Video Training Manual

Prepared for

Biogas Support Programme (BSP)

On

Correct Construction Method

for

GGC 2047 Mode Biogas Plant

And

Quality Standards

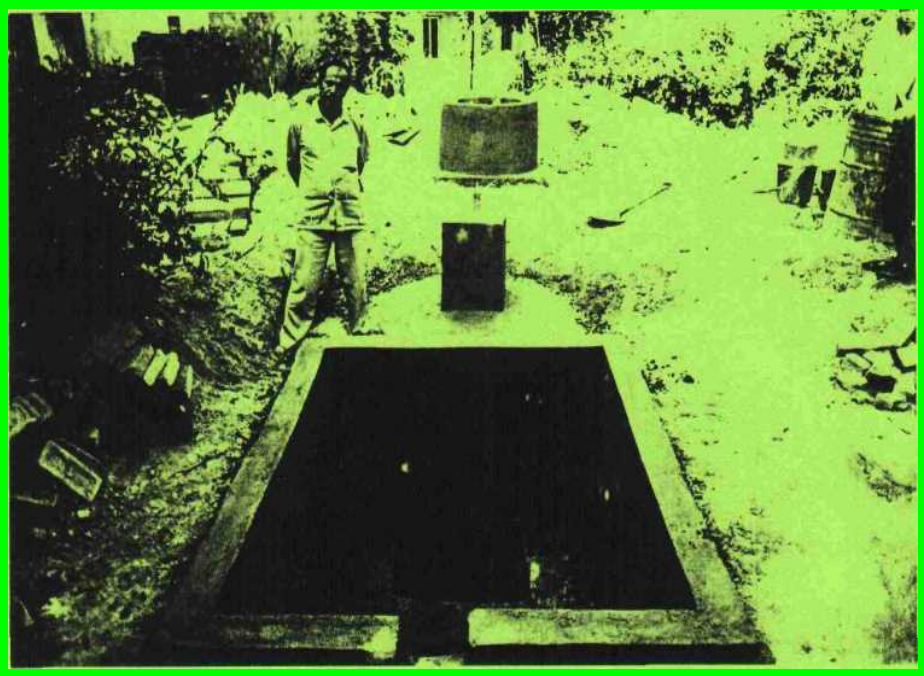

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Table of Contents

1.0 IMPORTANCE OF BIOGAS IN NEPALESE CONTEXT

1.1 Introduction

Nepal, despite being rich from the point of view of natural scenery - flora and fauna, its drastic environmental deterioration has become a matter of concern. Among various factors that are contributing to the ecological imbalance, the rapid depletion of forest resources is a major one. Most of rural households in Nepal completely depend upon the firewood from the nearby forests to fulfil the demand of domestic fuel. In order to check the rate of forest depletion, it is felt that development and promotion of alternate sources of energy is indispensable. Small hydropower, wind and solar energy and biogas are seen to be such viable options. Hydropower generation and distribution involves relatively higher costs. Similarly, wind and solar energy exploitation implies sophisticated technology and huge investment which could not be viable for Nepal. Considering these facts, biogas has been realised to be the best as an alternative source of energy which is promising and suitable in Nepalese context by means of which more energy could be extracted for fuel use while at the same time, the digested slurry could be used to maintain the soil-fertility of the land.

The Nepalese economy is primary based on agriculture. The agriculture is dominated by mixed farming system in which crop and livestock are combined. Most rural households maintain a few animals either for farm manure purpose or for some other household purposes. The livestock maintained by the farmers is a readily available source of raw material required to operate the biogas plants. Even though other organic feeding materials could also be used to produce biogas, cattle dung is seen to be the most appropriate because of its continuous and easy access and readily availability. Human excretion can also be used as a supplementary source. Although it does not contribute significantly in gas production, attachment of latrines to the biogas plants helps in enhancing the environmental sanitation.

A study carried out by BSP in 1991 suggested that in Nepal some 2.3 million fanners keep livestock. Some 1.5 million farmers, or 65% of the livestock owners, are estimated to be potential biogas families. Even though the livestock population is spread throughout the country, some districts have higher potential than others. The terai districts having higher potential are Jhapa, Morang, Saptari, Siraha, Dhanusha, Sarlahi and Rupandehi where over 50000 plants in each could be installed. Similarly, Khotang, Kavre, Nuwakot, Dhading, Makawanpur, Gorklia. Tanahun, Syangja, Kaski, Baglung, Gulmi and Achham among the hill districts have a potential of over 18000 plants in each. The average size of the potential plants is at 6 to 8 cubic meter, which, however, is lower than the average size of the plants installed in the fiscal year 1995/96 (8.77 cu. m.).

There were 31018 plants installed in Nepal by Jury 1996 which is only about 2% of the total technical potential. The districts with highest number of plant installation are Kaski (3756), Chitwan (2638), Tanhun (1994), Jhapa (1938), Morang (1914) and Rupandehi (1778). Most of these plants are installed with the loan assistance from the ADBN and technical assistance and subsidy from the BSP. A survey conducted in 1990/91 showed that the performance of most of these plants which have fixed dome design is highly satisfactory. Ninety percentage of the plants constructed since 1980 are functional and operating satisfactorily. This level of performance is much higher than in India, Pakistan and China. This indicates the success of the biogas programme in Nepal in supplying huosehold energy for the rural population.

1.2 Direct Benefits of Biogas

1.2.1 Cooking

One of the major uses of biogas is in cooking food. Because biogas is a smokeless fuel, its use helps in prevention of smoke-induced diseases. The utensils remain soot-less after cooking and their cleaning also becomes easier. The use of biogas in cooking results in a significant amount of time saved, for, the need for firewood collection is eliminated and cooking and cleaning jobs become easier and much faster. The time thus saved can be utilised in other productive activities in order to increase the family income.

1.2.2 Lighting

Biogas is also used for the purpose of lighting the house in the evening and at night. Supply of fuel like kerosene for lighting purpose in the remote hilly areas of Nepal is difficult and expensive and biogas, being cheaper and locally available fuel, can help in improving the supply situation. Since the biogas lamp provides much brighter light than a traditional kerosene lamp, there is a better environment for children's education and other household chores.

1.2.3 Other Uses

In addition to the above mentioned uses, biogas can also be used for various purposes like refrigeration, running of duel-fuel engines such as operation of motor or transport vehicles etc., electricity generation, etc. Such use of biogas, however, is to date not common in Nepal.

1.3 Indirect Benefits of Biogas

1.3.1 Effect of Biogas in Agriculture

Chemical fertiliser is not produced in Nepal and the country is dependant on imports to fulfil the demand. The imported fertiliser is expensive involving huge amounts of valuable foreign currency reserves. The supply is very erratic and the prices at the end user's level axe growing rapidly. Most of the farmers are gradually becoming unable to afford the chemical fertiliser and in this context the bi-product of a biogas plant, the slurry, can be a source of alternate fertiliser. The slurry is used to produce compost fertiliser which can be very valuable because it is highly nutrient is locally produced, and involves little additional cost to produce. The slurry can be used as follows:

- as major fertilising agent replacing the chemical fertiliser;
- as a supplementary fertiliser;
- as an insecticide;
- in the production of fruits and vegetable with higher economic and nutrient value; and
- in the production of high protein fodder.

Installation of biogas plants can also helps in increasing volume of the livestock farming. Because the livestock is to be kept in the stall, there is no need for allocating land for pasture use and additional land is available for cultivating purpose. Similarly the problem of over-grazing is also eliminated. The slurry can also be used in feeding material for pig and fish and hence, there is the potential for increased farming of pigs and fish.

1.3.2 Environmental Effect

As mentioned earlier, the use of biogas helps in reducing the demand of firewood. This helps in checking the already dwindling forest resources. The practice of keeping livestock in stalls instead of letting them forage in forests and pasture-land also reduces the pressure on forests and the surrounding area with increasing control on soil erosion. Besides, it helps in minimising the green house effects to some extent by the consumption of methane. The emission of CO2 can also be checked.

