



# Low Charge CO<sub>2</sub> Ammonia Cascade System

*Carnie B. Marsh – Alfa Laval*

# C02/Ammonia Cascade Systems

*Cascade CO2/Ammonia Refrigerating System have proven to be viable alternatives to conventional two-stage ammonia – especially at lower temperatures.*

*Lower temperature CO2 circuits can result in higher energy savings and operating cost utilizing a two stage CO2/Ammonia Refrigerating System at a typical operating temperature range of -58°F (-50°C) to +20°F (-6.67°C).*

*Various Application in Industrial Refrigeration where CO2 can play a vital role included:*

- Refrigerated Warehouses
- Process Plate Freezers
- Spiral Freezers
- Blast Freezing

# C02/Ammonia Cascade Systems

## PROS

- *Both carbon dioxide & ammonia are natural refrigerants*
- *No ammonia in the process area*
- *Lower operating cost – higher production yields*
- *C02 systems always operates at a positive pressure*
- *Reduced ammonia charge*

# C02/Ammonia Cascade Systems

## CONS

- *Higher working pressures at moderate temperatures*
- *Potential risks of mixing ammonia & carbon dioxide*
- *Not widely used (yet!) and limited experience with many Contractors in North America*
- *Typically requires electric defrost*
- *Carbon dioxide is not self alarming as ammonia*

# C02/Ammonia Cascade Systems

## *Semi-Welded Plate Heat Exchanger Technology*

*With Alfa Laval's long experience as world leader of plate heat exchanger technology. And with the over 30,000 successful Semi-Welded units installed for refrigeration applications we thought it would be a good idea to improve our Semi-Welded Plate Heat Exchanger to meet the higher design pressure needs for these applications.*



- M10BW-FT 600 PSI Rating (4" Port)
- MK15BW-FT 600 PSI Rating (6" Port)
  - New pressure design
  - New gasket development for refrigerants both sides

# C02/Ammonia Cascade Systems

**Reliability** is a top prioritized demand in every application and when there is a risk to mix  $\text{NH}_3$  and  $\text{CO}_2$  it will become a disaster, when it happens. In an All Welded unit **every** leakage is internal and ammonium carbonate will contaminate the system.

A leakage in a Semi Welded unit will always be **external !!!**



# C02/Ammonia Cascade Systems

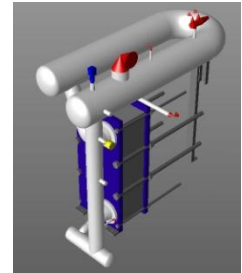
## *Low Charge for Ammonia Side*

*One of the major considerations impacting refrigeration plants today is the refrigerant charge. Any opportunity to reduce the overall charge can help.*

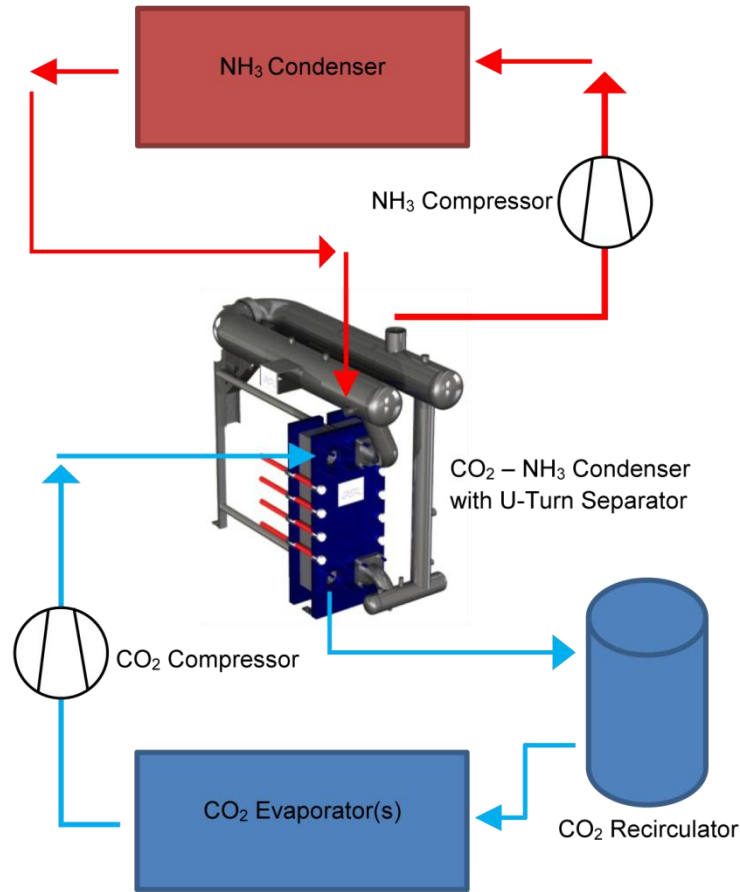
*One of the major advantages of the Semi-Welded plate Heat Exchanger is this lower charge opportunity.*

