Fort Frances Memorial Sports Complex Ice Plant Study

Comparison of the Options for the Replacement of the Ice Plants

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Prepared for:

Town of Fort Frances

Prepared by:

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1.0 INTRODUCTION

The Memorial Sports Complex in the Town Fort Frances consists of an Aquatic Centre, dry land sport facilities, conference room, auditorium and two ice surfaces, which are the focus of this project. The two ice surfaces are the 52 Canadians (52C) which was constructed in 1952 and the Ice for Kids (IFK) which was constructed in 2000. The 52C has had several upgrades since it was put into service, the IFK ice plant has had regular required maintenance and end of life replacements but no major upgrades. The 52C and IFK ice surfaces are 58mx24m (190'x80') and 61mx26m (200'x85') respectively.

The objectives of this study are as follows:

- Consolidate the two ice plants into a single ice plant or reduce the plants' over all power rating.
- Eliminate the need for a full-time refrigerant license holder as required by the Provence of Ontario Technical Standards and Safety Act, 2000 O. Reg. 219/01.
- Review and comment on the feasibility of waste heat capture from the new configuration.

1.1 EXISTING EQUIPMENT

The major pieces of equipment in the ice plants for 52C and IFK were installed as follows:

- 2000 – IFK Condenser, Cimco ATC-180, age 21 years
- 2008 – 52C Chiller Cimco 8009992A/8009992B, age 13 year
- 2010 – IFK Cooling Tower, BAC VF1-049-42M, age 11 years
- 2012 – IFK Chiller, Cimco 8017566A/8017566B, age 9 years
- 2013 – 52C Condenser, Evapco ATC-150E-1G, age 8 year

Based on the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) published data each of the pieces of equipment has a life expectancy. For the Chillers, Condensers and Cooling Towers the published mean life expectancy is 20 years. The longevity of equipment can be shortened or extended by factors such as, number or cycles, operating season, local environmental conditions, and maintenance.

Most of the existing equipment serving the 52C and IFK arenas are well into their expected life span, and the condenser serving IFK arena has exceeded its expected life span. Also, the need to reduce the operator requirements for the 52C and IFK arena necessitates the use of packaged ice plant systems to meet the requirements of Provence of Ontario Technical Standards and Safety Ace, 2000 O.Reg. 219/01, as discussed and outlined in the report below. The existing chillers serving 52C and IFK would not be able to be incorporated into a new packaged ice plant. The existing condensers and cooling towers could be modified to serve the new ice plants, but as nearly half of their expected lifespan has been expended and newer technology is more efficient and has a longer life span, replacing the equipment would be recommended.

2.0 ICE PLANT SYSTEMS

The systems used to make mechanically cooled ice surfaces are typically defined by their refrigerant type and in some cases broken down into sub-classifications as follows:

- Ammonia
  - Flooded System (Shell & Tube)
  - Direct Expansion System (Plate & Frame)
- Freon
- CO_2
  - Direct Cooled
  - Indirect Cooled

Ammonia systems use ammonia refrigerant (NH_3) to provide cooling to a brine solution which is then circulated through the floors of the refrigeration plant to produce the arena ice. The flooded system uses a shell and tube type chiller, which is a traditional method of providing the cooling to the brine and is the method that the existing ice plants at 52C and IFK use. This sort of chiller is effective, but they have a large refrigerant charge, typically between 3.6kg (8lbs) and 4.5kg(10lbs) per ton and are typically lower efficiency than a Direct Expansion System. A direct expansion system uses a plate and frame chiller and a much smaller refrigerant charge to cool the brine that serves the refrigerated slab. The typical refrigerant charge in a direct expansion system will be between 0.23kg(0.5lbs) and 0.45(1lbs) per ton. A comparison of the refrigeration plant types is available in Appendix A.

The Freon system uses a manmade refrigerant to provide cooling to a brine solution which is then circulated through the floors of the refrigeration plant to produce the arena ice. As the Freon system uses a manmade refrigerant there is the risk that the refrigerant may become end dated, meaning that it will no longer be produced. If the refrigerant is end dated the refrigerant would need to be replaced which may need costly upgrades to the plant. A comparison of the refrigeration plant types is available in Appendix A.

Carbon Dioxide (CO2) is a refrigerant that naturally occurs in the environment and as such cannot be end dated. A CO2 system uses two different methods of cooling the arena slab to make the artificial ice. The first method is a CO2 Direct method which pumps the cooled CO2 refrigerant directly into the arena slab and makes the ice through that method. To be able to pump the CO2 directly into the slab a special network of metal pipes needs to be installed in the arena slab and since the CO2 refrigerant is outside of the ice plant room additional ventilation needs to be provided for the arena and all the areas that directly interface with the arena. The second method is a CO2 indirect method which is like an ammonia or freon plant which provides cooling to a brine solution which is then circulated to the arena slab for production of the artificially cooled ice. A comparison of the refrigerant plant types can be found in Appendix A

2.1 REFRIGERATION COMPARISON MATRIX

The refrigeration comparison matrix compares eight options for replacement of the existing refrigeration plants. This includes ammonia shell and tube, ammonia direct expansion, freon, CO2 direct and CO2 indirect. The matrix also compares a site-built verses skid mounted ice plant with a separate building. Refer to Appendix A for the comparison matrix and Appendix B for the O.Reg 219/01 Table 6. The recommendation for the system can be found in section 6.0 Recommendations below.

2.2 CONSOLIDATED PLANT VS SEPARATE PLANTS

The 52C and IFK arenas can be served by two separate refrigeration plants as they are now or by a consolidated plant serving both arenas. Both options have pros and cons which can be found in Table 1 below.

