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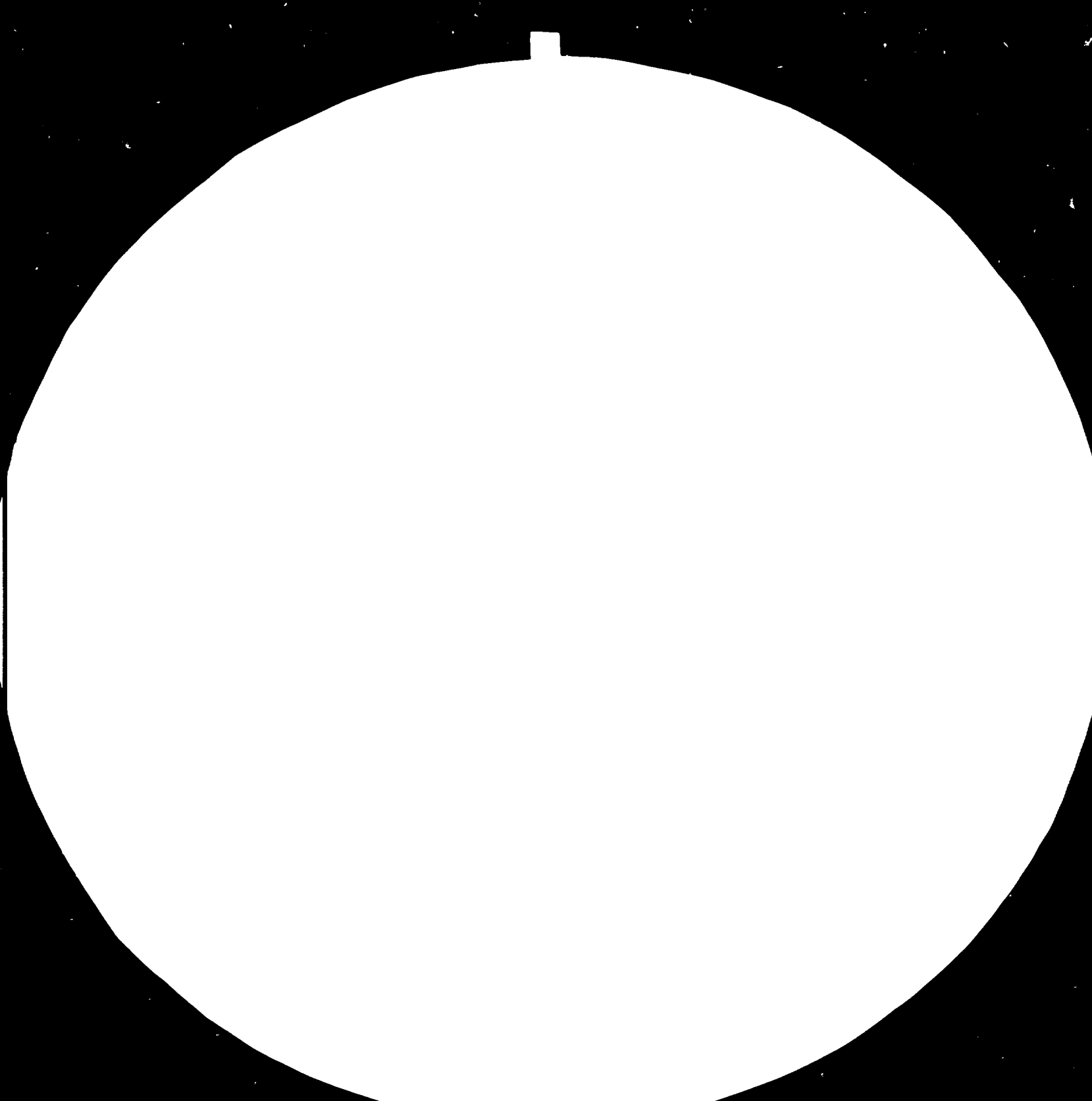
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1.0 25



1.1 22



2.0 18



1.8 16



Resolution Test Chart
NBS 1963-A

Resolution Test Chart
NBS 1963-A

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

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Egypt

PLASTICS DEVELOPMENT CENTRE . Drip irrigation -

DP/EGY/77/004/11-02/Y

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This report has not been cleared with UNIDO which does not, therefore, necessarily share the views presented.

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2. Current Status of Drip and Micro-Irrigation in Egypt
3. Current status of plastics industry in Egypt with reference to manufacture of drip and micro-irrigation equipment.
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SUMMARY

1. The author was assigned as a drip irrigation expert to the Plastics Development Centre (PDC), Alexandria for one month during June 1983.
2. The expert recommends the use of drip emitters, jets or mini-sprinklers on standard polyethylene hose as appropriate technology for Egypt because a large proportion can be manufactured in Egypt.
3. The expert recommends that PVC fittings, polyethylene hose fittings, emission devices, filters and control equipment be imported.
4. The expert recommends that staff from PDC be trained in design, installation and operation of micro-irrigation
5. The expert designed a trial for the West Nubariya experimental station and recommends that it is purchased and installed as soon as possible. This will help the PDC staff to learn about micro-irrigation.
6. The expert believes that the Egyptian Plastics Industry can manufacture high quality PVC pipe and polyethylene hose with guidance from the PDC.

1. Introduction

The author was assigned to the Plastics Development Centre (PDC) in Alexandria for one month as a drip irrigation expert. There were two major aims of this mission. The first was to review the status of micro-irrigation (see footnote) in Egypt and to set up an experimental trial at the West Nubariya experimental station for the benefit of the new farming community in that region and also to enable the PDC staff to become more familiar with all aspects of design, installation and operation of a micro-irrigation system. The satisfactory implementation of this aim was thwarted by the lack of the materials required within Egypt. Further details are provided in section 2.3

The second major aim was to review the Egyptian Plastics Industry, both public and private sector, to ascertain which micro-irrigation components are currently being produced, which components the industry is intending to produce and the ability of these companies to produce products to acceptable standards for the micro-irrigation industry. This aim is discussed in section 3.

The main purpose of the Plastics Development Centre is to provide a link between the plastics industry and the application of plastic products (including films, drainage pipe, etc.) in agriculture. The expert gives a review of how they are progressing towards achieving this goal in section 4 of this report.

The program of the expert is given in Appendix 1. The time was spent in three main areas:

- a) Inspecting current micro-irrigation systems and designing a trial for the West Nubariya experimental station.
- b) Inspecting plastic factories.
- c) Training of PDC staff especially in micro-irrigation design. This also included a seminar entitled "Drip and Spray Irrigation" given to PDC staff and invited guests on Monday 27 June in the PDC Lecture theatre. An outline of this lecture and a list of attendees (excluding PDC staff) is given in Appendix 2.

The term micro-irrigation will often be used in preference to drip irrigation. Micro-irrigation includes drip irrigation and also the allied irrigation techniques of jets and mini-sprinklers which are also low volume discharge devices operating at low pressures.

2. Current Status of Micro-Irrigation in Egypt

Several micro-irrigation systems have been installed in Egypt for both the public and private sectors. A large proportion of all these systems have been imported. The major limiting factor to the more rapid development of micro-irrigation appears to be problems with obtaining import licences. This may be a deliberate attempt on the part of the government to encourage the Egyptian plastics industry to manufacture some of the components itself.

The government has accepted the general concept of drip irrigation as suitable for the desert reclamation projects in West Nubariya. It also hopes that a large proportion of any systems will be made in Egypt. It is therefore important to discuss which of the micro-irrigation technologies are suitable for Egypt.

2.1 Appropriate Micro-Irrigation Technologies

All micro-irrigation systems commence with a pump, followed by a filter and assorted control equipment, main-line, submains and finally lateral lines with emission devices.

The laterals with emission devices may be of two types:

a) A lateral where the emission device is an integral part of the lateral and is manufactured at the same time as the lateral. These types of tubing are specially designed for row crops such as vegetables, strawberries, sugar cane and cotton although they have been used on a variety of other crops. The three main products of this type, and which together account for in excess of 90% of the worldwide market, are RIS Bi-Wall®, Chapin tubes and T-Tape®. Polyethylene hoses with moulded drip emitters inserted at the time of extrusion have not been included in this category. These are related to the above products but more properly fit into the second category because of cost. This concept is promoted by Israel.

The above three products are all manufactured in USA and are all very high technology products. The investment to produce the products is extremely high and the machine must produce the products continuously in high volume to obtain an adequate return on the capital invested. The technologies have not been transferred to any other country. It is therefore extremely unlikely that any of these companies will be prepared to, or have the ability to, transfer the technology to Egypt and that the Egyptian demand will be high enough to justify the investment.

The expert considers that this is not appropriate technology to be adopted in Egypt for the irrigation of crops

other than cotton and sugar cane for the following reasons:

- i) The product would have to be imported
- ii) The product contributes 50% of the cost of a system
- iii) The product is disposable after one or two years so would represent a continuing drain on foreign currency.

This concept has become well established in many countries for tomatoes, cucumbers, strawberries and many other row crops. It has only recently been adopted for cotton in the USA and Australia and is not likely to be adopted in Egypt for several years. However, the concept was developed for sugar cane and if there is a desire on the part of the government to increase the yield of sugar cane by using drip irrigation, then this concept is the one which should be adopted.

b) Standard polyethylene hose with drip emitters, jets or mini-sprinklers attached to it at regular intervals. This is the standard drip irrigation system. The hose is low density polyethylene and is usually in sizes of 10, 13, or 16 mm internal diameter for drip irrigation systems, in sizes of 13, 16, or 19 mm for jet irrigation systems and 16, 19, or 25 mm for mini-sprinkler systems.

This type of drip irrigation system is the most suitable for all tree crops and can be used just as satisfactorily

for most vegetables and row crops. Its advantages are:

- i) If manufactured to the correct specifications, it should have a life of 20 years or more.
- ii) It can withstand much more harsh treatment by laborers in the field.
- iii) The polyethylene hose which represents 50% of the cost of the systems should be able to be manufactured in Egypt.

The disadvantages of the system are:

i) The drip emitters should not be buried. However as the system is likely to be used on tree crops or vegetables, this will not present a major problem. Problems may be experienced if used for sugar cane or cotton depending on the agronomic practices used and, as discussed in the previous paragraph, the importation of the disposable type tubes may be necessary.

ii) The initial capital cost of the system is higher than for the disposable tubes but there is no recurrent cost at one or two year intervals.

The expert therefore considers that this latter option is the appropriate micro-irrigation technology for Egypt for the following reasons:

- i) A large proportion can be manufactured in Egypt
- ii) There is no need to continually import replacement products which would drain foreign currency reserves.

iii) It is generally an easier system to operate efficiently and requires less management expertise. There is less likelihood of a total system blockage if the water treatment is sub-standard and if this does occur, the drip emitters can be either cleaned (for some models) or replaced which is a small cost compared to replacing all the tubing in the disposable tubing systems.

2.2 Development of Micro-Irrigation Technology

If it is assumed that the development of micro-irrigation systems using standard polyethylene hose and emission devices is adopted as the preferred technology for Egypt, then the following factors should be considered:

- a) Selection of components
- b) Design of micro-irrigation systems
- c) Installation of micro-irrigation systems
- d) Operation and maintenance of micro-irrigation systems
- e) Manufacture of components

2.2.1 Selection of components

The success of any micro-irrigation system is dependent upon the selection of quality components. The development of micro-irrigation systems only became a possibility with the advent of versatile plastics and, in most applications, these plastics are being tested to their limits. A micro-irrigation system is subjected to harsh external environmental conditions in the form of ultra-violent radiation, high temperatures, wind-blown sand, mechanical abrasion, and attacks by vermin. It is also subjected to harsh internal conditions in the form of pressure, high water temperatures and chemicals, such as acid and chlorine, to which all plastics are not inert.

