# VOLUME 3

# TECHNICAL SPECIFICATIONS

Section 1

**SPECIFICATIONS OF ITEMS REQUIRED FOR THE MOVABLE SLAUGHTER FACILITY WITH COLD ROOM**

| **S/N** | **ITEM SPECIFICATIONS** | **QUANTITY** |
| --- | --- | --- |
| 1 | Shipping container: length – 12m; inside height – 2.7m; inside width – 2.4m; steel floor with chequered design; corrugated walls; one end, full height double doors; tare weight max 4,000kg  | 01 pc |
| 2 | Wall mounted manual winch: corrosion resistant / stainless steel version; max capacity 1,000kg; self-locking foldable / removable crank handle; max usable rope length 12m; spur gear drive; rope diameter 7mm; with brake safety to hold load in every position; winch base 130mm square; operation ambient temp up to 40⁰C | 01pc |
| 3 |  Steel rope pulleys: rope diameter 7mm; pulley diameter 60mm; corrosion resistant | 02pcs |
| 4 | Stainless steel, knee operated wash-hand basin: 0.4m by 0.25m; max water temp 85⁰C | 02pcs |
| 5 | Overhead stainless-steel dressing rail: standard; max carcass weight 750kg  | 18.0m long |
| 6 | Dressing roller hooks; standard; max meat750kg | 50pcs |
| 7 | Meat weight gambrels: standard, max weight 750kg  | 02pcs |
| 8 | Carcass Weigh Electronic Rail Scale (interweigh@inquiry.co): max capacity 750kg  | 01pc |
| 9 | Hand operated reciprocating saw (battery operated, re-chargeable): standard; for splitting carcass | 02pcs |
| 10 | Knife washer, Rinser & Sterilizer: wall mounted; standard (using chemicals & water) | 02pcs |
| 11 | Stainless steel trolley (for moving green & red offal): standard; max weight capacity 50kg | 02pcs |
| 1213 | Modification / reconstruction of the container |  |
| i | Raising side and end walls, and reconstructing the roof with mild steel plates: each 8ft by 4ft by 2.0mm thick | 21plates |
| ii | Roof trusses: rafters 30mm x 30mm x 2mm thick MS hollow sections @ 6.0m long | 02pcs |
| iii | Reinforcing new roof & added sides and ends: MS angles 30mm x 30mm x 2.5mm | 10pcs |
| Iv | Reinforcing container sides: MS hollow sections 100mm x 100mm x 3mm @ 6m long | 11pcs |
| v | MS I-beams welded across to receive the carcass rail: IPE 140 (Roofings) @ 6m long | 02pcs |
| vi | MS U-channels welded on walls for fixing hoisting winch: 65mm x 65mm x 3mm thick @ 6m long | 04pcs |
| vii | Partitioning chilling room from carcass preparation area: MS plates 8ft x 4ft x 2mm  | 02pcs |
| viii | Sliding doors to enter & exit chilling room:  |  |
| ix | Chequered floor for carcass preparation area: Aluminium 8ft x 4ft x 3mm thick; fixed to comply with US 734:2019 standards | 04pcs |
| x | Floor grates for blood: Corrosion resistant; gauge 8: 8ft x 4ft  | 04pcs |
| xi | Drainage for blood below: MS plate 8ft x 4ft x 2mm | 05pcs |
| xii | Laminated panels fixed inside the walls & ceiling: Standard 8ft x 3ft x 3mm thick; compliant with US 734:2019; fixed in compliance with US 734:2019 standards | 28pcs |
| xiii | Steel windows: 1.5m wide by 1.0m high; with burglar proof & dust proof screen | 02pcs |  |
| xiv | Heart and lung inspection: Corrosion free; with hooks; bolted to wall | 01pc |  |
| xv | Return rail for hooks: corrosion free; 75mm wide x 10mm thick flat bar | 15m long |  |
| xvi | Entrance side door:  | 01pc |  |
| xvii | Serrated plastic curtains: at entrance and exit from chilling room; compliant with US 734:2190 or International hygiene standards | 02pcs |
| xix | Arc welding electrodes: G10 and G8 | 15kgs each |
| xx | Insulation material between inside & outside walls: to comply with US 734:2019 standards |  |
| xxi | Spray painting: to comply with US 734:2019 standards |  |
| xxii | Stepped platform: corrosion free; four steps; 0.75m wide x 1.0m high | 01pc |
| xxiii | Stunning Unit (see 14 below) |  |
| xxiv | Chilling room (see 15 below) |  |
| 14  | Stunning Unit |  |
| i | MS U-channel: 40mm x 40mm x 2.0mm thick; 1.76kg/m @ 6m long | 03pcs |
| ii | MS plate: 8ft x 4ft x 2.0mm thick | 01pc |
| iii | MS hollow section: 30mm x 30mm x 2.0mm thick @ 6m long | 01pc |
| iv | Ball bearings: | 02pcs |
| v | MS shaft: | 01pc |
| vi | Restraining chain: 1.2m long; heavy duty | 02pcs |
| vii | Arc welding electrodes: G10 | 05kgs |
| Viii | Spray painting: to comply to US 734:2019 standards |  |

