SRI LANKA STANDARD 1002 : 1993

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CODE OF PRACTICE FOR

PARBOILING OF PADDY

SRI LANKA STANDARDS INSTITUTION

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SLS 1002 : 1993

Gr.11

SRI LANKA STANDARDS INSTITUTION
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Colombo 3,
Sri Lanka.

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This standard does not purport to include all the necessary provisions of a contract.

C O N T E N T S

SRI LANKA STANDARD
CODE OF PRACTICE FOR PARBOILING OF PADDY

FOREWORD

This standard was finalized by the Sectoral Committee on Cereals, Pulses and their Products and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 1993-12-26.

In Sri Lanka approximately 70 per cent of the paddy production is consumed in the parboiled form. This process is mainly done to improve the milling characteristics of paddy and to obtain rice with better cooking and eating qualities.

Parboiling, a hydrothermal treatment given to paddy before milling, consists essentially of soaking paddy in water, steaming the soaked paddy and drying to a moisture content suitable for milling. To achieve the purpose of parboiling these three steps should be well controlled.

In the preparation of this code, the valuable assistance derived from the following publications is gratefully acknowledged :

i) IS : 12064 : 1987 - Indian Standard Code of Practice for Paddy Parboiling.

ii) Publications of the Rice Processing Research and Development Centre.

1 SCOPE

This code recommends domestic, traditional, semi-modern and modern methods for parboiling of paddy.

2 DEFINITIONS

For the purpose of this code the following definition should apply :

2.1 **parboiling of paddy** : Parboiling of paddy is a hydrothermal process that may be defined as the gelatinization of starch within the rice grain. During the process, an irreversible swelling and fusion of starch granules occurs that changes the starch from a crystalline form to an amorphous form. As a result of this transformation, the orderly polyhedral structure of the compound starch granules changes into a coherent mass.

3 PARBOILING PROCESS

Parboiling of paddy requires three steps, namely soaking, steaming and drying.

3.1 Soaking

Paddy, being a hygroscopic material, can absorb water both as vapour and as liquid and thereby swells. The process of simultaneous absorption of water and swelling is known as soaking, steeping or imbibition. The main objective of soaking paddy is to remove air or void spaces trapped among the starch granules and this can be accomplished by either soaking in water at ambient temperature which is known as cold soaking or soaking in hot water maintained at 70 °C. Generally the moisture content of soaked paddy is about 30 per cent to 35 per cent. The soaking is basically a diffusion process. The movement of water into the paddy will continue as long as the vapour pressure inside the grain is less than that of the soaking water and will stop when equilibrium is reached.

3.1.2 For soaking to be effective, following conditions appear to be necessary :

a) Grain size should be uniform. This determines the depth to which the water penetrates;

b) The caryopsis should be entirely covered by the husk. If the caryopsis is exposed, its shape and colour would be spoilt;

c) A certain affinity must exist between paddy and water;

d) A diffusion pressure gradient must exist between the water vapour of the absorbent and that of the material to be imbibed; and

e) Temperature of water for soaking is to be maintained at 70°C for 3 hours to 4 hours depending on paddy variety, by circulation of water, if hot soaking method is used.

3.1.3 The diffusion pressure of dry paddy is practically zero, therefore, when it is immersed in water, a steep diffusion pressure gradient is established and water moves rapidly into the grain.

3.1.4 Soaking is the result of different processes, such as molecular absorption, capillary absorption and hydration. During soaking of paddy, water molecules first adhere to the surface of the husk and penetrates through the micropores of the husk into the rice kernel where they may be retained in voids or intergranular spaces due to capillary absorption. Some of the water molecules will be absorbed in starch granules whereas others will enter into the lattice of the starch molecules where they will be held as water of hydration.

3.1.5 The soaking time for paddy varieties are as follows :

a) Cold soaking

i) Long and medium grain - 48 to 72 hours, maximum; and
ii) Short grain - 24 to 36 hours.

b) Hot soaking

i) Long and medium grain - 4 hours; and
ii) Short grain - 3 hours.

3.1.6 During the prolonged cold soaking period some of the microorganisms which are present in the paddy become active and thrive on the readily available starch of the rice kernel causing putrefactive changes. These changes cause bubbling due to escape of carbondioxide and other gases, with a characteristic bad odour, which retained by the soaking water as well as the paddy. To avoid this problem the soaking water should be changed with fresh water every 10 hours to 12 hours.

3.1.7 The water is drained completely at the end of soaking process.

3.2 **Steaming**

When saturated starch granules are heated above the gelatinization temperature, which is just above 70 °C, the starch granules are burst and transformed into non-crystaline amophus form. This process is irreversible adding different properties to raw rice.

Gelatinization can be accomplished either by direct heating to just above 70 °C by roasting on a heated plate or using steam. Steam is introduced to paddy in an open container with ambient pressure or by sending under pressure generated by a boiler. Also, steam can be introduced to paddy under pressure in a closed container.

The use of steam for gelatinizing the starch is preferred to other methods of heating as it does not remove moisture from the soaked paddy, rather it adds moisture by condensation, which increases the total moisture content of the grain. The moisture content of paddy increases to about 36 per cent to 40 per cent during steaming. The other advantages of steaming are :

a) It has a high heat content which is applied at constant temperature;

b) It is clean and sterile, without smell or taste;

c) It can be used first to produce power before it heats the paddy; and

d) It can easily be controlled.

