First Place 2008 ASHRAE Technology Award – Industrial Facilities or Processes

I would like to thank you all of ITC staffs, Chair Prof.Tawee Vechaphutti and Mr.Sittidej Buddharee President ASHRAE Thailand Chapter who always assist and support me until I have succeeded on 2008 ASHRAE Technology Award. I hope this award will be useful for Thai engineers to promote and encourage their image to other countries around the world.

Factory Information

CPF Korat Project is an integrated poultry processing plant complex, integrating slaughter plant and further processing plant in one single building. This project is huge so that special design concepts were created in order to get the sustainable and energy saving operation.

Regarding to the refrigeration of this project, they had been divided into the building as follows :

1) Domestic processing plant
2) Primary (slaughter) and further processing complex
3) Refrigeration machine room

Due to it is a very large complex consisting of 46 screw compressors, 18,000 horse power and having all kind of facility such as offices, retail, food services, laboratories, guest / patient rooms, laundry and etc.

We focused only on the major facility (primary and further processing complex) and **on** the low temperature air conditioning processing room and spiral freezer that have the most significant innovation, energy and saving cost area.

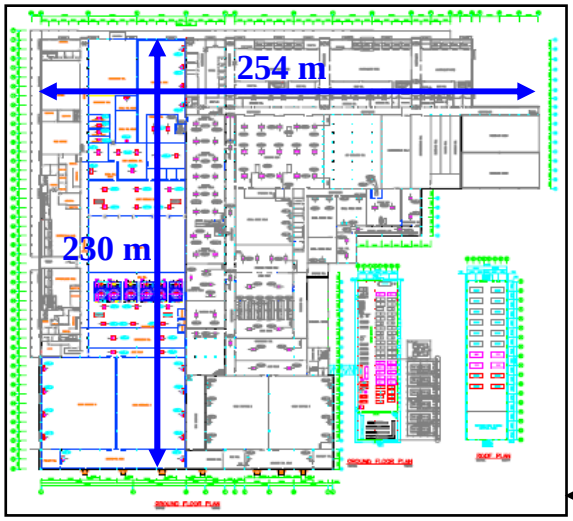
Outdoor Design Condition

Apart from the outdoor design condition from ASHRAE fundamental Handbook of the plant's location at Korat / Nakhon Ratchasima, Thailand, we based our design on the Tender of Requirement (TOR) of the end user specify outdoor dry-bulb 37Deg.C 60% RH and the evaporative condenser had specified to base on 28.3 Deg.C WB

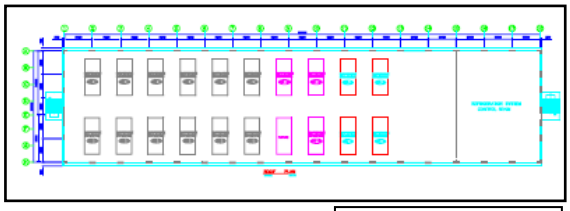
Project Description

1. **Type of building or process:** Refrigeration system and low temperature air conditioning for poultry slaughter and further processing plant.

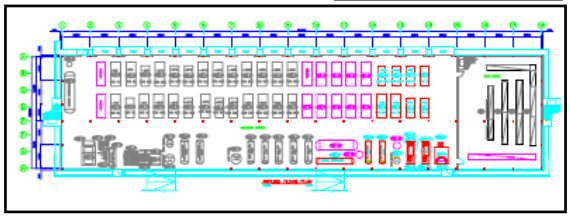
2. **Size gross floor area of building :** In the building area of 50,000 m^2.



PLANT LAYOUT



CONDENSER



COMPRESSOR

3. **Function of major areas** (such as offices, retail, food services, laboratories, guest/patient rooms, laundry, operating rooms, ware house/storage, computer rooms, parking, manufacturing, process, etc., or industrial process description):

The refrigeration facility consists of the following important capacity;

- 46 sets of Ammonia Screw Compressors with total power are 18,000 hp,
- 21 sets of Evaporative Condensers with 200 kilometers of Evaporative Condensers stainless steel.
- 2 Lines of Air Chilling Tunnel with total chilling capacity of 21,000 bird/hr,
- 6 sets of IQF Spiral Freezers with total freezing capacity is 12 ton/hr,
- 6 rooms of Air Blast Freezer with total freezing capacity were 15 Mton/hr,
- 6,000 m2 Processing Area controlled room temperature at +8^{O}C,
- 49,000 m3 Cold Storage at -20^{O}C,
- 50 Mton of Ammonia charge into the system,
- 360,000 birds/day Slaughter Capacity.

