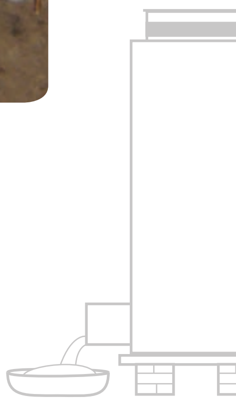
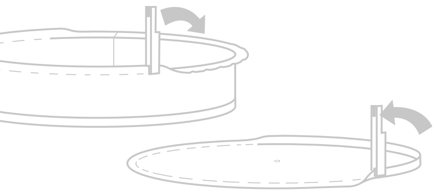
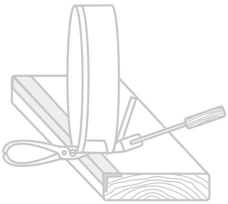
Food and Agriculture
Organization of the
United Nations

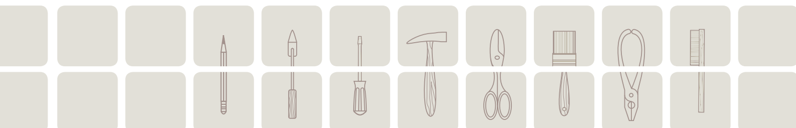
Technical manual

for the construction and use of family-sized metal silos to store cereals and grain legumes









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FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS
Rome, 2015

Recommended citation
FAO. 2015. *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes*, by Mejía-Lorío, D., Howell, M. & Arancibia, A. Rome, Italy.

Original title:
Manual técnico para la construcción y el uso de los silos metálicos familiares para almacenar cereales y leguminosas de grano.

This publication has been translated by the Meeting Programming and Documentation Service of FAO (CPAM). In case of discrepancies, the original language will prevail.

Cover photograph
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ISBN 978-92-5-108181-5 (print)
E-ISBN 978-92-5-108182-2 (PDF)

Contents

Preface

The *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes* was produced in the Division of Rural Infrastructure and Agro-industries (AGS) of FAO as a significant technical contribution to preventing losses in the post-harvest phase of grains and cereals. It is designed as a training manual for constructing, using and handling family-sized metal silos. It is aimed at farmers who produce basic grains and cereals for their own consumption for their food security and at tinsmiths, blacksmiths and other craftsmen who can construct them and adapt them easily to make silos of different capacities. The manual is divided into chapters and appendices. These include information on constructing metal silos of different capacities, their handling and correct maintenance as a structure for storing grain and cereals, where and how to locate them and protect them, and how to estimate their cost. Archives in Excel format can be downloaded from www.fao.org/ag/ags and www.fao.org/inpho to determine the cost anywhere in the world according to the local prices of the materials required to construct them and to carry out a brief, practical cost-benefit analysis.

The capacity of the models presented varies from small silos of 0.12 m³ to silos of 4.2 m³ (approximately 120 to 4 000 kg), including several intermediate sizes adapted to various user needs.

It is important to note that part of the technical material contained in this manual is the result of the cumulative experience of the Swiss Agency for Development and Cooperation (SDC) in Central America in projects for preventing post-harvest losses and which have been shared with FAO-AGS.

The manual is further divided into eight chapters and four appendices.

The first chapter gives a socioeconomic and technical view of the silo based on the experience of FAO in a number of countries where it has been introduced. Chapter two describes the parts of the silo and what should be considered when constructing one. Chapter three describes and presents the materials, tools and equipment necessary to construct one. The fourth chapter gives the basic requirements of the workshop and describes the skills needed by the craftsmen or builders, while the fifth teaches the basic steps involved in constructing the silo. Chapter six explains the necessary repairs for its maintenance. Chapter seven describes aspects of the installation, use, fumigation and maintenance of the silo. Finally,

the eighth chapter describes aspects concerning the economic evaluation and costs of metal silos.

This manual also contains four appendices showing various plans depending on the size of the metal sheets available on the market. These plans can be used to construct silos with volumes of from 0.12 m^3 to 4.2 m^3, including various intermediate sizes.

With the publication of this manual, we have again joined the collective effort to help to meet one of the key challenges of the millennium, i.e. achieving food security, a basic human right.

Part of this manual is based on the technical document entitled *Technical manual for the construction of small metal silos* first published in 2005 at www.fao.org/inpho.

Acknowledgements

The *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes* is partly based on materials originally produced by the Swiss Agency for Development and Cooperation (SDC); in fact the structure of the contents in some sections has generally followed that of the original document. FAO subsequently implemented numerous projects based on this model, and in addition many people have worked and contributed in different ways to the production of this manual.

Matthew Howell and Adolfo Arancibia provided the plans and texts for the construction of different sized silos and illustrations. It was translated into Spanish with the help of Gustavo Varela and Francisco López and was edited by Cadmo Rosell and Danilo Mejía-Lorío. The socioeconomic summary of the cost-benefit analysis of the silo was prepared by Dino Francescutti, from the Investment Centre (FAO).

We are also grateful to Divine Njie, Group Leader Agro-Food Industries Group (AGS), for his support, to Ann Drummond and Francesca Cabré-Aguilar (AGS) for their administrative and logistics assistance, to Larissa D’Aquilio (AGS) for coordinating production, and to Simone Morini for the graphic design.

The authors of this document were Danilo Mejía-Lorío, an Agro-Industries and Post-Harvest Management (AGS) officer, who coordinated the technical work, edited and translated many sections of the manual and was the author of the first chapter and co-author of chapter 8; Matthew Howell, an FAO consultant, who produced the guide and illustrations in English on how to construct the family-sized metal silo for food security in chapters 2 to 7 of the manual; and Adolfo Arancibia, an FAO consultant, who produced the guide and illustrations in appendices 1 to 4 of the manual on the various sizes of silos that can be constructed depending on the dimensions of the commonest metal sheets found in the various countries, and who prepared the Excel archives on how to estimate the costs of the family-sized metal silo in Spanish, English and French.

Summary

The *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes* presents simple instructions for the construction and use of various types of family-sized silos, with capacities of between 0.12 m^3 and 4.2 m^3 (approximately 120 and 4 000 kg). The contribution of this type of silo to food security, to meeting the Sustainable Development Goals and to the well-being of small farmers is extremely important, particularly during agricultural crises caused by a number of external factors, including financial problems. The silos have a key role, not only to safeguard family nutrition in the peasant sector, but also so that small farmers can regulate trading in surplus goods and have access to markets when they are favourable. The manual contains guidelines for the use and manufacture of family-sized silos at low cost, accessible to craftsmen and farmers. The manual is based on field experience gained by the Swiss Agency for Development and Cooperation (SDC) and subsequently by numerous projects carried out by FAO in more than 22 developing countries.

About the authors

Danilo Mejía-Lorio is a biochemical engineer and doctor of food sciences and nutrition. He is an Agro-Industries and Post-Harvest Management officer in the Division of Rural Infrastructure and Agro-Industries (AGS) of FAO and has 39 years' experience in education and advanced research, mainly in food and nutrition technology and science.

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CHAPTER **1**

FAO technical and socioeconomic view of the family-sized metal silo

1.1 Introduction

The storage of grain and cereals is a critical stage in which losses should be minimized and quality preserved as far as possible; appropriate technologies to achieve this are therefore necessary. There are various storage systems for the small and medium producer such as granaries, storehouses, metal drums, plastic containers, plastic or jute bags, metal silos, etc., and the choice of system will depend on the availability, convenience of use, efficiency and cost-benefit analysis that need to be considered by the farmer or user.

The *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes* describes the main aspects of this technology. The family-sized metal silo is a key ally of FAO in the struggle against world hunger as it helps to achieve food security. It has been tested and validated in the last ten years in more than 20 countries in Africa, Asia and Latin America.

The family-sized metal silo is a simple structure that allows grain to be stored long term and prevents attack by various pests such as rodents, insects or birds, among others. Moreover, if the grain has been dried properly (less than 14 percent moisture for cereals and less than 10 percent for legumes and oilseeds) and if the family-sized metal silo is under cover, there will be no problems of moisture condensing inside it. Family-sized metal silos generally take from 100 to 3 000 kg. A family-sized metal silo with 1 000 kg of grain can store enough to feed a family of five for a year. If a small or medium farmer has more than one family-sized metal silo, he can store surplus produce and keep it to sell when prices are better, which helps to increase his income.

1.2 Why is a family-sized metal silo an effective ally for food security?

There are clear technical and socioeconomic reasons why a metal silo is the ideal technology to help food security:

- it maintains product quality during storage;
- it is airtight and allows effective fumigation with non-residual fumigants;
- it avoids the use of insecticides;
- it requires little space and can be placed near the home;
- it reduces losses to almost zero;
- it allows the farmer to take advantage of fluctuations in grain prices;
- it gets rid of rodents and other pests which can have an adverse impact on consumer health and grain storage;
- it is easy to use, it is cost-effective and has a great impact on the struggle against poverty;

- it is cheap and if maintained properly can last for more than 15 years;
- it can take from 100 to 3 000 kg;
- it helps women in their work;
- it can be constructed *in situ* with local labour and readily accessible materials;
- it is a decentralized form of storage;
- the technology has been tested and validated in several countries.

There are other criteria in addition to the reasons mentioned above in favour of the use of the family-sized metal silo by small and medium farmers:

- efficiency;
- availability of materials for construction;
- price;
- cost-effectiveness;
- user acceptability.

1.3 Countries in which FAO has introduced family-sized metal silos in various projects 1997–2013

FAO has introduced family-sized metal silos in Afghanistan, Bolivia, Burkina Faso, Cambodia, Chad, Ecuador, Gambia, Guatemala, Guinea, Honduras, Iraq, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Nicaragua, Panama, Peru, Senegal, Somalia and Timor-Leste.

Approximately 95 000 family-sized metal silos have been constructed to date in these countries with the aim of training craftsmen in constructing, using and handling them and then giving them to farmers. These silos can store approximately 38 000 tonnes of grain with an approximate value of USD 8 000 000. Furthermore, more than 1 500 people including professionals, technicians and craftsmen have been trained in constructing, using and handling family-sized metal silos. This estimate at project completion does not take into account the multiple effect that each project has, to a greater or lesser extent, after its implementation. Some multipliers of the silo technology include national institutions and non-governmental organizations (NGO) and their staff.

FAO projects have supported the construction of various types of metal silos for family use. These projects have been funded by the governments of these countries and by emergency projects funded by international donors or have been implemented within the framework of the FAO technical cooperation programme, among others. The many requests for the construction of these silos received through the *TeleFood* programme should be noted.

1.3.1 FAO experience with family-sized metal silos in Bolivia

A socioeconomic study conducted in a post-harvest project as part of the FAO Technical Cooperation Programme in Bolivia found that of six post-harvest technologies analysed, the family-sized metal silo was the most acceptable to recipients. Ninety-six percent of 142 farmer-users who received these silos in four departments of Bolivia stated that the family-sized metal silo improved food security, reduced post-harvest losses and preserved grain quality and safety and, as a consequence, the health and nutrition of the population. The same study also asked the opinion of other groups associated with the project, such as technology transfer institutions, marketing authorities, governmental and non-governmental organizations in the farming sector and technicians and craftsmen working in the field; they all agreed that the family-sized metal silo had a positive impact on physical and commercial infrastructure and that it improved the food security of communities helped.

The comments and recommendations of the groups surveyed are summarized below:

a) Technology transfer institutions:
   - theory and practical workshops, demonstrations and audiovisual talks help to transfer this technology;
   - total/partial credit and "bartering" of voluntary work are appropriate strategies for acquiring a family-sized metal silo;
   - subsidies are necessary for training and buying materials for the construction of family-sized metal silos.

b) Marketing authorities and institutions:
   - the organization of family-sized metal silo users contributes to the socioeconomic impact;
   - training in markets and information networks empowers the user in the national and international market;
   - users who stored maize at a market price immediately after harvest of USD 13 per 100 kg sold it four months later at USD 38 per 100 kg;
   - the family-sized metal silo is also useful for the production of livestock and poultry because it can be used to store the grain and concentrates they consume.

c) Governmental and non-governmental organizations in the farming sector:
   - the family-sized metal silo contributes to food security and increases the farmer's income;
   - it is a sustainable, low-cost technology adaptable to the national setting;

- technology transfer institutions and technicians and craftsmen are capable of providing training and distributing the family-sized metal silo;
- technical assistance, together with microcredit and participatory research, are useful for recipients of the family-sized metal silo;
- the quality of seed for sowing stored in the family-sized metal silo is better, retaining colour and ability to germinate better than those stored in jute or plastic bags.

d) Technicians and craftsmen:
- acknowledge and recognize FAO as a pioneering organization in the introduction of the family-sized metal silo;
- point out that several NGOs have adopted these silos as the leading technology in their work programmes;
- identify the following as the main problems associated with the post-harvest of grain (in decreasing order): pests (insects, rodents, fungi and birds), lack of infrastructure for storage, poor handling practices, inadequate marketing and dirty grain.

e) Farmers on the price of the silo: the majority recommend not skimping on resources to buy a family-sized metal silo because it brings medium and long term benefits and contributes to the food security of families.

1.3.2 FAO experience with family-sized metal silos in Afghanistan

Two projects in the Technical Assistance Programme (PAT) of FAO concerning farming production and post-production technologies were implemented in 42 districts in seven vulnerable provinces of Afghanistan to improve food security. The family-sized metal silo was one of the technologies most widely used. The key findings were:

- 25 national professionals and technicians received instruction via the training programme, being trained as masters in the construction, use and handling of the family-sized metal silo;

TABLE 1

How farmers surveyed in Bolivia see the price of the family-sized metal silo (%)*

Cheap	59 %
Standard	17 %
Expensive	14 %
Average	8 %
No reply	2 %

Source: FAO, 2008.
*Normal market prices without subsidies.

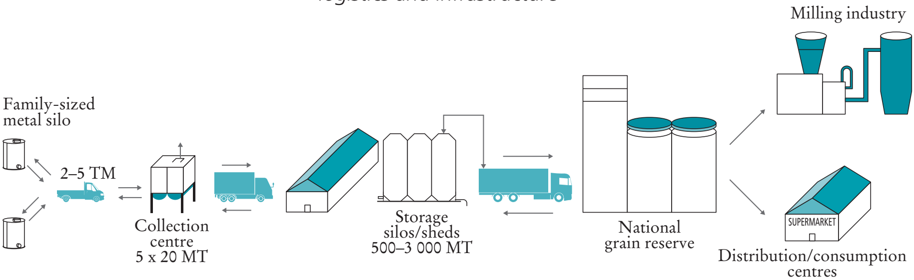
- the master group trained 61 tinsmiths and blacksmiths who in turn trained a further 300 national craftsmen;
- approximately 25 000 silos for storing between 250 kg and 1 800 kg of grain were constructed in the seven beneficiary provinces;
- the technical staff of some governmental and non-governmental organizations learned the technology and then joined as project participants in the family-sized metal silo national training programme;
- compared with traditional storage structures (clay silos), farmers who received a family-sized metal silo found that it was more lightweight and manageable, more durable and did not carry the risk of insects as it was airtight, and losses were therefore virtually non-existent;
- farmers who did not benefit directly from the project opted to buy the construction materials and paid craftsmen for labour to build a family-sized metal silo, or purchased a silo directly from the craftsman;
- approximately 4 500 additional family-sized metal silos were constructed by tinsmiths or blacksmiths and trained craftsmen who created their own silo manufacturing microenterprises owing to the training received in the projects.

1.4 The family-sized metal silo as a functional link in grain and cereal distribution logistics and infrastructure

The family-sized metal silo is a functional link in grain and cereal distribution logistics for food security. For example, in a farming community of 1 000 people, i.e. about 200 families, assuming that each family consumes slightly more than 1 kg of grain daily, a consumption of approximately half a tonne per family per year is achieved. If each family has a silo for storing one tonne of grain, the 200 families together will have 200 tonnes of grain stored. If we take away the 100 tonnes they consume annually, that leaves 100 tonnes available for other uses or for sale. It could be sold to other consumers, the local government or cooperatives which could store the grain in communal collection centres. The communal collection structures, in this case, could be five units of 20 tonnes each which could store grain for subsequent transport to other centres with a greater storage capacity, for example 500 to 3 000 tonne structures generally located in areas near to cities. The functions of the family-sized metal silo are then important to the grain distribution logistics for food security, as shown in Figure 1.

FIGURE 1

The silo in grain distribution logistics and infrastructure



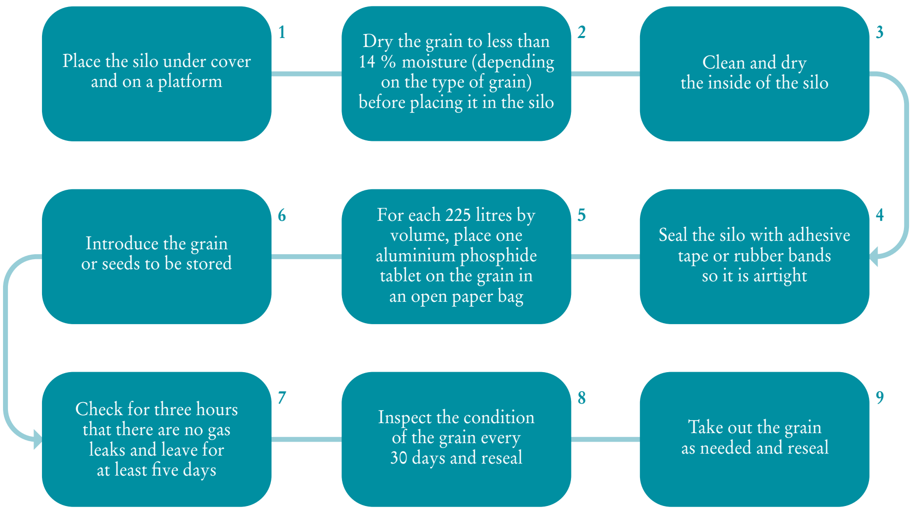
Source: D. Mejía, 2008.

1.5 Basic steps in the correct use of the silo

It is important to remember that the efficient working of the silo for storing grain and cereals will depend to a large extent on following the correct instructions. This generally means following the basic steps as described in Figure 2.

FIGURE 2

Basic steps for the correct use of the silo



Source: FAO, 2008.

1.6 The cost of the family-sized metal silo

The production costs shown in Table 2 include only materials, labour and depreciation of tools; they do not include utilities or transport of the silo to its destination, among other items. Although the costs given here vary depending on the circumstances of each country, the prices are generally accessible.

Projects implemented by FAO encourage purchasing by means of revolving credit and paying for the silo with grain, among other strategies. As the capacity of the silo increases, the cost of storage per kilogram of grain decreases. Seed for sowing should generally be stored in small-capacity silos and grain for consumption in larger-capacity silos.

1.7 Basic requirements for the construction and successful use of a family-sized metal silo

a) Agricultural technicians and craftsmen (tinsmiths and blacksmiths) trained to pass on their knowledge of the construction, use and handling of the silo in agricultural communities (Photo 1).

Constructing a silo requires a galvanized sheet measuring 100 x 200 cm and 0.5 mm thick, 26 gauge, and specific, simple tools (Photo 2).

Before placing in the silo, the grain to be stored must be dried to less than 14 percent moisture content for cereals and to less than 10 percent for legumes and oilseeds. If drying is insufficient, the whole stock could be lost (Photo 3).

TABLE 2

Production cost and capacity of the family-sized metal silo in countries in which FAO projects are carried out (in USD)

Country	120 kg	250 kg	500 kg	900 kg	1 800 kg
Afghanistan	–	28	70	–	92
Bolivia	20	35	60	77	111
Burkina Faso	26	29	42	56	70
Cambodia	12	20	30	–	50
Chad	–	66	97	128	187
Guinea	–	–	59	–	70
Madagascar	–	40	50	70	100
Malawi	–	22	45**	60***	–
Mozambique	20	34	54	75	–
Namibia	–	–	22*	–	–
Senegal	23	42	60	76	100

Source: FAO, 2008.
Cost without subsidies; *a silo of 400 kg; **a silo of 700 kg; ***a silo of 1 000 kg.

PHOTO 1

Technicians and craftsmen

©FAO/D. Mejia-Lorio

PHOTO 2

Tools and sheets

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PHOTO 3

Drying the grain before storage

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PHOTO 4
Silo under cover

©FAO

The silo with the grain must be positioned somewhere protected from the sun and rain (Photo 4).

1.8 FAO strategies for transferring family-sized metal silo technology

FAO uses different strategies to transfer family-sized metal silo technology:

- through South-South Cooperation and one- to two-week training workshops;
- the first group to be trained usually consists of 15 to 20 professionals and technicians who work in post-harvest in national institutions in the agricultural sector;
- a second group trained consists of farmers, craftsmen (tinsmiths and blacksmiths), technicians in non-governmental organizations and other related institutions;
- by promoting the family-sized metal silo by means of demonstrations and publicity, stressing that the silo has critical direct and indirect socioeconomic importance for all stakeholders: farmers, technicians, craftsmen, traders, hauliers and consumers in general.

1.9 Conclusions

By preventing post-harvest losses, the family-sized metal silo is a very valid technology for food security, particularly for small and medium farmers. It is also a major link in grain distribution infrastructure. In most countries where the family-sized metal silo has been introduced, it has had a positive, critical mass effect for the various stakeholders associated directly and indirectly with the grain distribution and production chain.

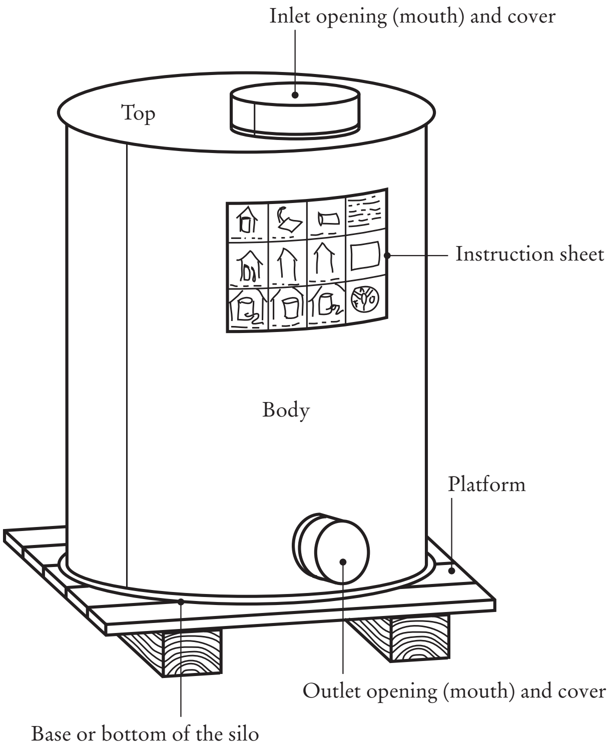
CHAPTER **2**

Parts of the silo and aspects which should be considered in construction

2.1 Parts of the silo

Figure 3 shows the various parts of the family-sized metal silo.

FIGURE 3
Parts of the silo



2.2 Aspects which should be considered in the construction of silos

2.2.1 Flexibility

When you are gathering and checking all the tools and materials you need to build the first silo, you may not find everything on the list. You will need to use simple tools. If you cannot find certain tools, you can ask for help from other blacksmiths or tinsmiths who will advise you about alternative soldering materials, about the use of cleaners and flux or about soldering aids.

The thickness of the galvanized steel sheets can vary slightly. Remember that thick sheets can be more difficult to cut with shears and thinner sheets may not be strong enough for large silos. Do not use sheets less than 0.4 mm thick. The tin/lead proportion in the solder is also variable; 50/50 is best, but 35 percent tin and 65 percent lead is acceptable.

Copper soldering irons heated in charcoal are reliable, low-cost tools which can be made and used in almost any community. In some areas, propane gas cylinders may be available and inexpensive. In that case, gas soldering torches can be used and may also be useful for other types of metalwork.

2.2.2 *Safety*

Precautions should be taken so that the operator and his family are protected from exposure to lead:

- Do not inhale vapour while you are soldering.
- Make sure the workshop is well ventilated.
- Do not eat, drink or smoke until you have washed your hands.
- Keep children away from the work area.
- Wet the floor when sweeping to reduce dust.
- Keep soldering waste in a separate container to take for scrap.
- Remove work clothing and leave in the workshop or take it off before entering the house.
- Never leave or discard lead near houses, sources of water or agricultural land.
- The cut edges of metal pieces are very sharp; use special gloves and shoes and sweep waste or scrap pieces off the work bench and floor with a brush.
- Protect eyes with glasses or goggles especially when using acid. Always have clean water in the workplace as well as an acid neutralizing agent such as sodium bicarbonate (baking soda) or calcium carbonate. Do not use acid directly from the original container; it may be expensive and dangerous if it spills. Use a small glass jar, 50-100 ml, with a lid or stopper. Clearly mark the jar "ACID" and keep it in a safe place.

2.2.3 *Markers*

A marker-measure should be used to indicate measurements of parts or pieces of the silo. It is particularly useful with larger pieces which need large templates or patterns. The marker-measure is a piece of wood, like a ruler, with markings that help to set your compass and mark large pieces without using a tape measure. It can help to reduce measuring errors. It is also important for marking

the length of the inlet band or strip and in various situations, as shown in Figures 4 and 5.

FIGURE 4

Example of the use of a marker-measure to set the compass and mark the hole for the inlet opening

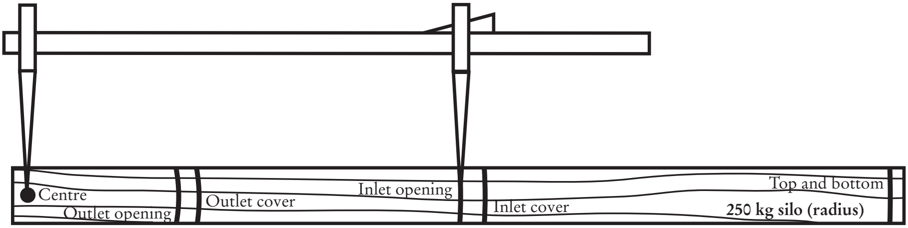
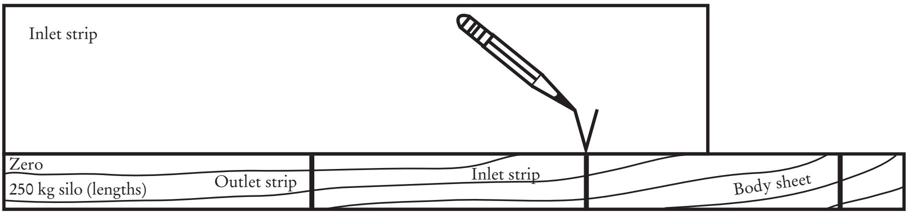


FIGURE 5

Example of the use of a marker-measure to mark the length of the inlet strip



2.2.4 *Templates or patterns*

Think about making templates or patterns for some of the smaller pieces of the silo. This can save time when drawing on the sheets before cutting them. You can use wood, plastic, card, paper, cardboard or scrap metal. Make the templates or patterns carefully, label them clearly with the name of the piece and the size of the corresponding silo and keep the templates or patterns for each silo size.

