

How Low is Low Charge? A clarifying discussion

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How low is low charge?

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Results of survey made by Monika Witt, Spring 2019

what is a low charge system?	flooded [kg/kW]	DX [kg/kW]	pumped [kg/kW]	reason	disadvantages low charge
		0,03	0,3-1,2		
< 1000 kg in the facility	0,4 (Chiller) 2,3 (freezer pack)	?	5,6	Government regulations (licence ammonia needed), safety (reduce risk)	factory assembled units expensive, sensitive towards leaks, weight of packaged units too high
IIR note: lowest charge required for stable operation of the unit over the full range of possible operating conditions while maintaining the system's rated capacity GCCA: < 1,3 kg/kW	0,09 to 0,65	1,16	2,32	safety	sensitive to overcharging or refrigerant leak
< 0,3 kg/kW flute&frame HX, roof top packages				elimination of liquid overfeed, replacing large vessels	
< 0,2 - 1 kg/kW	0,1 (lowest 0,05)	1 (lowest 0,6)	5-10 (lowest 2)	avoiding being classed as a Major Hazard Installation	
An ammonia refrigeration system that can run with small amounts of refrigerant when compared with traditional solutions < 10.000 lbs	0.5	0.1	not really low charge	Safer system, having a smaller ammonia charge makes it safer in case of a leak	

The topic "low-charge" mainly discussed in Australia, Europe and North America

A definition

- **Defining “low charge”**
- “The minimum charge in a refrigeration system is the minimum charge required for stable operation of the unit over the full range of possible operating conditions”
- *IIR 25th Informatory Note on Refrigeration Technologies*

Low Charge – important, but to who?

- The fire brigade – what is the total charge in the machine room?
- The service engineer – how big are each circuit?
- The customer – how much can I loose at any time?
- The neighbour(s) – can the leaked refrigerant be contained in the room?
- First responders – how much can we have when we enter the machine room?
- What does the standards (e.g. EN 378/ISO 5149) say?

- What risks do we consider?
 - Earthquake
 - Fire
 - Terrorism
 - Lack of competence

Classifying systems

- Chillers with all the pipes and vessels on a unit frame.
- Units connect to one application e.g. freezer, chiller, cascade heat exchanger
- Larger extended systems with many evaporators with common compressor units



Some ammonia properties

Properties at use

Properties at charging conditions

Temperature	Density			Specific weight
[°C]	[g/l], [kg/m ³]	[mol/dm ³]	[lb/ft ³]	[N/m ³]
-35	0.8843	0.0519	0.0552	8.672
-10	0.7938	0.0466	0.0496	7.785
0	0.7625	0.0448	0.0476	7.478
10	0.7336	0.0431	0.0458	7.194
20	0.7069	0.0415	0.0441	6.932
30	0.6822	0.0401	0.0426	6.690
40	0.6593	0.0387	0.0412	6.466
50	0.6380	0.0375	0.0398	6.257
75	0.5909	0.0347	0.0369	5.795
100	0.5509	0.0323	0.0344	5.402
125	0.5162	0.0303	0.0322	5.062
150	0.4858	0.0285	0.0303	4.764
175	0.4586	0.0269	0.0286	4.497
200	0.4341	0.0255	0.0271	4.257
250	0.3917	0.0230	0.0245	3.842
300	0.3573	0.0210	0.0223	3.503
350	0.3295	0.0194	0.0206	3.232
400	0.3058	0.0180	0.0191	2.999

Low charge

??

Source:
<https://www.engineeringtoolbox.com>

Chillers

Comparing low charge chillers

NH3 Solutions	Capacity	Charge	kg/kW
W01	50	5	0,100
W1	59	6	0,102
W2	70	7	0,100
W3	94	10	0,106
W4	108	12	0,111
W5	141	16	0,113
W6	162	17	0,105
W7	193	21	0,109
Average			0,107