3.2.1 During steaming, the following points should be considered :

a) When a boiler is used whether the steam is saturated or super-heated;

b) The pressure of the steam which determines the temperature at which heat is transmitted; and

c) The suitable steaming time, which determines the total heat applied to the different varieties of paddy to cause the gelatinization of the starch.

3.2.2 The total amount of heat applied to the paddy is equal to the heat provided by the soaking water and the heat derived from the condensation of steam during the steaming operation.

3.2.3 The temperature of the steam has a considerable effect on the colour of the rice although the causes are not yet fully understood. Apart from the spread of the colouring pigments contained in the husk and bran, it seems that colouring of the endosperm is caused by absorption of reducing sugars that react with the amino acids, and by fusion of the aleurone layers of the endosperm with the starchy core. However, by steaming the paddy with non-pressurized steam (at 100 °C) as in traditional methods, only small variations are found in the colour and quantity of soluble starch and in the amount of swelling of the milled parboiled rice. Spreading the steamed paddy immediately after steaming, rapidly reduces temperature and prevents dark colour developing.

3.3 **Drying**

Drying of steamed parboiled paddy is essential for proper milling and storing but it is different from drying raw paddy as the steamed paddy has a high moisture content (36 per cent to 40 per cent). The main aim of drying process is to reduce the moisture content to 13 per cent to 14 per cent without causing cracks or stresses in rice caryopsis which may lead to breakage during milling.

3.3.1 The manner in which excess moisture is removed is of considerable importance. If the moisture is removed at a very slow rate, microorganisms will grow and spoil the parboiled paddy partially or fully. On the other hand, if drying is done rapidly and continuously, cracks may develop due to internal stresses and the rice will break during milling. However, if parboiled paddy is uniformly dried by any means (shade, sun or hot air), practically no breakage will occur. Improper drying conditions may result in very high breakage.

3.3.2 During drying, two points are of great importance. First breakage does not occur throughout the drying process. It occurs when the moisture content drops to 18 per cent and below. After that breakage increases sharply. Second, the cracks do not develop during drying but over a period of two hours after the drying has been terminated. Drying of parboiled paddy should be done in 3 to 4 passes to avoid the breakage of rice during milling. Since shade drying has very slow moisture removal rate, sun drying and mechanical drying are commonly practised to dry parboiled paddy.

3.3.3 Drying parboiled paddy in a drying yard using solar energy is widely practiced by traditional/semi modern rice mills and domestic farmers. The hot parboiled paddy is spread to a thickness of 20 mm to 30 mm on the drying floor. After spreading, the paddy is continuously and systematically stirred and turned. During these operations, the grain is continuously mixed; therefore, each grain gets approximately equal exposure to the sun. These operations are repeated until the paddy is evenly dried to a moisture content of about 18 per cent to 20 per cent. Then the paddy is heaped and covered with mats, gunnies or with thick caps made of straw and tempered for about 2 hours to 3 hours. The tempered paddy is again spread and dried for about 1 hours to 2 hours to complete the drying to 14 per cent to 16 per cent moisture content. The dried paddy is heaped and covered with mats, gunnies or a tarpaulin, and left overnight in the warehouse or millhouse.

4 METHODS OF PARBOILING

The four major types of parboiling are :

a) Domestic;
b) Traditional;
c) Semi-modern; and
d) Modern.

4.1 Domestic (small scale) method

The parboiling of paddy at domestic level is done either in earthenware or iron or aluminium containers with sufficient water to cover the paddy. It is slowly heated over a fire (see Fig. 1). The water is brought to the boil and the paddy is allowed to cook in the steam until the husk is partly split open.

The main drawback of this method is that the grains do not get hydrated completely and also since there is insufficient heat treatment for complete gelatinization they tend to get unparboiled resulting in a product with a high percentage of white bellies and poor milling qualities.

Also boiling of grains in water for a long period of time may cause water soluble nutrient especially B vitamins, to dissolve in boiling water resulting in high nutrient losses. (Other draw backs are imparting off-flavour and development of myco-toxins in the rice because of fermentation due to prolonged soaking in cold water, labour and weather dependent and requires a large land area for drying.)

4.1.1 *Improved method of domestic level parboiling*

To overcome the drawbacks of the conventional method an improved domestic level parboiling method was introduced recently. In this method paddy is soaked separately and steamed in an especially designed parboiling vessel. Soaking time depends on the paddy type.

The parboiling vessel is fabricated from an empty diesel barrel of height 440 mm by providing wire mesh of 1.7 mm x 1.7 mm aperture size at a distance of 150 mm from the bottom through which paddy grains cannot pass (See Fig. 2).

4.2 Traditional method

A typical process is cold soaking of paddy for 24 hours to 72 hours depending on the paddy type and condition and then steaming it. There are various methods employed and have the following advantages and disadvantages :

Advantages

a) Low operational cost;
b) Specialized knowledge of the process and variables of the systems are not required;
c) Labour oriented; and
d) Low fuel requiremental cost.