Table 1 Plant Consolidation Pros & Cons

Consolidated Plant		Separate Plants	
Pros	**Cons**	**Pros**	**Cons**
• Smaller total plant size • Lower total refrigerant charge • High redundancy • Higher efficiency • Simplified heat recovery • Single service point • Single emergency services reaction point • Electrical upgrade to 52C could be avoided • Consolidated plant building comes with new ventilation system	• Longer brine runs to the arena slabs • Requires finding routing through the facility • Larger total loss of refrigerant in the case of a leak	• Shorter brine runs • Existing layout no additional routing required • Lower total loss of refrigerant in the case of a leak	• Larger total plant size • Larger total refrigerant charge • Lower redundancy • Lower efficiency • More complex heat recovery • Multiple service points • Multiple emergency services reaction points • Electrical upgrade for 52C required • Possible ventilation upgrades

3.0 ICE PLANT CONSTRUCTION

For IFK and 52C, based on the size of the ice sheets, the occupancy, and the possibility of making ice in late August early September we would expect the ice plant for each facility to be approximately 90 tons of refrigeration (TR). The two new plants would install them in the existing plant rooms with the required electrical and ventilation upgrades. A routing for the brine headers would not be required as existing the headers terminate in the mechanical rooms for each space. Connections for future heat recovery would be provided and future routing would need to be provided through the facility to connect to each of the ice plants.

If the two (2) arenas are combined into a single ice plant, then due to redundancy and allowing for only one sheet to be making ice at a time the plant would be approximately 125 TR. To allow for the installation of a single ice plant a location must be found for the new ice plant building and a routing for the brine piping through the facility so that both the IFK and 52C arenas are served from the plant. This option allows for two placement locations that we can identify, one in the existing Ice Plant 122c plant room or a new refrigeration plant mounted by the Northeast Corner of the facility outside of Ice Plant 122c. This location allows for ease of connection for future heat recovery from the ice plant for building heating. Refer to Appendix C for locations of the new ice plant.

From the new ice plant, chilled and warm brine pipes can be routed outside the facility in a purpose-built trench. The brine lines serving IFK arena will connect to the existing header in the floor of Ice Plant 122c. The brine lines serving 52C arena will be routed around the facility in the new trench eventually connecting to the existing header in the floor of 52C arena ice plant. Refer to Appendix C for the proposed routing of the new brine lines.

4.0 ICE PLANT ENERGY USE EXISTING VS OPTIONS

An energy model analysis was performed to investigate the estimated energy consumption of each of the proposed undegraded ice plant configurations as well as the current arena ice plant systems. There are four different ice plant types that were analyzed. Each ice plant type had an A and a B option. Option A represents a single chiller with a capacity of 125 Tons, while option B represents two identical chillers each with a capacity of 90 Tons. It should be noted that the existing ice plant system energy consumption is based on the energy model approximations and not metered energy data. These results are meant to be used as a comparative tool and not as predicated energy consumption results.

Table 2 shows the results of the energy model analysis.

Table 2 Ice Plant Energy Modelling Results

Modelling Scenario	Total Ice Plant Consumption [kWh]	Ice Plant Energy Savings [%]
Existing	576,061	
Option 1A	358,089	37.8%
Option 1B	344,279	40.2%
Option 2A	273,929	52.4%
Option 2B	262,323	54.5%
Option 3A	524,014	9.0%
Option 3B	507,423	11.9%
Option 4A	332,302	42.3%
Option 4B	319,182	44.6%

The results show that Option 2B, the dual ammonia plate and frame ice plant configuration, predicts the greatest energy savings compared to the baseline existing systems. The energy savings of the Option 4 scenarios follow closely behind results of the Option 2 scenarios. The lower system performance of the Option 2 scenarios in the summer months increases the overall energy consumption, lowering the perceived energy savings for that system type. The ice plant capacity curves have also been approximated for all options in this analysis. We do anticipate that the actual capacity curves for the CO2 chillers to provide a more favorable performance in the winter months. Therefore, the actual performance of the Option 2 and Option 4 configurations may be closer depending on the year-round operation of the ice surfaces.

Ice Plant Energy Use Existing vs Options

Figure 1 shows the breakdown the energy consumption between the chiller, cooling towers, and pumps for each of the modelled scenarios.