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| --- | --- | --- | --- |
| **Item** | **Description** | **Unit** | **Qty** |
|  | **BILL NO. 1 – COLDROOM WORKS-CONTAINER** |  |  |
|  | Skinning cradle: stainless steel; capacity 1,000kg; swinging rollers | lot | **1** |
|  | Cleaning materials (assorted; to comply with US 734:2019 standards) |  |  |
|  |  |  |  |
|  | **ELEMENT NO. 1 -**  |  |  |
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| **BEEF STROAGE COLDROOM WORKS -** |

 |   |  |
| **A** | The cooling unit shall be 2.5HP - NTZ-068-4 cooling unit 2.5kw. The system shall be N+1 configured | lot | 1 |
| **B** | Ribbed wall pannels,0.5mm, RAL9002 | SQM | 75 |
| **C** | Ribbed ceiling panels,0.5mm, RAL9002 | SQM | 30 |
| **D** | Cr-Ni floor Ribbed panel, 0.5mm,RAL9002 | SQM | 30 |
| **E** | Slide door with heater(100x190cm) RAL9002 polyurethane 38-42kg/m*3 resistance Cr-Ni inside* | No | 2 |
| **F** | pressure relief port | NO | 1 |
| **G** | Cr-Ni L Type external , 0.5mm,RAL9002 | LOT | 1 |
| **H** | Cr-Ni U Type profile, 0.5mm,RAL 9002 | LOT | 1 |
| **I**  | Cr-Ni 5x5 Type profile 0.5mm,RAL9002 | LOT | 1 |
| **J** | Pvc strip curtain 90x190cm | NO | 1 |
| **K** | Surface type LED waterproof lighting fixture IP65 | NO | 2 |
| **L** | Hanging hooks | LOT | 1 |
|  | **TOTAL CARRIED TO COLLECTION-1** |  |  |
| **A** | Refrigerant piping including insulation (Liquid/Gas) of sizes: |   |  |
| **B** | 22.2mm | LM | 10 |
| **C** | 19.1mm | LM | 10 |
|  | **Electrical works** |   |  |
| **D** | Poly vinyl sheathed interconnection cable 2.5mmSq Cable to be wired to all indoor units., 4mmSq cable from isolator and mains | Lot | 1 |
|  | **Drainage from Fan coil units** |   |  |
| **E** | 25mm uPVC drain pipe c/w all fixtures and terminated to a nearby wastewater drain | LM | 10 |
|  | **Additional refrigerant** |   |  |
| **F** | Allow for additional refrigerant for the refrigeration equipment | item | 0.5 |
|  | **AS Built Drawings** |   |  |
| **G** | Allow for 3No. Hard copies of as built drawings, 1No. Working drawing to clients approval. | item | 1 |
| **J** | Allow for metal works, demolish, and make good the wall to allow for cold room installation. | item | 1 |

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| --- | --- |
| **BILL NO. 2. Generator Set** |  |
| **SPECIFICATIONS:** | **Generator S** |
| Weight: | < 75 kg |
| Dimensions (LxWxH): | < 700 x <500 x <650 mm  |
| Electrical Voltage Output: | 12/24 VDC and 120/240 VAC |
| Electrical Power Output: | 2.7 kW maximum output and 2.5 kW continuous output |
| Alternator Type: | Permanent Magnet (brushless and direct mount to PTO Shaft without a coupling) |
| Frequency & Waveform Shape: | 50 or 60 Hz |
| [optional- adds ~1.0 kg (2.2 lbs)] | 50 or 60 Hz |
| Engine: | Four Stroke Direct Injection Diesel 211 cc |
| Engine speed: | 3000 to 4400 rpm and idle speed (2600) |
| Engine Cooling: | Forced Air |
| Fuel  | Diesel |
| Fuel Tank Capacity: | 3.5 L (0.77 gal.) |

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| --- | --- |
| **BILL NO. 3. Delivery to Site** |  |
| **SPECIFICATIONS:** | **Delivery** |
| Location | Exact location to be specified, but within Disease Control Zones 1 or 2 and at most 400km from Kampala |
| Unloading and Installation | Positioning Mobile Slaughter Unit (MSU) and connections to docking station (provided by beneficiary recipients) |
| Demonstration | One day training of beneficiary recipients on operation and maintenance of the MSU |

**Extracts from MSU design report –** (Full version is available as part of the dossier)

##

## Definitions

##

**Beef:** is the culinary name for meat from cattle.

**Bleeding:** Removing as much blood from the carcass as possible before further handling

**Carcass:** The body of an animal killed for meat or the trunk of an animal such as a cow, sheep or pig for cutting up as meat

**Dressing:** Preparation of carcass after evisceration, ready for storage or sale.

**Evisceration:** Process of removing the internal organs in the abdominal and thoracic cavities.

**Flay:** strip the skin off a carcass

**Green offal:** Digestive tract of ruminants such as the stomach, or the intestines which still contain faecal matter.

**Lairage:** pens, yards and other holding areas used for accommodating animals in order to give them necessary attention (including water, fodder, rest) before they are moved on, used for specific purposes or slaughtered.

**Meat:** Edible part of the muscle of cattle, sheep, goats or swine.

**Offal:** Part of internal organs of a slaughtered animal.

**Slaughterhouse:** Any building or place used for killing of animals where the flesh is intended for human consumption.

**Splitting:** Dividing carcass into parts.

**Sticking:** Severance of the major blood vessels in the neck or immediately anterior to the heart by means of a knife.

**Stunning pen:** Compartment which is suitable for confining only one animal at a time while it is being stunned and which is so constructed as to confine, without discomfort, to prevent any substantial movement of the animal forward, backward or sideway.

**Stunning:** to render an animal senseless before it is killed

* 1. **Conversion of a 40ft Long Container.**

This is referred to hereafter as the Long MSU.

From standard specifications and details of the sizes of available long shipping containers, a suitable container with the following dimensions is recommended and used in the design of this facility:

* Length: Inside 12.0m
* Height: Inside 2.7m
* Width: Inside 2.4m
* Floor: Steel, with chequered design
* Walls: Corrugated

For this container, it is recommended that the maximum spread load shall not exceed 3tons per running meter length. This shall be taken into account in the design process.