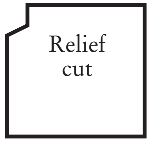
2.2.5 *Waste and recycling*

Clean the work space often and save left-over metal as this can be sold for scrap. Put small pieces in a box, set aside any large scraps and keep them as they can be used to repair damaged silos, for other small projects or sold to another blacksmith or tinsmith.

FIGURE 6

Templates or patterns

Template or pattern for marking the size of the outlet opening (hole)



Metal template or pattern for marking the relief cut at each corner of the sheets

Metal template or pattern for drawing large circles if you do not have a large compass

2.2.6 *Improving the workshop*

Some simple improvements in the workshop can help you work faster and more comfortably. For example, if you are going to build many silos, you can buy several sheets of metal at once. You can build a rack and store the sheets to prevent them getting in your way when you are working, or being damaged.

2.2.7 *The principle of the airtight seal*

The technology applied in the use of domestic metal silos is based on an airtight seal. This is the ability of the silo to keep its contents completely isolated. This prevents insects or moisture entering the silo or fumigation gases escaping. The gases used in fumigation are poisonous and fatal, and any gas leak from the silo constitutes a serious risk for the farmer's family. The silo must therefore never be placed inside the home.

Good soldering with tin/lead is the main means for the tinsmith or blacksmith to obtain a complete, permanent seal. It also strengthens the silo and helps to prevent bends opening when the silo fills with grain. All the bends and joints must be carefully soldered, cleaned and inspected for holes. Even the smallest holes must be soldered over.

It is easier to check each soldered joint immediately after making it rather than checking all the bends and joints once the silo has been completed.

Small holes generally appear in the following places:

- around the inlet and outlet openings;
- at the point where the silo body closures intersect with the top and bottom of the silo;
- around small nails used to strengthen the joints or fix the handles of the covers, although the use of nails should be avoided as far as possible.

CHAPTER **3**

Tools, materials and equipment

You will need a tidy area and surface to work on as well as all the items listed below.

3.1 Common tools

Most of these tools can be found in a hardware shop:

a) one square, 25 cm or more;
b) one tape measure, at least 3 m;
c) one pair of pliers, 1 cm wide;
d) one hammer with a flat face, 300–400 g;
e) one metal-working chisel, 1.5 cm wide;
f) one pair of good-quality metal cutting shears, number 12;
g) one wire brush;
h) one small acid brush or plastic dropper;
i) one large, flat screwdriver;
j) one paint brush, 5 cm wide;
k) two small clamps, minimum opening 6 cm;
l) two or three soldering irons (with copper heads), 500–750 g;
m) one small charcoal heater or a heatgun for the soldering irons;
n) one pair of gloves to protect your hands;
o) some type of glasses, mask or visor to protect your eyes;
p) one metal brush to clear away metal shavings and to protect your hands;
q) one graphite pencil or metal point to mark the sheet;
r) one marker or ink pen to mark and identify the pieces of the silo;
s) one simple box to hold small tools.

3.2 Special tools

A tinsmith or blacksmith can make some of these tools; craftsmen or farmers can make others themselves.

- one counterblow: this is a heavy piece of metal, about 500 g; it could be an old iron sheet or a large hammer head;
- one large compass able to open 65 cm; you may also need a small compass to draw small circles;
- one marker or metal measuring gauge because the measurements must be accurate;
- one wooden mallet; you can use a piece of wood about 5 cm x 10 cm x 30 cm and make a 10 cm handle in it;
- one spacer: this is a piece of the same metal used to build the silo with one edge bent over; an angled piece can also be used to make bends;
- one sheet metal bending tool: this is a small metal bar 2 cm wide, 0.5 cm thick and 5–10 cm long which has a cut in each end 8 and 8 mm deep (these measurements are important).

FIGURE 7

Description of common tools

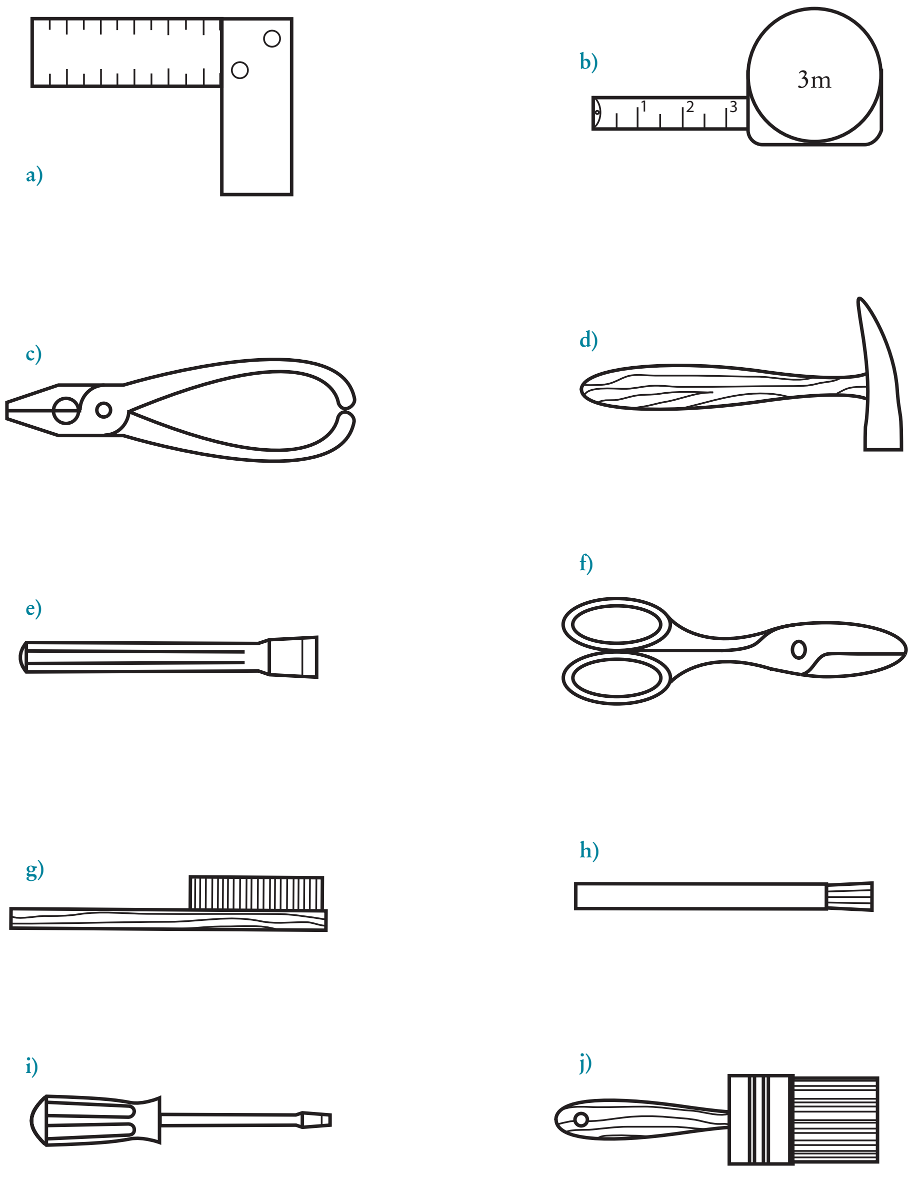
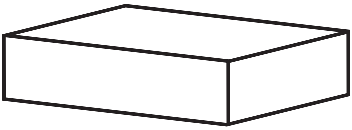


FIGURE 7 (continued)
Description of common tools

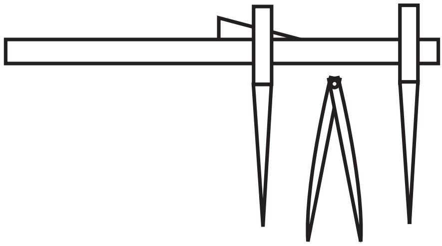
FIGURE 8

Description of special tools

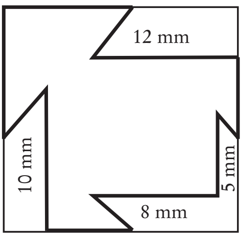
One counterblow: this is a heavy piece of metal, about 500 g; it could be an old metal sheet or a large hammer head



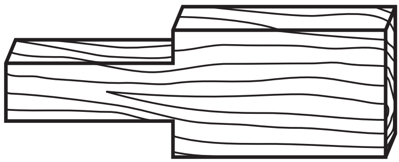
One large compass able to open 65 cm; you may also need a small compass to draw small circles



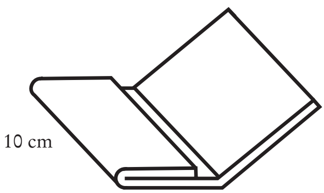
One marker or metal measuring gauge because the measurements must be accurate



One wooden mallet; you can use a piece of wood, about 5 cm x 10 cm x 30 cm and make a 10 cm handle in it



One spacer piece made of the same sheet or an angled piece to make bends (figure)



One sheet metal bending tool: this is a small metal bar 2 cm wide, 0.5 cm thick and 5-10 cm long which has a cut in each end 8 and 8 mm deep (these measurements are important)

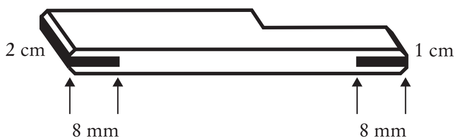
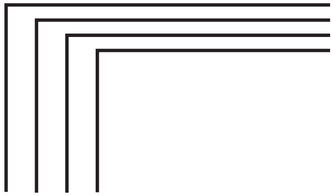


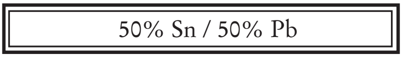
FIGURE 9

Materials for silos measuring 0.159 m³ to 2.410 m³

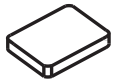
Galvanized steel sheets, 0.5 mm thick (or corresponding to 26 gauge); normally 200 cm long x 100 cm wide (see plans for other dimensions in the appendices)



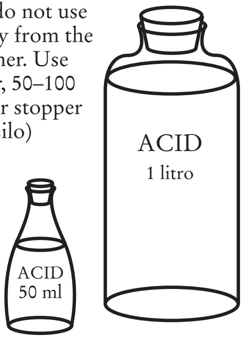
Solder in sticks or on a roll: the best is 50 percent tin, 50 percent lead (300 g to 1 kg per silo)



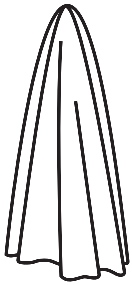
Soldering aid or flux such as a sal ammoniac bar (ammonium chloride) (20-50 g/silo)



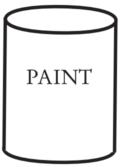
Hydrochloric or muriatic acid at a concentration of 10 percent; do not use the acid directly from the original container. Use a small glass jar, 50–100 ml, with a lid or stopper (20–50 ml per silo)



Soap powder and rags for cleaning



Aluminium-coloured anti-rust paint (80–250 ml/silo); never use lead-based paint



Charcoal for heating the soldering irons or gas in cylinders if available (2–6 kg/silo)

3.3 Materials

The materials are the things you need to construct a silo. The quantities needed for silos of 0.159 m³ to 2.410 m³ are given below.

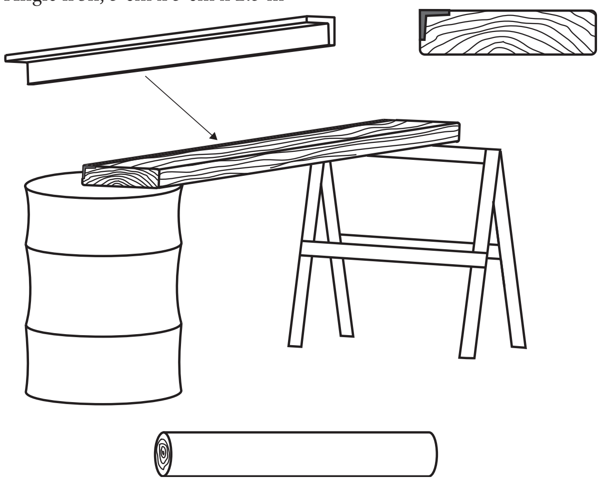
3.4 Description of the work bench

You need a simple work bench (you can make one as shown in Figure 10). You need to cover one edge of the wooden plank with a piece of angle iron. You will need the following materials:

- wooden plank, 5 cm x 25 cm x 2.5 m long;
- wooden log 10 cm in diameter x 1 m;
- one piece of angle iron, 3 cm x 3 cm x 2.5 m;
- two barrels or sawhorses, about 8 cm high.

If you have a good, sturdy work table, you can attach the angle iron to the table.

FIGURE 10
Work bench



CHAPTER **4**

Workshop and basic skills

4.1 Workshop

The work space can be very simple. To build large silos, the workshop should be at least 2.5 x 5 m, have a hard floor (the best is cement) and a small table for your tools. Your tools are valuable and are the key to good work; if you cannot lock them away, take them home with you.

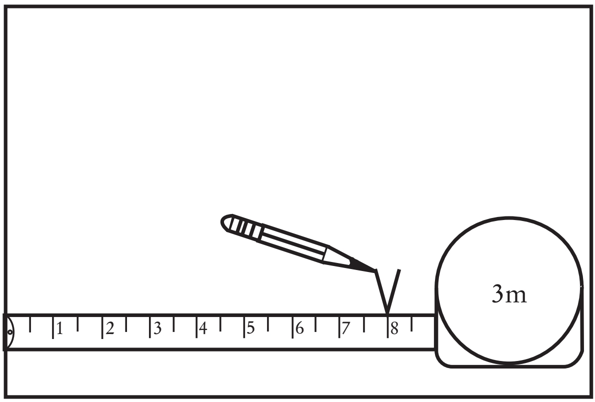
4.2 Basic skills

These are the skills you need at each stage of the process of making a silo.

4.2.1 Measuring and marking

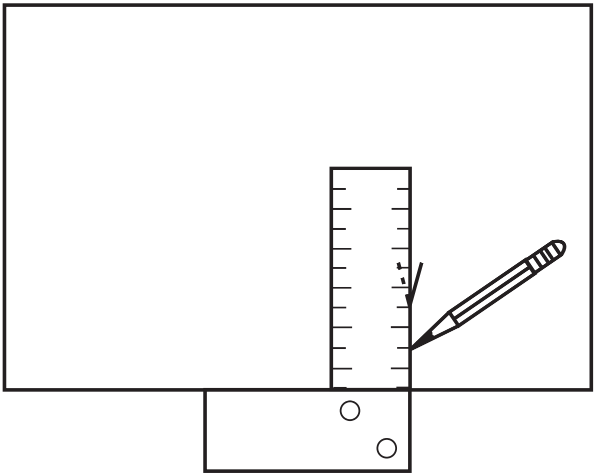
The tape measure has a hook at the end. Put the hook on the edge of the sheet and make a V-shaped mark with the point of the V at your measurement. Hold the tape parallel to the edge that you are measuring along.

FIGURE 11
Using the tape measure to mark 8 cm



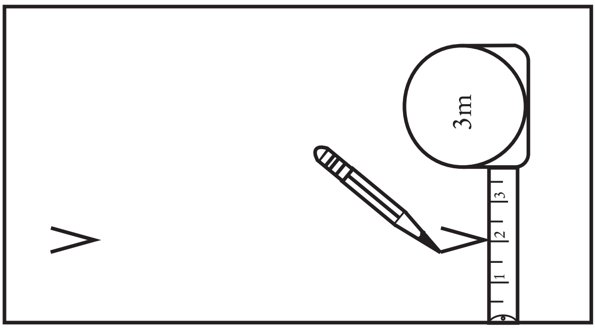
The square marks 90° to the edge of the sheet. Use it to mark short lines. Place the edge of the square along the edge of the sheet and the intersecting edge at the point of the V mark that you made with the tape measure.

FIGURE 12
Using the square



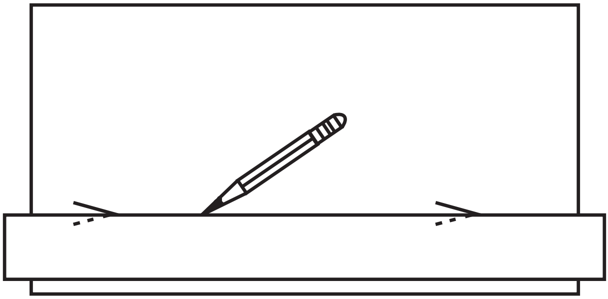
You will need two marks or points to draw a long line. Use the tape measure to make two marks 2 cm from the edge of the sheet.

FIGURE 13
Using the tape measure



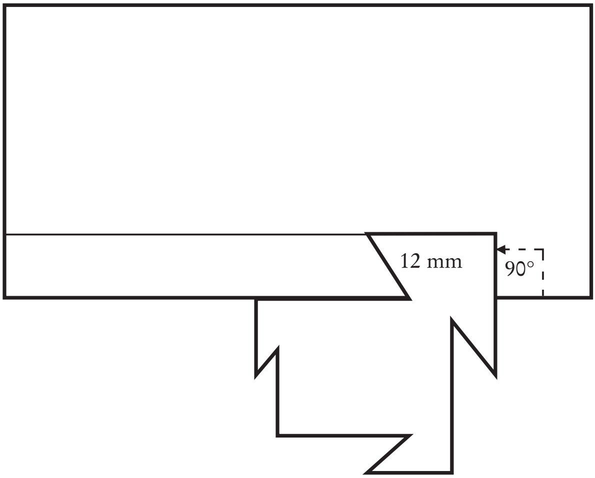
Use the right edge to connect the marks or points.

FIGURE 14
Connecting marks or points



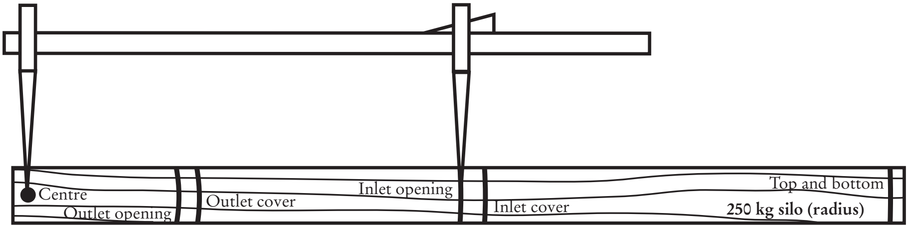
The marking gauge draws a line parallel to the edge of the sheet. In Figure 15, the gauge makes a line 12 mm from the edge. Hold the gauge 90º to the edge of the sheet.

FIGURE 15
Using the gauge



You will need the compass to make circles. To measure the opening of the points of the compass, use the marker-measure and adjust the compass to the mark.

FIGURE 16
Using the marker-measure



When the measurement is set, use the compass as shown in Figure 17 to find where to place the centre point of the circle (do not scratch too hard or you might damage the galvanization) and draw the circle (Figure 18).

FIGURE 17
Using the compass

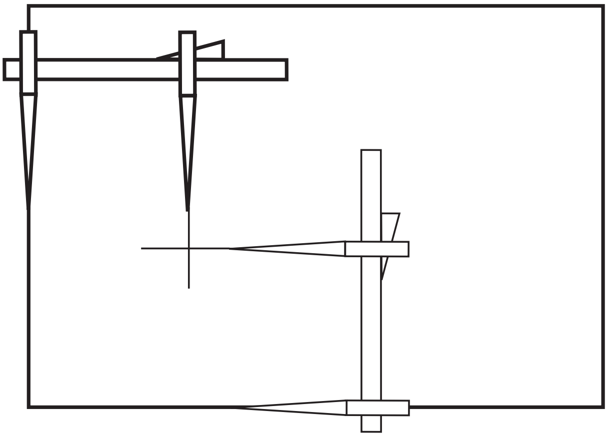
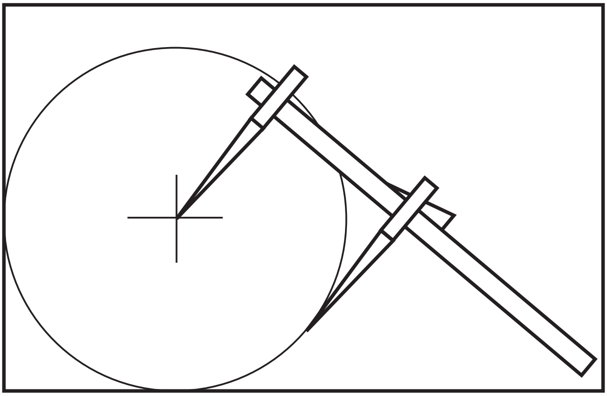


FIGURE 18
Drawing the circle



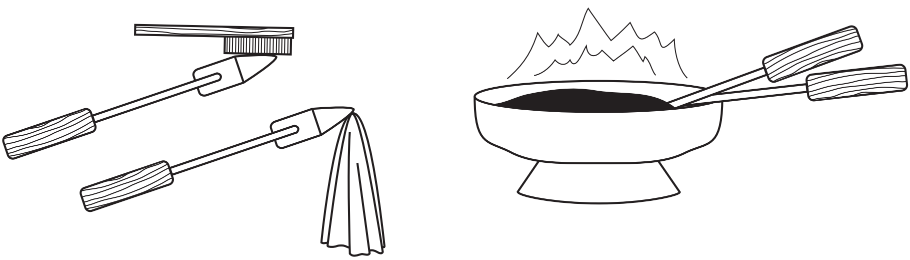
4.2.2 Soldering

Soldering is another important part of this process. Learning to solder well and quickly saves time, solder and charcoal. It will also help you make good quality silos that last for a long time.

First prepare the soldering irons. The face of the iron that you will use for soldering must be clean and coated with tin; begin by scrubbing the face of the iron with the wire brush and then wipe with a rag.

Heat the irons in the fire. When you heat the irons for soldering, they should never glow red hot. This will damage the copper and waste time and charcoal.

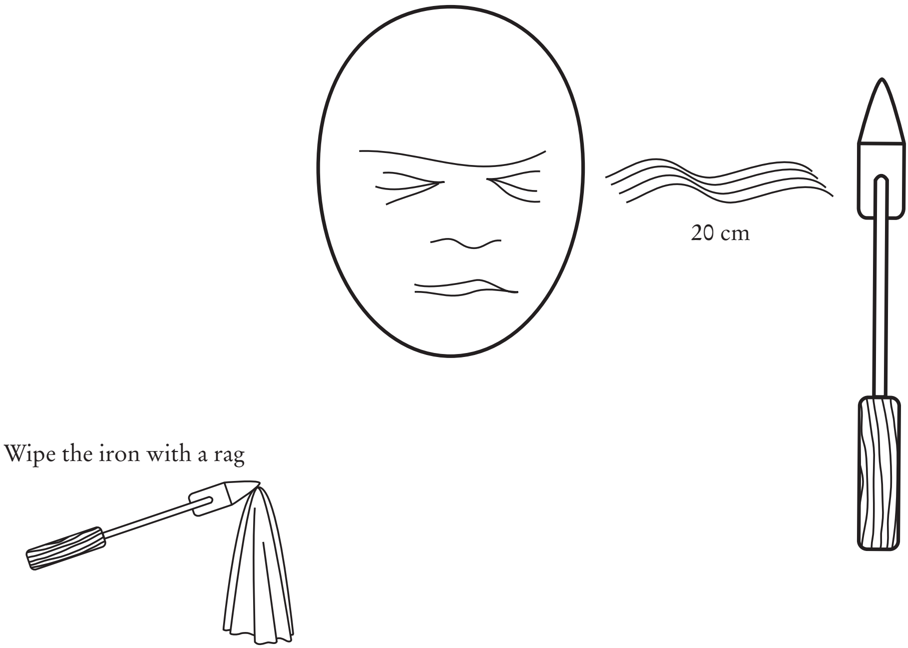
FIGURE 19
Wiping and heating the irons



Remove one of the irons to see if it is hot enough (it is ready when you can just stand it 20 cm from your face).

FIGURE 20

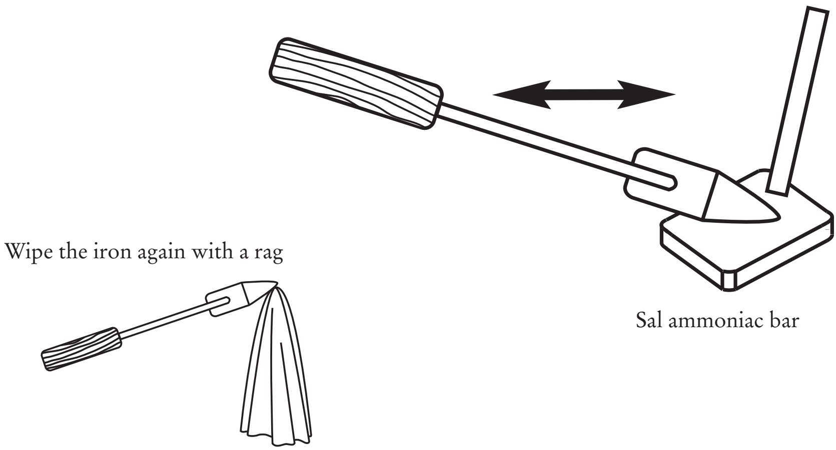
Irons that are hot enough



Rub the tip and one of the sides of the iron gently on the sal ammoniac bar, adding solder until the tip is covered in solder. This is called "tinning the soldering iron". You can also use resin in a shallow dish, mixing it with a little sand.