1.3.3 Effect of Biogas on Women

Women are increasingly under pressure because of the need for walking long distances in search of firewood. One estimate suggests that more than 20 percentage of the women's working hours is spent in firewood collection. A study carried out by M. van Vliet & Wim van Nes in Rupandehi district in 1993 revealed that woman from a biogas owning family can save from 2 to 7 hours every day. Cooking and cleaning also become faster. The operation of a plant involves some routine activities like collection of water, preparation of dung water solution, plant feeding, etc. requiring additional time that is not much of burden. Considering all these aspects, it can be said that on average the time saved by a family is over three hours a day (EAST Consult, 1994 - 3.06 hours, DevPart Consult, 1996 - 3.36 hours.). The time saved can be used in various important jobs like productive economic activities, child care, personal care and domestic hygiene, rest and recreation, etc.

In addition, women get rid of smoke and odour produced from the use of traditional fuel like firewood and dung cake, resulting in more pleasant atmosphere in the kitchen and the house and reduction in respiratory and eye diseases.

1.3.4 Environmental Sanitation

The effect of biogas on the reduction of certain diseases is already mentioned above. The increasing practice of joining a latrine to the biogas plant also helps in improving the environmental sanitation situation in rural households.

In urban areas bigger biogas plants fed by public toilets and domestic organic waste can be installed. This will enable in productive management of urban waste and cleaner environment.

1.3.5 Employment Generation

Several biogas companies have been established employing many people in semi-urban and rural areas. Many village level masons are also working in biogas construction. This positive impact of biogas in technology transfer and employment generation is also of great value.

2.0 IMPORTANCE OF QUALITY STANDARDS IN BIOGAS PLANT CONSTRUCTION

The installation of biogas plants at individual household level has picked up some momentum in Nepal recently. With the development in the sector of biogas, it is natural that the involvement of and co-ordination between the users, masons and teclinicians, company and bank personnel, etc. is increasing. The interest of general public in biogas is gradually becoming wider and the Biogas Support Programme (BSP) is being implemented efficiently.

This has necessitated the mechanism for an effective flow of practical information so that all the involved actors are benefited equally. In this context BSP has been developing and distributing different promotional and informative tools like booklets, brochure, posters, etc. Certainly these materials have contributed significantly in promotion and extension of biogas technology in the needy rural areas.

It is quite obvious that for the successful extension of the biogas technology the performance of plants constructed should be good. As an illustration, if the plant installed by a farmer does not perform well, the neighboring households will be reluctant to invest in the plant of their own. On the other hand a well performing plant is likely to become a catalyst for the spreading of plants in the vicinity. Furthermore, a plant has to be of good construction quality and in good operating condition in order to attain the optimum benefits from the investments. In the construction of such a quality plant, various factors such as quality of construction material and appliances, skill of technicians involved, knowledge and attitude of the owner, etc. play an important role. Considering these aspects, among many other activities, BSP has enforced a quality standard in the biogas plant installation and is updating it periodically.

3.0 GENERAL INTRODUCTION OF THE TRAINING VIDEO

As mentioned earlier in its endeavour to speedy extension of the technology Biogas Support Programme has been conducting various training programmes in the field of extension of technology and construction of biogas plants. These training programmes are intended for and directed towards different target groups like construction masons and supervisors, extension workers, company officials, bank staff, NGO and other line agency personnel, interested general public and farmers, etc. As part of training tools for the training of new biogas masons, refresher training for masons, training for new supervisors and refresher training for masons, DevPart Consult- Nepal (Pvt) Ltd was contracted by BSP to prepare a two hours long training video documentary on 'Quality Standards and Correct Building Methods for GGC 2047 Biogas Plant'. This manual is a supplementary part of the video.

This manual covers all subjects related to the construction method and procedure of the GGC 2047 model biogas plant which are included in the video. Attempt has been made to cover all relevant aspects of plant construction and operation. Hence, it is believed that this booklet will of value not only for trainees, but trainers as well.

The manual covers the following major subjects:

- Importance of good quality biogas plant in the Nepalese context
- Detailed description of plant construction methods and procedures
- BSP quality standards in plant construction and maintenance
- General operational procedures to be notified to the farmers and plant completion report filling procedures

4.0 INTRODUCTION OF THE DIFFERENT BLOCKS OF THE VIDEO

This video is divided into ten parts. The first part gives an introduction of biogas technology and biogas plant, the second part deals with the general conditions regarding plant construction, the third part explains about the selection procedure of plant site and construction materials, and the forth part deals with the quality of appliances.

Construction procedure of the digester is given in part 5 and part 6 deals with dome construction. Construction of outlet and inlet tanks is described in seventh and eighth parts respectively. Part nine is about pipe laying and fixing of appliances whereas part ten deals with construction procedure of compost pit and finishing works.

The detailed description of each part is given here.

4.1 Part - 1: Brief Introduction of Biogas Technology

4.1.1 Introduction

The importance of biogas technology in the Nepalese context is highlighted in this part. Attempt has also been made to acquaint the participants on the physical and geographical features of Nepal and the importance of the development and extension of biogas technology in safeguarding the ecological balance, the flora and fauna and the beautiful natural scenery of the country. Besides, introduction of the biogas technology, familiarisation with the different components of the plant and their function, the benefits which could be derived from a good quality plant and the negative effects of a low quality plant on the farmers have also been explained.

4.1.2 Objective

After watching this section, it is expected that the participants shall be acquainted with the following topics.

- The negative impact on the environment by the depletion of forest for the supply of fuel-wood
- The importance of biogas technology and its usefulness in Nepalese context
- Introduction to the biogas plant model most widely used in Nepal presently
- Introduction of different components of the plant and their function
- Gas production process
- The benefits of biogas at domestic and national levels
- Negative impact of poorly constructed plant on farmers.

4.1.3 Duration

The total duration of this block is 9 min 40 sec.

4.1.4 Video Narration

Nepal is one of the most beautiful countries of the world from the point view of natural scenery. Despite being rich in important natural resources, we are facing several problems because of our ignorance in making optimal use of these resources. The situation of fuel supply can be cited as an example. We are used to stockpiling firewood by cutting trees ruthlessly without giving much regard to other appropriate sources of energy. Likewise, we make dung cake and bum it instead of using the dung for enhancing land fertility. Because of such ineffective activities our forests are becoming encroached day by day and our fertile land is becoming unproductive. Presently, extension and development of biogas technology as an alternate to traditional fuel sources is being carried out in our country. This is an important step forward in solving this acute problem. Even though a little late it may be, tile emphasis on the use of biogas for supplying the domestic fuel demand is certainly an important step in this area.

This is the design of the most frequently adopted biogas plant in Nepal which was developed by the Biogas and Agricultural Equipment Development Company, GGC, in the year of 2047 B.S. The design of a biogas plant consists of 5 main structures. This is the inlet, where dung and water are mixed to prepare slurry. The slurry prepared in this inlet tank reaches the digester via inlet pipe, where it is digested to produce biogas. The gas thus produced is stored in the gas holder called dome. The digested slurry passes through the manhole to the outlet tank and comes out of it by virtue of the pressure of the gas produced. This slurry is then composted in appropriate composting pits. The gas is taken through pipe to the gas stove and lamp for domestic use. The fertiliser produced from the slurry after being composted in the compost pits is used for increasing the soil fertility to enhance agricultural production.

The use of biogas helps in improving the environmental sanitation situation in and around the house. Because it is a smokeless fuel, it also helps in getting rid of smoke-borne diseases like burning and itching of eyes, respiratory diseases, nausea, etc. The kitchen remains smokeless and clean. The biogas lamp is brighter in comparison to the kerosene lamps and there is more light in the house which is helpful for children's education as well as other household jobs. Considerable time is saved because there is no need for firewood collection, cooking is faster and the utensils are soot-less, and this saved time can be utilised in other productive activities, A study of 100 biogas households carried out in the year 1996/97 by DevPart Consult (P) Ltd. for Biogas Support Programme revealed that a biogas family saved about two and a half hours every day. In addition, the appropriate use of slurry produced from the plant helps to increase the agricultural production. Because the livestock is to be kept in the stall, the manure production is also increased. The rate of depletion of forest decreases because of reduced consumption of firewood. Soil erosion, flooding, landslides etc. are controlled and in this manner the whole nation is benefited. In order to be able to get all these benefits it is necessary that the biogas plant be of good quality and it should be operated and maintained in a proper way. The biogas plants of these women are built and maintained properly and they feel that they are getting all the benefits.

