Case – 4 Secondary Refrigerant

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Case Background:

1.0 The customer would like to add Ethylene Glycol to their chilled water system to obtain a 30% by weight Ethylene Glycol brine for the purpose of freezing protection. The chiller has been checked and will produce same capacity when the Ethylene Glycol added. The original capacity is to cool 864 GPM of chilled water from 48.4°F to 42°F; If the chiller is to maintain at same capacity and the same temperature range, what will the new GPM flow for the brine? (Use the attached Ethylene Glycol curves for calculation).

2.0 An Ethylene Glycol brine system is designed for ice making. The brine temperatures are 33°F in and 26°F out at the beginning of the ice making cycle. But, during the final pull down for the ice making, the brine leaving temperature is 10.4°F, return brine temperature is 13°F, the system is always operated at evaporative temperature not more than 14°F below the brine leaving temperature. What is the Ethylene Glycol concentration do you recommend for this system? What is the pumping horsepower increase for the final pull down over the beginning of the ice making cycle, assuming flow and the pump efficiency are not changed.

Notes:

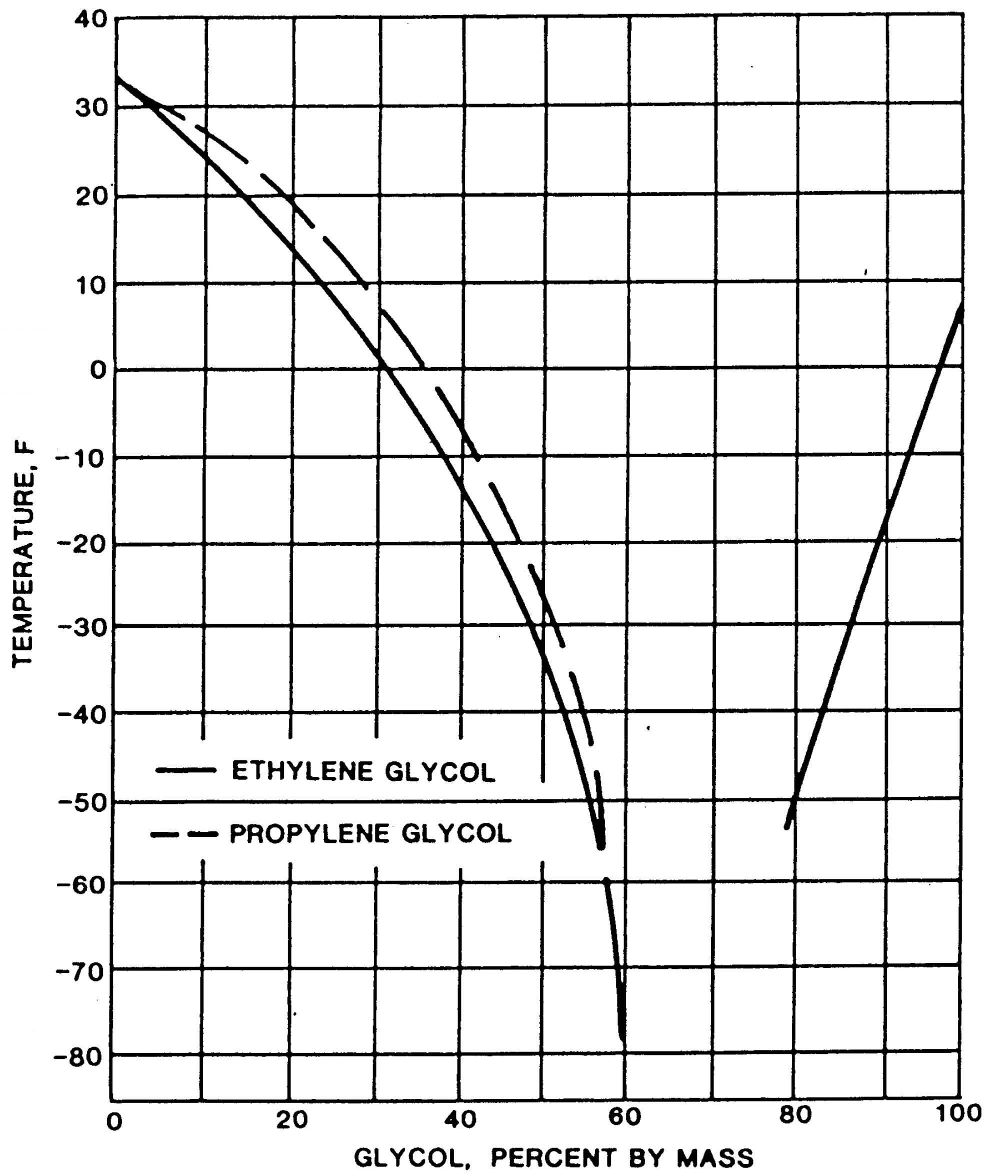
(A) Use brine properties from the attached charts instead from computer program.