FIGURE 21

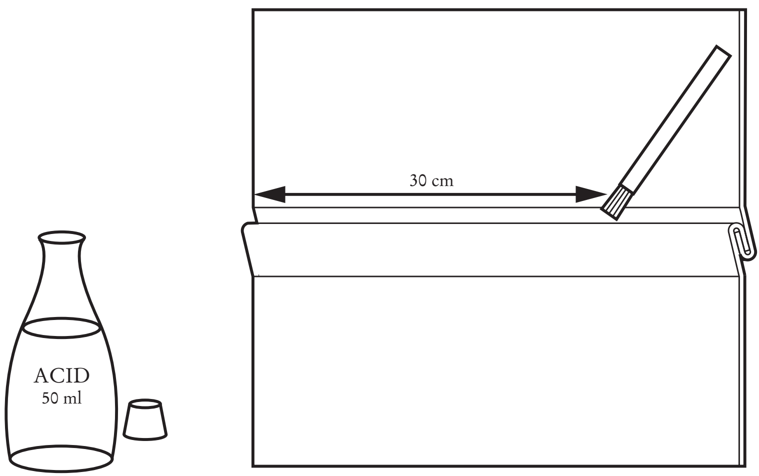
Tinning the soldering iron



Apply a little acid to clean the joint just before soldering. For long joints, only apply the acid for 30 cm at a time. Be careful not to spread the acid to other parts of the metal.

FIGURE 22

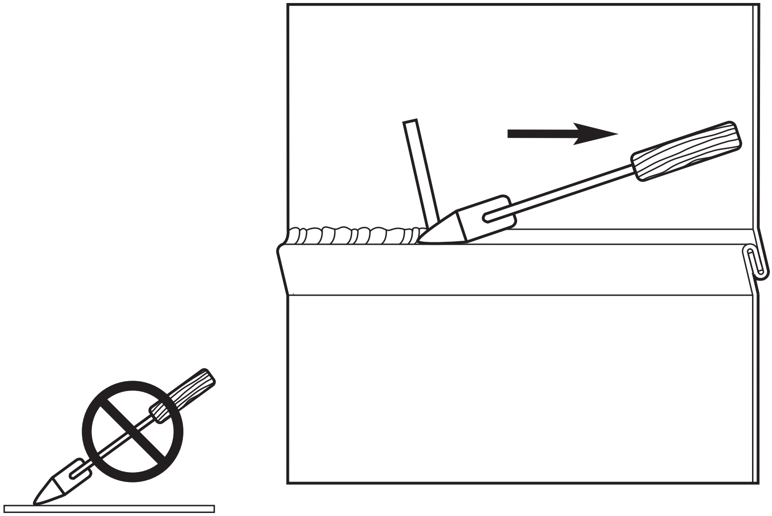
Applying the acid



Use the clean face of the iron to melt solder into the joint. Hold the whole face of the iron on the joint and drag the iron slowly along the solder as it melts from the bar. If you see any holes, go back and cover them. When the solder no longer melts easily, return the iron to the fire and use another one.

FIGURE 23

Using the iron to melt the solder



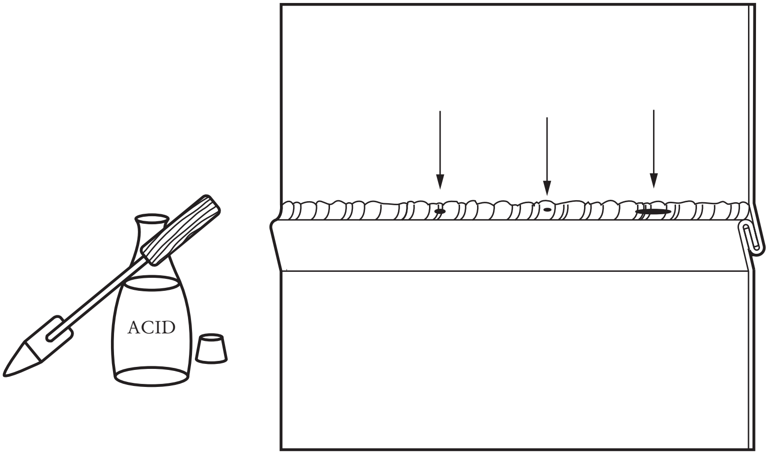
Important!

Use the whole face of the iron, not only the tip.

Check for holes along the whole joint. If you find any, fix them straightaway. Apply a drop of acid at the spot and melt a little solder into the hole.

FIGURE 24

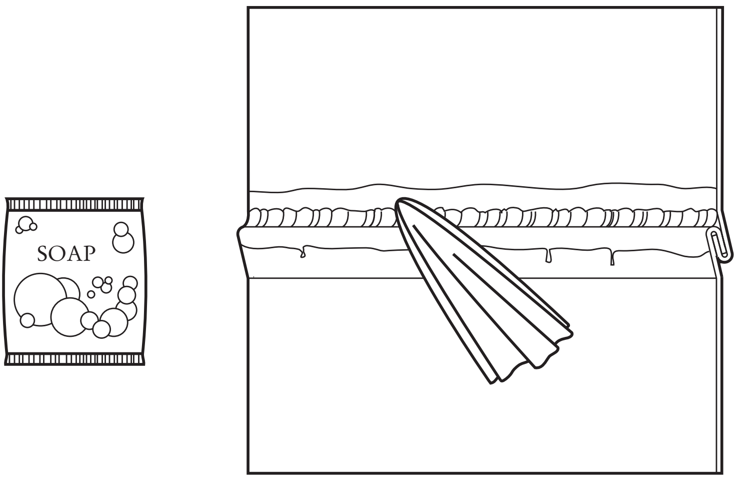
Fixing holes



Use a rag with soap and water to clean the areas where the acid touched. Dry the area with another rag or cloth.

FIGURE 25

Drying the area



4.2.3 About the silo's airtight seal

If the bends have been properly soldered, you will obtain a good airtight seal, as described in section 2.2.7., and you will not need to use nails or rivets. The presence of nails or rivets in a completed silo are an indication that the bends have not been made properly.

Using paint to seal holes or products to seal joints does not necessarily mean that the silo will be stronger or that it is completely sealed. Do not rely on paint to seal holes because after a time it will peel off and the silo will lose its seal.

Make all the joints and bends carefully, seal them and reinforce them with soldering. This combination of precision in joints and bends and the use of proper soldering will result in a high quality, long-lasting silo and, with good maintenance, will help to preserve it for 15 or 20 years.

A further important detail is that the height of the neck of the covers should be less than the height of the neck of the mouths so as to have sufficient space between the closures of the covers and necks and to be able to apply rubber strips or bands to seal them.

Always try to:

- make all the joints and bends carefully;
- solder all the joints and bends with a tin/lead soldering iron;
- clean and check all the soldering joints;
- fill all the holes with solder.

Never use:

- nails or rivets;
- products to seal joints;
- paint to cover holes.

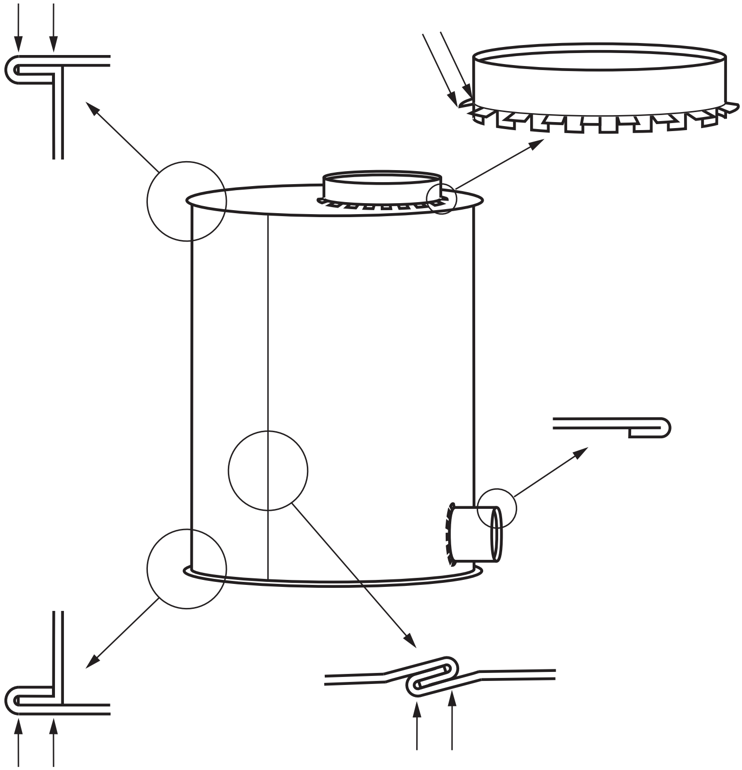
In order to check that the silo has no small openings or holes that have been missed during its construction, you might need to test the airtight seal before using the silo. A simple way to test this would be to fill the silo with water to see if there are any leaks in the joints and bends. This would therefore be a practical, advisable way of checking the silo's airtight seal.

It is also important, after testing the seal with water and before using the silo, to remove any moisture remaining inside the silo by drying it and ventilating it appropriately. This will avoid wetting the dry grain which will be placed and stored in the silo.

Figure 26 shows details and points in the body of the silo which should be tested for holes or openings.

FIGURE 26

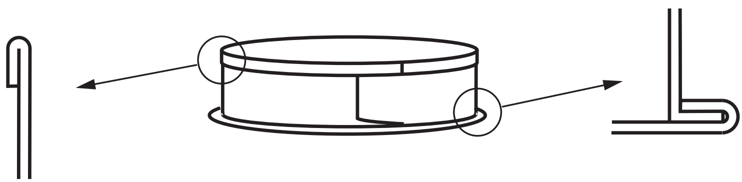
Construction details about closure



All the joints and bends should be soldered.

FIGURE 27

Covers



CHAPTER **5**

Building the silo

Important!

Read the manual before you start work so that you understand the basic process

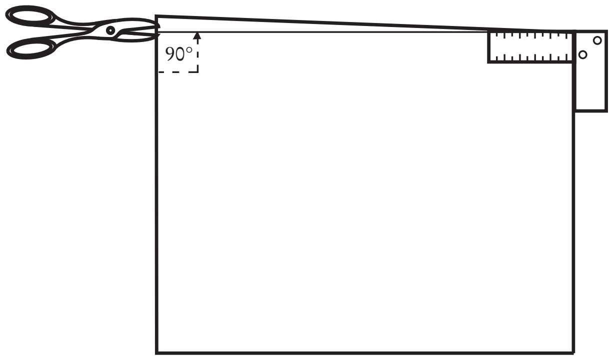
5.1 First steps

Before you start to build a silo, collect all the tools and materials and clean the work space.

Using the square, check that the corner angles of each sheet are 90°. This is particularly important for the sheets that will be used for the body of the silo. Cut off only the smallest amount necessary to make the end of the sheet square.

FIGURE 28

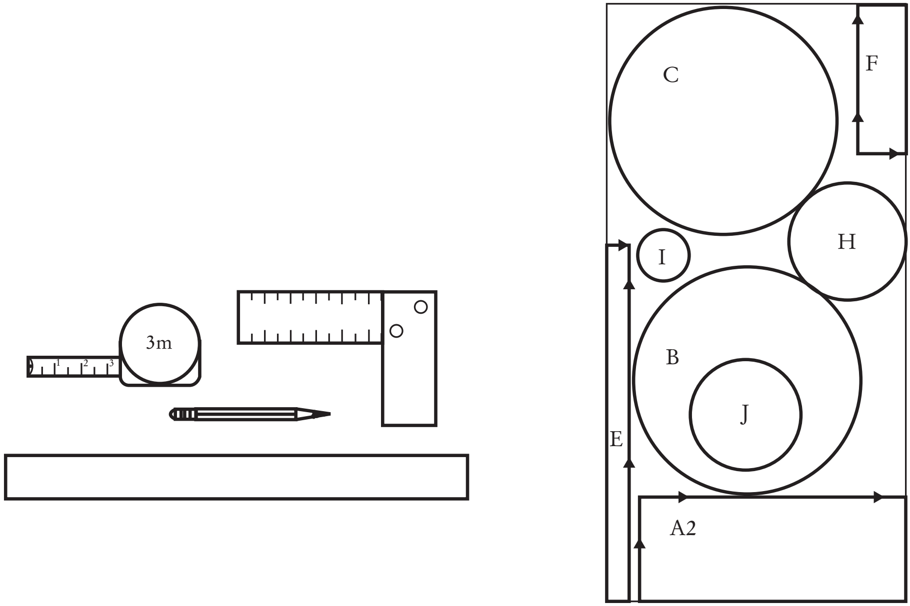
Cutting the sheet



Using the tape measure or the patterns or templates, mark the pieces for the silo body, openings and covers. Refer to the pages that show plans for the silo you want to build. Before starting to cut, be sure to write on each piece so you know which is which.

FIGURE 29

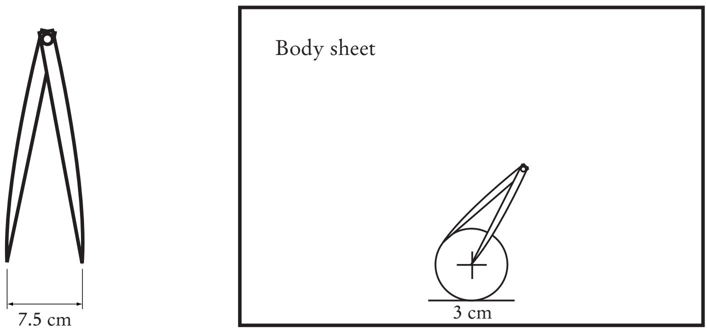
Marking parts



Cut the hole for the outlet opening in one of the body sheets. The edge of the hole must be 3 cm from the edge of the sheet.

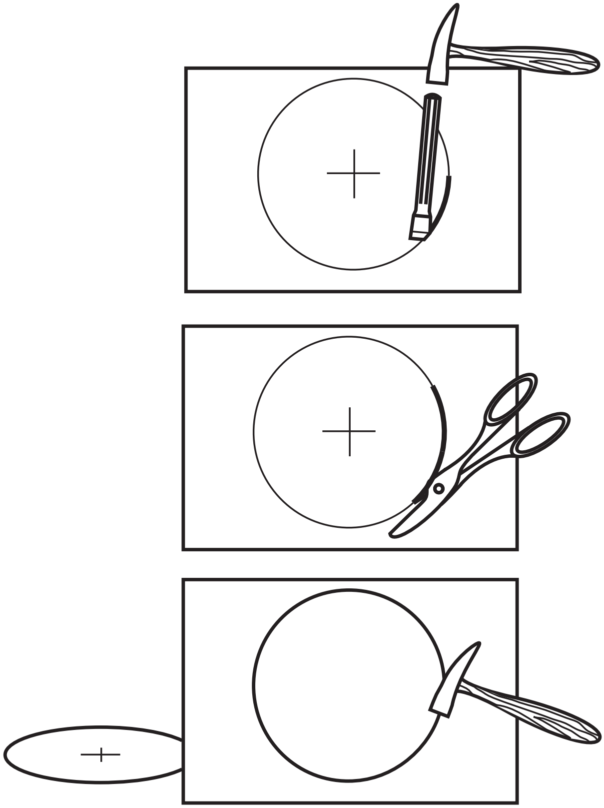
FIGURE 30

Cutting the outlet opening



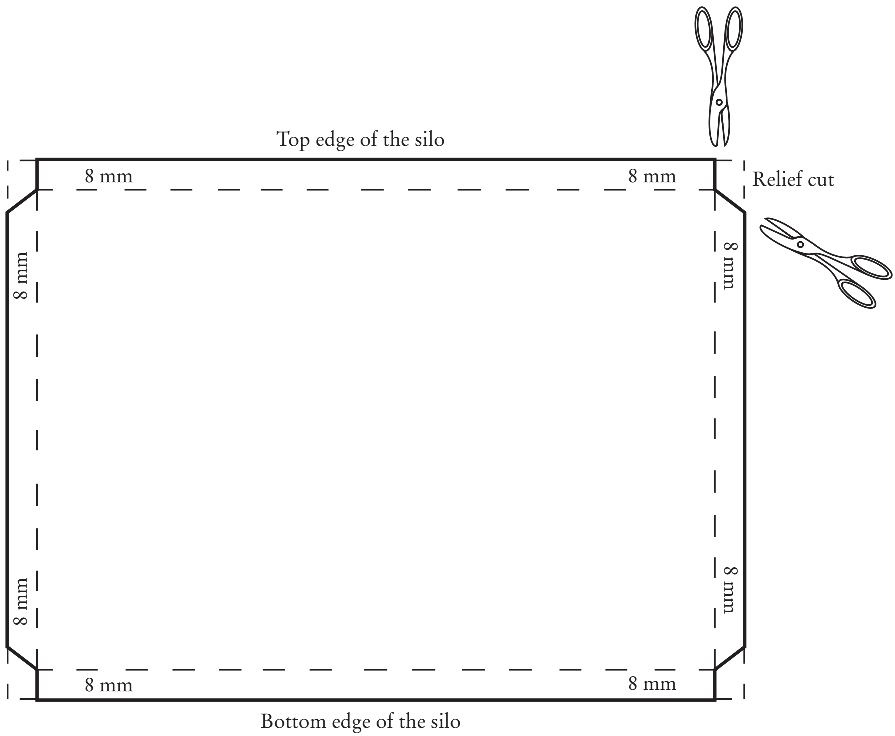
Use the hammer and chisel to start the cut and finish with the shears. Flatten the cut edge of the hole with the hammer on the work bench.

FIGURE 31
Cutting



Make the relief cut at all four corners of the sheets that make the body; make the square cuts on the ends or edges that will join to the top and to the bottom to make the bottom of the silo; and make the angled cuts on the edges that will join to each other or overlap to make the body of the silo.

FIGURE 32
Cutting the sheet



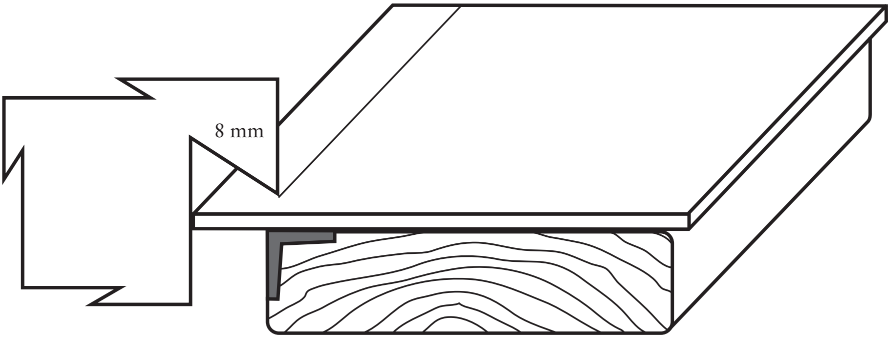
5.2 Making the body of the silo using the seam method

The folding or seam method is used to join the ends of the sheets that make the body of the silo. Carry out this whole process on two opposite edges of every sheet so that they look exactly like the drawing in Figure 33.

Use the marking gauge to make an 8 mm mark along the edge you are going to fold.

FIGURE 33

Marking before folding



Use the wooden mallet and the edge of the work bench with the angle iron to begin the fold.

FIGURE 34

Starting the fold

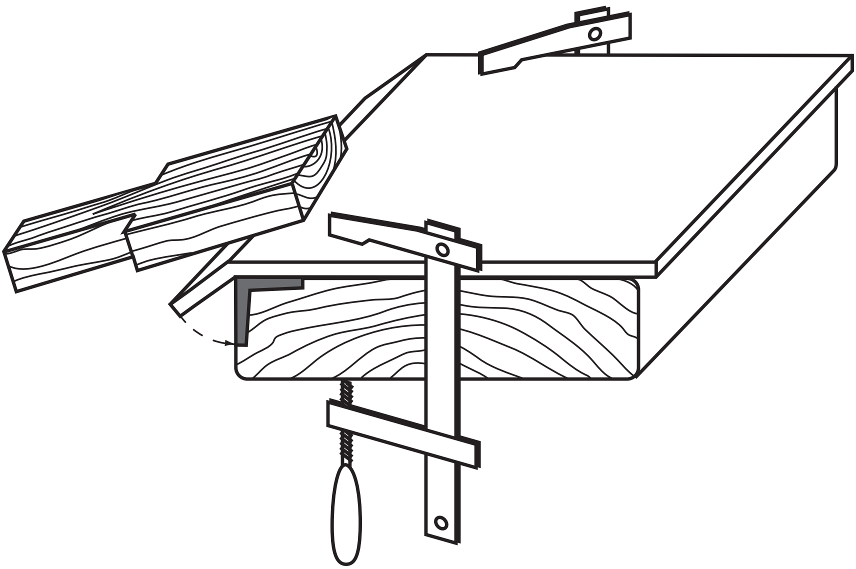
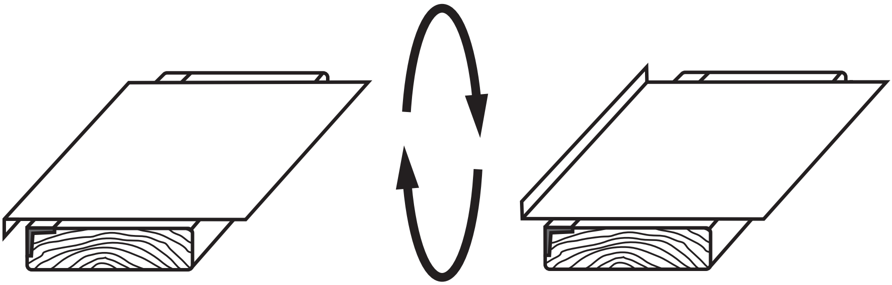


FIGURE 35

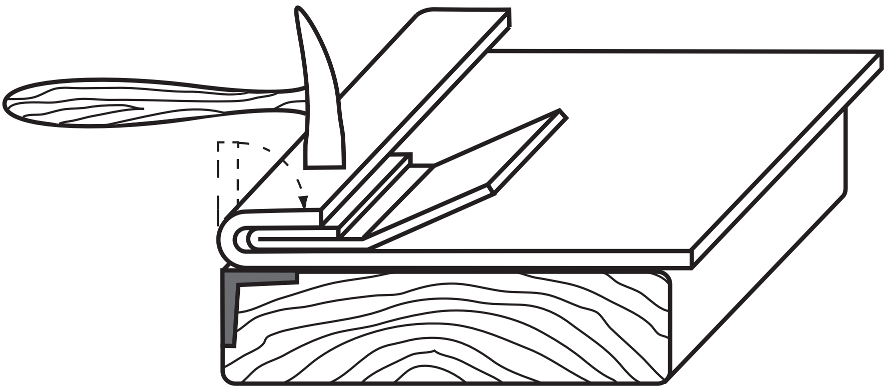
Folding the sheet



Use the spacer while you close the fold along the entire edge. At this point, the fold should be uniform and even.

FIGURE 36

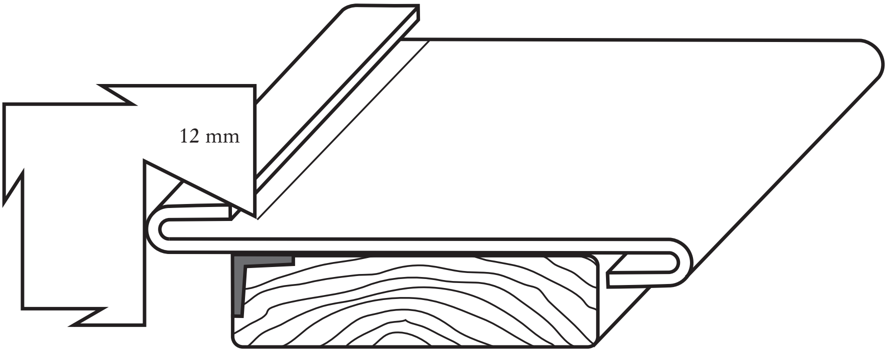
Using the spacer during folding



Use the marking gauge to make a 12 mm mark on the same side of the sheet as the fold.

FIGURE 37

Using the marking gauge



Use the spacer and the wooden mallet to bend the edge to about 20° on the work bench. The edge must be bent away from the side with the fold.

FIGURE 38

Bending the edge

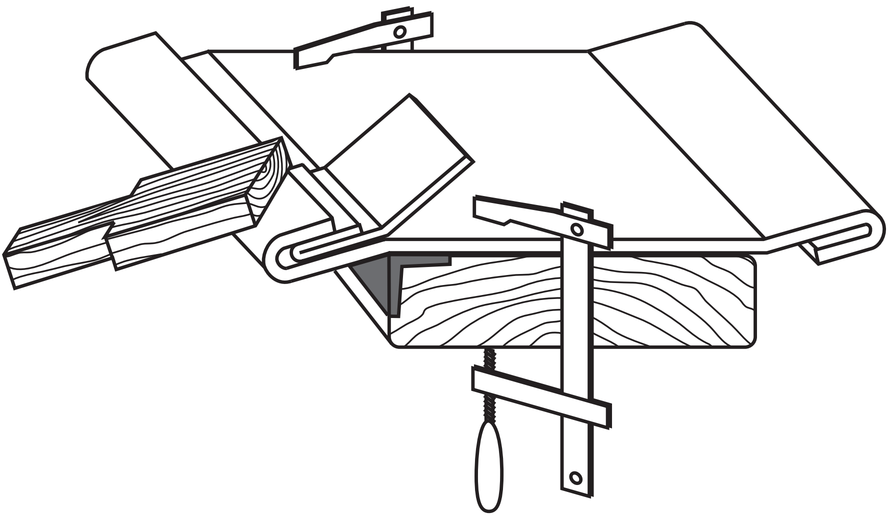
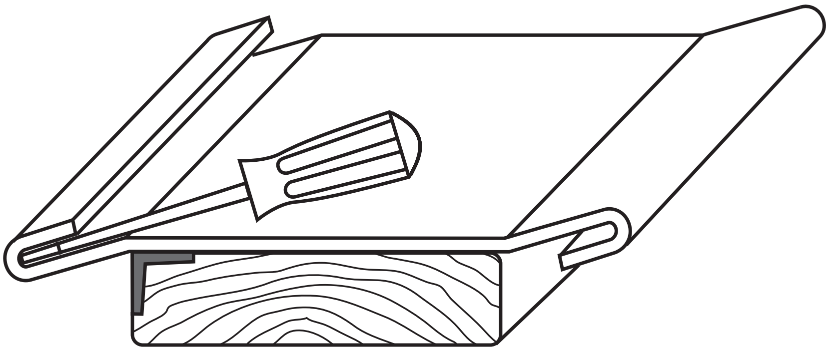


FIGURE 39

Using a screwdriver to reopen the folded edge



The body of the silo you are making may be made of more than one galvanized sheet. Fit the sheets together on the work bench or on the floor. It must be somewhere flat. Make sure that the folds or seams overlap the whole length of the edge of the sheet and that the top and bottom of the two sheets are well aligned.

