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PROEXAG

NON-TRADITIONAL AGRICULTURAL EXPORT SUPPORT PROJECT

ASSESSMENT OF EL SALVADOR COOLING SYSTEMS  
FOR MELON, SQUASH AND CUCUMBER

Assignment Number: ST/89-13

Contract Number: 596-0108-C-00-6060-00

SUBMITTED TO:

Regional Office for Central America and Panama (ROCAP)  
U.S. Agency for International Development  
Guatemala City, Guatemala

SUBMITTED BY:

Lowell Flowers

through

Chemonics International Consulting Division  
2000 M Street, Northwest  
Suite 200  
Washington, D.C. 20036

May 1989

April 16, 1989

Guatemala

LaMeseta

LaMeseta had constructed a palletized hydrocooler along with 60 tons of mechanical refrigeration. The water temperature failed to achieve the design temperature of 34°F.. Due to the lack of a qualified refrigeration serviceman, the start up instructions were not followed to the letter. Upon removal of the temporary filters and some valve adjustments, the system is now cycling off at 33°F. water and cycling on at 34°F. water with a full load of celery in the cooler. Some electrical wiring connections supplying the unit with power were found to be loose and causing the unit to stop intermittently. This was corrected.

Some water raining down over the product was bypassing along the sides. Suggestions were made to correct this condition and improve the cooling of the product. The water pump is supplying ample water if it is properly directed.

## OVERVIEW OF EL SALVADOR TRIP

Dr. Emilio Suadi proved to be an excellent host and displays great zeal and a genuine concern for the promotion of Salvadorian agricultural products.

There appears to be a lot of progress in melon production and the facilities to handle same. The trend is centered primarily around forced air cooling and the construction of larger cold storage rooms. While this method is effective, it is also expensive and represents a fair sized long term debt. There is a definite lack of expertise in the cold storage and precooling design. No real major problems exist but it would be more economical to prevent the problems than to repair them after construction.

Various opinions are incorporated into the structures rather than sound and proven practices. An example is melo pac, where the pre-cooling room is designed and built very similar to a blast freezer. While the existing system will work, it could have been several times more efficient with a proper design for the same or less cost of construction.

Refrigeration technology is limited in El Salvador and equipment selection is basically left up to the discretion of the vendor. Sometimes this is o.k., sometimes it is not. It is recommended that specifications be developed and distributed to the various vendors for price quotations. Fusades requires three quotations for each project. With the present lack of specifications, there is no basis for comparison or assurance that the systems will properly perform.

There is a desire for some of the larger facilities to have a double duty function. Specifically to operate as a cooler during melon season and operate as a freezer during the off season. This has certain merits but can become quite costly. A cooler room is very forgiving with regard to construction techniques, a freezer design and construction. To ignore these rules is to guarantee failure.

One area of concern should be mentioned at this point. It involves the installation of ammonia refrigeration in the outlying areas of the country. This is not to categorically condemn ammonia.

It is an excellent refrigerant, but can be very dangerous unless operated and serviced by fully trained and qualified personnel. As mentioned before in this document, refrigeration technology is limited in El Salvador therefore; ammonia systems should be limited to plants only where trained personnel are available. Even in the United States, in the rural areas, freon systems are predominate for this reason.

Even though refrigeration systems should be installed by Salvadorian contractors, the successful bidder supplying the refrigeration equipment should be required to furnish installation instructions and wiring diagrams with the equipment.

The vendor should also be required to include a short trip to the job site by a qualified technician to correct any installation mistakes and to properly balance the system.

While forced air systems are the trend in El Salvador, hydrocoolers may very well be the better method of cooling melons for export. Hydrocooling is fast, dependable and usually represents a much less initial cost.

Hydrocooler sizes, styles and refrigeration capacity must be specified before quotations are accepted. A case in point is the proposed Magana purchase. Two quotations were received and the sizes and refrigeration capacities varied widely. Both quotations are incorrect for the production required. The refrigeration should be evaporative cooled due to the heavy duty construction and is not as subject to mechanical damage as are air cooled condensers.

Mobile or portable hydrocoolers are normally generator powered. For this reason, belt drive compressors are more desirable than "hermetics" due to voltage fluctuations from the generator and are less likely to incur electrical problems.

Clarksville Machine Works, Inc. has been contacted to quote Mr. Magana with the proper requirements. With this quote, a successful conclusion to Mr. Magana's needs can be met.

Tuesday April 18, 1989

El Salvador

### FRUVEX PLANT

This facility is under construction for melon cooling and to serve also as a freezer plant.

#### VAPOR BARRIER

It is unknown at the time of this writing whether or not the floor of the room contains a proper vapor barrier. The wall insulation is being glued in place with a vapor barrier mastic. It was suggested that a mortar mix be floated on the block wall to close up small holes to insure the integrity of the mastic. The ceiling of the room is composed of prefabricated insulated panels. With proper caulking of all joints the insulated panels provide a perfect vapor barrier as well as insulation.