There are no international standards for the majority of the components of a micro-irrigation system and therefore it is unwise to mix components from several manufacturers without their approval as they may not be compatible.

The major components are PVC pipe and fittings, polyethylene hose and fittings, emission devices, filters and control equipment. Each will be discussed separately.

a)PVC Pipe

There are several standards for PVC pipe throughout the world but they can be grouped into two main categories, the European DIN standard and the USA, Australia and British Imperial group of standards. These latter three all have approximately the same outside diameter so fittings are

interchangeable but wall thickness, and hence pressure ratings vary between countries. A discussion on the advantages and disadvantages of the two groups of standards is given in section 3. Some countries use high density polyethylene as an alternate to PVC. This requires expensive fittings and the pipe can be susceptible to cracking and is therefore not recommended.

b) Polyethylene hose

High density polyethylene is not an acceptable material for micro-irrigation laterals. It is essential that this component is made from high grade low density polyethylene or linear low density polyethylene. Linear low density polyethylene is a low density polyethylene resin made by a new process and produces many desirable properties for irrigation applications. However, linear low density resin is more expensive and is not available in all regions of the world. There are also many different grades of linear low density polyethylene resin and these produce hoses of vastly differing qualities. A perfectly acceptable polyethylene hose can be produced using standard low density polyethylene. The important specifications and quality control standards which any polyethylene hose must conform to are:

- i) a minimum carbon black percentage of 2%
- ii) no failure in the Igepal test for 1500 hours
- iii) acceptable internal or external diameter and wall thickness tolerance
- iv) control of incorporation of regrind material

All of the above will be discussed in greater detail in Section 3. It is very important that all manufacturers realize the repercussions of producing hose which does not meet all the above criteria. It is not possible to detect hose with low carbon black content or one which will fail the Igepol test except by chemical analysis. However such hose may crack or burst after only a year or two in the field whereas it should have a field life of twenty years or more.

c) Polyethylene hose fittings

There have been a variety of types of fittings produced which have included barbed fittings (most popular), RIS Irrigation Systems Loc-Eze® type, female compression type for outside diameter controlled hose, and various screw-up compression types similar to those used for high density polyethylene hose. Barbed fittings suffer from several major disadvantages which include a relative sensitivity to hose internal diameter, a risk of promoting stress cracking, a necessity to cut the hose to remove in many cases and the possibility of blow-off at pressures lower than the burst pressure of the hose. However they are generally inexpensive. Screw-up compression fittings tend to be expensive because of the many components involved. The female compression type are satisfactory if there is good control of external diameter but it is impossible to remove the hose or to easily re-use the fitting. The Loc-Eze® type fitting is a very satisfactory fitting which will not blow off but again it, like the other fittings, will only fit

hoses within a limited range of internal/external diameters.

Each system requires several types of fittings (tees, elbows, connectors and several others). Generally, however, the quantities of each are small. As a result, the number of molds to produce these fittings is high and the utilization is low making the fittings relatively expensive. The expert therefore considers that it would be preferable to allow importation of hose fittings at this stage.

d) Emission devices

Emission devices including drip emitters, jets and mini-sprinklers can be divided into two main groups- non-compensating and compensating devices. The reason a compensating device is recommended by some people is that design is not so critical, they are good for undulating ground, and the laterals can be longer because a greater variation in pressure is possible. However in 90% of irrigation designs the ground is not undulating and, even with compensating devices, careful design is necessary. Therefore the additional effort to design to within $\pm 10\%$ of discharge for a non-compensating device is minimal and this is a cost which occurs once only. Compensating devices generally require a higher input pressure to achieve the benefits of a longer lateral length. However the most important factor in choosing between a compensating or non-compensating device is in the product itself and in the materials incorporated in the product. All compensating devices must have a material which reacts to pressure. This may be rubber or silicone. In the early drip emitters there

were many problems with the rubber components and even though improved rubbers are now available, many of these are not resistant to acid and chlorine which are injected into many micro-irrigation systems. Silicone is resistant to these chemicals but this is a relatively new material and it is not proven that its life will extend beyond five years. Non-compensating devices made from polypropylene have been in the field for fifteen years and show no deterioration.

The expert therefore recommends that the use of simple non-compensating drip emitters and mini-sprinklers be promoted.

e) Filters

Filters are a vital component of any micro-irrigation system and are one of the few components incorporating metal parts. There are two basic types of filters- sand media and screen filters. Sand media filters are a three-dimensional filter and are used with dirty water sources (eg. canals, reservoirs, etc.) or for drip emitters with small flow paths. Screen filters are a two-dimensional filter and are used with clean water sources (eg. wells with clean water). They are also used as back-up filters for sand media filters.

The principle of both types of filters is very simple and this encourages many individuals or irrigation dealers to attempt to make their own. However, to survive corrosion, bursting, ineffectiveness and by-pass of seals over a range of flow rates and pressures and with water which may contain

acids and chlorines, good design and the use of the latest techniques for corrosion resistance are very important.

There are many types of these filters available at fairly competitive prices. The technology is continually changing and this is an area where there may be major breakthroughs in the future. The expert, therefore, advises that it is probably preferable to import filters for the present. An approach of making filters without obtaining technology from a leading filter manufacturer will probably lead to the production of inferior products and this may cause failure of the total system.

f) Control equipment

This category includes all the items not previously discussed which make up the total system. It includes valves, controllers, injection equipment, flow meters and other monitoring equipment. Controllers are only required for an automatic system and they will also require electric solenoid valves, wire cabling and associated components. Although there is an increasing interest in the total automation of systems in Australia and USA, this technology is not essential to the operation of an efficient micro-irrigation system and the expert recommends that manual systems be promoted. Manual systems only require a gate valve. All micro-irrigation systems should incorporate injection equipment for the purpose of injecting water treatment chemicals and fertilizers. Due to the very high technology of these specialty items, they should be imported.

2.2.2 Design of micro-irrigation systems

This is one of the most important aspects to consider for an efficient micro-irrigation system.

The aim in designing the system is to ensure that each emission device operates within $\pm 10\%$ of its nominal discharge. For a typical non-compensating drip emitter, this entails keeping the pressure variation between 0.85 bar and 1.15 bar for a nominal operating pressure of 1.0 bar.

The first step in designing a micro-irrigation system is to measure up the field and obtain a contour map. If a detailed contour map is not available and the land slopes evenly, a measure of the height at key points in the field may be sufficient. The design will also require information about the crop, the climate of the region and the water source.

Several methods can be used for the design of micro-irrigation systems but one of the more popular is the Polyplot™ method. This will shortly be published in a metric edition to replace the previous edition using imperial gallons and feet.

The expert spent a considerable part of his mission in teaching the agriculturalists at PDC the basic elements of micro-irrigation design. The successful development of

micro-irrigation in Egypt will require adequate facilities for the design of micro-irrigation systems. It is likely that the major companies which market micro-irrigation systems will provide these services. However it may be necessary or desirable that staff of the PDC are capable of designing irrigation systems. If this is so, the expert recommends that some staff should be provided with additional training in micro-irrigation design. This should preferably be included with training in the installation, operation and maintenance of systems (see following sections).

2.2.3 Installation of micro-irrigation systems

The installation of micro-irrigation systems is no more difficult than most other types of irrigation systems but as with any system there are certain techniques which must be learned to obtain an efficient system. These are not techniques which can be learnt from a textbook. If it is necessary for staff of the PDC to learn these techniques for the efficient development of micro-irrigation, then some staff should be provided with this training. It can probably be included with training in design (see section 2.2.2).

2.2.4 Operation and maintenance of micro-irrigation systems.

This is a very important area for the successful development of micro-irrigation systems. In many instances a

system is designed and installed correctly by a major irrigation company which also educates the farmer how to operate and maintain it. However problems develop and the farmer blames the components or the installation whereas the farmer should really blame himself for failure to operate and to maintain it correctly. This is an area where it would be desirable to have staff from the PDC available to offer independent advice to the farmer. However, considerable experience is required to be able to offer this advice and a training course should be considered for some PDC staff. It would be appropriate that these people also learn how to design and install micro-irrigation systems so that they have total knowledge of the system.

2.2.5 Manufacture of components

The production of quality components is crucial to a successful micro-irrigation system. The Egyptian government is concerned that they have been importing the major proportion of most micro-irrigation systems. They hope that the Egyptian plastics industry can manufacture a large proportion of these systems. It is important that a balance is struck between local manufacture and import. The technology of micro-irrigation is continually changing and it is therefore important that Egypt ensures it has continued access to this new technology. The successful development of micro-irrigation will also require the experience gained by the major irrigation companies in the areas of design,

operation and maintenance. For these reasons it will be preferable if the plastics industry is encouraged to work with the irrigation suppliers in producing some of the products. The expert suggests that it would be appropriate for the plastic industry to concentrate on the manufacture of PVC pipe and polyethylene. These account for 80% of the material cost of most systems and for 90% of the freight costs. If there is a relative freedom to import fittings, emission devices, filters and control equipment, the country will ensure that it obtains quality components, the latest technology and it will also encourage the supplying companies to provide the technical services required for the expansion of micro-irrigation. The alternatives are:

- a) to buy the technology outright which has the disadvantage that it is out of date in a few years.
- b) to enter into joint venture but this is probably only feasible for some of the components of a micro-irrigation system.
- c) to enter into a contract for technology transfer. This is very difficult to define and probably not feasible other than in specific areas. In the case of a hotel or a factory, a management contract can be offered which guarantees the supply of the technology and expertise. This may be appropriate for the plastic factories but this does not ensure assistance with the installation, operation and maintenance of the system which extends to many locations and would only work if the organisation providing the technology were managing every farm which is obviously not feasible.

2.3 Trial at West Nubariya experimental station

The Plastic Development Centre operates an experimental station at West Nubariya for the purpose of demonstrating the use of plastics in agriculture to the farmers of the region. They have decided to allocate approximately 50% of the 20 feddan (8 hectares) experimental station to a comparison between micro-irrigation and furrow irrigation. In discussions between the PDC staff and the expert, it was agreed that this would include the following crops.

System		Micro- Irrigation Area	Furrow Irrigation Area
Citrus	Mini-sprinklers	1 feddan	1.7 feddan
Grapes	Drip emitters	1 feddan	1.7 feddan
Tomatoes	Drip emitters	0.75 feddan	1.3 feddan
Water melons	Drip emitters	0.75 feddan	1.3 feddan
		-----	-----
		3.5 feddan	6.0 feddan

Full details on this trial are provided in Appendix 3. The expert considers it important that this trial is installed as soon as possible. Once installed, it will give the PDC staff a much greater insight into what is involved in a micro-irrigation system and enable them to talk more knowledgeably about micro-irrigation to farmers and the plastics industry. The trial could not be installed during the visit of the expert because materials were not available in

Egypt because of problems with import licenses.

The expert obtained a quote from an Australian supplier for the material but this was considered high even though the company involved was prepared to make only a small profit on this sale. This always occurs with small trials because of the large numbers of submains, fittings, etc., and because some components such as filters could be used for a greatly increased area. In this case the filter could be used to irrigate at least four times the area and still only operate sixteen hours per day. In addition the small volume made the freight look very high but the aim was to bring all components from one source to avoid any compatibility problems.

The PDC staff have decided to wait until the materials are available in Egypt for other projects and then purchase locally.

3. Current status of the plastics industry in Egypt

The expert visited many of the major plastics factories during his visit and was surprised that such a wide range of products were being produced.

