

## **SESSION NINE**

### **QUALITY STANDARDS**

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### Quality Standards

#### **9.1 Introduction**

Biogas is a relevant technology to make use of our development opportunities and to deal with various constraints being faced, as discussed in the previous sessions. However, the gap between the potential and its realization is so wide that there is an urgent need to expedite the rate of adoption of this technology in a mass scale.

The decision for adoption of biogas technology is made at the household level. A majority of families in Nepal are still not aware of the technology. Only a few of them have developed interest in it and still fewer are actually ready to adopt it. A well functioning plant with satisfied users, which is a prerequisite for its adoption, is the only reliable means to develop and maintain people's confidence in the technology.

Poorly installed biogas plants result in inefficiency and mal-functioning systems which lead to capital loss, frustration among owners, promoters and the donors as well. This will also damage the reputation of biogas technology causing negative impact on its adoption. The only precaution to take against such a possibility is to ensure that the desired quality is maintained for each plant that is constructed.

This session deals with various parameters required to ensure the quality of biogas plants. By the end of this session, the participants will be able to:

explain why quality control measures for the construction of biogas plants are important; and enumerate the measures being taken to ensure high quality biogas plant construction and their improved performance.

#### **9.2 The Need for Quality Control**

In the early years of 1990s, the biogas sector of Nepal witnessed (a) sharp rise in the demand of biogas plants, mainly augmented by new subsidy policy, (b) emergence of more than 20 new biogas companies with varying degree of technical capability and institutional strength as a result of the government privatization policy, (c) growing interest of NGOs, banks and other organizations to get involved in the promotion of biogas technology, and (d) implementation of a comprehensive biogas programme with long term vision, i.e., BSP phases I, II and III (BSP, 1992; de Castro, et al., 1994; BSP, 1996).

The crucial factor that led to these developments was the satisfactory performance of more than 90 percent of the plants installed. This high rate of success is taken for a period when most of the plants were of GGC design constructed by a single company (GGC). Thus, Nepal moved from a "Single-Agency, Single Model" to "Multi-Agency, Multi-Model" approach to biogas development in the country. This change favoured the strategy for rapid realization of the potential but also created a greater concern for maintaining a high rate of successful plants attained in the past. Therefore, quality control and quality assurance has become a subject of concern to all institutions involved in the biogas sector.

Till now, Nepal does not have any government agency with the mandate and capability to implement programmes for controlling the quality of plant construction and use of standard biogas appliances. It is in this context that BSP Phase II developed programmes and procedures for quality control and started the implementation procedure.

### **9.3 Development of a System for Quality Control**

BSP has devised 66 parameters for ensuring the quality of plant construction and its proper functioning (Lam and van Nes. 1994). The parameters are grouped into three categories and are presented in Annex 9.1. Any plant that fails to meet the stated parameters in category' 1 is not provided subsidy. Failure to meet specifications of category 2 requires the biogas company to pay a penalty to BSP in addition to correcting the faults without any additional fee to the user. The concerned company is warned not to repeat the mistake for failure to comply with requirements of category 3 parameters.

#### **9.3.1 Enforcement of Quality Control Measures**

The quality control system consists of four steps : Agreement on standards, agreement on penalties, control visits and calculation of the total penalty payment as described briefly below.

**Agreement on Standards :** All companies and banks involved in the BSP implementation have to agree on the parameters, their classification and definitions as given in Annex 9.1. This is a prerequisite for a biogas company to get involved in the construction of biogas plants under BSP. These parameters and their classification can be revised in agreement with all agencies involved in the programme.

**Agreement on Penalties :** All companies and banks involved in BSP implementation have to agree on the penalty system designed to enforce the quality standards. The penalty amount for different categories of defaults or failure to maintain the quality arc given in Annex 9.2.

**Control Visits :** BSP has a core group of staff/technicians who regularly make field visits to check if the agreed parameters of quality control are actually followed in the field. They randomly select 5 percent of the plants constructed by each company in the recent past (one year) for field checking. The sample includes both plants in use (filled plants) as well as plants under construction (non-filled plants). Information on these sample plants are collected through a standard questionnaire and forms developed for (a) interview with the owner of the biogas plant or, if not at home, with a relative of the owner; (h) making notes on observations; and (c) taking measurements of the plant visited. In doing so. the presence of a staff or representative of the concerned company is also required. The information thus collected by BSP staff has to be signed by the collector as well as by the representative of the company present during information collection. A report thus generated is compiled and sent to die concerned company for comments.

**Calculation of the Total Penalty Amount :** The penalty system requires companies to enter into an agreement with BSP to pay the penalty sum for any construction work that does not meet the pre-set standards. After the end of a fiscal year, the total penalty amount to be borne by the company is calculated. This is done by multiplying the penalty amount for sample plants with the 'population factor". For example, if the average penalty for different defaults found in 5 percent of the sample plants amounts to Rs 100 per plant, and if the company has constructed 20 plants in that fiscal year. the total penalty to be paid by the company would be Rs 2.000. This method is justified as long as the sample has been taken at random.

A total of 271 plants equivalent to 5 percent of the total plants constructed in FY 1995/96 were inspected by BSP staff/technicians. The average penalty per plant was calculated at Rs 98.78. This amount is substantially lower than the average penalty for the previous year. This reduction in penalty amount can be taken as an indicator of improvement in the quality of plants constructed this year compared to those of the previous year. A clear and long term policy on the use of penalty fund thus generated is yet to be formulated.

## **9.4 Important Parameters for Quality Control**

Brief descriptions on some of the important parameters for quality control are discussed below.

### **9.4.1 Designs**

The importance of different design has been dealt with in Session One. The concrete dome digester popularised by GGC was approved by BSP to be eligible for subsidy (Karki, et al., 1993). Besides this, the Deenbandhu design was approved by BSP last year for its eligibility to receive subsidy. Prior approval of BSP is necessary for (a) introduction of new designs, and (b) altering the dimension of approved designs. Failure to comply with this requirement would lead to cancellation of subsidy.

The general engineering diagram of these two designs have been presented in Session One (see Figures 1.2 and 1.3). The list of construction materials, appliances and accessories required for different volumes of GGC model biogas plants (4, 6, 8, 10, 15, 20 m<sup>3</sup>) is presented in Annex 9.3. A typical sketch of the GGC model plant is given in Figure 9.1. Figure 9.2 presents detailed dimensions of an average family size GGC plant of 8 m<sup>3</sup> capacity. Dimensions mentioned in the drawings for each part of the plant, i.e., fermentation chamber, gas chamber, inlet and outlet, must be maintained within the allowable tolerance limit.