The design option to be followed is:

1. The Long MSU which shall have three major Sections (Technical Preparation Office, Carcass Processing Area, and the Cold Room Section)

The MSU will not have its own means of transport, but will require specialist container removal services.

***2. Dimensions of the Long MSU***

Like the Short MSU, the US 734:2019 Standard requires that the minimum clearance for rails and equipment in dressing areas (for cattle dressing) from rail to floor shall be 3.4m. The inside height of the selected container is 2.7m. Therefore, the entire container roof shall also be raised by 0.7m at the walls, and given a gentle pitched roof height so that the overall height is 3.71m.

The mild steel plate to be used in raising the side walls of the MSU shall be of the same thickness as that of the walls of the container selected (for easy joining by welding).

In order to firmly hold the top rail so as to be able to withstand the carcass weights, and to give the MSU additional strength and rigidity of the raised roof, some steel reinforcements shall be made at all the four corners using square pipes which shall be welded on the existing corner pillars. Three additional pairs of pillars (square steel pipes of 100m and 2.5mm thick) shall be placed at points partitioning the Sections, and one pair placed half way the length of the cold room. Details are indicated in the drawings in Appendix 4.

In addition, and in order to fix the winch for lifting the carcass up to the dressing rail and its pulleys, steel U-channels shall be welded to the walls in the middle Section, and running above the carcass dressing rail. Laminated plates which conform to international hygienic requirements for handling meat shall be fixed, in accordance with the US 734:2019 Standard, to cover the entire MSU walls at the inside and ceiling.

***3. Floor Plan of the Long MSU with Three Sections –*** *see drawing documents*

This MSU design option shall have three main sections, namely the Technical Preparation Office, Dressing Area, and the Chilling Room – all described in details hereunder:

**3.1 Technical Preparation Office**

This office shall measure 2.0m in length, and shall be accessed from outside through a single leaf, steel door measuring 0.75m wide and 2.7m high (i.e. the height of the original container). It shall have, inside it, a store measuring 1.2m wide by 1.2m long and 2.7m high to keep MSU items (gloves, footwear, chemicals for sterilisation, overcoats etc); a lockable, single leaf steel door 0.6m wide and 2.1m high shall be used to enter this store.

A stainless-steel wash-hand basin, measuring 0.4m by 0.25m, and a standard first aid kit box positioned as shown.

A solar powered knife sharpener (capacity 180Watts) shall be placed near the wash hand basin. Knives shall be sharpened here and then kept in the store. However, the Meat Inspector shall always have a pocket type hand sharpener with him / her.

The rest of the space shall be used as an office with an office table (with lockable drawers for keeping records), an office chair and three visitors’ chairs.

A lockable, single leaf steel door (0.6m wide and 2.7m high) opening to the inside of the office shall be fixed to a permanent steel wall partitioning this office area from the Dressing Area. This door shall be self-closing and shall only be used by technical staff because only approved personnel shall be allowed access to the slaughterhouse/abattoir (US 734 Standard). There shall be a serrated, plastic curtain covering the width of this door to minimize air and dust coming from outside through the office and entering the Dressing Area.

A 7.5kg Class A fire extinguisher shall be placed in the office, at a height of 1.5m from the floor.

Due to limited space, this office shall also be used to handle all records of the MSU including the final sales and products and other correspondences. It may also be used for simple consultations, information sharing and problem resolutions with stakeholders.

**3.2 Dressing area**

This area shall be of 4.0m length with the following facilities:

There shall be a double-leaf steel door 1.2m wide and 2.7m high, opening to the outside of the MSU, through which the beheaded animal shall be moved into the MSU. This door shall also have 2.75m high serrated translucent plastic curtain fixed from inside, running from top to bottom – with the bottom flushing with the facility floor. This door shall also be self-closing.

The animal shall be stunned and slaughtered from outside the MSU while inside a special cage (designed to restrict the animal from side, back, front and neck movement while being stunned and slaughtered), and blood collected through a receptacle placed below the neck. The beheaded animal shall then be gently lowered onto a skinning cradle (which was placed beside it while being stunned and slaughtered), then be pushed inside the MSU through the double leaf door (the beheaded animal facing up, lying with the hind limbs last). The skinning cradle shall measure about 2.0 m long and 0.75m wide and made out of stainless-steel pipes, with swinging and lockable rollers.

Skinning of the animal shall then commence as soon as it is inside the MSU, and most of it accomplished from here (except the back side).

It is a requirement that the top dressing rail shall be located 0.7m from the wall of the MSU, and 3.4m height from its floor (US 734:2019 Standards), and it shall run straight through the length of MSU from the steel wall separating the Technical Preparation Office from the Dressing Area right, and straight through into the Chilling Room.

Directly opposite the double leaf door entrance to the MSU (through which the beheaded animal was pushed into it) and on the wall of the MSU shall be located a winch with a first pulley at the top. There shall be a second pulley directly above the skinning cradle on which the beheaded animal is lying. A wire rope at the end of which (above the skinning cradle) shall be a short steel bar with two short steel wire ropes shall run over the second pulley to the first pulley (near the wall) and down to the winch. The winch shall be located 1.2m from the floor and shall be operated manually to lift the carcass up from skinning cradle using the hind limbs up to the level of the hooks hanging from the dressing rail. The Meat Inspector shall then use a short-stepped platform, climb it so as to reach the dressing rail hooks, and hook the carcass through the hind limbs’ tendons. The steel rope over the second pulley shall be relaxed using the winch so that it (the wire rope with steel bar) can be released from the carcass thereby transferring, gently, the entire carcass to the dressing rail.

The short, stepped platform shall be kept in the store (in the Technical and Preparation Office) when the MSU is being moved from one place to another.

