MANUFACTURING AND ASSEMBLING MANUAL FOR AFFORDABLE MICRO IRRIGATION TECHNOLOGY (AMIT)

Prepared by

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INTRODUCTION

1.1 What is Micro Irrigation?

Micro irrigation is the slow and regular application of water directly to the root of plants through a network of economically designed plastic pipes and low-discharge emitters.

1.2 What is the Low-Cost Drip Irrigation Kit?

Drip irrigation is a type of micro irrigation. Micro irrigation is an emerging technology that has the potential to produce high-value crops, increase crop yield and reduce water use. Micro irrigation requires less time and money than traditional ways of cultivating and irrigating commercial crops. Micro irrigation also protects the environment through soil conservation and providing cleaner and safer water and fertilizer resources, while still increasing farmers' incomes.

However, a majority of smallholders in developing countries are deprived of this technology due to its high capital cost and lack of adaptability to small land holdings. Until recently, drip irrigation systems were too expensive for poor families and too large for tiny plots of land. International Development Enterprises (IDE), a not-for-profit development organization, has overcome this problem by developing a range of small and easy-to-use affordable micro irrigation kits that produce high-value crops.

IDE has been working on low-cost micro-irrigation technology in India and Nepal since 1995. These products are sold as ready-to-use kits, assembled and packaged so that they can be moved off-the-shelf, installed and used by farmers. The low-cost drip system is an example of Affordable Micro-Irrigation Technology (AMIT), consisting of a network of plastic pipes with emitters. The emitters deliver water directly to the root zone in quantities that approach the consumptive use of the plants.

Most of the components in a typical low-cost micro irrigation system are manufactured from polyvinyl chloride and various types of polyethylene and polypropylene. The manufacturing technology is based on a simple extrusion or injection molding process. Because of this, manufacturers of plastic pipes can easily adapt the technology to the needs of the farmers.

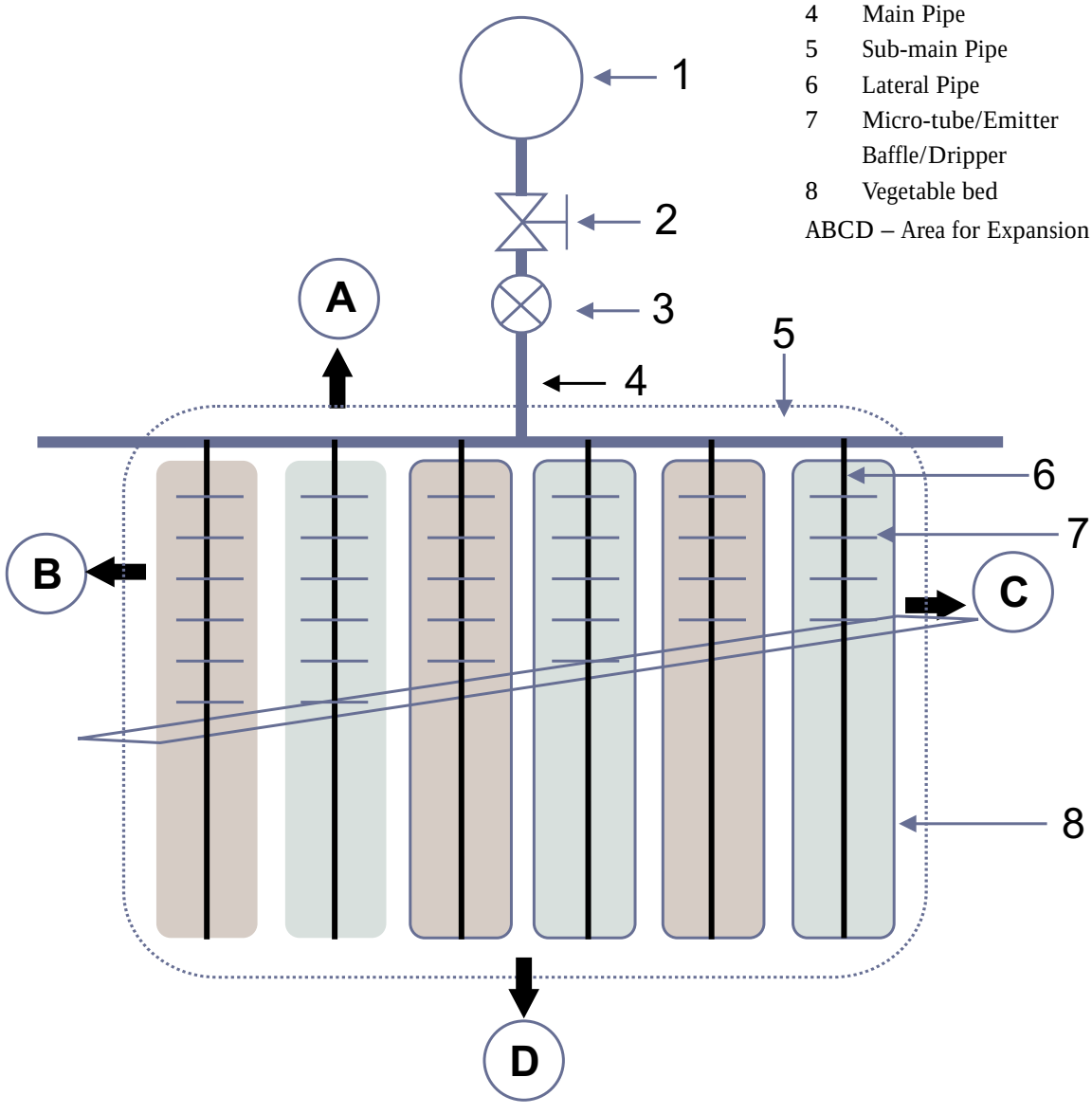
While working in India, Nepal, Vietnam and China, IDE observed that affordable micro-irrigation technology enables smallholders to cultivate high-value cash crops and increase their crop productivity using small amounts of water. The increase in crop production allows smallholder farmers to multiply their incomes two to three times of what it was when they practiced traditional crop irrigation methods.. Farmers also can increase the area under irrigation by using AMIT systems, thereby further increasing their agricultural production.

This manual seeks to provide basic information on manufacturing and assembling various components of AMIT. The potential entrepreneurs / manufacturers will able to use this manual to get information on different raw materials and equipment that can be used to manufacture components of AMIT. The manual will also provide information on how to assemble and package small drip irrigation kits so that they are available to smallholders directly off the shelf. The manual also can be used by professional and technical staff for training courses for implementing organizations, as well as for training potential Manufacturers and Assemblers.