### **9.4.2 Decision on the Size or Capacity of a Plant**

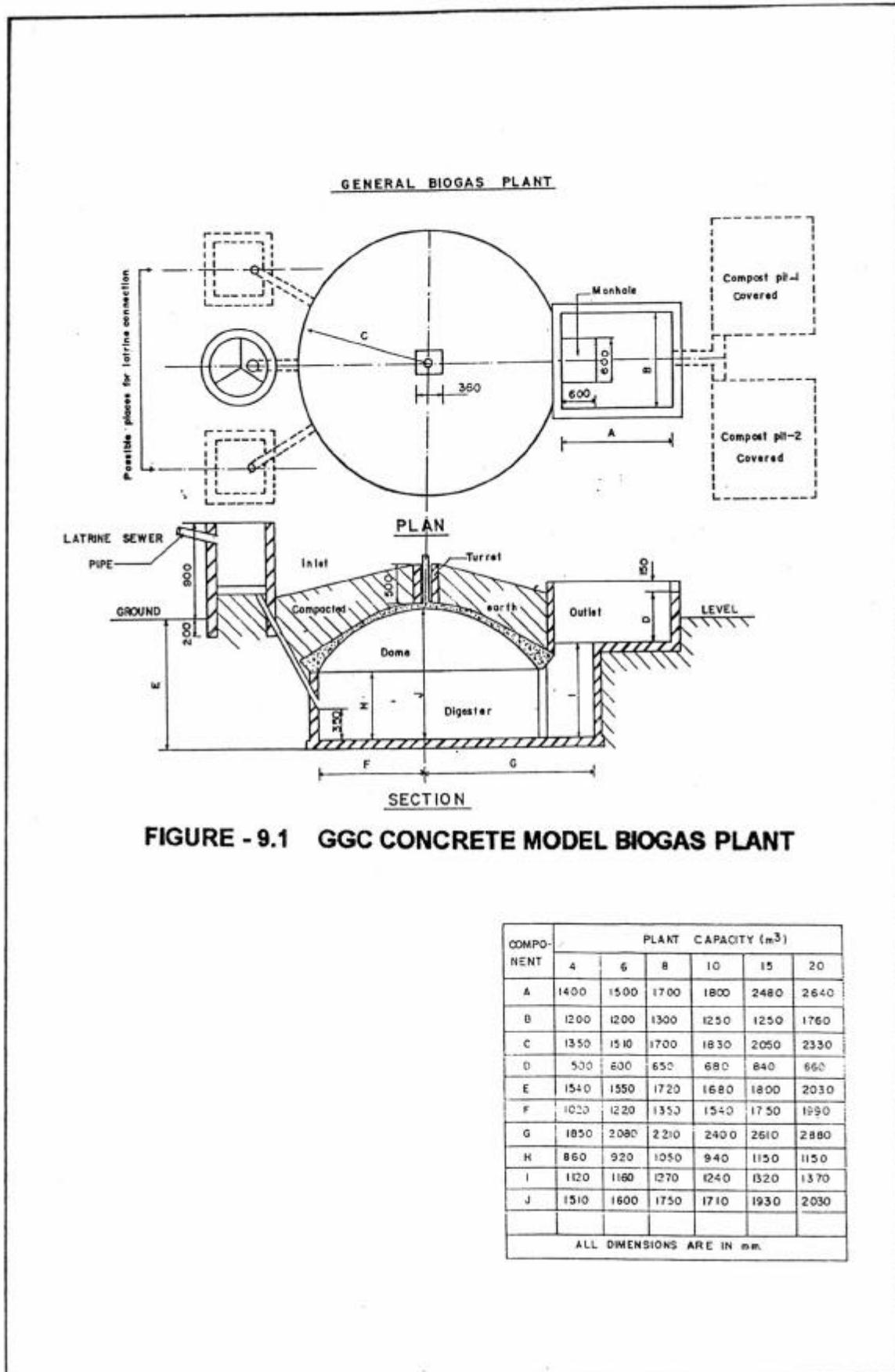
Installation of a correct size of biogas plant is important both for economic efficiency and trouble free operation. Many of the existing plants in Nepal are over-sized and hence underfed. The average size of plants constructed each year is on decline from 10 m<sup>3</sup> in 1992 to 9.25 m<sup>3</sup> in 1995. Efforts are being made to bring the average size further down to about 8 m<sup>3</sup> which is more appropriate in view of the animal holding and gas requirement of an average potential user household (de Castro, et al.. 1994),

The main criteria to decide on the correct size of plant are the cooking and lighting requirements of a family along with the number of cattle heads for die availability of feeding materials. A 8 to 10 m<sup>3</sup> capacity biogas plant produces 1.5 to 2.0 nr of gas per day which is sufficient to cook for a family of 6 to 8 members. On an average, about 0.3 m<sup>3</sup> of gas is needed per person per day for cooking, and biogas lamps consume 0.10 m<sup>3</sup> to 0.15 m<sup>3</sup> of gas per lighting hour {Karki and Dixit, 1984}. A thumb rule of 6 kg of dung in 24 hours per m<sup>3</sup> of gas production can be used to estimate required amount of dung and die size of a digester.

### **9.4.3 Site Selection**

Following are the factors to be considered in selecting the appropriate site for plant construction.

- The site should be exposed to the sun.
- The plant should be close to the animal shed and water source. It should also be close to the kitchen to minimize the cost of gas delivery pipe.
- It should be at least 10 m away from well or any other groundwater sources to avoid groundwater pollution
- As far as possible, plant construction should not be encouraged if the water source is located at a distance of more than 20 minutes' walk.