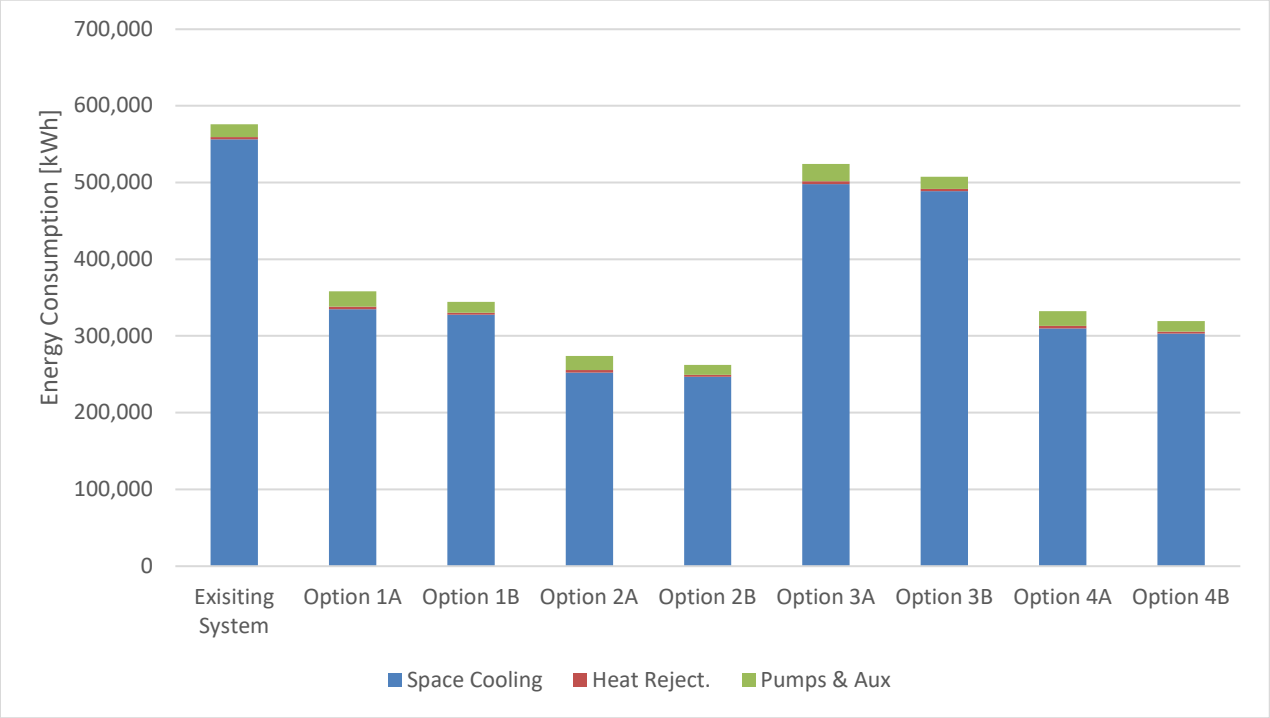

Figure 1 Energy Consumption Breakdown

5.0 CLASS D ESTIMATE

The following costing is to be considered a Class D[1] Estimate. The following costs are based on cost data from the latest edition of RS Means, supplier information and recent construction experience. All costs below are rounded to the nearest $1000. The estimate does not have any allowance for structural to support the new packaged refrigeration plant as unknown ground conditions can have a major effect on the type of structural system that is used and subsequently the cost of the system.

5.1 OPTION 1A AMMONIA SHELL & TUBE SITE BUILT

- Demolition $91,000
- New Construction $2,970,000
- **Total $3,061,000**

5.2 OPTION 1B AMMONIA SHELL & TUBE PACKAGED

- Demolition $91,000
- New Construction $2,422,000
- **Total $2,513,000**

5.3 OPTION 2A AMMONIA PLATE & FRAME SITE BUILT

- Demolition $91,000
- New Construction $2,916,000
- **Total $3,007,000**

5.4 OPTION 2B AMMONIA PLATE & FRAME PACKAGED

- Demolition $91,000
- New Construction $2,692,000
- **Total $2,783,000**

[1] A Class D estimate is generally an estimate based on the initial functional program and broad concept approach. The accuracy of this estimate is generally +/- 20 to 30% accurate depending on the complexity of the project and whether the project is new construction on a greenfield site or a renovation.

5.5 OPTION 3A FREAON SITE BUILT

- Demolition $91,000
- New Construction $1,800,000
- **Total $1,891,000**

5.6 OPTION 3B FREON PACKAGED

- Demolition $91,000
- New Construction $1,693,000
- **Total $1,784,000**

5.7 OPTION 4A CO2 DIRECT SITE BUILT

- Demolition $498,000
- New Construction $6,624,000
- **Total $7,122,000**

5.8 OPTION 4B CO2 DIRECT PACKAGED

- Demolition $639,000
- New Construction $4,447,000
- **Total $5,086,000**

5.9 OPTION 5A CO2 INDIRECT SITE BUILT

- Demolition $91,000
- New Construction $3,564,000
- **Total $3,655,000**

5.10 OPTION 5B CO2 INDIRECT PACKAGED

- Demolition $91,000
- New Construction $2,917,000
- **Total $3,008,000**

5.11 OPTIONAL EXTRA

- **New Prefabricated Plant Building $324,000**

6.0 RECOMMENDATIONS

The production of artificial ice has many valid options but the correct option for any project is the one that best fits the need of the owner and operator of the facility. We feel that the flowing items, in order of importance, are the most critical to the selection of a refrigeration plant for the Town of Fort Frances:

1. Must reduce the operating staff requirements.
2. Must be energy efficient and operationally efficient.
3. Must be affordable.

If we were to provide two separate plants the total system would need to be larger to allow for ice making in the shoulder season and we would get no benefit from non-simultaneous loads e.g., a hockey tournament in IFK while 52C is unoccupied. By providing a factory fabricated packaged plant the Province of Ontario Technical Standards and Safety Act, 2000 O. Reg. 219/01 allows the plant to be registered as a R6, which does not require a fulltime operator, refer to Appendix A and Appendix B. This applies if we use two separate plants or one larger plant. If we were to use a plant that is constructed on-site we would then have to register the plant as a R13, which requires a full time operator, refer to Appendix A and Appendix B.

Each of the refrigerant systems have their own coefficient of performance (COP) with the larger the number the more efficient that the system operates. Some of the refrigerants are also affected by the seasonal conditions and their efficiency drops when the outdoor temperature is higher in the summer. The freon system has the lowest, with a COP between 1.5 and 2.5. The indirect CO2 has a COP of between 2.0 and 3.0. The shell and tube Ammonia has a COP of approximately 3.0. The direct CO2 has a COP of 2.5 and 4.0. Finally, the plate and frame Ammonia system has a COP of approximately 4.0.

The cost of the various plants varies based on the technology and as the existing plants are Ammonia shell and tube, we have used that system as the baseline for cost comparisons. The highest cost refrigerant system is the direct CO2 system which requires the existing slabs to be removed and new slabs to be installed with a network of stainless-steel piping in the slab; it would also require the ventilation system in the arenas to be upgraded to allow for evacuation of the CO2 gas if the refrigerant leaks. The CO2 indirect system would allow for the use of the existing headers and brine piping but since the technology is patented and only available from one supplier, using CO2 indirect has a cost premium. Freon is the lowest first cost option but has a shorter equipment life span as less of the equipment is designed for industrial operation. The Ammonia plate and frame system has a higher first cost than an ammonia flooded system but is less expensive than either of the CO2 options. Ammonia plate and frame also benefits from the same longevity of equipment that the Ammonia shell and tube system enjoys and in the case of the chillers the life span is typically longer than an Ammonia shell and tube. We have not calculated the cost of upgrading the electrical systems for arena 52C but the arena will need some electrical upgrades if individual plants are provided.

In addition to the defined needs of the owner and operator of the facility a critical consideration is the safety of the system to the staff and community. While Ammonia refrigeration has had incidents in the past which have caused injury and death, new systems and technologies have been developed to improve the safety of ammonia refrigerant. Low ammonia charge systems allow for Smart Transfer Systems and water tank discharges so that when the system is being maintained or if there is an emergency the ammonia refrigerant can be held in a separate location or discharged to a water tank so that the ammonia is not discharged to the atmosphere. This will reduce the risk to maintenance staff and to the public at large.

