RIPENING CHAMBER:

1. Background Facts-

Background facts

Ripening is the process by which fruits attain their desirable flavour, quality, colour and other textural properties. On the basis of ripening behaviour, fruits are classified as:

(i) Climacteric: Fruits ripen normally when they are harvested at optimum maturity. Technically, in climacteric fruit, the ‘ripening’ is controlled by the production of ethylene and CO\(_2\). Many a time, the farmers harvest these fruits prior to maturity with a view to get premium price or to send long distances but such fruits do not ripe normally and need ripening aids. Climacteric fruits are mango, banana, papaya, guava, sapota, kiwi, persimmon, fig, apple, passion fruit, apricot, plum and pear.

(ii) Non-Climacteric: Fruit does not ripen after harvest. Non-climacteric fruits once harvested never ripen further. Non-climacteric fruits produce litter and no ethylene is produced and there is no large increase in CO\(_2\) production. Non-climacteric fruits are citrus, pineapple, grape, strawberry and cherry.
Technical Standards for Modern or Pressurised Ripening Chambers

1. **Background** - It is also noticed that ripening chambers which are being set up under various schemes of horticulture development, do not adhere to appropriate technical standards. Main shortcomings noticed are as follows-
   - Inadequate building design;
   - Use of inadequate / unreliable insulation material with insufficient K value
   - Use of obsolete and energy inefficient refrigeration units
   - Lack of uniform air flow circulation system
   - Lack of controlled conditions and technology for ethylene, temperature and relative humidity
   - Lack of proper ventilation systems and exhaust fans for Co₂ emission
   - Lack of monitoring and control system and display devices;
   - Use of unsafe electrical devices

It is therefore, necessary to prescribe appropriate technical standards in respect of modern, pressurised fruit ripening units which are given in following chapter.

2. **Technical Parameters for Pressurised Ripening Chamber**

   Storage capacity of ripening chamber may depend on fruits to be ripened and stacking and air-flow system. In this context, banana may be taken as reference crop for calculation of storage capacity for a given volume of storage space.

   Generally relevant 'IS specification' and 'Code of Practices' shall be used for all electrical, mechanical and civil works / installation, however, wherever IS code is not available, relevant standard codes of ASME / ASHRAE / IIAR or other International Codes are to be followed. Latest revisions will be followed in all cases. Even for Ripening of Fruits and Vegetables’ the process as recommended by IS Standards (e.g. IS 11977 of 1987 for ripening of green banana) or as per International Standards should be followed. For further guidance, following technical parameters may be followed:

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<th>S. No.</th>
<th>Items / Particular</th>
<th>Minimum Technical Specifications</th>
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<td>1</td>
<td>Civil Structure - building design</td>
<td><strong>Civil Structure</strong>&lt;br&gt;a. Structural Safety – Structural design as per BIS Code&lt;br&gt;b. Adherence to local Building Regulations&lt;br&gt;c. Concrete floor with sufficient load bearing capacity.&lt;br&gt;d. Chamber size is not smaller than 50 Cu M for preventing building up of high concentration of ethylene.</td>
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<td>2</td>
<td>Ripening Room Dimensions</td>
<td>a. Ripening Room dimensions will depend on number of tiers and number of pallets to be stored. On an average 9M³ per MT of banana fruits in CFB boxes and 10 M³/MT in plastic crates may be assumed for calculation of capacity in MT in pressurised chamber.&lt;br&gt;b. Number of chambers may vary from four to eight depending on ripening cycle in terms of number of days. Chambers will be generally identical in dimension.</td>
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Further Increase in number of chambers in multiple of ripening cycle may be undertaken but situation in which mechanised handling is possible it would be better if multi-tier ripening chamber is undertaken. The number of tiers may go up to three.

### 3 Ripening Room Construction

**Construction Features -**

a. Pressurised Ripening Room Chambers should be designed and constructed to hermetically seal with appropriate closures / doors. The key feature of pressurised ripening rooms is that conditioned air is forced through the product rather than the product just being stored in a temperature controlled room. The system passes air though each pallet or series of pallets before returning to the evaporator. Therefore, any “air-stacking” or “cross-stacking” of boxes is not necessary, and the result is less space requirement, lesser handling of the fruit and improved product quality. It is for this reason that they are recommended even for ripening of fruits in crates and are mandatory for fruits in CFB boxes and multi-tier stacking system.

b. For pressurized ripening, plenum chamber is recommended so as to equalise pressure through the product for uniform distribution/flow of air and ethylene through the product.

c. In any case, inner chamber surface should be of food grade cladding.