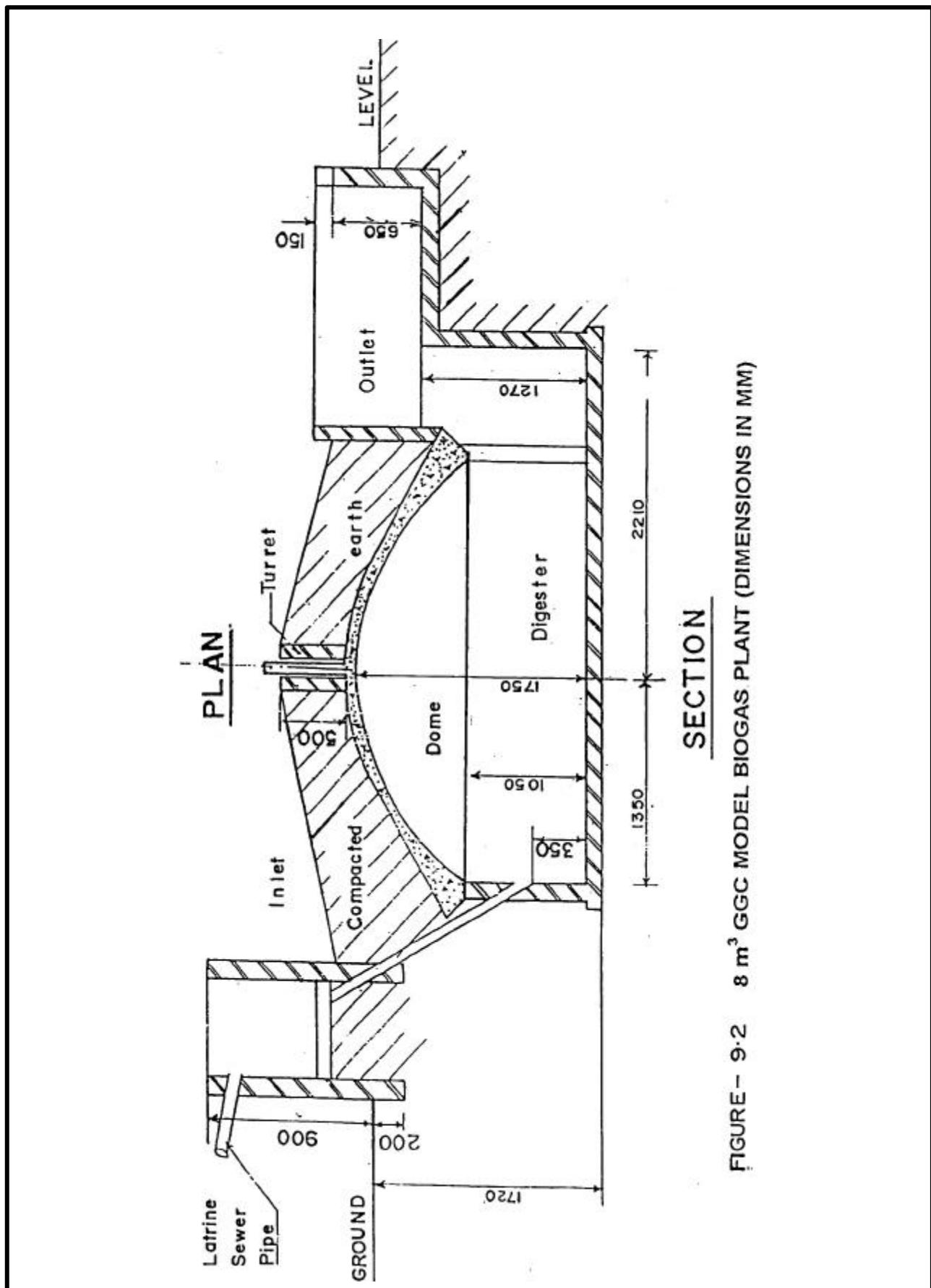


FIGURE – 9-2 8 m<sup>3</sup> GGC MODEL BIOGAS PLANT (DIMENSIONS IN MM)

#### 9.4.4 Construction Materials and Trained Masons

Even if the approved design and trained masons are used, the actual construction work could still suffer due to the use of the poor quality construction materials such as cement, sand, bricks, water and aggregates.

**Cement** : Cement containing  $3\text{CaCO}_3\cdot\text{Al}_2\text{O}_3$  and  $3\text{CaCO}_3\cdot\text{SiC}_2>2$  is preferred because of its fast hydration rate and less shrinkage. Cement containing impurities may lead to poor quality structure. Cement should be fresh (not more than six months old), without lumps and should be stored in a dry and cool place.

**Sand** : Sand containing more than 3 percent dirt or soils should not be used. Preferably, sand should be washed with clean water before mixing it with cement.

**Gravel/Aggregates** : The dome thickness of GGC design is not more than 7.5 cm. Therefore, gravel of 10 to 20 mm size should be used. If gravel is mixed with soils, it should be washed in clean water.

**Water** : Water is needed to prepare mortar for masonry work, concreting and plastering. It is also required for washing the aggregates, bricks and the stones used for construction. To ensure the quality of construction, clean water should be used for masonry work. Water from ponds and irrigation canals containing sediments and colloidal materials should not be used for masonry work.

**Bricks** : Bricks are generally used in the construction of biogas plants in the plains and in urban areas where it is easily available. Well baked bricks with uniform dimension should be used. The quality of the baked bricks can be judged by hitting two bricks together. Well baked bricks produce metallic sound when struck against each other. It is necessary to soak bricks in water before use. If the bricks are not wet, they will absorb moisture from the cement mortar which will weaken the joints.

**Stones** : Usually stones are used in those places where bricks are not easily available, particularly in the hills and mountains. Hard, clean and good quality stones should be used. If they are dirty, they should be washed with clean water before use.

**Use of Trained Mason** : Masons from biogas companies are well trained in all aspects of the construction including site selection. They are assigned to the construction work only after providing theoretical and practical training for two months. Therefore, the services of well trained masons from the recognized biogas companies should be used for plant construction.

#### 9.4.5 Critical Stage of Construction

Although every stage of the construction is important, the following stages are considered critical. Once a faulty structure is established, it will be very difficult to rectify it and sometimes, the whole structure needs to be demolished. These stages should be carefully noted and corrected on time to save the wastage of the scarce resources as well as to keep up the popularity of the technology among users and potential users.

**Locating the Central Point** : Special attention has to be paid for fixing the central point of the biodigester. If the central point is not properly located, the plant size will differ which leads to malfunctioning of the plant. Therefore, before excavating the pit for the construction of the plant, the central point should be well located and the same reference point should be used to locate other points in the course of construction. The method of the fixing the central point has been illustrated in Figure 9.3.

**Dome Casting :** Casting of dome is a critical stage of construction. After construction of the digester wall, the plant is filled with soil up to its highest point in such a way that it should take a shape of a dome. Required shape of the dome can be maintained precisely by using a template (Figure 9.4). A thin layer of sand is spread over the desired shape of dome so that the soil can be removed easily after casting the dome. Cement, sand and gravel are used at the ratio of 1:4:8 for dome casting. Concrete work needs to be completed in one day. Curing of the dome should be done properly. A simple method of curing is to cover the dome with well soaked gunny bags for at least seven days.

**Back Pilling :** The gap between the wall of the structure and outer excavated part should be carefully filled with sufficient amount of soil. Then, it should be rammed well for compaction. Digester walls may show cracks if the back fill is not sufficiently compacted.