Based on the judging criteria, we recommend that the Town of Fort Frances select and install a new packaged stand-alone Ammonia plate and frame refrigeration plant, or Option 2b as per the refrigeration matrix found in Appendix A. This plant will be capable of providing ice to both the 52C and the IFK arenas with reduced operator requirements a more energy efficient system and redundancy. This system will also allow for connection of energy recovery systems to allow the plant to provide heating to the existing systems and expanded systems in the future.

A summary of the relative rating of the plants, based on the above identified priorities and the refrigeration matrix found in Appendix A, is as follows:

1. Option 2b – Ammonia (Plate & Frame) Skid Package
2. Option 3b – Freon Skid Package
3. Option 1b – Ammonia (Shell & Tube) Skid Package
4. Option 5b – CO2 Indirect Skid Package
5. Option 2a – Ammonia (Plate & Frame) Site Constructed
6. Option 1a – Ammonia (Shell & Tube) Site Constructed
7. Option 3a – Freon Site Constructed
8. Option 5a – CO2 Indirect Site Constructed
9. Option 4b – CO2 Direct Skid Package
10. Option 4a – CO2 Direct Site Constructed

Appendix A REFRIGERATION COMPARISION MATRIX

Appendix A - Ice Plant Analysis Matrix

Colour Code	Good	Caution	Trouble	Not Required

Type	Option 1A Ammonia (Tube + Shell) Site Constructed	Option 1B Ammonia (Tube + Shell) Skid Package	Option 2A Ammonia (Plate + Frame) Site Constructed	Option 2B Ammonia (Plate + Frame) Skid Package	Option 3A Freon System (R507) Site Constructed	Option 3B Freon System (R507) Skid Package	Option 4A CO2 Direct Site Constructed	Option 4B CO2 Direct Skid Package	Option 5A CO2 Indirect Site Constructed	Option 5B CO2 Indirect Skid Package
Relative Plant Cost	100%	119%	101%	120%	63%	81%	230%	249%	124%	143%
Approximate Lead Time (weeks)	10 to 12	16 to 18	10 to 12	16 to 18	10 to 12	16 to 18	10 to 12	16 to 18	10 to 12	16 to 18
Approximate Installation Time (weeks)	12 to 18	4 to 6	12 to 18	4 to 6	12 to 18	4 to 6	16 to 24 (include ice slab)	10 to 18 (include ice slab)	12 to 18	4 to 6
Approximate Total Installation (weeks)	22 to 30	20 to 24	22 to 30	20 to 24	22 to 30	20 to 24	26 to 36 (include ice slab)	26 to 36 (include ice slab)	22 to 30	20 to 24
Existing Mechanical Room Installation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Standalone Plant Building	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Standalone Building Dim LxWxH (m)	Not Applicable	12.2x3.5x3	Not Applicable	12.2x3.5x3	Not Applicable	12.2x3.5x3	Not Applicable	12.2x3.5x3	Not Applicable	12.2x3.5x3
Plant Building Foundation	Not Applicable	Yes	Not Applicable	Yes	Not Applicable	Yes	Not Applicable	Yes	Not Applicable	Yes
Existing Ice Plant Operate During Construction	No	Yes	No	Yes	No	Yes	No	No	No	Yes
Smart Transfer System (STS)	Yes (available)	Yes (available)	Yes (available)	Yes (available)	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Water Diffuser Tank	Yes (available)	Yes (available)	Yes (available)	Yes (available)	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
Ice Rink Slab Replacement	No	No	No	No	No	No	Yes	Yes	No	No
Use Existing Header Trench	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Smell (refrigerant smell)	Yes (detectable)	Yes (detectable)	Yes (detectable)	Yes (detectable)	No (non-detectable)	No (non-detectable)	No (non-detectable)	No (non-detectable)	No (non-detectable)	No (non-detectable)
Refrigerant Outside of Plant	No	No	No	No	Yes (outside)	Yes (outside)	Yes (in building)	Yes (in building)	No	No
High Pressure	No	No	No	No	No	No	Yes	Yes	Yes (plant only)	Yes (plant only)
Enviromental Impact	Low	Low	Low	Low	High	High	Low	Low	Low	Low
Lifespan (years)	35 to 40	35 to 40	35 to 40	35 to 40	15 to 20	15 to 20	20 to 25	20 to 25	20 to 25	20 to 25
Operating Cost (Ammonia Baseline)	100%	100%	95%	95%	125%	125%	80%	80%	95%	95%
Approximate Coefficient of Perfomance	3.0 Winter / 3.0 Summer	3.0 Winter / 3.0 Summer	4.0 Winter / 4.0 Summer	4.0 Winter / 4.0 Summer	2.5 Winter / 1.5 Summer	2.5 Winter / 1.5 Summer	4.0 Winter / 2.5 Summer	4.0 Winter / 2.5 Summer	3.0 Winter / 2.0 Summer	3.0 Winter / 2.0 Summer
Vestibule Required	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Machine Room (B52 Code)	Class T	Class T	Class T	Class T	Regular Plant Room	Regular Plant Room	Regular Plant Room	Regular Plant Room	Regular Plant Room	Regular Plant Room
Plant Technology	Established	Established	Established	Established	Established	Established	New	New	New	New
Servicability	Good	Good	Good	Good	Good	Good	Cimco Only	Cimco Only	Cimco Only	Cimco Only
Patented Technology	No	No	No	No	No	No	Yes (Cimco only)	Yes (Cimco only)	Yes (Cimco only)	Yes (Cimco only)
Tender (multiple bidders)	Yes	Yes	Yes	Yes	Yes	Yes	No (Cimco only)	No (Cimco only)	No (Cimco only)	No (Cimco only)
Combinded Plant Size	125 TR	125 TR	125 TR	125 TR	125 TR	125 TR	125 TR	125 TR	125 TR	125 TR
Individual Plant Size (52C/IFK)	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR	90 TR / 90 TR
Operator Requirement O. Reg. 219/01 (Combined/Individual)	R13 / R13	R6 / R6	R13 / R13	R6 / R6	R13 / R13	R6 / R6	R13 / R13	R6 / R6	R13 / R13	R6 / R6
Summary	Good - 17 Caution - 8 Trouble - 2 Not Required - 2	Good - 23 Caution - 6 Trouble - 0 Not Required - 0	Good - 18 Caution - 7 Trouble - 2 Not Required - 2	Good - 24 Caution - 5 Trouble - 0 Not Required - 0	Good - 13 Caution - 5 Trouble - 7 Not Required - 4	Good - 19 Caution - 3 Trouble - 5 Not Required - 2	Good - 7 Caution - 5 Trouble - 13 Not Required - 4	Good - 10 Caution - 5 Trouble - 12 Not Required - 2	Good - 10 Caution - 8 Trouble - 7 Not Required - 4	Good - 16 Caution - 6 Trouble - 5 Not Required - 2
notes	Relative costs based on a 100TR Ammonia Shell and Tube Plant, the CO2 direct system cost allows for replacement of the slab R6 - Requirements, unattended, registered, guarded controls & maintenance program R13 - Requirements registered, 3rd class power engineer & 4th class power engineer each shift									