The winch shall be designed to have the capacity to lift up to 750kg at a time. It shall be fixed on a hot rolled U-channel pillar (of cross section dimensions measuring 0.2m high, 0.08m wide, 0.075m thickness) welded to the MSU wall, about 3.25m from the front end of the MSU. There shall be same size beams welded onto these pillars at the top so as to hold the dressing rail. The dressing rail shall run below the top U channel, attached to it by a bolt and nut.

With the carcass now hooked to the dressing rail, skinning of the back side can be completed (although it could also be done when the carcass was being lifted using the wire rope). The skin shall be pushed through an opening, measuring 0.5m diameter created on the wall to an outside receptacle for appropriate handling. This opening shall have self-swinging closing cover (from outside) and shall be closed from inside at the of the day’s operations, after cleaning it, to stop other animals (eg cats), flies and dust from entering the MSU.

The carcass shall then be pushed manually to the middle of the dressing area. Here, evisceration shall start. The offal shall be removed and through an opening, measuring 0.3m diameter) on a wall (behind the operator) pushed to a receptacle placed outside the MSU to receive it. Again, this hole shall be closed at the end of the day’s operations to stop cats, flies and dust from entering the MSU but shall also have a self-swinging closing cover from outside.

There shall be a metal bar, measuring 0.45m with three hooks welded to it and fixed on the wall of the Dressing Area near the wash hand basin. This shall be used to hang the red offal (heart, lungs, kidney) for inspection. Care shall, however, be taken to ensure that the red offal does not touch the wall of the MSU. The certified red offal may be sent to the chilling room.

The carcass shall then be split in the middle using a portable, reciprocating battery powered hand saw (or manually by use of an axe or hand saw). The reciprocating saw shall have a long chain attached to it and fixed to the MSU wall (to prevent theft / loss). The split carcasses shall then be moved towards the entrance to the Chilling Room where they shall be subjected to final inspection, then weighed.

Any condemned carcass from this final inspection, shall immediately be pushed through another opening, measuring 1.0m square) to a specialised receptacle placed outside the MSU to receive it, and appropriately handled according to veterinary regulations and standards as condemned meat. Again this opening shall be cleaned and closed (from inside and outside) to avoid pests and dust from entering the MSU.

Carcasses which are certified shall be moved to a particular position of the dressing rail which has been cut to allow for the carcass to be weighed. The reading shall be displayed on the digital unit screen placed or clamped nearby the dressing rail. Particular attention shall be directed in ensuring that the weight of the hooks should be netted from the reading of the digital weighing scale.

The carcass shall then be stamped in accordance with the legal requirements and pushed, through the 1.0m wide sliding door, into the Chilling Room.

A knee operated wash hand basin (stainless steel measuring 0.4m by 0.24m), to provide water at a temperature not less than 40⁰C (US 734 Standard) shall be positioned at one corner. Close (or attached) to it shall be a steriliser (standard specifications); sterilisation shall be by use of appropriate chemicals.

Water heated to 85⁰C shall be made available through appropriate piping system.

Hand wash-basins shall be readily accessible and be placed within 3m of workstations in rooms and areas where meat is handled (US 734:2019 Standard). Similarly, sterilizers shall be readily accessible and shall be placed on dressing platforms and within 3 m of workstations, adjacent to hand wash-basins in rooms and areas where meat is handled (US 734:2019 Standard).

Two windows, measuring 0.75m wide by 0.4m high, shall be positioned 1.8m from the floor to facilitate air circulation inside the MSU and also provide additional natural lighting inside it. They shall be opened from outside, and have protective screens (against flies and dust), and shall have burglar proofing installed inside them. They shall be light coloured, corrosion resistant frames and glazed, and shall have window sills that slope at 45⁰ (US 734:2019 Standard).

Two small solar powered rotating fans shall be installed - one on the wall separating the Dressing Area from the Chilling Room, and the other on the wall separating the Technical Preparation Office from the Dressing area, each at a height of 2.5m from the floor and midway the walls widths.

Two solar powered neon lights of intensity 220lux (US 734:2019 Standard) shall be installed on the ceiling.

The floor of the MSU shall be covered with chequered aluminium plate (to avoid slipping) and shall have a slope of 1:60 towards the drainage points or channels (US 734 Standard). Drainage channels shall be smooth and washable.

Interior wall surfaces, pillars and partitions shall be smooth, light coloured and washable and shall be rounded at floor to wall, as well as wall to wall, junctions with a minimum radius of 50mm (US 734 Standard).

A sliding door, measuring 1.0m wide, shall be provided through which the certified carcasses shall be pushed into the Chilling Room. This door shall have a groove at its top part, measuring 0.5m, which shall be designed to slide up and down (to allow the entire door to be slid sideways to open for the carcass to be pushed inside the Chilling Room). That top part groove of the sliding door shall be shaped so as to mesh firmly with the dressing rail when the door is closed and it (the part) is pushed up (so as to keep the Chilling Room temperature controlled.

**3.2 The Slaughter Unit**

This is the key, and most important, component of this facility.

In transportation, this steel unit (measuring 1.0m wide, 2.0m long and 2.0m high) shall be fully enclosed, and locked into the transportation mode inside the MSU. The floor locks shall be foot operated.

When the facility is positioned at site, its two-leaf doors shall each be opened 90⁰ and locked in position as shown in Fig 2. This exposes the Slaughter Unit in its locked position inside the facility. The floor locks shall then be released, so as to enable the Unit to be pushed outside to the slaughter area which has an enclosure around it. When it is pushed outside the facility, it shall again be moved (to the left position, directly aligning with the race through which the animal to be slaughtered shall be led into it) and then firmly locked into position ready to withstand the stunning process.