#### INSULATION

Is assumed that the floor insulation is 4" of urethane. The walls are two layers of 2" thick urethane. While 5" or 6" is desirable for operational economy, the 4" thickness will suffice and is normal for this application.

#### DOOR(S)

This room contains only one door. While this is sufficient for the proposed freezer use, it is insufficient for any real future volume of fresh melons. 100% of the crop must pass through this door to be cooled and then out the door again to be loaded into trailers. To avoid congestion, it is strongly recommended to add another door to the room. Heaters must be added to the existing door for freezer operation.

#### FLOOR WARMING

Formed rigid conduit containing tape heaters should be installed in the slab at the doorway. Failure to heat this area will result in ice formation on the concrete in the doorway.

The 4" underslab vent pipes should be 4' or center in lieu of the present 8'. Due to the relatively narrow width of the room the present system may be adequate. Owner's discretion applies here.

#### REFRIGERATION

This plant is using ammonia and the capacity appears to be adequate for the proposed melon volume. Three cooler blower coils are ceiling suspended and are equipped with water defrost capability making them usable for freezer operation. There is one large freezer coil equipped with water defrost capability and larger horsepower fan motors. Unless a fan motor speed reduction device is used to control fan speed, normal condensation on the coil will be carried over into the airstream and wet the melon cartons. Without knowing the original intention of the use of this coil, the location of the coil is somewhat puzzling. It appears that the blower coil fans were to be to draw the air through the melon cartons, a variation of forced air cooling that is seldom successful. It is recommended that the blower coils be used to refrigerate only and a separate fan be used for the forced air movement.

### HUMIDIFICATION

It is recommended that 20 lbs. per hour be provided by power humidifiers in this room during operation above freezing temperatures. Varying conditions may affect the amount of water vapor required, more humidification can be added if needed.

### DEAD AIR SPACE

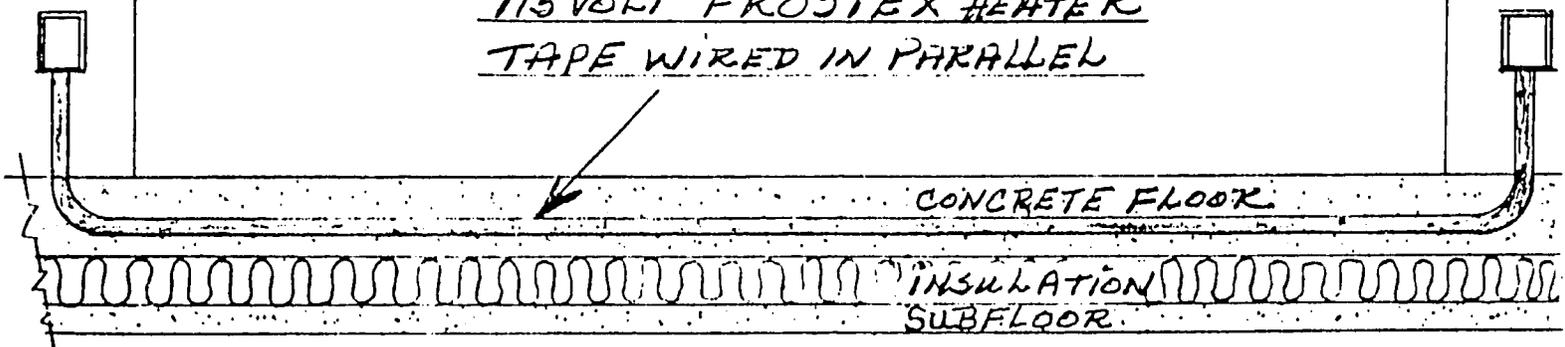
The area between the roof and the insulated ceiling must be power ventilated. Four to five air changes per hour is recommended. An electric powered fan in one end and a fixed vent in the opposite end is required to prevent condensation in this area.

### COMMENTS

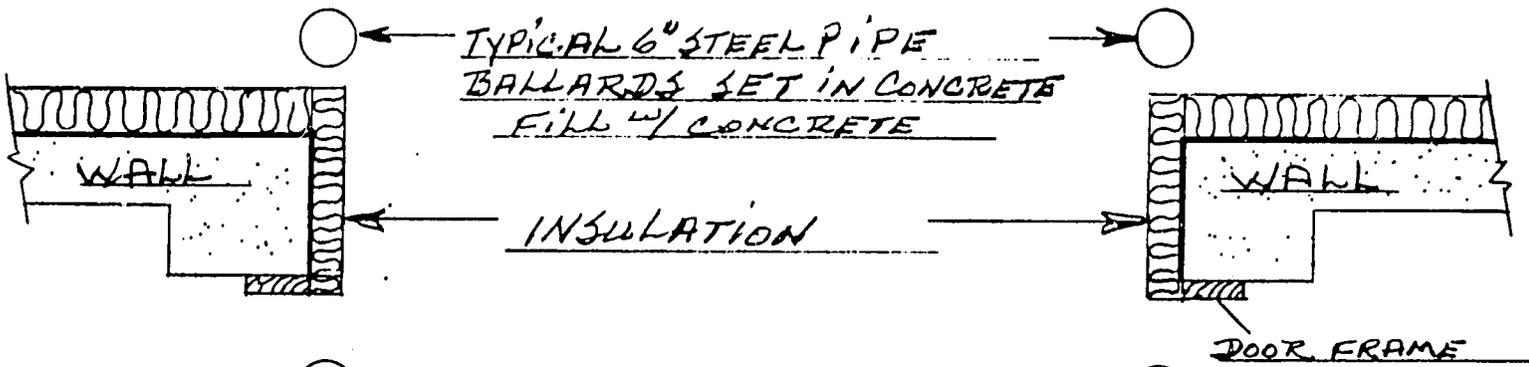
The building is well constructed and from all appearances, there is a conscientious effort to do a good job. It is hoped that these recommendations will be heeded to make it a better facility.