Appendix B ONTARIO TECHNICAL STANDARDS AND SAFETY ACT, 2000 O. REG. 219/01 TABLE 6 EXTRACT

TABLE 6

REFRIGERATION PLANTS REGISTRATION REQUIREMENTS

PLANT TYPE (A) IS POWER RATED (B) TO DETERMINE REGISTRATION REQUIREMENT (C)													
EXPLANATORY NOTES AND ADDITIONAL REQUIREMENTS		PLANT REQUIREMENTS FOR REGISTRATION (C)											
Compressor Operator Certificate of Qualification are not approved for the operation of refrigeration compressors. Steam Prime Mover Plants governed by Table 4 or 3, as required. Failure to provide a plant Certificate of Qualification prescribed refrigeration compressor maintenance and service program to a standard prescribed by the refrigeration compressor manufacturer will result in the suspension of non-attended status and the attendance of a certified Operating Engineer/Operator will be required, to the requirements of a guarded plant, until the prescribed maintenance and service requirements are attained. Any refrigeration plant using a refrigerant other than class 1 or 2 must receive the approval of the Chief Officer. Plants designated with guarded controls may operate with operator attendance as prescribed in sections 23-24. Plants - R9, R13, R14 may have guarded controls applied in order to allow operator attendance as prescribed in sections 23-24.		PLANT CODE	UNREGISTERED	UNATTENDED	REGISTERED	GUARDED CONTROLS	MAINTENANCE PROGRAM	ATTENDED - 8HR/DAY OF OPERATION - 4TH CLASS/B-CHIEF	ATTENDED - 8HR/DAY OF OPERATION - 3RD CLASS/B-CHIEF	ATTENDED - 8HR/DAY OF OPERATION-2ND CLASS/A-CHIEF	ATTENDED -3RD CLASS/B-CHIEF & 4TH CLASS/B-EACH SHIFT	ATTENDED - 2ND CLASS/A-CHIEF & 3RD CLASS/B-EACH SHIFT
TYPE OF PLANT REFRIGERATON PLANT (A)	**RATING & REFRIGERATON CAPACITY (B)**												
LOW PRESSURE • All units or installations	Unlimited	R1	✓	✓									
NON POSITIVE DISPLACEMENT COMPRESSORS • Centrifugal • Turbine	Unit < 97 kW (130 BHP, 3TH)	R2	✓	✓									
	Unit > 97 kW (130 BHP, 3TH) < 969 kW (1300 BHP, 33TH) and installations < 2983 kW (4000 BHP, 102TH)	R3		✓	✓	✓	✓						
• High Pressure • All units or installations	Unit > 969 kW (1300 BHP, 33TH) and installations > 2983 kW (4000 BHP, 102TH)	R4			✓	✓				✓			
SELF CONTAINED SYSTEMS • No Refrigerant Field Piping • All units or installations	< 75 kW (100 BHP, 2.45TH)	R5	✓	✓									
	> 75 kW (100 BHP, 2.45TH) < 485 kW (650 BHP, 17TH) and < 2000 lb. (907 KG) of refrigerant	R6		✓	✓	✓	✓						
	> 485 kW (650 BHP, 17TH) and < 746 kW (1000 BHP, 25TH) < 3000 lb (1361 KG) or refrigerant	R7			✓	✓			✓				
	> 746 kW (1000 BHP, 25TH) < 969 kW (1300 BHP, 33TH) < 4000 lb (1814 KG) of refrigerant	R8			✓	✓				✓			
	> 969 kW (1300 BHP, 33TH)	R9			✓								✓

PLANT TYPE (A) IS POWER RATED (B) TO DETERMINE REGISTRATION REQUIREMENT (C)													
EXPLANATORY NOTES AND ADDITIONAL REQUIREMENTS		PLANT REQUIREMENTS FOR REGISTRATION (C)											
		PLANT CODE	UNREGISTERED	UNATTENDED	REGISTERED	GUARDED CONTROLS	MAINTENANCE PROGRAM	ATTENDED - 8HR/DAY OF OPERATION - 4TH CLASS/B-CHIEF	ATTENDED- 8HR/DAY OF OPERATION - 3RD CLASS/B-CHIEF	ATTENDED - 8HR/DAY OF OPERATION-2ND CLASS/A-CHIEF	ATTENDED-3RD CLASS/B-CHIEF & 4TH CLASS/B-EACH SHIFT	ATTENDED - 2ND CLASS/A-CHIEF & 3RD CLASS/B-EACH SHIFT
TYPE OF PLANT REFRIGERATON PLANT (A)	RATING & REFRIGERATON CAPACITY (B)												
BUILT UP PLANT	< 37 kW (50 BHP, 1.3TH)	R10	✓	✓									
	> 37 kW (50 BHP, 1.3 TH) < 75 kW (100 BHP, 2.5TH)	R11			✓	✓	✓						
• No refrigerant field piping	>75 kW (100 BHP, 2.5TH) < 149 kW (200 BHP, 5TH)	R12			✓	✓		✓					
• Refrigerant piping outside machinery room	> 149 kW (200 BHP, 5TH) < 597 kW (800 BHP, 20TH)	R13			✓						✓		
• All units or installations	> 597 kW (800 BHP, 20TH)	R14			✓							✓	