Disadvantages

a) Disagreeable odour;
b) Discolourations;
c) Poor hygiene - bacteria, fermentation;
d) High labour cost; and
e) Non-uniformity of product (Presence of white bellies etc.).

4.2.1 *Cold soaking method*

Cleaned paddy is soaked in water at room temperature in a series of tanks made of brick and suitably plastered. These tanks are usually rectangular in shape with a holding capacity of each tank matching the capacity of the mill.

After the required quantity of paddy is loaded, the tank is filled with cold water so that the water level is about 200 mm to 300 mm, above the level of paddy. The husk, immature grains and light foreign matter floating on the surface of the water is skimmed off manually by means of a large perforated metal sheet strainer. The paddy is allowed to soak in water normally for 24 hours to 72 hours depending on the paddy type and condition. It is desirable to drop paddy into the soaking water, instead of other way about. In this way all chaft and immature grains can be removed or skimmed off.

Water should be changed with fresh water in every 10 hours to 12 hours. At the end of soaking period water is drained and paddy is transferred to the steaming tank in which a perforated sieve is fitted about 300 mm above from the bottom. Tanks must be scrubbed and washed after each batch.

The soaked paddy is steamed for about 45 minutes to 60 minutes in the metal rectangular tank. The tank has a perforated sheet at the bottom. Below the perforated sheet the water level in the tank is about 250 mm. This water is converted to steam by heating either using husk or firewood in a furnace below the tank. Husk is blown into the furnace by a blower and the case of firewood it is fed manually. The quantity of paddy that can be steamed at any one time in this manner is about 75 bushels (approx. 1.5T).

Once the top layer of paddy in the tank is splitted open, paddy is immediately discharged through the side doors and spreaded on the drying yard to the thickness of 25 mm for continuous drying, paddy is cut into forrows to dry the wet floor surface and after drying the floor, paddy is spread again using a wooden rack. This process is repeated until paddy is dried to the level of 18 per cent to 20 per cent moisture content and heaped on the yard itself and covered with gunnies or specially made cones for tempering in order to spread moisture within the grain. After two hours or so, paddy is spread again for further drying to 14 per cent to 15 per cent moisture content.

4.3 Semi-modern methods

4.3.1 *Single boiling*

Cleaned paddy is soaked in water at room temperature in tanks as described in 4.2.1.

In this method soaked paddy is steamed in cylindrical hopper bottom kettles kept on an elevated platform such that the bottom of the kettle is about one meter above the floor level. The kettles are made of mild steel or sometimes metal drums. The holding capacity of these kettles vary and the most common size being 350 kg. In this method the boiler is used to generate steam. Steam is passed through pipes in to the kettles. After the kettle is filled up with soaked paddy the steam valve is opened and steaming is continued until the paddy at the top of the kettle starts splitting. Normally it takes about 3 minutes to 10 minutes depending on the steam pressure. Quality of rice is better than traditional method due to even steam distribution throughout the mass of paddy. Also, due to shorter steaming distribution of 3 minutes to 4 minutes against 45 minutes in the traditional method, rice is whiter. Steam condensate water is allowed to drain and the hot parboiled paddy is discharged as quickly as possible.

4.3.2 *Govia hot soaking*

In this process, a rectangular metal tank is used for both soaking and steaming operations. The best manageable dimensions of the tanks are 2 m x 1 m x 1 mm. The tank of this size can handle 1.5 tons of paddy per batch. The tanks has a false bottom perforated (placed 300 mm above the bottom). The false bottom slopes towards one side for easy removal of paddy.

The upper section of the tank is provided with water tight rectangular doors on one side (drying yard side) for discharging the paddy. This tank is mounted on a fire place with a chimney (furnace) to provide a drought. Firewood and husk can be used as fuel. It is more economical to utilize paddy husk blown into the fire place by means of blower.

First the tank is filled with paddy and water for the soaking operation. The water, paddy mixture is kept warm (70 °C) by keeping the furnace running.

The soaking operation is continued for 3 hours to 4 hours depending on the paddy type. The heating is continued till the water in the lower section boils and steam is generated. Steam generated this way at atmospheric pressure is passed through the paddy. The steam operation is done for nearly 48 minutes or until the husks begin to split. The depth of the paddy in the tank should not exceed three feet.

4.4 Modern method

The modern methods of parboiling may appear to be more expensive as compared to other methods due to high initial investment and higher operational cost. The increased capacity due to shorter parboiling time, resulting in an increased output, justifies installation of modern plants.

4.4.1 *CFTRI Hot - soaking method*

In this method, the parboiling tanks are filled with clean water and heated to a temperature of about 85 °C to 90 °C by passing steam through the coils inside the tank. Sometime, hot water is prepared in a separate and hot water tank before, it is pumped into the parboiling tank. The later process saves time and increases the capacity. The paddy is dumped into the hot water as quickly as possible. By a mechanical system, the paddy is lifted by an elevator and dumped into the parboiling tanks for soaking. The resulting temperature of the paddy water mixture in the tanks stays at about 70 °C to 75 °C. The soak water can be recirculated into the hot water tanks to maintain a constant temperature of 70 °C. After letting the paddy soak for 3 hours to 4 hours, the soak water is drained and the water discharge valve is left open to remove water. During steaming soaked paddy is exposed to steam heat by letting steam at pressure of about 400 kPa (4 kgf /cm^2) through the open steam coil. Splitting of husks usually indicates completion of the parboiling process. After steaming is complete, the paddy is removed for drying. If a mechanical is to be used, the parboiled paddy is conveyed to the dryer by a conveyor. If the parboiled paddy is to be sun dried, it is transported to the drying yard. Mechanical drying is preferable to sun drying because it saves and minimizes the cost of parboiling apart from uniform drying resulting less brokens.