This farmer, on the other hand, is not happy. He installed a biogas plant with loans and borrowings, but defects started to develop within two months from the installation of the plant. The inlet cracked and slurry came to the kitchen through the pipe. The outlet tank walls also collapsed. The plant constructed only two years ago is in this condition. The biogas construction company did not respond to the repeated requests for repair. Now he does not want even to hear about biogas plant because of the burden of the loans and the tremendous pressure related to it. He blames the biogas company as well as himself for the failure. " The company did not send a good mason. He was not very skilled, but we constructed the plant somehow. What to do? The lamp, stove and pipes were also apparently of bad quality. I also did not think much at that time. Now I don't know what to do. It is too late."

In order to get the optimum return from the investments made and to attain the maximum benefits from the biogas plant, it is necessary to construct a plant of good quality. This video attempts to explain in detail the construction procedures and quality standards of GGC 2047 model biogas plant. This video is divided into ten parts. The first part gives an introduction of biogas plant, the second part deals with the general conditions regarding plant construction, the third part explains about the selection procedure of plant site and construction materials, and the forth part deals with the quality of appliances. Construction procedure of the digester is given in part 5, part 6 deals with dome construction. Construction of outlet and inlet tanks is described in seventh and eighth parts respectively. Part nine is about pipe laying and part ten deals with construction procedure of compost pit and finishing works.

Detailed description about the plant construction procedure has been given in this construction manual.

4.2 Part - 2: General Conditions For Biogas Plant Construction

4.2.1 Introduction

Realising the importance of biogas technology in Nepal where fuel supply situation is difficult and problematic. His Majesty's Government has been actively assisting in this sector. In recent years the installation rate of biogas plants has been increasing significantly due to the financial and technical assistance provided by the Government of The Netherlands through SNV-Nepal under the framework of Biogas Support Programme, BSP. Part of the financial assistance goes to the biogas installing farmers in the form of subsidy channelled through recognised Biogas Companies. In order to be eligible to get such subsidy, there are certain general conditions to be followed. These general conditions, the primary objective of which is to reap maximum benefit from the installed plant, have been dealt with in this section.

4.2.2 Objectives

After watching this section the participants shall be acquainted with the following topics.

- The responsibilities of the farmer prior to plant construction like ensuring separate kitchen for each plant, selection of proper plant size, ensuring the easy availability of sufficient quantity of water for plant operation, etc.
- The responsibilities of the concerned biogas company such as construction of plant of approved model and design, involvement of trained and registered masons only in plant construction, provision of appropriate guarantee and after-sale-services, etc.
- Joint responsibilities of the farmers and the company such as selection of proper size of plant depending on the dung availability, etc.
- The method of plant size selection based on daily dung availability: in terai regions where the dung digests faster, on the basis of 55 days retention time, it is necessary to have a minimum of 7.5 kg of dung per cubic meter of plant size, and in hilly areas where the retention time is assumed to be 70 days, minimum of 6 kg dung per cubic meter of plant size.

4.2.3 Duration

The total time duration of this block is 8 min 45 sec.

4.2.3 Video Narration

For the construction of biogas plant in accordance with the quality standards, the farmer also has certain responsibilities. A family should have only one plant, or, in other words, it is necessary that each plant has a separate kitchen. For the proper operation of a plant it should be fed with prescribed quantity of dung daily and this factor should be considered carefully beforehand, a plant should never be built with toilet connections only. There should be an easy access to water source for the daily preparation of the dung-water solution. For this purpose the permanent source of water should not be farther than a 20 minutes walking distance. If water is to be brought from far away, the family will have additional burden and more time will have to be spent in fetching water than the time saved because of plant installation.

In the construction of the plant according to the quality standards, the concerned Biogas Company has even greater responsibilities. The company should build the plant of GGC 2047 model only, using trained and appropriately registered masons. After the commissioning of the plant there should be a guaranty of three years for the main components like inlet, dome, digester and the outlet, and one year for pipes and appliances. Necessary after-sale service should also be provided for a period of three years.

It is the responsibility of both plant owner and the company to build the plant of proper size. Before deciding the plant size, it is necessary to collect and inspect the dung produced from the farmer's livestock regularly for a few days. Thus the daily average amount of dung produced can be determined and based upon the weighing of dung in this type of bucket which contains about 10 KGs dung, the plant size can be decided. The important point !o consider is that the plant size has to be determined by the amount of dung dairy available, not the family size or toilet connection, hi relatively warmer places like the terai regions where the dung digests faster, on the basis of 55 days retention time, it is necessary to have a minimum of 7.5 kg of dung per cubic meter of plant size. Similarly, in cooler hilly areas where the retention time is assumed to be 70 days, minimum of 6 kg dung is required per cubic meter of plant size. On the basis of this calculation the size of the plant can be selected as follows.

Hilly Areas:

If the amount of total dung available is 24 to 35 kg per day	-	4 cubic meter plant
If the amount of total dung available is 36 to 47 kg per day	-	6 cubic meter plant
If the amount of total dung available is 48 to 59 kg per day	-	8 cubic meter plant
If the amount of total dung available is 60 to 89 kg per day	-	10 cubic meter plant
If the amount of total dung available is 90 to 119 kg per day	-	15 cubic meter plant
If the amount of total dung available is more than 120 kg per day	-	20 cubic meter plant

Terai Regions:

If the amount of total dung available is 30 to 44 kg per day	-	4 cubic meter plant
If the amount of total dung available is 45 to 59 kg per day	-	6 cubic meter plant
If the amount of total dung available is 60 to 74 kg per day	-	8 cubic meter plant
If the amount of total dung available is 75 to 109 kg per day	-	10 cubic meter plant
If the amount of total dung available is 110 to 149 kg per day	-	15 cubic meter plant
If the amount of total dung available is more than 150 kg per day	-	20 cubic meter plant

In order to get a subsidy from His Majesty's Government under the Biogas Support Programme, it is necessary to build an appropriate size plant of 4, 6, 8, 10, 15 or 20 cubic meter size only. But if the plant constructed is of any other size, the plant is built by unskilled and unregistered masons, if there are no separate kitchens for each plant, if the plant is connected to the toilet only without dung filling, three years guarantee on the plant and one year guarantee on pipes and appliances is not provided, or there is no provision for three years after sales service on the plant, no subsidies shall be provided.

4.3 Part - S : Selection Of Construction Site And Materials

4.3.1 Introduction

For the long lasting of the plant and its good performance it is necessary that the plant is placed at a proper site. Likewise, the construction material used should be of best quality available. One important tiling to understand is that a good quality plant can not be built with sub-standard material no matter how good or skilled the constructing mason might be.

4.3.2 Objectives

The objective of this part of the video is to acquaint the participants on the following aspects of selection of construction site and construction materials:

- Consideration of various factors while selecting a plant site. The important factors to be considered are: plant to be cited at sunny and warmer place for proper functioning; site to be as close as possible to the kitchen and the cattle shed; water source to be near enough; plant to be located at least 2 meters away from the foundation of structures like house and trees and at least 10 meters from a well; and there should be enough place near the plant for compost pits,
- Type and quality of the construction material to be used for plant construction,
- BSP quality standard on the construction material and its importance, and
- Selection of the proper quality construction material and some simple field test methods to determine the quality of such materials.

4.3.3 Duration of the block

The duration of this part of the video is 9 min 05 sec.

4.3.4 Video Narration

<u>Selection of Construction Site</u>

The following points should be kept in mind when deciding on a site for biogas plant construction:

- For proper functioning of the plant, the right temperature has to be maintained in the digester. Therefore, a sunny site has to be selected.
- To make plant operation easy and to avoid wastage of raw materials, especially the dung, the plant must be as close as possible to the stable (cattle-shed) and water source. If the nearest water source is at a distance of more than 20 minutes walk, the burden of fetching water becomes too much and no plant should be installed in such places. Moreover, it should be kept in mind that the plant should be at least 10 meters away from the well or any other under ground water sources to protect water from pollution.
- If longer gas-pipe is used the cost will be increased as the pipe is expensive. Furthermore, longer pipe increases the risk of gas leakage because there are more joints in it. The main valve has to be opened and closed before and after use. Therefore, the plant should be as close as possible to the point of use so that the above described problems are eliminated.
- The edge of the foundation of the plant should be at least two meters away from the house or any other buildings to avoid risk of damages.
- Sufficient space for compost pits should be available nearby.

Selection of Construction Materials

After selecting the best site for the construction as mentioned above, the next step is the selection of materials of best quality.