O. Reg. 219/01, Table 6.

TABLE 7
STEAM TRACTION PLANTS REGISTRATION REQUIREMENTS

Appendix C NEW ICE PLANT LOCATION AND BRINE PIPE ROUTING

RENOVATION NOTES

1. PATCH AND MAKE GOOD ALL SURFACES & FINISHES
2. REMOVE EXISTING WALLS AS SHOWN
3. REMOVE PLUMBING FIXTURES
4. REMOVE EXISTING DOOR AND FRAME
5. APPLY 16 GYPSUM BOARD ON 19 RESILIENT CHANNELS TO EXISTING WALL
6. REMOVE HEATER SEE MECHANICAL DRAWINGS
7. HEATER TO BE RELOCATED SEE MECHANICAL DRAWINGS
8. REMOVE STAGE FLOOR
9. REMOVE PROJECTION SCREEN AND CURTAIN TRACK RETURN TO OWNER
10. CLEAN, PATCH AND PAINT EXISTING WALL
11. ENCLOSE WITH 16 GYPSUM BOARD ON 38x89 METAL STUDS
12. REMOVE AND REINSTALL PLAYERS BOXES AS SHOWN ON OPPOSITE SIDE OF RINK
13. REMOVE TROPHY CASE AND RETURN TO OWNER

north

EXISTING ZAMBONI ROOM

NEW CHILLED AND WARM BRINE TO SERVE 52C. CONNECT TO THE EXISTING HEADER.

EXISTING 52C ICE PLANT ROOM

BRINE LINES TO RISE UP TO HIGH LEVEL IN THE 52C ARENA

NEW CHILLED AND WARM BRINE TO 52C FROM THE NEW PLANT IN THE EXTERIOR TRENCH

NEW TRENCH FOR BRINE LINES

APPROXIMATE LOCATION OF THE NEW PACKAGED REFRIGERATION PLANT.

EXISTING IFK ICE PLANT ROOM

NEW CHILLED BRINE AND WARM BRINE TO SERVE IFK. CONNECT TO THE EXISTING HEADER

EXISTING ICE RINK
T/O ICE EL.+100.199

ICE RINK 146
T/O FLOOR EL.+100.000

CRAWL SPACE E92
CORRIDOR 138
ZAMBONI RM 134
OFFICIAL'S ROOM 134
CRAWL SPACE 145
EXISTING ACCESS E150
PLAYER ACCESS 133
ACCESS 139
STOR 132C
PLAYER'S ROOM-1 132
EXISTING PLAYERS ROOM E148
SHOWERS 132B
SHOWERS 132A
CRAWL SPACE 144
ACCESS 149
FIGURE SKATING ROOM-2 131
PLAYER'S ROOM-3 130
EXISTING STORAGE E149
CRAWL SPACE 143
MECHANICAL SERVICE ACCESS
SPECIAL PURPOSE PLAYER'S ROOM 128
PLAYER'S ROOM-4 127
PLAYER'S ROOM-5 126
CRAWL SPACE 142
SEE STRUCTURAL FOR SEATING TIER SUPPORT DIMS.
PLAYER'S ROOM-6 124
HOT WATER TANK RM. 122C
ELEC. ROOM 123
FOYER 121
SPRINK. ROOM 122A
STAIR 121
MAINT. OFFICE 107
MENS WASHRM 108
WOMENS WASHRM 109
FIRST AID 110
VAN. 111
ELEV. MACH. 106
OFFICE 114
OFFICE 115
BOX OFFICE 113
SKATE SHOP 116
LEAGUE STOR 118
LEAGUE STOR 119
EXISTING SQUASH COURTS
EXISTING CHANGE ROOMS
EXIST. POOL VIEWING DECK E134
EXISTING CORRIDOR E146
REMOVE EXISTING CONCESSION
EXISTING ARENA LOBBY E142
EXISTING SERVICE RM. E143
STOR E145
VEST. E147
CONCESSION 103
STAIR 102
VESTIBULE 100
FOYER 101
MECH. 148
RAMP 149
EXISTING POOL CORRIDOR E133
EXISTING POOL
EXISTING WEIGHT ROOM
EXISTING CHANGE ROOMS
PLANK COVER
EXTENT OF SP
SEE STRUCTURAL FOR SEATING TIER SUPPORT DIMS.
BOLLARDS-TYP. SEE DET 13
PLAYERS BOX #5
PLAYERS BOX #7
EXIST. OF NEW MASONRY, SEISMIC OR CMU BLOCK WALL
TO FACE OF EXIST. POOL AND EXIST. ARENA
TO FACE OF EXIST. POOL AND EXIST. ARENA

1 A1 MASTER PLAN MAIN FLOOR 1:200

Appendix D CLASS D COSTING SUPPORT

	Cost/Unit	Amount	Units		Total
Option 1A Ammonia Shell and Tube Site Built					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00
New 90TR Plant 52C					
New Refrigeration Plant	$800,000.00	1	$/plant		$800,000.00
New 90TR Plant IFK					
New Refrigeration Plant	$850,000.00	1	$/plant		$850,000.00
New Construciton Sub Total					$1,650,000.00
Option 1A Total					$1,700,343.00
Option 1A Total + Local Correction				50%	$2,550,514.50
Option 1A Total + Contingency				20%	$3,060,617.40

Option 1B Ammonia Shell and Tube Packaged					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00
New 125TR Plant					