COMPONENTS OF AMIT SYSTEM

No.	Notation
1	Water Source
2	Control Valve
3	Filter
4	Main Pipe
5	Sub-main Pipe
6	Lateral Pipe
7	Micro-tube/Emitter Baffle/Dripper
8	Vegetable bed

ABCD – Area for Expansion



1A typical AMIT System will contain each of the following components:

1. Water Source: The AMIT Kit is a low-pressure system that uses gravity to increase water pressure. The water source can be an overhead tank placed at a minimum of one meter above ground level for smaller systems up to 400 m^2 area. For larger systems, the height of the tank should be increased. If the height of the tank is not increased the system can be connected to a pump that lifts water from sources such as a well, farm pond, storage tank, or a stream / canal. A manually operated pressure pump also can be used to lift water from a shallow water table (up to 7 meters) and used for AMIT kits.

2. Control Valve: Valve made of plastic or metal to regulate required pressure and flow of water into the system. There are valves of various sizes depending on flow rate of water in the system.

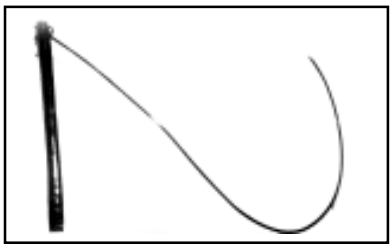
3. Filter: Strainer filter to ensure that clean water enters into the system. There are different types of filters viz. Screen, media and disc type filters. Different sizes of filters are available depending on flow rate of water in the system.

4. Mainline: Poly vinyl chloride (PVC) or Polyethylene (PE) pipe to convey water from source to the sub-main. Polyethylene pipe material is normally made from HDPE, LDPE and LLDPE. Size of pipe depends on flow rate of water in the system.

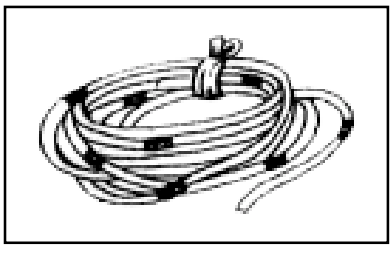
5. Sub-main: PVC / HDPE / LDPE / LLDPE pipe to supply water to the lateral pipes. Lateral pipes are connected to the sub-main pipe at regular intervals. Size of pipe depends on flow rate of water in the system.

6. Lateral: LLDPE / LDPE Pipes placed along the rows of the crop on which emitters are connected directly or through spaghetti to provide water to the emitters. The lateral pipe size is from 12 mm to 16 mm in most of the drip systems.

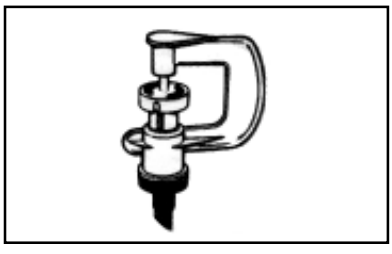
7. Emitters: Device through which water is emitted at the root zone of the plant with required discharge. Different types of emitters used in AMIT Kits are described below:



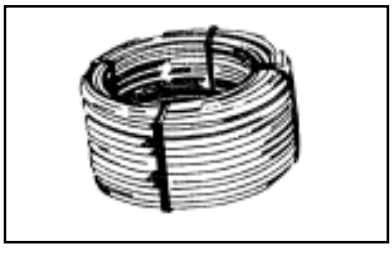
i) Micro-tube: Straight or curled LLDPE tube with an inner diameter ranging from 1 to 1.2 mm. The discharge from the micro-tube is directly proportional to the operating pressure and inversely proportional to its length. The operating pressure that is required can be as low as 1m to 5 m.



ii) Baffle : The hole on the lateral pipe is 0.75 mm in diameter. This hole is covered with a plastic device called baffle so that water is discharged using a desired flow at a given pressure. Operating pressure required is as low as 1m to 5 m.



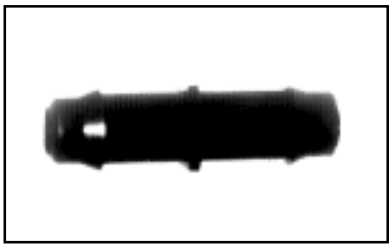
ii) Micro-Sprinkler : The sprinkler is able to spray water with coverage of 3 to 4 m in radius. It has a small rotating device to cover larger areas. Operating pressure required is from 5m to 15 m.



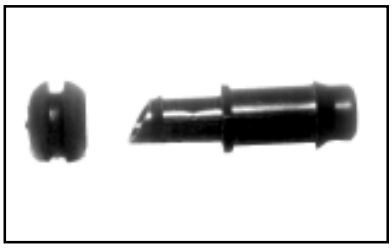
iv) Drip Tape / Easy Drip: It has inbuilt drippers / outlets on the lateral line which give a continuous wetting strip. It is mainly used for row crops. Operating pressure required is from 1m to 5m.

8. Fittings: Various fittings required in AMIT System are described below.

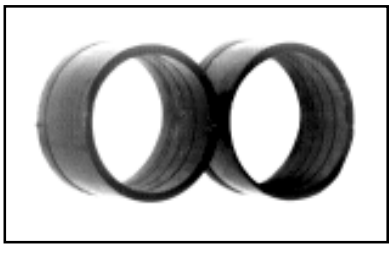
i) Tee Connector: Tee Connectors of various sizes are required in AMIT system to connect a branch to the Main pipe, Main pipe to Sub-main pipes, Lateral Pipes to Sub-main pipes etc. The Tee Connectors can be Equal Tee or Reducing type Tee viz. 12mm x 12mm, 16mm x 12mm, 16mm x 16mm, 25mm x 12mm, 32mm x 12 mm etc.



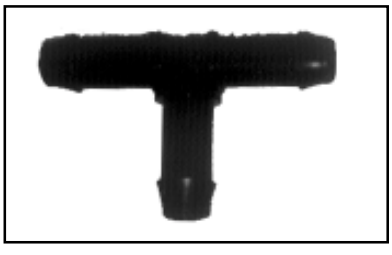
ii) Straight Connector: Also called as Joiner. It is required to connect pipes. It can be Equal Joiner or Reducing Joiner viz. 12mm x 12mm, 12mm x 16mm, 25mm x 32mm, 32mm x 40 mm, 40mm x 50mm etc.



iii) Take-Off: It is used to connect lateral pipes to the sub-main pipe in larger systems. It is fixed in the wall of sub-main pipe with the help of a rubber washer called as Gromate. It is available for different sizes of lateral pipes viz., 12mm, 16mm.