TYPICAL DOOR OPENING

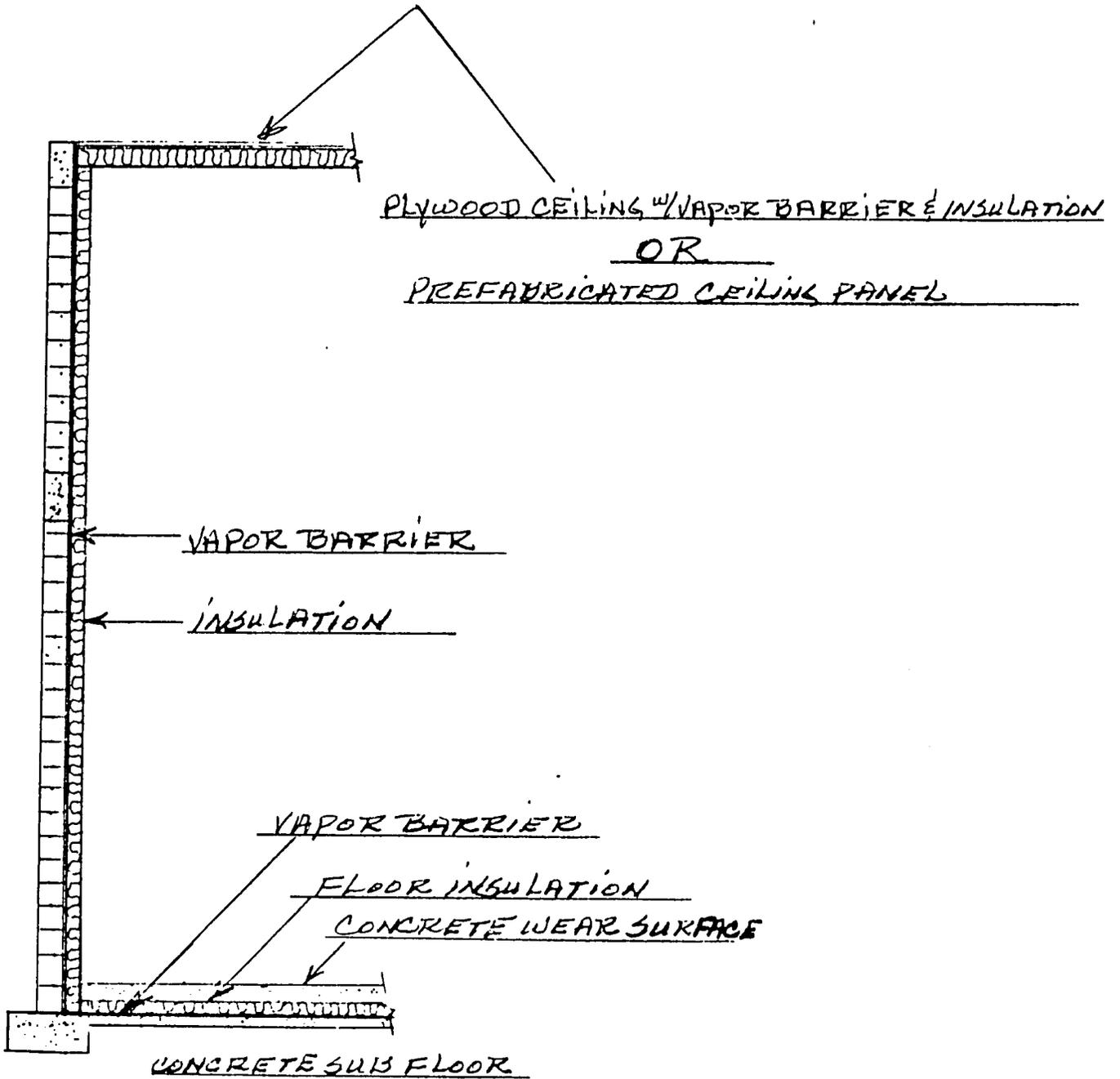
1" RIGID CONDUIT FORMED AS  
SHOWN W/ 4 LENGTHS OF  
115 VOLT FROSTEX HEATER  
TAPE WIRED IN PARALLEL



FLOOR WARMER AT FREEZER DOOR ENTRANCE



TOP VIEW DOOR ENTRANCE  $\frac{1}{2}'' = 1'-0''$



WALL SECTION SCALE  $\frac{1}{4}'' = 1'-0''$

Tuesday April 18, 1989

El Salvador

AGRIDSA - Cucumber facility

INSPECTED PLANT

Plant is very well designed, good traffic pattern. Coolers are constructed of prefabricated panels. Cooler doors adequately sized and well placed. Forced air systems well designed. Coolers are adequately powered. No reitique required.