Comparing low charge chillers

Azanechiller water cooled	AW200	AW350	AW450	AW600	AW700	AW850	Average
Capacity (kW)	235	348	446	610	708	856	
Refrigerant Charge (kg)	32	38	52	63	77	86	
kg/kW	0,136	0,109	0,117	0,103	0,109	0,100	0,109
Azanechiller HT air cooled	AA275	AA400	AA400E	AA550	AA500E	AA850	Average
Capacity (kW)	273	407,3	407,2	540	541,9	636,5	
Charge approx (kg)	47	66	68	87	90	97	
kg/kW	0,172	0,162	0,167	0,161	0,166	0,152	0,162

Low charge

Charge 0,083kg/kW

Tecnofreddo trumpets low-charge NH₃ experience

By Charlotte McLaughlin, Feb 27, 2019, 08:52 GMT+1 • 1 minute reading

The firm has installed 75+ low-charge ammonia units.



ECO₃ SERIES, from Tecnofreddo, which is an ammonia unit for indoor installation.

Tecnofreddo, with over 25 years of experience in commercial and industrial refrigeration engineering, has now installed over 75 low-charge ammonia systems in Europe, according to Manuela Rallo, sales area manager at Italian manufacturer Tecnofreddo.

The charge of these units is around 50 kg of ammonia in 600 kW of capacity (a ratio of 12 kW to 1 kg of ammonia charge). “It’s not a big deal for us,” said Rallo at Refrigera 2019 in Piacenza, Italy. “We have done so many [low-charge ammonia] units.”

Most of Tecnofreddo’s installations have been in the industrial refrigeration or process-cooling sector, particularly in Italy, which restricts the amount of ammonia allowed in a system.

In Europe, “we have [also] been installing ammonia chillers [as reversible] heat pumps.” she added.

These installations include HVAC too. For example in Norway, the manufacturer recently installed an ammonia chiller at a medical centre for heating and cooling the building.

Rallo cited Norwegian tax discounts for natural refrigerants as playing an important role in growing the market.

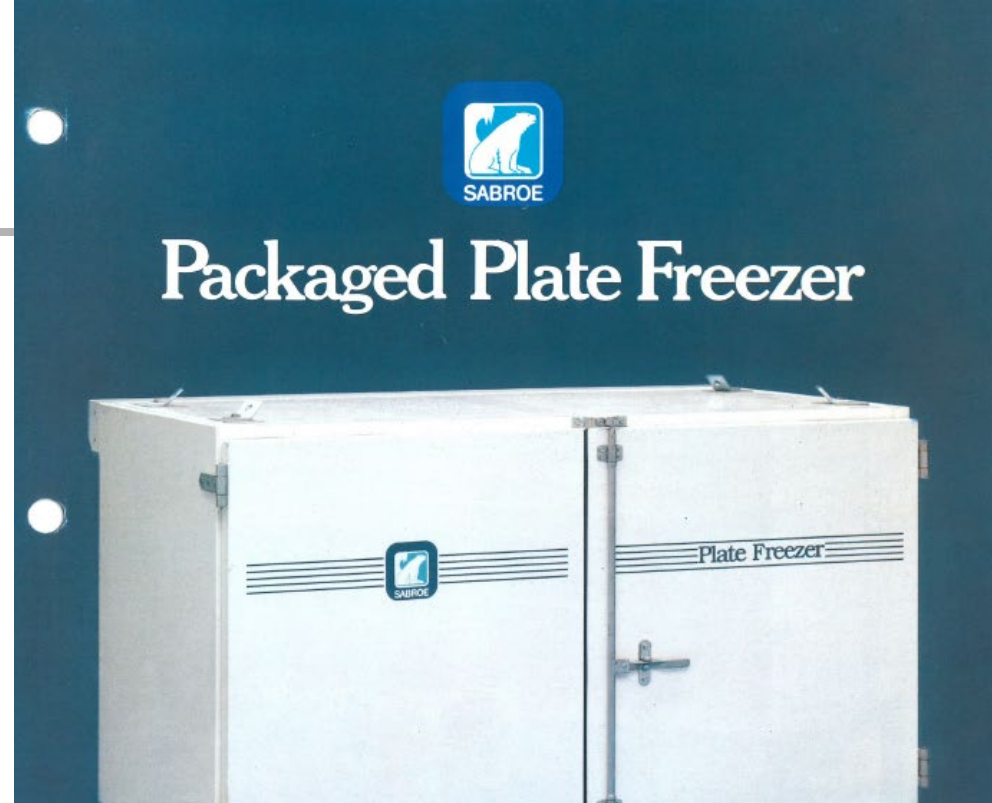
Comparing low charge chillers

SABROE	Capacity	Charge	kg/kw
ChillPAC 24A	117	10	0,085
ChillPAC 34A	137	10	0,073
ChillPAC 26A	176	12	0,068
ChillPAC 36A	205	13	0,063
ChillPAC 28A	233	14	0,060
ChillPAC 38A	275	16	0,058
ChillPAC 104 S-A	273	15	0,055
ChillPAC 104 L-A	361	21	0,058
ChillPAC 104 E-A	369	19	0,051
ChillPAC 106 S-A	406	20	0,049
ChillPAC 106 L-A	544	27	0,050
ChillPAC 106 E-A	553	27	0,049
ChillPAC 108 S-A	573	28	0,049
ChillPAC 108 L-A	709	31	0,044
ChillPAC 108 E-A	729	34	0,047
ChillPAC 112 S-A	851	40	0,047
ChillPAC 112 L-A	1055	46	0,044
ChillPAC 112 E-A	1076	50	0,046
ChillPAC 116 S-A	1114	51	0,046
ChillPAC 116 L-A	1348	53	0,039
ChillPAC 116 E-A	1350	53	0,039
Average	12454	59	0,047

Freezers

From a brochure - a reference

Ver. 7
Printed 1987



PFP 174-10 => 1,25kg/kW

Also available for NH₃

No. of freezing stations	6	7	8	9	10
Charge of R22/R717 kg	80/40	85/42	90/45	95/47	100/50
Operating weight	3350	3425	3500	3575	3650

Modern solutions for freezers



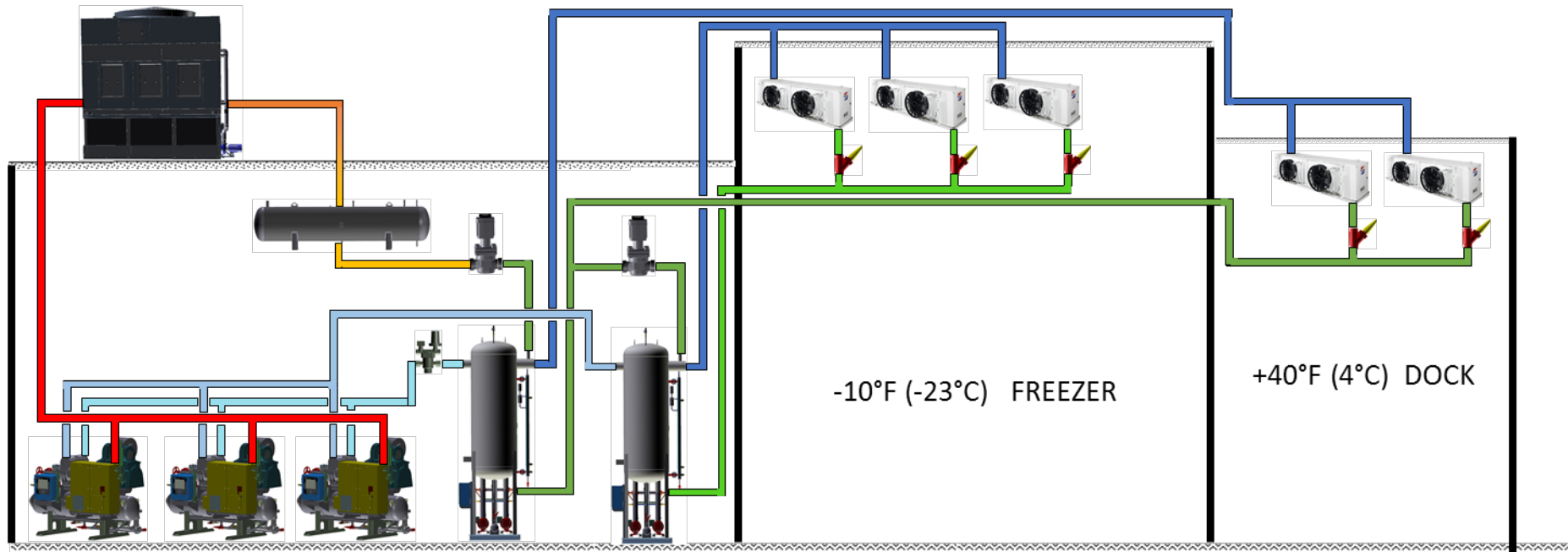
Average kg/kW 0,642

	Azanefreezer						
Models	AF 110	AF 120	AF 140	AF 200	AF 250	AF 300	AF 350
System capacity (kW)	107	117,2	140,6	200,2	254,8	305,4	382,2
Refrigerant charge	95	104	112	138	146	175	198
kg/kW	0,888	0,887	0,797	0,689	0,573	0,573	0,518

Cold store systems

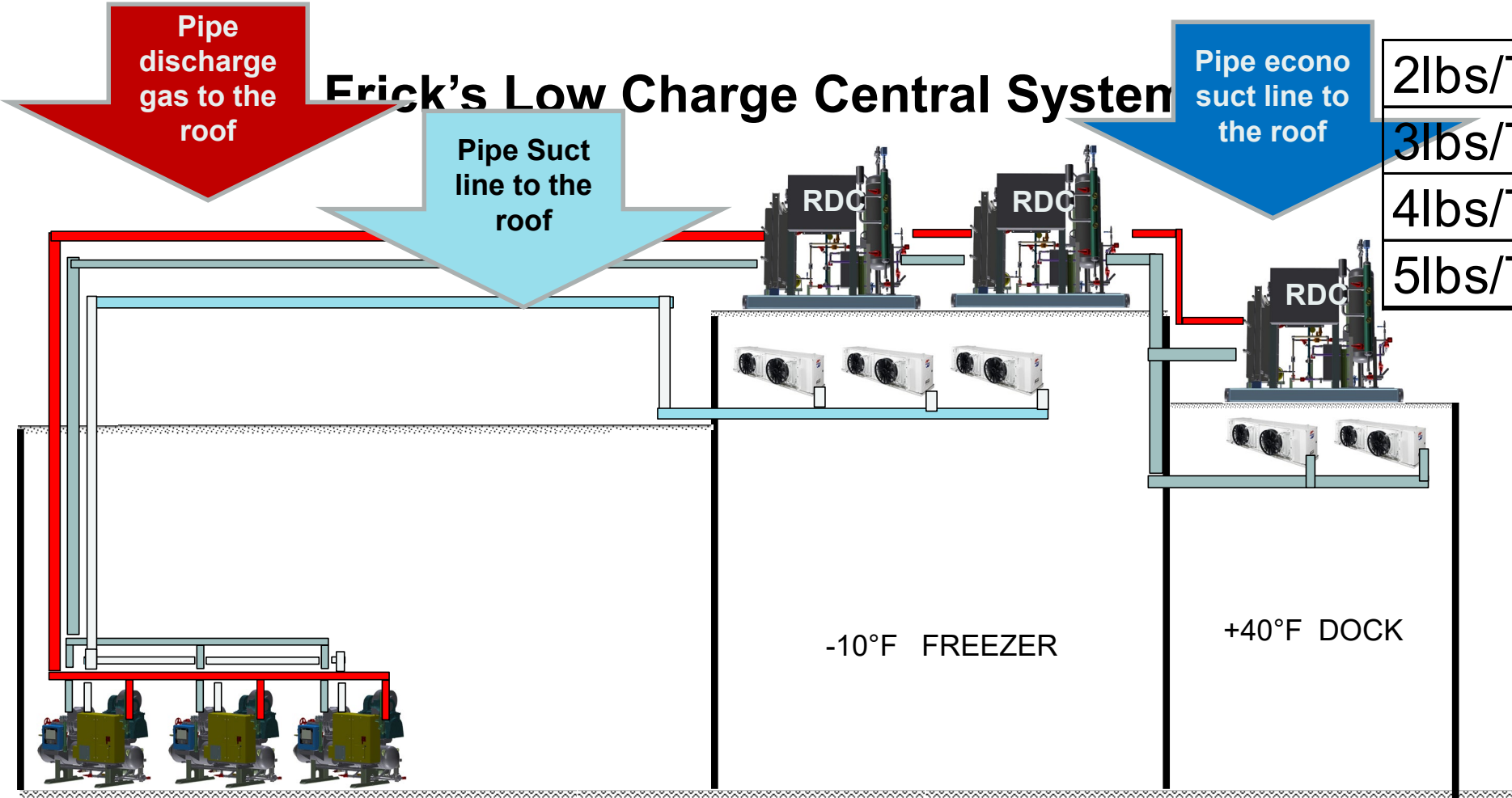
Traditional Liquid Recirculation System
Flexible – Efficient – Well known.
But : High NH3 Charge 20-23 lbs/TR (0.4- 0.3 kW/kg)

20lbs/TR	2,585	kg/kW
21lbs/TR	2,715	kg/kW
22lbs/TR	2,843	kg/kW
23lbs/TR	2,971	kg/kW



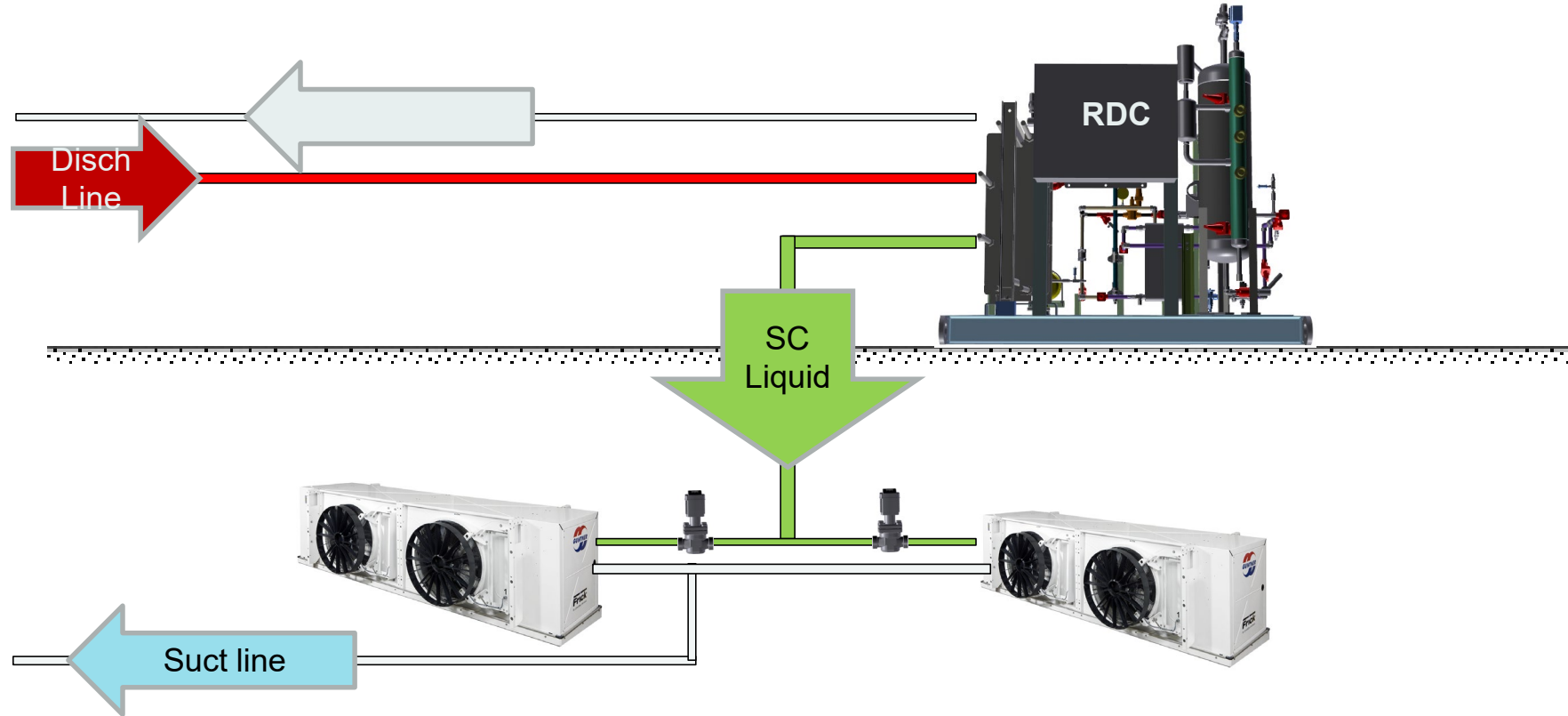
LCCS

Erick's Low Charge Central System



2lbs/TR	0,259	kg/kW
3lbs/TR	0,387	kg/kW
4lbs/TR	0,518	kg/kW
5lbs/TR	0,645	kg/kW

Frick's Low Charge Central System – Each RDC would feed two DX evaporators in close proximity



**ACUair
Hygienic Air
Handlers**



**Falling Film
Heat
Exchangers**

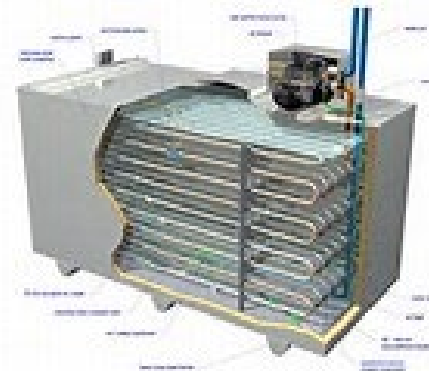
**LCCS can also connect to process
equipment**



**Ice Cream
Votators**



PFHE



Ice Builders

Condensing can be any type

- Adiabatic
- Glycol Plate HX with Evaporative fluid cooler
- Evaporative
- Air-cooled

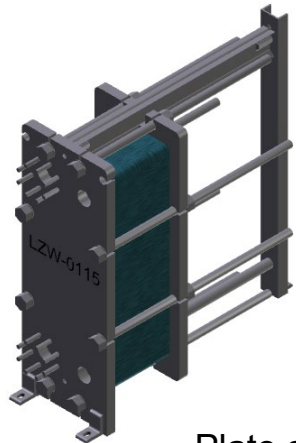
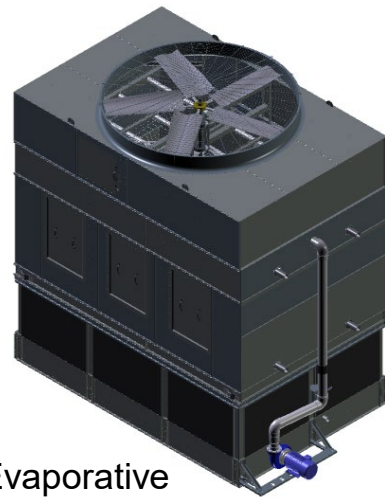
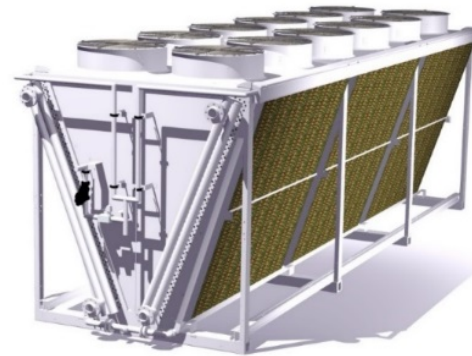


Plate and Frame



Evaporative



Adiabatic



Air- Cooled



Lower ammonia charge – not low

7lbs/TR	0,904	kg/kW
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Benefits:

» **Significantly smaller ammonia charge**

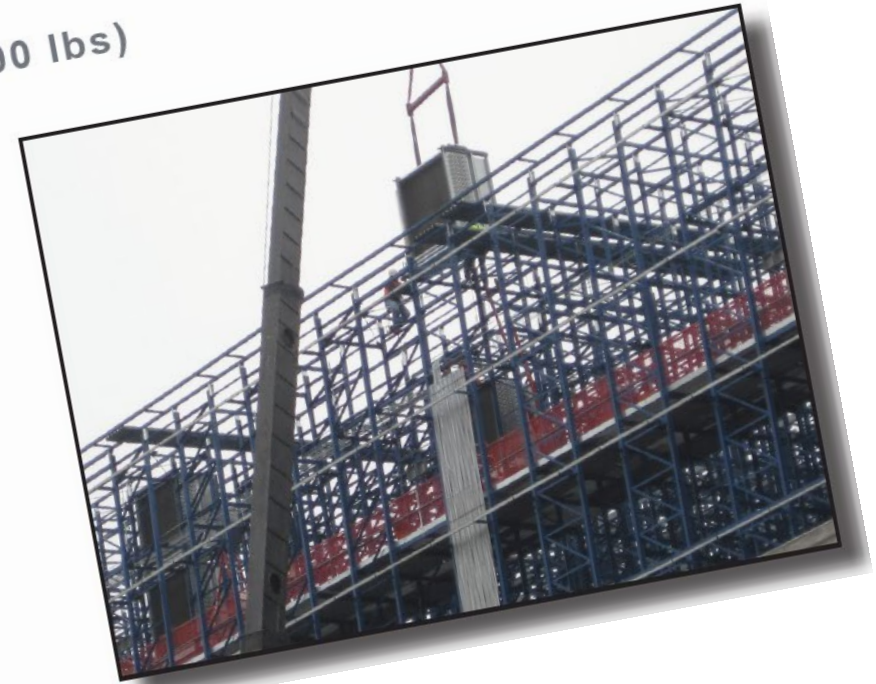
- 7 lbs/TR vs 30 lbs/TR for pumped bottom feed
- Reduced health and safety risks
- Reduced regulatory burden (< 10,000 lbs)
- Faster defrost cycle

» **Energy efficient**

» **Lower first cost***

» **Simple operation**

*Compared to traditional pumped ammonia



What is the total charge and capacity?

2lbs/TR	0,259	kg/kW
6lbs/TR	0,774	kg/kW



LCR-P Penthouse Models

The Evapcold LCR-P product line is based on a penthouse configuration and includes 250 models that have an ammonia charge ranging from 2 to 6 lbs. per TR (actual charge amount dependent on the model size). The LCR-P is specifically designed to be roof mounted on the refrigerated space. Penthouse units are available with Pumped Recirculated Liquid (PRL) ammonia evaporators for low and medium temperature applications, or Direct Expansion (DX) evaporators for medium and high temperature applications.

NH₃/CO₂ cascade systems

Model	Capacity	Min. Charge	kg/kW
CAFP 80	144	120	0,833
CAFP 120	264	120	0,455
CAFP 160	363	120	0,331
CAFP 200	415	180	0,434
CAFP 300	599	300	0,501
CAFP 400	793	400	0,504
Average			0,481