The cement to be used in the plant construction has to be of high quality Portland cement of a reputed brand. It must be fresh, without lumps and stored in a dry place. Bags of cement should never be stacked directly on the floor or against the walls but wooden planks or plastic sheets should be placed on the floor to protect cement from dampness. The piles of cement bags should not be higher than 10 bags to avoid the compressing of the lowermost bag.

Sand for construction purpose must be clean. Dirty sand has a negative effect on the strength of the structure. If the sand contains 3% or more impurities, it must be washed. The quantity of impurities especially the mud in the sand can be determined by a simple test using a transparent bottle. This is called the "bottle test". For this test, small quantity of sand is put in the bottle. After this, water is poured in and the bottle is shaked vigorously. The bottle is then left stationary to allow the sand to settle down. The particles of sand are heavier than that of mud so it settles down quickly. After 20-25 minutes, the layers of mud and sand are measured. Coarse and granular sand can be used for concreting work but fine sand will be better for plastering work.

Gravel to be used for plant construction should not be too big. It should not be bigger titan 25% of the thickness of concrete product. As the slabs and the top of the dome are not more than 3" thick, gravel should not be larger than 0.75" (2 cm) in size. Furthermore, the gravel must be clean. If it is dirty, it should be washed with clean water.

In the construction of biogas plant water is mainly used for preparing mortar for masonry work, concreting work and plastering. Besides these, water is also used for washing sand and aggregate, soaking bricks and washing and soaking stones before using them. It is advised not to use water from rivers and irrigation canals for these purposes as it is usually too dirty'. Dirty water has an adverse effect on the strength of the structure, hence water to be used must be clean.

Bricks to be used for the construction must be of the best quality available. When striking two bricks against each other, the sound must be clear. Brick must be well baked and regular in shape. While dropping two bricks in this manner, they are usable if they don't break. Before use, bricks must be soaked for about 15 minutes in clean water. Such bricks will not soak water (moisture) from the mortar afterwards.

If stones are to be used for masonry work, they have to be clean, strong and of good quality. Stones should be washed if they are dirty. Stones should not be too soft.

Acrylic emulsion paint is used to make the dome of biogas plant air-tight. Paint of such type should meet the quality standard and they must be approved from the concerned quality control authority.

The mild steel bars to be used to construct the cover of outlet slab should meet the quality standard and should be of appropriate diameter. For the plants of 4, 6, 8, 10 and 15 cubic metres, mild steel rods of 8 millimetre diameter, and for 20 cubic meter plant 10 millimetre diameter should be used. It should be free from heavy rust.

The internal diameter of pipes which convey, the mixture of dung and water from inlet, and night-soil from the toilet, to the digester should at least be 10 centimetre. The material may be polythene or PVC.

If the sand does not meet quality standards or it contains impurities more than 3%; if the aggregate is dirty and of poor quality and the size exceeds 2.5 cm; if the quality of cement does not meet the set quality standards; if the acrylic emulsion paint is other than that specified or other than the brand approved by the concerned authority; if the internal diameter of inlet pipes is less than 10 cm; the concerned company responsible for these faults is liable for penalty. Hence, all the construction materials to be used for construction should meet the set quality standards.

4.4 Part - 4: Quality Of Appliances

4.4.1 Introduction

In a biogas plant various appliances are necessary for the production of the gas, for conveying the produced gas to the place of use, and for controlling or regulating the gas flow from plant to the point of use. If such appliances to be used are not of good quality, the plant shall not function properly even though the plant-structure itself may be of very high quality. For example, if the main gas valve is of sub-standard quality and is leaking, the fanner will not be able lo use the produced gas. Therefore, it is very important to ensure beforehand that the appliances to be used in the plant such as main gas valve, pipes and fittings, gas stove, gas lamp, water trap, etc. are of high quality.

4.4.2 Objective

The objective of this part of the video is to acquaint the participants on the following issues:

- The importance of the use of quality appliances in a biogas plant to reap desired benefit,
- Introduction to the various devices to be used and their functions,
- Qualify standard of the appliances and some important and delicate points to be kept in mind while selecting the appliances, and
- The condition of using appliances of approved quality and brand only.

4.4.3 Duration of the block

This block is of 10 min 40 sec duration in total.

4.4.4 Video Narration

If the appliances used are not of good quality, the plant shall not function properly even if the construction work is carried out according to quality standards. Therefore this part attempts to explain about the quality standards of the appliances to be used in plant construction.

This is the main gas pipe to be connected to the dome. From this pipe the gas stored in the dome is conveyed to the point of use through the pipeline. This reduction elbow should already be fitted and sealed to the dome gas pipe in the factory. This joint should be perfect, otherwise gas leakage through this cannot be stopped afterwards. This dome gas pipe should meet quality standard, be properly galvanised and approved by the concerned authority. This pipe made up of light quality iron, together with the rods and elbow should weigh about 3 kg and its length should be 77 centimetre.

This is the main gas valve. It controls the flow of gas in the pipeline. It is opened when gas is to be used and closed after each use. If this is of sub-standard, there is always a risk of gas leakage. Therefore, this valve should be of very high quality and of approved brand.

The pipe to be used to convey gas from dome to the point of use should be of light quality galvanised iron confirming to quality specifications as per Indian Standard Code ISI 1243. The pipe should be labelled with either Nepal Standard (NS) or Indian Standard (ISI) mark on it. The light duty galvanised iron pipe is marked by the factory with yellow colour. The pipe should be of half inch diameter. A six meter long pipe should weigh 6 kilograms.

The other fittings to be used in the pipeline of a biogas plant are socket, elbow, tee and nipple. These fittings should also meet the quality standards. It is essential that these fittings are labeled with IS or other standard marks and are well galvanised. The weight of 100 pieces of each fitting should be as follows: tee - 13 kilogram, elbow - 9, and socket - 6 kilogram.

This is the water outlet to drain the water condensed inside the pipe. This is an important appliance of the plant and its quality should be carefully controlled. This should be easy to operate and threads in it should be perfect. It should be ensured that, the hole in the screw nut is bored properly and is at the right place, the thickness of the nylon washer is 4 millimetre, and either a 4 centimetre handle pin or such a proper knurled opener should be used. Such appliances to be used are to be approved by the concerned authorities.

These are the gas taps. These are used for regulating the flow of gas to the gas stove. Different types of such gas taps are available in the market. But only the Kapoor and GGC model laps are approved by BSP presently. It has been found that in many plants the gas taps are becoming problematic with gas leaking through them. Therefore care should be taken in the selection of the tap. It is important that the "O" ring is placed properly and is greased thoroughly and regularly. The gas tap should not be too tight or too loose to operate. The taps to be used are to be approved by the concerned authorities.

This rubber hose pipe is used to convey the gas from the gas tap to the stove. This pipe should be made of high quality neoprene rubber and should not crack while folding. It should have 15 millimetre outer diameter, 9 millimetre inside diameter, and the minimum wall thickness should be two and a half millimetre.

The gas stoves available in the market are of different quality and brands. The stove widely used in Nepal is the GGC model. It consumes 16 cubic feet of gas per hour. The stove used should be of good quality and strong and should sit firmly on the ground. The ring for controlling the air flow should be easily adjustable and the air flowing hole should be placed properly. The jet and the pipe leading to the burner should be straight and aligned properly. The holes in the burner should be evenly spread.

Another important appliance to be used in the biogas plant is the gas lamp. There have been many complaints from the users about the problematic lamps. The lamps most widely used in Nepal are Santosh and Agnidoot brands. Presently, the Ujeli brand which is produced in Nepal, is also being used on a trial basis. Whichever brand is used, it is necessary that it should be approved by the concerned authorities.

This is the mixing device used for preparing water - dung solution. In smaller plants of up to 15 cubic meter size, vertical mixing device are used whereas in bigger plants horizontal devices are installed. The device should be of good quality and well galvanised, and the blades should be properly aligned.

The pipe, fittings and the appliances are Important and indispensable parts of the biogas plant Therefore, it is necessary that the appliances used, such as, dome gas pipe, main gas valve, pipes and fittings, water outlet, gas taps, rubber hose pipe, gas stoves, gas lamps and the mixing device used should be of good quality and approved by the concerned authorities. Otherwise the biogas construction company shall be held liable for paying fines.