From conversations it was indicated that the surrounding growing area has multiple disease problems and not suitable for cucumbers. Plant equipment could be moved to another location and reinstalled.

Tuesday April 18, 1989 .

El Salvador

CASVEL

NELSON CASTROL PLANT

COMPLAINT:

Hydrocooler system cooling melons achieving proper temperatures, but requiring longer to produce results than normal.

Checked refrigeration and found start up instructions had not been followed. Temporary filters in the system had not been removed per instructions. Changed drier cores but could not remove compressor filter due to lack of tools and gasket had been misplaced. Will send replacement gasket and tool to remove filter. Mr. Castro will have a refrigeration serviceman from San Salvador to accomplish the work. System is operating at approximately 90% efficiency and holding water at 34°F.

Monday April 17, 1989

El Salvador

### EXSALVA PROJECT

EXSALVA is in the process of constructing a new melon packing and cooling plant. Their present plans are to prepare the room for conversion to a freezer facility in the future for dual purpose.

#### 1. - FREEZER CONVERSION

Above 32°F. cooler construction is very forgiving, below 32°F. freezer capability is not forgiving. Certain areas such as underslab warming, vapor barriers and proper insulation must be considered at the time of initial construction. To defy physics is to guarantee failure.

- A. VAPOR BARRIER - Moisture penetration prevention of the insulation is mandatory. Sketches of proper construction techniques are provided with this report.
- B. INSULATION - Insulation is not as critical except from an operational economical standpoint. Inadequate insulation can cause extended compressor operation resulting in higher power consumption and possibly inadequate room temperature reduction. Recommended minimum insulation thicknesses are provided on the accompanying sketches. If funds are available, thicker insulation is advised. Heat that is kept out of the room does not have to be removed by the refrigeration system.

#### 2. - DOORS

One more door is needed at this facility between the main storage room and the largest precooler room. Exsalva has been provided with cooler doors. In order for these doors to operate as freezer doors, door heaters must be added. Failure to accomplish this will result in the doors freezing in the closed position. In future facilities, provided funds are available, electric door operators are recommended for facility operational economy.

#### 3. - FLOOR WARMING -

The recommended size and spacing of PVC pipes to prevent substraat freezing is: 4" diameter @ 4' on centers. At Exsalva the 4" diameter pipes @ 8' on center. This may not cause a problem due to the relatively narrow width of the rooms. If funds are available, it is recommended that additional pipes be installed. Formed rigid conduit with tape heaters are recommended to be installed in the doorway slabs where they are subjected to ambient temperatures. Failure to do this will result in ice formation on top of the slab in the doorway.

#### 4. - ROOM CEILINGS

It is undecided at this time if the ceiling is to consist of conventional insulation or prefabricated insulated panels. In either case, a suspended flat ceiling is recommended. To follow the roof slope with insulation will make it very difficult to properly provide ventilation between the roof and the insulation.

#### 5. - DEAD AIR SPACE

It is imperative that the dead air space between the building roof and the insulated ceiling of a cooler or a freezer be ventilated to prevent condensation in this area. Four to five air changes per hour

are recommended. A power fan on one end and a fixed VENT on the other end of the "ATTIC" space are required in this facility.

#### 6. - REFRIGERATION EQUIPMENT

Ammonia is the refrigerant used at this plant. Single stage compressors were selected and to this, a booster compressor must be added to provide the desired freezing capability. Some of the blower coils are specifically designed for freezer duty. The balance of the coils are designed for cooler duty only. It was suggested that a water spray might be added to make these coils freezer compatible. This may work but it is not an ideal application. In a meeting with refrigeration and one of the owners, it was expressed that a lack of funds was a limiting factor on equipment selection. The supplied freezer coils on the job have a higher face velocity than is used in rooms operating above 32°F.. The high face velocity will cause the normal condensation on the coils to be carried over into the airstream and will wet the cartons in the room. This can be rectified by using a solid state device that varies the cycles of the electric power supply to the fan motors. The fans can be slowed to the proper face velocity. The coil manufacturer should be consulted prior to installing these devices lest the warranties be voided. Two speed fan motors would have possibly prevented this problem.

#### 7. - RELATIVE HUMIDITY

Power humidifiers should be installed in each room for above freezing temperatures only. A relative humidity of 92% to 94% is recommended at 38°F. room temperature. Due to many variables, cooler humidification is not an exact science. This author recommends 20 lbs. per hour in the storage room, 20 lbs. per hour in the larger precooler room, and 10 lbs. per hour in the smaller precooler room. More can be added if necessary.