*We decided to go a step further with our separation experience and reduce the conventional flooded separator vessel to a more compact and lower charge design.*

*And thus was born the U-Turn<sup>®</sup>™ Ammonia Flooded Separator!!*



# CO<sub>2</sub>/Ammonia Cascade With Semi-Welded Plate Heat Exchanger & U-Turn™ Separator System





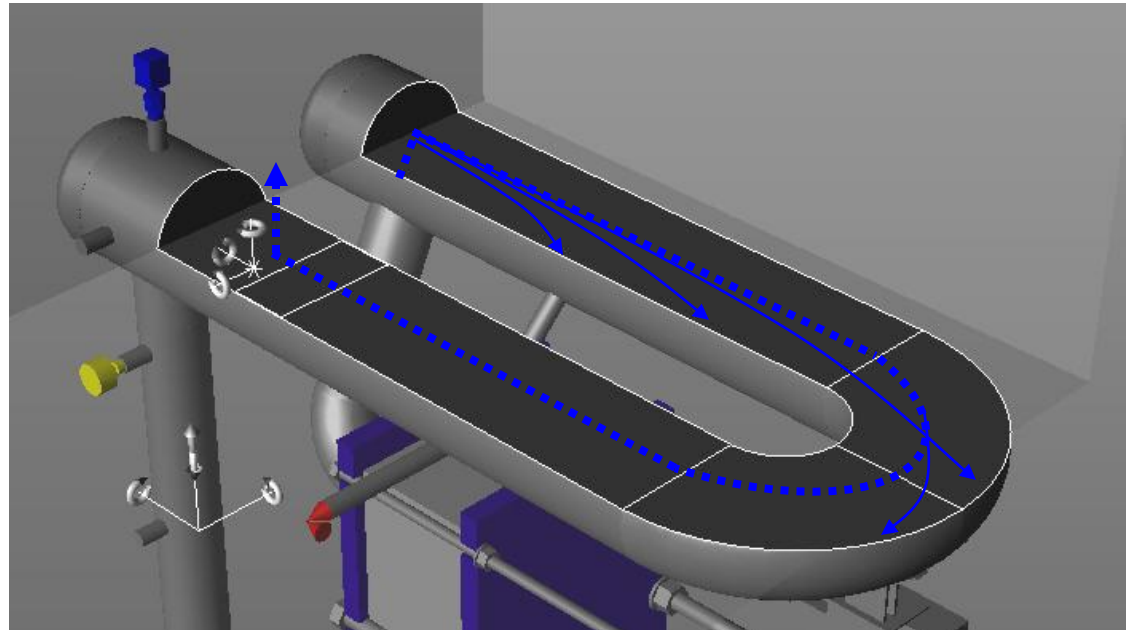
# C02/Ammonia Cascade With Semi-Welded Plate Heat Exchanger & U-Turn<sup>®</sup>™ Separator System