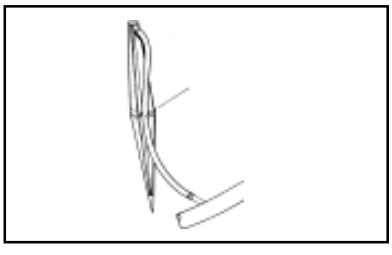


iv) Lateral End Stop: The lateral pipes are closed at the other end with the help of plastic ring in the shape of figure of '8', or barbed End Cap. It is available for different sizes of pipes viz. 12mm, 16mm etc.



v) Micro-Tee: It is used to connect Micro-tube to the lateral pipe. Simply inserting it into the lateral pipe and tying a knot around the lateral pipe can also connect the Micro-tube. Micro-tee makes it simple and easy for assembling purpose as well as to dissemble the system and pack it after harvest.

vi) Pegs: Small plastic pegs are used to place the micro-tube and lateral pipe in place. The pegs for micro-tube are mostly used in Micro-tube drip kit while pegs for laterals are used in baffle drip kits for shifting of laterals.



vii) Stakes: Micro-Sprinklers are mounted on 12" or 18" long plastic / metal stakes and micro-sprinkler are connected to lateral pipes through extension / spaghetti tube of 6 mm diameter.

RAW MATERIAL FOR AMIT COMPONENTS

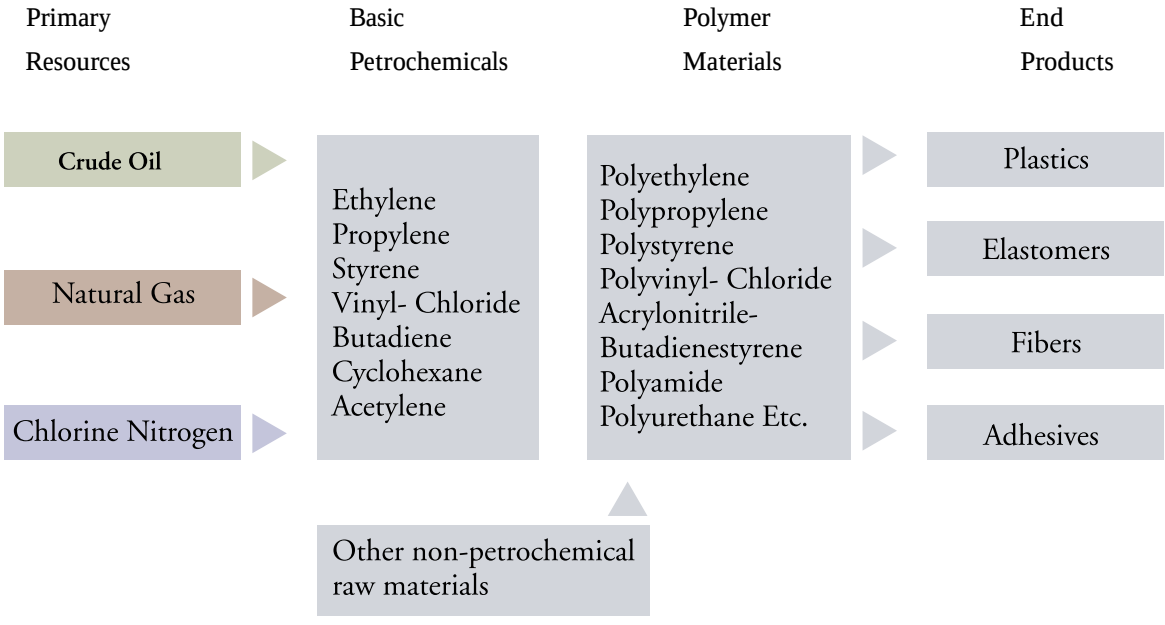
Most of the components for AMIT System are made from plastic materials such as polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC) etc. The following table provides material specifications for different AMIT components and specifications.

Sr. No.	Component	Dimensions / Shape	Raw Material
1	Water Storage Tank / Bag	50 liters to 1000 liters	Low Density Polyethylene (LDPE)
2	Take-off 16 mm	13 mm O.D.	Polypropylene (PP)
3	Valve 16 mm	13 mm O.D.	Polypropylene (PP)
4	Lateral 16 mm	13 mm I.D. 16 mm O.D.	Linear low density polyethylene (LLDPE)
5	Lateral 12 mm	10 mm I.D. 12 mm O.D.	Linear low density polyethylene (LLDPE)
6	Microtube 1.2 mm	1.2 mm I.D. 3 mm O.D.	Linear low density polyethylene (LLDPE)
7	End Cap 12 mm	Figure of 8' 13 mm I.D.	Polypropylene (PP)
8	Reducer 16 x 12		Polypropylene (PP)
9	Tee 12 mm	10 mm O.D.	Polypropylene (PP)
10	Joiner 12 mm	10 mm O.D.	Polypropylene (PP)
11	Elbow 12 mm	13 mm O.D.	Polypropylene (PP)
12	Stake		Polypropylene (PP)
13	Filter Cloth	3 ft x 3 ft	Cotton / polyester / mixed
14	Packaging Material	Plastic Sac / Paper Carton	High Density Polyethylene or Low Density Polyethylene / paper

INTRODUCTION TO PLASTIC MATERIALS

4.1 Source of Plastic Materials:

The plastic used for the irrigation systems is made from polymers, material derivedfrom basic petrochemicals. The following chart presents the different plastic polymers and the end products.



4.2 Thermosetting and Thermoplastic Behavior:

The plastic components of AMIT system are made from Thermoplastic materials. Once Thermosetting plastics are set into a particular shape they cannot be returned to their original condition. Thermoplastics will soften upon heating, thus allowing them to be reworked by extrusion or molding. Thermosetting plastics are used in products where chance of severe stress or loading is remote but resistance to heating is required e.g. electrical fittings. Thermoplastics find their most common uses in low temperature conditions.

4.3 Thermoplastic Materials used in AMIT System:

1. Linear Low Density Polyethylene (LLDPE):LLDPE is available in granules, which can be extruded into small diameter flexible pipes or rolls of sheets with varying width and thickness. It has excellent electric insulating properties and resistance to moisture. It has very good resistance to ultraviolet rays i.e.