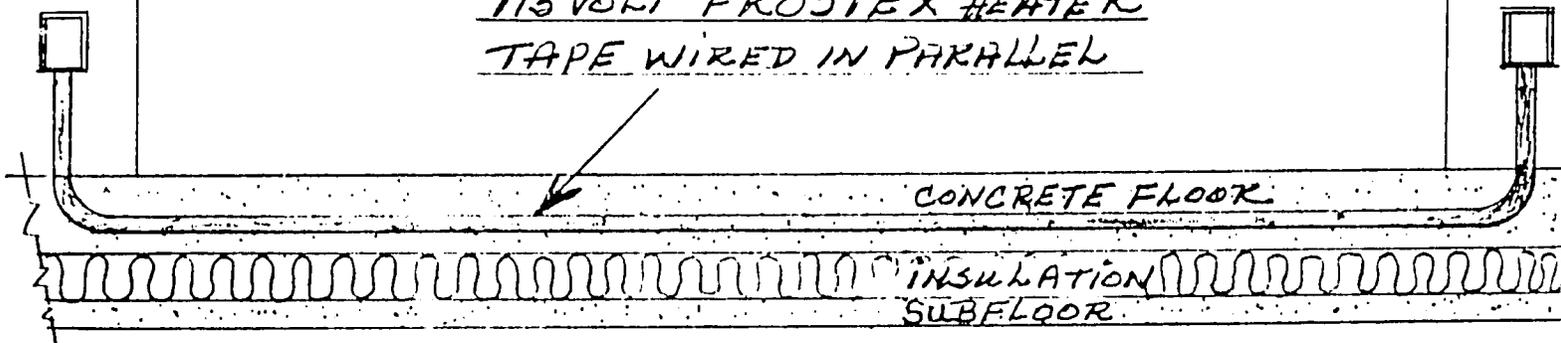
#### COMMENTS

A project of this size should have consise prior planning and properly engineered drawings available before construction is begun. A meet point at this time is , had this plant been rotated 180 degrees, the natural topography of the land could have been utilized. The truck well would have been on the lower part of the hill involving less excavation and drainage provisions. Also, the packing area would have been on the "shady" side in the afternoon when ambient temperatures are the highest.