FIGURE 40

Several galvanized sheets with overlapping folds

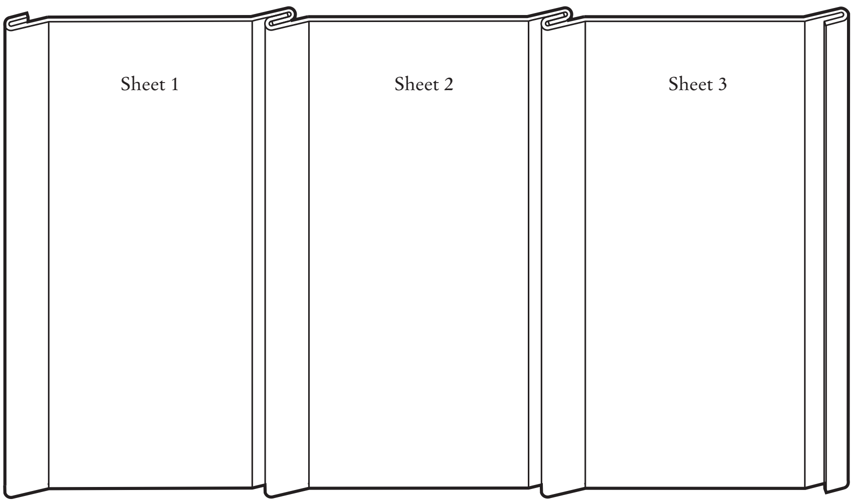
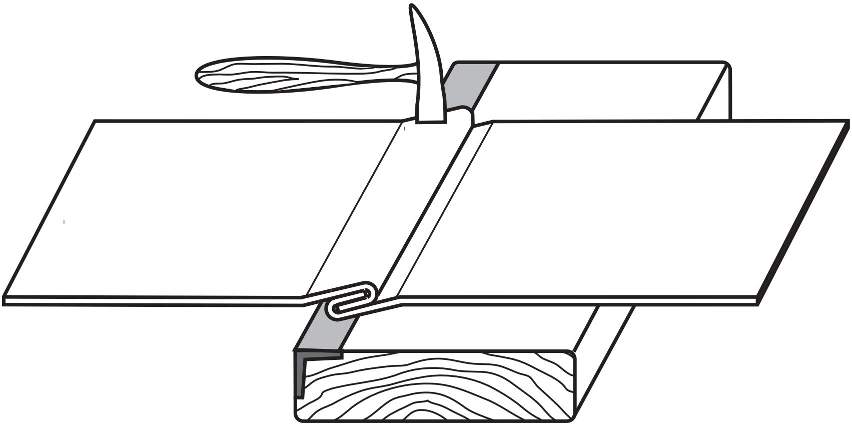


FIGURE 41

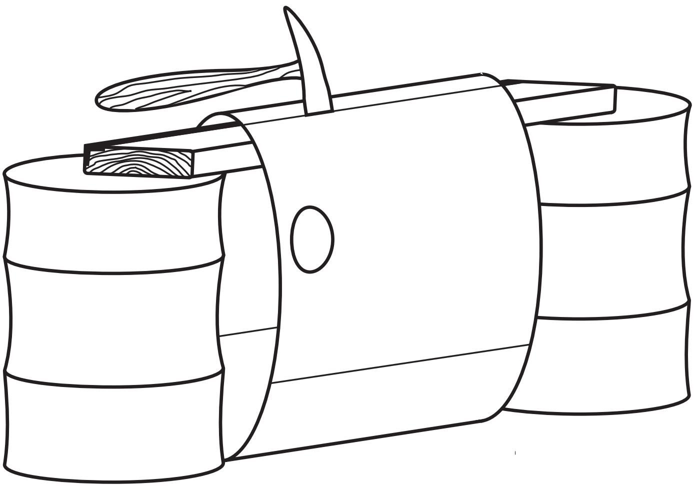
Hammering the overlapping seams



Join the folds or seams in the edges over the work bench so that they overlap to make the last fold. Close the last seam the same way you did the others.

FIGURE 42

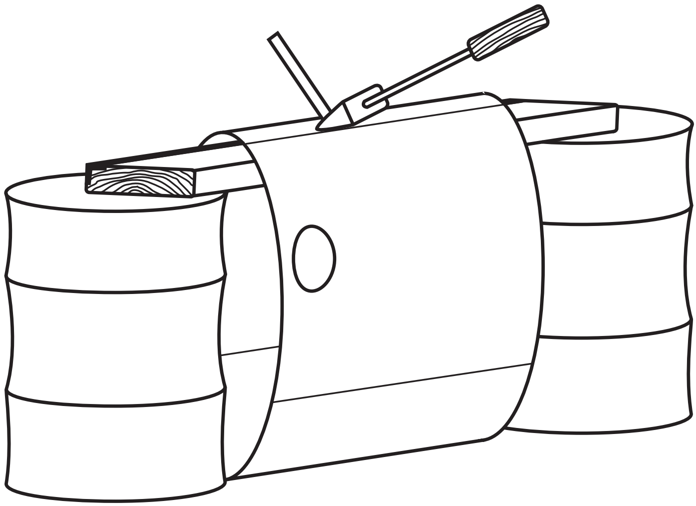
Joining the seams



Solder the folds or seams on one side of the sheet. The seam must be completely sealed with solder. The side with the solder will be the outside of the silo.

FIGURE 43

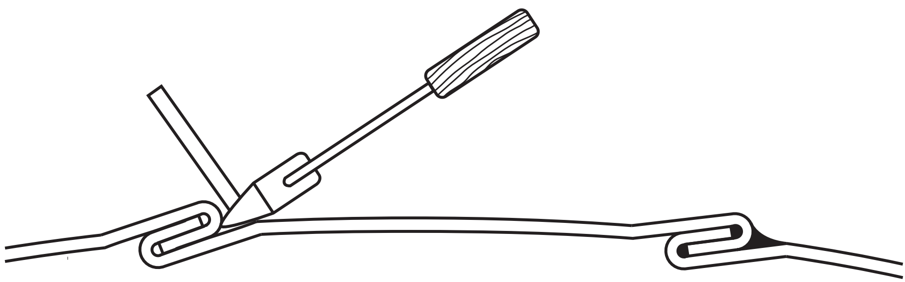
Soldering the seams



Solder only on the outside of the silo.

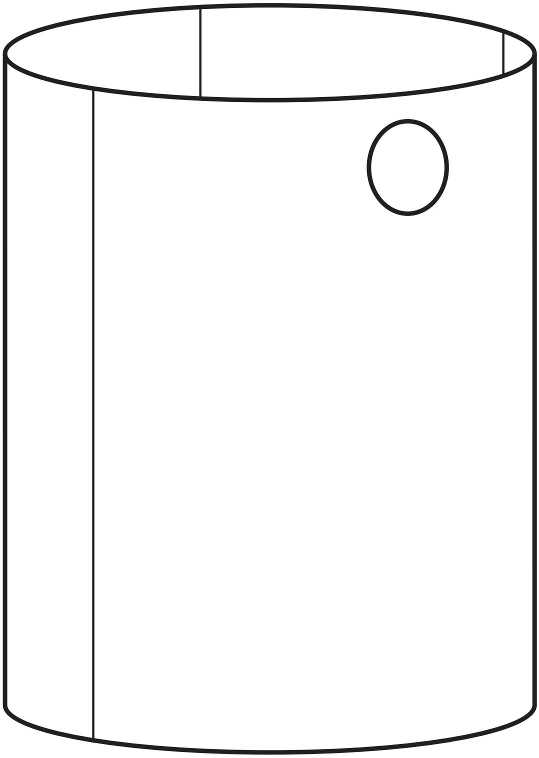
FIGURE 44

Soldering on the outside of the silo



Stand the silo with the outlet opening at the top to begin the process of joining the bottom or base of the silo to the body.

FIGURE 45
Silo standing with the outlet opening at the top

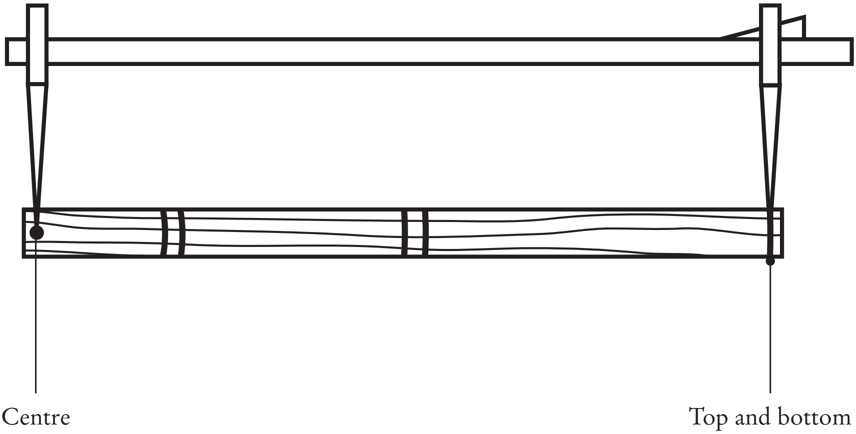


5.3 Making the top and bottom of the silo

Smaller silos have tops and bottoms made from one piece. Larger silos have tops and bottoms made from two pieces. This section shows how to make both types.

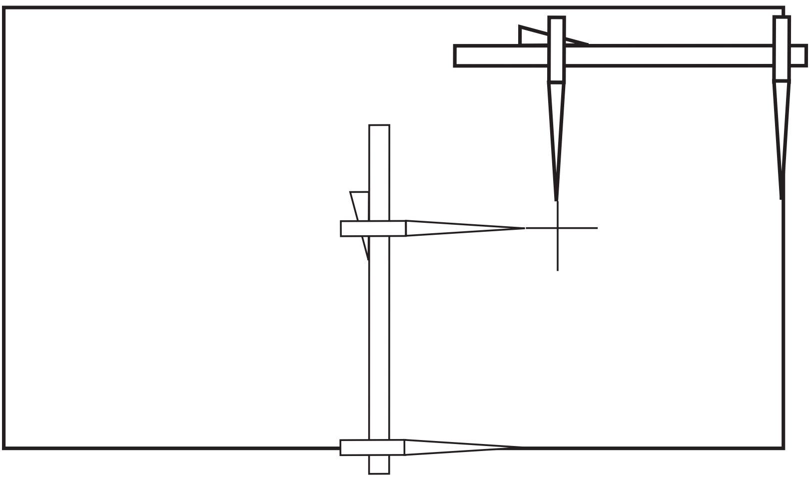
The compass draws the large circles. To measure the opening of the points of the compass, use the marker-measure and adjust the compass to the top and bottom radius mark.

FIGURE 46
Using the marker-measure



When the measurement has been set, use the compass as shown in Figure 47 to find where to place the centre point of the circle.

FIGURE 47
Using the compass

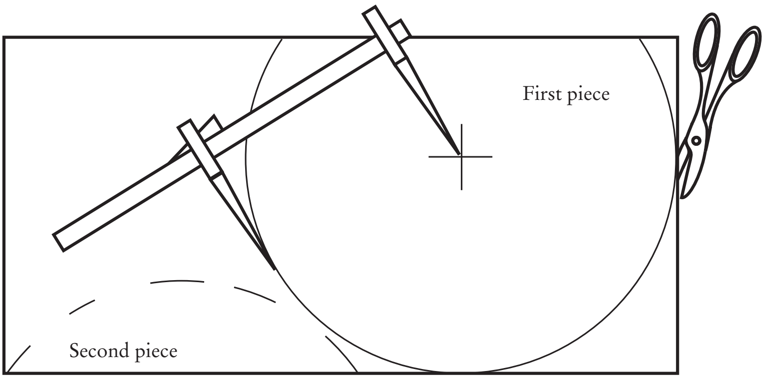


The next steps show how to make tops and bottoms from two pieces.

Clearly mark the centre point. You will need to find the centre again later to draw the smaller part of the circle. Be careful not to pierce the centre point.

FIGURE 48

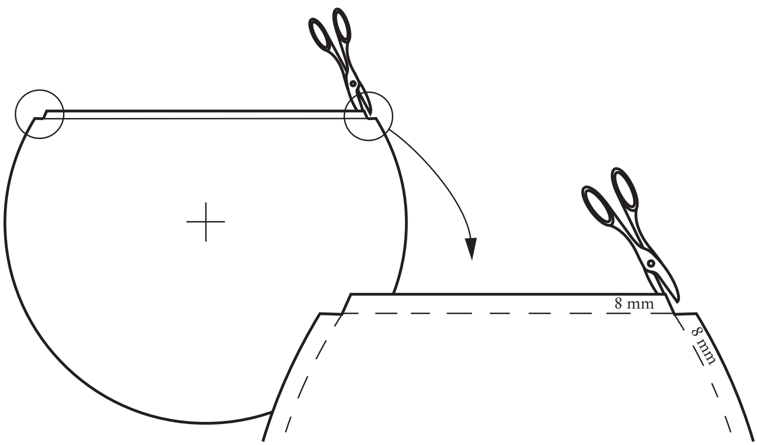
Marking the centre point



Make relief cuts at the edge of the end or straight part, i.e. where the seam or fold will be.

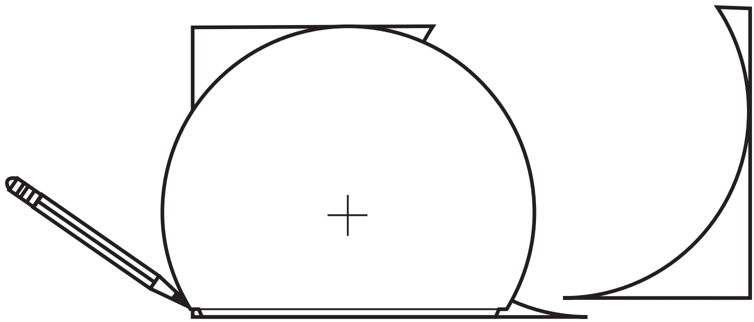
FIGURE 49

Relief cuts



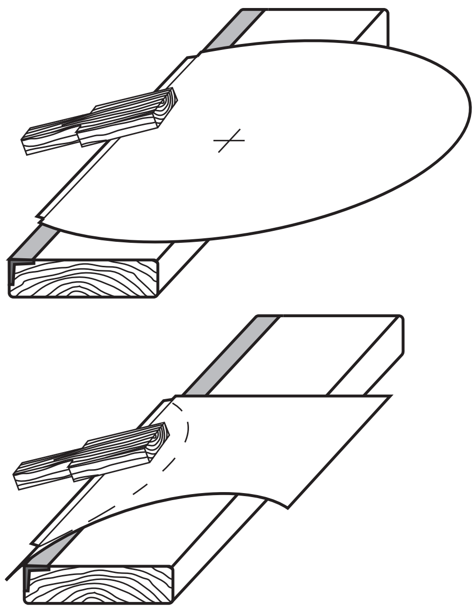
Put the larger piece of the circle on top of the sheet that you will use for the smaller piece. Align the edges and draw the relief cuts.

FIGURE 50
Positioning the pieces and drawing relief cuts



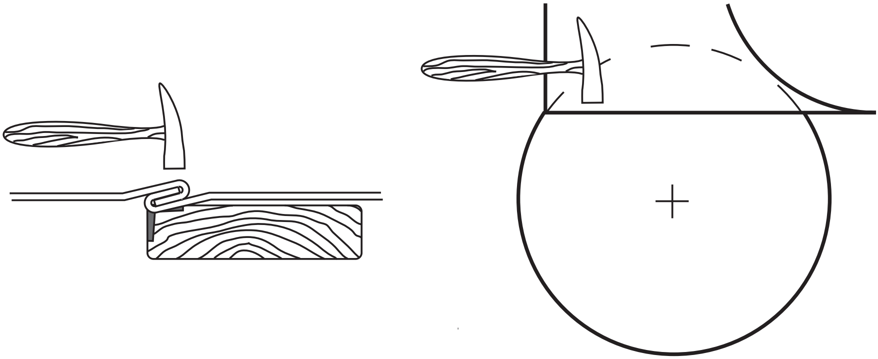
Use the seam method to join the pieces together.

FIGURE 51
Joining pieces by the seam method



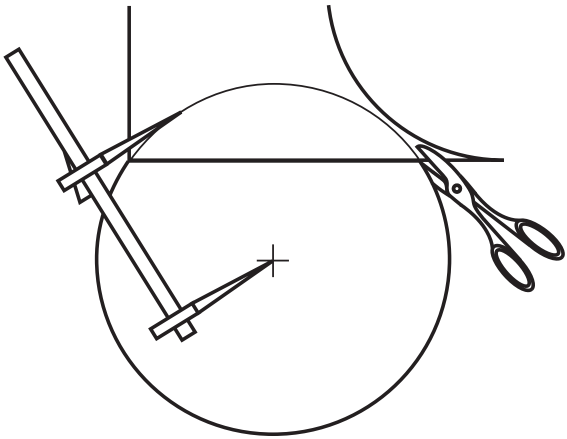
Hammer the seam closed but do not solder yet.

FIGURE 52
Hammering the seam



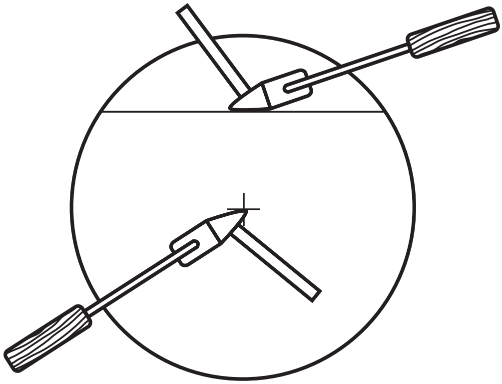
Use the same centre point. Mark and cut the rest of the circle.

FIGURE 53
Marking and cutting out the rest of the circle



Solder only on the outside of the silo. Put a drop of solder to cover the centre point of the circle.

FIGURE 54
Soldering the outside and the centre point

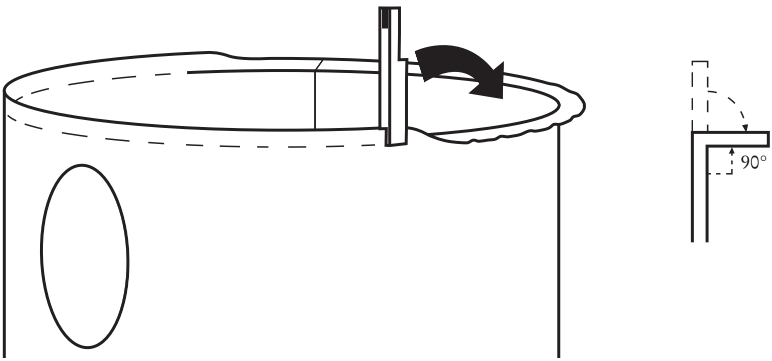


5.4 Joining the bottom of the silo to the body using the flange method

The flange method is used to join the top and bottom of the silo to the body of the silo. This section describes joining the bottom of the silo to the body, but the method is the same for the other assemblies.

Use the 8 mm bending tool to create a flange around the entire circumference of the cylinder. The flange must be bent to 90° towards the outside of the silo.

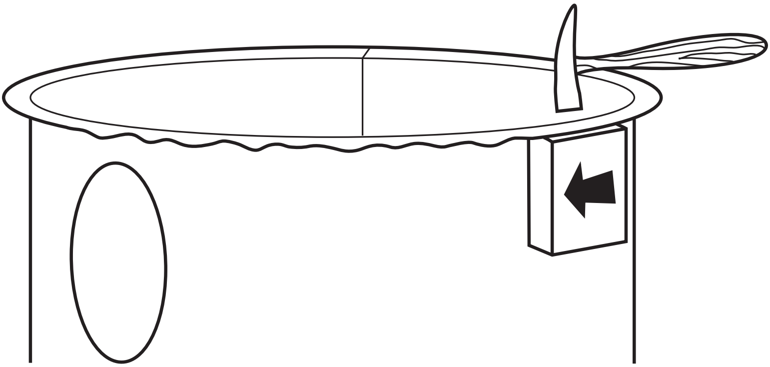
FIGURE 55
Flange bent to 90° around the circumference



After using the bending tool, the flange will be wavy and uneven. Go around the outside edge carefully with the hammer and the counterblow to flatten out the flange until it is flat and even.

FIGURE 56

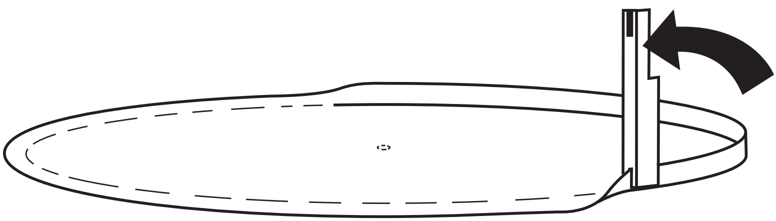
Flattening the flange with the hammer and counterblow



Now use the 8 mm bending tool to create another flange around the edge of the bottom piece. Bend the entire edge up 90° all the way around. There is no need to flatten this flange like you did before because it will be completely folded when you have finished.

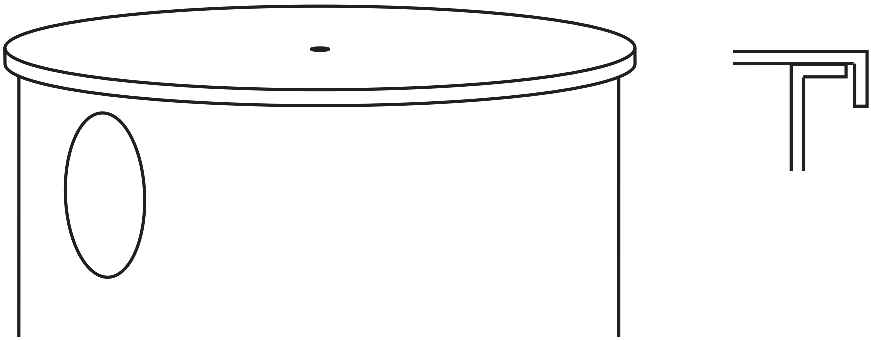
FIGURE 57

Bending the edge up



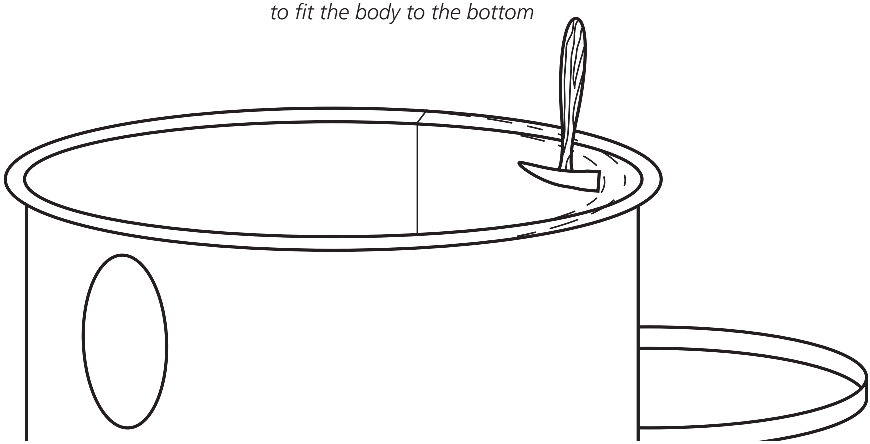
Put the bottom piece with the flange down over the body of the silo to check they are the same shape.

FIGURE 58
Checking the shape



When you put the pieces together they might not fit well at first. The body of the silo might not be a true circle. Mark with a pencil the places where it does not fit the bottom. Then gently tap it with the hammer from the inside. Only hit near the edge and be careful not to damage the soldered seams.

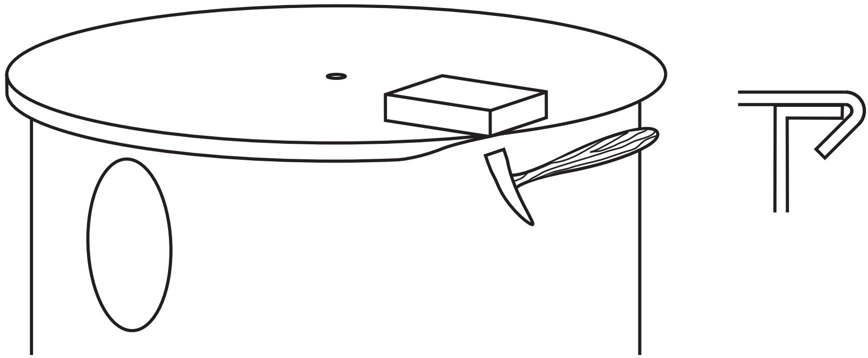
FIGURE 59
Tapping with the hammer to fit the body to the bottom



When the body of the silo fits the bottom, you can start to join them together. Use the counterblow over the place that you are hitting with the hammer as you work around the body of the silo. First hammer the flange to about 45°.

FIGURE 60

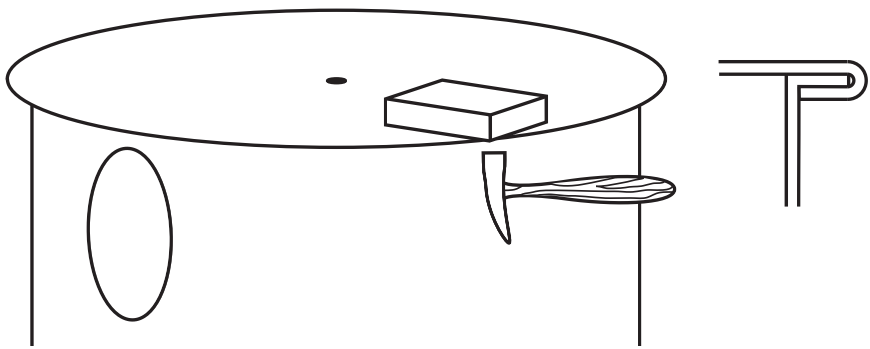
Joining the body of the silo to the bottom



Go around the circle again with the hammer and counterblow. Close the flange of the bottom piece completely over the flange of the body of the silo. Try to avoid wrinkles in the flange as you hammer it down and take care not to damage the body of the silo with the hammer.