4.4.1.1 Before the paddy is fed into the parboiling unit it is desirable to remove chaff, dirt and other impurities by passing the paddy through a cleaner. Greater cleanliness can be achieved by washing the paddy in a separate tank before it is dumped into parboiling tanks. In this operation, even light chaff and heavy stones can be separated from paddy.

4.4.1.2 For parboiling, the water requirement is about 1.25 times the mass of paddy to be parboiled and the requirement for steam is about 200 kg/t of paddy.

4.4.1.3 Suggested equipment for parboiling plants are as follows :

a) Cleaner;
b) Receiving bin;
c) Receiving elevator;
d) Holding bin;
e) Parboiling tank elevator;
f) Parboiling tank;
g) Belt conveyor;
h) Drier;
j) Tempering bin; and
k) Boiler.

4.4.2 *Pressure parboiling method*

The principle of this method is the penetration of moisture into the paddy in the form of water vapour under pressure which gelatinizes the starch in the kernels.

4.4.2.1 The paddy is soaked in warm water (85 °C to 90 °C) or cold water for 30 minutes to 60 minutes. Water is then drained out. The steam is passed to raise the pressure gradually. After steaming for 20 minutes to 30 minutes, steam is blown out. The air entrapped inside the rice kernel is driven out by the penetration of water vapour, therefore, the presence of bellies in the parboiled rice is avoided. The rice obtained by this method is pleasing, slightly yellowish and uniform colour. The main advantages of this method are reduction in soaking time, reduction in drying time and cost, and increase in shelling eficiency (nearly 80 per cent of the paddy husk splits during steaming) and increase in milling outturn because the grains are resistant to breakage. Increase in the fat content in the barn and in the storage life of grain has also been observed. In this method, the parboiling tanks must be completely closed and made of thick metal sheets to withstand pressure.

4.4.2.2 The process should be easy to convert to a continuous one and have the potential to be introduced even in small size mills as a replacement for the conventional parboiling system.

4.4.2.3 For parboiling the paddy for the purpose of making rice, clean paddy is fed into the parboiling tanks filled with cold water which is recirculated for some time and then it is drained out. Steam is let into the tanks. The tanks have a welded top cover and hence work as a pressure vessel during steaming. This hastens the parboiling process and the requirements of water and steaming are reduced.

4.4.3 *Improved method of modern parboiling*

In this method paddy is soaked in water in cylindrical parboiling tanks preheated to 100 °C for 12 hours to 18 hours depending upon the paddy type. This method of soaking reduce both soaking time and soaking temperature which are two important factors that affect grain discolouration, while bringing the paddy to a moisture content of 30 per cent. The steaming is carried out using steam at high pressure generated from the boiler.

5. SEQUENCE OF OPERATION

To maximize the use of processing plant and its machinery, a process analysis of all the unit operations is to be used to determine the sequence of various operations and the utilization efficiency of the handling equipment. Various unit operations of a parboiling process are given in Table 1.

TABLE 1 - Details of unit operations in parboiling and drying process

Sl No. (1)	Operation (2)	Time Required (3)	Remarks (4)
i)	Cleaning of raw paddy to remove dirt, dust, stones, chaff and other impurities	-	Time of operation depends upon the amount of foreign matter present
ii)	Soaking of clean paddy in hot water keeping the temperature of the paddy-water mixture (constantly at 70 °C) recirculate water if required to maintain temperature	3 h to 5 h	-
iii)	Steaming the soaked paddy, after draining the soaking water, by injecting saturated steam at pressure of 400 kPa (4 kgf/cm^2)	20 min to 40 min	Time for steaming depends on quality of paddy to be steamed and capacity of boiler
iv)	First drying pass, paddy is recirculated in dryer and 95 °C air is blown through the paddy	2 h	-
v)	Temperature of paddy in tempering bin to equalise mixture	8 h	-
vi)	Second drying pass, paddy is recirculated in dryer and 75 °C air is blown through the paddy	2 h	-