The industry has put considerable effort into the production of rigid PVC pipe and this is made to both British /American standards and to European DIN standards. There appears to have been considerable technology transfer provided by extruder manufacturers particularly Cincinnatti. The expert did not conduct any tests on burst pressure, internal diameter control or wall thickness, but the quality of the pipe appeared satisfactory. However there were several instances where the pipe was stored and/or handled inappropriately which could affect its field performance.

Many of the factories involved in extrusion of PVC pipe also indicated that they could produce polyethylene pipe including, in most cases, both high density and low density pipe. However, low density pipe may have been produced in small quantities, but the expert believes that there is little appreciation of the quantities that will be required if the industry is to service the irrigation market and hence the extrusion rates which will have to be obtained. The lack of international standards for low density polyethylene make it more difficult for the extruder manufacturers to set the factories in production. The expert believes that the PDC

will have to play a major role to ensure that any low density polyethylene which is produced is of an acceptable standard.

The industry is producing a large range of injection and blow molded products for the textile, medical, and food industries. The expert did not witness the production of any irrigation components. The majority of the products which are being produced are products where tolerances are not critical and where some flashing is not critical and can be removed later. This is not true for most irrigation components especially drip emitters, jets and mini-sprinklers. As discussed in section 2, it will be necessary to buy the technology for these molded products and then it will be outdated in the near future. The expert suggests that the development of micro-irrigation will develop most rapidly if importation of these products is allowed. However, in the future, if the major irrigation companies are involved in the manufacture of PVC pipe and low density polyethylene, they may also wish to get involved in the manufacture of some other components. This can often be on a selective basis where some components are imported and some are manufactured within the country.

The only plastics company which showed an interest in marketing irrigation systems rather than just manufacturing them was Al Sharif Plastics. The expert indicated to them that it was a bold venture to try to manufacture the majority of the components and then to also market the complete system because this involves many other disciplines than

manufacturing and includes design, installation, operation, etc.

The expert strongly recommends that the industry puts its initial effort into manufacturing good quality PVC pipe and low density polyethylene and that the government allows the import of drip emitters, jets, mini-sprinklers, polyethylene hose fittings, PVC fittings, filters and control equipment.

3.1 Manufacture of PVC Pipe

Micro-irrigation systems tend to require larger quantities of the smaller sizes of PVC pipe (2" and smaller) and relatively smaller quantities of the larger sizes (6" and larger). These systems also require a large range of fittings.

There are two standards which the industry could accept for PVC pipe, the European DIN standard or the American ASTM standard. In view of the proximity to Europe it would seem appropriate that the Egyptian plastics industry is encouraged to adopt the DIN standard. However, in view of the fact that some companies are already manufacturing pipe to American standards, pipe to these standards should be acceptable. All tenders should allow for pipe manufactured to either DIN or ASTM standards.

The PDC should regularly test PVC pipe and ensure that quality pipe is being produced. It is relatively easy for the PDC to test pipe and identify when the quality is not acceptable, but it will be much more difficult for them to order the regrind of such pipe unless they obtain a high degree of co-operation from industry. The expert believes that the PDC will be more effective in the long term if they endeavour to convince management of the importance of quality control and then assist them in the implementation of quality control in their factory. Many of the quality control tests should be done on-line and this then allows immediate correction and minimal regrind of pipe. The tests that the PDC then conducts in Alexandria should ensure that the quality control is being carried out satisfactorily.

PVC fittings are needed in a great range of types and sizes which means a lot of very expensive molds. Even in the USA, there are only four major PVC fittings manufacturers. It does not therefore seem appropriate to manufacture any PVC fittings and they should be imported from Europe or USA.

3.2 Manufacture of low density polyethylene hose

The discussion in section 2 pointed out the importance of producing high quality low density polyethylene hose. This is probably the most critical of all the components of a micro-irrigation system and represents in excess of 50% of the cost. The major problem is that this hose, if inferior, will not fail until it has been in the field for at least a year and probably two years. This then presents the manufacturer with a major problem of replacement or the farmer loses all confidence in micro-irrigation systems which then limits further conversion to micro-irrigation and possibly a reversion to furrow irrigation.

The following standard is suggested for low density polyethylene hose.

RESIN. The resin should be linear low density of broad molecular weight distribution. The melt index should be in the range 0.6 to 1.0 grams per 10 minutes and be determined using ASTM standard D1238 (Part 35). The density should be in the range 0.920 to 0.922 g/cc. The volatile content should not exceed 0.04%. The resin should be comparable to Union Carbide 7510 or Exxon LL2101.

CARBON BLACK. The product should have a minimum of 2.1% carbon black for ultra-violet stability. There should be one sample per day per extrusion line.

IGEPAL TEST. The product should survive this test for 1500 hours. For routine resins and extrusion techniques, five samples should be taken at the same time per extrusion line at a fixed date every month. The five sample give statistical reliability. Details on the test are given in Appendix 4.

PRODUCT DIMENSIONS. A sample should be removed from every coil and tested for internal diameter and wall thickness. The length of coil should be 300 metres or less. Details of appropriate product dimensions are as follows:

Nominal size	Internal Diameter	Wall Thickness	External diameter (reference)	Weight per 1000 feet	Quick Burst Pressure Minimum
mm	inch	inch	inch	lb	psi
13	0.506-0.518	0.035-0.042	0.590	27	57
16	0.624-0.636	0.042-0.049	0.720	40	45
20	0.804-0.816	0.058-0.064	0.932	80	60

Internal diameters should be determined with a 2 - stage steel gauge. One end of a steel rod is machined down to the minimum tolerance and the other to the maximum tolerance. The minimum end must insert into the hose easily and the maximum end should not insert freely.

The wall thickness should be measured at several points around the circumference.

QUICK BURST. A quick burst test should be carried out according to standard ASTM 1180 (Part 35).

4. Role of the Plastic Development Centre

The aim of the PDC to provide a link between the plastics industry and the application of plastic products in agriculture is an ambitious aim but in their early years they seem to have established a very good base.

The staff who have been employed seem very keen to learn and are people with a practical rather than theoretical approach to the problems which is ideal. They have put a lot of emphasis into the use of films for both canal lining and housing. The latter includes both protective cropping (greenhouses, tunnels, etc) and chicken houses. There has also been some work on the use of films for mulch. This reflects the specialisations of previous experts to PDC. They have also set up a very good quality control laboratory with a range of equipment which will carry out the majority of the tests required by the plastics industry.

There was considerable interest in the PDC by the plastics industry and several of the factories visited indicated that they were looking to the PDC to set the standards for the products they should produce for the irrigation industry. The expert believes they should set the standards for PVC pipe and low density polyethylene as soon as possible. They should then ask for samples of the products which are currently produced for testing. If these samples do not meet

these standards, then they should work with the factory concerned to assist in rectifying the problem. They should also set quality control standards and assist in the implementation of quality control checks. An organised quality control system was not evident in any of the factories visited although one factory did indicate that it was using an outside laboratory. Information on some suggested formats was given in section 3.2.

Appendix 1 Program of the expert, June 1983

The expert is normally resident in Sydney, Australia. The expert had business in California, USA before and after this mission.

Wednesday	1 June	Los Angeles/Frankfurt
Thursday	2 June	Frankfurt/Vienna
Friday	3 June	Briefing, UNIDO, Vienna and Vienna/Cairo
Saturday	4 June	Briefing, UNDP, Cairo
Sunday	5 June	Cairo/Alexandria Meeting with PDC Director and Head of Technical Affairs
Monday	6 June	Visit to West Nubariya Experimental Station
Tuesday	7 June	Discussions on micro-irrigation with PDC staff
Wednesday	8 June	Discussions with visitors from other UNIDO centres
Thursday	9 June	Meeting with Chairman of Egyptian Plas- tics and design of micro-irrigation trial
Friday	10 June	Off
Saturday	11 June	Meeting with Chairman, Behera Corpora- tion
Sunday	12 June	Visit to Al Shanti for Chemical Industry Company, Cairo
Monday	13 June	Training of PDC staff in micro- irrigation design
Tuesday	14 June	Visit to Behera Corporation developments in West Nubariya
Wednesday	15 June	Training of PDC staff in micro- irrigation (continued)
Thursday	16 June	Training of PDC staff in micro- irrigation (continued)
Friday	17 June	Off
Saturday	18 June	Off-public holiday
Sunday	19 June	Visit to Al Sharif Plastic Factory, Cairo
Monday	20 June	Training of PDC staff in micro- irrigation (continued)
Tuesday	21 June	Preparation of lecture
Wednesday	22 June	Visit to factory of Egyptian Plastics, Alexandria
Thursday	23 June	Visit to Meico Plastics and Medical Packing Company, Cairo
Friday	24 June	Off
Saturday	25 June	General discussions with PDC staff
Sunday	26 June	Visit to National Plastic Company, Cairo and GOFI
Monday	27 June	Lecture by expert on "Drip and Spray Irrigation"
Tuesday	28 June	Final discussion with PDC Director and Head Technical Affairs
Wednesday	29 June	Meeting with staff in offices of Al Sharif Plastics, Cairo
Thursday	30 June	Debriefing UNDP, Cairo and Cairo/Vienna The expert was advised just prior to leaving Cairo that

debriefing was not required in Vienna so the expert continued on to London and back to California.

Appendix 2

Lecture entitled "Drip and Spray Irrigation" given by Dr. Stephen D. English on 27 June 1983 in the PDC lecture theatre, Alexandria.

Attendees

Mr. Fathy Metwaley Ahmed	Behera Corporation
Eng. Thab M. Ashour	" "
Eng. Handy Abbas	" "
Ms Eng. Iglal Ibrahiem	" "
Chem. Abdalloh Keelany	
Mr. Sherief El Harawy	Chairman Rasheed Rice Co.
Dr. Yehia Zakaria El Shafey	Prof Irrigation, Falculty of Agric., Alem
	Lashein Plastics Co, Head Tech Dept.
Ms Eng. Nabila Lasheen	Head Plastics Research Medical Packaging Co.
Eng. Nasrat Ghobreal	Egyphian Plastics Co.
Chem. Magdy Youssef	El Sherief Plastics
Mr. Galal Abou El Eyoun	" "
Eng. M Shafeek Hassaneiu	" "
Eng. M Ahmed Tayel	" "
Mrs. Mona Hattata	UNDP, Cairo

TEXT OF LECTURE

To begin with, I will be talking about the various components of a drip irrigation system and/or a micro-irrigation system. I will be using those two words interchangeably. A micro-irrigation system includes drip irrigation and also systems with jets and mini-sprinklers. A jet throws water anything up to about 5 meters in diameter, and is generally 2-part and clips into the polyethylene lateral, and they are located above ground and vertical, so that they spray out horizontally. If we need to throw further, we use a mini-sprinkler with a moving part, and this will enable us to throw the water about 10 meters in diameter. This is usually attached to a stake in the ground with a lead-off to a lateral which because there is more water going through it, must be in a larger size. The length of the lateral is determined by the amount of water and the more water there is, the greater the pressure loss so the larger the size of the lateral.

Another sprinkler which has got slightly different applications is the rotating sprinkler which is good for nurseries. Then there is a very small impact type sprinkler, and that is really where micro-irrigation ends because with all of the above you have one or more emitters per tree, or per bush, or for a certain length of row. With sprinklers and sprinkler irrigation you attempt to cover the whole of the ground area without relation to an individual tree.

We cannot discuss irrigation or drip irrigation without considering agronomy. What is agronomy? Agronomy is the study of the effects of soil type, of climate, of water, of fertilizers, of crop variety, of plant population, and weeds on crop growth. In irrigation, we are looking primarily at water, but we will also be talking about the soil type, fertilizers, and plant population.