FIGURE 61

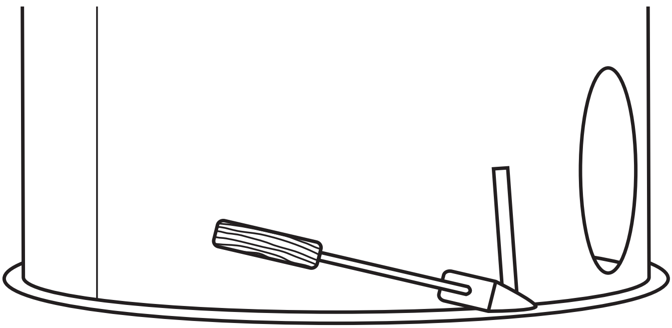
Completely closing the flange of the bottom piece over the flange of the body of the silo



Turn the silo the other way up. Solder around the flange. Be careful not to leave holes, especially around the seams in the body of the silo.

FIGURE 62

Soldering around the flange



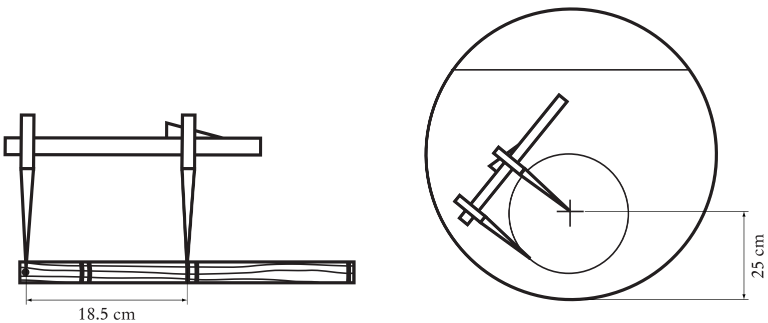
5.5 Making the inlet and outlet openings

This section describes how to make the openings used for filling and emptying the silo. The inlet opening is the large hole in the top and the outlet opening is the small hole in the side of the silo near the bottom.

Set the large compass to 18.5 cm and mark the hole for the inlet opening in the top piece. The centre of the circle must be 25 cm from the edge of the top piece.

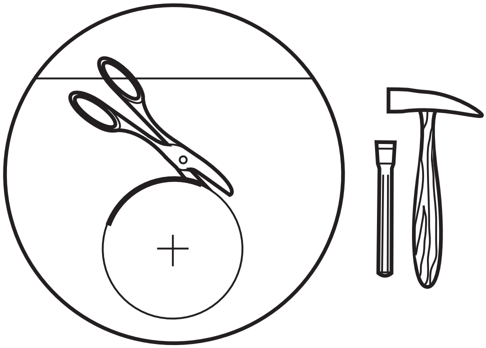
FIGURE 63

Marking the inlet opening



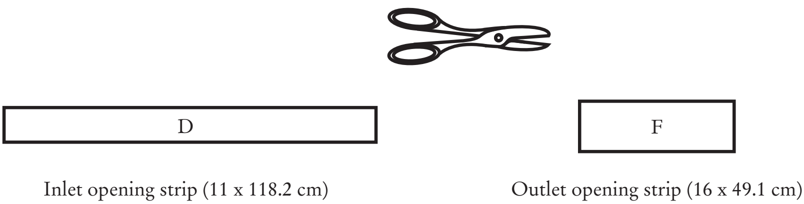
Use the chisel and shears to cut out the hole.

FIGURE 64
Cutting out the hole



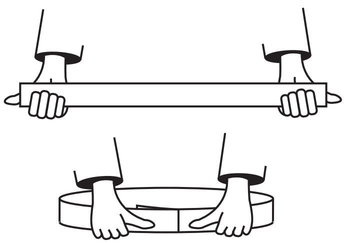
Cut out pieces D and F.

FIGURE 65
Cutting out pieces D and F



Take piece D and carefully bend it into a circle.

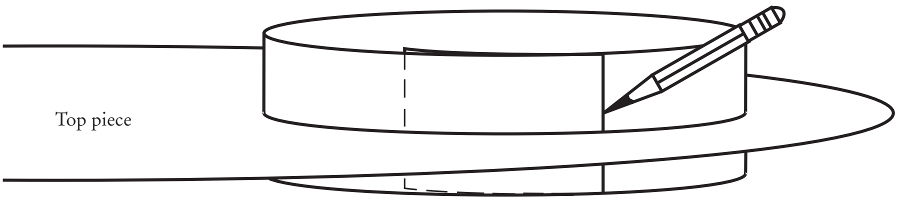
FIGURE 66
Bending piece D



Place the strip in the hole in the top. Make sure that the long edges are lined up evenly. Make a mark where the end of the strip overlaps itself, but do not cut it yet.

FIGURE 67

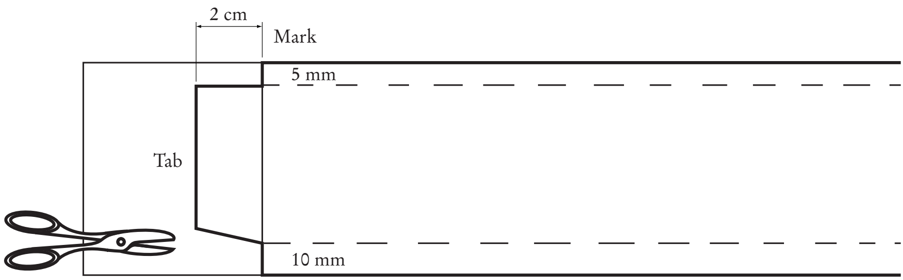
Mark where the strip overlaps itself



Lay the strip down flat again. From the mark you made, add 2 cm to make the piece longer. This 2 cm section will be the tab. The tab needs relief cuts so that the edges of the strip can be folded.

FIGURE 68

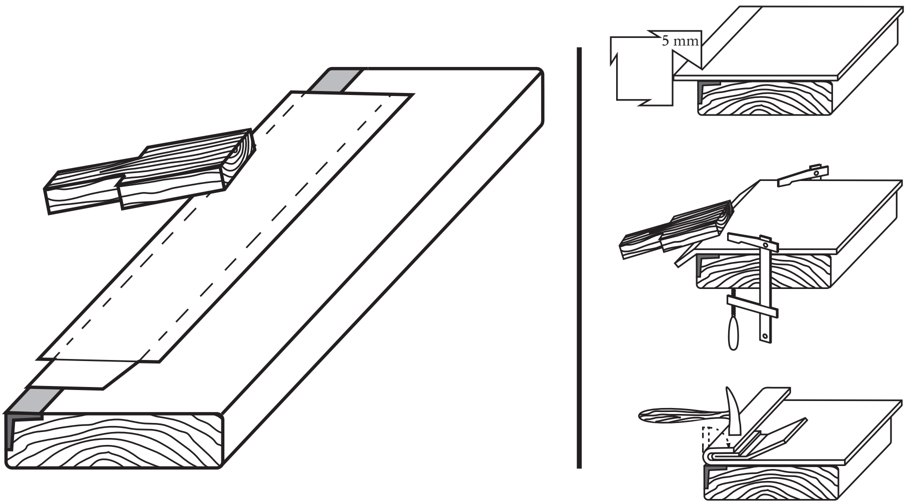
Marks and cuts in the tab



Bend the 5 mm edge of the strip.

FIGURE 69

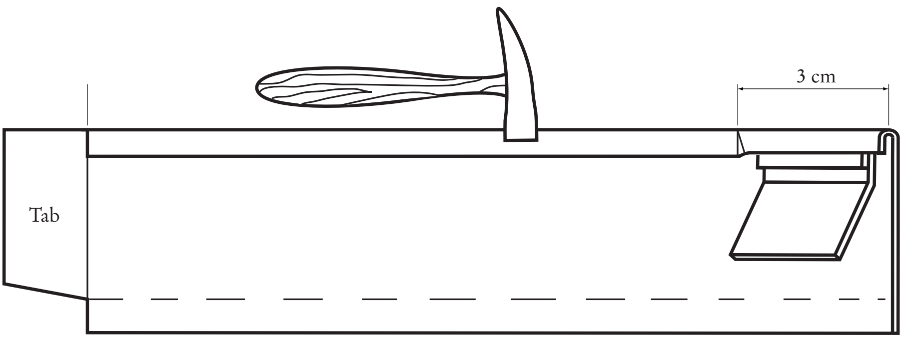
Bending the edge of the strip



Use the hammer to completely close the fold but use the spacer for the last 3 cm on the end away from the tab.

FIGURE 70

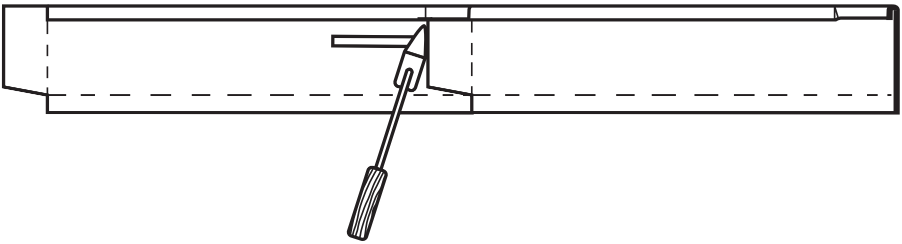
Closing the fold



For some silos, the strips of metal used to make the openings are made from two pieces. This is so that you can get all of your materials from the smallest number of sheets. Make a flange on each piece and solder them together.

FIGURE 71

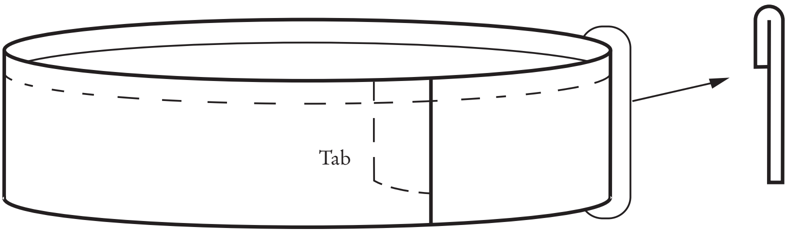
Soldering the flange



Bend the strip into a circle with the folded edge on the inside. Carefully align the measuring marks. The tab goes on the inside of the circle. The top edge of the tab fits under the folded edge of the strip.

FIGURE 72

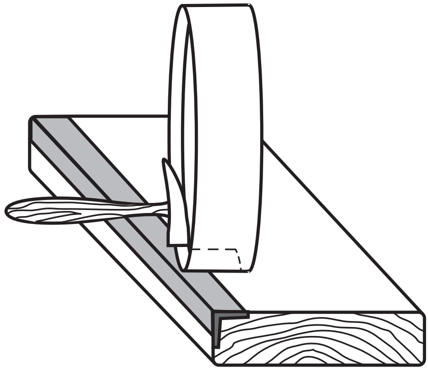
Folding the strip



The folded edge must be closed where it overlaps the joining tab.

FIGURE 73

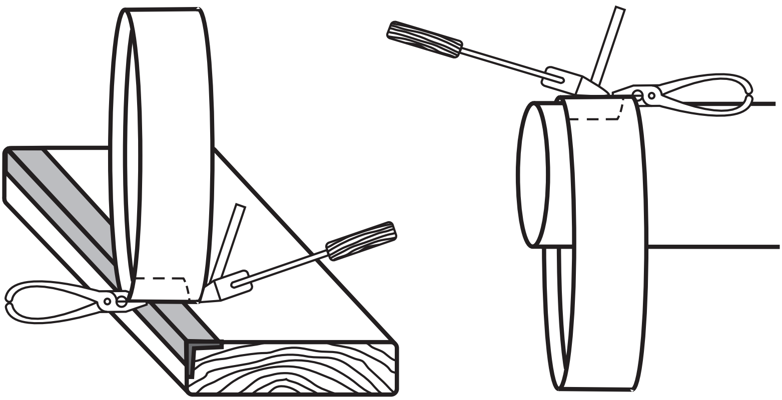
Closing the edge



Use acid to clean all the metal parts that might be touching. Hold the joint together with a clamp or the pliers. Solder the joint both inside and out, especially under the flange.

FIGURE 74

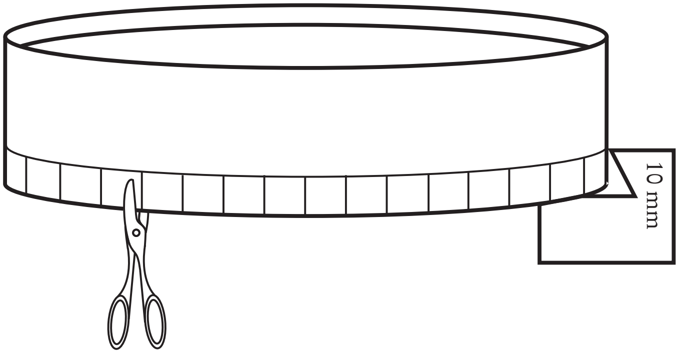
Fixing and soldering the joint



Use the marking gauge to mark 10 mm from the bottom edge. Make a small cut to the line every 15 mm. Cut exactly to the line. This will help to make a good joint.

FIGURE 75

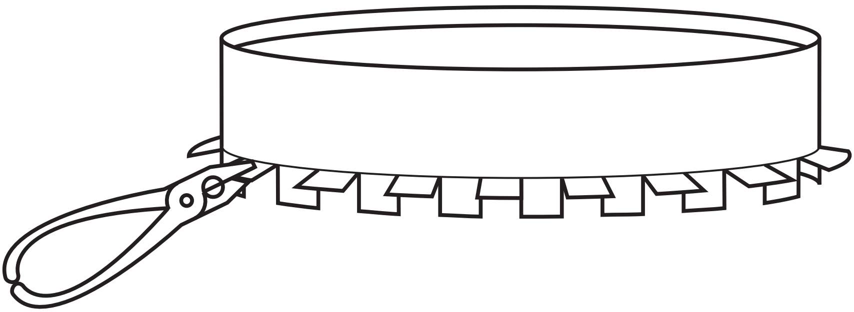
Cutting 10 mm every 15 mm



Bend alternate "teeth" 90° outwards. Be careful to bend exactly on the marked line.

FIGURE 76

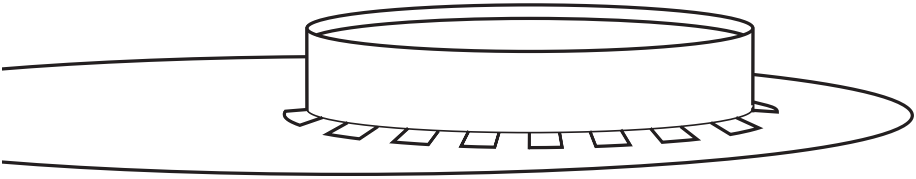
Bending alternate teeth



Put the opening in the circular hole in the top of the silo. The teeth that are not bent go inside the hole.

FIGURE 77

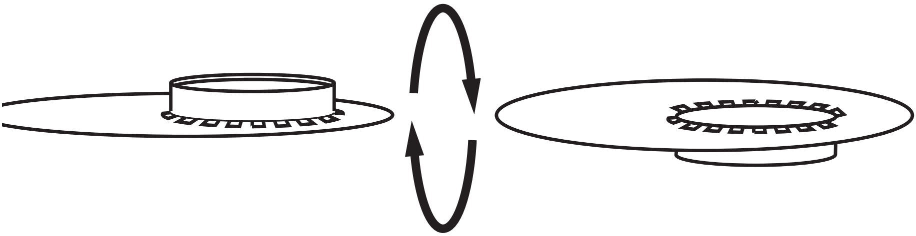
Positioning the opening over the top of the silo



Turn the top piece over.

FIGURE 78

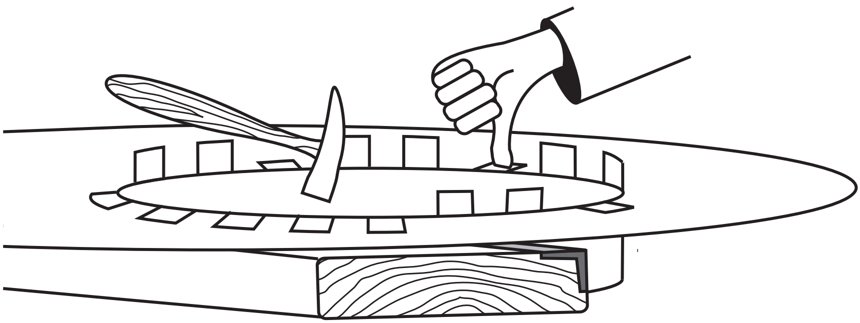
Turning the top piece over



Bend some of the teeth to hold the opening in place. Go around the circle with the hammer using the edge of the work bench. Hammer the teeth flat.

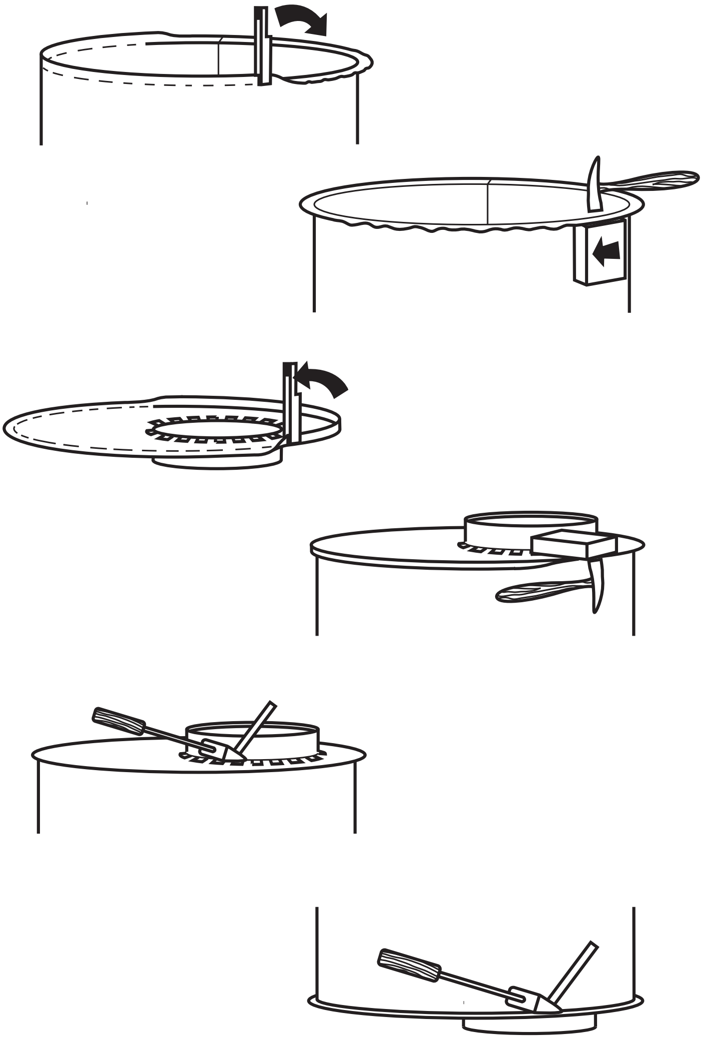
FIGURE 79

Fixing the opening



The top of the silo is ready to be joined to the body. Use the flange method which you used to attach the bottom of the silo to the body.

FIGURE 80
Flange method

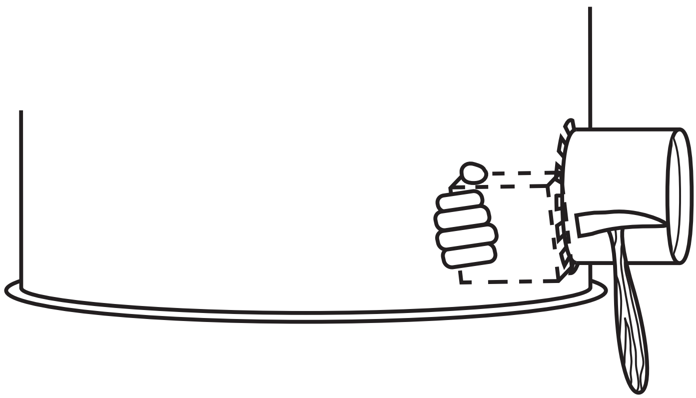


Use the same process to make the outlet opening.

FIGURE 81
Making the outlet opening

Hold the edge of the counterblow against the inside of the silo. The hammer blows should make a solid sound as you hammer the teeth against the body of the silo.

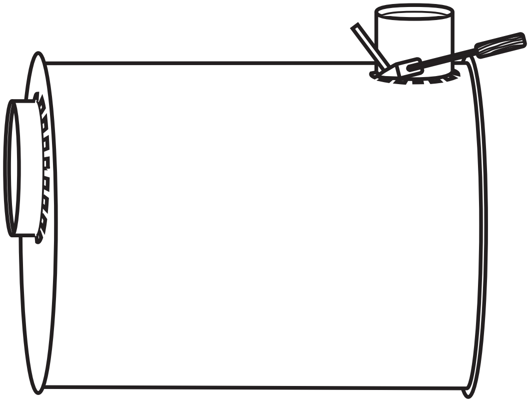
FIGURE 82
Fixing the outlet opening to the body of the silo



Solder well.

FIGURE 83

Soldering the outlet opening to the silo



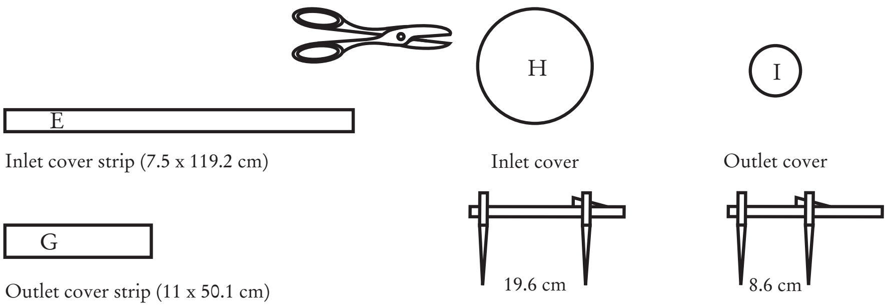
5.6 Making covers for the openings

The covers have two pieces: the cover strip and the top. An airtight cover keeps the fumigation gases in and prevents moisture, insects and fungi entering the silo. The process is the same for both covers, the inlet opening and the outlet opening.

Cut out pieces E, G, H and I.

FIGURE 84

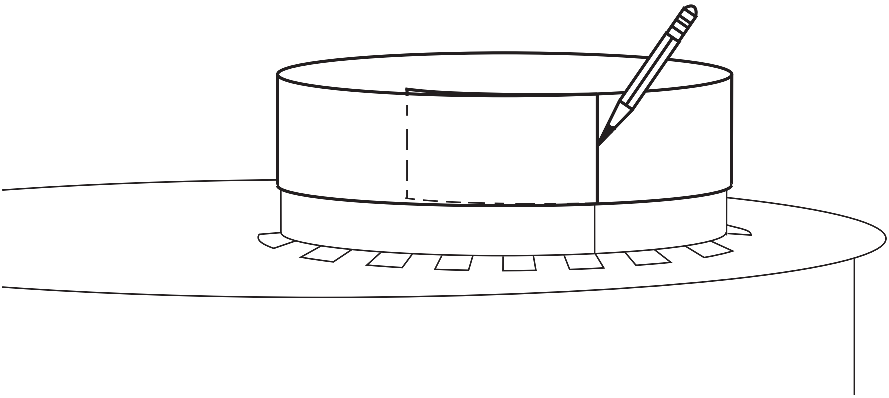
Cutting out pieces E, G, H and I



Wrap piece E around the inlet opening. Make a mark where it overlaps on itself.

FIGURE 85

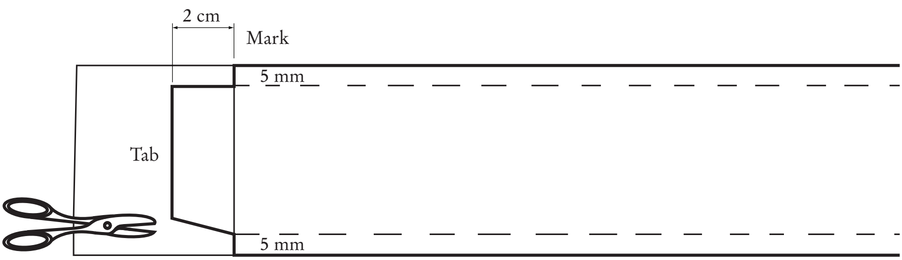
Marking where piece E overlaps at the inlet opening



Lay the strip down flat and add 2 cm to the length. This time the flange will be 5 mm. Use the tab method as you did before for the openings.

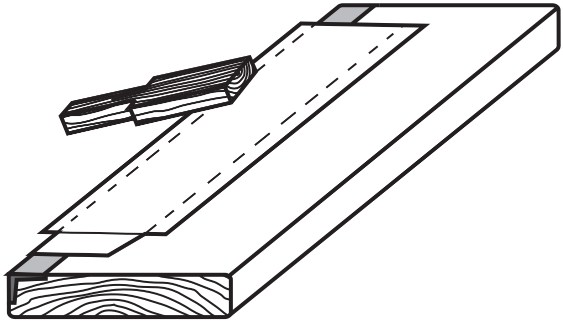
FIGURE 86

Tab method



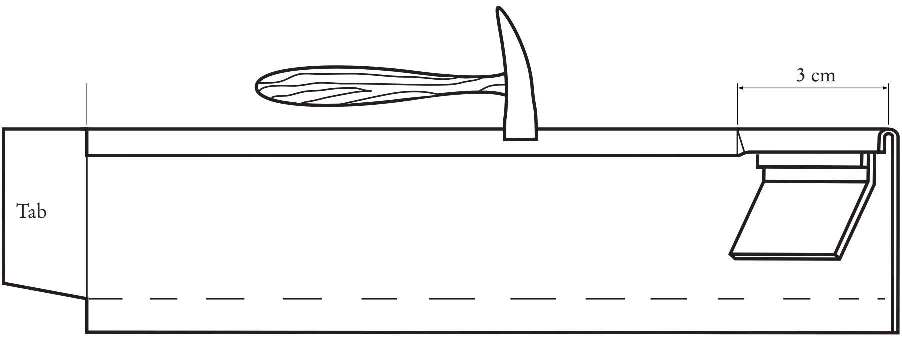
Fold over 5 mm of the edge of the strip.

FIGURE 87
Folding the edge



Use the hammer to close the fold but use the spacer for the last 3 cm on the end away from the tab.

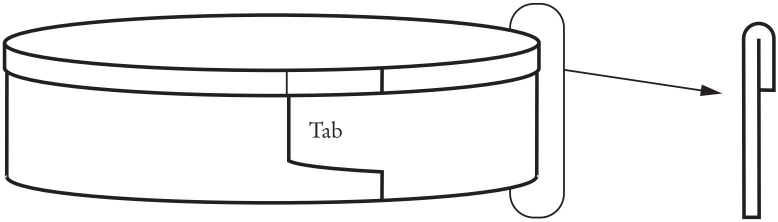
FIGURE 88
Closing the fold



Bend the strip into a circle with the tab and the folded edge on the outside.