Environmental Stress Crack Resistance property (ESCR). It can be softened at around 85 degree centigrade temperature. For AMIT it is mainly used as raw material for water pipes.

2. Low Density Polyethylene (LDPE): LDPE is available in granules, which can be molded and extruded. It has excellent electric insulating properties and resistance to moisture. It can be softened at around 85 degree centigrade temperature. It has good ESCR property. It is used as raw material for water pipes, wire insulation, water tanks, bottles, packaging material etc.

3. High Density Polyethylene (HDPE): HDPE is harder and more durable type of polyethylene. It has higher resistance to some of the chemicals that attack low-density polyethylene. The softening temperature for HDPE is around 120 degree centigrade. It has good ESCR property. It is used as raw material for water pipes, crates, dustbins, water tanks etc.

4. Polypropylene (PP): It is similar to polythene in many respects but has a stronger fatigue resistance and it is also harder and more rigid than polythene. It has excellent electrical and chemical resistance and can remain rigid up to 140 degree centigrade. It is used as raw material for manufacturing ropes, fans, battery boxes, cable insulation, refrigerator parts etc.

5. Polyvinyl Chloride (PVC): It is the most commonly used thermoplastics. It is resistant to most chemicals and solvents. It will not soften below 90 degree centigrade. It gives rigid products but can be made soft and flexible by compounding with other materials. It can be produced in many attractive colures. It has less ultraviolet resistant as compared to polyethylene. It is used as raw material for water pipes, cable insulation, plastic rigid and foam sheets, doors, windows, toys etc.

4.4 Thermosetting Plastics and their Uses:

Sr. No.	Plastic Material	Uses
1	Polyurethane	Paint base, gears, bearings, handles, adhesives, foam etc.
2	Polyester	Boat hulls, wheelbarrows, surface coatings, radio grilles, archery bows etc.
3	Epoxy Resins	Adhesives, surface coatings, drop hammer, dies etc.
4	Bakelite	Electrical equipment, vacuum cleaners, ignition system, instrument panels etc.
5 etc.	Urea-Formaldehyde	Kitchen equipment, radio cabinets, buttons, buckles, bottle tops, cloak cases
6	Melamine-Formaldehyde	Furniture, laminates, light-fixtures, trays, handles, ignition blocks etc.
7	Alkyd Resins	Electrical equipments, motor insulation, Enamels, TV parts etc.

4.5 Thermoplastic Materials and their Uses:

Sr. No.	Plastic Material	Uses
1	Polyethylene (PE)	Water pipes, water tanks, baby baths, dust bins, electrical insulation, fixtures, kitchen equipment, films, sheets, packaging etc.
2	Polypropylene (PP)	Pipes, fittings, refrigerator parts, battery boxes, automobile parts etc.
3	Polyvinyl chloride (PVC)	Pipes, electric cables, protective clothing, sheets, ducting, packaging, profiles, doors, windows, toys etc.
4	Polystyrene	Food containers, kitchen equipment, toys, insulation, packaging etc.
5	Acryl-butadiene- styrene (ABS)	Tool handles, automobile body work, radio cabinets, pumps etc.
6	Cellulose nitrates and acetates	Fountain pens, combs, photographic film, cable covering, instrument dials, tool handles etc.
7	Polytetra-fluoro-ethylene (PTFE)	Non stick coatings, bearings, gaskets, laboratory equipment, piston rings etc.
8	Nylon	Gears, bearings, climbing ropes, shock absorbers etc.
9	Perspex (Acrylic)	Window panes, tail lamps, goggles, protective shields, building panels, telephones, advertising panels etc.
10	Polycarbonate	Window panes, protective shields, green houses, building panels etc.

4.6 Basic Properties of Plastic Polymers:

Plastic Polymer	Density (Gm/cc)	Specific Volume (cc/gm)	Melting Point (centigrade)	Compatibility with Extrusion & Molding
LLDPE	0.910 – 0.925	1.10 – 1.08	110 – 141	Yes
LDPE	0.910 – 0.925	1.10 – 1.08	110 – 141	Yes
HDPE	0.941 – 0.970	1.06 – 1.03	110 – 141	Yes
PP	1.4	0.714	172 –176	Yes
PVC	1.4	0.714	200	Yes

BASIC MANUFACTURING PROCESS FOR AMIT

Most of the components of AMIT are manufactured through an extrusion and injection molding process. These processes and different types of machines involved in the processes are described below.

5.1 Extrusion:

Extrusion is the process by which thermoplastics are shaped into pipes. The extrusion plant consists of the following basic machinery as shown in the adjoining pictures:

5.1

1. Mixer for Master batch: It is used to mix the master batch with the raw material. The mixer consists of a cylinder with a rotor (as shown in picture 5.1. It allows raw material to be mixed uniformly. It is driven by motor. Small manufacturers can also mix the master batch manually or purchase ready mixed bags from the suppliers.
2. Feeder / hopper: The material is fed to the extruder through the hopper as shown in picture 5.2. The material can be poured into the hopper manually or with the help of a pump.
3. Screw barrel: It is the main part of the extruder and its size and length to diameter ratio (L/D Ratio) has a bearing on type of material to be extruded. As the diameter of the screw increases, the extrusion rate increases. As the extrusion rate affects the size of the pipes that have to be extruded from the machine.

5.2

4. Control Panels: Control panels are required to maintain the temperature, speed of the motors for haul off, screw barrel, and voltage etc. As shown in picture 5.2.

5.3

5. Dye & Sizer Unit: It determines the shape and size of the pipe interms of diameter and wall thickness. It can be vacuum based or operated by using by using the blower. The dissembled dye and sizer is shown in picture 5.3.

6. Cooling chamber: After the pipe comes out from the sizer unit, it needs to be cooled properly so that it sets into desired shape and size. The cooling chamber is shown in picture 5.4.

5.4

7. Haul-off: The Haul-off pulls the pipe from the sizer and maintains the size and shape of the pipe. The speed of haul off is very crucial and has to be maintained in order to get uniform size and thickness of the pipe. The haul-off is shown in picture 5.4 after the cooling chamber.

8. Winder: It winds the pipe into rolls of desired lengths. It can be manual or automatic. A calibrated counter can be fixed with the haul off to measure the exact length of the pipe extruded. The winder is shown in picture 5.4 after the haul off.

9. Motor drives: Motor drives are required to run the screw, haul off and sizer unit.

5.5

10 Mini Extrude for Color Line: A mini-extruder is used to put a colored line on the pipe and can be installed perpendicular to the dye & sizer-unit. The mini extruder is shown in picture 5.5.