4. **Project study period:**

- Design January – April 2004
- Installation April – October 2005
- Start-up November 2005 – February 2006.

System Design Goal

1. The refrigeration system should be safe for workers and improve the quality of life**.**
2. The refrigeration system should be less environmental impact and sustainable design.
3. The refrigeration system should be save the investment cost**.**
4. The refrigeration system should have a stable and minimum of down time operation.
5. The refrigeration system should be the energy efficient system.

Design Consideration

To design the refrigeration system for this plant, some areas were emphasized and concerned to meet the purpose of the project.

1. **Suction pressure drop :**

Distance between Spiral Freezer and machine room is very far away, approximately 230 meter (755 feet) long. How to reduce pressure loss in the wet return line of the recirculation system? How to reduce the risk of liquid hammer within the two phase flow wet return line and vapor propel of hot gas defrost line?

2. **Corrosion from ambient air :**

Boiler room and refrigeration machine room cannot separate far enough, so the exhaust gas from boiler will contaminate air intake of evaporative condenser, then cooling water in the evaporative condenser become acid and high corrosion will occur.

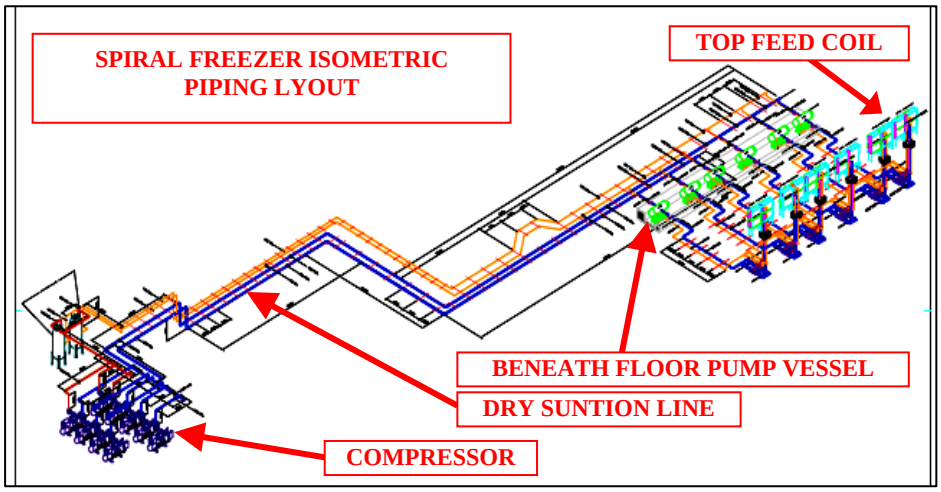
3. **Special production demand :**

Continuous Freezing for 6 days x 24 hours is demanded from the customer.

4. Climate and raw water supply

The location of this plant has hot and humid climate. High $CaCO_3$ content in raw water supply and the limitation of water supply cause the soft water supply quality is hardly to control. This will cause difficulty in reject heat through condenser which will impact on the stability of screw compressor oil temperature

Unique Design Technique



1. Eliminate long wet return line by installing the pump package just next to and underneath the Spiral Freezer. Only the long dry suction vapor come instead connecting pump package with the compressors. This will give the following benefit :

- Equipment cost saving
- Installation and Material cost saving
- Energy saving,
- Safe operation.

2. Stainless Steel Evaporative Condensers were used to withstand the tough ambient air and very high Hardness Water quality. However, water treatment and bleed off control are still essential to maintain the cooling water in good condition as much as possible.

3. The special Spiral Freezers were designed to fulfill the 6-day continuous-freezing demand.

4. The highly reliable “SOC” (Special Liquid Injected Oil Cooling System) Design is the best solution to overcome this hot and humid climate and raw water supply issue.

5. Apply the long distant wireless Supervisor Control Analysis Data Acquisition (SCADA) software to control and monitor the whole refrigeration system with Mimic Diagram together with pop up warning light at the computer monitor screen for maintenance schedule when reach the service and maintenance period of each individual rotary equipment and able the head quarter control engineering able to supervise the whole system.