FIGURE 89

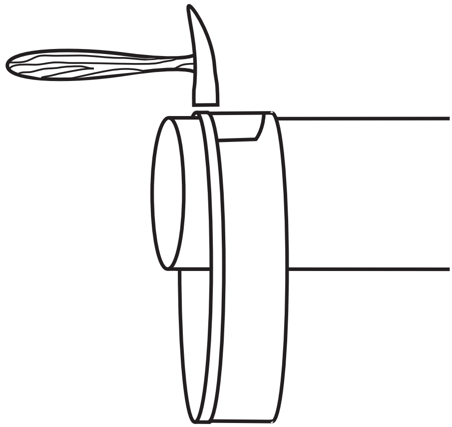
Bending the strip



Close the fold where it overlaps the tab.

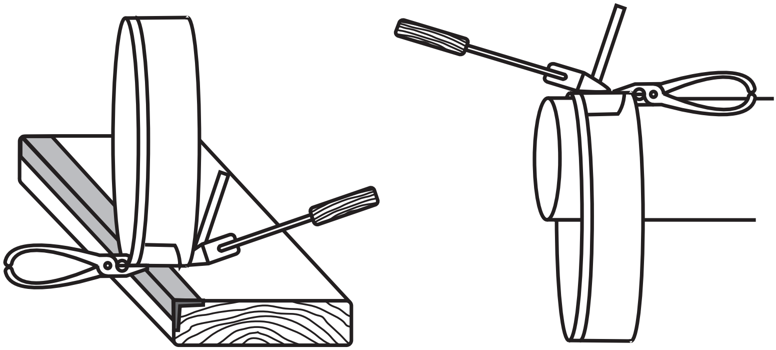
FIGURE 90

Closing the fold



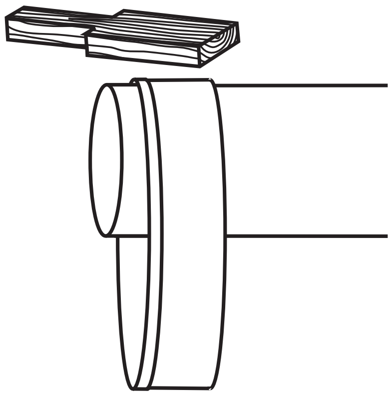
Solder well inside and out.

FIGURE 91
Soldering the fold



Use the wooden mallet to level out the circle.

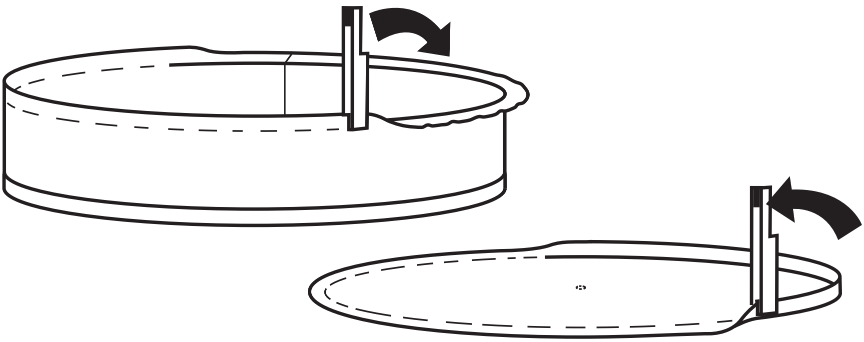
FIGURE 92
Levelling out the circle



Use the flange method to join the top of the cover to the collar. Use the 8 mm bending tool.

FIGURE 93

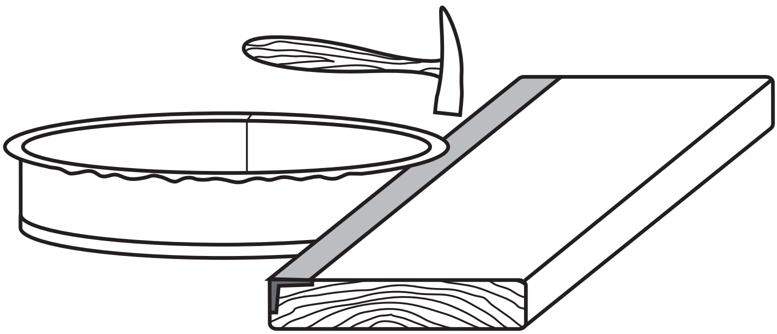
Joining the top of the cover to the collar by the flange method



Level out the flange of the collar of the cover on the work bench.

FIGURE 94

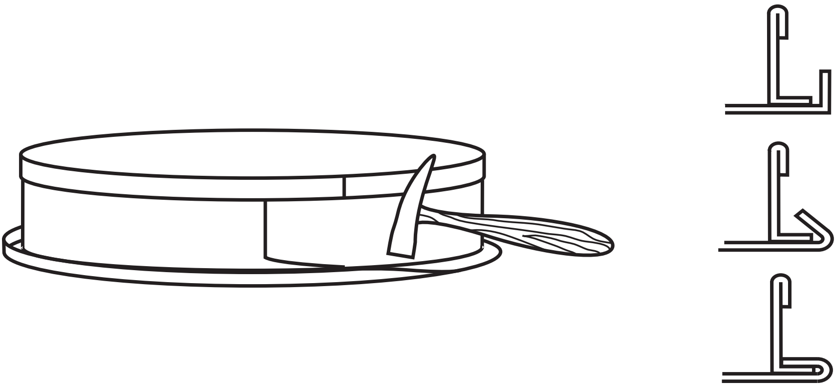
Levelling out the flange of the collar of the cover



Close the flange of the top piece over the flange of the collar.

FIGURE 95

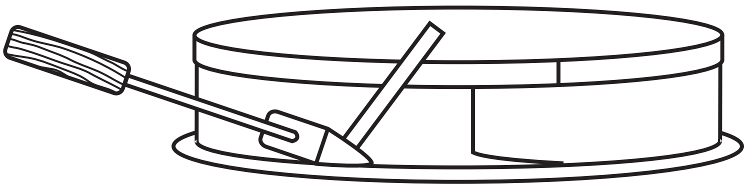
Closing the flange



Solder well around the flange.

FIGURE 96

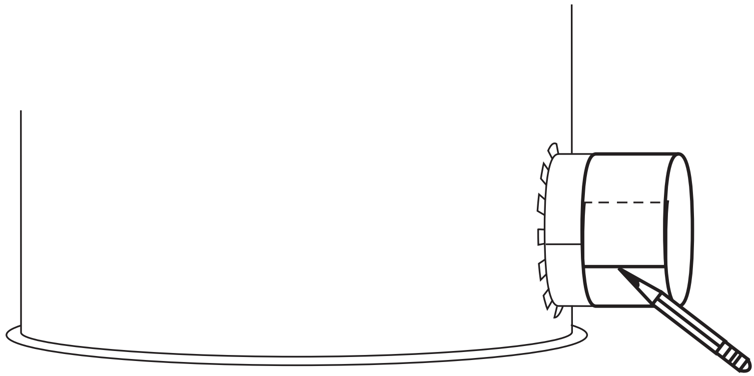
Soldering



Repeat the process to make the cover for the outlet opening.

FIGURE 97

Making the outlet opening cover



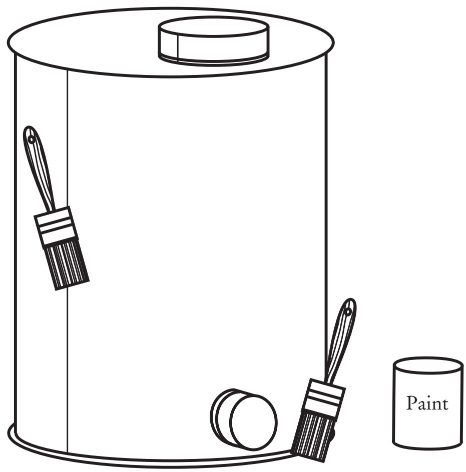
5.7 Final steps

The silo is almost finished but there are a few more important things to do. Painting the joints will help to prevent the metal from rusting. A platform is also required to prevent rusting against the ground and for easier removal of the stored grain. The instruction sheet is important for showing how to use the silo.

Paint all the joints inside and out with lead-free anti-rust paint. Also paint any scratches or areas touched by the acid.

FIGURE 98

Painting joints and scratches



Make a wooden platform the same size as the bottom of the silo. This should be 15 cm high. Large silos are heavy when they are full and need a strong platform.

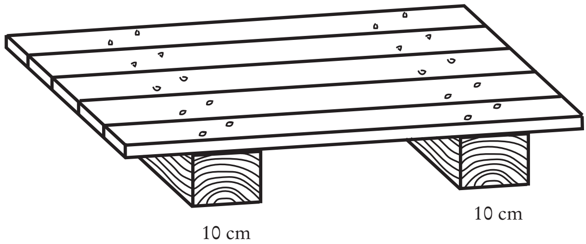


FIGURE 99
Platform to support the silo

Place the instruction sheet on the body of the silo where it is easy to see.

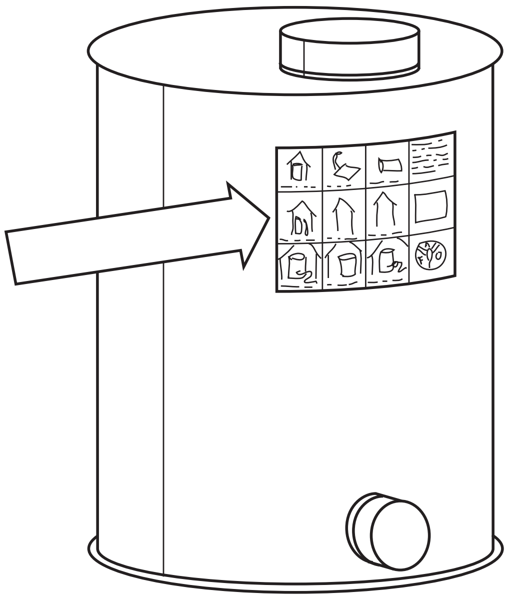
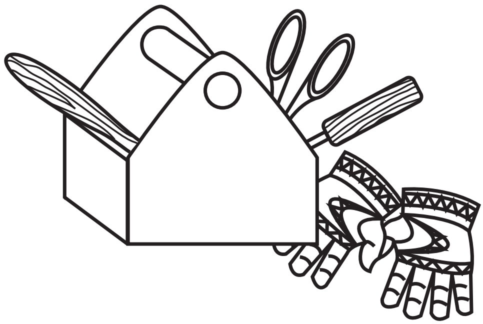


FIGURE 100
Instruction sheet on the body of the silo

This manual describes in appendices 1 to 4 a total of 20 different sizes of silos that can be built depending on the size of galvanized zinc sheet available on the market. The approximate storage capacities range from 95 kg, which is the smallest, to 3 200 kg, which is the largest, with intermediate sizes suited to the user's needs.

Good job. The silo is finished!



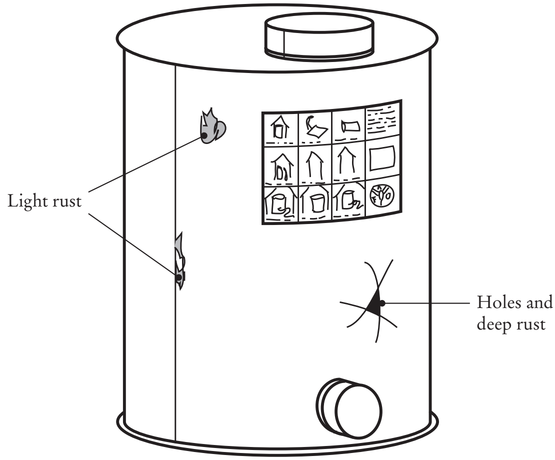
CHAPTER **6**

Repairs

A silo can be damaged in different ways. After many years, even well-made silos that have been well looked after may begin to rust. Holes may also appear and this affects the airtight seal (see section 4.2.3. of Chapter 4). So check it regularly.

FIGURE 101

Signs of damage

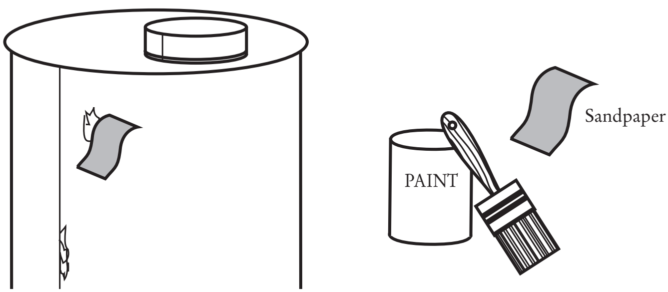


6.1 Light rust

Rust is common in older silos but a little maintenance will help them last for longer. If the rust is on the surface of the silo, remove it with sandpaper and paint the whole area. After making repairs to joints, look for any new small holes in the soldering.

FIGURE 102

Repairing rust on the surface of the silo

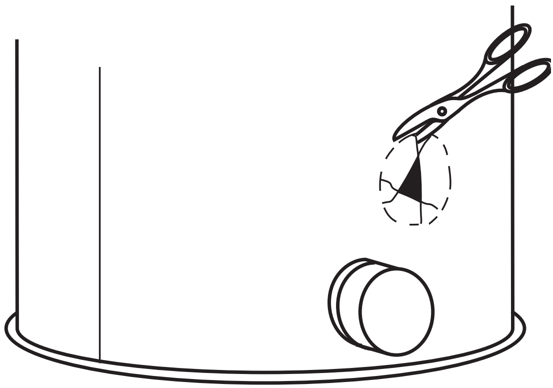


6.2. Holes and deep rust

A large hole that appears in the silo can very probably be repaired with a patch. A patch can also be used to fix or cover an area of rust where the metal has started to become too thin to be sanded and painted. The silo must be empty before you start to repair the damaged area.

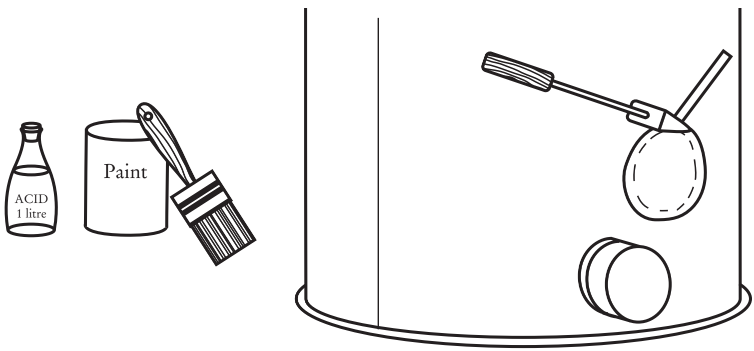
Use the shears to cut away any sharp metal and even out the edges of the hole.

FIGURE 103
Cutting away sharp metal edges with shears



Cut a patch from scrap metal large enough to cover the hole, 2 cm larger than the part to be covered. Use acid to clean the metal. Solder the patch and paint the soldered joints inside and out as usual.

FIGURE 104
Positioning the patch



CHAPTER **7**

Installation, use, fumigation and maintenance of the silo

7.1 Installation

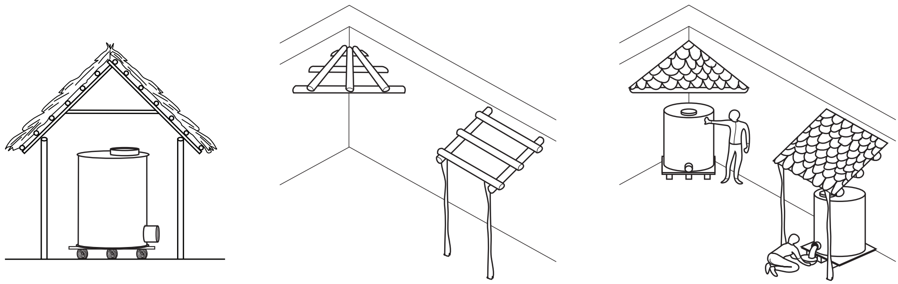
The silo should be installed under cover in a shady, ventilated place avoiding direct contact with the ground. On the one hand direct solar radiation and lack of ventilation can cause overheating of the grain and moisture migration, which result in its deterioration. On the other hand contact with the ground can cause the bottom of the silo to rust; and if the level of the outlet opening is higher, it will be easier to remove grain.

7.2 The roof and platform for the silo

A silo that is well looked after can last for 15 to 20 years. It should therefore be under a roof and on a platform. The roof should be at least one metre higher than the silo, for easy filling, and be large enough to protect it from sun and rain.

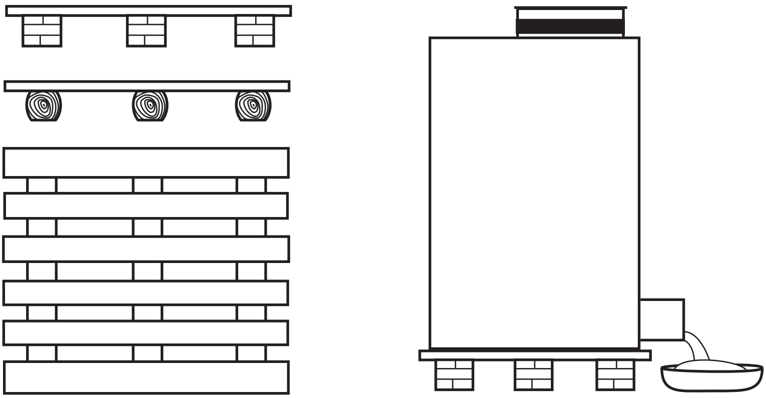
FIGURE 105

Putting a roof over the silo



The platform should be slightly wider than the bottom of the silo and should be at least 15 cm high. It is built with wooden planks 1.5 cm thick on wooden blocks or mud bricks to support it, as shown in Figure 106.

FIGURE 106
Silo platform



The dimensions of the platform are shown in Table 3.

TABLE 3
Platform dimensions

Size of silo	Height of platform	Size of platform	Number of supports
120 kg		50 x 50 cm	2
250 kg		75 x 75 cm	2
500 kg	15–20 cm	100 x 100 cm	3
900 kg		125 x 125 cm	3
1 800 kg		125 x 125 cm	3

7.3 Preparing the grain

Before you put grain in the silo, both grain and silo must be completely clean and dry. The moisture content of the grain should be 14 percent at most for cereals and less than 10 percent for legumes and oilseeds for them to store well (see section 7.6.). If wet grain is stored, all the produce could be lost.

The grain is loaded into the silo through the top opening and should not fill the silo completely. Leave a space 5 to 10 cm at the top to allow circulation of fumigation gases. If bags are used inside the silo, they should be made of cloth, not plastic.

7.4 Fumigation to control pests

Use aluminium phosphide fumigation tablets which react with moisture releasing toxic hydrogen phosphide gas (phosphamine or phosphine) leaving an aluminium hydroxide residue. Several commercial fumigation products are available for silos, based on aluminium phosphide. In any case, follow the manufacturer's recommendations as shown on the product pack labels. The product generally contains 55 percent active substance.

The tablets are not combustible but if exposed to moist air they release hydrogen phosphide which is a toxic, flammable gas. Spontaneous combustion can occur when the tablet comes into contact with water, acid or other fluids.

Mixtures of hydrogen phosphide with air above the minimum limit can ignite spontaneously. The ignition of high concentrations of hydrogen phosphide can cause a violent reaction. Explosions can occur under these conditions and serious injuries can be caused. If intoxication occurs, take appropriate measures and seek medical aid immediately.

The number of tablets you should add for fumigation will depend mainly on the volume of the silo, not on the quantity of grain inside it. The weight of the grain stored will vary according to the type, and a volume of 1 m^3 of beans and wheat generally weighs approximately 780 kg, maize 720 kg and rice with husks 580 kg.

TABLE 4

Recommended tablet for various product types

Capacity of silo (in m^3)	Equivalent in kg (specific weight of grain kg/m^3) Wheat 780 kg	Maize 720 kg	Rice with husks 580 kg	Number of tablets (of 3 g at 55% aluminium phosphide)
4.20	3 360	3 024	2 436	16
2.41	1 930	1 880	1 398	9
2.00	1 600	1 440	1 160	7
1.76	1 400	1 268	1 020	6
1.00	800	720	580	3.5
0.50	400	360	290	2
0.32	250	230	185	1
0.12	100	72	58	0.5

Source: C. Rosell and D. Mejía-Lorio; prepared by the authors, 2010.

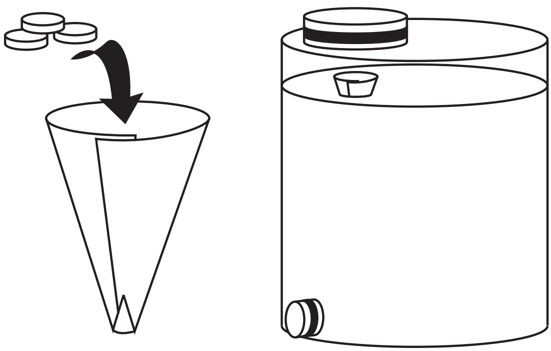
The recommended doses for some of the silo models described in this manual are shown in Table 4.

Handle fumigation tablets with care and not with bare hands. When you take tablets out of the original pack, close again carefully to preserve the remaining tablets.

FIGURE 107
Closed pack of tablets after some have been taken out

Place the tablets you are going to use for fumigation quickly in a paper cone and put the cone on top of the grain in the silo, as shown in Figure 108. The tablets must not be in direct contact with the grain. The recommended fumigation period is 10 days. After this time, the grain will be free from eggs. larvae and adult insects.

FIGURE 108
Placing the tablets in the cone in the silo

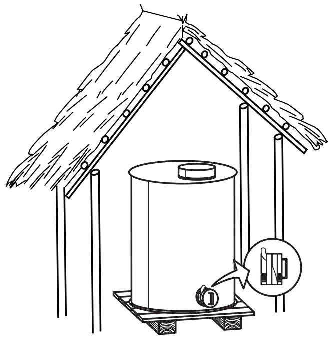


7.5 Sealing the silo so it is airtight[1]

Once the silo contains the grain with the fumigation tablets, it must be immediately sealed so it is airtight by applying rubber bands or strips (e.g. from tyres), wide adhesive tape (sealing tape), animal fat or soap around the edge of the covers. This will seal the joints between the inner and outer necks of the inlet and outlet opening covers.

FIGURE 109

Sealing the silo after fumigation



It is important to check for gas leaks for the first three to five hours of fumigation. If you notice gas smelling of garlic or onion, you must find the leak without delay and seal it immediately with fat or soap. The silo must be kept sealed for at least 10 days to make sure that the tablets have completely reacted and that insects in all their various stages are controlled. After this time the grain will be free from eggs, larvae and adult insects.

After fumigation, uncover the silo to ventilate the grain for two hours. Remove the paper cone containing the tablet residues and bury it as shown in Figure 110. After fumigation and then ventilation, the grain will be ready to use, but it is important to check it every 30 days for insects.

1 Also see sections 2.2.7. and 4.2.3.

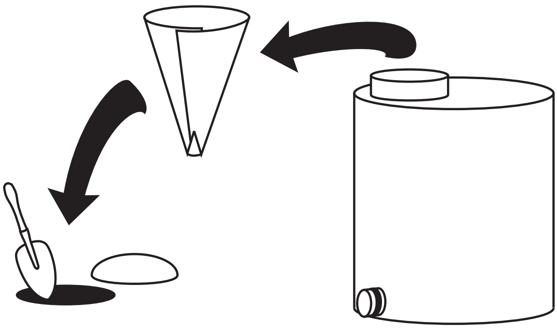


FIGURE 110
Removing and burying the cone containing tablet residues

If you find live insects as in Figure 111, repeat the above fumigation process. After ventilation you can consume the grain, provided no characteristic smell persists. Whenever you open the silo, you must reseal it to avoid re-infestation.

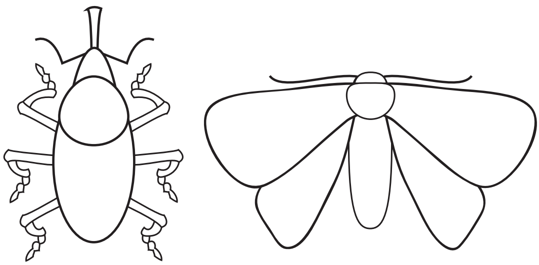


FIGURE 111
Insects

You must also regularly check the moisture content of the grain; it should be dried again if necessary (see section 7.6.).

Remove grain for consumption through the bottom opening. Use a small wooden rake to empty the silo completely. Do not tilt the silo, even when completely emptying it.

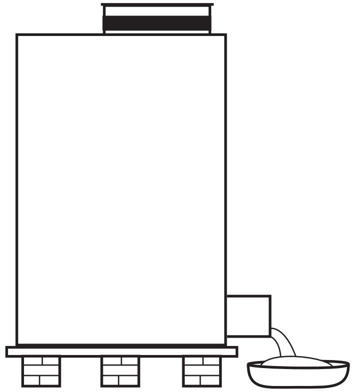


FIGURE 112
Removing grain

It is also important to inspect the condition of the silo regularly, particularly for leaks, rust, etc., to help it last.

7.6 Two simple tests to determine moisture content

The grain stored in the silo must be properly dry. To dry it, spread the grain on cloth or a plastic sheet in direct sun for a couple of days. To keep better in the silo, the grain must have a maximum moisture content of 14 percent for cereals and less than 10 percent for legumes and oilseeds. There are several simple ways of estimating moisture content.

For the first test bite a grain. If it breaks cleanly, it is dry. If the grain feels soft, it is not dry and suitable for storing; it must be left in the sun for longer.