5.2 Injection Molding:

The injection molding process was developed and first used for making articles of cellulose acetate in 1921. Today it is one of the most important process of plastic manipulation in terms of variety of products made and amount of materials being handled. Practically every known plastic material and rubber can be processed in suitable injection molding machine to make items using single cavity mold for large items and multi cavity mold for smaller items. There are various types of injection molding machines and the mold design would be different as per the type, size and capacity of the machine. Capacity of the machine is measured by hydraulic pressure of the machine. Some of the injection molding machines is described below:

1. Vertical Hand Molding Machine: It is the simplest form of an injection-molding machine. It has an electrical heater to melt the plastic material and a plunger to push the material into the cavity of the mold. The plunger is connected to the lever, which is operated by hand. This machine has smaller capacity in terms of size & weight of the article to be produced and production rate. The mold is in two parts and has to be opened manually after the product has been set into it. AMIT components viz. lateral tees, joiners, reducers, end stops, take offs etc. can be manufactured with the help of this machine.

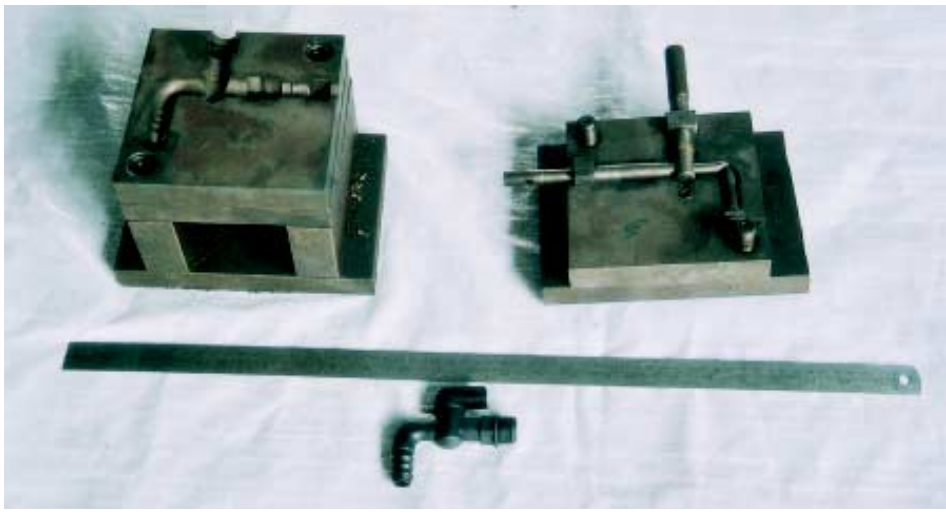
2. Vertical Semi-Automatic Machine: This machine is similar to the Hand Molding machine but has a larger capacity. It is shown in picture 5.6. It is operated using electric power. The plunger operates with the hydraulic pressure by pressing the switch. It is faster than hand molding machine and can produce bigger articles than hand molding machine in terms of weight and size. The mold is in two parts and has opened manually after the product has been set into it. AMIT components viz. tap, lateral tees, joiners, small filter, end stop, reducers etc. can be manufactured with the help of this machine.

3. Horizontal Semi-Automatic Machine: This machine is bigger than the Vertical molding machines and has a larger capacity. It is also operated using electric power. Raw material is melted in a separate chamber and then pumped into the cavities of mold. The plunger operates with the hydraulic pressure by pressing the switch. The mold is in two parts and is locked with the pressure. It opens automatically after the product has been set in the mold. It is faster and can produce bigger articles than the Vertical Molding machine in terms of weight and size. AMIT components viz. big filters, valves, tees, joiners, end stop, reducers etc. can be manufactured with the help of this machine.

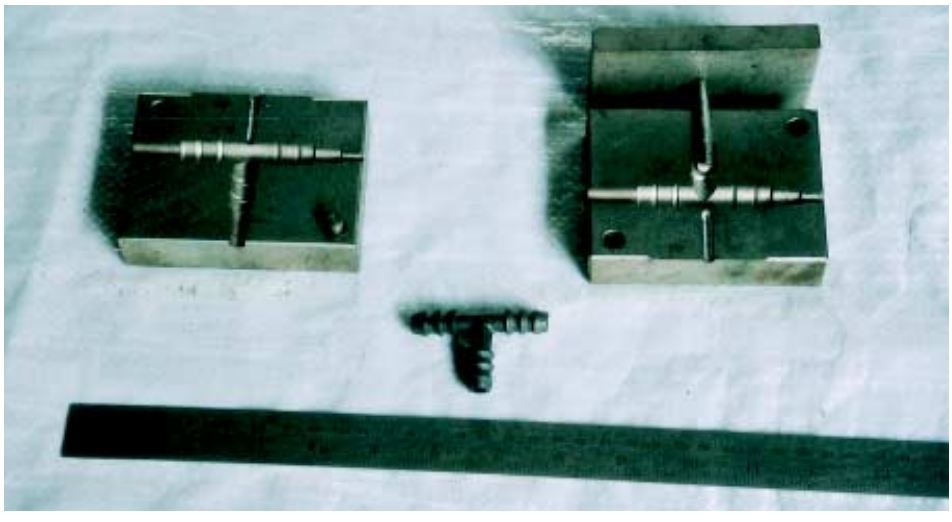
4. Horizontal Fully-Automatic Machine: This machine is bigger than the Vertical Molding machines and has larger capacity. It is operated using electric power and can be programmed to operate automatically. Raw material is melted in a separate chamber and then pumped into the cavities of mold. The plunger operates with the hydraulic pressure automatically as per the program. The mold is in two parts locked with the pressure. It opens automatically after the product has been set in the mold. It is faster than vertical molding machines and can produce bigger articles than vertical molding machine in terms of weight and size. AMIT components viz. big filters, valves, tees, joiners, end stop, reducers etc. can be manufactured with the help of this machine.

5. Moulds: Each separable plastic part of AMIT component is manufactured through separate mould, e.g. The 16mm filter for 100 sq.m drip kit has three parts viz. 1. The top lid with barbed connections for 16mm pipe. 2. The bottom housing for the screen. 3. Plastic strainer base for wire mesh. Each part is produced through separate mould. For bigger parts viz. filter the mould is normally single cavity. For smaller parts like end cap, micro-tee, mould can be designed as multi-cavity. Following pictures show different moulds for production of different components and parts.

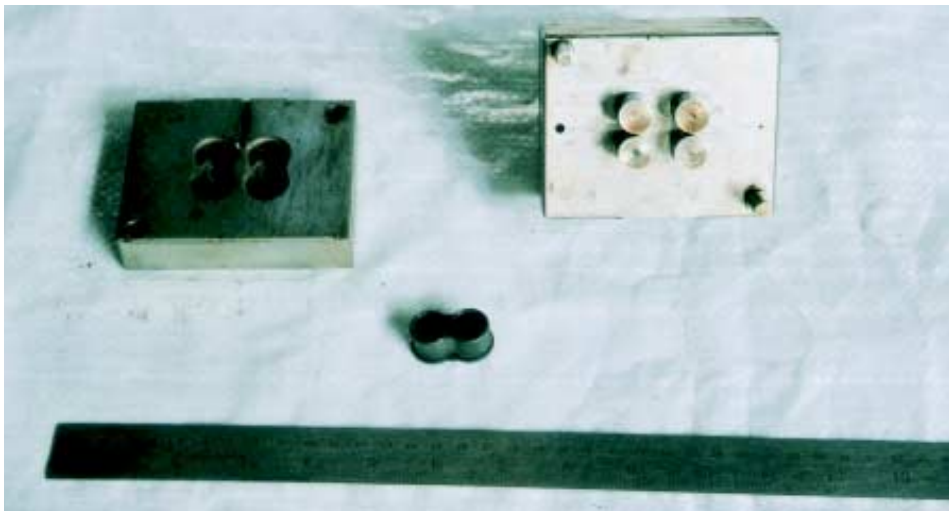
1. Single cavity mould of Plastic Valve:



2. Single cavity mould of 16mm Equal Tee:



3. Double-Cavity Mould of 16mm End Cap:



QUALITY ASSURANCE FOR MANUFACTURER

6.1 Quality Assurance System for Manufacturers:

The quality of the product is a critical and basic function determining customer satisfaction. For AMIT Kits, it is important to set the quality parameters because at the farmer level it becomes difficult to differentiate between a good product and bad product. If the product fails, then there is the possibility that the technology will get rejected – causing a setback. The quality of the AMIT components mainly depend on manufacturing process and it should be ascertained at following levels.

i) Quality of the raw material.

ii) Manufacturing Process

iii) Quality of the raw material

Most of the components of AMIT kits are manufactured through extrusion and injection molding processes using different plastic raw materials, which vary greatly in characteristics and properties. It is important for the manufacturers to test the samples and ensure quality. The table below describes some of the tests that can be performed to check the quality of raw materials and products. If small manufacturers do not have access to a nearby laboratory, it may be necessary for that manufacturer to send samples to outside laboratories for testing.

Test	Test Sample	Equipment
Specific gravity	Raw material for PVC / polyethylene	Specific gravity apparatus
Melt flow index (MFI)	Raw material for PVC / polyethylene	MFI tester
Dimensions of finished product (diameter, wall thickness etc.)	Pipe samples, fitting samples	Measuring tape, digital vernier, digital micrometer
Reversion test	Pipe samples, fitting samples	Temperature control air oven
Tensile test	Pipe samples	Tensile testing machine
Environment stress crack resistance (ESCR)	Pipe samples	Temperature control water bath.
Hydraulic test	Pipe samples	Hydraulic testing machine
Emitter flow test	Emitter samples (micro-tube)	Emitter flow test

ESTIMATE OF MANUFACTURING PLANT FOR AMIT

COST ESTIMATE FOR MANUFACTURING SETUP OF LOW COST DRIP IRRIGATION

Sr. No.	Machine, Accessories and Specifications	Quantity	Drip Components Manufactured	Cost (US$)
	Machines			
1	Plastic Extrusion Plant : Consisting of - 50mm Extruder Screw with helical gear box, 25 Kg/hr output, complete with digital variable AC drive and 10 HP motor, Digital temp. control panel, 1.2mm, 12mm, 16mm dies, vacuum pump and sizer with sets for 12 and 16 mm, water cooling tank, caterpillar haul off with variable dc drive and hand operated coiler. Also 20 mm extruder assembly for colored lining.	1	1.2 mm microtube, 12mm and 16 mm LLDPE lateral pipes, 25 mm to 50 mm LDPE / HDPE pipes.	15000
2	Vertical Injection Molding Machine : Consisting of 60 gms capacity, Fully automatic, 15 tons direct locking suitable for all hand operated injection moulds as under.	1	Valve-16mm, Tees-12mm, 16mm, 16mmx12mm, Reducer-16mmx12mm, Joiner-12mm, 16mm, Filter-16mm, Endstop 12mm, 16mm	3000
	Moulds			
1	Mould for Valve Assembly : Three sets of moulds, one each for cock body, rotor, and female threaded adapter	3		500
2	Mould for Tees : Three sets of moulds, one each for 12mm, 16mm and 16mm x 12mm reducing tee, with manual core pins	3		450
3	Mould for Reducer : One set mould for 16 mm x 12 mm Reducing Joiner	1		100
4	Mould for Joiner : Two sets of moulds, one each for 12 mm & 16 mm Joiners	2		200
5	Mould for Microtee : One set for 8 cavity mould	1		1500
6	Mould for Holding Pegs : One set for two cavity mould	1		200
7	Mould for 16 mm strainer filter: Two sets of moulds, one each for filter and rubber strainer molding	2		250
8	Mould for End Stop: One set of four cavity mould for 12 mm and 16 mm End stops	1		300
	Total			21500

TROUBLE SHOOTING IN PLASTIC MANUFACTURING

7.1 Trouble –Shooting of Extruders:

Following table gives common extrusion problems and remedies as recommended by equipment manufacturers.