	Cost/Unit	Amount	Units		Total
New Refrigeration Plant	$1,100,000.00	1	$/plant		$1,100,000.00
IFK Cold Brine Lines (Sched 80 8")	$82.84	69	$/lf		$5,715.96
IFK Cold Brine Fittings (8" 90° Elbow)	$518.83	5	$/fitting		$2,594.15
IFK Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
IFK Warm Brine Lines (Sched 80 6")	$58.49	69	$/lf		$4,035.81
IFK Warm Brine Fittings (6" 90° Elbow)	$257.13	5	$/fitting		$1,285.65
IFK Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Cold Brine Lines (Sched 80 8")	$82.84	1065	$/lf		$88,224.60
52C Cold Brine Fittings (8" 90° Elbow)	$518.83	14	$/fitting		$7,263.62
52C Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
52C Cold Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
52C Warm Brine Lines (Sched 80 6")	$58.49	1065	$/lf		$62,291.85
52C Warm Brine Fittings (6" 90° Elbow)	$257.13	14	$/fitting		$3,599.82
52C Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Warm Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
Pipe Trenching and Burying	$5.69	280	$/lf		$1,593.20
New Construction Sub Total					$1,345,807.26
Option 1B Total					$1,396,150.26
Option 1BTotal + Local Correction				50%	$2,094,225.39
Option 1B Total + Contingency				20%	$2,513,070.47

Option 2A Ammonia Plate & Frame Site Built				
Demolition 52C				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon	$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week	$1,700.00
Demolition IFK				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon	$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week	$1,700.00
Demolition Sub Total				$50,343.00
New 90TR Plant 52C				
New Refrigeration Plant	$810,000.00	1	$/plant	$810,000.00
New 90TR Plant IFK				
New Refrigeration Plant	$810,000.00	1	$/plant	$810,000.00

	Cost/Unit	Amount	Units		Total
New Construciton Sub Total					$1,620,000.00
Option 2A Total					$1,670,343.00
Option 2A Total + Local Correction				50%	$2,505,514.50
Option 2A Total + Contingency				20%	$3,006,617.40

Option 2B Ammonia Plate & Frame Packaged				
Demolition 52C				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon	$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week	$1,700.00
Demolition IFK				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon	$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week	$1,700.00
Demolition Sub Total				$50,343.00
New 125TR Plant				
New Refrigeration Plant	$1,250,000.00	1	$/plant	$1,250,000.00
IFK Cold Brine Lines (Sched 80 8")	$82.84	69	$/lf	$5,715.96
IFK Cold Brine Fittings (8" 90° Elbow)	$518.83	5	$/fitting	$2,594.15
IFK Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting	$1,041.00
IFK Warm Brine Lines (Sched 80 6")	$58.49	69	$/lf	$4,035.81
IFK Warm Brine Fittings (6" 90° Elbow)	$257.13	5	$/fitting	$1,285.65
IFK Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting	$609.20
52C Cold Brine Lines (Sched 80 8")	$82.84	1065	$/lf	$88,224.60
52C Cold Brine Fittings (8" 90° Elbow)	$518.83	14	$/fitting	$7,263.62
52C Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting	$1,041.00
52C Cold Brine Insulation/Jacketing	$30.94	1065	$/lf	$32,951.10
52C Warm Brine Lines (Sched 80 6")	$58.49	1065	$/lf	$62,291.85
52C Warm Brine Fittings (6" 90° Elbow)	$257.13	14	$/fitting	$3,599.82
52C Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting	$609.20
52C Warm Brine Insulation/Jacketing	$30.94	1065	$/lf	$32,951.10
Pipe Trenching and Burying	$5.69	280	$/lf	$1,593.20
New Construciton Sub Total				$1,495,807.26
Option 2B Total				$1,546,150.26
Option 2B Total + Local Correction			50%	$2,319,225.39
Option 2B Total + Contingency			20%	$2,783,070.47

	Cost/Unit	Amount	Units		Total
Option 3A Freon (R507) Site Built					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00
New 90TR Plant 52C					
New Refrigeration Plant	$500,000.00	1	$/plant		$500,000.00
New 90TR Plant IFK					
New Refrigeration Plant	$500,000.00	1	$/plant		$500,000.00
New Construction Sub Total					$1,000,000.00
Option 3A Total					$1,050,343.00
Option 3A Total + Local Correction				50%	$1,575,514.50
Option 3A Total + Contingency				20%	$1,890,617.40

Option 3B Freon (R507) Packaged					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00

	Cost/Unit	Amount	Units		Total
New 125TR Plant					
New Refrigeration Plant	$695,000.00	1	$/plant		$695,000.00
IFK Cold Brine Lines (Sched 80 8")	$82.84	69	$/lf		$5,715.96
IFK Cold Brine Fittings (8" 90° Elbow)	$518.83	5	$/fitting		$2,594.15
IFK Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
IFK Warm Brine Lines (Sched 80 6")	$58.49	69	$/lf		$4,035.81
IFK Warm Brine Fittings (6" 90° Elbow)	$257.13	5	$/fitting		$1,285.65
IFK Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Cold Brine Lines (Sched 80 8")	$82.84	1065	$/lf		$88,224.60
52C Cold Brine Fittings (8" 90° Elbow)	$518.83	14	$/fitting		$7,263.62
52C Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
52C Cold Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
52C Warm Brine Lines (Sched 80 6")	$58.49	1065	$/lf		$62,291.85
52C Warm Brine Fittings (6" 90° Elbow)	$257.13	14	$/fitting		$3,599.82
52C Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Warm Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
Pipe Trenching and Burying	$5.69	280	$/lf		$1,593.20
New Construciton Sub Total					$940,807.26
Option 3B Total					$991,150.26
Option 3B Total + Local Correction				50%	$1,486,725.39
Option 3B Total + Contingency				20%	$1,784,070.47

Option 4A C02 Direct Contact Site Built					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Disposal	$7.50	1000	$/gallon		$7,500.00
Slab Removal	$5.20	15000	$/sf		$78,000.00
Dumpster Rental (10 Tons/Load)	$850.00	6	$/week		$5,100.00
Trucking	$200.00	57	$/load		$11,400.00
Dumping Fees	$100.00	570	$/ton		$57,000.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Disposal	$7.50	1000	$/gallon		$7,500.00
Dumpster Rental (10 Tons/Load)	$850.00	6	$/week		$5,100.00
Trucking	$200.00	57	$/load		$11,400.00
Dumping Fees	$100.00	570	$/ton		$57,000.00
Demolition Sub Total					$276,943.00