### 4 Ripening Room Doors

a. Pressurised Ripening Room Door is designed for minimal gas leakage. As manual handling is common in India (including manually operated forklifts), sliding doors with rubber seal are commonly used.

b. When stacking is multi-tier and handling of pallets is mechanised, wider openings of doors are required. In such cases, doors should be manufactured from heavy gauge recycled plastic. In such a situation, doors are rolling up type and therefore, following desirable safety features for doors should be ensured:
   i. Internal Door Release
   ii. Bottom Edge Pressure Operated Safety Stop
   iii. Cable Break Electrical Safety Stop
   iv. Spring Break Mechanical Safety Stop
   v. Vision Panel with emergency Knock out panel

c. Vertical “D” section flexible seal for effective sealing in condition of reverse airflow for uniform ripening. Seal should be strong enough to withstand impact from pallets during loading operations and flexible enough to create an adequate seal between air distribution system and product. Horizontal pallet seals should be supported continuously along the full length of room but should be easy to remove a seal for cleaning or replacement.

d. Door protection by Goal Post Protection which protect door perimeters or Single Fixed Bollards doors suitable for ripening chamber.
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<th>Insulation material</th>
<th>Some manufacturers recommend Rockwool or Poly-isocyanurate (PIR) core composite panels for fire proofing. However, Polyurethane (PUR) Foam / EPS / Extruded polystyrene may also be used. Minimum 60 mm thick up to 120mm thick (PUF) insulated sandwiched panel depending on the design requirements; or any other insulation material having minimum R value of 2.6 m2.K / W are recommended. Floor shall have PUF slab 60 mm or any other equivalent insulating material.</th>
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<td>6</td>
<td>Temperature &amp; Humidity levels</td>
<td>Ripening is preferred at a lower temperature but above level of chilling injury. Desirable ripening conditions for the designated fruit may be (Temp 10°C to 23°C) at RH &gt;90% up to 95%.</td>
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<td>7</td>
<td>Heat Load Calculation and Refrigerant</td>
<td>Cooling and heating system needs to be designed based on heat load calculation. Freon R407/410 is generally used as refrigerant for small installations and Ammonia for larger industrial applications. Any other eco-friendly refrigerant may be used.</td>
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| 8 | Cooling / heating coils and plenum chamber | a. Cooling coils are manufactured from marine grade NS4 aluminium casing with copper coils and aluminium fins / Copper or Stainless Steel Tubes and Aluminium Fins. The coils must provide exceptionally large surface area to ensure high natural humidity levels within ripening rooms. Each cooling coil must be fitted with a sloping drain tray which is manufactured using marine grade aluminium. The trays must be further protected by treating their interior section with powder coated paint finish.
b. In case of a plenum chamber; cooling coils and fans must be easily accessible via single access hatch located above or at end of the plenum chamber at roof level. Ceiling void should be fully illuminated to facilitate inspection of coils at regular intervals.
c. Electric heating elements should be used for heating ripening room during lower temperature season as per design requirement and be placed in easily accessible locations. Open flame type chamber heating should never be used due to explosive nature of ethylene. |
| 9 | Material to be used for ripening | Ethylene gas with suitable detection and dosing equipment to maintain ethylene concentration within required levels depending on product (Range 10 to 200 ppm). |
| 10 | Ethylene Generator and Dosing device | Ethylene may be introduced in ripening chambers in one of the three ways- by using Catalytic ethylene generator with regulator; ethylene cartridges and 5% ethylene + 95% nitrogen cylinder. Whichever method is used, the duty holder should ensure that there are adequate means of dispersing the ethylene gases throughout the ripening room on its release. Centralized Ethylene with Automation for multiple chambers for controlled and safe dosing of ethylene may be preferred. It may be borne in mind that ethylene in concentration above 27000 p.p.m. may explode. |
### Specification for Air circulation system

a. Minimum air flow should be 2000 M³ per hour, per MT of product ripened at 95%.

b. In pressurised ripening units speed of the fans is linked with cooling demand and number of pallets in the ripening chamber. In this case, large diameter axial fans are used for supply of air under pressure.

c. Air circulation is modified for uniform ripening by introduction of system of Ordinary Tarp, Tarp with Improved air circulation, Side Curtains with Reversible Air Flow, Lock Sock System, Air Bag for Vertical Air Circulation, Horizontal Air Flow, Pallet Isolation etc. These may suffice for fruits in plastic crates.

d. For pressurized ripening of product in palletised CFB boxes / plastic bags, air circulation fans should have adequate static pressure for uniform air/ethylene flow through the ventilation holes provided in the boxes. In such a case of pressurised ripening chambers for palletised CFB boxes, large diameter, reversible axial flow fans should be installed in the false ceiling accessible via a single access hatch for **air supply under pressure**. Each fan should preferably be equipped with venturi inlet to provide maximum efficiency throughout the ripening process. In such cases, pallet isolation must be provided for energy savings in part load conditions by providing a series of isolation dampers along the length of the ripening chamber. This function is operated by making proper selection for pallet isolation on Ripening Room Management System – “RMS”.