This unit, shaped as an open box, shall essentially be used to receive and confine the animal as it is being stunned and, soon after, slaughtered. At one end, the unit has a shape to receive and hold the animal’s neck during stunning and beheading, and directly below the neck is a receptacle, fixed / welded to the unit, for collecting the blood.

Once the animal enters this facility, it shall be constrained at its hind by either a sideways opening door or up and down sliding door or by metal pokes / ropes.

It should be noted that this unit shall be able to handle animals with horns as wide as 2.0meters apart / between them.

Note also that directly in front of the Slaughter Unit (in its operation opposition) and fixed on the wall of the enclosure is a wide window. This window with translucent glasses, besides allowing light into the enclosure, shall allow the animal not to be scared while being led into the Slaughter Unit. At the same time, people outside the Unit shall not be able to view the stunning and slaughter processes.

A lockable, wheeled skinning cradle shall be positioned to the right-hand side of the Unit. The purpose for this is that after stunning the animal, it shall be lowered to it and pushed inside the facility through serrated plastic curtains. The front and rear limbs shall then be severed manually.

**4. The Skinning & Dressing Section for the Two Section Long MSU**

The Skinning and Dressing Section is 6m long and therefore presents more space to carry out the necessary activities. The locations and placements of other facilities eg wash hand basins, steriliser, winch and pulley systems, dressing rails, and the side openings to dispose of the skin, offal, lung and heart, and condemned meat are also similar to the earlier designs.

**Long MSU Facility Roof.**

Given the US 734:2019 Standard which requires that the minimum clearance for rails and equipment in dressing areas, for cattle dressing, from rail to floor shall be 3.4m (and yet the inside height of the selected container is 2.7m), the entire container roof shall be raised by 0.7m.

Additional reinforcements shall be made at all the four corners using angle bars of size (depending on the container selected) which shall be welded on the existing corner pillars. Technical details are given in the drawings.

A very gentle pitched roof design, with trusses is given. The overall height of the MSU shall be 3.71m. Details of the roof and its trusses are also given in the drawing.

**5. Long MSU Facility Walls**

The MSU walls shall be reinforced with hollow square M/S pipes of 100mm and 3mm thickness at the four corners and also equally spaced along its length (ie a total of eight pillars).

The entire MSU walls shall be covered with laminated plates from inside. The fixing shall comply with the US 734 Standard regarding curvatures at the corners and at the floor (ie a radius of 50mm).

**6. Transportation of the Three Section Long MSU**

This MSU facility shall be moved from site to site by use of a low bed platform loader of 10-ton capacity, with a crane for loading and off-loading, and positioning the MSU on site. The type of loader shall be multi-purpose such that it can be towed by different tractor heads.

Generally, platform trailers are also designed for transporting materials that must be loaded/unloaded from the top or side of the trailer.

The mode and method of transporting the MSU, and its anchoring at site shall influence and dictate the design of the docking site. However, care shall be taken to ensure that the docking site shall enable the MSU to be positioned horizontally otherwise moving the carcasses inside shall be a challenge.

The height of the platform (flat-bed) trailer shall not exceed 1.2m. Therefore, adding the MSU overall height (3.7m) makes the total height of the system to be 4.9m, which shall enable the MSU to be transported and pass under most overhead bridges in Uganda.

The cost of moving the trailer may either be borne fully by its management organ without transferring such cost to the farmers or such costs may be shared with the farmers. It is recommended that this cost be borne by management / Government.

**7. Docking Site for the Three Section Long MSU**

Since for this option the MSU facility shall be off-loaded at site, the Docking Site design is the same as that for the Short MSU. Appendix 1 gives two possibilities of the Docking Sites depending on whether or not the MSU shall be off-loaded from the loader used to transport it. The 3D Models in the same appendix explain this further. As stated earlier, the MSU floor plan remains the same but the major difference is in the mode of its transportation to the site.

For each of the two possibilities, a cost-benefit analysis has been made and presented in Section 4.1.7 below. However, estimated costs have been used in some instances as these shall largely depend on the topography and other factors at the different docking sites. and described in Section 4.1.3.1 above

**8. Similarities in both Designs of the Long MSU**

For both designs of the Long MSU (i.e. the Three Section Long MSU, and the Two Section MSU) the design factors described here below shall be the same.

**9. Long MSU Facility Roof.**

Given the US 734:2019 Standard which requires that the minimum clearance for rails and equipment in dressing areas, for cattle dressing, from rail to floor shall be 3.4m (and yet the inside height of the selected container is 2.7m), the entire container roof shall be raised by 0.7m.

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A very gentle pitched roof design, with trusses is given. The overall height of the MSU shall be 3.71m. Details of the roof and its trusses are also given in the drawing.

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The entire MSU walls shall be covered with laminated plates from inside. The fixing shall comply with the US 734 Standard regarding curvatures at the corners and at the floor (i.e. a radius of 50mm).

* + - 1. **Chilling Room**

The floor plan and detailed design of the Chilling room is given in Appendix 2, while its description, calculations and cost are given in the appendix.

This room shall be 6.0m long. The inside top rail shall also be at least 700mm from columns, pillars or the side of a doorway through which carcasses shall pass (US 734:2019 Standard). To accommodate more carcasses, the rail shall be split into two inside the room but converge at the exit door at the side of the facility (for ease of transfer to the Refrigerated Truck).

The room temperature shall be adjustable in the range of 0 - 7⁰C. The inside walls shall be of Styrofoam material.

The floor shall be tiled, and with a slope to aid in draining water (when washing the facility of when the AC is switched off).

The carcasses shall not touch each other in this room.

The total length of the rail in the Chilling Room area is 12.0m Therefore, this room shall be able to store a maximum of 12 split carcasses (i.e. 6 animals) if distance between carcasses is reduced to 0.1m.