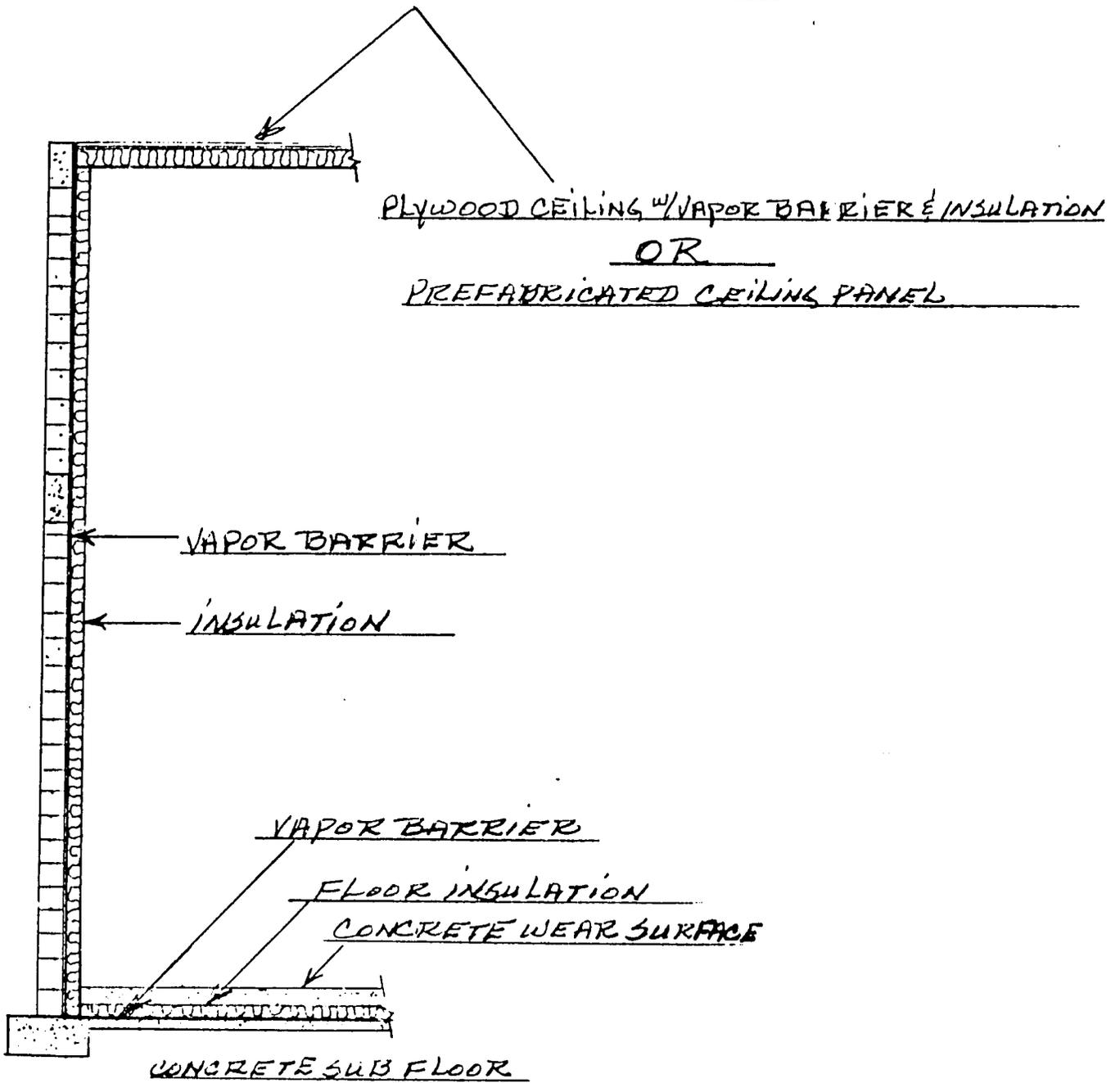
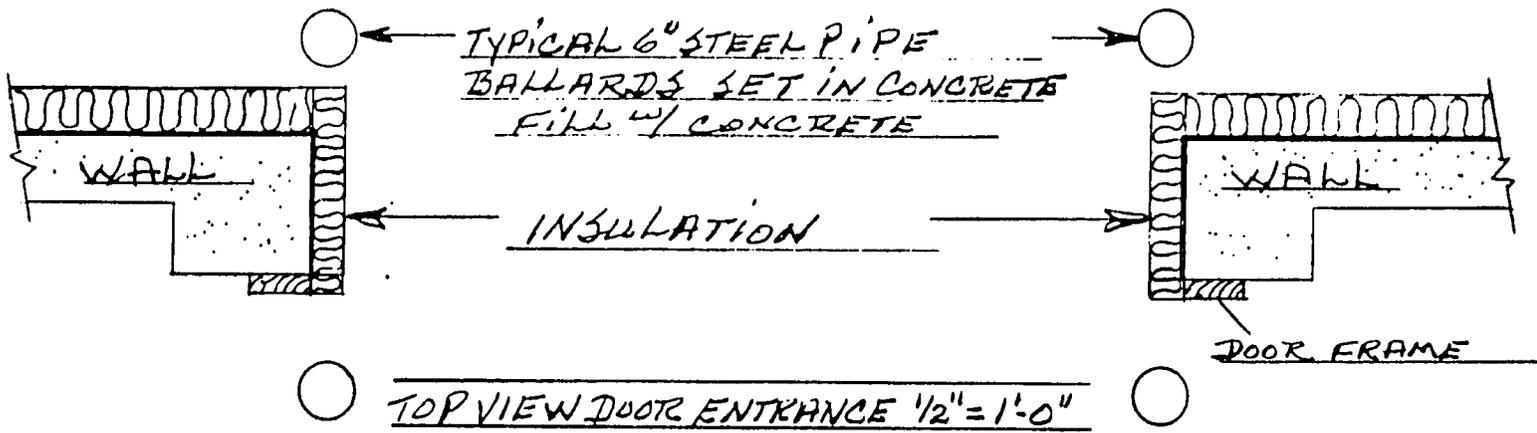
While it is idealistic to build a dual purpose facility, realism normally dictates that a cooler or a freezer, one or the other, be built, but not to be double duty.

TYPICAL DOOR OPENING

1" RIGID CONDUIT FORMED AS  
SHOWN W/ 4 LENGTHS OF  
115 VOLT FROSTEX HEATER  
TAPE WIRED IN PARALLEL



FLOOR WARMER AT FREEZER DOOR ENTRANCE



WALL SECTION SCALE 1/4" = 1'-0"

MAGANĀ JOB

ITEM	CLARKSVILLE MACHINE	AMERICAN CONVEYOR
overall hydrocooler length	32' long	23' long
actual cooling length	30' long	20' long
pump horse power	(2) @ 10 h.p. each	(1) @ 15 h.p.
pump size	(2) 10"	(1) 10"
retention time	45 minutes underwater	15 minutes underwater
tons of refrigeration	35 tons	20 tons
40 lb. crates per hour	250 packages	250 packages
temperature reduction (F.)	36° (95°-36°=59°)	20° (95°-20°=75°)
final fruit temperature °F.	59°	75°
ACTUAL TONS NEEDED IS:	(43 tons)	(43 tons)
variable speed	yes	yes
isolation built in	3/4" marine plywood	none
water sump warranty	10 years	1 year
coil tank warranty	10 years	1 year
base unit warranty	1 year	1 year
electrolytic action (coils to tank)	no	yes
generator size	100 k.w.	35 k.w.

This comparison indicates that the superior system is quoted by Clarksville Machine Works.

