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Vaporizers for Cryogenic Service

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Vaporizers

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Vaporizer types

- Vaporizers are heat exchangers that transfer heat to vaporize the cryogenic liquid into vapor and supply the customer with gas product.
  - There are five types of vaporizers utilized in customer installations:

Ambient

Steam Heated Water Bath

Shell and Tube

Electric

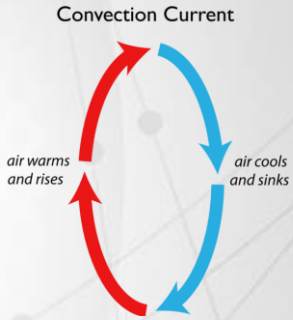
Fan Assist

Heat transfer

- 3 Modes of Heat Transfer
  - Conduction – heat transfer through solids or stationery fluids
  - Convection – heat transfer through the movement of fluids
  - Radiation – heat transfer through electromagnetic waves

Vaporizers – Ambient

- Ambient vaporizers are the most commonly used vaporizer in bulk installations.
  - They consist of aluminum finned extrusions connected to one another with u-tubes allowing liquid to make multiple passes through the heat exchanger.
  - Natural convection of air transfers heat to liquid product, vaporizes it and superheats the gas prior to exiting the vaporizer.
  - Pros:
    - Require no utilities from the customer
    - Low cost
    - Low maintenance and high reliability due to no moving parts
  - Cons:
    - Cannot warm gas above ambient temperature
    - More space required for larger systems



Vaporizers – Ambient

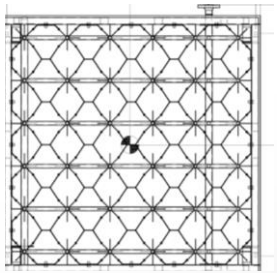
- Two common uses of Ambient Vaporizers
  - Process: Used to vaporize liquid product in order to supply customer with gas product.
  - Pressure Building: Designed to provide additional pressure build capacity for the vessel.

Pressure Building

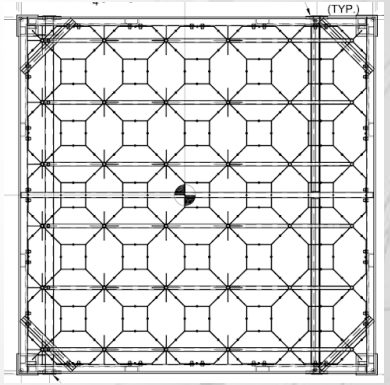
Process

Vaporizers – Ambient

- Construction of Process Ambient Vaporizers
  - Supergap:
    - 4” gap between fin tips
    - 12” center to center spacing
    - For normal use
  - Widespace:
    - 8” gap between fin tips
    - 18” center to center spacing
    - For higher flows and high humidity areas
    - Longer time for ice to bridge passes
    - Longer use time