4.5 Part- 5 : Construction Of Digester

4.5.1 Introduction

The digester or the digesting pit, is an important component of the biogas plant where the raw material used is digested and gas is produced. The water - dung solution conveyed through the inlet tank and the night-soil conveyed through the latrine is digested in this pit producing the biogas. This pit is continuously filled with the slurry. The dome for the storage of the gas is built right above the digester. If there is even a slight mistake made in the digester construction, it may have a severe negative effect on the plant performance. For example, if the excavated area behind the round wall of the digester is not back-filled properly, the wall may collapse by the pressure of the slurry and the weight of the dome. This part of the video explains this and other important factors to be considered during the construction of the digester.

4.5.2 Objective

After watching this part, the participants shall be familiar with different stages of digester construction as well as the following important points.

- The lay out work for the construction of digester,
- Points to be considered carefully while digging the pit, such as, maintaining the correct pit depth, proper alignment of the pit wall, proper disposal of excavated soil, etc.,
- Important conditions to be fulfilled before the wall erection, for example, wall to be based on firm ground and not on filling, proper placement of the central rod/pipe for maintaining correct radius of the digester pit, importance of the use of the thread of rope used as guiding line attached to the central pole or pipe, etc.,
- Construction procedure of the round wall,
- Careful placement of the inlet and toilet connection pipes,
- Back-filling method of the pit behind the round brick wait
- Reasons of the stone round wall to rest directly against the pit wall
- Construction procedure of the digester floor,
- Method of plastering of the inside surface of the wall.

4.5.3 Duration of the block

The time duration of this block in total is 16 min.

4.5.4 Video Narration

When a suitable site and construction materials and appliances to meet the quality standard are selected, the lay-out work of biogas plant has to be commenced. For this purpose, a small peg has to be stuck in the ground at the centre spot of the digester. A cord has to be attached to this peg with the length indicated on the drawing under dimension "C". Now this cord is the radius of the digester pit and the circumference can be decided by moving the edge of the cord in a circular fashion. When the circumference is marked, the next step is to decide the position of manhole and outlet tank as per plant size. When the position of digester, manhole, outlet and inlet is decided, marking has to be done with lime. Now, the excavation work should be started. The pit depth is indicated on the drawing under dimension "E". The pit walls should be as vertical as possible. While digging, excavated soil should be thrown at least one metre away from the lay-out, so that it does not fall inside the pit when the construction work is in progress. Most important, the pit bottom must be leveled and the earth here must be untouched.

After the excavation work is over, the construction of the round wall has to be stalled. At the centre of the pit, a straight rod or stick or pipe must be placed in exact vertical position. At ground-level, a heavy pole or pipe has to be placed horizontally on the centre of the pit. The vertical pipe or stick should be checked for its verticality from all sides. Once it is made vertical with precision, it can be secured to the horizontal pipe or pole. After securing, the vertical pipe has again to be checked whether it is still in the right position.

Now, after ramming the floor properly, a string or wire can now be attached to the vertical pipe to fix the inner circumference of the round wall to be built. The length of this wire can be found on the drawing under dimension "F". One cm has to be added to this length to allow space for plastering. Every brick or stone which is laid in the round-wall lias to be exactly F+l cm away from the vertical pipe.

After deciding the radius of digester , the round wall is started to be constructed. 'The cement mortar to be used for wall construction can be of the ratio 1 cement - 4 sand to 1 cement - 6 sand depending on the quality of the sand. Over this mortar, the first row of bricks must be positioned on their sides so that a 2.5" high, 9" wide base is made. It is essential that first row is placed on a firm, untouched and level soil. The next course of bricks can be positioned on their lengths so that the wall thickness becomes 4.5". It is essential that the centre pole be checked for its verticality time and again during the progress of work.

The dung inlet pipe and toilet pipe must be placed in position when the round wall is 35 cm high. To reduce the risk of blockages, the inlet pipe(s) must be placed as vertically as possible. Exactly to the opposite of the dung inlet pipe, a 60 cm wide opening must be left in the round wall which acts as manhole. The digested slurry also flows out to the outlet through this opening. The inlet pipe from the latrine should be placed as close as possible with the dung inlet pipe with a maximum distance of 45 degrees from the dung inlet on the dung inlet-centre manhole line (hart-line). The height of the round wall can be found on the drawing under dimension 'H' when measured from the finished floor.

It is not necessary to make pillars in the wall and pit-side must be compacted with greater care. This back-filling has to be done prior to the commencement of other construction works. Earth should be well compacted by adding water and gentle ramming all along the circumference of the digester. Poor compaction will lead to cracks in (he round-wall and dome.

If stone is used for the construction of round wall, the wall should rest against the pil-side as it is difficult to have proper back-filling because of the irregular shape or the outside of the stone wall.

When the round wall is constructed to its required height, the floor of the digester should then be constructed. For this purpose, the wastage pieces of bricks have to be used. If the floor is to be made up of stone, such stones used should be those not used during wall construction. Once the floor is pitched with stone or brick like this, it has to be applied with thick plaster and levelled.

When the round-wall has reached the correct height and the floor is made , the inside must be plastered with a smooth layer of cement mortar with a mix of 1 unit of cement and 3 units sand.

The important points to be considered while constructing digester are: plant should be placed at required depth; the radius of the round wall should not differ by ±2% with the standard one: the round wall should be vertical - the difference should not be more than 1 cm, the height of round wall should not differ by 5 cm from the standard measurement; the outside of the brick walls must be filled properly with rammed earth and the stone-wall should rest against the pit side; the inside of the digester wall should be plastered with smooth layer of cement sand mortar prepared in the ratio of 1:3; the floor of the digester should be levelled and smooth - the level difference should not be more than 0.5%; and finally, the inlet pipe from the latrine should be placed as close as possible with the dung inlet pipe with a maximum distance of 45 degrees to the hart-line. The details of construction is given in this construction manual.

4.6 Part - 6 : Construction Of Dome (Gas Holder)

4.6.1 Introduction

For the storage of the gas produced in the digester with the decaying of the dung-water mixture and the night-soil, a dome-shaped gas holder is constructed above the digester which directly rests on the top of the round wall of the digester. If this dome is not built properly and if the gas leaks from it, the farmer cannot get the expected benefit from his investments. Hence, it is essential that the dome is constructed in a systematic manner and the quality standard is maintained during its construction. This part of the video deals with various stages of dome construction in a systematic order.

4.6.2 Objectives

It has been expected that after watching this part, the participants will acquire the following information on dome construction:

- Necessary work to be accomplished before dome construction such as back-filling of the pit behind the digester wall, plastering of the inside surface of the wall and the possible consequence if these points are neglected,
- Preparation of earthen form-work (mould) for maintaining the proper shape and size of the dome and the importance of the use of right sized template.

- Other necessary steps to be carried out after the preparation of the mould and before dome casting such as proper compaction of the mould, wetting of the mould in order to avoid the soaking of water from the casted concrete, placing a thin and smooth layer of sand above the mould, and arrangement of necessary construction material and labour required for casting,
- The mortar preparation procedure,
- Important points to be considered during dome casting such as proper and even compaction of the mortar, the mortar to be used within 30 minutes from its preparation, casting work to be completed uninterrupted in order to avoid construction joints, correct placing of the dome gas pipe, etc.,
- Curing procedure and its importance,
- Removal of the earthen mould and preparation of the inner surface of dome for further treatment,
- Different steps to be followed while plastering the inside of dome and importance and function of each coating to be applied with special focus on the use acrylic emulsion paint coatings, etc.
- Use of earth removed in back-filling of the top of dome, outlet walls or inlet base.

4.6.3 Duration

The total time duration of this block is 17 min 50 sec.

4.6.4 Video Narration

When the construction works of round wall as described above is completed, then the gas holder called "dome" has to be constructed. Before filling the pit with earth to make the mould for the dome, the backside of the round wall should be properly compacted. If this is not done, the pressure of the earth for the mould can lead to cracks in the round wall.

Filling of earth to make mould can now be started. The height of mud to be filled is given as "J" in the plant drawing. The vertical pipe or stick placed at the centre of the pit should remain there as it makes easier to mark the measurement equivalent to "J" in it. When the earth reaches this level the stick can now be removed by pulling it upwards. It has to be replaced by a shorter 0.5" diameter pipe, approx. 0.5 metres length in the earth exactly at the same spot. It is important (hat the earth of the mould is well compacted. If the earth is further compressed after casting the dome, by its own weight and that of the concrete, it can lead to cracks in the dome. Now the right-sized template should be used to make the shape of the dome. The top of the round-wall must be clean when the template is in use. The template should be checked to make sure that the top of it is horizontal and the side exactly vertical. Furthermore, the part of the template that touches the. round-wall must be in the same position all over the round wall.