## 9.5 Appliances and Accessories

Among various appliances, the biogas users need gas stove (burner), lamps and accessories like main stop cock, gas tap and other fittings. These appliances, mainly the burners and lamps, are imported from India. Presently, due to rapid increase in the installation of biogas plants in Nepal, import of large number of appliances is becoming difficult day by day. Suitable types of biogas burners are being manufactured in Nepal, especially by GGC Workshop at Butwal, and the quantity produced does not meet the demand of all the biogas companies. Therefore, import of these appliances from India is necessary. As reliable quality of the main stop cock is not available in Nepal and India, it is being imported from the Netherlands and is costly. The quality of biogas accessories available in the market vary widely.

Some of the materials available in the nearest market are too expensive or last for only a short period. The users have to replace them very frequently. This is the reason for importing the main gas valve from the Netherlands.

The specification of biogas burner manufactured by GGC Workshop is given in Figure 9.5. A list of BSP approved appliances and their manufacturers is given in Annex 9.4.

BSP performs quality test of biogas appliances and provides approval certificate to the suppliers or producers in Nepal and India. It also verifies whether the appliances are according to the required sizes. BSP also provides limited support to encourage in-country production of biogas appliances.

The companies that produce or use such standard appliances need to provide a one year guarantee services to users. If there is a malfunction in these appliances within the guarantee period, the companies are required to replaced them free of charge. However, applying quality control measures on lamps has been comparatively difficult as they have to be imported from India. GGC has made some attempt to produce lamps in Nepal but this is still in the experimental stage.

## 9.6 Commissioning

After construction, the plant is loaded with a mixture of dung and water. For example, if cow dung is used, one part of water should be mixed to one part of fresh dung for achieving the desired consistency of the slurry (see Session One). Depending upon the season and ambient temperature, it may take from one week to about 4 weeks for the production of combustible gas in the digester. Addition of effluent from operating plants have been found to reduce the gas generation time. The gas first generated has high CO<sub>2</sub> content and does not burn. Therefore, the initial gas volume needs to be vented to release excessive CO<sub>2</sub>. Regular feeding of digester with recommended amount of input mixture has to be continued till the gas starts burning smoothly. Regular feeding of inputs in required quantity and