Problem	Causes	Remedy
Contaminants like small specks / gels.	Melt temperature too high. Not enough progression in screw.	Lower melt temperature. Use new screw.
Rough surface finish, called as Melt fractures.	Melt temperature too low. Die gaps too narrow.	Increase melting temperature. Heat die lips. Increase die gaps. Use processing aids.
Wrinkles	Dirty collapsing frame. Too much web tension. Improperly designed air ring. Insufficient cooling.	Clean frame. Adjust tension. Use new air ring. Use refrigerated air. Increase flow of air.
Blocking	Inadequate cooling. Excessive winding tension. Excessive pressure on nip roles.	Use better cooling method. Adjust tension. Adjust pressure.
Port lines	Melt temperature too low. Die too cold or too hot.	Increase melting temperature. Adjust die temperature.
Splitting	Excessive orientation in machine direction. Degraded resin.	Increase blow up ratio. Lower melt temperature.
Die lines	Nick on die lip. Dirty die. Inadequate purging.	Charge die. Clean die. Increase purging time.
Gauge variations (Machine direction)	Surging. Inconsistent take up speed.	Check temperature. Check hopper for bridging. Check take up speed.
Streaks	Contaminated system.	Clean hopper, screw & die.
Total discoloration	Excessive Regrind.	Check amount of regrind.
Discontinuous lines	Too much moisture.	Increase resin drying.
Blisters	Insufficient vacuum. Excessive moisture.	Increase vacuum.
Burn Streaks	Gases entrapped. Dirty die, high temperature, High air pressure on puller.	Check moisture percentage. Clean die and reduce temperature.
Uneven Circumference	Insufficient air pressure.	Check air pressure and all connections.

7.2 Trouble–Shooting in Injection Molding Machine:

Following table describes common injection molding problems and remedies as recommended by equipment manufacturers.

Problems	Remedies
Material leaks between nozzle & sprue.	Nozzle seal is jammed, Injection pressure starts too early, Check nozzle setting, and increase nozzle contact time.
Mold is not being filled completely.	Increase injection pressure, increase cylinder temperature, increase nozzle temp., inject with rotating screw.
Screw does not return.	Increase screw rotation speed, decrease screw backpressure, pre dry material.
Sink marks in molded parts.	Increase holding pressure time, increase nozzle temp., decrease injection speed, decrease screw backpressure.
Burning in the molded parts.	Decrease cylinder temperature, decrease injection speed, increase nozzle orifice, and keep mold vents.
Flash on molded parts.	Decrease injection pressure, decrease cylinder temperature Decrease mold temp. or it requires maintenance.
Inferior surface finish	Increase cylinder temperature, increase screw rotation speed, inject with rotating screw, and decrease injection speed.
Flaking	Increase cylinder temperature, increase screw rotation speed, inject with rotating screw, and decrease injection speed.
Molded parts stick to the cavity.	Decrease cylinder temperature, decrease holding pressure time, decrease injection speed, and polish molds.
Tearing of sprue.	Increase cylinder temperature, decrease mold temp., polish sprue runners and channels, and check nozzle setting.
Discoloration at sprue.	Decrease cylinder temperature, decrease injection speed, increase nozzle orifice, and increase mold temperature.
Flow seams.	Increase injection pressure, increase cylinder temperature, inject with rotating screw, increase injection speed, and increase injection speed.
Brittleness of molded parts.	Increase cylinder temperature, decrease holding pressure time, increase screw rotation speed, inject with rotating screw, and decrease injection speed.
Wavy finish of the surface.	Increase injection pressure, increase cylinder temperature, increase holding pressure time, and decrease injection speed.
Material temperature too high.	Decrease cylinder temperature, decrease holding pressure time, decrease screw rotation speed, decrease screw backpressure, decrease molding temperature.
Streak formations.	Check cylinder temp., decrease screw rotation speed, check nozzle setting, and decrease injection speed.

ASSEMBLING OF AMIT KITS

In AMIT Kit assembling required quantity of AMIT components for particular configuration of crop and area are connected and packed in ready to use form. The kit is packed into a box along with instruction manual for the farmer so that it is user friendly.

9.1 Basic Infrastructure for Assembling:

Assembling can be done at various levels in the supply chain depending on volume of business. A covered space for storage of raw material and finished goods is required. Actual assembling can be done in open area or under cover depending on the climate. However covered space is always better. A typical assembling house should have 12m x 6 m of covered space for working and three rooms one each for office, storage of raw material and storage of AMIT Kits. Following table gives specifications for different types of AMIT kits.

9.2 Micro-tube Drip Kits (MTD):

Specification	Bucket Kit / Micro-tube Drip Kit (MTD20)	Micro-tube Drip Kit (MTD 100)	Micro-tube Drip Kit (MTD 500)	Quarter Acre kit (QAK 1000)
Area Coverage	20 sq. meter	100 sq. meter	500 sq. meter	1000 sq. meter
Type of Emitter	Micro-tube 1.2 mm I.D., 60 cm long	Micro-tube 1.2 mm I.D., 60 cm long	Micro-tube 1.2 mm I.D. 60 cm long	Micro-tube 1.2 mm I.D., 60 cm long
No. of Emitters / Micro-tubes	60	300	1500	3000
Emitter / Micro-tube Spacing	30 cm / 60 cm	30 cm / 60 cm	30 cm / 60 cm	30 cm / 60 cm
Type of Lateral	LLDPE 12 mm O.D.	LLDPE 12 mm O.D.	LLDPE 12 mm O.D.	LLDPE 12 mm O.D.
Lateral Length	5.0 m	9 m	16 m	16 m on each side of the sub-main
No. of Laterals	2	5	16	32
Lateral Spacing	2 m	2 m	2 m	2 m
Type of Sub- Main	LLDPE 12 mm O.D.	LLDPE 16 mm O.D.	LLDPE 32 mm O.D.	LLDPE 32 mm O.D.
Sub-main Length	1.8 m	10 m	32 m	32 m
Filter	Screen Filter (12 mm inlet & outlet size)	Screen Filter (16 mm inlet & outlet size)	Screen Filter (25 mm inlet & outlet size)	Screen Filter (25 mm inlet & outlet size)
Operating Pressure / Height of Tank	1 meter	1 meter	2 meter	2 meter
Emitter Flow	2.5 lit / hour	2.2 lit / hour	2.4 lit / hour	2.2 lit / hour
Water Storage	20 liters	200 liters	1000 liters	2000 liters

9.2 Baffle Drip Kits(BDK):

Specification	Small BDK	Medium BDK	Large BDK
Area	125 m2 with one shift	250 m2 with one shift	500 m2 with one shift
Size	12 m x 10 m	12 m x 20 m	12 m x 40 m
No. of Baffles	80	160	320
Baffle spacing	60 cm	60 cm	60 cm
No. of laterals	4	8	16
Lateral length	12 m	12 m	12 m
Lateral spacing	2.5 m	2.5 m	2.5 m
Operating head (height of the water source)	1 m	1.5 m	1.5 m
Average water requirement per day	100	200	400

9.3 Micro Sprinkler Kits(MSK):

Specification	MSK-2	MSK-4	MSK-8	MSK-15
Area	100 m^2 in five shifts	200 m^2 in five shifts	400 m2 in five shifts	800 m^2 in five shifts
Size of one kit	3 m x 7 m	3 m x 13 m	6 m x 13 m	16 m x 10 m
No. of Micro sprinklers	2	4	8	15
Micro sprinklers spacing	3 m	3 m	3 m	3 m
No. of laterals	1	1	2	5
Lateral length	4.5 m	10.5 m	10.5 m	11 m
Lateral spacing	3 m	3 m	3 m	3 m
Operating head (height of the water source)	10 to 15 m	10 to 15 m	10 to 15 m	10 to 15 m
Average water requirement per day	400 liters	800 liters	1600 liters	3200 liters

9.4 Assembling Process:

All types of AMIT Kits share the following process for assembling purposes. For detailed understanding of the process the prospective assembler has to see the assembling process on the ground or refer to the video prepared with this manual.