Two solar powered neon lights, 220lux each, shall be provided to light this room.

Technical details and corresponding costs of other facilities required for the Chilling Room are given in the attached design.

* + - 1. **Staff requirements for the Long MSU**

For the Long MSU, the following eleven staff shall be required to operationalise it:

1. MSU Facility Supervisor – a Veterinary Officer, with vast experience in animal welfare matters, meat inspection, and operation of a movable / mobile slaughter unit s added advantage.
2. Three Technical Officers, namely:
* in charge of the lairage
* Two Butchers
1. Two Drivers – one for the service van and the other for the truck to move the MSU
2. Maintenance Technician – Electro-mechanical qualification and experience
3. Two Security Officers – on full time, and with accommodation on site
4. Two Cleaners

**Approved Design Scenario**

This scenario starts in 2019 with an average of 25 cows only. The annual growth set at as indicated in the table below, together with gross operating profit over the five years.

Staff levels are kept at a minimum, and operational costs are also indicated.

The CBA for this growth scenario should show that the MSU operation shall become profitable in the year 2020.

In this scenario, the MSU shall be used exclusively to slaughter cattle only.

However, the capital costs for purchase of the trailer head ($50,000) and land (at Government rate of UGX 5,000,000/= per acre) have both been included.

The CBA model developed below has used 5 (five) acres of land purchased for analysis (i.e a total of UGX 25,000,000/= or $ 6,580 for the five acres). The reasons for this size of land are:

* After slaughter at one site, the MSU shall be moved to another site. But farmers at the first site may still bring their animals for slaughter, and these animals need to be kept at site until such a time that the MSU is available again. This requires that some pasture is planted for these animals to graze.
* There may be unavoidable delays that may occasion the delay for the MSU to be availed at a particular site or the delay for a Refrigerated Truck to go and pick the processed meat. Again this calls for availability of some pasture – hence sufficient land for the purpose.
* Animals brought for slaughter shall be handled very well and according to the required standards. This shall require that the said animals are properly confined and looked after – hence the need for large pieces of land.

Here again the number of slaughter days per year shall be 202 days.

* + - 1. **Solar Power Unit**

A solar system has been designed for the facility to run the fans, facility neon lights, and security lights. Design details are given in Appendix 6.

Since the overall height of the MSU (3.71m) and the restriction that the legal height of a bridge built over a road in Uganda is at least 5.2m, it shall not be possible to install the solar unit atop the MSU. Therefore, every docking site shall have its own installation of a solar unit. The system shall have a converter (to convert direct current to alternating current) so as to enable use of solar power, generator power as well as electricity supplies by UMEME.

Where there is electricity supply from the national grid (UMEME grid), this shall be extended to the site to provide the needed power during both day and night (for security reasons). A budget for this has been provided.

The system shall have a Solar hart 100lt water tank connected to it, and water shall be heated to 85⁰C by the solar unit and supplied to the facility.

However, a small stand by diesel generator which shall be housed in the facility office shall be provided at each site to provide the needed power for the fans and lights when the solar unit fails or is unable to supply the desired power. Besides, the generator shall power the security lights tor the entire site even when the MSU is moved away from that site.

**DESIGN OF THE SOLAR POWERED FACILITIES**

1. **Introduction**

Two solar PV systems are to be installed on a 20 feet container and another on a 40 feet container. Two solar water heating systems are to be installed as well, one on each of the containers to cater for hot water demand. The designs are presented below.

1. **Electrical energy demand for the containers**

The solar system has been designed to cater for the electricity energy demand as shown in table 1. The energy demand caters for operating fans and lighting only.

**Table 1:** Energy demand for the 20 feet container

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Usage**  | **Qty** | **Rating (W)** | **Total Rating(W)** | **h/day** | **Total Energy demand (Wh)** |
| Fans | 3 | 25 | 75 | 4 | 300 |
| Lights | 4 | 11 | 44 | 4 | 176 |
|   |   |   |   |   |   |
| **Total** |  |  | **119** |  | **476** |

**Table 2:** Energy demand for the 40 feet container

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Usage** | **Qty** | **Rating (W)** | **Total Rating(W)** | **h/day** | **Total Energy demand (kWh)** |
| Fans | 5 | 25 | 125 | 4 | 500 |
| Lights | 8 | 11 | 88 | 4 | 352 |
|   |   |   |   |   |   |
| **Total** |  |  | **213** |  | **852** |

1. **Solar PV systems**

The Solar PV systems have been sized to satisfy the energy demand above. The solar PV systems are entirely direct current (dc). Fans and lights shall be dc appliances. The solar PV modules shall supply the energy demand during the day and also charge the batteries in order to store excess electricity that can be used when the sun irradiance is not available or insufficient. The batteries are designed for two days of autonomy (can store two days’ energy supply when full).

The solar PV systems are designed and costed in table 3 and 4 below:

**Table 4:** Bills of Quantities for the 40 feet container solar PV system

|  |  |  |
| --- | --- | --- |
| **No.** | **Item** | **Qty** |
| 1 | Deep cycle sealed GEL batteries - 200Ah/12 Vdc | 2 |
| 2 | Solar Modules 150 Wp | 2 |
| 3 | Charge controller 20 Amp 12/24V dc  | 1 |
| 4 | Battery connection and wiring accessories (Lagged cables-16sqmm) | Lump sum |
| 5 | Battery rack (ventilated, with hinged, lockable top cover | Lump sum |
| 6 | Module Frames (Rust free-corrosion resistant material) | Lump sum |
| 7 | Cabling and interfacing materials cables, switches, lamp holders’ connectors, conduits. etc)  | Lump sum |
| 8 | CFL 11W DC (Philips, Osram) | 8 |
| 9 | Fans – 25W dc | 4 |
| 10 | Labour | Lump sum |
|   | **Total** |   |

1. **Solar Water Heater**

A quality solar water heater has been suggested to provide hot water to each facility. The solar water heater has a storage volume of 300litres. The system has been costed as shown in table 5.