The earth used for the mould has to be damp to prevent dry earth from soaking up water from freshly casted concrete. When the earth mould has the exact shape of the template, a thin layer of fine sand has to be spread on the mould-top by gently patting it on the surface. Any excess sand or soil that falls on the round wall has to be removed immediately.

Before starting the casting work, enough manpower and construction materials like sand, gravel, cement and water has to be made ready on the site. A constant, adequate supply of concrete mix prepared in the ratio of one part of cement, three parts of sand and three parts of gravel must be made available to the mason. No concrete older than 30 minutes should be used. Special care

should be taken to maintain the right thickness of the dome while casting, i.e. the thickness in and near the edges should be more than the thickness in the centre. For 6, 8. 10 & 15 cubic metres plants, the thickness in the centre should be 7.5 cm and that in the edge should be 25 cm. The thickness in the edge for 4 and 20 cubic metre plants should be 22 and 28 cms respectively.

The small piece on the top of the mould must be left in place till the main gas pipe is installed. This is to make sure that the main gas pipe is exactly in the centre. The casting has lo be done as quickly as possible and without interruptions as this will negatively affect the quality of the cast. After the completion of dome casting, the beam which acts as the base for the outlet wall should also be casted as per the specified height.

Already during the casting, the concrete has to be protected against strong sun-light by covering it with jute bags or straw mats. This protection is to be left in place for at least one week. The day after the casting, the turret must be made. Any delays can lead to leakage between main gas pipe and dome. The diameter of the turret should at least be 36 cm if it is made circular and if it is square the size should be of 36 cm. Also from the day after the casting onwards, the dome has to be sprinkled with water 3 to 4 times a day which is known as 'curing'. After approximately on week, depending on the temperature, the earth of the mould can be removed through the manhole. When all earth is removed, ^iq inside of the dome has to be thoroughly cleaned with a brush and clean water.

On the clean surface the following plaster coats have to be applied to make the dome gas-tight.

- First, it should be flushed with thin cement, -water mix.
- Then it should be plastered with 10 mm thick layer of 1 cement - 2 sand mortar.
- When the cement plaster sets 5 mm thick layer of cement - sand punning in the ratio of 1:1 should be applied.
- Afterwards a coat of Cement/acrylic emulsion paint of 1.5 part of paint and 20 parts of cement.
- Finally Cement/acrylic emulsion paint coating of 1 part of paint and 2 parts of cement.

A plaster coat must be at least properly set before the next layer can be put on. When a layer of plaster is applied, the work must be executed with the greatest care and without interruptions. The well-functioning of the plant depends primarily on the gas tightness of dome.

The major points to be considered while constructing dome are: the properly designed and right sized template should only be used to make mould; the height of dome should not differ by the maximum of 5 cm, the radius of dome should be of exact dimension - when measured from finished surface it should not differ by ±2% from the specified measurement; the inside of dome should be plastered with smooth layers of different coats as specified; gas pipe should be in the centre - if not in the centre, the maximum deflection should not be more than 2% of the radius of the dome; while constructing the turret the sizes have to be made of proper dimensions and the placement of gas pipe in it should be as per the specification. The diameter of the turret should at least be 36 cm if it is made circular and if it is square the size should be of 36 cm and the height should at least be 50 cm. There should at least be a support of 12 cm for the gas pipe in it. This construction manual incorporates the construction procedures of dome in detail.

4.7 Part- 7: Construction Of Outlet Chamber

4.7.1 Introduction

The digested slurry is displaced from the digester by virtue of pressure exerted from the gas produced to the outlet chamber through the manhole. The outlet tank has an important role in the flow of the gas to the place of use, as the gas flows because of the pressure exerted by the slurry in the outlet tank. Hence the right size and placement of the outlet tank is essential for maintaining the required pressure in the gas pipe system. For the optimum use of the gas produced the volume and dimensions of the outlet tank is pre-determined depending on the plant capacity, and it is very important to adhere to the given dimensions while constructing this tank. Particularly important is the distance between the top of the manhole and the bottom of the tank floor which is known as pressure height.

4.7.2 Objectives

This part of the video deals with the following points of outlet tank construction:

- The role and importance of the outlet tank in the functioning of a plant,
- The influence of the tank dimensions on the gas flow and the possible negative effect on gas use if the dimensions are not maintained as specified,
- Construction procedure of the outlet tank and maintaining the quality standards,
- The role of the pressure height (distance between the top of manhole and the bottom of outlet floor) in gas flow, and the possible negative effect on gas use if this distance is not maintained within the limit specified,
- The importune of covering the tank with a slab for the prevention of falling of human and animals into the tank and to avoid excessive evaporation of the slurry in dry and hot season,
- Construction method of the outlet tank slab and maintaining the quality standards including the selection and arrangement of the reinforcing rods,

4.7.3 Duration

The total time duration of this block is 12 min 55 sec.

4.7.4 Video Narration

Once the construction of dome is over, the work of outlet construction starts. Before commencing the work of outlet, the manhole has to be constructed. To construct the man hole of size 60 cm by 60 cm, the works should be started like this. To construct the outlet tank, excavation has to be done just behind the manhole. The level of excavation to be done can be measured from the digester floor by taking the dimension "I" minus the thickness of the digester floor. The earth behind the manhole and under the outlet floor has to be very well compacted otherwise cracks will appear.

The inside dimensions of the outlet can be found on the drawing under A, B and D. The distance from the digester floor to the outlet floor is given by the dimension "I". It is important that these dimensions should be accurate as they determine the useful capacity of the gas holder. When the excavation is done as per the requirement, the construction of outlet should be commenced. First of all on the untouched and rammed surface, one layer of brick-bats have to be placed to make the digester floor. When this layer of mortar sets, the construction of outlet walls has to be started.

For deciding exact dimensions of outlet tank, the wall has to be measured from all sides and diagonally once the first layer of bricks is placed in position. After ensuring that it is all right, the second layer of bricks has to be placed. During the course of wall construction, the plumb bob has to be used to check whether it is truly vertical or not. The construction of each layer of brick wall has to be started with the bricks placed in all the four corners like this. Then it should be checked to make the wall exactly vertical and perfectly horizontal. When the height of outlet reaches (he height "D" as shown in the drawing, an opening has to be made preferably in the centre of the outer wall for the slurry to flow out. This is known as over-flow opening. The height of this opening should at least be 15 cm. The walls have to be vertical and finished with a smooth layer of cement plaster with a mix of 1 part cement and 3 parts sand. On the outside, the walls have to be supported with sufficient earth body of at least 1 meter wide up to the overflow level. This again is to avoid cracks.

The outlet tank should be on a slightly higher elevation than the surrounding so that there are no chances of water running into the outlet during the rainy season.

At the same time of dome casting, the concrete slabs for the outlet should be constructed. It is easy to make some additional concrete at this time and the slab will be well cured before they are placed on the outlet. Construction details of outlet and slabs are given in this manual.

The surface on which the slabs are casted, has to be flat and clean. The slab should be casted over plastic or cement bags as bed sheets on the ground. This will help the bottom of the slab to be smooth and the soil in the bottom will not soak water from the mortar. Special care has to be taken for the compaction of the concrete, as small holes will expose the steel reinforcement to corrosive vapour coming from the slurry in the outlet and will cause the corrosion which may ultimately lead to the slab collapse. The slab not only prevents men and animal from falling inside the outlet but also helps in avoiding excessive evaporation of the slurry in dry season. If, by chance, holes are formed in the slab these should be blocked with plaster layer. The slabs must be of such size that they can be handled by 4-5 men without great difficulty. The drawing and other details of outlet slab have been outlined in this table.