The inputs into any system for crop growth are radiation or sunshine, labor, fertilizers, energy, soil, and water. Egypt is not short of radiation and it is not a limiting factor. I have been told repeatedly that one of the reasons people want to adopt drip irrigation is to reduce the amount of labor, which is expensive. This is true and to go from a flood irrigation system to a drip irrigation system, there is a very marked saving of labor. However, a totally automated system, so it can be operated at the farm office is not necessary because even though labor may be increasing in price, it is still probably about one tenth of the cost that it is in Australia or the USA. Fertilizer must be added and obviously it is a benefit if we can reduce the amount of fertilizers to grow a particular crop. The energy to pump the water through the irrigation system is reduced because drip irrigation and micro-irrigation operate at low pressure. In America, they are becoming very, very conscious of the high cost of energy, generally electric energy for the pumps. Soil or land area, is a limiting factor in many parts of the world.

I think it is a fascinating challenge that the Plastics Development Centre has been given in trying to relate the resources of the plastic industry through to agriculture and tie the two together. You have got a plastics industry which is developing rapidly and you have huge resources of land out there in the desert and with new canals to provide the water and plenty of water in the Nile, I think there is an amazing challenge there to produce more food. The last factor is water which is probably one of the most limiting things in the world. There are lots of deserts that could be cultivated if they had water. Egypt has plenty of deserts but this includes large areas of desert where you can provide it with water. The aim of the reclamation from the desert is to try to use that water efficiently to produce more crops.

Water. There are two things to consider: how to apply it, and how much to apply. Firstly I will discuss how to apply it.

In discussing water requirement, we have to ask "Is the irrigation supplementary or essential?" Supplementary irrigation means the application of irrigation to an area which was already growing a crop. In many parts of the world crops like apples and grapes have been grown for many years without irrigation, and they grow by either a small amount of summer rainfall, or they grow slowly on the moisture which was stored in the soil profile during the winter season. In Egypt in all instances it is essential irrigation, which means if no irrigation was applied there would be no crop. That is true of a vast proportion of irrigation that is carried out in Australia, on the traditionally irrigated crops. Obviously, there are a lot of crops like wheat that can be grown in Australia without irrigation, and are grown without irrigation, but they tend to be very low input and low output crops.

It is also necessary to ask "What was the previous irrigation system?". If it is a conversion to a drip or micro-irrigation system which has been irrigated previously then this will have affected where the roots are, and hence it will affect the type of irrigation system which is needed. It will also affect the management of that system and to when you start applying water during the course of the year.

Crop type is an important factor in calculating the water requirements because different crops require vastly different amounts of water.

Rainfall patterns affect an irrigation system, because most people who are in irrigation do not like rainfall to fall during the irrigation season. If you are scheduling irrigation around a farm, and with flood irrigation it takes a week or ten days to go around the complete farm, and then it rains, it brings the whole farm back to the same state, watered up to saturation. Then, a few days later, you have to decide which fields are going to be watered first and which ones are going to be watered last. The ones which are

watered first will receive water too soon, and the ones watered last will receive it too late and it will affect the crop yield.

The main thing with supplementary irrigation, is to produce yield, not for survival of the crop. In other words, it is to increase the yield and to reduce the variability of the yield between years. You get a very good return on the money you spend, because you get a higher price for your crop because of the better quality, but you do not always have to apply a lot of water. You can apply the water just when it is required and not on a regular basis. You improve the quality of the crop, and very often, you get faster establishment of the crop. Young crops, if they are growing in a stress-free environment will tend to produce faster.

In considering husbandry, we include weeds, cultivations, fertilizer, and picking operations. One of the major advances of drip irrigation over all the other systems is that it reduces the number of weeds. With a flood irrigation system, you often have to go through and cultivate the ground quite regularly to allow an even waterflow down through the furrow during the season.

Fertilizers can be applied through a drip irrigation system just before the filter and they are transmitted all the way through the system to every plant.

Picking operations is one of the reasons why the Californian strawberry industry moved over to drip irrigation. Drip irrigation was the only method where they could irrigate and pick the fruit at the same time. You can have dry soil for the pickers to walk through and pick the crop and irrigate at the same time.

The irrigation efficiency is affected by the level of evaporation and also by wind. Wind, as you know, has a major influence on spray irrigation systems, and even more with big travelling irrigators, travelling guns, which throw a lot of water into the air. It has very little influence on a drip or a mini-sprinkler irrigation system. Another system that has overcome some of those problems is a centre pivot that is going around in a circle. If the wind remains constant it is better than a sprinkler system, because if it misses it on one part, it should get it on another.

With drip irrigation there is dry soil over the whole of the area, except for a small area around the drip emitter. A few weeds do not matter because they can grow around the dripper without any effect. Weeds can reduce the efficiency of a mini-sprinkler if they are allowed to grow too large, but trials have been conducted with putting herbicides through the micro-irrigation systems. As long as you are aware of what chemicals are in the herbicides it is usually possible to put them through the PVC and the polyethylene laterals without doing any damage to either the PVC or the laterals.

Irrigation efficiency is the amount of water which is pumped, which actually reaches the plant. In other words, with a drip irrigation system, if you are pumping 100 litres of water about 90-95 litres are going to reach the plant and be usefully used by that plant. With mini-sprinklers, it is probably down to 85%. This is because the soil surface is wet so there is a certain amount of evaporation from the soil surface. With impact sprinklers underneath the tree which are down near the soil surface the efficiency may be 80%. If you put them above the trees, which wets all the leaves of the trees, you are looking at 75%. With a traveling irrigator, with high pressure up to 150 psi, or 10 bars, and throwing water very large distances, the efficiency can be down to 60-65%. Flood irrigation or furrow irrigation is generally less than 50% and that depends on the soil type and on how much water you are losing in the conveyencing system through all the channels by seepage and how much is lost by evaporation from the open water surface in the channels.

If an irrigation system is 90% efficient it means we have to pump 1.1 litres per hour and the plant will receive one litre per hour. If it is 50% efficient, we have to pump 2 litres per hour for the plant to also receive 1 litre an hour.

However, we can relate this to the amount of energy that has to be used in relation to the depth of the water source. A flood irrigation system uses less energy because it is at a lower pressure if you only have to pump it to a few metres to get the water into or out of the channel. We have to pump 2 litres of water from a surface source, we have a small amount of energy required. A micro-irrigation system will require more energy because we have to pump it to two to three bars. However, if we started to pump that water from below ground, we have to add the pressure to pump it up to the soil surface. If we are pumping from 100 metres depth, we have to pump twice as much water, we have to pump 2 litres of water, and we have to pump it from 100 metres to get it to the soil surface, and then a small amount to give us the pressure for the system. With a micro-irrigation system, we are only pumping 1.1 litres of water from 100 metres plus the amount of energy to pressurize the system. Therefore when you are pumping from a depth greater than 30 metres, you are going to be using more energy in a flood irrigation system than you are in a micro-irrigation system.

From an agronomic viewpoint, one of the reasons why drip irrigation is so much more efficient than flood irrigation is because by irrigating daily or every two days, the soil can be maintained at, or very close to, field capacity and never decreases to close to the permanent wilting point where plant growth is severely affected.

Water quality is very, very important in any micro-irrigation system. We have two factors to consider: the salinity, and filtration. One of the advantages of drip irrigation is that you can use it with highly saline water.

In Abu Dhabi, they built a freeway from Abu Dhabi to Al Ain across the desert and it continually blocked with sand. They planted Eucalyptus trees for 125 metres on either side. They pumped the water from below ground, and it had a salinity of 17 500 mg/L which is about half the concentration of sea water. The reason that it was successful is because the rooting zone is kept continuously moist and the salts all migrate to the edge of the wetted zone. There is a build up of salt around the edge of the wetted zone but if it is a permanent tree crop, it is not going to matter, because you are always putting water in and pushing the salt out of the rooting zone.

Filtration is an expensive part of an irrigation system but it must be included. It is a very a bad mistake to try to save money on the filtration system because it will affect the efficiency throughout the life of the system.

Soil type is also important in choosing an irrigation system, because it affects the wetting patterns and infiltration rates. Infiltration rate is the rate at which the water moves into the soil. Now, with a drip irrigation or a mini-sprinkler system, it is usually not important, because you are applying water at a very low application rate, but if you are using big spinklers and applying a lot of water or using a flood irrigation system, this is a factor you have to consider.

In South Australia, there was a major problem with the citrus industry, which was irrigated from the River Murray. A total citrus industry was developed and the livelihood of a lot of people depend on it. They were irrigating all the citrus with overhead sprinklers above the trees. Over the last 10 years, the salinity of the River Murray has increased, and it increased to such an extent that if you sprayed the water on to the leaves of a citrus crop, you lost a lot of leaves and got no fruit. The industry asked "How is the irrigation industry going to solve our problem?" They could not irrigate by overhead sprinklers, and in this particular region drip irrigation was not a satisfactory solution, for several reasons: firstly a very sandy soil, so it meant you had to put a lot of drippers per tree and you had to have two laterals, one down either side of the tree, spaced about a metre from the tree, and this made cultivation difficult. Secondly the other, more determining factor was the fact that water was only available once every two weeks, because it comes from the River Murray in channels to each individual farm. They had to be able to apply enough water, in one or two days to last for two weeks. With drip irrigation, it was just not possible to apply enough water. So, the options were either to use mini-sprinklers or impact sprinklers beneath the tree. Even with low angle impact sprinklers it is still very difficult not to wet a lot of the foliage on citrus which has got a fairly low skirt to the ground. The mini-sprinkler has been a very satisfactory solution to the problem.

POLYETHYLENE

There have been many disasters in the field with polyethylene hose, because manufacturers have put the wrong levels of carbon black, which is the additive that prevents degradation by the ultra-violet radiation, or because the method of extrusion has put a lot of stresses into it and has formed stress cracking in the field in two or three years time. Polyethylene laterals cost about 50% of the cost of the system, and it is a very time consuming job to go through and replace it all. The best thing is to produce a quality tube in the first instance and to check that with adequate quality control during manufacture. And the experience of manufacturers over the last ten years has been such that, with adequate tests, people can predict what the field life is going to be. And if that tubing has been made well, it should have a life of 20 years in the field, or more. In Australia, the tubing that was made in about 1968, which was the very first drip irrigation tubing, is still out in the field 15 years later. We know that the polyethylene resins we use in the manufacture of this tubing today are far, far superior to the resins that we were using in 1968.

PVC PIPE

PVC pipe is the other major component as regards to the price of a system. The polyethylene and the PVC make up somewhere approaching 80% of the cost of a micro-irrigation system. PVC pipe is probably not as hard or as critical to make as polyethylene. It looks harder to manufacture, but in the things that can go wrong, it is not as hard as polyethylene. It is easier to detect any errors at the point of manufacture. I think the reason that the Plastics Development Centre has been started, to form a link between the Plastics industry and agriculture is to avoid the importation of the PVC pipe and the polyethylene hose which make up 80% of the cost of the system, and 90% of the freight costs. There is no reason why the Egyptian Plastics Industry cannot produce PVC pipe and polyethylene of a quality which is the same as that manufactured in the rest of the world.