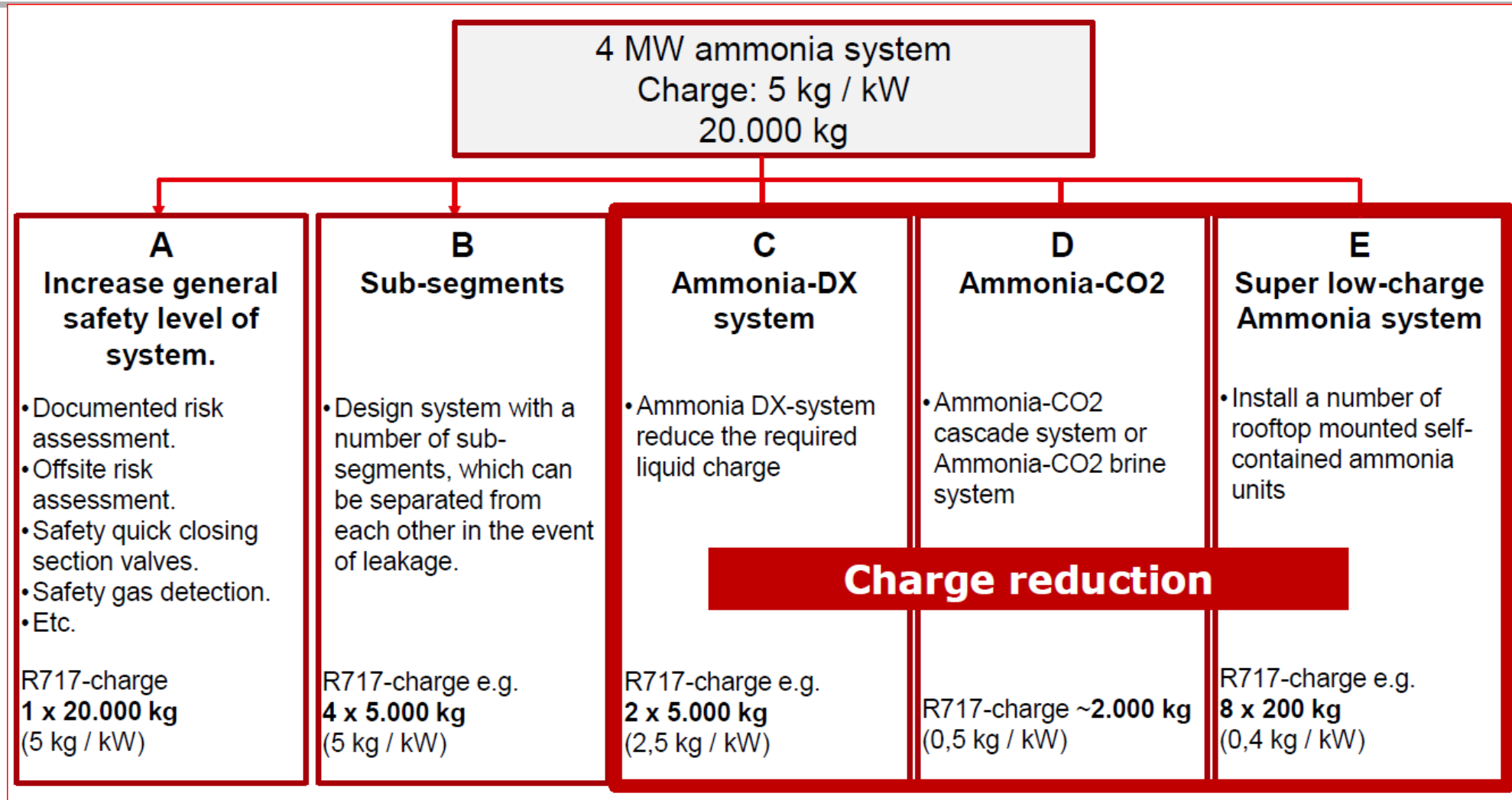
Charge size highly depends on the distance to the freezer and the freezer internal volume

Temperature matters

Model	Temperature (°C)	Capacity (kW)	NH ₃ charge (kg)	kg/kW
CAFP 400	-35	793	400	0,504
CAFP 400	-40	667	400	0,600
CAFP 400	-45	520	400	0,769
CAFP 400	-50	421	400	0,950

Conclusions

A proposal from Danfoss



In conclusion

- Low charge chillers from 30 – 110 g/kW
- Freezer charges down to about 500 g/kW depending on a number of factors
- Cold stores from about 200 g/kW and up depending on a number of factors
- Cascade systems from about 300 g/kW and up depending on a number of factors

- HOWEVER, g/kW or kg/kW does not tell the user anything about the total charge on site
- Competence of the personnel working with the systems must always be according to ISO 22712
- Between 40% and 60% of all accidents and releases happen during the service and maintenance
- Most reported accidents seen could be prevented had the persons been properly trained and educated

Conclusions

- Charge depends on the application and temperature
- Charge depends on the technology used
- Charge depends on length of pipes
- Charge depends on the heat exchangers used
- Charge depends on a variety of other factors as well
- Total ammonia charge on site is important and not only the individual circuit

- The expression “low-charge” is a meaningless marketing expression especially without a reference
- More clarity and transparency to the claims if you want to claim low or lower charge
- It is not the ammonia which is the problem – it is the competence of the technicians and engineers
- Most accidents could have been prevented with adequate education and regular training
- It is all about safety for products, humans and investments

Thank you for your attention