	Cost/Unit	Amount	Units		Total
New 90TR Plant 52C					
New Refrigeration Plant	$990,000.00	1	$/plant		$990,000.00
New Slab	$850,000.00	1	$/slab		$850,000.00
New 90TR Plant IFK					
New Refrigeration Plant	$990,000.00	1	$/plant		$990,000.00
New Slab	$850,000.00	1	$/slab		$850,000.00
New Construction Sub Total					$3,680,000.00
Option 4A Total					$3,956,943.00
Option 4A Total + Local Correction				50%	$5,935,414.50
Option 4A Total + Contingency				20%	$7,122,497.40

Option 4B CO2 Direct Contact Packaged				
Demolition 52C				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Disposal	$7.50	1000	$/gallon	$7,500.00
Slab Removal	$5.20	15000	$/sf	$78,000.00
Dumpster Rental (10 Tons/Load)	$850.00	6	$/week	$5,100.00
Trucking	$200.00	57	$/load	$11,400.00
Dumping Fees	$100.00	570	$/ton	$57,000.00
Demolition IFK				
Cooling Tower Removal	$1,741.50	1	$/unit	$1,741.50
Refrigerant Removal	$13.42	750	$/lb	$10,065.00
Ice Plant	$6,665.00	1	$/unit	$6,665.00
Brine Removal & Disposal	$7.50	1000	$/gallon	$7,500.00
Slab Removal	$5.20	15000	$/sf	$78,000.00
Dumpster Rental (10 Tons/Load)	$850.00	6	$/week	$5,100.00
Trucking	$200.00	57	$/load	$11,400.00
Dumping Fees	$100.00	570	$/ton	$57,000.00
Demolition Sub Total				$354,943.00
New 125TR Plant				
New Refrigeration Plant	$1,375,000.00	1	$/plant	$1,375,000.00
IFK Cold Brine Lines (Sched 80 8")	$82.84	69	$/lf	$5,715.96
IFK Cold Brine Fittings (8" 90° Elbow)	$518.83	5	$/fitting	$2,594.15
IFK Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting	$1,041.00
IFK Warm Brine Lines (Sched 80 6")	$58.49	69	$/lf	$4,035.81
IFK Warm Brine Fittings (6" 90° Elbow)	$257.13	5	$/fitting	$1,285.65
IFK Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting	$609.20
52C Cold Brine Lines (Sched 80 8")	$82.84	1065	$/lf	$88,224.60

	Cost/Unit	Amount	Units		Total
52C Cold Brine Fittings (8" 90° Elbow)	$518.83	14	$/fitting		$7,263.62
52C Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
52C Cold Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
52C Warm Brine Lines (Sched 80 6")	$58.49	1065	$/lf		$62,291.85
52C Warm Brine Fittings (6" 90° Elbow)	$257.13	14	$/fitting		$3,599.82
52C Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Warm Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
Pipe Trenching and Burying	$5.69	280	$/lf		$1,593.20
New Slab	$850,000.00	1	$/slab		$850,000.00
New Construciton Sub Total					$2,470,807.26
Option 4B Total					$2,825,750.26
Option 4B Total + Local Correction				50%	$4,238,625.39
Option 4B Total + Contingency				20%	$5,086,350.47

Option 5A CO2 Indirect Site Built					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Slab Demolition					
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00
New 90TR Plant 52C					
New Refrigeration Plant	$990,000.00	1	$/plant		$990,000.00
New 90TR Plant IFK					
New Refrigeration Plant	$990,000.00	1	$/plant		$990,000.00
New Construction Sub Total					$1,980,000.00
Option 5A Total					$2,030,343.00
Option 5A Total + Local Correction				50%	$3,045,514.50
Option 5A Total + Contingency				20%	$3,654,617.40

	Cost/Unit	Amount	Units		Total
Option 5B CO2 Indirect Packaged					
Demolition 52C					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Disposal	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition IFK					
Cooling Tower Removal	$1,741.50	1	$/unit		$1,741.50
Refrigerant Removal	$13.42	750	$/lb		$10,065.00
Ice Plant	$6,665.00	1	$/unit		$6,665.00
Brine Removal & Storage	$5.00	1000	$/gallon		$5,000.00
Cartage, Dumpster and Dumping Fees	$850.00	2	$/week		$1,700.00
Demolition Sub Total					$50,343.00
New 125TR Plant					
New Refrigeration Plant	$1,375,000.00	1	$/plant		$1,375,000.00
IFK Cold Brine Lines (Sched 80 8")	$82.84	69	$/lf		$5,715.96
IFK Cold Brine Fittings (8" 90° Elbow)	$518.83	5	$/fitting		$2,594.15
IFK Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
IFK Warm Brine Lines (Sched 80 6")	$58.49	69	$/lf		$4,035.81
IFK Warm Brine Fittings (6" 90° Elbow)	$257.13	5	$/fitting		$1,285.65
IFK Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Cold Brine Lines (Sched 80 8")	$82.84	1065	$/lf		$88,224.60
52C Cold Brine Fittings (8" 90° Elbow)	$518.83	14	$/fitting		$7,263.62
52C Cold Brine Fittings (8" Flange Set)	$260.25	4	$/fitting		$1,041.00
52C Cold Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
52C Warm Brine Lines (Sched 80 6")	$58.49	1065	$/lf		$62,291.85
52C Warm Brine Fittings (6" 90° Elbow)	$257.13	14	$/fitting		$3,599.82
52C Warm Brine Fittings (6" Flange Set)	$152.30	4	$/fitting		$609.20
52C Warm Brine Insulation/Jacketing	$30.94	1065	$/lf		$32,951.10
Pipe Trenching and Burying	$5.69	280	$/lf		$1,593.20
New Construciton Sub Total					$1,620,807.26
Option 5B Total					$1,671,150.26
Option 5B Total + Local Correction				50%	$2,506,725.39
Option 5B Total + Contingency				20%	$3,008,070.47

Optional Extra Standalone Plant Building				
Plant Building	$150,000.00	1	$/building	$150,000.00
Piling/Foundations	$15,000.00	1	$/building	$15,000.00
Utility Connections	$15,000.00	1	$/building	$15,000.00

	Cost/Unit	Amount	Units	Total
Optional Extra Total				$180,000.00
Optional Extra Total + Local Correction			50%	$270,000.00
Optional Extra Total + Contingency			20%	$324,000.00