Plant Size (m3)	Slab Size (cm)		No. of slab	Diameter of Steel (mm)	Weight of Steel to be purchased (kg)
	Length	Width			
4	145	55	3	8	10.50
6	145	58	3	8	10.50
8	155	65	3	8	13.50
10	150	68	3	8	13.50
15	150	6S	4	S	1S.00
20	201	72	4	10	44.00

For all slabs

1.	Thickness	3" (7.5 cm)
2.	Cover	1" (2.5 cm)
3.	Spacing of rods placed longitudinally	6" (15 cm)
4.	Spacing of rods placed in cross section	*V* (30 cm)
5.	Concrete ratio	1 part of cement, 2 parts of sand and 4 parts of aggregate
6	Curing period	One week

It is important that the length, breath and height of the walls of outlet tank be constructed as per the specified dimension. The length and breadth should not he more or less than 3% of the specified dimension and the height should not differ by more than 5 centimetre. In no case, the volume of outlet tank should differ by more than 10%. The walls should be vertical - the inclination should not be more than 1 cm. The inside surface of walls should be plastered smoothly with cement sand mortar of 1:3 ratio. The outlet floor should be smooth and levelled, in no case it should be more than 0.5% out of level. While casting the slab, the reinforcement rods should be placed properly and the size of the such slabs should be as per the specification. The distance between the floor of the outlet and the top of the manhole should not differ by more than 4 centimetre.

4.8 Part - 8 : Construction Of Inlet Tank and Joining of Toilet

4.8.1 Introduction

The raw material used in the gas production, (he water-dung solution, is prepared in the inlet tank and conveyed to the digester from it through the inlet pipe. For the production of the expected amount of gas, the quality of this solution, among other things, plays an important role. Hence, for the preparation of the appropriate quality solution, it is essential that the tank is built properly and the mixing device in it is fixed accordingly. It is also possible to connect a household latrine to the biogas plant. Construction and use of a toilet not only helps in improving the environmental sanitation of the household, but the quality of the fertiliser produced is also improved if latrine is connected to the plant. There are, however, certain precautionary measures to be taken while connecting a latrine to the plant such as proper placement of the inlet pipe, use of straight pour flush pan in the toilet instead of a water seal pan for the purpose of minimising the water use, etc. hi short, the inlet lank and the latrine are also important components of the plant and care should be taken while constructing them.

4.8.2 Objectives

This part of the video deals with the following topics related to the construction of inlet tank and the latrine to make participant well acquainted:

- Necessary conditions to be met before the construction of the tank such as preparation of compacted, firm and levelled area for foundation, proper placement of the inlet pipe opening at the floor of the tank so that the flow of the solution to the digester is unobstructed and there is no residue left at the tank floor,
- Consideration of the tank height above ground for the ease in mixing the solution,
- Construction procedure of the tank and adherence to the given dimensions,
- The floor level of the inlet tank to be at least 5 cm above the bottom of the overflow opening at the outlet tank,
- Importance of the mixing device and points to be considered while selecting and fixing it,
- Discussions about the possible effects of the improper placement of inlet pipe in the inlet tank,
- Points to be considered while constructing a latrine and connecting it to the plant such as, use of straight pour flush pan instead of water seal pan, correct placement of the inlet pipe, the level at pan of the toilet to be at least 15 cm above the level at the bottom of the overflow opening of the outlet tank, etc.

4.8.3 Duration

The total time duration of this block is 7 min 05 sec.

4.8.4 Video Narration

When the construction of outlet tank is completed, now it is the turn to construct inlet tank. This tank is constructed to mix dung and water and make appropriate paste. The foundation of inlet pit should be placed in the well rammed, hard and levelled surface, hi this rammed surface, first of all the base of the inlet tank is constructed like this. Once the base is constructed the circular portion of the inlet tank is constructed where the dung and water are mixed. This pit should be constructed with a provision of mixing device. Installation of mixing device is preferable not only because it makes plant operation easier for the user but also because it improves the quality of mix. Before commencing to construct the circular portion of the tank, to fix the mixing device in position, the pivot should be placed in cement concrete like this. Then the floor of the inlet tank is made, hi this finished surface, a mark should be made of 30 cm radius to decide the circumference of die inside of the inlet tank. The inlet walls can now be constructed with the bricks kept in a circular fashion. When the height of inlet tank reaches this level, the iron bracket should be placed for the mixing device to fix in it. The mixing device has to be firmly attached to the structure, easy to operate, effective in the mixing process and the steel parts in contact with the dung are to be galvanised. The top of the structure should not be more than one meter high from the ground level.

After the completion of wall construction, one day should be allowed for it to set properly. Then both inside and outside of the tank wall has to plastered with a smooth layer of mortar with 1 part cement and 3 parts of sand. The bottom *of* the tank must at least be 5 cm above the outlet overflow level. The position of the inlet pipe in the floor must be such that pole or rod can enter through it without obstructions. For the same reason the inlet pipe must be without bends. If the inlet pipe is not placed in the right place, that is on the other side of the dome, the inlet wall has to be dismantled to insert rod or pipe through it to clear it, in case it blocks.

In case of toilet attachment to the plant it is better to construct without siphon or trap as the pan with siphon needs more water which may result in excess water inside the digester. It is also not possible to de-block the pipe when the toilet has a trap. The toilet should not be farther than 45 degrees from the hart-line. Additionally, the toilet pan level should be at least 15 cm above the outlet overflow level.

The following main points should be considered while constructing inlet tank and the toilet:

The inlet pipe should be positioned in a straight line with the turret and the centre of manhole (hart-line), the bottom of inlet tank should at least be 5 centimetres above from outlet overflow level, for easy operation the height of inlet should not be more than one metre above ground level. The walls and floor of inlet should be plastered with a smooth layer of cement sand mortar in the ratio of 1:3, the mixing device has to be firmly attached to the structure, easy to operate, effective in the mixing process and the steel pails in contact with the dung are to be galvanised and the blades should not be farther than 3 centimetre from the walls and floor. The inlet pipe should be fitted properly - a rod or pipe must be able to penetrate the digester via the inlet pipe. If toilet is be attached, the pan level should be kept at least 15 cm higher in elevation than the outlet overflow level.

4,9 Part- 9 : Pipe Laying And Fixing Of Appliances

4.9.1 Introduction

The gas produced in the digester and stored in the dome is conveyed to the point of use through the pipeline. If the pipe alignment is inappropriate or the joints and fittings are faulty, then the gas may leak or the flow may be interrupted or erratic. Hence, it is essential that the pipe and fittings used are of good quality and the mason/plumber is skilled enough to execute the task of laying and jointing of pipeline. Likewise, appliances to be used such as main gas valve, water trap, gas taps, gas lamp, gas stove etc. should also meet the set quality standards and should be fitted properly. This part of the video highlights the quality standard of the pipe and appliances and describes their fixing procedure.

4.9.2 Objectives

It is expected that the participants shall be acquainted with the following points and topics after watching this part.

- The pipe to be used for conveying the gas produced, should be of high quality galvanised iron of light class and of approved brand. The fittings should also be of good quality and of approved brands only,
- Points to be considered while selecting a proper pipe route from dome to the point of use,
- Tools and equipment required for cutting and joining of pipe such as pipe vice, die set, hacksaw, etc. and their use,
- Pipe joining method using Teflon tape for making the pipeline gas-tight,
- Importance of using as little joints and fittings as possible for minimising the risk of leakage,
- Importance of burying the pipeline under the ground for its protection,
- Points to be considered while connecting and fixing appliances like main gas valve, gas taps, gas stove, and gas lamp,
- The importance of the water trap device, its fixing method, and its placement from the point of view of protection and ease in use,
- Simple methods of leak detection.

4.9.3 Duration

The total time duration of this block is 11 min 25 sec.

4.9.4 Video Narration

The biogas produced in the digester and stored in the dome is conveyed to the point of use through pipeline. If the laying and joining of pipes is not done properly, the produced gas could not be conveyed to the point of use efficiently. Prior to starting laying of pipes, (he best possible alignment from the plant to the kitchen has to be decided. As far as possible such route should be the shortest one and with the minimum risk of damages to the pipes (hereafter. When the proper alignment is selected digging of trench has to be started. The slope of such a trench has to be gentle and appropriate so that the laying of pipe therein could be done with required slope. Now (he main gas valve has to be fitted. Attention should be given not to have any fittings rather than a nipple between the dome gas pipe and this main gas valve to avoid the risk of gas leakage.

Pipes and fittings to be used for this purpose have to meet required quality standards and they should be approved by the concerned authorities.