## Gravity Separation

*Droplets separate by gravity forces along the flow path*

*Separation margins:*

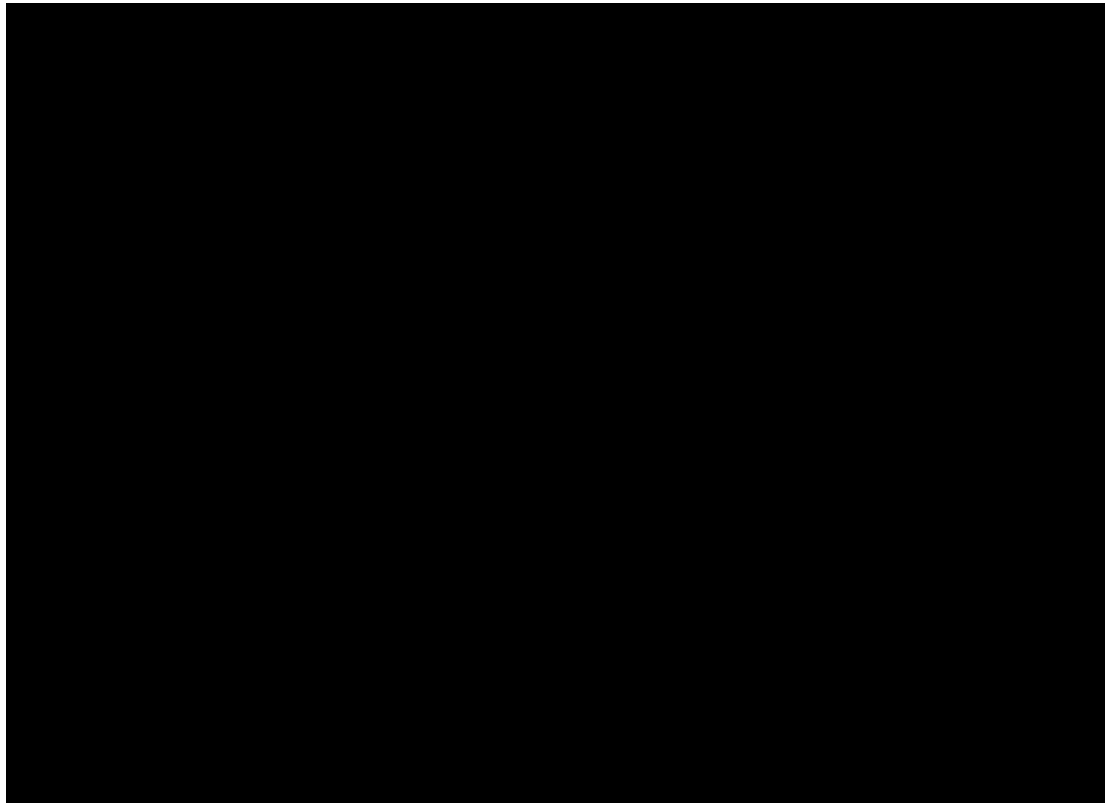
- ✓ *Separation Length 25 %*
- ✓ *Max velocity is only 60 % of re-entrainment velocity*



- *The U-Turn<sup>®</sup>™ Separator not only uses the Conventional Gravity Separation .....*

# C02/Ammonia Cascade With Semi-Welded Plate Heat Exchanger & U-Turn<sup>®</sup>™ Separator System

- Agglomeration
  - Surface Tension
    - Centrifugal Forces



# C02/Ammonia Cascade Systems

## *Results and Comparisons*

*Based on:*

***A C02 -58°F (-50°C) Low Temperature System. Load 1380 MBH.***

***C02 Condensing at +0°F (-17.8°C). Flooded Ammonia cooling  
Evaporator at - 10°F (-23.2°C)***

*Flooded Shell & Tube = 210 Lbs Ammonia (95.3 kg)*

*Shell & Plate = 175 Lbs Ammonia (79.4 kg)*

*SWPHE w/Conventional Separator Vessel = 146 Lbs Ammonia (66.2 kg)*

***SWPHE with U-Turn®™ Separator = 26 Lbs Ammonia (11.8 kg)!***



business case

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**natural refrigerants**

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Thank you very much!