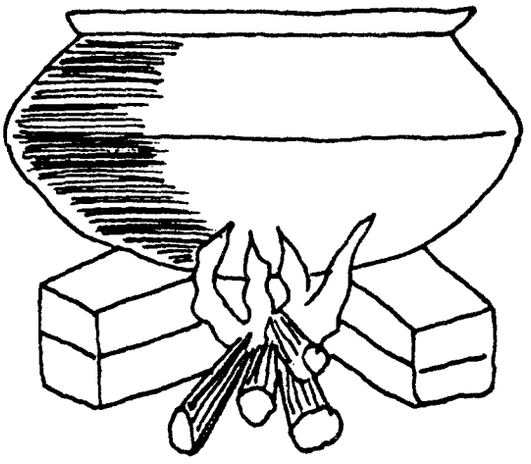


FIGURE 1 - DOMESTIC METHOD

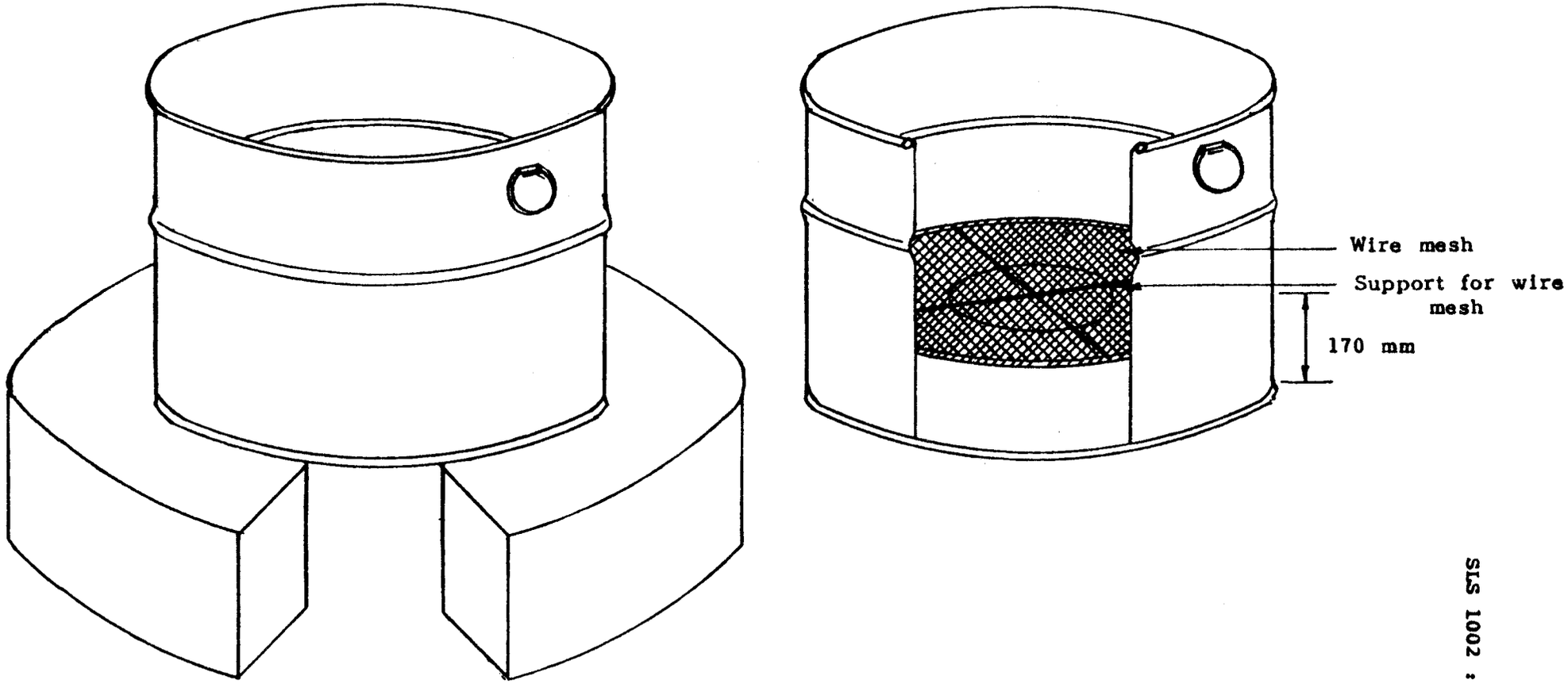


FIGURE 2 - IMPROVED DOMESTIC LEVEL PARBOILING