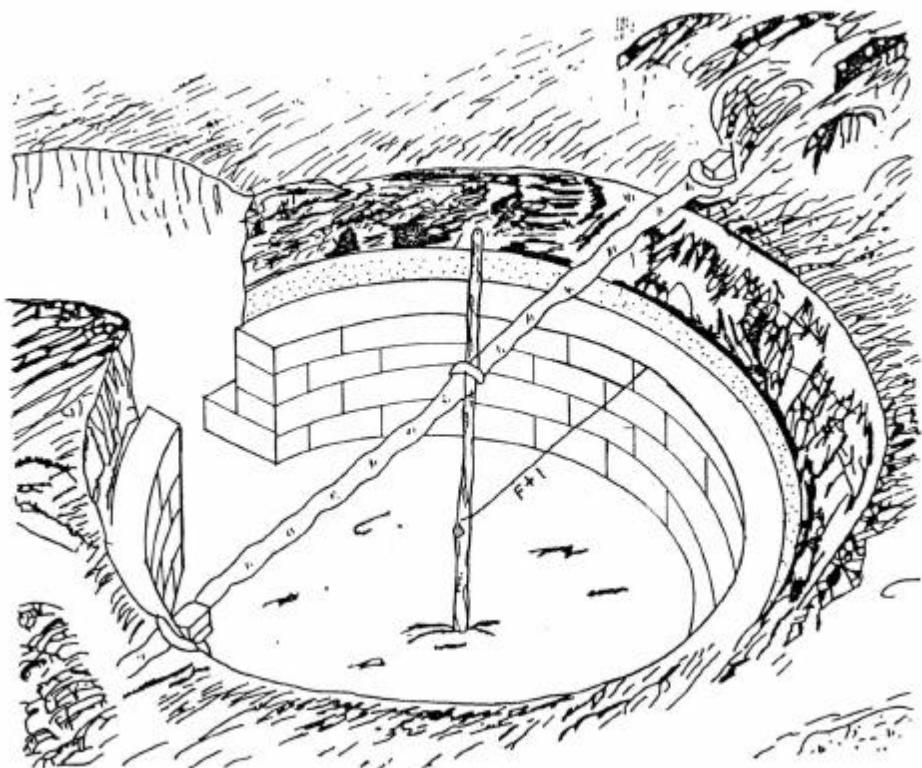


FIGURE-9-3 FIXING THE CENTRAL POINT OF BIODEGESTER

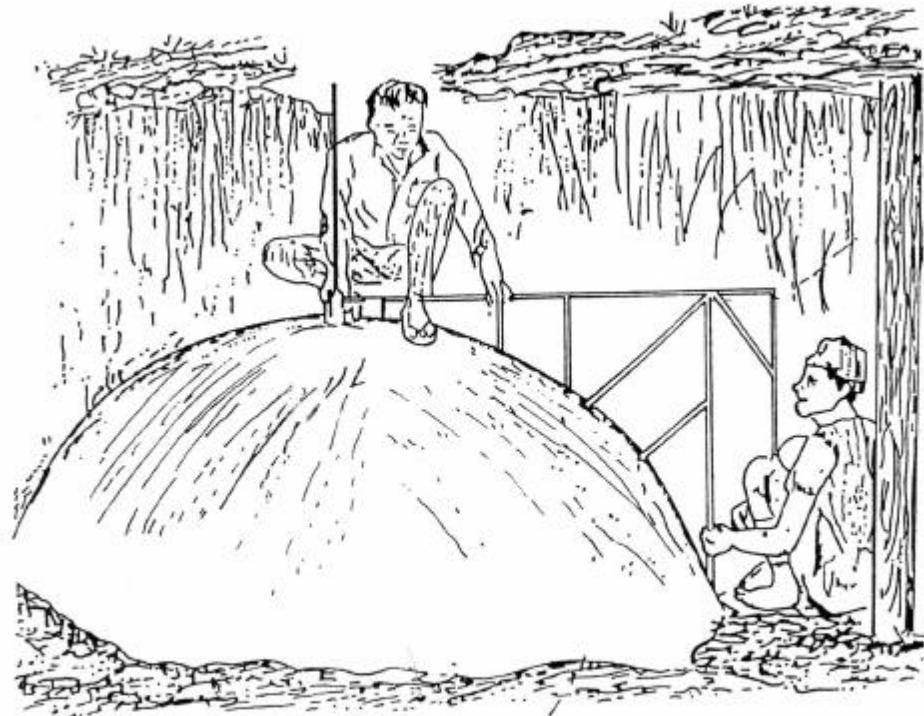
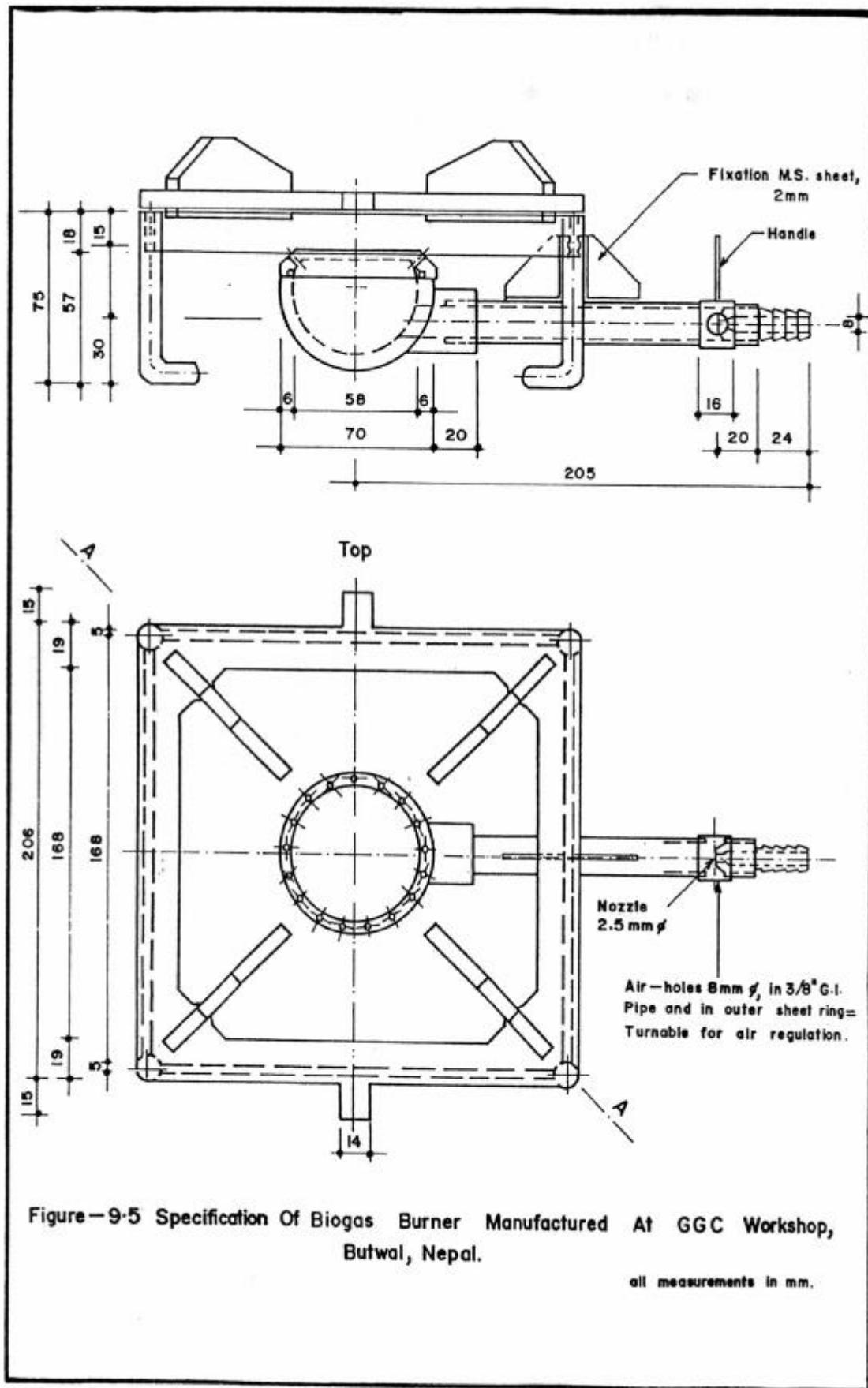


FIGURE - 9-4 MAINTAINING REQUIRED SHAPE OF THE DOME WITH THE HELP OF A TEMPLATE



**Figure—9·5 Specification Of Biogas Burner Manufactured At GGC Workshop, Butwal, Nepal.**

all measurements in mm.

regular use of the gas will ensure trouble-free operation of the biodigester (Karki and Dixit, 1994; Khandelwal and Mahdi, 1989).

First hand knowledge on operation procedures of biogas plants is provided to the users by the masons at the time of plant construction. Following their instructions, the users operate their plants for six months. Then, the biogas company organizes users' training for the benefit of users of nearby areas. Women users are given priority in such training.

Various problems encountered during initial plant operation phase are discussed in the training. The training covers different aspects of plant operation including technical problems and their possible solutions, proper utilization of digested slurry, advantages and disadvantages of biogas plants, after-sale-services of the biogas companies and repayment of bank loan. Due to geographical inaccessibility, it is very difficult to cover all biogas plants by group training and therefore, they are also supported by after-sale-service

s of the companies. The users' training and users-to-users contact encourages beneficiaries to operate their plants with improved performance and this also motivates non-users for biogas plant installation.

### **9.7 After-Sale-Services**

After-sale-services consist of six years guarantee on structural part of the plants and one year guarantee on appliances and fitting works. Furthermore, guarantee fee paid by the plant owners also covers annual follow-up visits up to the guarantee period of six years. The technicians inspect the plants and repair/replace the defective parts of the plants free of cost within the guarantee period. The cost of repairing the defects after the expiry of guarantee period has to be borne by the plant owners.

There is a general complaint that the biogas companies have the tendency to ignore the post installation services. In principle, it is the duty of the company to rectify the defects noticed in the plants within the guarantee period. Many users have reported that there is a delay on the part of the company to send their technicians for timely inspection after construction. The users have also been instructed to lodge complaints in case problems arise but they generally fail to do so. They are reluctant to report in writing. On the other hand, there is a general tendency that the representatives of the companies ignore the verbal complaints of the users.

One of the measures taken by BSP to ameliorate such problems is to deposit the guarantee fee charged by a company in a bank account jointly operated by BSP and the company. A part of this deposit is released to the company only after a report is submitted by the company on site visits made to plants constructed in the previous year.

### **9.8 Mobile Team for Supervision, Follow-up and Monitoring**

Biogas companies tend to construct as many plants as possible within a short duration. Their intention is to make more profit by economizing the construction materials. There is also a possibility of using low quality materials by the companies to take advantage of limited knowledge and ignorance of the users. To deal with such possibilities, BSP has employed a mobile team of technicians.

It is physically difficult to inspect every plant constructed by all of the 23 companies and NGOs involved in the construction of biogas plants. Therefore, the mobile team randomly selects 5 percent of plants to be visited every month. Appropriate forms and questionnaire have been developed to record information on the plants visited. Based on the report of this team, BSP informs companies about the problems of the plants and suggests necessary repair works. Depending upon the type of the problems, the company is charged a penalty amount.

## 9.9 Common Problems in Plant Operation

A properly installed biogas plant with regular maintenance provides trouble-free services to the user for years. It is important to educate the users on O&M of the plants. Some of most common problems in the course of day-to-day operation as reported by the biogas users in Nepal are discussed below (Karki. etal., 1994;Gautam, 1996).

**Leakage from Pipe Line :** The low quality plumbing materials and their fittings have been the main cause of gas leakage from the joints of the delivery pipes. When low quality pipes such as thin walled PVC pipes are used for gas delivery, they tend to burst frequently. Compared to GI pipes. PVC pipes are more affected by temperature differences and degrade faster. Taking this into consideration, BSP strictly prohibits the use of PVC pipes for biogas conveyance and recommends the use of GI pipes.

**Leakage from Main Gas Valve :** Leakage from the main gas valve is one of the most common and serious problems. The valves found in the market are not durable and need to be changed frequently. Several products which have already been tested are proved to be inefficient in this regard. This has caused inconvenience to the users. However, attempts are being made to locally manufacture these products. At present, high quality main valves are imported from the Netherlands.

**Slurry in the Pipe Line :** Entry of slurry into the gas pipe has been a problem in appreciable number of biogas plants. Some of the reasons for this problem are described below:

- In course of feeding the digester for the first time, users generally tend to fill it upto the uppermost level leaving little space for the collection of gas. In this situation, when gas production starts, the pressure thus developed pushes the slurry into the gas pipe.
- Gas production decreases in the winter. The users continue to feed the digester with the same amount of dung as in the summer. In such overfilled digesters, the upward pressure of gas trapped at the bottom and the suction effect created at the top (gas chamber) cause the slurry to flow into the pipe system.

To solve this problem, some slurry should be taken out from the outlet and the gas pipe should be disconnected and cleaned thoroughly.

**Carbon Deposition in the Gas Burner :** Carbon collected in the burner jets blocks the flow of gas when kitchen appliances are not regularly cleaned after use. To overcome this problem, the cooking stoves should be cleaned daily after use.

**Lamps :** So far as cooking is concerned, the users are satisfied with the performance of biogas stoves and burners. No major problems have been reported. Compared to biogas stoves, the biogas lamps have more problems in terms of frequent gas leakage and breakage of glass and mantles. The attention of the manufacturing companies has to be drawn to improve the quality of their lamps based upon the feedback from the users.

**Over-sized Plants :** The users generally tend to install larger size plants than they require or can feed with the amount of dung available. In many cases, plant sizes do not correspond to the number of cattle that the user possesses, or more specifically, the amount of dung available and hence the plants are underfed. Construction of such over-sized plants results in added financial burden to the user without any additional benefit.

**Moisture in Drain Pipe :** Water vapour together with the gas condense in the pipe line. After a lapse of time, water accumulates inside the pipe and thereby restricts the flow of gas. To drain this water, a

moisture trap is installed at the lower level of the gas pipe. Sometimes, gas also leaks from the drain pipe as the gasket of the stop cock gets loosened. In such cases, a rubber disk is attached to the gasket and tightened.

**Gas Formation During Winter :** During the winter season, microbial activities decrease as a result of the decrease in the atmospheric temperature which affects the rate of gas production. To overcome this problem, various methods have been tried but no effective solution has been found as of yet. For example, the slurry was warmed in the sun during the day time and was then fed into the digester in the late afternoon. Another method tried was to insulate the digester by covering it with a thick layer of straw which was then covered with a plastic sheet. These methods were found useful to raise the temperature of the digester to some extent but no appreciable difference in gas production was noticed.

Most common problems in plant operation and their possible remedies are given in Table 9.1.

**Table 9.1**  
**Common Problems with Biogas Plants and Their Remedies**

Defect	Cause	Remedy
<p>1. Installation</p> <ul style="list-style-type: none"> <li>- Cracking of digester wall</li> <li>- Gas leakage</li> <li>- Accumulation of water in pipe lines</li> </ul>	<p>Sinking of foundation or improper back filling Improper sealing of joints Improper installation of water trap</p>	<p>Repair and do proper back filling Check and repair Check level and set the water trap at correct position. Drain water on a weekly basis.</p>
<p>2. Operation</p> <ul style="list-style-type: none"> <li>- No gas after first filling or plant</li> <li>- Slurry level does not rise in outlet chamber even insufficient gas is coming.</li> <li>- No gas in the stove but plenty in the plant</li> <li>- Gas does not burn</li> <li>- Flame far from burner</li> <li>- Flame dies quickly</li> <li>- Clogging inlet and outlet pipes</li> <li>- In sanitary condition around biogas plant</li> </ul>	<p>Lack of time Insufficient amount of feeding Leak in pipe Gas pipe blocked by water condensation Wrong kind of gas Pressure too high or deposition of carbon on the nozzle Insufficient pressure Addition of materials other than clean dung Improper digestion Improper disposal of slurry</p>	<p>It may take 3-4 weeks Add more dung and water Check and correct Remove water from moisture trap. Add properly mixed dung Adjust gas outlet valve and clean nozzle Check quantity of gas production and feeding Use dung only after filtering other materials. Clean inlet and outlet with a bamboo stick Add correct quantity of dung and water Regularise</p>

Source: Khandelwal and Mahdi, 1989

## 9.10 Session Plan

Activity No	Topic and Area of Discussion	Time {min.}	Methods of Training	Teaching Aids
1.	Highlighting the importance of quality control	3	Lecture	Transparent sheets, flip chart
2.	The need for quality control and programme development	4		
3.	Development of a system for quality control	4		
4.	Important parameters for quality control	4	Lecture cum discussion	O/H projector, screen, and flip chart
5.	Various parameters for quality standards	6	Lecture cum discussion	O/H projector
6.	Bringing the plant to operation	4	Lecture cum discussion	O/H projector
7.	After-sale services	4	Lecture cum discussion	O/H projector
8.	Mobile team for supervision, follow up and	4	Lecture cum discussion	O/H projector
9.	Supervision, follow up and monitoring, after sales	5	Lecture cum discussion	O/H projector
10.	Common problems in plant operation	7	Lecture cum discussion	O/H projector
11.	General discussion	15	Discussion	
<b>Total Time</b>		<b>60</b>		

## 9.11 Review Questions

- Why is quality control so important for the promotion of biogas system, especially in the present context?
- List the important parameters for quality control.
- What appliances are manufactured in Nepal?
- Why is selection of plant design based on the feeding materials available for biodigester?
- Explain different critical stages in biogas construction.
- What are the after-sale services that a biogas company is required to provide?
- How is the penalty system enforced on biogas construction companies?
- List the common problems of biogas plants and their solutions.