### Ventilation System

a. When bananas are ripening, they release carbon dioxide which will build up in a ripening room. The CO₂ production begins as the fruit ripens enters the “climacteric” phase, or the period when bananas release ethylene and have an elevated rate of respiration (along with a great deal of other physiological changes). Respiration involves the uptake of oxygen, the release of carbon dioxide, and the breakdown of starches. Carbon dioxide concentrations above 1% (10,000 ppm) will retard ripening, delay the effects of ethylene and cause quality problems.

b. In pressurised ripening rooms but without pallet isolation, automatic exhaust fans (either timed or sensor-based) or “flow-though” (constant) ventilation are provided at two locations (one near ceiling of chamber and another a little above floor level) in each chamber. This also evacuates the ethylene after the desired exposure period and helps to maintain CO₂ concentration low (below 4000 ppm) during the ripening cycle for proper ripening.

c. In case of pressurised ripening rooms with pallet isolation, ventilation is provided by a roof mounted fan which is identical in specification to the pressure fans. A dual inlet / discharge damper operates in parallel with the fan to allow fresh air from outside to replace the air within the room when vent is required.
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| 13   | Sensors and Control devices | a. Temperature & humidity loggers and Ripening Chamber Air Analysis Kit (for Ethylene and CO2 levels) may be used. Temperature and Ethylene gas sensors should be located inside chamber, within pallets and within boxes / plastic bags.  
   b. PLC device also known as Ripening Room Management System – “RMS” is must in pressurised ripening rooms. The controller provides total control of the ripening system allowing operators secure and password protected access to following functions:  
     c. Clear real time temperature display and control  
     d. Fan speed and energy usage  
     e. Ventilation intervals  
     f. Relative humidity indicator and control  
     g. Ethylene level monitoring and regulation  
     h. Door control  
     i. Lighting control  
     j. Pallet loading and isolation  
     k. Differential Pressure Display  
     l. Differential Pressure Display provides the ripener with an indication of air pressure drop across the fruit pallets. This information along with information from Temperature.  
   m. Ethylene gas sensors located inside chamber, within pallets and within boxes / plastic bags, is used to determine the setting of the inverter drive based on factors such as the type of product packaging and fruit, amount of pallets in the room and current stage of the ripening process.  
   n. The RMS for multi-chamber pressure ripening system should preferably be able to be configured to allow all rooms to be viewed and controlled locally and, or remotely. |
| 14   | Electrical plug point | Flame proof type as the room is filled with Ethylene gas. |
| 15   | Pallet Racking and Material Handling | a. Ripening unit with single tier racking should have at least a manually operated fork lift and pallet lifting device. Pallet racking system comprises of box section construction which should be designed as per BS 5950 or equivalent IS standards for strength and cleanliness providing easy access for pallet loading at high level should be used.  
   b. For multi-tier stacking motorised forklift should be provided. In such cases, in order to assist loading at upper levels, fork lift guides are to be installed to form a centre aisle which are strengthened by back filling with concrete. These guides are to be tapered at the front. To facilitate loading and centralising the fork lift truck in the drive in racking, the middle and upper tiers of racking are offset from the lower tier. An access ladder is also provided to the rear wall for access to an optional grated walkway at middle and upper pallet levels. high level |
| 16 | Some Useful Appliances and Instruments | Weighing Scales and Fruit Inspection Instruments such as follow-
|    |                                          | a. Weighing Scale  
b. Firmness Tester  
c. Refractometer  
d. Sizers and Callipers  
e. Produce Knife |
| 17 | Safety Certification                   | Certification for safe storage of ethylene and for system for prevention of ignition and explosion from competent authority, as per statutory requirement, if any, must be taken. Similarly, safety for workers against suffocation must be ensured. |
A Tentative layout for Banana Ripening Facility
Typical Air Flow Systems

Tarp

Tarp with improved air circulation
Air bags (vertical air circulation)

Lock Sock system

Lock Sock system
Horizontal air Circulation

Racks and Pallet Isolation
Banana Ripening
Suggested Guide For

NOTES: