachment:** An apparatus consisting of the individual components of a sprayer (tank, pressure source, pressure controls, spray liquid lines, pressure nozzles, etc.) in an arrangement to permit its mounting on another implement to permit application of spray at the same time another field operation is performed.

4.12 **Thermal aerosol:** Any device using thermal energy which produces a liquid dispersion which has a volume median diameter less than 50 um.

4.13 **Thermal vaporizer:** An apparatus consisting of a container for chemical and a heater to maintain the vessel at a temperature sufficiently high to accelerate evaporation or sublimination of the pesticide. The apparatus may contain a blower to disperse the pesticide vapor into a treated area, or may rely upon natural turbulent diffusion for dispersion.

4.14 **Wheelbarrow sprayer:** A sprayer consisting of a spray solution container mounted on a frame with wheelbarrow-type handles and one or two wheels, and a pressure source connected to hydraulic nozzles which forms and distributes the spray.

SECTION 5—ATOMIZERS

5.1 **Blast atomizer:** Devices that use kinetic energy of a gaseous stream for spray atomization. A jet of compressed gas or air impinges on a stream of spray liquid, or the liquid is aspirated into an air stream in such a way as to cause it to disintegrate into spray droplets.

5.2 **Electrostatic atomizer:** Devices that impart an electrical charge to a spray liquid for enhancement of atomization and/or deposition.

5.3 **Pressure atomizers:** Devices that use flow energy for spray atomization. Liquid may be transformed into jets, fan, conical, or other patterns.

5.3.1 **Orifice atomizer:** A pressure atomizer having a circular orifice, or converging flow nozzle that produces a simple liquid jet that breaks up at some distance from the nozzle.

5.3.2 **Fan spray atomizer:** A pressure atomizer having an orifice formed by the interception of a groove with a cone shaped chamber which produces a fan shaped liquid sheet that disintegrates into spray droplets at some distance from the nozzle.

5.3.3 **Deflector atomizer:** A pressure atomizer discharging a jet which impacts and spreads on a deflector plate. After leaving the edge of the plate it forms a fan-shaped liquid sheet which breaks into spray droplets.

5.3.4 **Swirl spray atomizer:** A pressure atomizer having a circular orifice, opening from a chamber with tangential inlets, a slotted distributor, vanes, cones or other devices positioned to impart a swirl to the liquid. The spray is released in a hollow or solid conical pattern.

5.4 **Rotary atomizers:** Devices that use rotational kinetic energy for spray atomization.

5.4.1 **Rotary disc atomizer:** Devices that use rotational kinetic energy of a disc to produce fluid shear and surface tension forces that adjust the fluid sheet thickness leaving the disc for subsequent atomization. The disc may be flat or saucer shaped. Multiple discs may be used.

5.4.2 **Rotary wheel atomizer:** A rotary atomizer consisting of a rotating circular wheel constructed with vanes, bushings and perforated or porous openings. The liquid is fed to the inside of the wheel, moves through the constructed openings and is broken into droplets.

5.5 **Vibrating atomizers:** Devices that use kinetic energy of a vibrating member for spray atomization.

5.5.1 **Acoustic atomizer:** A vibrating atomizer that uses piezoelectric, magnetostrictive, other electrical, or gas driven devices at 6-20 kHz to control the atomization of jet streams.

5.5.2 **Ultrasonic atomizer:** A vibrating atomizer that uses electrically driven devices at 40-1000 kHz to control the atomization of jet streams.

5.5.3 **Vibratory atomizer:** A vibrating atomizer that uses vibrating blades, reeds, or rods to detach drops from liquid feeding through stationary capillary tubes.