INSTALLATION

I will now talk about how we go about an irrigation system from having a piece of bare land through to actually installing the system. If you wanted a drip irrigation system designed, someone would measure up the land, because a contour plan is required, or if a contour plan is not available, at least a scale drawing of the field with an indication of the levels. One of the advantages of a micro-irrigation system is that you do not have to have everything perfectly level. A drip irrigation system can be designed on a slope and you can have slight undulations in the ground, and the system will work just as satisfactory as if it were perfectly level. In many cases a lot of the land leveling costs can be saved. If there is a slope, in certain instances, you can take advantage of that slope, and reduce

the sizes of either the laterals or the submains and hence, save on the cost of the system. A common lateral length is 100 metres and in normal cases you can go 100 metres on both sides of your submains, which means you have several submains across the field. It is very easy to use a micro-irrigation system for a large block of hundreds or thousands of feddans. It is no harder to design a micro-irrigation system for 1000 feddans than it is to design a flood irrigation system for 1000 feddans.

WATER TREATMENT

The handout on water treatment talks in some considerable detail about all the different types and a copy is included in Appendix 6. If you have iron in the water, you can either remove the iron which you can do by aeration and settling, or by chlorine precipitation, or you can retain the iron in solution by chelation which is a chemical which chelates the iron which stops it from oxidizing and precipitating out, or in some cases you can do it by pH control because one of the reasons the iron oxidizes is because of the change in the pH level of the water when it comes above ground.

In micro-irrigation systems, it is often necessary to inject chemicals to kill bacteria, to kill algae, or in some of those cases you have to inject acid. If you are injecting chlorine, you can either inject this in the form of calcium hydrochlorite, or sodium hydrochlorite, or chlorine gas. The cheapest running cost is with chlorine gas, but you have got a lot of capital equipment, and it is fairly dangerous to inject, and in a lot of places it is hard to get chlorine in cylinders. Usually when people do it, they have chlorine cylinders and they put them in a fixed location, and have a special chlorine injector. In any micro-irrigation system, it is important that people consider the injection of chlorine and make provisions for it in the design, because sooner or later you are going to need to inject it, and you might have to do it at fairly short notice, if you suddenly get a build up of bacteria in the system.

END OF LECTURE

Appendix 3

DESIGN FOR DRIP IRRIGATION TRIAL AT WEST NUBARIYA EXPERIMENTAL STATION

A design is attached for the following areas:

Citrus 4200 square metres (1.0 feddan)
Grapes 4200 " " (1.0 feddan)
Vegetables
(eg Tomato) 3150 " " (0.75 feddan) Vegetables
(eg Water Melon) 3150 " " (0.75 feddan)

CITRUS

Row spacing: 5 metres
Tree spacing: 5 metres

Irrigation device: One Waterbird Mark 2 Mini-sprinkler (with white jet) per tree discharging 54 L/h at a nominal pressure of 1.5 bar. Pressure at start of submain should be set to 1.8 bar.

Water requirement of citrus block = 8800 L/h
Size of submains: 1-1/2" and 1" PVC
Size of laterals: 19 mm and 13 mm Polyethylene

GRAPES

Row spacing: 2 metres
Grape spacing: 1.5 metres

Irrigation device: One Key Clip drip emitter per grape-vine discharging 4 L/h at a nominal pressure of 1.0 bar. Pressure at start of submains should be set to 1.15 bar.

Water requirement of grapes block = 5320 L/h
Size of submains: 1-1/2" and 1" PVC
Size of laterals: 13 mm Polyethylene

VEGETABLES-TOMATOES

Row spacing: 1 metre

Irrigation device: One Key Clip drip emitter every 50 cm discharging 2 L/h at a nominal pressure of 1.0 bar. Pressure at start of submains should be set to 1.15 bar.

Water requirement of tomato block = 11400 L/h
Size of submains: 1-1/2" and 1" PVC
Size of laterals: 13 mm Polyethylene

VEGETABLES-WATERMELONS

Row spacing: 1.5 metres

Irrigation device: One Key Clip drip emitter every 50 cm discharging 2 L/h at a nominal pressure of 1.0 bar. Pressure at start of submain should be set to 1.15 bar.

Water requirement of Water melon block = 7600 L/h
Size of submains: 1-1/2" and 1" PVC
Size of submains: 13 mm Polyethylene

Note: This submain has been designed in such a way that the row spacing can be reduced to 1.0 metre if required.

TOTAL WATER REQUIREMENT

The total water requirement is as follows

Citrus	8800 L/h	
Grapes	5320 L/h	
Vegetables-Tomatoes		11400 L/h
Vegetables-Watermelons		7600 L/h

Total 33120 L/h

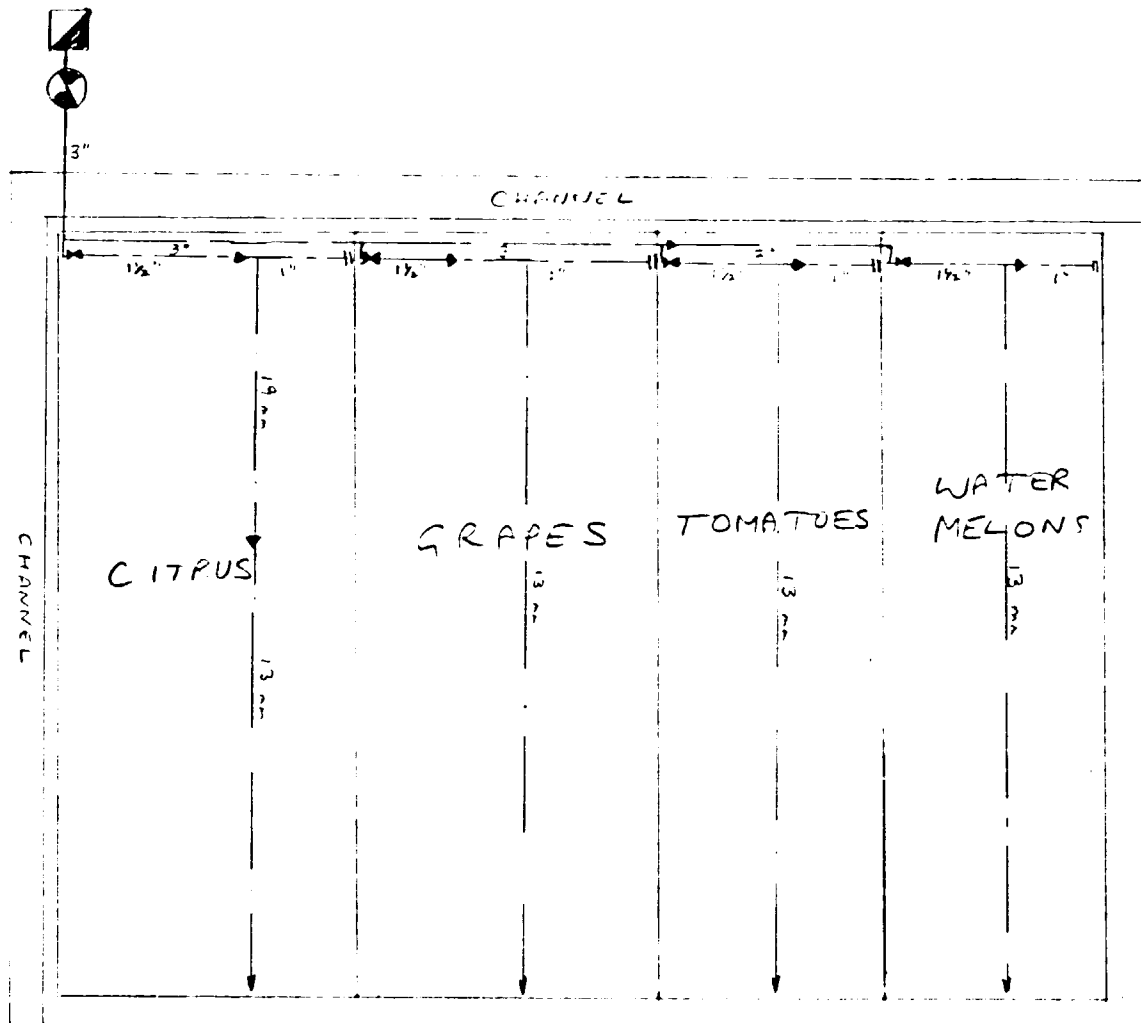
Pressure calculation:

Operating pressure(maximum)	1.80 bar
Mainline losses	0.15 bar
Filter losses	0.17 bar
Fertilizer injector ope	0.70 bar
Miscellaneous-bends,tees,etc	0.35 bar

Total 3.17 bar

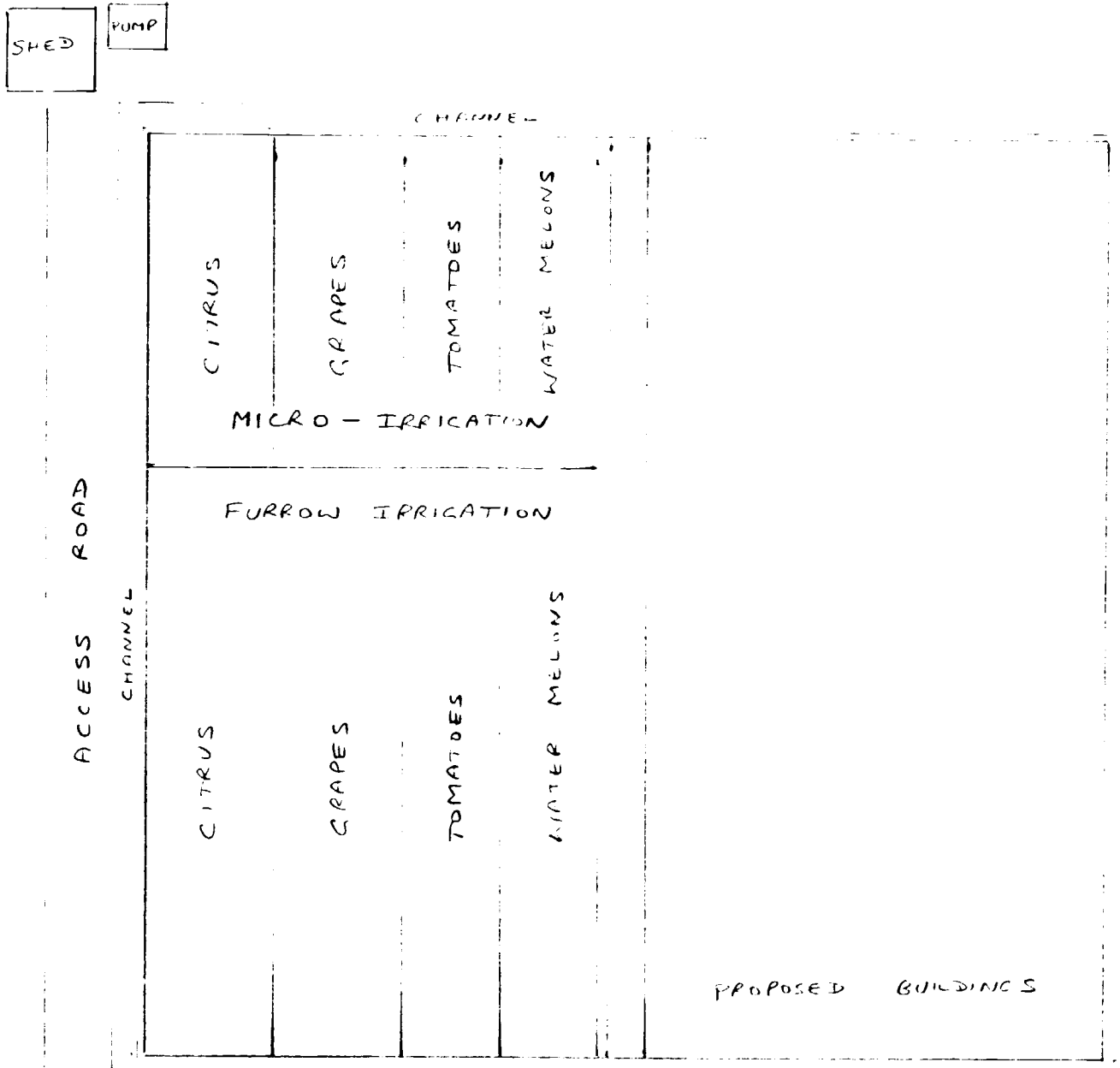
Pump specification: 36 cubic metres per hour at a pressure of 3.3 bar.