A. Soaking tank/s

B. Husk blower

C. Steaming tank

D. Drying floor

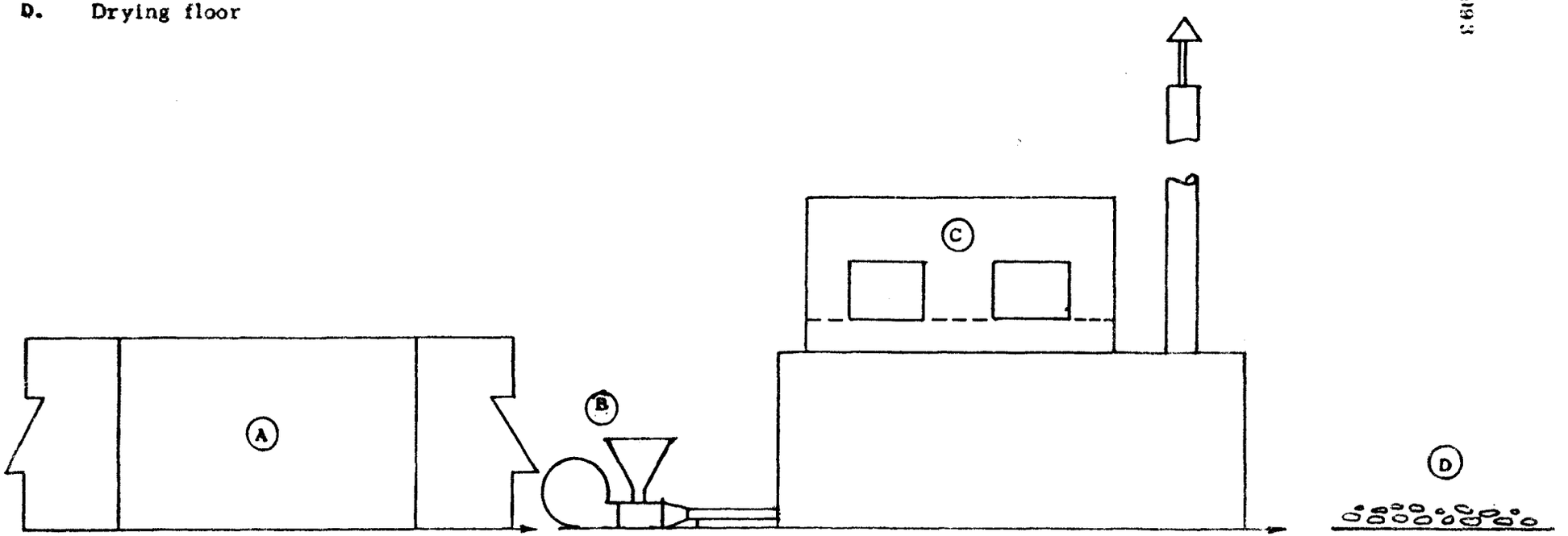


FIGURE 3 - FLOW DIAGRAM OF THE TRADITIONAL METHOD OF PARBOILING

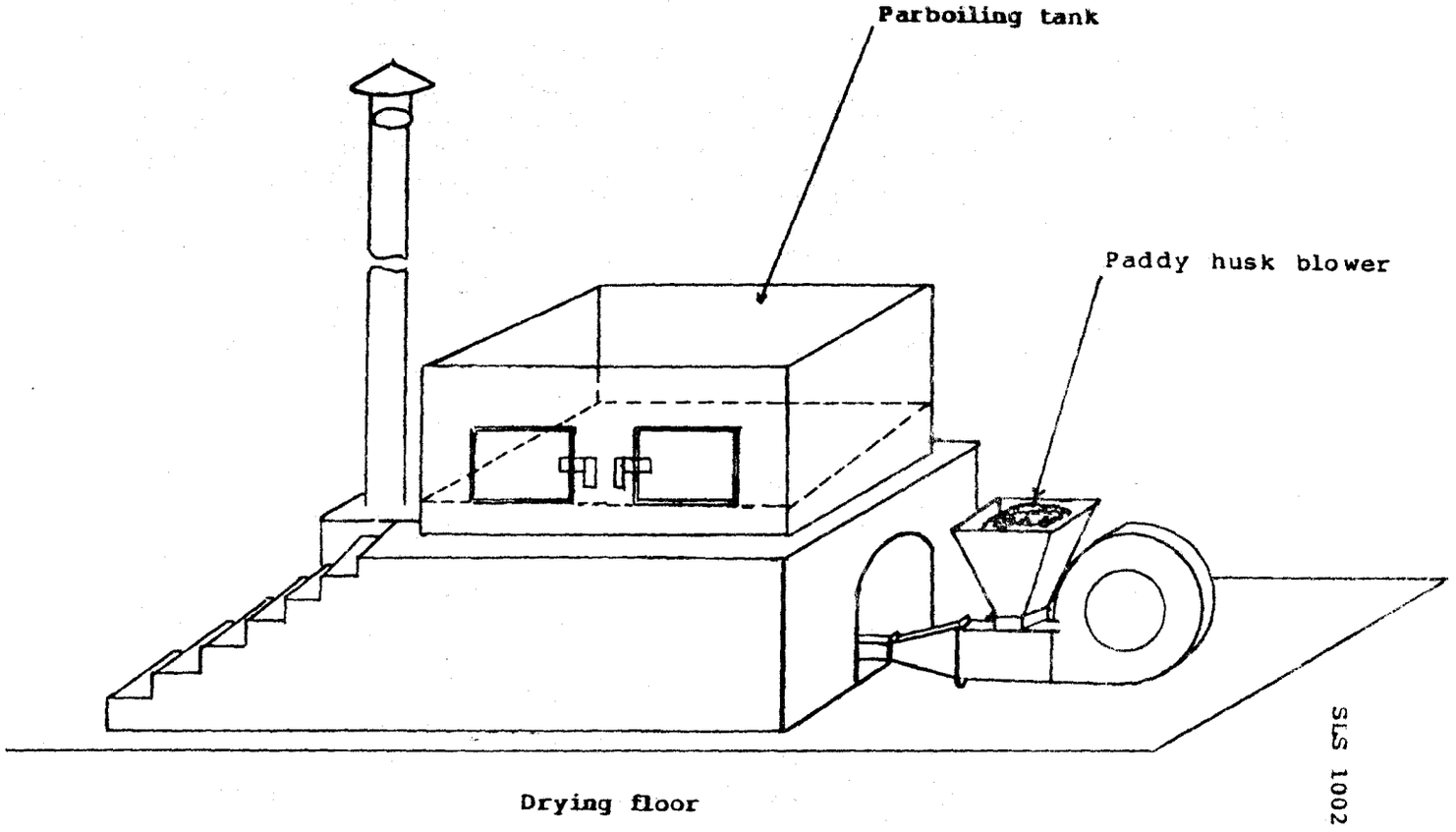
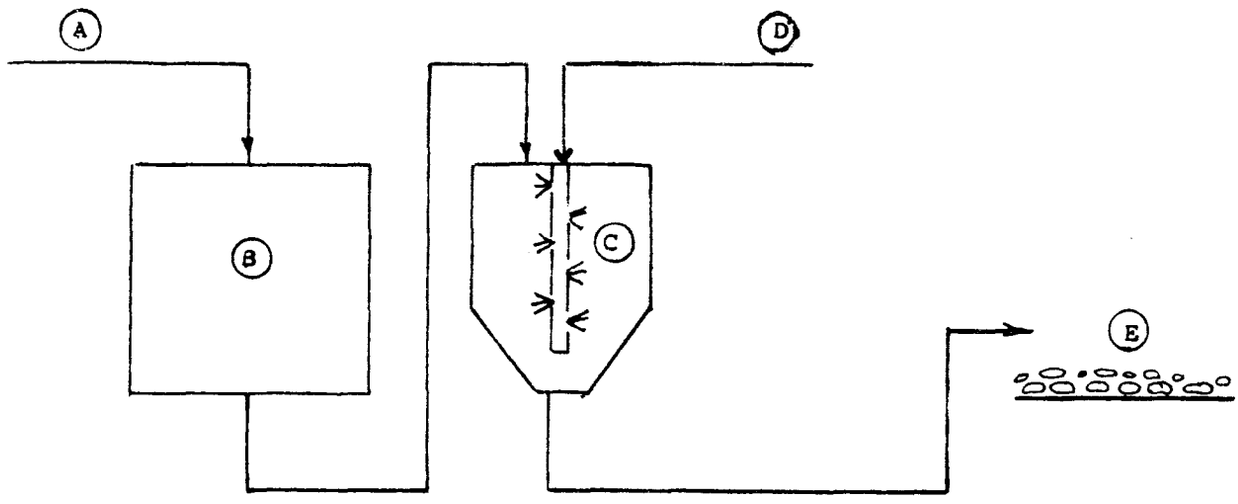