1. Measuring correct length of the pipes as per kit specifications.
2. Cutting of pipes as per required length for sub main and lateral pipes.
3. Cutting / drilling the sub main pipe to connect tees / take offs at given spacing.
4. Putting holes on lateral pipe with the help of punch at given spacing.
5. Connecting the micro-tubes / microtees / baffles to the lateral pipe.
6. Preparing coil of pipes as per given size.
7. Packing additional material viz. filter, valve, fittings, pegs, micro-tubes, spares, instruction manual, filter cloth etc. into a polythene bag.
8. Checking again all the items on the list before packing into a box.
9. Packing the box of all the components.
10. Paste the packing slip on the box.

Following pictures show the assembling process in progress.

1. Various components stored in separate boxes and pipes in coils:

2. Required length of pipe being coiled after punching holes and fixing micro-tubes:

3. Components / Fittings being packed in smaller polyethylene bags:

4. The Drum Kit components (100 sq.m Micro-tube Drip Kit) ready to be packed:

5. The Micro-sprinkler Kit components ready to be packed:

QUALITY ASSURANCE IN ASSEMBLING

10.1 Quality Assurance System for Assemblers:

The quality of the product is a critical and basic function determining customer satisfaction. For AMIT Kits, it is important to set the quality parameters because at the farmer level it becomes difficult to differentiate between a good product and bad product. If the product fails, then there is the possibility that the technology will get rejected – causing a setback. Therefore quality should be maintained for assembling process.

The assembler procures components from different manufacturers / suppliers and prepares a final product. If the product fails, it will affect the assembler more than any one in the supply channel. It is important for the assembler to be conscious about quality and take the following measures to ensure it:

- Assemblers should be equipped with all the engineering drawings of the AMIT kits and components along with the complete details required for assembling.
- Assembler should check the quality of the component samples for dimensions and compatibility with other components e.g. diameter, wall thickness, visual appearance etc. for pipes and compatibility of fittings with pipes.
- A random check of sub assemblies should be carried out to ensure accurate lengths of micro-tubes, lateral, main pipe and quality of connections.
- A checklist should be used on every package to ensure all the components and instruction manuals are included in the kit and signed for quality. The checklist will also serve as a ready reference for the user.
- The sample package should be opened and checked for the presence of the different components.
- Sample kits should be tested for performance, leakages, loose joints etc.

Following table gives the specifications for different AMIT components:

Sr. No.	Item	Unit	Weight	Outside diameter	Inside diameter	Wall thickness
1	1 mm LLDPE pipe	meter	0.006 Kg/m	3 mm	1 mm	1 mm
2	12 mm LLDPE pipe	meter	0.030 Kg/m	12 mm	10 mm	1 mm
3	16 mm LLDPE pipe	meter	0.045 Kg/m	16 mm	13 mm	1.5 mm
4	25 mm LLDPE pipe	meter	0.125 Kg/m	25 mm	21 mm	2 mm
5	12 mm end cap	number	0.002 Kg/unit	-	-	-
6	16 mm end cap	number	0.003 Kg/unit	-	-	-
7	12 x 12 Tee	number	0.008 Kg/UNIT	-	-	-
8	16 x 12 Tee	number	0.012 Kg/Unit	-	-	-
9	25 x 12 Tee	number	0.020 Kg/unit	-	-	-
10	12 mm filter	number	0.016 Kg/unit	-	-	-
11	16 mm filter	number	0.300 Kg/unit	-	-	-
12	25 mm filter	number	0.670 Kg/unit	-	-	-
13	12 mm tap	number	0.180 Kg/unit	-	-	-
14	16 mm tap	number	0.180 Kg/unit	-	-	-
15	25 mm tap	number	0.450 Kg/unit	-	-	-
16	Micro tube peg	number	0.002 Kg/unit	-	-	-
17	Tap hole punch	number	0.220 Kg/unit	-	-	-
18	Micro tube punch	number	0.003 Kg/unit	-	-	-
19	Pipe cutter	number	0.250 Kg/unit	-	-	-
20	Micro sprinkler	number	0.050 Kg/unit	-	-	-
21	Micro sprinkler riser	number	0.225 Kg/unit	-	-	-
22	Instruction Manual	number	-	-	-	-
23	Box for Packaging	number	-	-	-	-

APPENDIX

11.1 Glossary:

Abbreviation	Description
AMIT	Affordable Micro Irrigation Technology
IDE	International Development Enterprises
MIS	Micro Irrigation System
MDK	Micro-tube Drip Kit
BDK	Baffle Drip Kit
MSK	Micro-Sprinkler Kit
ET	Evapo-transpiration
Hp	Horse Power
LPH	Liter per Hour
LPS	Liter per Second
LPH per meter	Liter per hour per meter
Ha	Hector
Ft	Feet
Inch	Inches
Mm	Millimeter
Cm	Centimeter
M	Meter
Sq.m	Square meter
PVC	Polyvinyl chloride
PE	Polyethylene
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
ABS	Acrylonitrile-butadiene-styrene
BMC	Bulk moulding compond
CA	Cellulose acetate
CD	Compact disc
CPVC	Chlorinated polyvinyl chloride
UPVC	Unplasticized polyvinyl chlorode
FRP	Fiberglass reinforced plastic
GP	General purpose
IMM	Injection molding machine
MFI	Melt flow index
OPET	Oriented polyethylene terephthalate
PC	Polycarbonate
PS	Polystyrene
POM	Poly-acetal
PVA	Polyvinyl acetate

REFERENCES:

1. Plastic Engineering Handbook by Gokul Polymers, Ahmedabad.

2. Technical Manual for Affordable Micro Irrigation Technology (AMIT) by International Development Enterprises, Denver USA.