The pump has been specified so that all areas can be operated at the same time. This is so that sufficient water is available for adequate backflushing of the sand media filter. However, this means that there is still a large proportion of each day remaining which could be used to irrigate additional areas in the future.



SCALE: 1:1000

	CITRUS	GRAPES	TOMATOES	WATER MELONS
ROW SPACING :	5 m	2 m	1 m	1.5 m
EMITTER SPACING :	5 m	2 m	50 cm	50 cm



SCALE: 1:2000

MATERIAL REQUIREMENTS

One pump and motor as specified above complete with suction hose, foot valve and 2" or 3" BSP female threaded discharge.

Micro-irrigation equipment as specified below.

The following quotation for the micro-irrigation equipment was obtained from RIS Irrigation Systems in Australia.

RIS Irrigation Systems, P.O. Box 72, Elizabeth, SA, 5112 Australia. Telex 89256 Telephone (08) 252-0011

Quote in Australian dollars as of 16 June 1983

Total materials ex works Elizabeth	4730
FAS costs	60
Ocean freight 6.53 cubic metres	1882
Insurance	37
Total CIF (see note 3)	6709

Notes

1. Above is via FOS-SUR-MER in France
2. Above cost should not be used to calculate cost of a system for commercial application because items such as filters and fertilizer injectors are required regardless of system size and the items quoted are larger than required. Also, the freight cost is excessive because it is less than one container and no shipping line operates Australia to Alexandria direct for LCL freight. Freight on one FCL 20' container is 3360 Australian dollars for approximately 28 cubic metres.
3. The above quote is 'Free Out' with all stevedoring costs to discharge, inward wharfage, etc. to be paid by receiver.

MATERIAL LIST

PVC PIPE

6 m	PRPP10009	100 mm CLASS 9
90 m	PRPP8006	80 mm " 6
36 m	PRPP5006	50 mm " 6
84 m	PRPP4006	40 mm " 6
84 m	PRPP2509	25 mm " 9
18 m	PRPP2012	20 mm " 12

PVC FITTINGS

2	N00510080	100 x 80 mm Reducing Bush
2	N0088050	80 x 50 mm " "
1	N0085040	50 x 40 mm " "
5	N0084025	40 x 25 mm " "
2	N013100	100 mm Elbow 90 degree
8	N01380	80 mm " "
1	N01350	50 mm " "
18	N01340	40 mm " "
4	N01325	25 mm " "
10	N01320	20 mm " "
1	N01780	80 mm Valve Socket
1	N01750	50 mm " "
18	N01740	40 mm " "
6	N01725	25 mm " "
10	N0194020	40 x 20 mm Tee
4	N0192520	25 x 20 mm Tee
8	N0214025	40 x 25 mm Faucet Tee
4	IPT8040	80 x 40 mm Irrigation Tee

POLYETHYLENE HOSE

6900 m	EHD913	13 mm Polyethylene Hose
400 m	EHD919	19 mm
250 m	EHD905	5 mm

DRIP EMITTERS

10500	DCK02	2 L/h Key Clips
1400	DCK04	4 L/h " "
170	SWM411	White Waterbird 2

FITTINGS

40	FCC1300	13 mm Joiner
5	FCC1900	19 mm "
65	FGA1300	13 mm GT0
65	FGP08	Rubber Grommets
75	FJK13	13 mm End Stops
10	FAL1920	19 mm Poly Adaptors
170	IPS1504	5 mm Stakes

FILTER

2	ASP1150	Filter Tank
6	AFP0077	Sand
1	ASP0201	Discharge Manifold
1	ASP0202	Inlet Manifold
1	AMC1011008	Clearflo™ Blowdown 100 mm

CONTROL EQUIPMENT

8	VGB0400	40 mm Gate Valve
4	VBG0250	25 mm " "
4	IPA2009	Pressure Testing End Caps
6	GPV02	Schrader Valves
2	GPM420	Pressure Gauge
2	GPP03	Adaptors
200	FPG01	Goof Plugs
1	FMD2964	Drill
3	FMP10	Punch
2000	FMC12	Tie straps
6	JSC0500	500 mL Solvent Cement
6	JCF0500	500 mL Cleaner
5	JTT12	Teflon Tape
1	-	Mazzei Injector and hook-up kit

ENVIRONMENTAL STRESS CRACK RESISTANCE TEST

1. Introduction:

The Stress Crack Test Procedure is a test of environmental stress crack resistance (ESCR) of polyolefin irrigation tubing. This test, often referred to as the "Igepal Test", exposes the product to a surface-active agent which subjects the sample to stresses similar to those seen in the field. This test is not an all-inclusive determiner of the field longevity of a product.

A stress crack is "an internal or external rupture or crack caused by tensile stresses less than its shorttime mechanical strength." Stress cracks that appear on irrigation tubing will occur in areas that have been stressed from bending, folding or the insertion of fittings. These cracks generally run in a linear or machine direction on the product. The size of the failures vary from multiple fine cracks, called crazing, up to total failure of a section of the tubing due to one large rupture in the entire stressed area. For testing purposes, any stress crack that forms in the test solution is considered a failure of that particular specimen.

2. Sampling:

Samples (specimens) are removed from a section of completed production. Samples from experimental resins and processes, or resins with little or no previous history should be tested in a series of 5 or 10 individual pieces from one sample source (i.e., one finished reel). Statistical reliability is greatly improved by testing numerous pieces from the same source and comparing them for repeatable results. Routine tests of "known" resins can be made with less pieces per source as long as the sample can be identified back to the source for retesting in the event of a failure. The actual number of pieces tested is most often limited by the capacity of the test receptacles.

3. Test Period:

The amount of time that a sample spends in the test solution and the frequency of inspection of the sample are somewhat dependent on the sample source. Products from resins with little or no test history require more vigilance and inspections than routine tests. One important fact which should be kept in mind is that there is no known correlation between time to failure in Igepal and time to failure in the field. Experience has shown that any sample that fails the ESCR test in Igepal in less than 1500 hours is suspect of having eventual field problems. It appears that the shorter the time to failure in Igepal, the less likely that the particular resin and/or process conditions of the tested sample are suitable for use as an irrigation tubing. Samples that fail within the first 300 hours of testing have historically been totally unsuitable for field use. The speed in which a sample fails in the Igepal solution is

primarily useful for comparison purposes of different R&D resins and process conditions.

Samples from normal production (non R&D) should be left in the test bath for at least 2000 hours total elapsed time if no failure occurs earlier. A sample that develops any stress cracking (of any degree) should be pulled from the test bath. Other pieces from that particular series should be carefully inspected for similar failure, but testing should continue on them if they have not cracked. It is advisable that some production samples be left in the test solution indefinitely for long term studies. If the heater in the test bath is turned off, the elapsed test time period shall stop until the test temperature is re-established.

As with any test of a product, accurate record keeping is essential. Summaries of test results should be made on a regular basis and made available to management.

The following is a list of suggested inspection intervals for samples of known and unknown stress crack test performance. These time periods are suitable for hose type products.

NOTE: "Known" refers to a product, whose resin and process conditions have had considerable ESCR testing experience.

TABLE 1. TEST PERIOD TABLE

	Unknown Performance	Known Performance
Inspection Intervals	10 minutes	30 minutes
	20 "	60 "
	30 "	8 hours
	60 "	24 "
	3 hours	72 "
	8 hours	1 week (168 hours)
	24 hours	Check weekly to 2000+
	48 "	hours
	72 "	
	1 week (168 hours)	
	Then check weekly	
	to 2000+ hours.	

4. Test Solution and Temperature:

The stress crack test solution is prepared from a surface acting nonionic surfactant, Nonylphenoxy poly (ethyleneoxy) ethanol.

Chemical formula: C₉H₁₉C₆H₄(OC₂H₄)₉OH

This reagent is available from GAF Corporation under the tradename IGEPAL CO-630.

A solution of 10% by volume, Igepal CO-630 with water as the solvent is used for the Stress Crack Test. (ie, 9 parts water to 1 part Igepal)

The solution must be maintained at 170°F +-5° (77°C +-3°)

and an accurate thermometer is a necessity. The bath temperature should be checked daily. The solution should be stirred at least daily. Maintain the liquid level by adding only water as the Igepal itself will not evaporate out of the test bath. The entire solution should be changed about every 6 months under normal testing.

5. Test Apparatus:

The ESCR test requires a non-corroding constant temperature bath which is capable of maintaining the required $170^{\circ}\text{F} \pm 5^{\circ}$. The size of the test bath is dependent on the quantity of samples that must be tested at the same time. For most small operations, a 4000 mL Griffin type Pyrex glass beaker heated by a heating mantle (see Figure 1) sized to fit the beaker will work well. The heating mantle is controlled by a thermostatic controller (made for the particular mantle) or by a varistat (variable voltage transformer or a varistat (variable voltage transformer)). Some sort of a non-corrosive cover should be placed over the beaker to lessen liquid loss through evaporation. If a varistat is used for heat control, temperature adjustment should be made using a trial-and-error method with the cover installed.

Another possibility for a test bath would be to adapt an automatic roaster oven of the type sold for household use. Smaller pots can also be used. Units should have fully adjustable automatic thermostats, able to regulate at $170^{\circ}\text{F} \pm 5^{\circ}$. The interior of the pot should be stainless steel, ceramic, or heavily porcelainized enameled steel. Aluminum (interior) pots will corrode very quickly. It should be understood that this style pot was not intended for 24 hour a day operation and may not last as long as laboratory quality equipment.

An assortment of Figure 8 clamps and barbed couplings is required for stressing the samples (see test procedure for listing). Ensure that the barbed couplings will cause noticeable stress (bulging) at the barbs when installed in the tube to be tested. A laboratory quality mercury thermometer is needed for temperature measurement. A source of fresh water should be available near the test bath for washing the samples prior to inspection.

6. Safety:

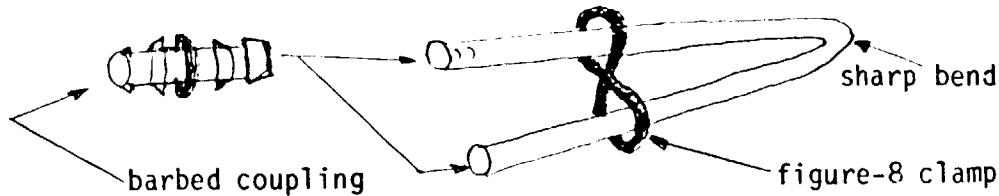
Igepal is basically a simple detergent and as such is not particularly dangerous. Care should be taken to avoid long term exposure to skin as it might cause skin rashes. Wash hands carefully following exposure to Igepal to prevent this.