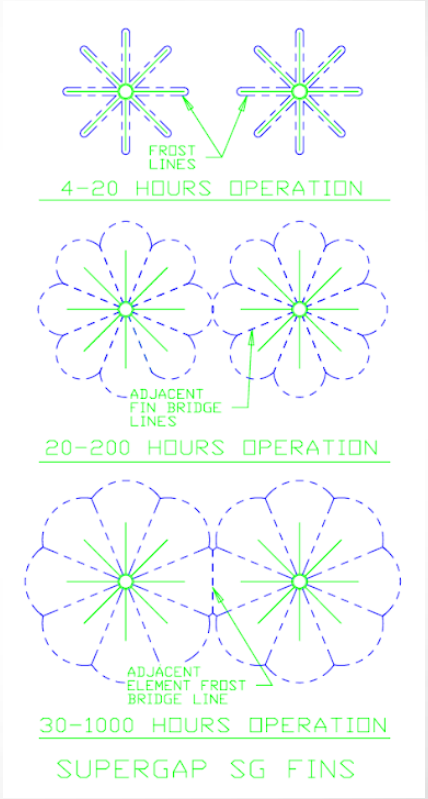
Supergap

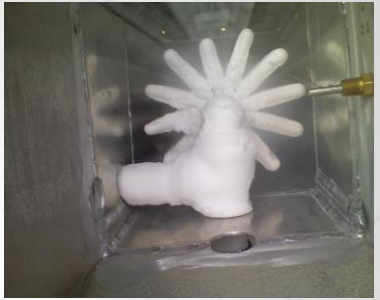


Widespace

Why to we have all these options

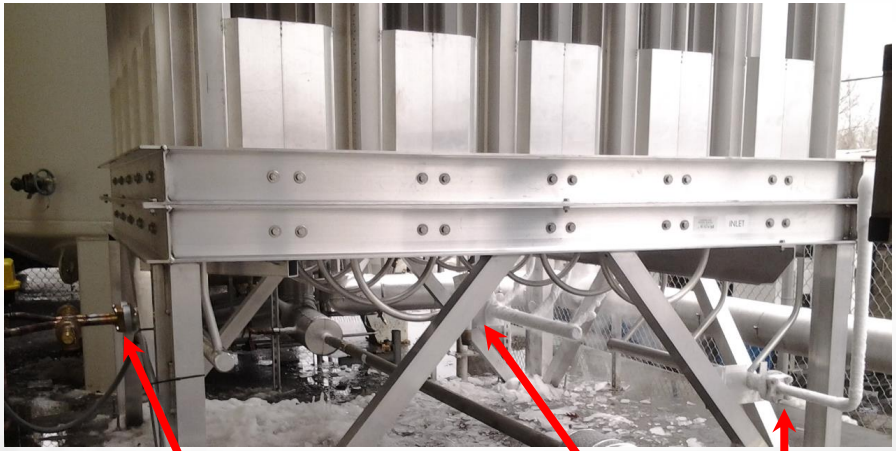
- In vaporization, frost growth is your enemy
- Frost on the extrusions reduces heat transfer between the ambient air and the fluid which leads to a loss of capacity
- Relative humidity
- Surface area vs. derating (frost growth) is key to sizing using different extrusion types
- 1:1 ratio of in-use to defrost time





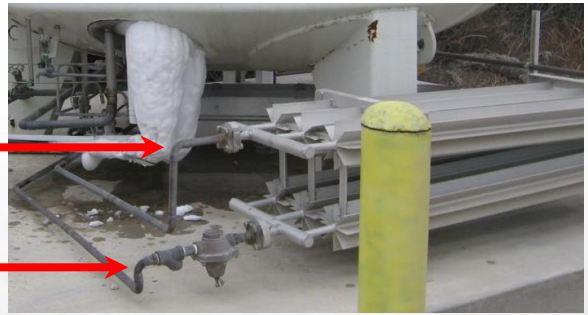
Vaporizers – Ambient

- Construction of Process Ambient Vaporizers
  - Dual Circuit:
    - Some larger vaporizer have two inlets and one or two outlets. These vaporizers are used to optimize flow (lower pressure drop) through the vaporizer.



Vaporizers – Ambient

- Construction of Pressure Building Ambient Vaporizers
  - The inlet is at the bottom and the outlet is at the top of the vaporizer to ensure low pressure drop.
  - They are designed with inlet and outlet headers and one pass flow to provide optimal pressure building functionality. They come in vertical or horizontal orientation.



Vaporizers – Ambient

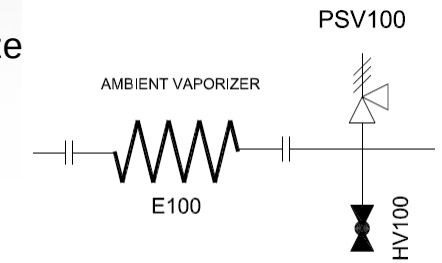
- Sizing of Ambient Vaporizers
  - Vaporizers are sized according to their capacity in standard cubic feet per hour (scfh) based on 8 hours of continuous flow at standard ambient conditions (70F).
  - Many factors affect the efficiency of an ambient vaporizer.
    - Average outside temperature – colder climates will require greater vaporization capacity
    - Average relative humidity – higher humidity will accelerate the accumulation of ice on the vaporizer reducing the overall capacity. This capacity reduction will take place even if the ambient conditions are warm.
    - Altitude – the reduced density of ambient air at higher altitudes will reduce the total vaporization capacity
    - Physical location – obstructions of air flow and reduced exposure to direct sunlight will adversely affect the vaporizer's efficiency.