Prior to the laying of pipes, the length of pipe and required quantity of fitting should be estimated. The pipe has to be cut in pieces as per the requirement by the hexa-blade and thread has to be made skill fully. To make thread in pipes, vice and die-sets have to be used in a proper way. The pipe has to be secured well in the vice and die set should be used properly lo make threads. Oil a an lubricant has to be used to make the work easier. This also helps in making the thread perfectly sharp. When the threads are made and fittings are decided, the work of pipe laying and jointing can now be started.

The gas pipe conveying the gas from the plant to the point of use is vulnerable to damages by people, domestic animals and rodents and, hence, suitable measures have to be adopted for its protection. Therefore, quality galvanised iron pipe should only be used which must be, where possible, buried at least: one foot below ground level. Fittings in the pipeline must be sealed with zinc putty, Teflon tape or jute & paint. Any other sealing agents, like grease, paint only, soap etc. must not be allowed. To reduce the risk of leakage, the use of fittings should be kept to a necessary minimum. Unions should not be used.

The biogas coming from the digester is saturated with vapour. This water will condense at the walls of the pipeline. If this condense water is not removed regularly, it will ultimately clog the pipeline. Hence, a water drain has to be placed in the pipeline. The position of the water drain should be vertically below the lowest point of the pipeline so that water will flow by gravity to the trap. Water can be removed by opening the drain. As this has to be performed periodically, the drain must be well accessible and protected in a well maintained drain pit. The cover for this pit has to be casted during the period of dome casting.

When the laying of pipe is done correctly from dome *to* the kitchen, the next step is to fit the gas stove. After positioning gas tap perfectly, neoprene rubber hose pipe has to be used to join the gas tap and the gas stove. No other pipe than the approved neoprene rubber hose pipe of the best quality has to be used for this purpose. Now, as per the requirement of the user, the gas lamp has to be fitted. The assembling of different components of gas lamp has to be done with greatest care.

As soon as there is gas production, all joints and taps must be checked for leakage by applying a thick soap solution. If there is leakage the foam will either move or break.

The following main points have to be considered while laying and jointing of pipes and appliances:

- No fittings should be placed between the main gas valve and dome gas pipe and to reduce the risk of leakage the use of fittings should be kept to a necessary minimum.
- No leakage should occur from the pipeline and for this the fittings in pipeline must be sealed with appropriate sealing agents.
- To avoid damages to the pipeline by men or animals, it should be buried at least 30 cm below ground level.
- AH water condensed in the pipeline should flow by gravity to the water trap, the water trap must be well accessible, easy to operate and protected in a well maintained pit with proper covering.

The details are outlined in this construction manual.

4.10 Part- 10 : Construction Of Compost Pits And Plant Finishing Works

4.10.1 Introduction

A biogas plant provides valuable benefits to the user family. Apart from gas, the plant provides by-product, the digested slurry, which can be used as a valuable and very nutrient fertiliser, if composted properly. If the slurry is left to flow freely without composting, most of its nutrient value is lost due to evaporation and teacher. To reap optimal benefit of the slurry nutrients, it should be composted in compost pits of appropriate construction and size. Hence it is very beneficial to construct compost pits as an integral part of the biogas plant. It is also necessary to orient the farmer on the procedure of composting and the use of the fertiliser. The orientation of the farmer is also the responsibility of the plant constructing mason.

When all construction works of the plant is completed, before filling the plant with dung, the supervisor from the concerned biogas company should inspect the plant and check the construction quality as well as dimensions and installation of all components and appliances. For this purpose, the standard format prescribed by BSP (the Plant Completion Report) should be used to make note of dimensions of all components of plant and other information and remarks including that of plant owner in particular. This form is the primary source of information about the plant for BSP and care should be taken while filling the form so that relevant information is included. After the inspection of the plant and filling of the form, the farmer should be oriented on plant operation and maintenance and should be provided with the instruction booklet which deals in plant operation. Finally, the farmer should be provided with a guarantee card as prescribed by BSP. This part of the video attempts to deal with all these aspects.

4.10.2 Objectives

It is expected that participants will be familiar with the following points after the seeing this section of video:

- Importance of compost pit to reap the maximum benefit from biogas plant,
- Selection procedures of the sizes of compost pit and correct construction methods,
- Appropriate composting methods of digested slurry and proper use of slurry after composting,
- Simple post construction operational activities to be carried out for the proper functioning of plant by the plant owner,
- Points to be considered by the mason while delivering instruction to the users,
- The importance of correct filling of plant construction completion report,
- Importance of Instruction Booklet and Guarantee card and the role of company to deliver them to plant owner, and
- Completion of plant construction works.

4.10.3 Duration

The total time duration of this block is 11 min 24 sec.

4.10.4 Video Narration

Compost pits are an integral part of the biogas plant; no plant is complete without them. A minimum of 2 compost pits must be dug near to the outlet overflow in such a way that the slurry can run freely into the pits. These two pits should be used alternately to fill slurry coming out from the plant. Enough earth body must remain however, at least 1 metre, between the pits and the outlet chamber to avoid cracking of the chamber walls. The total volume of the compost pits must be at least equal to the plant volume.

Size, Numbers and Volume of Compost Pits for Different Plant Capacity should be as mentioned hereafter.

Plant Size (m3)	Minimum Size of Compost Pit (m)			Number of Pits	Total Minimum Volume of Pits
	Length	Width	Depth		
4	2.0	1.0	1,0	2	4m3
6	2.0	1.5	1.0	2	6 m3
8	2.0	2.0	1.0	2	8m3
10	2.5	2.0	1.0	2	10 m3
15	3.0	2.5	1.0	2	15 m3
20	4.0	2.5	1.0	2	20rn3

To make a potent and easy to use fertiliser, the compost pits should be filled with agricultural residue together with the slurry from the plant. The earth coming from digging the compost pits can be used for back-filling of the inlet and outlet chamber and for top filling over the dome. For proper insulation during the cold season and as counter-weight against the gas pressure inside, a minimum top filling of 40 cm compacted earth is required on the dome. If because of high ground water table, the plant is not positioned deep enough, the top filling will be prone to erosion due to wind and rain. In these cases, proper protection has to be applied.

Now, the construction works of biogas plant is complete. The mason then is providing general information on the plant operation. He made the users acquainted about the requirements of daily feeding in the digester with the paste like mixture of equal volume of water and dung as per the prescribed rate; the importance of closing of main valve after each gas use; the operation of water outlet to drain water; leak checking in the pipe joints etc. The users also get knowledge on the use of stove and importance of primary air intake. They were also taught to use and carry out minor repairs of biogas lamp. Finally, the composting methods and importance of biogas slurry was also made known to the users. Spending some days in the plant owners house as a family member, the mason in saying good-bye to the family members with the promise that he would be coming frequently to meet them.

Once the work of the mason is completed, the company sends a supervisor for the final checking of the plant. The supervisor fills the plant completion report prepared by BSP in which is mentioned the BSP file number, name and address of the company and biogas plant owner, information of cattle number and total available dung, total cost of construction, conditions of different structures and quality and brand name of fitting and appliances etc. The measurement of various parts of the plant is done and also noted in this report. Information on whether or not the plant owner is given with the operation booklet and guarantee card is also written here. If all the aspects are found satisfactorily, the plant owner is permitted to fill Ms plant with required quantity of dung and water mix.

The plant is now being filled up with the dung that was collected for many days. This family is eagerly looking to get return from their investment. See; the gas production has now started. The blue flame and this bright light of gas lamp are indicating that this family may not get trouble in fulfilling the fuel need as in the past. Further benefits through the use of nutrient slurry will increase agricultural production.

All of us involved in this field, let us help others to build quality biogas plants, let us build biogas plants for ourselves also and reap all of its benefits. Let us all contribute towards building a balanced environment of our nation. Let us walk towards the light from darkness and work all together for the bright future of our descendent.

5.0 CONCLUSION

If the concerned mason and plumber strictly follow the instructions as described in this video, during the construction phase of the biogas plant, the plant will be of high quality. Hence, the plant owner will be benefited ultimately from the investment and positive return will b e achieved as per the expectations. This again will encourage his relative and neighbors to install a biogas plant as well, while a poorly constructed plant will do harm to the reputation of biogas technology. Finally, the mason should be well acquainted with the fact (hat good quality plant will help in increasing the rate of installation of biogas plant in the country which ultimately benefits not only the plant owner but also the nation as a whole.