- (A). C.M.W. unit has 50% longer area under water.
- (B). C.M.W. has 70% more refrigeration capacity.
- (C). C.M.W. has 34% more pump capacity.
- (D). C.M.W. has 300% more retention time.
- (E). C.M.W. has 80% more temperature reduction.
- (F). C.M.W. has better insulation quality.
- (G). C.M.W. has better warranty.
- (H). C.M.W. has better corrosion resistance.
- (I). C.M.W. has 236% more generator capacity.
- (J). C.M.W.'s price is only 25% more than A.C.C.

In my opinion the refrigeration capacity should be increased to 43 tons.

American Conveyors Jan. 30 quote is:

24' long cooler with 30tons of cooling for 190 crates per hour at 30 minutes cooling time.

Their Feb 9th quote is:

23' long cooler with 20 tons of cooling for 250 crates per hour at 15 minutes cooling time. (This is not consistent).

This job actually required a 32' cooler with 43 tons of cooling at 45 minutes cooling time.

250 crates per hour x 40 lbs. per crate x 45° temperature reduction (95° to 50°)  
x 1.15 (15% heat gain) - 12,000 BTUH = 43-1/8 TONS OF REFRIGERATION PER HOUR  
REQUIRED.

COMMENTS:

It appears that American Conveyor is only interested in making a sale whether it works or not.

Clarksville Machine Works is interested in the proper requirements, but are not familiar with the high heat content of the melons. More refrigeration should be included in their quotation.

April 19, 1989

El Salvador

MELO PAC

This facility showed good expertise in layout except for the pre-cooling room. The pre-cooler room as implemented will cool melons faster than normal room cooling, but not nearly as fast as a properly constructed forced air system. A sketch is provided on the pre-cooling room as it exists and as it should be.

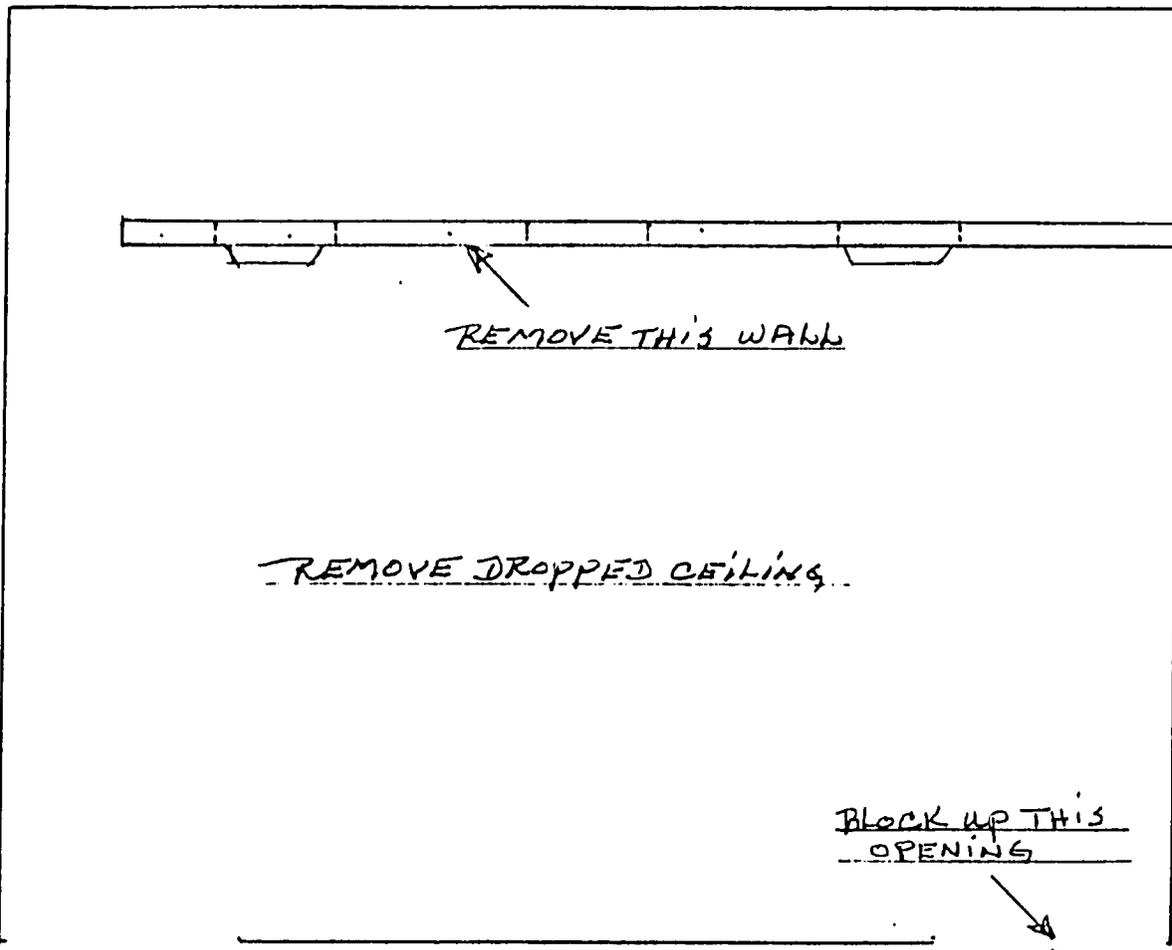
The refrigeration system is causing some problems due to an imbalance between the capacity of the condensing units and the blower coils. Unfortunately, refrigeration manufacturers do not always post the true ratings for their equipment. This is called "commercialization" by their sales departments. This job was "commercialized" to the point that it is causing problems. This problem can be corrected by adding one additional blower coil to each of the three systems.