Vaporizers – Ambient

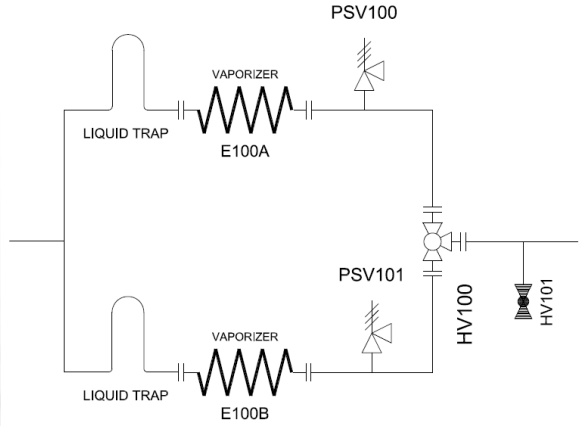
- Required Information for Sizing of Ambient Vaporizers
  - Customer's use pattern: How often is the customer pulling product? 24 hrs/ 7 days a week, 8 hrs/ 5 days a week, etc.
  - Flow pattern: Does the customer have a steady draw? Or do they have peaks and for how long?
  - Freeze period: Number of consecutive days that the highest temperature is below freezing.
  - Atmospheric conditions

Vaporizers – Ambient

- Configuration
  - Single Vaporize

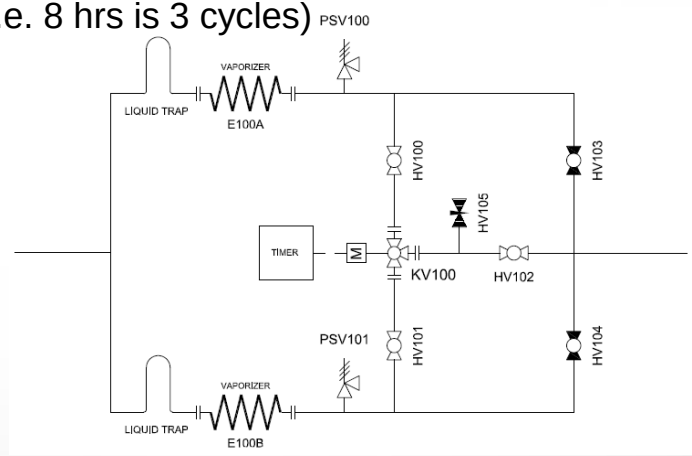


  - Parallel: Two vaporizers piped in parallel so each is getting half the flow rate. Both stay online continuously.



Vaporizers – Ambient

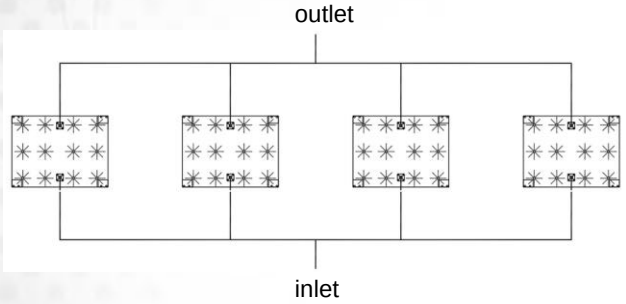
- Configuration
  - Switching: Two vaporizers piped in parallel that alternate being online and offline to de-ice. Each vaporizer sees the full flow rate while online.
    - Vaporizers should be switched so that there are an odd number of cycles in a day to alternate vaporizers during daytime and nighttime (i.e. 8 hrs is 3 cycles)



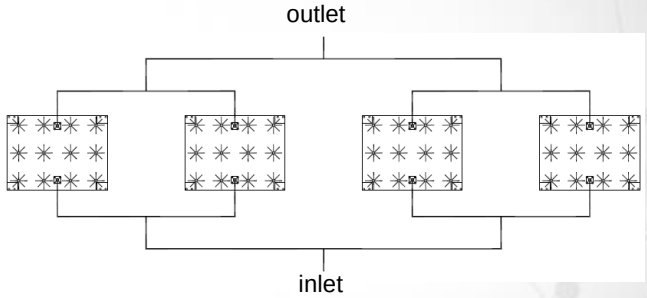
  - Multiple Vaporizers: Multiple vaporizers can be piped in parallel for continuous use or for switching.