I.29

159

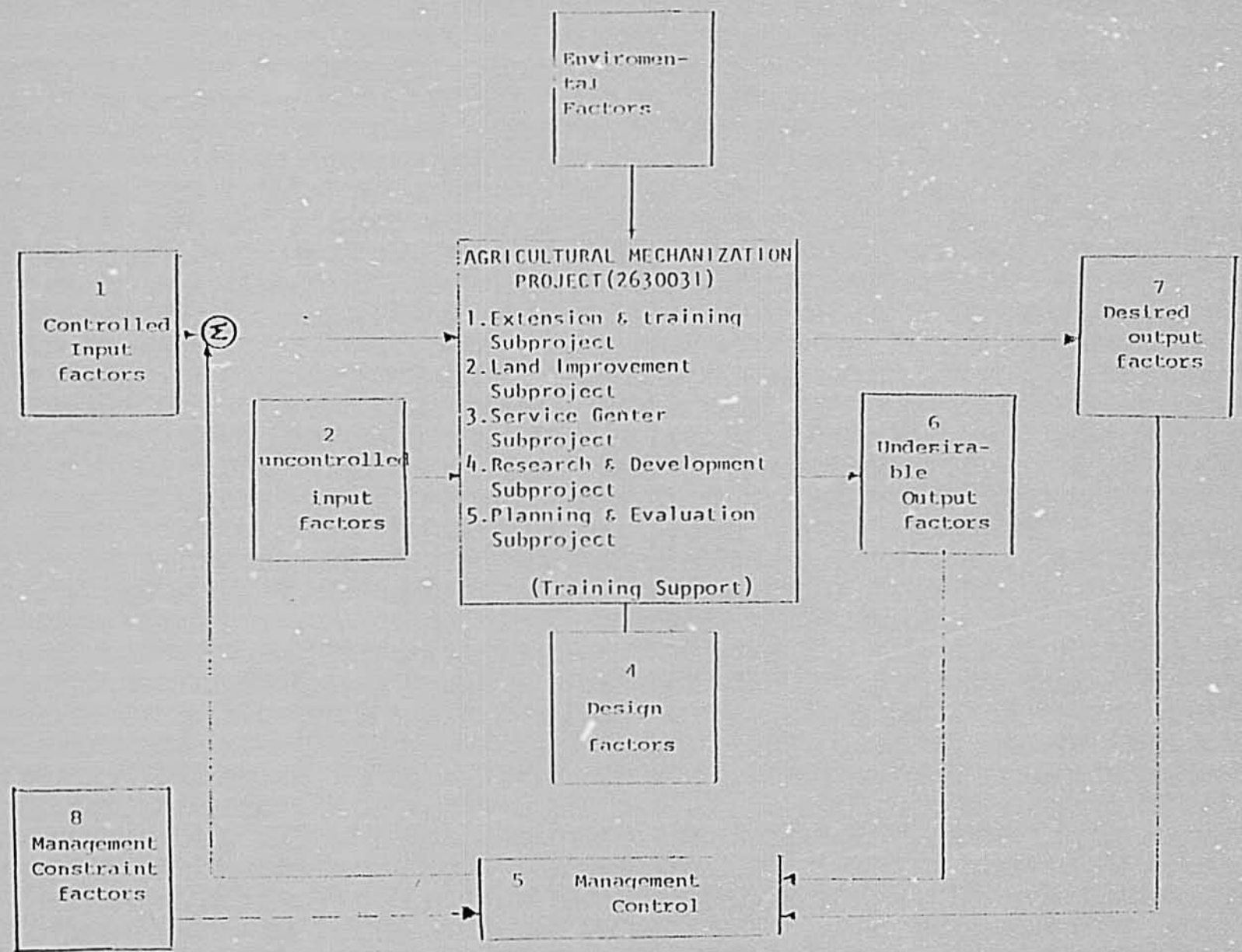


Figure Relationship of factors affecting the Project

List of Individuals Interviewed

Dr. Mohamed Abbas
Undersecretary for the Minister's office, MOA

Dr. Bangat M. Abdel Maksoud
Member of the Planning & Evaluation Committee
Faculty of Agriculture