(B) Use the attached Pressure Drop Correction Factor curve for brine pressure drop calculation.

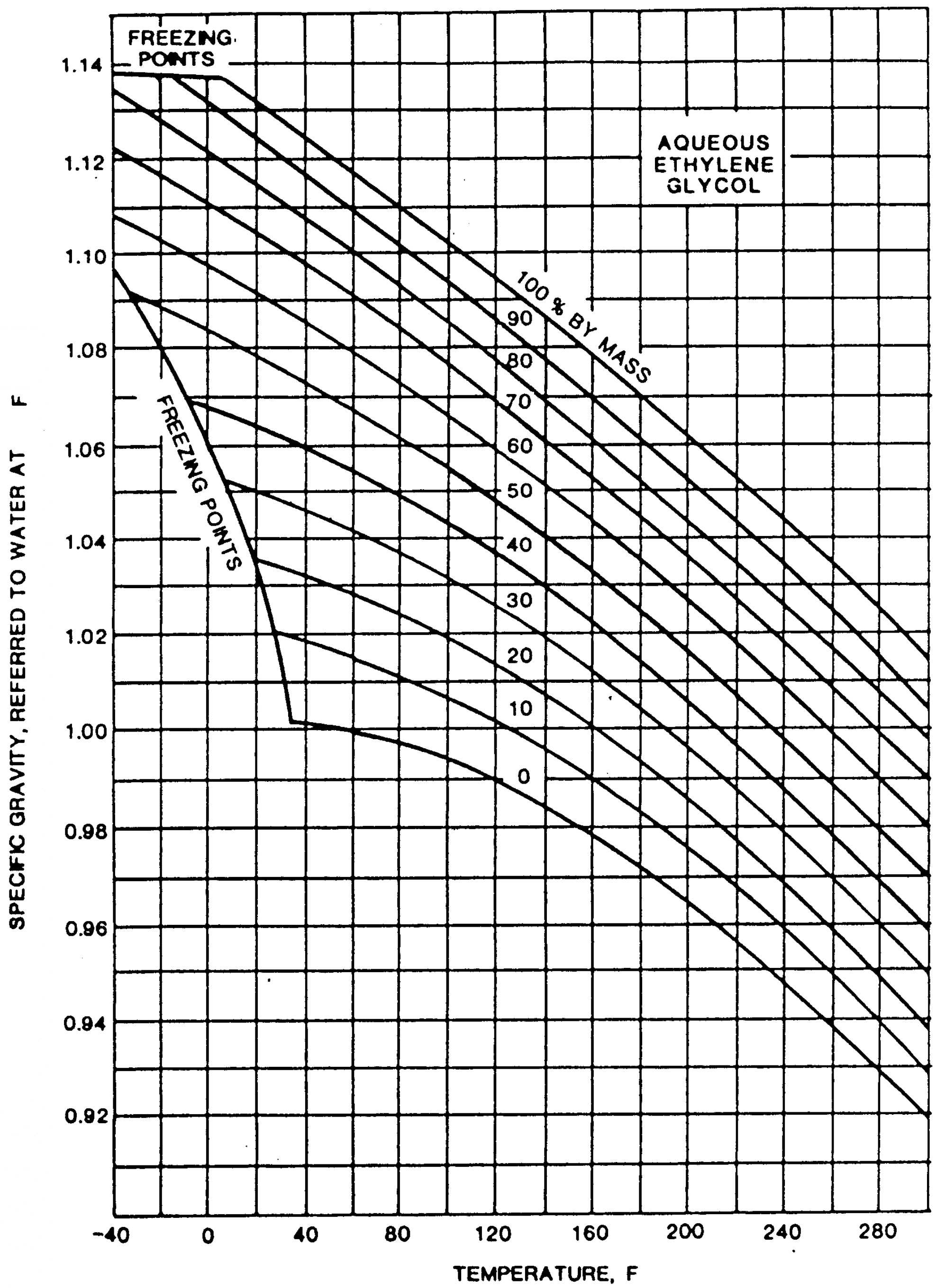
Fill in Data for the Summary Sheet:

1.0 (a) What is the TR for the chilled water duty. TR	
1.0 (b) What is the EG brine flow for 30% by wt. GPM	
2.0 (a) What is the Recommended EG brine concentration for the system. % by wt.	
2.0 (b) What is the percent of the pumping HP increase for the system at the final pull down cycle over the beginning of the ice making cycle.	

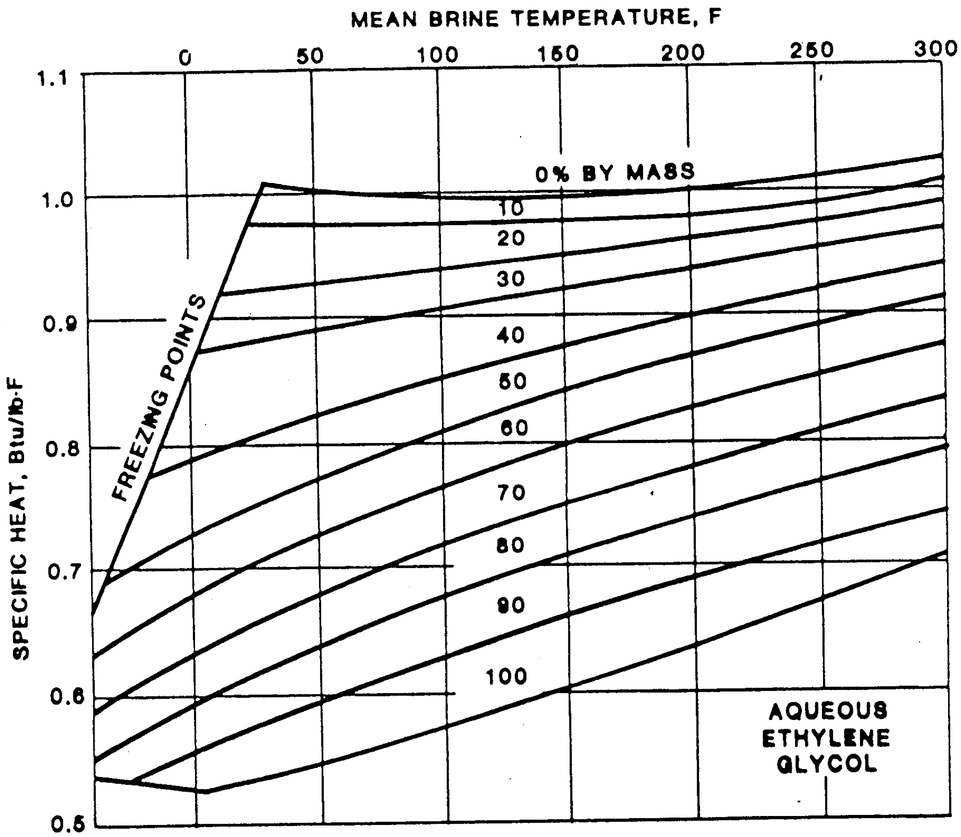
Related Technical Data and Engineering Information for the Case:



Freezing Points of Aqueous Solutions of Ethylene Glycol and Propylene Glycol



Specific Gravity of Aqueous Solutions of Ethylene Glycol

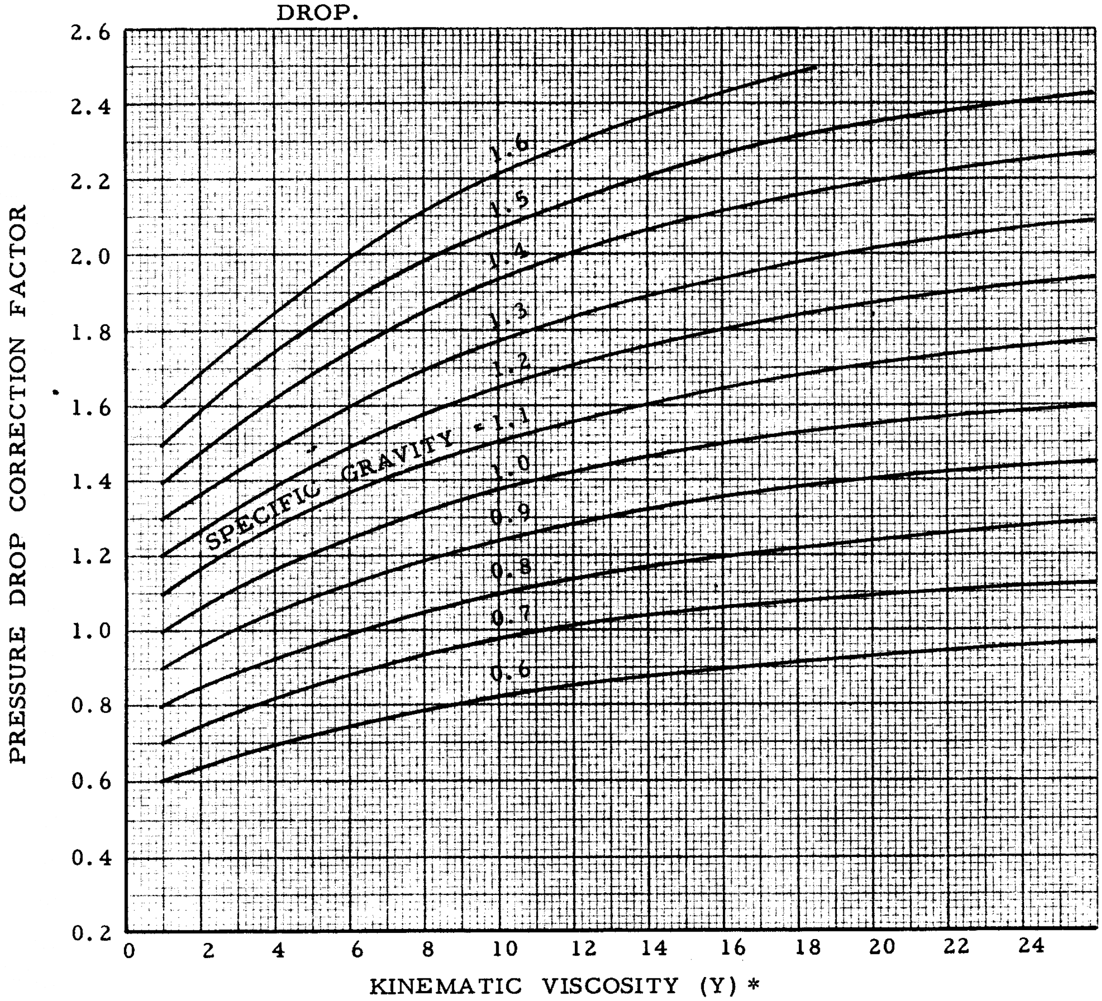


Specific Heat of Aqueous Solutions of Ethylene Glycol

PRESSURE DROP CORRECTION FACTORS

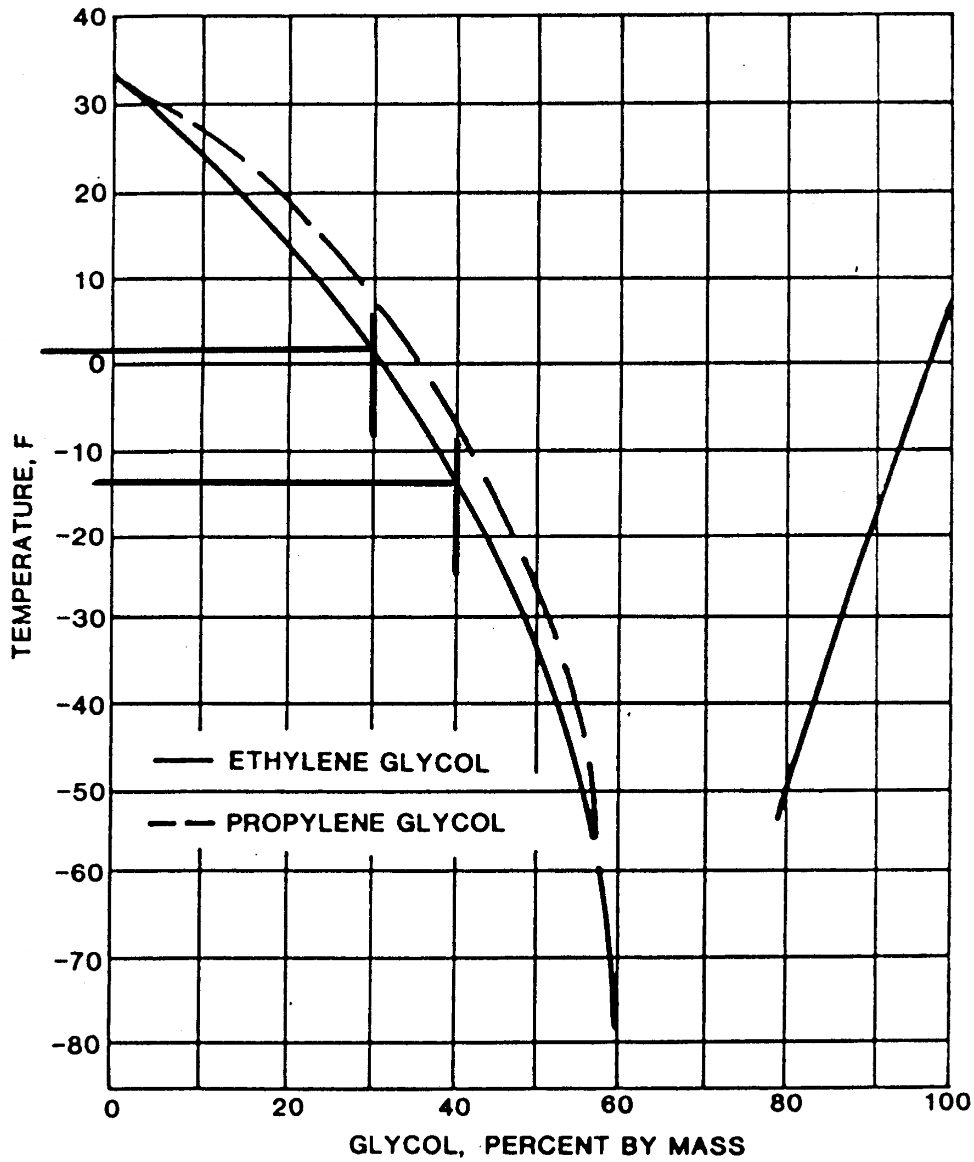
FOR TURBULENT FLOW ONLY

MULTIPLY PRESSURE DROP FROM WATER FLOW BY FACTORS TAKEN FROM THIS GRAPH TO GET CORRECT PRESSURE DROP.



*Kinematic Viscosity (Y) is Obtained From Formula $Y = \frac{U}{S}$

Where U Is Absolute Viscosity In Centipoise & S Is Specific Gravity



Freezing Points of Aqueous Solutions of Ethylene Glycol and Propylene Glycol

Cogitation

1.0 Question: The customer would like to add 30% by weight of Ethylene Glycol to their chilled water system for the purpose of freezing protection. The chiller has been checked and will produce same capacity when the Ethylene Glycol added. The original capacity is to cool 864 GPM of chilled water from 48.4°F to 42°F; If the chiller is to maintain at same capacity and the same temperature range, what will the new GPM flow for the brine?

(a) Calculate TR for the chilled water:

$$TR = \frac{GPM}{24} \times S.G. \times C_p \times (T_1 - T_2)$$

GPM = 864 GPM
T_1 = 48.4°F
T_2 = 42.0°F
S.G. = 1.0
C_p = 1.0

$$TR = \frac{GPM}{24} \times S.G. \times C_p \times (T_1 - T_2)$$

$$= \frac{864}{24} \times 1.0 \times 1.0 \times (48.4 - 42)$$

$$= 230.4 \text{ TR}$$

(b) At 230.4 TR, same temperatures range.