At a meeting with Requipsa, a Salvadorian air conditioning and refrigeration company, recommendations were made to correct the imbalance of equipment. Mr. Lopez is to approach the owners of Melopac with pricing.

Eventually an additional 12 tons of refrigeration capacity will have to be installed in the pre-cooler room to bring it up to full capacity.

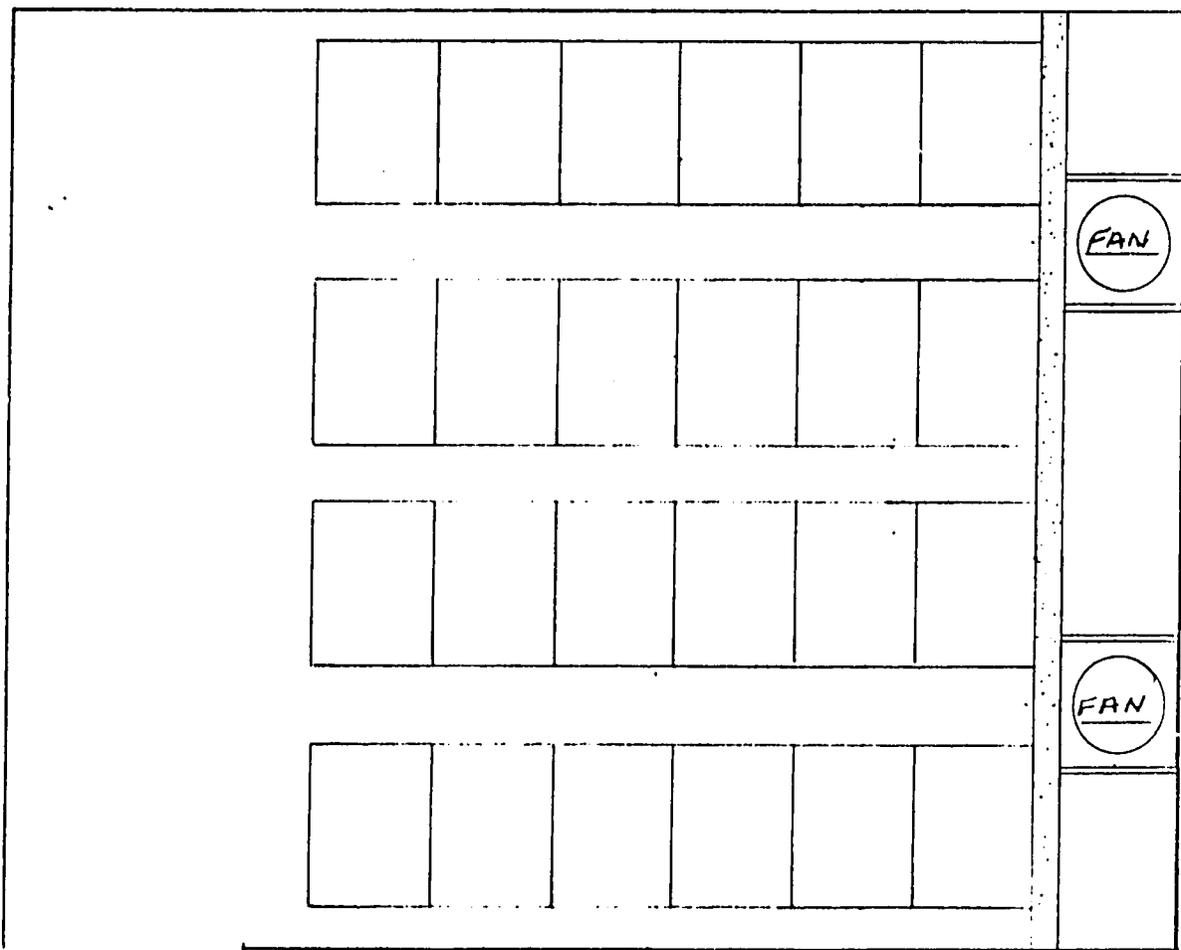
According to how the storage room is used, may dictate that more refrigeration be added.

Approximately 10 lbs. per hour power humidification is needed in each of the two rooms. More can be added if needed.



EXISTING FLOOR PLAN SCALE 3/16" = 1'-0"

MELOPAC



NEW FLOOR PLAN SCALE 3/16" = 1'-0"