FIGURE 4 - STEAMING TANK (TRADITIONAL METHOD OF PARBOILING)



A. Raw Paddy

B. Soaking tank/s

C. Steaming kettle

D. Steam from the boiler

E. Drying yard

FIGURE 5 - FLOW DIAGRAM OF A SEMI-MODERN PARBOILING PLANT

E – Elevator

PB – Parboiling tank

D – Dryer

TB – Tempering bin

BC – Belt conveyor

C – Cleaner

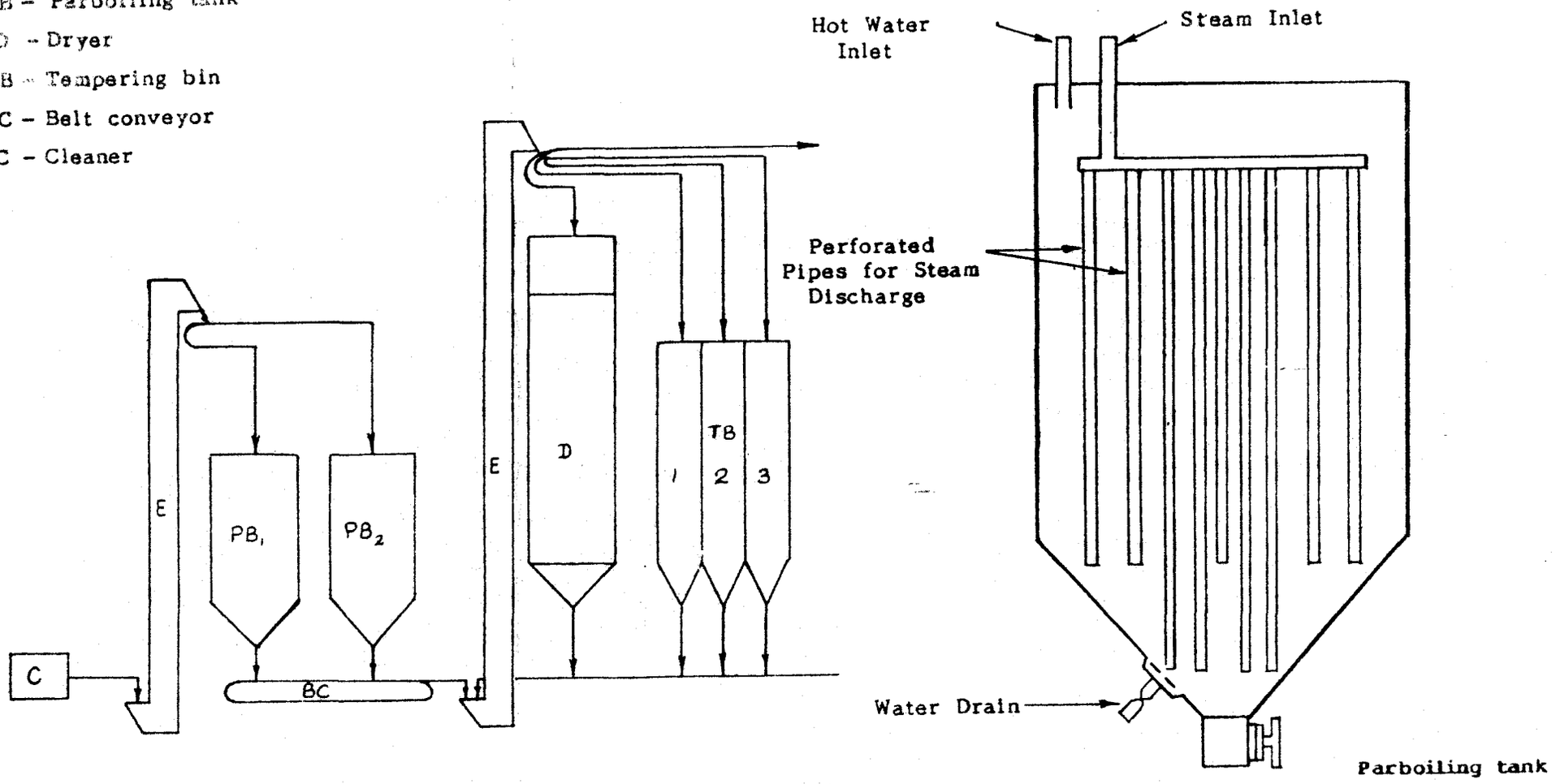


FIGURE 6 - FLOW DIAGRAM OF THE PARBOILING PLANT (CFTRI METHOD)

A. SUN DRYING YARD

B. GOVIA METAL TANK WITH PERFORATED SHEET

C. COLD SOAKING CEMENT TANKS

D. HUSK FURNACE

E. CHIMMNEY

F HUSK BLOWER

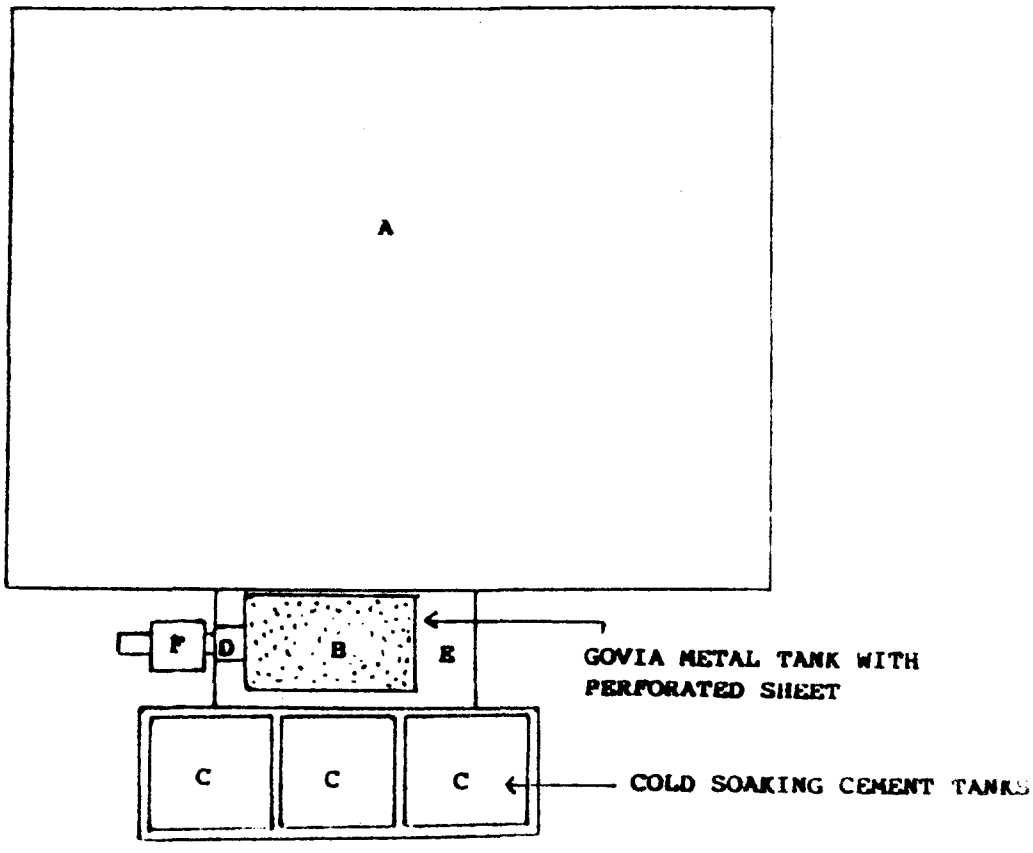


FIGURE 7 - DESIGN FOR A PARBOILING PLANT OF ONE TON/HOUR CAPACITY

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SRI LANKA STANDARDS INSTITUTION

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