Chilled water change to 30% by weight of Ethylene Glycol, the thermodynamic properties:

$$\text{Brine Average Temperature} = \frac{T_1 + T_2}{2} = \frac{48.4 + 42}{2}$$

$$= 45.2°F$$

At 45.2°F average brine temperature, from the curves:

S.G. = 1.045
C_p = 0.89

$$TR = \frac{GPM}{24} \times S.G. \times C_p \times (T_1 - T_2)$$

$$GPM = \frac{TR \times 24}{S.G. \times C_p \times (T_1 - T_2)}$$

$$= \frac{230.4 \times 24}{1.045 \times 0.89 \times (48.4 - 42)}$$

$$= 928.98$$

Flow for 30% by weight E.G. = 929 GPM

2.0 Ethylene Glycol brine system for ice making.
The brine temperatures: 33°F in, 26°F out at the beginning of the ice making cycle.
Final pull down for the ice making, 13°F in, 10.4°F out.
The system is always operated at evaporative temperature not more than 14°F below the brine leaving temperature.

(a) What is the Ethylene Glycol brine concentration recommended for this system?

Lowest evaporative temperature = 10.4 - 14 = -3.6°F

The brine concentration for freezing protection should be 5°F below the lowest ET, therefore, the freezing point of the E.G. should be below down to (-3.6 - 5) = -8.5°F.

From the chart, the brine concentration for -8.5°F protection is 37% by wt. Therefore, a 40 % by weight Ethylene Glycol brine for this brine system is recommended.

(b) What is the pumping horsepower increase for the final pull down over the beginning of the ice making cycle.?

Beginning of ice making cycle operation:

The brine temperatures at beginning of ice making cycle: 33°F in, 26°F out. Average brine temperature is 29.5°F. the brine properties for 40% by weight of E.G. at 29.5°F are:

S.G. = 1.066
μ_{cp} = 5.97 c.p.

$$y = \frac{\mu_{cp}}{S.G.} = \frac{5.97}{1.066} = 5.6$$

From pressure drop correction curve at y = 5.6, S.G. = 1.066

φ_1 = Brine Correction Factor = 1.31

$$BHP = \frac{W \times H}{33{,}000 \times \eta}$$

W = Weight of liquid per min.
= GPM x S.G. x8.33

H = Total head in feet
= Head x φ

$BHP_1 \approx W \times H$

$\approx$ (GPM x S.G. x8.33) x (Head x φ_1)

$\approx$ (GPM x 1.066 x8.33) x (Head x 1.31)

Final pull down of ice making cycle operation:

The brine temperatures at final pull down of ice making cycle: 13°F in, 10.4°F out. Average brine temperature is 11.7°F. the brine properties for 40% by weight of E.G. at 11.7°F are:

$S.G. = 1.068$

$\mu_{cp} = 9.07$ c.p.

$$y = \frac{\mu_{cp}}{S.G.} = \frac{9.07}{1.068} = 8.493$$

From pressure drop correction curve at y = 8.493, S.G. = 1.068

φ_2 = Brine Correction Factor = 1.42

$BHP_2 \approx W \times H$

$\approx$ (GPM x S.G. x8.33) x (Head x φ_2)

$\approx$ (GPM x 1.068 x8.33) x (Head x 1.42)

The pumping horsepower increase:

$$= \frac{(GPM \times 1.068 \times 8.33) \times (Head \times 1.42)}{(GPM \times 1.066 \times 8.33) \times (Head \times 1.31)}$$

$$= \frac{1.068 \times 1{,}42}{1.066 \times 1.31}$$

$= 1.086$

Therefore, 8.6% pumping horsepower increase during final pull down over the beginning cycle of ice making.

Fill in the Data for the Summery Sheet:

1.0 (a) What is the TR for the chilled water duty. TR	230.4 TR
1.0 (b) What is the EG brine flow for 30% by wt. GPM	929 GPM
3.0 (a) What is the Recommended EG brine concentration for the system. % by wt.	40% by wt.
2.0 (b) What is the percent of the pumping HP increase for the system at the final pull down cycle over the beginning of the ice making cycle.	8.6%