7. Stress Crack Test Procedure

a) Cut a 12 inch (30 cm) long sample from the production to be tested. Ensure that the sample is permanently identified as to the sample source, date, resin, etc. Use cardboard tag, attached to the sample with copper wire or string, for this identification.

b) Samples removed from current production should be allowed to rest at room temperature for 24 hours to condition them.

c) Fold the sample in half and secure with a figure-8 clamp or use stainless steel wire.



d) Insert an appropriate sized barbed coupling (see below) into each end of the tube. The coupling should induce noticeable stress on the tube at the barbed areas.

e) Ensure that the Igepal solution test bath temperature is at 170°F \pm 5° (77°C \pm 3°) and that the liquid level is full.

f) Immerse the sample into the Igepal solution and ensure that both the fold and barbed ends are completely in the solution.

g) Allow the test period to elapse. See the Test Period Table for details.

h) Remove the sample from the test bath and rinse it in cold tap water to stop the Igepal's action on the part. Unfold the sample.

i) Drain and wipe the sample dry. Do not remove the barbed couplings.

j) Inspect the sample for cracks at all stress points of the barbed coupling and fold areas. Ensure that good lighting is available. Cracks need not extend completely through the sample to be considered a failure. Double check the sample using a magnifying glass of at least 10 power.

k) Record findings as applicable.

Extended Tests and Continuing Tests:

a) Re-install the end clamp or wire and re-fold the sample in exactly the same spot. The barbed couplings should still be inserted into the sample.

b) Re-immerses the sample into the Igepal test bath, still maintained at 170°F, for the next test interval.

c) Remove, wash and inspect the sample, as above, at the end of the time period.

d) The sample may undergo continued testing in this manner as required. Refer to the Test Period Table for details (section 1).

e) Ensure that the bath temperature, liquid level, and occasional stirring of the solution are maintained.

Appendix 5

HANDOUT ON WATER TREATMENT

WATER TREATMENT FOR MICRO-IRRIGATION SYSTEMS

1. INTRODUCTION

Micro-irrigation systems have a large number of emitting devices per unit area. This means that the orifices of these devices are small and therefore better quality water is required than for sprinkler or furrow irrigation systems.

Water from any source is usually of a lower quality than necessary for the successful long term operation of a micro-irrigation system. The most common method of water treatment is the physical removal of blocking or plugging agents using a filtration medium. However, in most cases, the injection of chemicals may also be necessary.

2. TYPES OF PROBLEMS

The various water quality problems encountered in operating micro-irrigation systems are outlined below. In some situations, two or more of these problems may be interrelated giving rise to more complex treatment procedures.

- (a) Presence of large particulate matter (organic or inorganic) in the water supply
- (b) Presence of high silt and colloidal clay loads in the water supply leading to excess colloidal sludge in the laterals.
- (c) Growth of algae within the water supply or the system.
- (d) Growth of bacterial slime within the mains, submains, laterals and/or emitters.
- (e) Bacterial precipitation of iron or sulphur.
- (f) Chemical precipitation of iron.
- (g) Chemical precipitation of salts in laterals and/or emitters.

3. ANALYSIS OF THE POTENTIAL PROBLEMS

The first step in treating any water problem is the analysis of a water sample. The procedure for taking a water sample is described in the Appendix of this section. The following tests should be requested from the water testing laboratory: pH, Calcium, Magnesium, Iron, Carbonate, Bicarbonate, Sulphide, Sulphate, Chloride, Total Dissolved Salts (TDS), the quantity and size of particulate matter and, for city water supplies, the free chlorine level. To test for iron take another collection vessel, add three drops of hydrochloric acid (muriatic acid from hardware stores) and then fill with water as described in the Appendix.

The water should also be tested for the presence of any oil in the water especially in areas close to oilfields. Oil will very rapidly block both sand media and screen filters.

4. PREVENTION

Preventative maintenance is an essential part of micro-irrigation system operation. Periodical chemical treatment prior to the development of a blockage allows the treated water to reach all parts of the system allowing complete cleansing. If treatment is delayed until a blockage has occurred, it is difficult to transmit the treatment chemical to the point of blockage because untreated water already in the system acts as a buffer between the chemical and the blockage.

It is recommended that drip irrigation systems be inspected at regular intervals. The use of drip emitters which can be taken apart is recommended as these allow the system to be efficiently monitored.

If there is a period of the year during which the micro-irrigation system is not operated, it is recommended that it be turned on at least at monthly intervals. This assists in preventing the drying out of any sediment which may block the lines when it flakes off, the build up of slimes and the invasion of ants and other insects into the system.

5. INJECTION OF CHEMICALS

5.1 ADDITION OF CHEMICALS TO WATER

Water sources vary in their chemical composition and their reaction to the addition of chemicals is not always predictable. A simple compatibility test should be carried out before any chemical, including fertilizer, is injected into the system. Take a clean bottle and fill with water from the water supply. Add a small amount of the chemical to be injected so that the concentration is slightly higher than that anticipated in the system and shake well. Allow to sit undisturbed for twenty-four hours and then examine for any sediments on the bottom or scum on the surface of the water. If any reaction occurs, injection of this chemical is not recommended. It is preferable that only one chemical is injected at any one time.

5.2 INJECTION OF CHLORINE

Chlorine is a strong oxidizing agent and in concentrated liquid or gaseous form can be hazardous if used without following the manufacturers instructions. Air relief valves should be included in any tanks holding solutions of chlorine to guard against a build up of pressure.

Chlorine is available in many forms which include gaseous chlorine, swimming pool chlorine (calcium hypochlorite) which is a solid form or household bleach (sodium hypochlorite) which is a liquid form. The percentage of active ingredients decreases from gaseous to liquid and hence a larger physical quantity of material must be injected. However, the capital costs of injection equipment also decreases from gaseous to liquid. In certain areas it may be difficult to get supplies of gaseous chlorine which is supplied in cylinders. If long term and regular chlorination is required a gaseous system is recommended, but for smaller systems or intermittent chlorination, the solid or liquid forms may be more appropriate.

Chlorination of a system may be either continuous or intermittent. Intermittent treatment has generally proved to be quite adequate and is cheaper than continuous treatment. However, it is more difficult to supervise if hired irrigation labor is employed. General recommendations for injection of chlorine are as follows:

(a) The injection point should be upstream of the filter. This prevents growth of bacteria or algae in the filter which reduces the filtration efficiency. It also permits the filtration of any precipitates caused by the injection of chlorine.

(b) Calculate the amount of chemical to inject. Details on this are given in the appendix but you will need to know the following information: Volume of water to be treated, active ingredient of chlorine chemical being used, and desired concentration in treated water.

(c) Injection should be started with the system operating and the injection pump should be running at about half of its maximum capacity. If using the solid form, calcium hypochlorite, a saturated solution is recommended which means that there is extra solid calcium hypochlorite on the bottom of the tank. For gaseous chlorine a special injector is required.

(d) Proceed to an emitter on the nearest lateral and determine the level of free chlorine using a swimming pool test kit. Allow sufficient time to achieve a steady reading.

(e) Adjust the injection rate. Repeat steps (d) and (e) until the desired concentration is obtained.

(f) Proceed to the end of the most distant lateral and determine the free chlorine concentration. If there is a decrease in the concentration, increase the injection rate to compensate for the chlorine absorption in the system.

(g) After the system is set up, it may be used as required (see later sections).

The following are guidelines for the concentrations which may be required.

Continuous treatment to prevent growth of algae or bacteria: 1 to 2 parts per million (ppm) (also equal to milligrams per litre)

Intermittent treatment to kill a build up of algae or bacteria: 10 to 20 ppm for 30 to 60 minutes.

These concentrations are sampled at the end of the furthest lateral.

Dissolving of organic material blocking emitters. Drain the system and then fill the system's pipelines and laterals with water at a chlorine concentration of 500 ppm. Stop the system and leave for up to 24 hours and then flush all submains and laterals. This high concentration of chlorine vigorously attacks organic material and clears the blockage.

5.3 INJECTION OF ACID

The injection of acid is generally done to lower the pH which can be a control mechanism for some water quality problems to be described later. Hydrochloric acid (muriatic acid) is the most suitable acid to inject to lower the pH of water, although sulphuric acid or sulphur dioxide can be used. All acids are hazardous if used incorrectly. Acid must always be added to water rather than water to acid.

The injection of acid is generally done on an intermittent basis and the following procedure will not affect the growth of most perennial plants. However, a thorough irrigation is recommended immediately after the treatment is complete. Many injection pumps are not resistant to acid and only pumps with acid resistant materials should be used.

The procedure to use is as follows:

- (a) Drain the system of as much water as practically possible.
- (b) Calculate the amount of acid to inject. Details on this are given in the appendix but you will need to know the following information: volume of water to be treated, concentration and type of acid being used, pH of water and desired pH during treatment.
- (c) Injection should be started as soon as the system pump is started and the injection pump should be running at about half its maximum capacity.
- (d) Proceed to an emitter on the nearest lateral and determine the pH using a pH test kit or pH indicator paper. Allow sufficient time to obtain a steady reading.
- (e) Adjust the injection rate. Repeat steps (d) and (e) until the desired concentration is obtained.
- (f) Proceed to the end of the most distant lateral and determine the pH.
- (g) After injecting acid for half to one hour, stop injecting and leave for up to 24 hours. Then flush all submains and laterals.

6. SOLVING THE PROBLEMS

6.1 PRESENCE OF LARGE PARTICULATE MATTER

Particulate matter in the water supply is generally removed physically by placing a filter in the mainline. Solids passing through the filter will be of a sufficiently small size to pass through the pipeline system and the emitters. There may be a graded accumulation of particles at the extremities of the system. These can be flushed out using the flushing points which should be designed into every system. Experience with a system will indicate the required time interval between flushings but it should be done at weekly intervals initially.

The most common types of filters used in micro-irrigation systems are listed below along with the approximate particle retention size.

Type	Mesh Screen opening (a)			Minimum particle retention size	
	inch	mm		inch	mm
Paper Cartridge	-	-	-	0.0004	0.010
Screen (b)	20	0.0280	0.711	-	--
	40	0.0165	0.420	-	--
	80	0.0071	0.180	-	--
	100	0.0060	0.152	-	--
	120	0.0049	0.125	-	--
	140	0.0041	0.105	-	--
	150	0.0041	0.105	-	--
	180	0.0035	0.089	-	--
	200	0.0030	0.076	-	--
Sand media (c)	-	-	-	0.0016	0.040
Sand separator (d)	-	-	-	0.0028	0.071

(a) Screen openings quoted are only approximate because for a given mesh size, the opening is dependent on the diameter of the threads in the mesh.

(b) Minimum particle sizes cannot be quoted for a two-dimensional screen filter because the particle retention is dependent on particle shape.

(c) Minimum particle retention size is dependent on type of sand media used.

(d) A sand separator will only remove high density particles down to this size.

Every micro-irrigation system should incorporate some form of screen filter as a minimum requirement. The aperture size of the screen opening should always be between one seventh and one tenth of the orifice size of the drip emitter, jet or mini-sprinkler. The filter should be easy to clean and increasingly filters are manufactured so that they can be easily automated. In addition to saving labor, the filter is less likely to become blocked and then extrude material through the screen under pressure which can then combine together again and block the emitter.

6.2 PRESENCE OF HIGH SILT AND COLLOIDAL CLAY LOADS

Silts in the water supply are easily removed with a sand media filter if they are larger than forty micrometres (0.0016 inch). However, high silt loads quickly block a filter resulting in inefficient operation and increased cleaning time at shorter intervals. It is usually preferable to construct a holding reservoir prior to the input to the irrigation system. The settling time required is determined by the particle size which in turn determines the size of this reservoir. Any system operated from an open channel supply requires at least a silt trap to settle the larger particles. Colloidal clay may be removed using a similar treatment procedure. These clay particles are of a sufficiently small size to pass completely through the system. However, they may precipitate out of the water in the lateral lines or drip emitters due to bacterial action, a change in pH or a change in temperature. The settling time for colloidal clays is longer than for silts because the particle size is smaller. The size of the holding reservoir required may be too large. If so, the settling time can be reduced by the addition of alum or soda ash to flocculate the material (The positively charged particles combine with the negatively charged clay particles to form larger particles which precipitate out more quickly). The quantity of chemical required is dependent on the amount and nature of the colloidal clays and the acceptable settling time.