**Table 5:** Solar water heater system

|  |  |  |
| --- | --- | --- |
| **No.** | **Item** | **Qty** |
| 1 | 300l Passive Solar Water heater | 1 |
| 2 | Mountings of SWH | 1 |
| 3 | Piping work and accessories | 1 |
| 4 | Labour | Lump sum |
|   | **Total** |   |

## Design Concept for a Cold Storage for Meat

A cold storage room has been designed to provide a better storage facility for meat, to enable proper transportation and storage. It is an adaptive design aimed at designing the cold room to suit the prevailing factors for meat storage with design calculations. The design complies with all standard refrigeration principles and theory to best suit the prevalent climatic condition in Uganda. This design is intended to serve as a guide for future fabrication and erection of cold room storage. The cold room has an estimated total refrigeration capacity of about 4Hp, and a maximum COP of 6.09. Its operating ambient temperature is over 43oC with a rated evaporator capacity of 1.85Hp and a rated condenser capacity of 2.15Hp, respectively. In practice, the cold room will operate for 24hours daily and will provide storage for meat. The cold room is expected to serve and last for a period of fifteen years before a complete overhaul.

Refrigeration is the process of removing heat from a substance under controlled conditions.

Refrigeration uses the evaporation of a liquid to absorb heat. Before mechanical refrigeration systems were introduced, people cooled their food with ice and snow, either found locally or brought down from the mountains. The first cellars were holes dug into the ground and lined with wood or straw and packed with snow and ice. This was the only means of refrigeration for most of history.

All the foods utilized by man are obtained either from plants or animal kingdom. Most of these foods are not produced in a whole year. They are produced at different places in a particular season especially when it involves much technicalities to produce them. Also, some of these foods are imported, since some of them are required all round the year in various parts of the country.

Thus, it becomes very essential and imperative to preserve them during transportation and subsequent storage until they are finally consumed.

Cold room storage generally tends to depict the views and ideas of a system that embarks on a continual extraction of heat from its body whose temperature is already below its surrounding temperature. Thus, refrigeration inevitably is the only means of preserving food in its original freshness.

The refrigeration industry became important commercially during the 18th century. Early refrigeration as the source reported, was obtained by use of ice which usually were cut from lakes and ponds and stored in the winter in insulated store rooms for summer use. Nowadays, different modern refrigeration systems existing in the market today went through various modifications since the inception of the early ones, as reviewed and documented by other different scientists.

With respect to refrigerant, research and development are resulting in some additional substitutes, such as R507 and R404A as replacement for R502 and HCFC22 which are widely used in the Africa and other parts of the world. These are also, the predominant refrigerants used in screw, scroll and reciprocating equipment.

Presently, in virtually all unitary equipment these days, R134a, R407C and R410A, etc serve as potential replacements of such refrigerants. Basically, a cold room like refrigerators and air-conditioners utilizing these refrigerants as their working fluids consists principally of different integrated components which uniquely work in alliance with other auxiliary equipment to achieve the required cooling.

## Principles of Operation of a Cold Storage Room

The cold room like every other refrigerating systems of the same magnitude employs the vapour compression method of mechanical refrigeration

Fig.1 presents the T-s diagram of the vapour compression cycle, while the Fig.2 illustrates the processes of the refrigeration employed in the cold room, respectively

The cold room like any other conventional refrigerator has four refrigeration cycle processes.

1. Heat Load Determination

The total heat load consists of the amount of heat to be removed from a cabinet during a certain period. It is dependent on two main factors: heat leakage or heat transfer load, and heat usage or service load, respectively. Thus, the following types of heat loads were considered in the design of this cold room:

b) Heat Leakage Load, HL

Heat leakage load or heat transfer load is the total amount of heat that leaks through the walls, windows, ceiling, and floor of the cabinet per unit of time (usually 24 hours). Heat leakage therefore, is affected by the amount of the exposed surface, thickness and the kind of insulation used, and the temperature difference between the inside and the outside of the cabinets. Thus, it is the heat transfer from the outside into the refrigerating space via the insulated wall of the refrigerator.

c) Heat Usage Load

The heat usage or service load is the sum of the following heat loads per unit of time (usually 24 hours): Cooling the contents to cabinet temperature, Cooling of air changes, Removing respiration heat from fresh or “live” fish and from meat, Removing heat released by electric lights, electric motors, and the like, and Removing heat given off by people entering and/or working in the cabinet, respectively. Usage or service heat load of the cabinet was determined by the temperature of the articles that were put into the refrigerator, their specific heat, generated heat, and latent heat, as the requirements demanded. Another consideration was the nature of the service required. This involved air changes (determined by the number of times per day that the doors of the refrigerator would be opened) and the heat generated inside by fans, lights, and other electrical devices.

1. Air Change Heat Load, Hc

Air that enters a refrigerated space must be cooled. Air has weight and it also contains moisture. When air enters the refrigerated space, heat must be removed from it. Air which entered the refrigerated space usually cools and reduces in pressure. If the cabinet is not air tight, air will continue to leak in. Also, each time a service door or a walk-in door is opened, the cold air inside, being heavier, will spill out the bottom of the opening allowing the warmer room air to move into the cabinet. The actions of moving materials in or out of the cabinet, and a person going in or leaving a cabinet, result in warm air moving into the refrigerated space through the process of infiltration of air. Hence, the Air change heat load is the heat transfer due to opening and closing of the refrigerator doors and subsequent change in air-heat content in the refrigerating space.