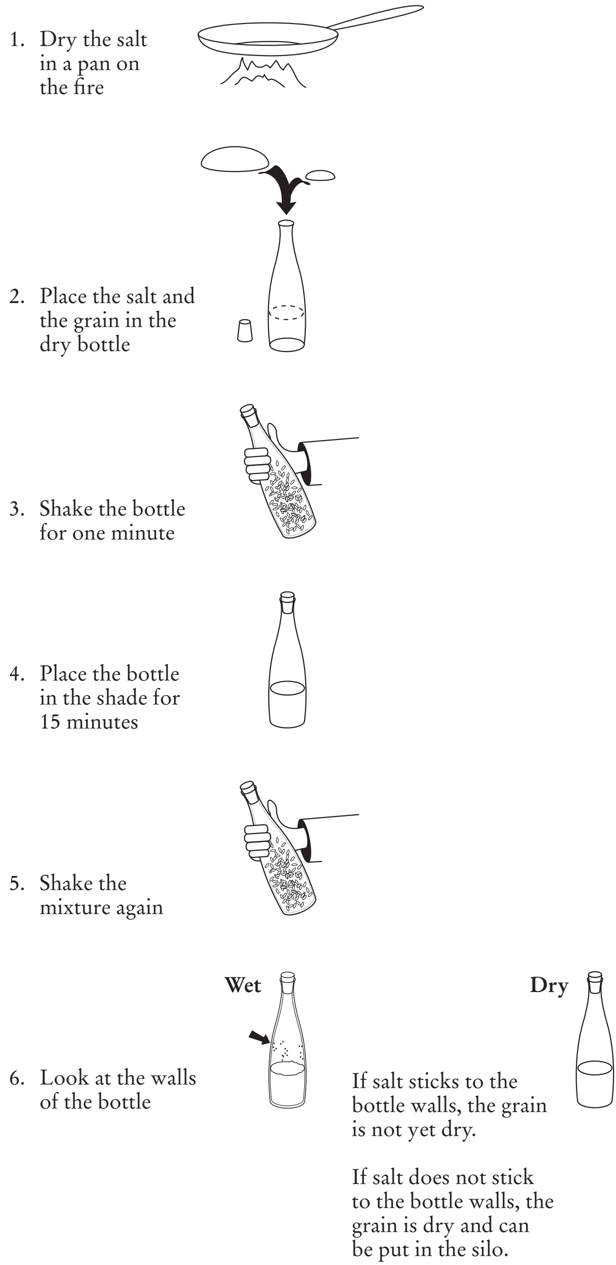
Warning!

If the grain is not dry, it can deteriorate in the silo; if you think the grain is not dry enough, leave it in the sun for another day.

The next test is called the salt test as follows:

- Dry about 30 g of fine table salt in a pan over the fire and you will need a glass bottle of about 750 ml. Both the salt and the bottle must be completely dry.
- Fill the bottle to one-third its capacity with the grain you want to test.
- Add the salt and close the bottle.
- Shake the mixture for one minute and leave the bottle in the shade.

FIGURE 113
Salt test



- After 15 minutes, shake once again.
- Look at the walls of the bottle.
- If salt sticks to the bottle walls, the grain is not yet dry. If salt does not stick to the bottle walls, the grain is dry and can be put in the silo.

7.7 Transport and maintenance of the silo

Transporting a silo is relatively difficult due to its volume and because it is fragile, so it should preferably be made locally by qualified persons. Where long distances are involved, the silo can be transported on a truck, securing it with ropes through the opening; make sure that nothing is pressing on the body to prevent it being dented. If short distances are involved, two people can transport the silo with two poles tied together with a rope like a stretcher.

As regards maintenance, after emptying the silo it must be dried and cleaned inside and out. Any rust must be cleaned off with wet sandpaper #0, washed, dried with a cloth and painted with anti-rust paint. When it is empty, it must be secured to prevent it falling over and getting damaged. The silo can last for between 15 and 20 years with these simple measures.

CHAPTER **8**

Financial aspects

8.1 Financial evaluation of the metal silo

Metal storage silos are very useful for improving the food security of small and medium grain and cereal producers. The technology is fairly simple and relatively easy to implement, and also helps to preserve and maintain product quality during storage.

Its main characteristics and advantages are:

- the storage capacity can range from 120 kg to 1 800 kg;
- local technology is required for manufacture and maintenance, which can be provided by rural communities themselves;
- it is easy to purchase and cost-effective;
- it is airtight and allows effective fumigation;
- it requires very little space;
- it does not require the use of insecticides and allows the use of fumigation agents that do not leave residues.

Its main benefits are:

- losses of stored grain can be virtually completely reduced;
- harvest surpluses can be stored and sold at a later date, and at a better price;
- grain quality is kept high;
- it keeps the home free from rodents and the diseases they can transmit;
- it helps women in their work;
- it is a simple technology that can last for up to 20 years.

8.2 Estimation of costs

Table 5 shows the costs of the silo, depending on its size, in some developing countries where the technology has been introduced. The manufacturing costs include: costs of materials, depreciation of the manufacturing equipment, labour, financial costs and income of the craftsman. Additional materials represent 2 percent of the total cost and are basically aluminium phosphide tablets and adhesive tape or rubber to seal the cover. These costs have been adjusted to 2009 costs based on the IMF producer price index and the general average has been estimated.

8.3 Estimation of minimum expected benefits

Bearing in mind the benefits mentioned above, the reduction in post-harvest losses is the main item commonly estimated. Depending on the country and product stored, losses range from 10 to 50 percent. Considering a conservative scenario of 10 percent post-harvest losses, the minimum annual expected benefit of a met-

TABLE 5

Costs of manufacturing metal silos and additional materials (USD/silo)

Country	Storage capacity				
	120 kg	250 kg	500 kg	900 kg	1 800 kg
Afghanistan	–	37	92	–	122
Bolivia	36	63	108	–	–
Burkina Faso	49	55	79	106	132
Cambodia	21	35	53	–	88
Chad	–	54	79	104	152
Guinea	–	–	103	–	123
Madagascar	–	53	66	92	132
Mozambique	35	60	95	131	–
Senegal	43	79	113	143	189
Average	37	54	88	115	134

Source: various studies conducted by FAO between 1998 and 2005, with prices updated to 2009 according to the IMF producer price index.

TABLE 6

Minimum expected benefit of reducing post-harvest losses by 10 percent

Product	Value (kg)*	Storage capacity				
		120 kg	250 kg	500 kg	900 kg	1 800 kg
Maize	0.19	2.30	4.78	9.57	17.22	34.44
Wheat	0.23	2.75	5.73	11.46	20.64	41.27
Sorghum	0.18	2.10	4.38	8.75	15.76	31.51
Rice	0.40	4.83	10.07	20.15	36.26	72.52
Bean	0.90	10.82	22.54	45.07	81.13	162.26

Source: World Bank Commodity Price Data: average 2008-10 prices for bean; Market Integration and National Information System of Mexico (SNIIM): average 2008-10 prices for black bean.

al silo would be the value of reducing these losses from 10 percent to virtually 0 percent. Table 6 shows an estimate of this benefit based on the value of the most commonly stored products. The estimated economic value is based on the international prices of the products, taking into account the last three years' average and a conservative correction factor of the international price and the farm gate price of 2 percent.

8.4 Estimation of economic cost-effectiveness

If the minimum expected benefit in the above table were obtained over the 20-year useful life of metal silos, a minimum economic internal rate of return could be estimated for silos of different capacities and for the commonest products. This analysis would be based on the average cost in the countries mentioned in Table 5, adjusting the cost to 2009 prices. At the end of its useful life, the silo is recognized to have a salvage value of 10 percent of its initial value. The results of this analysis are shown in Table 7.

It should be emphasized that if we can assess other benefits, such as the improvement in grain quality, the reduction in rodent damage and the reduction in work for rural women, the economic cost-effectiveness would be substantially greater. Although the estimated minimum economic return for 120 kg silos is negative for maize and very low for wheat and sorghum, this return is at least 10 percent for rice and bean. In view of this, the silo can only be recommended for the storage of maize, wheat and sorghum seed, as seed grain is higher in value than grain for consumption.

8.5 Costs of making a metal silo

A short program is available at www.fao.org/ag/ags and www.fao.org/inpho for calculating the cost of making silos in any of the dimensions described in this manual and in any currency. The program (in Excel format) is in English, French and Spanish. This example is for Bolivia using December 2007 prices.

TABLE 7

Estimation of the economic internal rate of return considering minimum benefits

	Storage capacity				
Product	**120 kg**	**250 kg**	**500 kg**	**900 kg**	**1 800 kg**
Maize	0 %	4 %	7 %	13 %	25 %
Wheat	2 %	7 %	10 %	16 %	30 %
Sorghum	-1 %	3 %	6 %	11 %	23 %
Rice	10 %	17 %	22 %	31 %	54 %
Bean	29 %	41 %	51 %	70 %	121 %

Source: Mejía and Francescutti, 2011.

TABLE 8

Detailed costs

Description	Quantity	Unit	Unit price	Total
Materials	–	–	–	**645.40**
Sheet no. 26 (100 x 200 cm)	6	Sheet	90.00	540.00
Sn-Pb soldering (50 %)	1.18	kg	70.00	82.60
Hydrochloric acid	0.06	Litres	60.00	3.60
Sal ammoniac/Flux	40	g/ml	0.20	8.00
Aluminium anti-rust paint	0.25	Litres	40.00	10.00
Charcoal	1.2	kg	1.00	1.20
Labour				**180.00**
Skilled	12	Hours	10.00	120.00
Assistant	12	Hours	5.00	60.00
Depreciation of tools				**4.79**
Cost of a tool kit	1	Kit	1 534.00	
Other costs	**1**	**Overall**	0.00	0.00
Total production cost				**830.19**
25 % profit				207.55
			Total BOB	**1 037.74**
			Total USD	**135.30**

Source: Arancibia/TCP/MLW/3103, 2007.
Exchange rate: 7.67 BOB = 1 USD.

Silo type: silo of 2.41 m³.

Silo capacity (maize): 1 806 kg.

Volume: 2.41 m³.

Number of sheets: 6.

Labour: labour was calculated based on one working day for a qualified (skilled) craftsman at 80 BOB/day and for an assistant at 40 BOB/day and an estimated requirement of 12 hours to make a silo of this size: 80/8 = 10 x 12 = 120 and 40/8 = 5 x 12 = 60; 120 + 60 = 180 BOB.

Depreciation of tools: the depreciation of tools was calculated from the total cost of the tools, estimated at 1534 BOB, a duration of 2 years or 480 working days and the estimated requirement of 12 hours to make a silo of this size: 1 534/480 = 3.19 BOB/day; 3.19/8 = 0.40 BOB/hour; 0.40 x 12 = 4.79 BOB.

The unit prices of all these items differ for each individual case or country.

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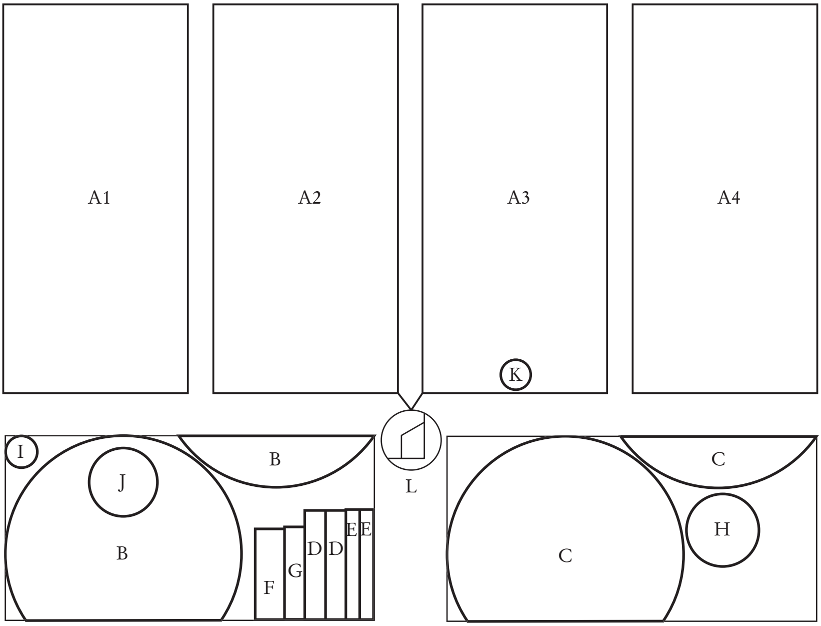
APPENDIX **1**

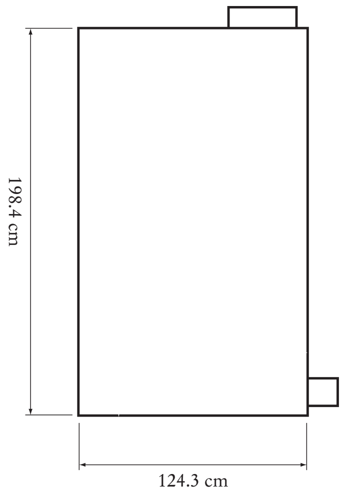
Silos made from 100 x 200 cm sheets

■ **Appendix 1** – Silos made from 100 x 200 cm sheets

Plan for a 2.410 m³ silo
6 sheets (100 x 200 cm) / Approximate content: 1 800 kg

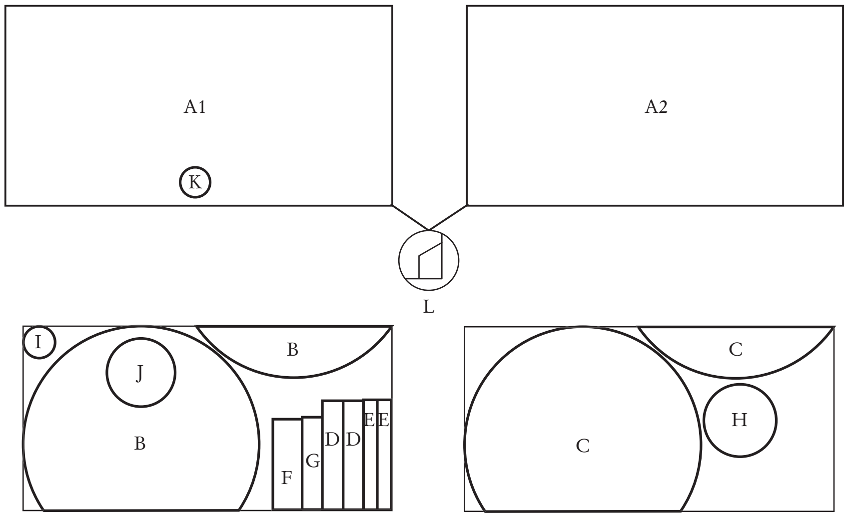


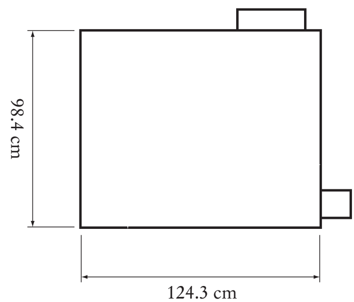
A1, A2, A3, A4: Body sheets (100 x 200 cm)
B: Top of silo (r = 64 cm)
C: Bottom of silo (r = 64 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)



Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 1.190 m³ silo
4 sheets (100 x 200 cm) / Approximate content: 900 kg



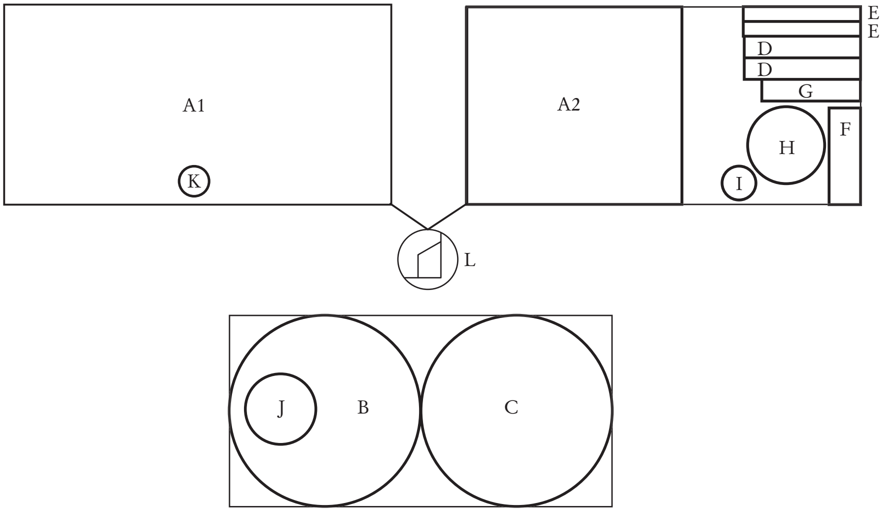


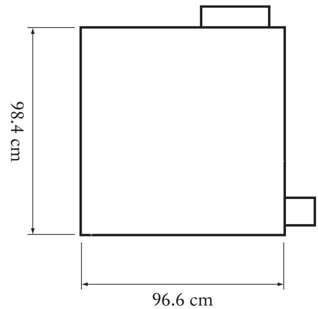
A1: Body sheet 1 (100 x 200 cm)
A2: Body sheet 2 (100 x 195.2 cm)
B: Top of silo (r = 64 cm)
C: Bottom of silo (r = 64 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

■ **Appendix 1** – Silos made from 100 x 200 cm sheets

Plan for a 0.721 m³ silo
3 sheets (100 x 200 cm) / Approximate content: 500 kg

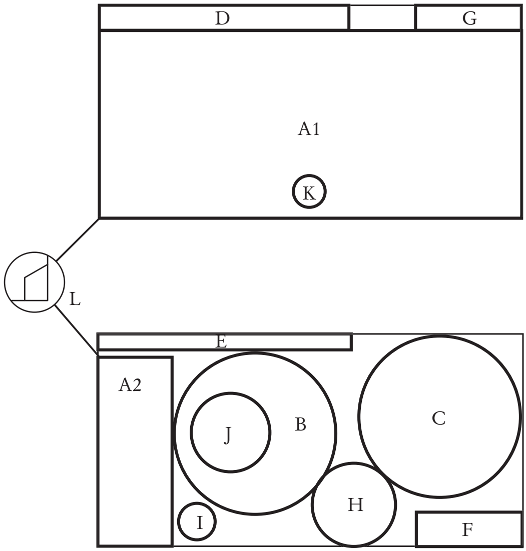




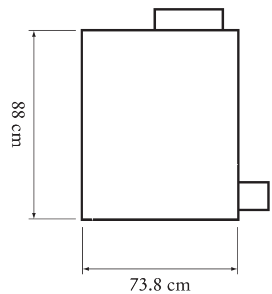
A1: Body sheet 1 (100 x 200 cm)
A2: Body sheet 2 (100 x 108.3 cm)
B: Top of silo (r = 50 cm)
C: Bottom of silo (r = 50 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18,5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 0.376 m³ silo
2 sheets (100 x 200 cm) / Approximate content: 250 kg



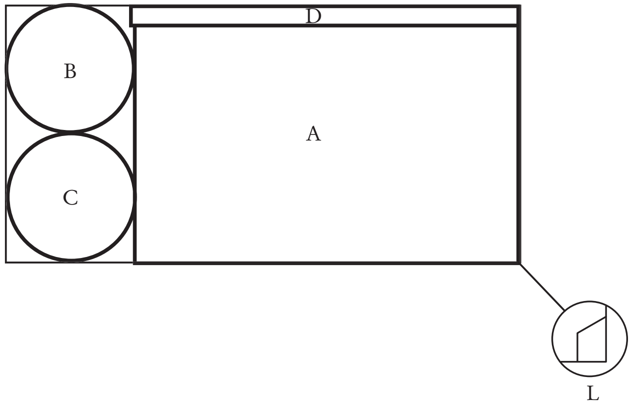
A1: Body sheet 1 (89 x 200 cm)
A2: Body sheet 2 (89 x 34.9 cm)
B: Top of silo (r = 38 cm)
C: Bottom of silo (r = 38 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

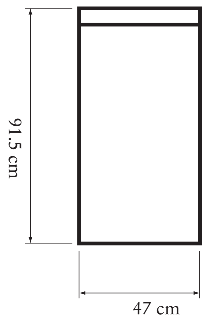


Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body, top, bottom and inlet and outlet cover flanges measure 5 mm.

■ **Appendix 1** – Silos made from 100 x 200 cm sheets

Plan for a 0.159 m^3 silo
1 sheet (100 x 200 cm) / Approximate content: 120 kg





A: Body sheet (149.1 x 92.5 cm)
B: Top of silo (r = 24.7 cm)
C: Bottom of silo (r = 24.6 cm)
D: Inlet cover strip (150.6 x 7.5 cm)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

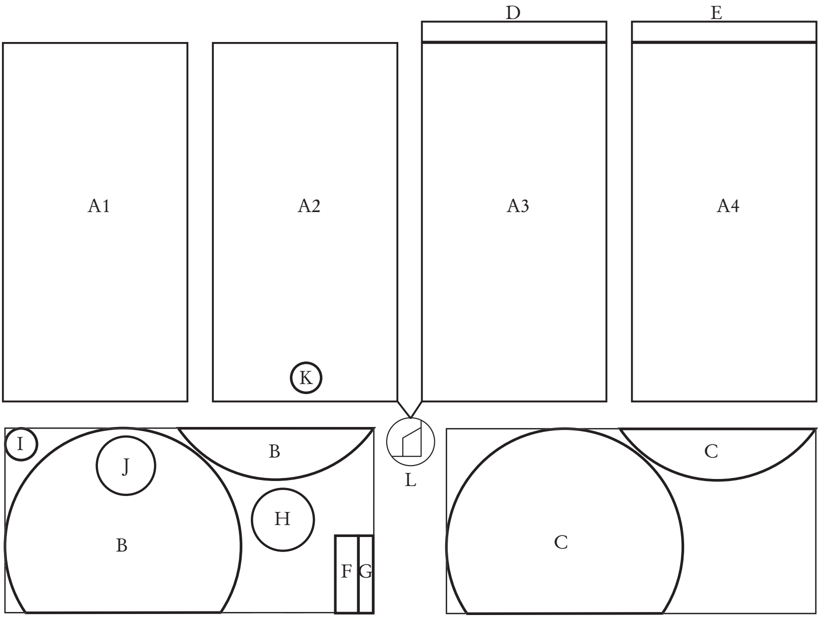
Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body and cover flanges measure 5 mm.

APPENDIX **2**

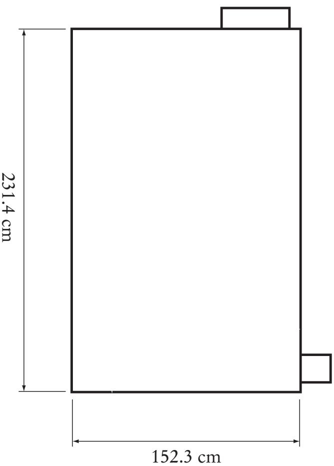
Silos made from 122 x 244 cm sheets

■ **Appendix 2** – Silos made from 122 x 244 cm sheets

Plan for a 4.214 m³ silo
6 sheets (122 x 244 cm) / Approximate content: 3 200 kg

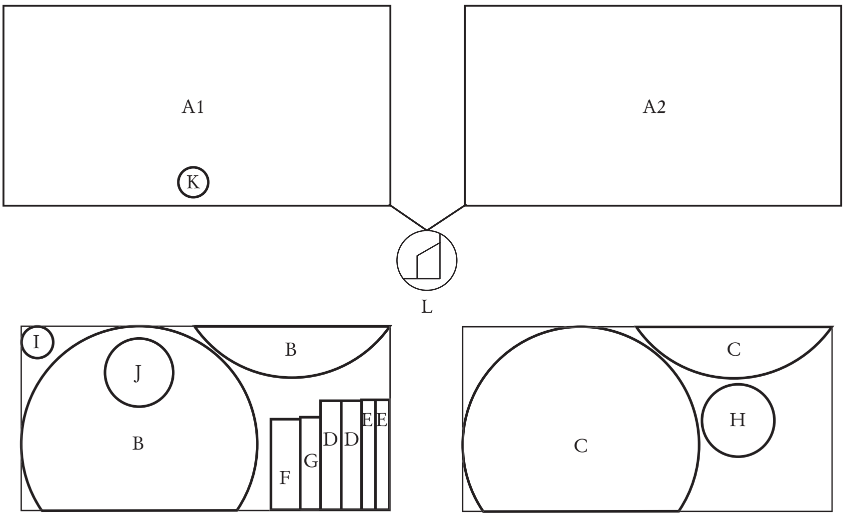


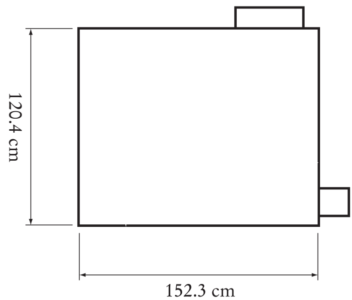
A1, A2, A3, A4: Body sheets (122 x 233 cm)
B: Top of silo (r = 78 cm)
C: Bottom of silo (r = 78 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)



Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 2.190 m³ silo
4 sheets (122 x 244 cm) / Approximate content: 1 600 kg

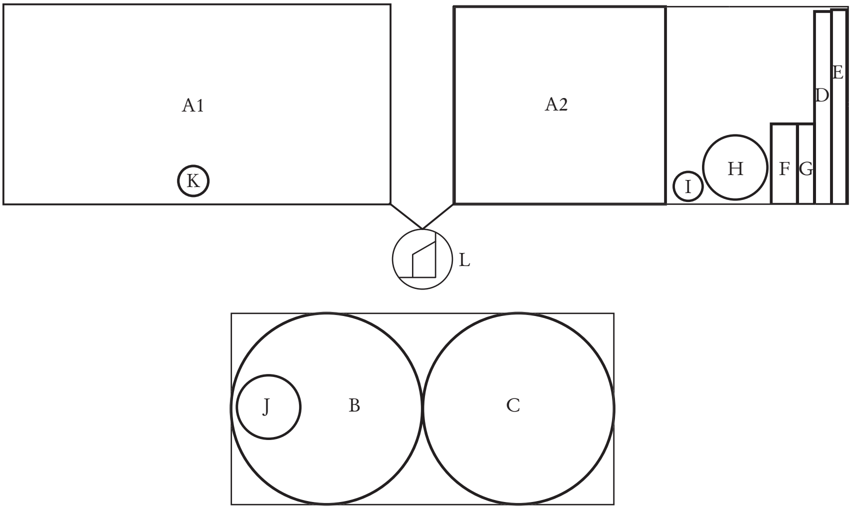


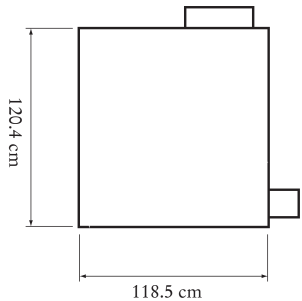


A1: Body sheet 1 (100 x 200 cm)
A2: Body sheet 2 (100 x 195.2 cm)
B: Top of silo (r = 64 cm)
C: Bottom of silo (r = 64 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 1.327 m^3 silo
3 sheets (122 x 244 cm) / Approximate content: 1 000 kg

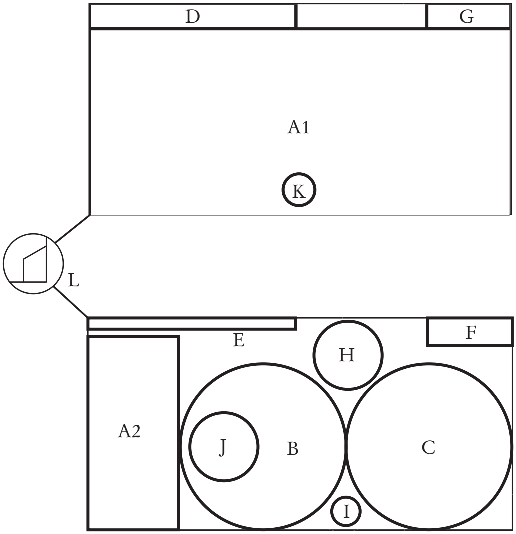


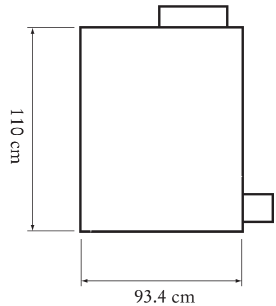


A1: Body sheet 1 (122 x 244 cm)
A2: Body sheet 2 (122 x 133 cm)
B: Top of silo (r = 61 cm)
C: Bottom of silo (r = 61 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet opening (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 0.754 m³ silo
2 sheets (122 x 244 cm) / Approximate content: 600 kg



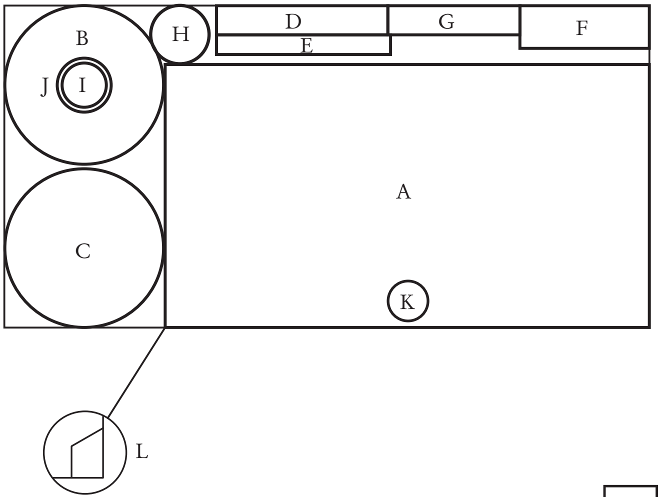


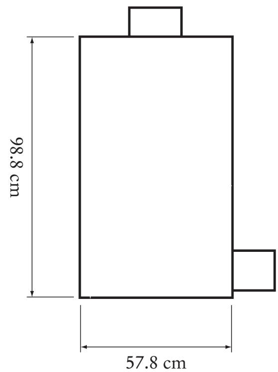
A1: Body sheet 1 (244 x 111 cm)
A2: Body sheet 2 (52.4 x 111 cm)
B: Top of silo (r = 47.8 cm)
C: Bottom of silo (r = 47.8 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body, top, bottom and inlet and outlet cover flanges measure 5 mm.