Eng. Amal H. Abdel Meguid
Manager of International Loans, PBDAC

Mr. Hassan Abdel Razek
Extension Coordinator of Minia Governorates

Dr. Eng. A.M. Abou-Sabe
Chairman of the Managing Board, International Center for Rural Development

Eng. Mohamed Sabry Afifi
Specialist, Tankh District

Mr. Abdel Sattar Ali Ali Ahmed
Workshop Owner Minia

Eng. Ibrahim Alavi
Engineer for Service Centers and Workshops

Mr. Paul Armstrong
Gabal Asfar Farm Advisor, AMP

Eng. Mohamed Abdel Aziz
Field Coordinator for Beheira and Garbiya Governorates

Eng. Ahmed A. Bahgat
Agricultural Mechanization Consultant,
Catholic Relief Servies

Dr. Ahmed Mamdouh
Machinery Management and Information specialists, AMP

Eng. Ahmed El-Behery
Field Extension Officer, AMP

Mr. Al-Blanshine
Machinery Development Advisor, AMP

Eng. Minial El-Camia
Agricultural Mechanization Specialist

Eng. Mohamed Kamel El-Gamal

Mr. Roger Engstrom
Agricultural Extension Technical Advisor, AMP

Eng. Sablty Faid

Eng. Mourad Fawzy
Director Service Center Sub-Project, AMP

Eng. Ahmed El-Fayoumi
Planning and Topographic Survey Engineer

Mr. Abdel A. Fiekha

Eng. Ahmed Fouad
Extension Engineer

Eng. Ahmed Gaad
Director of Extension for Minia Governorate

Mr. David Gaiser
Team Leader, Project Technical Director, AMP

Eng. Ibrahim Ghattas
Training Official, AMP

Mr. Ronnie G. Gollehon
Team Leader, Small Farmer Production Project

Dr. Zakaria El-Haddad
Deputy Director/Project Coordinator, AMP

Eng. Moustafa Said Hashem

Mr. Fred Hodgson
Land Improvement Equipment Specialist, AMP

Dr. Eng. A.M. El-Hossary
Undersecretary for Engineering Affairs,
Ministry of Agriculture

Mr. Mohamed Hassan Ibrahim
Senior Accounting Advisor, AMP

Eng. Maher Iskandar
Manager Gabal Asfar Farm,
Head of Sub-Project, AMP

Eng. Aly Nashaat Ismail
Secretary General, Agriculture Research Center

Eng. Aly El Aziz Shatta El Said Kassem
Extension Specialist

Eng. Abdel Raouf Mohamed Khalifa
Service Center Operations Director

Prof. Dr. A.Y. Korayam
Chairman Agricultural Engineering Department
Faculty of Agriculture, University of Alexandria

Mr. Essa Labib
Cooperative Officer

Mr. Jeffry R. Lee
Project Officer, USAID

Eng. Mohamed El-Sayed Majak
Specialist, Beltan Distrit

Dr. Amin M. Mashali
Director of Research, SAO-FAO Project

Mr. James McClung
Irrigation Engineering Advisor, AMP

Dr. Mahmoud Mesbah
Member Planning Evaluation Committee
Associate Professor Agricultural Economics,
Kafr El-Sheikh

Eng. Taha Younes Moustafa

Eng. Aly Ibrahim Mohamed Moussa
Agricultural Engineer

Eng. Kamal Nabih
General Manager for International Loans, PBDAC

Eng. Mohamed El-Naggar
Director Research and Development Sub-Project, AMP

Eng. Mahmoud Nour
Director Small Farmer Production Project

Mr. Arnold J. Radi
Agriculture Development Officer, USAID

Dr. Carl Reeves
Reseach Administration Advisor, AMP

Dr. Peter Reiss
Evaluation Advisor, AMP

Dr. Ahmed F. El-Sahrigi
Project Director, AMP

Eng. Mohamed M. El-Salhy
Director World Bank Agriculture Development Project
Sohag, Minoufia