6.3 GROWTH OF ALGAE WITHIN THE WATER SUPPLY OR THE SYSTEM

(a) In the water supply.

Algae may grow profusely in the water supply reservoir and become quite dense. This is more likely if the water has been receiving plant nutrients, and especially nitrogen, from the run-off water. In certain cases, this may cause difficulty with primary screening or filtration. The algae can usually be controlled in the reservoir by adding copper sulphate (bluestone) at the rate of 0.5 to 2.0 ppm. This remedy is effective and will not harm fish if carefully used. (It is more likely to kill fish if all the algae are killed at once and then the algae use up oxygen as they decompose and this can suffocate fish). The copper sulphate may be placed in bags equipped with floats and anchored at various points in the reservoir. Chelated copper products may be more effective particularly if there is a heavy silt load in the water but they are considerably more expensive. Copper sulphate should not be used in any system with aluminum pipe. In certain cases, it may be easier to use a self cleaning gravity screen filter or a self-cleaning floating suction type filter.

(b) In the system.

Green algae can only grow in the presence of light. They will not grow in buried PVC pipelines or in black polyethylene laterals or emitters. However, enough light may enter through white PVC pipes on the surface or through filter bodies or fittings to permit growth in isolated parts of the system. These algae will then die when deprived of light in other parts of the system and the dead material can cause blockage problems when washed into laterals or emitters. This material is usually readily noticeable during flushing of the submains or laterals.

The treatment to kill algae is the injection of chlorine into the system (chlorination). The system should be treated section by section and immediately flushed so that the large amount of dead algae material does not enter the emitters. The chlorine concentration should be 1 to 2 ppm continuously or 10 to 20 ppm for between 30 and 60 minutes. If significant blocking of emitters occurs, it may be necessary to inject the higher concentration of 500 ppm.

6.4 GROWTH OF BACTERIAL SLIME IN THE SYSTEM

Bacteria can grow within the system in the absence of light. They either produce a mass of slime or they cause iron or sulfur to precipitate out of the water. The slime may act as an adhesive to bind fine silt or colloid clay particles together to form a composite particle which is large enough to cause blockages. In certain cases the slime itself may block the drip emitter and will be seen protruding in a strand from the emitter outlet. This is often a difficult form of blockage to detect as the only evidence may be that slightly more blockages occur than usual or traces of gelatinous slime are expelled when flushing laterals.

The usual treatment is chlorination on a continuous basis to give a residual concentration of 1 to 2 ppm or 10 to 20 ppm for between 30 and 60 minutes. If blockage has occurred, it may be necessary to inject the higher concentration of 500 ppm.

6.5 BACTERIAL PRECIPITATION OF IRON OR SULPHUR

There are certain forms of bacteria which can produce precipitation of insoluble ferric oxide by oxidizing soluble ferrous oxide. Problems with iron bacteria have occurred with iron concentrations as low as 0.5 ppm. The iron precipitate forms as a red filamentous sludge which can attach to PVC and polyethylene tubing and may completely block the emitting device.

Bacteria can also produce an organic sulphur slime if there is hydrogen sulphide in the water. This produces a white gelatinous slime which may also completely block the emitting device.

The treatment for these bacteria is using chlorination either on a continuous basis at 1 to 2 ppm or intermittently at 10 to 20 ppm for 30 to 60 minutes.

If the source of bacteria is due to contamination of the well, a super chlorination of the well may greatly reduce the problem. This is done by injecting chlorine at 200 to 500 ppm. The volume of water can be estimated by knowing the depth and cross sectional area of the well.

Problems can also be experienced by interactions of iron and sulphur in the system. Stainless steel filter screens can cause precipitation of iron sulphide if used to filter water with a high concentration of sulphides. The presence of iron and sulphide may cause a reaction under certain conditions to produce the same effect. Under certain conditions, the injection of nutrients containing iron into high sulphide water will also cause precipitation.

6.6 CHEMICAL PRECIPITATION OF IRON

Iron can also be precipitated out of water by a change in the chemical environment when the water is pumped out of an aquifer. The iron in the aquifer water will generally be in the ferrous form as ferrous oxide. When the chemical environment changes, the ferrous oxide becomes less soluble at a higher pH or it may precipitate out as ferric oxide after oxidation.

This problem can be treated by removing the iron from the water or by retaining it in solution.

(a) Aeration and settling. This is the most reliable method of removing iron from irrigation water. It is generally necessary to re-pump from the settling pool after precipitation. However, there is no sophisticated equipment, no calculations to perform nor chemicals to purchase and inject.

The system operates by thoroughly aerating the water on entry to the settling pool either by allowing it to fall through and/or run over a series of baffles or by spraying the water through the air. Either method will allow the incorporation of large amounts of oxygen into the water which oxidizes the ferrous oxide to ferric oxide. The ferric oxide will precipitate out on the bottom providing sufficient time is allowed. The pump suction should be at the opposite side of the pool to the water entry point and should preferably be filtered with a floating suction. A surface baffle may also be necessary. The holding pool should be lined to prevent the pick-up of colloidal clay and loss by seepage. It may also be necessary to control algae.

(b) Chlorine precipitation. Free chlorine will instantly oxidize ferrous oxide to ferric oxide which will precipitate out. The iron concentration must be determined and chlorine must be injected at the rate of 1 ppm for each 1 ppm of iron. Some additional chlorine may be required to kill any iron bacteria and so prevent bacterial slime. The precipitated iron must be removed prior to entry to the system. There must be complete mixing of the chlorine which is best achieved by creating turbulence within the system. If not, iron will pass into the submain and lateral where it will precipitate. After complete mixing, the iron is removed by filtration. A sand media filter is the most appropriate filter; it should be readily backflushable and preferably automated.

(c) Chelation. This protects the iron from air oxidation and precipitation until it has passed through the micro-irrigation system. The chelation is done by injecting poly-phosphate material into the system at a concentration slightly higher than is required to chelate all the iron. This tends to be an expensive solution and professional advice should be sought before it is used.

(d) pH control. Iron is more soluble at lower (acidic) pH values. The pH may rise when water is pumped out of an aquifer and the iron will precipitate out. Acid may be injected to maintain the iron in solution.

This method can also be used to clear a system which has become blocked with iron related problems prior to implementing one of the above preventative measures. The pH is reduced to 4.0 or less for a period of 30 to 60 minutes. This resolubilises the iron and flushes it from the system. The injection should be started with the system as well drained as practical and a slightly higher pressure than normal should be used.

6.7 CHEMICAL PRECIPITATION OF SALTS IN EMITTERS AND LATERALS

Many other salts may precipitate out of water if they are at a high concentration and the conditions are suitable. The precipitation of calcium salts in emitters and laterals appear as a white film on the inner surfaces of the system.

This problem is easily corrected by the injection of acid at a rate such that the pH is lowered to less than 4.0 for between 30 and 60 minutes. However, it is most important that this is done before total blockage of the emitters occurs.

7. APPENDIX

7.1 HOW TO TAKE A WATER SAMPLE

It is most important that a representative sample is taken.

Sample source.

Well/bore. Run the pump for 30 minutes before taking the sample.

Faucet/tap on domestic water supply. Supply should run for several minutes before taking sample.

Reservoir/dam. Take the sample from the centre and from below the surface.

Sample container.

A glass container is preferable and it should hold at least 0.5 gallons US, 2 litres. The container should be thoroughly cleansed and rinsed before use to avoid contamination.

Number of samples.

The first sample should be used for all tests except iron and no additives are required. The second sample is used for the iron analysis and prior to adding the water three drops of hydrochloric acid should be added. This is available from hardware stores in the form of muriatic acid.

The samples should be sent immediately to a water testing laboratory.

7.2 HOW TO CALCULATE AMOUNT OF CHLORINE TO INJECT

LIQUID FORM - SODIUM HYPOCHLORITE

METRIC - Litres per second

$$\text{Injection rate (L/h)} = \frac{\text{Flow rate (L/s)} \times \text{Desired concentration (ppm)} \times 0.36}{\text{Active ingredient (\%)}}$$

Example:

$$\begin{aligned} \text{Injection rate} &= \frac{29 \text{ L/s} \times 15 \text{ ppm} \times 0.36}{12.5\%} \\ &= 12.5 \text{ L/h} \end{aligned}$$

METRIC - Cubic metres per hour

$$\text{Injection rate (L/h)} = \frac{\text{Flow rate (m}^3\text{/h)} \times \text{Desired concentration (ppm)} \times 0.1}{\text{Active ingredient (\%)}}$$

Example:

$$\begin{aligned} \text{Injection rate} &= \frac{105 \text{ m}^3\text{/h} \times 15 \text{ ppm} \times 0.1}{12.5\%} \\ &= 12.6 \text{ L/h} \end{aligned}$$

USA - Gallons per minute US

$$\text{Injection rate (gph US)} = \frac{\text{Flow rate (gpm US)} \times \text{Desired concentration (ppm)} \times 0.006}{\text{Active ingredient (\%)}}$$

Example:

$$\begin{aligned} \text{Injection rate} &= \frac{460 \text{ gpm US} \times 15 \text{ ppm} \times 0.006}{12.5\%} \\ &= 3.3 \text{ gph US} \end{aligned}$$

GASEOUS FORM

METRIC - Litres per second

$$\text{Injection rate (kg/day)} = \text{Flow rate (L/s)} \times \text{Desired concentration (ppm)} \times 0.0864$$

Example:

$$\begin{aligned} \text{Injection rate} &= 29 \text{ L/s} \times 15 \text{ ppm} \times 0.0864 \\ &= 37.6 \text{ kg/day} \end{aligned}$$

METRIC - Cubic metres per hour

$$\text{Injection rate (kg/day)} = \text{Flow rate (m}^3\text{/h)} \times \text{Desired concentration (ppm)} \times 0.024$$

Example:

$$\begin{aligned} \text{Injection rate} &= 105 \text{ m}^3\text{/h} \times 15 \text{ ppm} \times 0.024 \\ &= 37.8 \text{ kg/day} \end{aligned}$$

USA - Gallons per minute US

$$\text{Injection rate (lb/day)} = \text{Flow rate (gpm US)} \times \text{Desired concentration (ppm)} \times 0.012$$

Example:

$$\begin{aligned} \text{Injection rate} &= 460 \times 15 \times 0.012 \\ &= 82.8 \text{ lb/day} \end{aligned}$$

Note: For all the above examples, the amount of chlorine required will be higher than that calculated using the desired concentration at the end of the lateral. This is because of the "chlorine demand" of the water. This can only be obtained by trial.

7.3 HOW TO CALCULATE AMOUNT OF ACID TO INJECT

There is no simple way to calculate the amount of acid to add to reduce the pH of the water. A titration curve is necessary and this requires a laboratory with the appropriate equipment. In the field situation it is easiest to take a 55 gallon, 200 litre drum and fill it with water. Then add the acid you wish to inject to the drum and stir the water to ensure complete mixing. Then measure the pH of the water and repeat until the desired pH is obtained. The quantity of the acid required in a drum of this size may be quite small and, using sulphuric acid, as little as 0.7 fluid ounces or 20 mL may be required to reduce the pH from a pH of 7 to a pH of 4.

When the quantity required to correct the pH of the 55 gallon US, 200 litre drum has been calculated, it is a simple operation to calculate the amount of acid to inject into the system assuming the amount of water passing into the system is known. It is still advisable to measure the pH at the end of a lateral.