1. II.3.4 Product Heat Load, Hp

Any substance which is warmer than the refrigerator is placed where it will lose heat until it cools to the refrigerator temperature. Three kinds of heat removal are evident. First, is the specific heat as the ratio of

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Table 2: Chart for Total Heat Removed to Cool Storage Room Air under Varying Conditions of Humidity and Temperature

All heat sources not covered by heat leakage, product cooling and respiration load are usually listed as miscellaneous heat loads, i.e. Light, electric motors and defrosting heat sources. This may also include heat loads introduced into the refrigerating space. And it is represented as

HS = Motor load + Lamp load

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**Design Calculations**

Psychometric properties of R134a have been considered. The values have been selected the chart for R134a.

* Operating temp. Range = 15 to 35 degrees Celsius
* Suction pressure, p1=p4=343kpa, heat pressure, p2=p3=958kpa.
* Ratio of heat to suction pressure=2.79, theoretical power=0.68hp
* Thus with calculation suction line velocity is 10.15m/s
* The thermal properties of refrigerant R134a at 15 degrees according to Roberts (16)are specified as the thermal conductivity ,k=9.048x10 to the power of 3w/mk.
* Conversely its thermal properties at 38 degrees according to Roberts will be 0.0824w/mk
* The products that is assumed to occupy the room is meat,
* Also the length=4.6, width =3 and height =2.7, wall thickness will be 0.127m
* Area of insulation=2({3x4.6}+(3x2.7)+(4.6x2.7)}, insulated area will be 68.64sq.mtrs

Evaporator capacity:

This is the refrigerator system at which heat is removed from a refrigerated space, this is also the product of the mass flow rate (M) and the refrigerating effect Q41.

Hence: Ce= MQ41

Volume flow rate, V is the amount of saturated vapor produced when 1kg of refrigerant vaporizes, this depends on the refrigerant used in this case R134a.

When the vaporizing temperature of R134a is known, volume of vapor produced per unit mass is determined from the saturated tables

V=mv, where v=the specific volume of vapor.

With the above and in summary the evaporator capacity, will be =0.02x140x1000=2800w (j/s) or 2.8kw rated capacity.

Condenser capacity

In summary and from selection tables.

Condensing capacity cc=m(h2-h3)

0.02(256-93)x1000

0.02x93x1000

2.1535hp

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Component parts used and choice of refrigerant

i. Compressor: The compressor type selected is the hermetic reciprocating compressor of 4Hp capacity; operating between suction pressure of 343KPa and discharge pressure of 955KPa for the whole cold room system. With the control aid of a system of thermostat, the compressor is switched on or off automatically depending on the load requirement. The compressor was chosen considering the comparatively low specific volume of R134a, its large pressure differential and the ease of repair and servicing.

ii. Evaporator: The type of evaporator selected is a bare tube coil, forced connection, dry expansion; and made of aluminium material. It is forced connection because air is forced over the coil by a fan, to increase heat transfer rate as well as distributing the cooling effect evenly round the room. The bare tube is chosen because of its relatively low cost due to ease of construction.

iii. Condenser: The condenser selected is a base mounted, forced convection, air cooled condenser made of copper material. It lies on the same base with the compressor. With the aid of the thermostatic system, the air-blowing fan switches off when heat load is low and switches on when heat load is high. This helps the air in circulation cool the refrigerant efficiently.

iv. Choice of Refrigerant: The refrigerant, R134a was selected for the following reasons: It is an almost odourless liquid with a low boiling point of -260c at atmospheric pressure. It has low specific volume of vapour with a good volumetric efficiency. It is non-toxic, non-corrosive, non-irritating and non-flammable. Its ozone depletion potential is zero with a little global warming potential. More importantly, its cost is comparatively low, and it produces relatively good refrigerating effect at moderate and economical operating condition. Also, its leakage can be easily detected by soap solution.

## Conclusion

A cold storage room for meat storage has been designed. The cold room has an estimated total refrigeration capacity of 0.82TR (about 4Hp), and a maximum COP of 6.09. Its operating ambient temperature is 36oC with a rated evaporator capacity of 1.85Hp and a rated condenser capacity of 2.15Hp, respectively.

The cold room as designed compared favourably well within the limits of an already manufactured and traditionally erected commercial one of the same condensing capacity. This inevitably eliminated every doubt of its feasibility, commercialization and viability if erected. Hence, the objective of the design has been justified and achieved. It is thus, highly recommended for fabrication, construction and commercialization.

## Recommendation

Installation of any cold room entails proper assembling of all refrigeration component parts with regards to the design specifications. Hence, it is recommended that these design specifications should be inculcated and followed as failure to meet up the desired specifications during installation leads to poor performance of the system.

During installation, the cold room, and its component parts should be properly levelled and aligned on the container to avoid any imbalance that might cause unwanted sound and vibration. Also, a cold room should not be installed close to any power generators, boilers, radiators, or any other heat generating machinery.

The evaporator should be installed inside the room on the wall at the width end, directly opposite the door end, whereas the condensing unit is to be installed on the base at the outside end or the top, behind the evaporator wall. Moreover, vibration of the compressor should be avoided by mounting it on vibrating dampers.

As it relates to maintenance and operation, reliability and durability, adequate maintenance practice should be carried out on the cold room regularly to enhance its efficient performance. In this regard, preventive and predictive maintenance seem to be more adequate and suitable for the cold storage system.

Operators should be given proper training on the job so as to have knowledge of some repairs; and failure analysis chart of some critical equipment such as the compressor and the expansion valves should be provided on the equipment to assist the operators and the cold room personnel in case of any failure.