Mr. Frederick Schantz
Training and Extension Coordinator, AMP

Ms. Neamat Shafik
Evaluation Officer, USAID

Eng. Ahmed El-Sharaky

Mr. Steven Shepley
Assistant Team Leader/Planning and Financial Advisor, AMP

Mr. Robert Snyder
Repair and Maintenance Advisor, AMP

Eng. Soiden
Coordinator, Sharkeya

Mr. Graham Sparow
Service Center Development Advisor, AMP

Eng. Saad El-Wishahy
Chairman, Bank for Development and Agricultural Credit

Dr. Abdel Tawab El-Yamani
Member Planning Evaluation Committee
Chairman Agricultural Economics Department,
Kafr El Sheikh

REFERENCES

Agricultural Development Systems: Egypt Project, University of California, Davis.

- Agricultural Mechanization in Egypt: Hopes and Fears, Economic Reprint Series No. 2 1981.
- An Economic Evaluation of Farm Mechanization in Egypt, Economic Working Paper, No. 117, January 1983.
- Experience of Some Countries In Agricultural Mechanization, Economic Working Paper, No. 15, May 1981.
- Farm Mechanization Policy in Egypt, Economic Working Paper, No. 118, January 1983.
- Mechanization Decisions In Egyptian Agriculture, Economic Working Paper, No. 55, December 1981.
- Mechanization Issues In Egyptian Agriculture, (Ministry of Planning, Cairo) Economic Working Paper, No. 129, March 1983.
- Public Policy And The Demand For Mechanization On Egyptian Farms, Economic Working Paper, No. 133, March 1983.
- Supply Of Agricultural Machines In Egypt, Economic Working Paper, No. 128, March 1983.
- The Economics Of Tractors In Egyptian Agriculture, Economic Working Paper, No. 39, October 1981.

American Society of Agricultural Engineers. 1983-1984 Agricultural Engineers Yearbook
ASAE, St. Joseph, MI. USA. June 1983.

Arab Republic of Egypt, Ministry of Agriculture, Agriculture Mechanization Project. Inception Report, August 1984.

- Activity Report No.1, October, 1981.
- Activity Report No.2, December, 1981.
- Activity Report No.3, December, 1981.
- Activity Report No.4, March , 1982.
- Activity Report No.5, June, 1982.

1106

- Activity Report No.6, September, 1982.
- Activity Report No.7, December, 1982.
- Activity Report No.9, June ,1983.
- Activity Report No.10, September, 1983.
- Activity Report No.11, December, 1983.
- Activity Report No.12, to be completed by late July 1984.
- An Evaluation of the Water-Lift Loan Fund April, 1982.
- Agricultural Mechanization Cost Model.
- A Plan For Prototype Production , August 1983.
- A survey of suitability of Egyptian Soils for Mechanized Agriculture,
  Working paper No.13, March - April 1983.
- Basin Survey, Minia Governorate, Results of the Preliminary Survey,
  Working paper No.4, October 1982.
- Cost Reimbursable contract between the Ministry of Agriculture and Louis Berger International Inc. September 1980.
- Egyptian Agricultural Mechanization Five Year Development Plan, 82/83/86/1987.
- Egyptian Cotton Production Economics and Farmer Response to Government Price Intervention and Meat Import Policies, April 1984.
- Egypt Strategies; For Accelerating Agricultural Development (in cooperation with USAID) July 1982.
- "Farm Machinery Manufacturing: A Systems Approach". Second International Conference on Production Engineering, Design, and Control, Alexandria, Egypt, December 1983.
- Machinery Demonstration Evaluation Series
  No.1 Silage Mower for Cotton Stalk Removal May 1983.
- No.2 Wheat Cultivation : Graindrills Mower - binders, Combines, October 1983.
- Mechanization Extension Programs for Project Villages, October 82 - October 83, 1983.
- Producing Maize Losses through optimizing the date of planting. Working paper No. 7, April 1983.