■ **Appendix 2** – Silos made from 122 x 244 cm sheets

Plan for a 0.259 m^3 silo
1 sheet (122 x 244 cm) / Approximate content: 200 kg





A: Body sheet (183.1 x 99.8 cm)
B: Top of silo (r = 30 cm)
C: Bottom of silo (r = 30 cm)
D: Inlet opening strip (11 x 64.8 cm)
E: Inlet cover strip (7.5 x 65.8 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 11.1 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 10 cm; centre of B)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body, top, bottom and inlet and outlet cover flanges measure 5 mm.

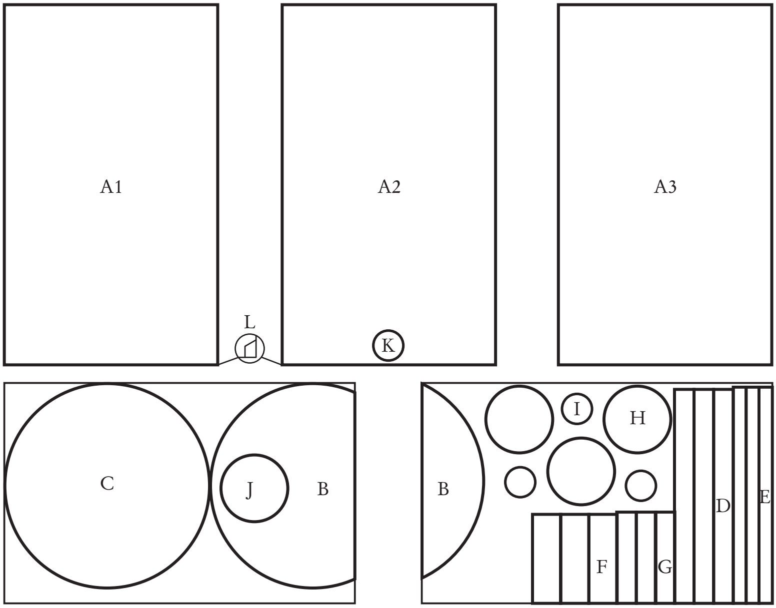
APPENDIX **3**

Silos made with 122 x 200 cm sheets

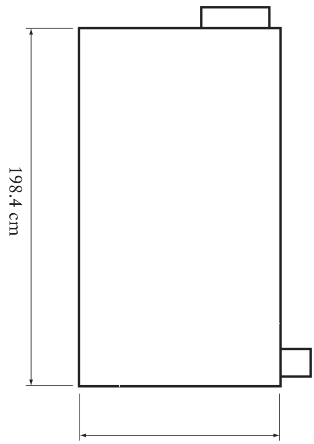
Appendix 3 – Silos made with 122 x 200 cm sheets

Plan for a 2.030 m³ silo
4(1/3) sheets (122 x 200 cm) / Approximate content: 1 520 kg

Components D to I can be cut out for three silos from a single sheet

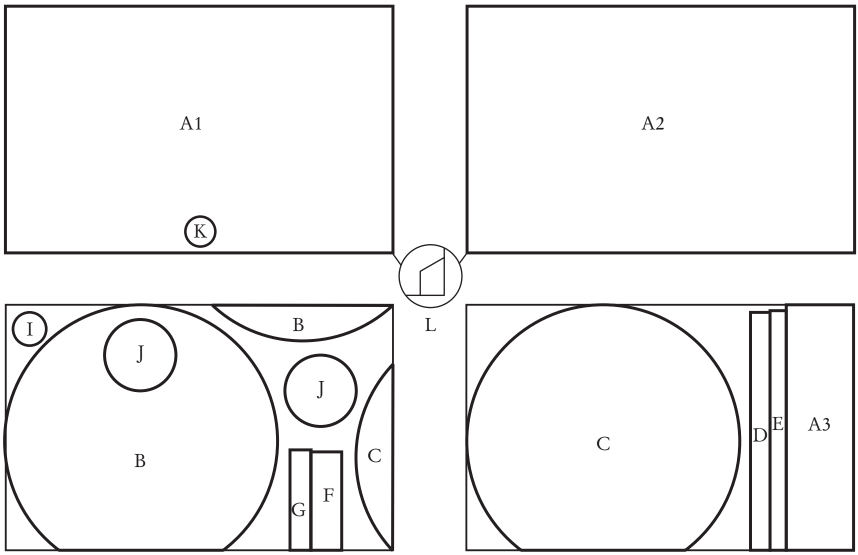


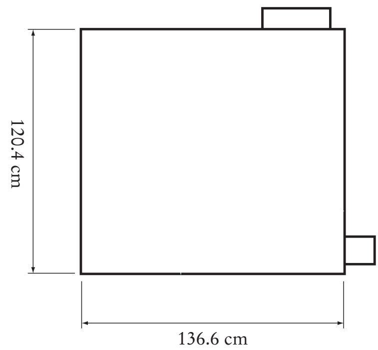
A1, A2, A3: Body sheets (122 x 200 cm)
B: Top of silo (r = 58.9 cm)
C: Bottom of silo (r = 58.9 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)



Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 1.758 m³ silo
4 sheets (122 x 200 cm) / Approximate content: 1 400 kg

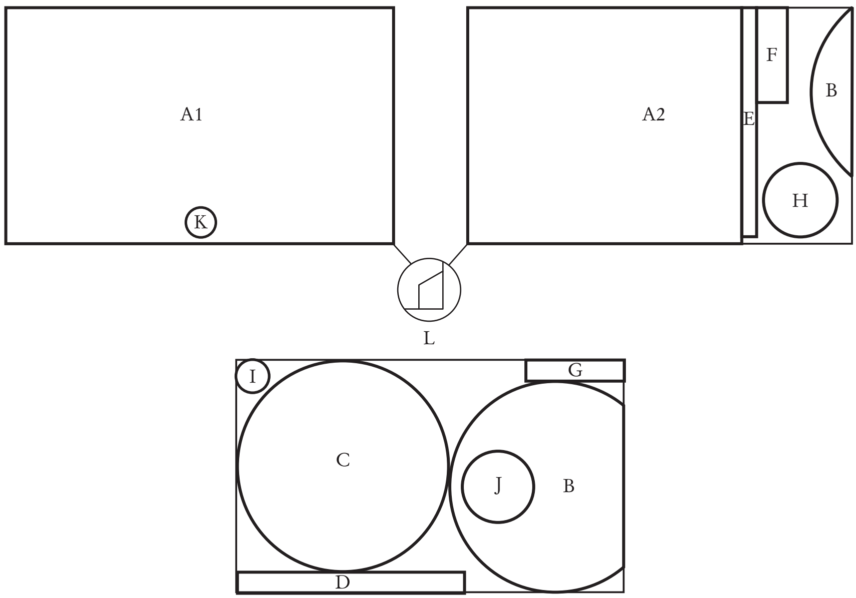




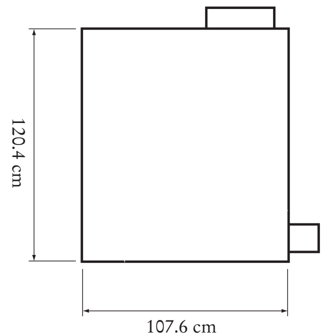
A1, A2: Body sheets 1 and 2 (200 x 122 cm)
A3: Body sheet 3 (35.5 x 122 cm)
B: Top of silo (r = 70 cm)
C: Bottom of silo (r = 70 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 1.095 m^3 silo
3 sheets (122 x 200 cm) / Approximate content: 800 kg

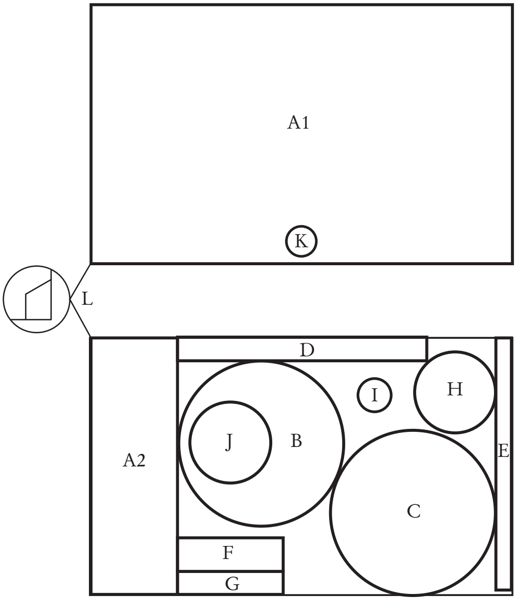


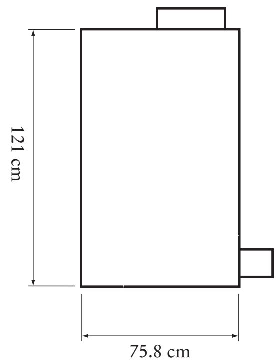
A1: Body sheet 1 (200 x 122 cm)
A2: Body sheet 2 (142.8 x 122 cm)
B: Top of silo (r = 55.5 cm)
C: Bottom of silo (r = 55.5 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)



Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 0.546 m³ silo
2 sheets (122 x 200 cm) / Approximate content: 400 kg

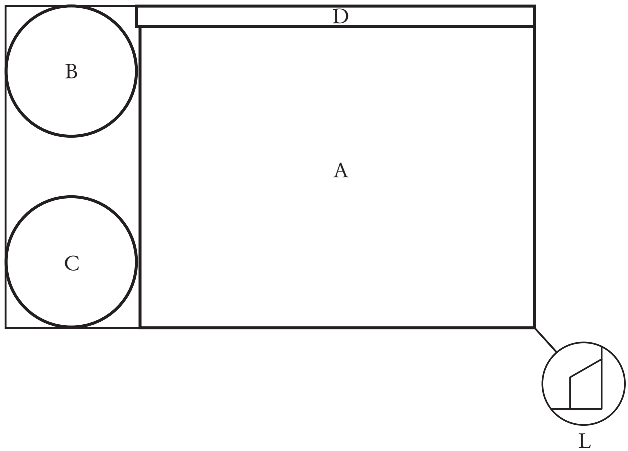


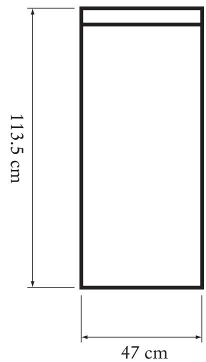


A1: Body sheet 1 (200 x 122 cm)
A2: Body sheet 2 (41.1 x 122 cm)
B: Top of silo (r = 39 cm)
C: Bottom of silo (r = 39 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body, top, bottom and inlet and outlet cover flanges measure 5 mm.

Plan for a 0.197 m^3 silo
1 sheet (122 x 200 cm) / Approximate content: 150 kg





A: Body sheet (149.1 x 114.5 cm)
B: Top of silo (r = 24.7 cm)
C: Bottom of silo (r = 24.6 cm)
D: Inlet cover strip (150.6 x 7.5 cm)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

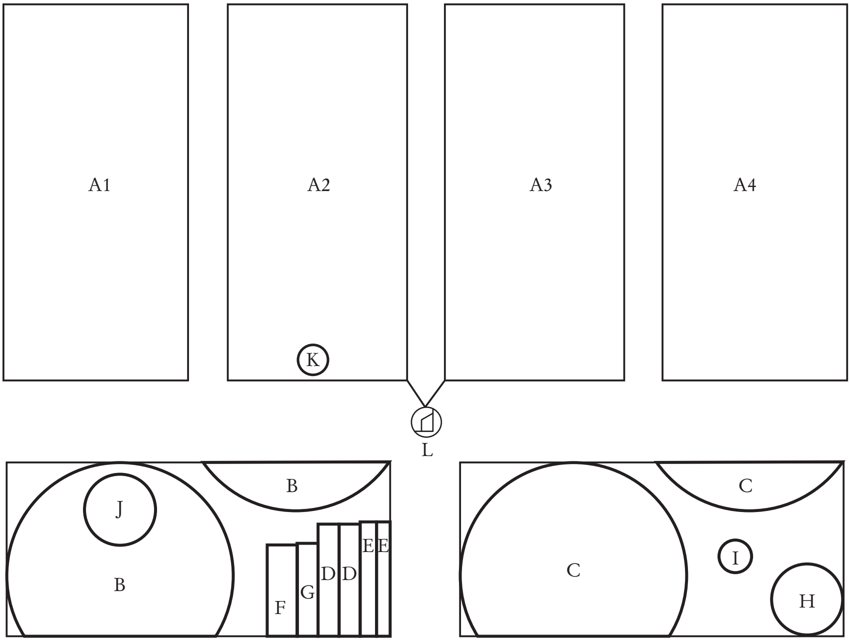
Note: the seam in the body is made with a 5 mm fold on one side and a 10 mm fold on the other. The body and cover flanges measure 5 mm.

APPENDIX **4**

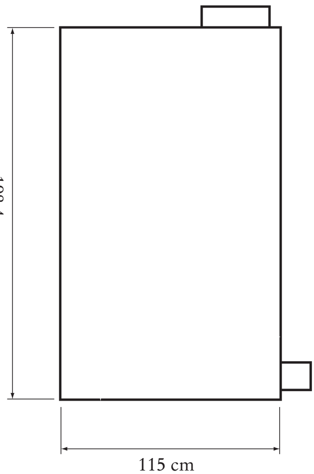
Silos made with 92.7 x 200 cm sheets

■ **Appendix 4** – Silos made with 92.7 x 200 cm sheets

Plan for a 2.060 m^3 silo
6 sheets (92.7 x 200 cm) / Approximate content: 1 540 kg

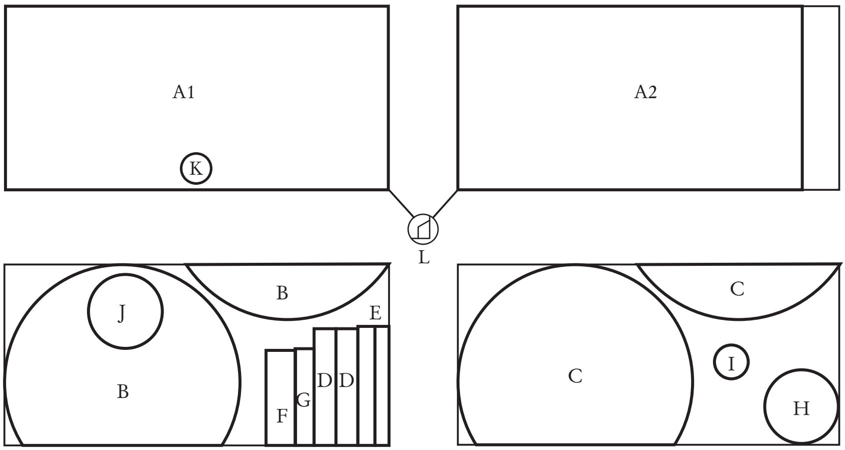


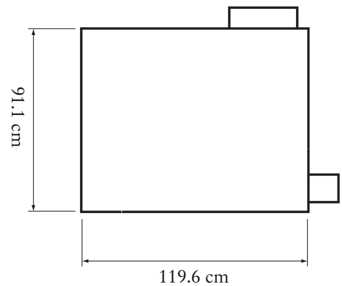
A1, A2, A3, A4: Body sheets (92.7 x 200 cm)
B: Top of silo (r = 59.3 cm)
C: Bottom of silo (r = 59.3 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)



Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 1.020 m³ silo
4 sheets (92.7 x 200 cm) / Approximate content: 770 kg

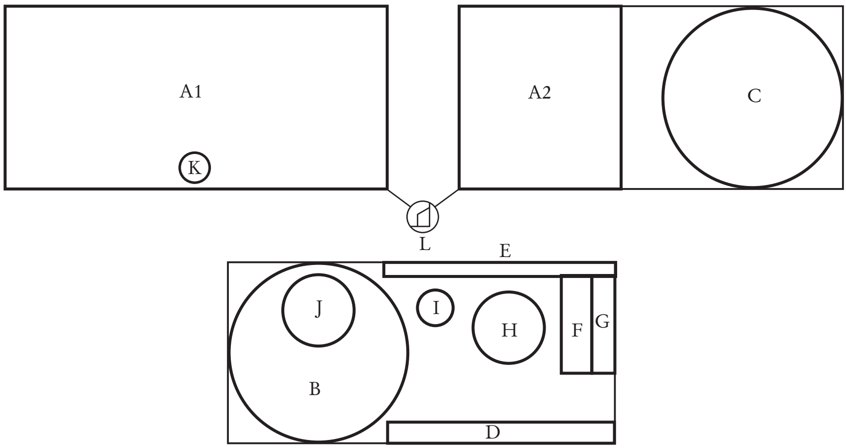


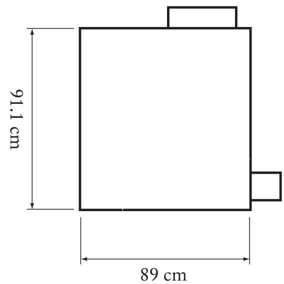


A1: Body sheet 1 (200 x 92.7 cm)
A2: Body sheet 2 (180.5 x 92.7 cm)
B: Top of silo (r = 61.6 cm)
C: Bottom of silo (r = 61.6 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 0.570 m³ silo
3 sheets (92.7 x 200 cm) / Approximate content: 425 kg

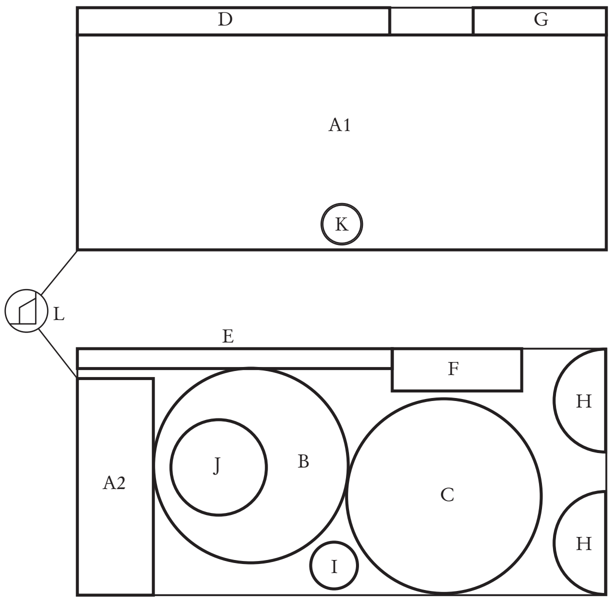




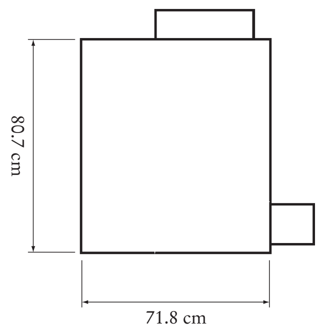
A1: Body sheet 1 (200 x 92.7 cm)
A2: Body sheet 2 (84.4 x 92.7 cm)
B: Top of silo (r = 46.3 cm)
C: Bottom of silo (r = 46.3 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.8 cm straight; 1.2 cm relief)

Note: the seams in the body are made with an 8 mm fold on one side and a 12 mm fold on the other. The body, top and bottom flanges measure 8 mm. The inlet and outlet cover flanges measure 5 mm.

Plan for a 0.327 m³ silo
2 sheets (92.7 x 200 cm) / Approximate content: 245 kg



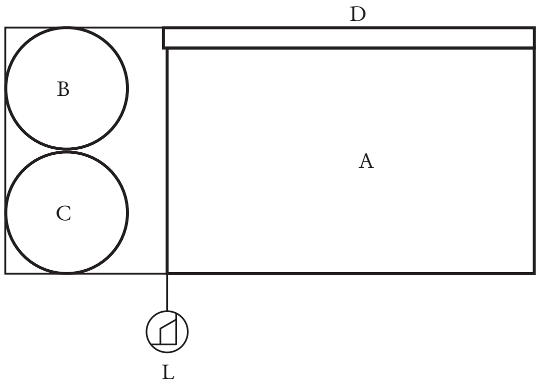
A1: Body sheet 1 (200 x 81.7 cm)
A2: Body sheet 2 (28.6 x 81.7 cm)
B: Top of silo (r = 37 cm)
C: Bottom of silo (r = 37 cm)
D: Inlet opening strip (11 x 118.2 cm)
E: Inlet cover strip (7.5 x 119.2 cm)
F: Outlet opening strip (16 x 49.1 cm)
G: Outlet cover strip (11 x 50.1 cm)
H: Top of inlet cover (r = 19.6 cm)
I: Top of outlet cover (r = 8.6 cm)
J: Inlet opening (r = 18.5 cm; with centre 25 cm from the edge)
K: Outlet opening (r = 7.5 cm; with centre 10.5 cm from the edge)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

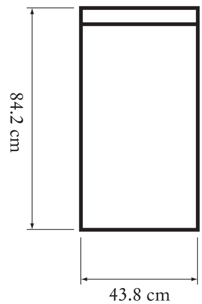


Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body, top, bottom and inlet and outlet cover flanges measure 5 mm.

■ Appendix 4 – Silos made with 92.7 x 200 cm sheets

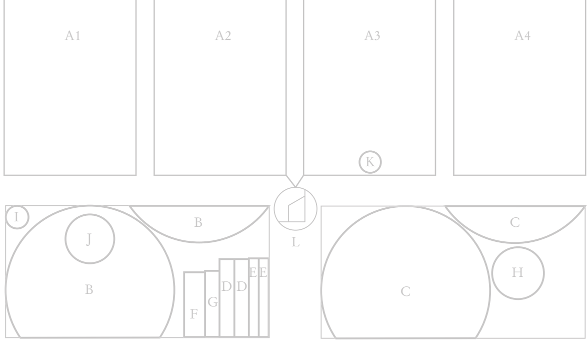
Plan for a 0.127 m³ silo
1 sheet (92.7 x 200 cm) / Approximate content: 95 kg





A: Body sheet (139 x 85.2 cm)
B: Top of silo (r = 23.1 cm)
C: Bottom of silo (r = 23 cm)
D: Inlet cover strip (140.5 x 7.5 cm)
L: Relief cut (0.5 cm straight; 0.7 cm relief)

Note: the seams in the body are made with a 5 mm fold on one side and a 10 mm fold on the other. The body and cover flanges measure 5 mm.



Technical manual
for the construction and use of family-sized metal silos
to store cereals and grain legumes

The *Technical manual for the construction and use of family-sized metal silos to store cereals and grain legumes* presents simple instructions for the construction and use of various types of family-sized silos, with capacities of between 0.12 m^3 and 4.2 m^3 (approximately 120 and 4 000 kg). The contribution of this type of silo to food security, to meeting the Sustainable Development Goals and to the well-being of small farmers is extremely important, particularly during agricultural crises caused by a number of external factors, including financial problems. The silos have a key role, not only to safeguard family nutrition in the peasant sector, but also so that small farmers can regulate trading in surplus goods and have access to markets when they are favourable. The manual contains guidelines for the use and manufacture of family-sized silos at low cost, accessible to craftsmen and farmers. The manual is based on field experience gained by the Swiss Agency for Development and Cooperation (SDC) and subsequently by numerous projects carried out by FAO in more than 22 developing countries.

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of the United Nations (FAO)
Viale delle Terme di Caracalla, 00153 Rome, Italy
www.fao.org

ISBN 978-92-5-108181-5

9 789251 081815

I3632E/1/12.15