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### **9.13 Further Reading Materials**

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**BSP Standards as to Quality of Biogas Plants (Fy 2050/51)**

S.N.	Quality Standards	Category	Specification
<b>A.</b>	<b>General</b> 1. Only one plant per family 2. No. of plants fed with only night-soil 3. One year guarantee on appliances and 4. Six years guarantee on structure 5. six years after-sales -service	1 1 1 1 1	Inlet should be constructed and used Except mantle and glass of gas lamp  According to annex of letter
<b>B.</b>	<b>Labour</b> 6. Certified mason	1	Trained by GGC for minimal 60 days and certified
<b>C.</b>	<b>Design</b> 7. Based on GGC - drawings dated (14-05-	I	Plant sizes: 4. 6. 8, 10, 15. 20 m <sup>3</sup> including round wall
<b>D.</b>	<b>Construction materials</b> 8. Good quality bricks 9. Good quality sand 10. Good quality gravel  11. good quality stones 12. Good quality cement 13. Acrylic emulsion paint 14. Rod (to be used (o reinforce slabs)	3 2 2  3 2 2 3	Best quality locally available Less than 3% impurity by bottle-test Clean; size; 0.5-1.5 cm temporarily maximum; 4 cm clean Fresh; no lumps  Diameter minimum 6 mm
<b>E.</b>	<b>Construction</b> <i>(a) Digester</i> 15. Accuracy radius of round-wall 16. Accuracy plumb of round-wall 17. Accuracy height of round-wall 18. proper Back -filling brick wall  19. Proper back -filling stonewall 20. Well finishing of inside round-wall  <i>(b) Dome</i> 21. Proper use of template make mud mould 22. Accuracy height of dome 23. Accuracy radius of dome 24. Proper treatment inside dome  25. Gas pipe at centre point 26. Proper top-filing done  <i>(c) Turret</i> 27. Proper diameter to protect gas pipe 28. Proper height lo protect gas pipe 29. Gas pipe in centre of turret	2 3 2 3  3 3  2 2 2 2  3 3  2 2 2  2	± 2% on basis of plastered wall ± 1 cm ±5 cm By a compacted mix of small stones and water Against the pit side Smooth layer of plaster (mix = 1 :3 sand ), no cracks  Template as fabricated by GGC ±5 cm ± 2% on basis of plastered dome To GGC instructions; clean and surface; no cracks ± 2% of radius round -wall Min 40 cm compacted earth, protected against erosion  Round (diameter min 36 cm) or (min. 36x36 cm) Top turret maximum 5 cm below reduction elbow Minimal 12 cm support at every side

S.N.	Quality	Category	Specification
	<i>(d) Outlet</i>		
30.	Accuracy of length	2	$\pm 3\%$
31.	Accuracy of width	2	$\pm 3\%$
32.	Accuracy of depth	2	$\pm 5$ cm
33.	Accuracy plumb of walls	3	+ 1 cm
34.	Proper back-filling walls	3	Upto overflow level with enough earth body
35.	Well finishing inside walls	3	Smooth layer of cement plaster (1:3); cracks
36.	Covered by proper reinforced slabs	2	Manage able without problems. reinforced at 2 cm from bottom
37.	Accurature distance "bottom outlet-top manhole"	3	$\pm 4$ cm
	<i>(e) Compost pits</i>		
38.	Digging of at least two compost pits	3	Total volume minimal equal to plant volume
	<i>(f) Met</i>		
39.	Proper position	2	In straight line with turret and manhole
40.	Maximum height	3	Maximum 100 cm above ground level
41.	Well finishing inside wall	3	Smooth layer of cement plaster (1:3); crack
42.	Proper installation mixing device	3	Firmly attached to structure
43.	Easy to operate	3	
44.	Straight inlet pipe	2	
	<i>(g) Toilet attachment</i>		
45.	Proper position inlet pipe	2	Minimal 135° with turret and manhole
46.	Proper position toilet pan	2	Level minimal 15 cm higher then level overflow of outlet
F.	<b>Appliances and pipes</b>		
47.	Dome gas pipe	2	Length: 75 cm; 1.5 GI-light quality 1239-1979); anchors
48.	Main gas valve	2	Holland made ball valve (vhs )
49.	Pipe and accessories	2	GI-light quality (IS 1239-1979); 0-100 m, 0.5*; 100-200 m; 0.75*
50.	Water drain	2	Made by GGC-work shop
51.	Gas tap	2	Tested by GGC Workshop at 300 m pressure
52.	Gas stove	2	Made by GGC Workshop or from India (IS 8749-1978)
53.	Rubber hose	3	No cracks when folded
54.	Gas lamp	3	In working condition at delivery
55.	Inlet pipe	2	At least 10 cm internal diameter
56.	Mixer	3	Made by GGC workshop (galvanised)
G.			
57.	No fittings between reduction elbow and valve	2	
58.	No unnecessary fittings in pipe line	3	
59.	No gas leakage in pipe line	3	