- Project Files.
- "Project Research Investigations: Tillage Experiments with Cotton, Maize, and Peanuts." Working Paper No. 14, 1984.
- The State of Agricultural Mechanization in Egypt. Results of a Survey, June 1982.
- Training Plan, 1980-1982.
- Training Plan, 1983.
- Training Plan, 1984.
- Villages Profile, working paper No. 6, December 1982.
- Mechanization Extension in Egyptian Agriculture, working paper No. 8, April 1983.

Arab Republic of Egypt, Ministry of Planning. The Detailed Frame of Five-Year Plan for Economic and Social Development 1982/82-1986/87, December 1982.

Catholic Relief Services. Ten Horse Power Agricultural Mechanization Series - Phase III.

Coles, E.D. and J.A. McClung. " Constraints in Developing a Small Farm Land Improvement Program." ASAE paper No. 83-5502, 1983.

El-Haddad, Z.A. and A.F. El Sahrigi. Farm Machinery Manufacturing: A General Review. Second International Conference on Production Engineering, Design, and Control, Alexandria, Egypt. December 1983.

El-Sahrigi, A.F., R.K. Berky, R.E. Garrett. " Machinery Introduction, to Promote Mechanization of Egyptian Agriculture." ASAE paper No. 84-5003, 1984.

ERA-2000 Inc. Further Mechanization of Egyptian Agriculture Gaithersburg, Maryland, April 15, 1979.

Gaiser, David W.Jr. A Systems Approach to Agricultural Mechanization Development in Egypt. ASAE paper No. 82-5538, American Society of Agricultural Engineers. St. Joseph, MI. December 1982.

Gaiser, David W. and Steven C. Shepley. " Land-Use Intensity: A Simulation Routine and Economic Analysis of Maize Planting Dates in Egypt with Implications for Mechanization." ASAE paper No. 8-4-5002, 1984.

168

Gaiser, David W. Jr. and Steven Shepley. Simulation Model for Evaluating Cropping Intensity and Mechanization Impact, ASAE paper No. 84-5001, USA. June 1984.

Ikram, Khalid. Egypt, Economic Management In a Period of Transition, World Bank Country Economic Report. The Johns Hopkins University Press, 1980.

McColly, H.F. and J.W. Martin. Introduction to Agricultural Engineering. McGraw-Hill Book Co., New York, USA. 1955.

MOA/USAID, Egypt. Strategies for Accelerating Agricultural Development, July 1982.

Pischke, J.D. Von. et.al. Rural Financial Markets in Developing Countries, Their Use and Abuse. The World Bank, 1983.

Richards, Alan and Philip L. Martin. Migration, Mechanization and Agricultural Labor Markets in Egypt. The American University in Cairo Press, 1983.

Ronco Consulting Corporation. Evaluation, Small Scale Agricultural Activities Project, Egypt, June 1984.

United States Agency for International Development. Cairo mission, Agriculture Division, Agricultural Mechanization Project 263-0031, Project files:

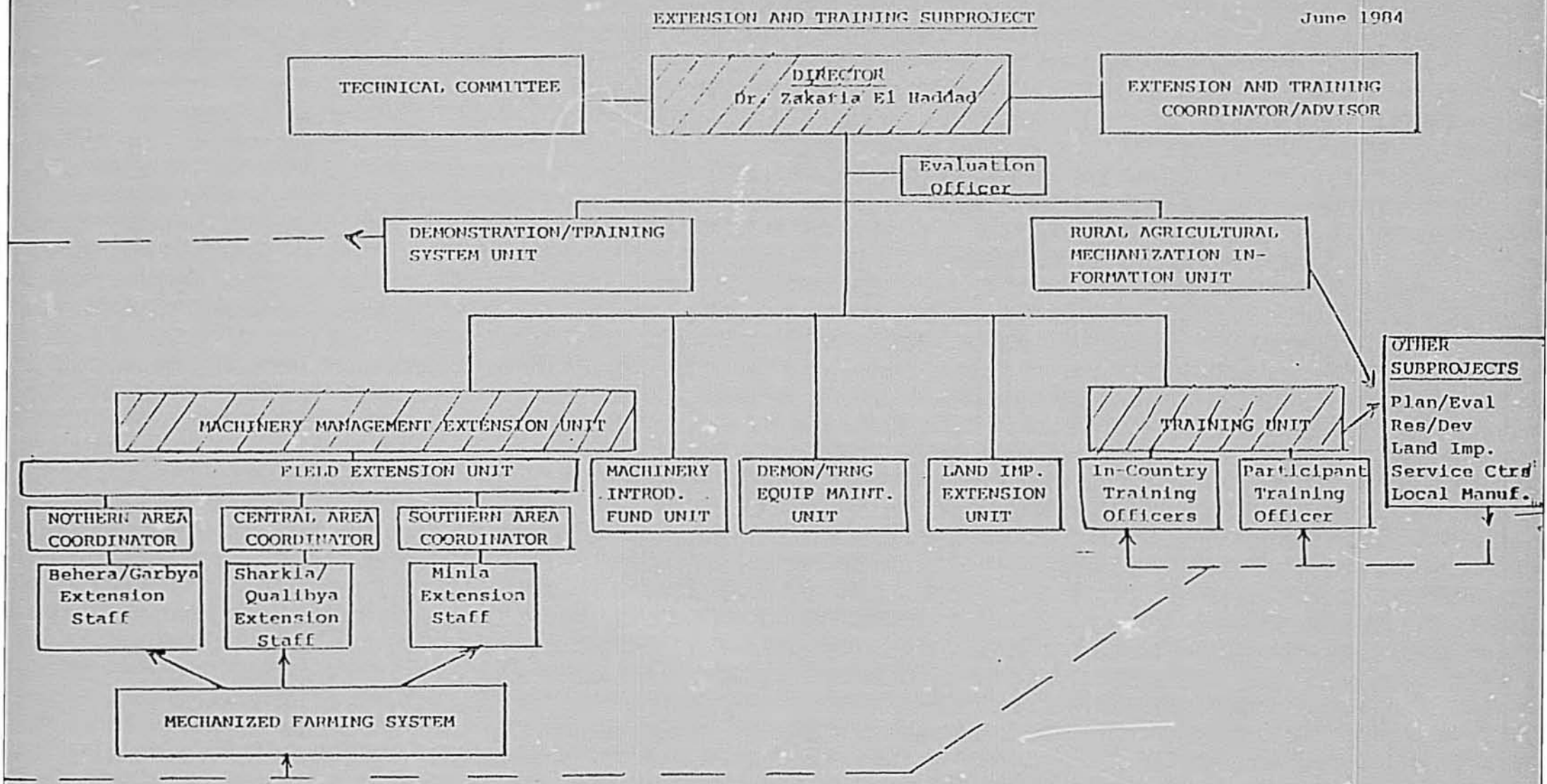
- An Evaluation of the Agricultural Mechanization Project, February 1983.
- Invitation for Bids for Commodity Procurement.
- Project Correspondence.
- Project Implementation Letters (No. 1-29)

United States Agency for International Development, Washington, Egypt Agricultural Mechanization Project paper, August 1979.

- Implementation of A Strengthened Agricultural Extension Problem in Egypt, April 1982.
- Increasing Agricultural Production Through More Effective Use of Technology - Recommendations for a Strengthened Extension Program in Egypt. USAID, Washington, November 1981.
- Project Grant Agreement between the Arab Republic of Egypt and the United States of America for Agricultural Mechanization, September 15,1979.

University of Alexandria. Proceedings: Second International Conference on Production Engineering, Design and Control, Alexandria, Egypt, December, 1983.

170



Organization Chart of the
Machinery Management Extension and Training Subproject

Appendix M
Figure 1