Vaporizers – Ambient

- Balancing
  - Flow needs to be balanced when vaporizers are in parallel so each vaporizer is equally loaded.



UNBALANCED

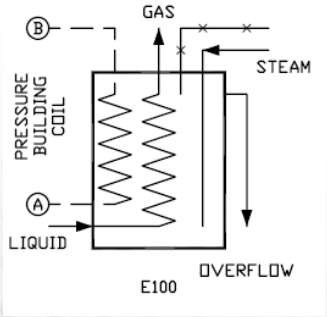


BALANCED

- Layout
  - Spacing of at least 3’ between vaporizers allows maximum airflow and minimizes ice build up
  - Vaporizer inlet should installed to promote de-icing (sun exposure, air flow exposure, spacing, etc)

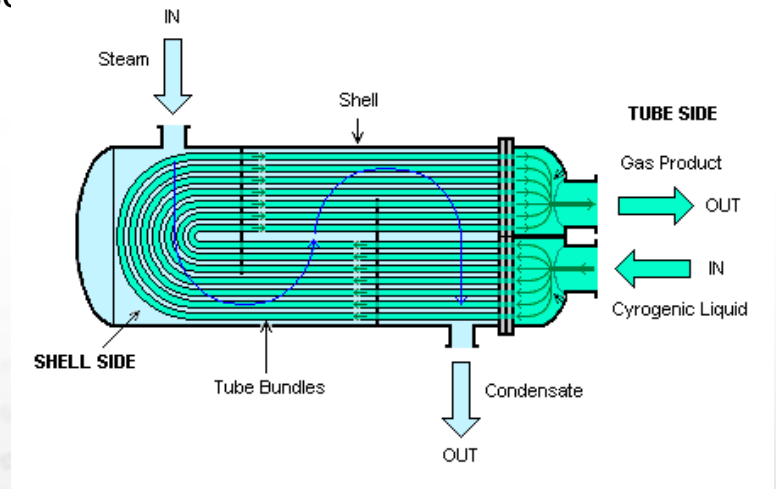
Vaporizers – Water Bath

- The water bath vaporizer uses steam heated water in an insulated tank to vaporize the cryogenic liquid. Steam is sparged into water in an insulated tank. A submerged heat-exchanger coil in the tank carries cryogenic liquid through the steam-heated bath.
- Water bath heat exchangers are most commonly used when customers have high flow requirements and ambient vaporizers are not an option due to space restrictions or other considerations. Customers using water bath heat exchangers must have steam available.



Vaporizers – Shell and Tube

- Shell and tube heat exchangers provide the greatest capacity for high-flow installations. The shell and tube heat exchanger consists of a an outer pressure vessel – the shell – with a bundle of tubes inside it. Cryogenic liquid runs through the tubes while steam flows through the shell. Heat is transferred to the cryogenic liquid through the tube walls. The steam exits as condensate and cryogenic liquid exits as gase



Vaporizers – Electric

- Electric vaporizers provide the heat for vaporization through stainless steel heat transfer coils cast into an aluminum block. They require power to be provided by the customer. Because of the combustion hazards associated with oxygen, There are additional requirements for the use of electric vaporizers in oxygen systems.
  - Require 240V or 480V 3-Phase Power
  - Trim heater can be used to warm gas

Vaporizers – Fan Assist

- Fan assisted vaporizers reduce the footprint required by normal ambient vaporizers by adding an electrically powered fan. They consist of a standard ambient vaporizer enclosed in an aluminum shroud with a fan mounted on top. Air is forced down through the duct increasing the heat transfer. This is not the preferred means of vaporization per Air Liquide standards due to high maintenance costs and lower reliability (loss of power).

Summary

- Wide Variety of process vaporizers that we can use
  - Selection mainly based on flow and heat transfer mechanism.
  - Fin type and spacing, internal extrusion geometry

Questions