Energy Efficiency

The ASHRAE and LEED standard were used as guidance due to the standard does not have a category that meet this application. Because of this facility comprises of Low Temperature Air Conditioning, Chill Room, Frozen Storage and Blast Freezing Room, R-Value for both polystyrene for the major endorse prefabricated insulation panel cover around the building and high R-Value for the polyurethane for the Spiral Freezer were used for the building envelope to minimize the refrigeration heat load.

In addition from our Unique Design Technique, we are able to gain the following significant energy efficiency from the Refrigeration System and Equipment;

1. Low pressure drop induces draft Evaporative Condenser of our own designed consume installed motor only 418 kW for total 19 units, which will save 1,333,800 kW-hr/year when compare with T.O.R. specified brand model-CXV (installed motor 703 kW)

2. Low internal static air pressure design Spiral Freezer (installed motor 360 kW) let us save 413,100 kW-hr/year from the conventional spiral freezer (installed motor 444 kW).

3. We can also save another 1,280,335 kW-hr/year from this plant by applied the Top Feed Evaporator instead of the traditional Bottom Feed Evaporator Design (typical design in Thailand, 99% of installation) so we are able to eliminate the long wet return line.

This design stage saving compare to the total yearly expect for this group of Spiral Freezer is 19,850,688 or equal $\frac{3,027,235}{19,850,688} \times 100 = 15.25\%$ that fall in the LEED standard.

Indoor Air Quality (IAQ)

ASHRAE Standard was used as guidance in the design of IAQ in this facility. This ASHRAE standard does not have a processing plant category to follow. We have estimated the nearest figure of 15 cfm/person, this seem to be very high when compare to the latest version of ASHRAE standard 2004 and 2007.

However, the ventilation of this plant is even far better than IAQ requirement. The further processing plant is zoning to meet HACCP and GMP purpose. There are High Risk Zone, Medium Risk Zone and Low Risk Zone. The High Risk Zone has the highest internal positive pressure +++, the other zone has ++ and + internal pressure respectively.

To create the internal pressure, we introduce plenty of out door air (OA), which filtering by pre, medium and finally by HEPA filter and pre-conditioning to the room temperature, dumping into the room. Then the exhaust fans were placed at the low risk zone and discharge to the roof. Beside the cleanliness of the indoor air for foods processing, the indoor air also highly good quality for occupancy.

The pre / medium filter was selected at 25-30% of dust spot efficiency as per ASHRAE standard but the HEPA filter was selected at 99.99%.

This pre-conditioning outdoor air (OA) Air-Handling Units were designed with the "GEP" (Good Engineering Practice) type either walk-in or reach-in to access for cleaning.

This AHU was double skin insulated enclosure and special design with round corner, Frame work are prevented the cold bridging to reduce risk of condensation, mold and fungus that many built up in the later state.

The internal load is taken care by the Low Velocity Draught Free air dual discharge air cooler for human comfort, the air velocity at occupy zone about 1.60 meter above floor level is approximately 0 to 0.4 m/s.

The other areas we introduce 15 cfm of out door air (OA) per working person.

Innovation

1. By taking the advantage of installing the Pump Package below the machine room level, we can supply liquid make up to the Pump Package from the Open Flash Inter Cooler in the machine room, eliminate the temperature different from the Coil Type Inter Cooler. The saturated liquid from Inter Cooler can flow from machine room to Pump Package 230 meters (755 feet) far away without any vapor lock problem. This simply installation because of the Liquid Head Gain gives us the highest sub-cooling liquid supply to the Pump Package.

However, to have some degree of safety in the system, we install a small Tube in Tube heat exchanger to have an extra small amount of liquid sub-cooling.

2. The special defrost designed of these Spiral Freezers consisting of four evaporators were used in each Freezer without pausing belt running. The evaporators also use special very wide plus variable fin spacing with special heavy duty thick fin to avoid air blockage and withstand pressure cleaning during operation.

The gravity flow of Pump Package is also very helpful to get rapid defrosting. The liquid inside the evaporator will drain freely into the Pump Package suddenly when stop cooling.

3. The Spiral Freezers are also designed to have a very high sanitary level for HACCP and GMP requirement. The major points are following;

- Total fully welded both interior and Exterior Insulation enclosure.
- More than 50% Perimeter area were reduce compare to the old conventional style due to less Structure Column, reduce Bolt and Nut with washer. No Chain and sprocket drive by using outside direct top drive system.