S. N		Category	Penalty (Rs)
35.	Plaster not smooth or cracked	3	
36.	No slabs	2	
37.	Bottom outlet -top man hole not within ± 4 cm <i>(e) Compost nits</i>	(***) 3	100
38.	No or insufficient volume compost pit <i>(f) Met</i>	3	
39.	Not in straight line with turret and manhole	2	
40.	More than 100 cm above ground level	3	100
41.	Plaster not smooth or cracked	3	
42.	Mixing device not firmly attached	3	
43.	Not easy to operate	3	
44.	No straight inlet pipe <i>(g) Toilet Attachment</i>	2	50
45.	Inlet pipe (135 degrees with turret and	2	50
46.	Level toilet pan (15 cm higher than overflow level)	2	50
<b>F.</b>	<b>Appliances and Pipes</b>		
47.	Dome gas pipe not according to specification	2	100
48.	No Holland made ball valve	2	150
49.	No GI - light quality	2	200
50.	Water drain not made by GGC workshop	2	50
51.	Gas tap not tested by GGC workshop (300 m	2	50
52.	No GGC or India /IS approved stove	2	
53.	Rubber hose cracks when folded	3	
54.	Not in working condition at delivery	3	
55.	Inter diameter inlet pipe less than 10 cm	2	50
56.	No GGC mixer ( galvanised)	3	
<b>G.</b>	<b>Fitting and Layout of Gas Pipes</b>		
57.	Fitting s between reduction elbow and gas	2	150
58.	Unnecessary fittings in pipe line	3	
59.	Leakage in the pipe line	3	
60.	No proper sealing agent	2	50
61.	Pipe buried less than 30 cm	3	
62.	Pipe not safe against damage by animals &	3	
63.	Drain not able to trap all water in pipe	(*) 2	50
64.	Drain not easy accessible	3	
65.	Drain not easy to operate	3	
66.	Drain not protected by proper pit with cover	(*) 2	50

Default related to (\*) will be penalised only once.

(\*\*\*) higher toleration's in filled plants due to measuring faults.

Source: Gobar Gas Sahayog (BSP) Gobar gas plant ko Gunastar Niyantran (in Nepali) F.Y.  
2052/53 (A working document on quality control 1994).

**Lists of Construction Materials and Appliances**

S. N.	Particular	Unit	4 m <sup>3</sup>	6 m <sup>3</sup>	8m <sup>J</sup>	10 m <sup>J</sup>	15 m <sup>3</sup>	20 m <sup>3</sup>
<b>1.</b>	<b>Building Materials</b>							
	Bricks	piece	1,200	1,400	1,700	2,000	2,400	2,800
	Sand	bag	60	70	80	90	110	120
	Gravel	bag	30	35	40	50	60	70
	Cement	bag*	11	13	16	19	27	34
	6 mm rod	meter	50	60	70	70	90	100
	Paint	liter	1	1	1	2	3	4
<b>2.</b>	<b>Building Labour</b>							
	Skilled labour	days	8	8	11	11	13	15
	Unskilled labour	days	20	25	30	35	45	55
<b>3.</b>	<b>Pipe and Appliances</b>							
	Vertical mixture device	piece	1	1	1	1	1	-
	Horizontal mixture	piece	-	-	-	-	-	1
	Inlet pipe	piece	2	2	2	2	2	2
	Dung gas pipe	piece	1	1	1	1	1	1
	G 1 pipe	piece	12	12	12	12	12	12
	Sockets	piece	3	3	3	5	5	6
	Elbow	piece	5	6	8	8	10	12
	Tee	piece	1	2	2	3	4	5
	Union	piece	1	1	1	1	1	1
	Nipple	piece	3	3	4	4	6	6
	Main gas valve	piece	1	1	1	1	1	1
	Water tank	piece	1	1	1	1	1	1
	Robber hose	meter	1	1	1	2	2	2
	Gas stove	piece	1	1	1	2	2	2
	Gas lamp	piece	-	1	1	1	2	3
	Teflon tape	roll	2	2	2	3	3	4

\* In case of stone masonry, the extra cement required for different sizes of plants is given below:

- |                              |                        |
|------------------------------|------------------------|
| for 4 and 6 m <sup>3</sup>   | 1 extra bag of cement  |
| for 8 and 10 m <sup>3</sup>  | 2 extra bags of cement |
| for 15 and 20 m <sup>3</sup> | 3 extra bags of cement |

**Most Common Defects and Penalty Categories including the Penalty Amount**

S. N	Default		Category	Penalty (Rs)
<b>A.</b>	<b>General</b>			
1.	Second, third etc. plant per family	(*)	1	All subsidy deducted
2.	Plant fed with only night soil	(*)	1	"
3.	1 year guarantee on appliance/pipes not	(*)	1	"
4.	6 years guarantee on structure not provided	(*)	1	"
5.	6 years after -sales -services not provided	(*)	1	"
<b>B.</b>	<b>Labour</b>			
6.	No certified mason	(*)	1	"
<b>C.</b>	<b>Design</b>			
7.	Other design than 04-05-2047(no round-wall)	(*)	1	"
<b>D.</b>				
8.	Unnecessary low quality bricks		3	
9.	Impurity in sand more than 3%	(**)	2	700
10.	Size gravel bigger than 4 cm	(**)	2	700
11.	Dirty stones		3	
12.	Not fresh cement or with lumps	(**)	2	700
13.	No acrylic emulsion paint		2	150
14.	Diameter rod not less than 6 mm		3	
<b>E.</b>	<b>Construction</b>			
	<i>(a) Digester</i>			
15.	Radius of round - wall not within $\pm 2\%$	(***)	2	100
16.	Plumb of round -wall more than $\pm 1cm$		3	
17.	Height of round -wall not within $\pm 5 cm$	(***)	2	100
18.	No proper back -filling brick wall		3	
19.	Stone wall not constructed against pit wall		3	
20.	Plaster not smooth or cracked		3	
	<i>(b) Dome</i>			
21.	No use of template	(**)	2	700
22.	Height of dome not within $\pm 5 cm$	(***)	2	50
23.	Radius of dome not within $\pm 2\%$	(**)	2	50
24.	Not like GGC instructions; not smooth or		2	700
25.	Gas pipe not within $\pm 2\%$ of radius round-wall		3	
26.	Less than 40 cm top-filling on done		3	
	<i>(c) Turret</i>			
27.	Diameter less than 36 cm		2	100
28.	Top turret more than reduction elbow		2	25
29.	Less than 12 cm support at any side		3	
	<i>(d) Outlet</i>			
30.	Length not within $\pm 3\%$		2	25
31.	Width not within $\pm 3\%$		2	25
32.	Depth not within $\pm 5 cm$		2	25
33.	Plumb of walls not within 1 cm		3	
34.	Black-filling more than 5 cm below overflow		3	

S.N.	Quality Standards	Category	Specification
60	Use of proper sealing agent	2	Jute & plant, zinc putty or Teflon
61	Pipe buried at least 30 cm, if possible	3	
62	Pipe safe against damage by animals &	3	
63	Drain able to trap all water in pipe	2	
64	Drain easy accessible	3	
65	Drain easy to operate	3	
66	Drain protected by proper pit with cover	2	

Category I means: No subsidy, 2: penalty; 3: no penalty

Source: Jan Lam and Wim J. VanNes (1994) Enforcement of Qualify Standards upon Biogas Plants in Nepal. BSP