- Use the Re-Circulation Hot water CIP system, whole spiral freezer run as the House Washing Machine hence easy to clean, saving chemical, water, energy and preserve our planet to be more sustainable. Water consumption is only 936,000 gal/year. (the conventional CIP and bottom feed system consume water 10,800,000 gal/year)

4. Air Chilled Tunnel is used to instantly chill poultry instead of the conventional Ice Water Spin Chiller to reduce the Cross Contamination. The Air Chilling process is also eliminating the unfair to the consumer by adding water weight back into poultry meat.

5. All Glycol Unit Coolers for processing area are designed to the Drop Down hanging from the ceiling and Hinge Type drain pan in order to able to thoroughly clean the whole unit to reduce to risk of bacteria growth and accumulation.

Operation & Maintenance

1. We changed freezer wet return to pure vapor line and use Glycol as the Secondary Refrigerant for Low temperature Air Condition so we can reduce ammonia charge of 23,000 kg (50,700 lbs) from the system we designed.

2. The eliminating of freezer wet return, it is also reduce risk from liquid propel in the long wet return line thus this system will not have liquid hammer occur.

3. Our over 20 years' record in the Thailand industrial refrigeration, in this hot and humid climate we found that the Special Liquid Inject Oil Cooling System (SOC) is the best. Nevertheless how high of the condensing pressure, the oil temperature is still stay within the controlled range, so reduce the operation down time and give high reliability. We also found that the compressor's main bearing can last as long as 7-10 years live span, compare to the other oil cooling system that main bearing live can last long only in between 3-5 years.

4. Easy to maintenance, also reduce number of service mechanic to record the data by applying the SCADA system and able to service / maintain the equipment on schedule, end user is easy to out sourcing the consultant to monitoring, supervise and control the refrigeration system from the remote long distance office.

5. Easy to maintain and saving from reducing number of worker to clean the spiral freezer with these sequential defrost, re-circulation type CIP, totally welded enclosure and top drive system.

Cost Effectiveness

1. We can save approximately 200,000 US$ of the first cost of the equipment and material cost by installing smaller compressors, smaller suction pipe size and insulation material cost due to substitute the two-phase flow return line to the dry vapor suction line.

2. We can save the energy consumption per year approximate (1,333,800+413,100+1,280,335) x 0.085 US$ / KWh = 257,315 US$ per year. The 0.085 US$ /KWh was the past 19 months actual record of Electrical Consumption and can be submitted as per requested.

3. By Recirculation CIP and Top Feed System, we can save the fresh water consumption = 115,255.8 US$ per year.

4. The long term man power expense is another essential saving of this plant.

Environment Impact

1. From the total energy saving of appx 3,000 MW-hr per year of this plant, and from Thailand's Electricity CO_2 Emission Factor of 0.624 $kgCO_2/kWh$ (www.dede.go.th), we achieve the total Reduction of CO_2 Emission equal to 1,900 Metric Ton of CO_2 per year to save our planet.

2. Also Ammonia Refrigerant charge can be lower to 23,000 kg (50,700 lbs.). It is toxicity refrigerant, the less Environment Impact and sustainable designed we can achieved.

3. To reduce the water usage by 91.3% (from 10,800,000 gal/year reduce to only 936,000 gal/year) also reduce a lot of impact to the Dissolved Oxygen (DO) figure of the waste water treatment plant.

Article in ASHRAE Journal from ASHRAE Society Website

Apichit Lumlertpongpana, managing director, and Wichai Rungruangprug, engineering manager, I.T.C., Bangkok, receive first place in the new industrial facilities or processes category for his design of Charoen Pokphan Foods Public Co., Chokchai, Thailand.

The design focused on a refrigeration system and low-temperature air conditioning for a poultry slaughter and processing plant, with a slaughter capacity of 360,000 birds per day.

By installing smaller compressors, smaller suction pipes and insulation material, the system saves some $200,000 of the first cost of equipment and material. The estimated annual energy savings is nearly $300,000 a year, with an estimated total reduction of carbon dioxide emissions equal to 1,900 metric tons per year. Water usage was reduced by 91.3 percent.

ASHRAE, founded in 1894, is an international organization of 50,000 persons. ASHRAE fulfills its mission of advancing heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing and continuing education.