

Climate Affects the Selection of Ambient Air Vaporizers

When designing ambient air vaporizers, many factors need to be considered. The environmental effect is one such criterion. When designing and specifying fan-assisted and natural draft ambient air vaporizers, four main climate zones are used: tropical, Mediterranean, humid continental, and marine. Each of these zones, however, may contain micro climate zones with significantly different climate than the surrounding area.



Figure 1

In discussing climatic effects, a basic understanding of the principles of ambient air vaporizers is necessary. Fan-assisted vaporizers utilize forced convective heat transfer whereas natural draft ambient air vaporizers utilize natural convective heat transfer. Natural convective vaporizers are typically manufactured with three different fin spacings, depending on how long the vaporizers are going to be operated before complete defrost is achieved. Standard spaced vaporizers typically operate less than 24 hours before complete defrost and have a fin tip-to-tip air gap roughly 1.5" (38 mm). [Figure 1]

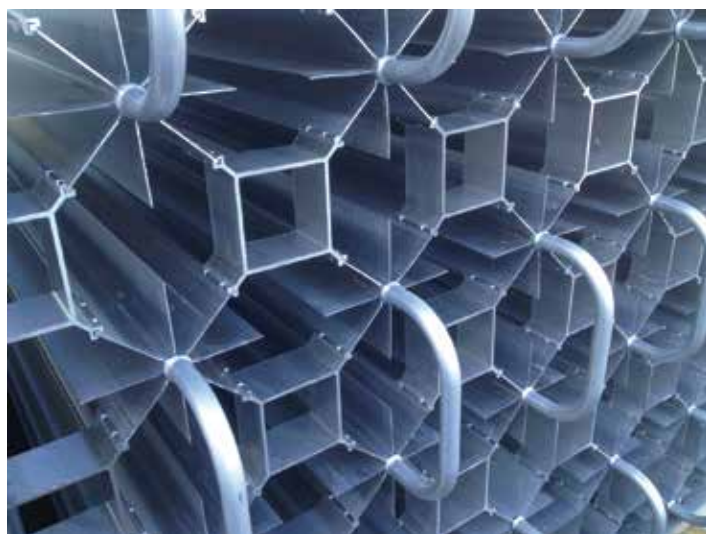


Figure 2

Wide gap natural convection vaporizers are generally designed to operate three to seven days without defrost and typically have a fin tip-to-tip air gap spacing of 3" (75 mm) or more. [Figure 2] Super-wide spaced ambient air vaporizers are designed to operate continuously, with the possibility of manual defrost required several times per year. These vaporizers have a typical fin tip-to-tip spacing of 10" (254 mm) or more. [Figure 3] Forced convective vaporizers are designed with maximum heat transfer area in a minimum space. They typically have fin tip-to-tip air gap spacing of considerably less than 1.5" (38 mm). [Figure 4]

Natural draft ambient air vaporizers operate on the principal of natural convective heat transfer. Air is cooled as gravitational force pulls it past the heat exchanger fins. It therefore becomes more dense and heavier. This density further promotes a downward motion due to gravitational effects. Forced convective heat transfer vaporizers rely on mechanical fan driven forced-stimulation movement of the air, and therefore does not rely on gravity.



Figure 3

The following are basic vaporizer design considerations when dealing with the issues of location and duration of operation of ambient air vaporizers. Other considerations also must be reviewed, such as electrical/fuel requirements, availability of land or real estate, proximity to roads, walkways, driveways and occupied businesses or housing.

Tropical Climate Zones

For the purpose of specifying vaporizers, tropical climate zones include equatorial regions such as Malaysia, Thailand, Indonesia, Panama, Venezuela, and Brazil. Other regions such as Japan and the southern United States replicate this climate zone closely in their summer months or monsoon season, but are generally closer to the humid continental zone. Tropical climate zones are characterized by dew point temperatures greater than 70°F (21°C). Dry bulb temperatures generally range from 80°F (27°C) to 95°F (35°C) year round. The temperature between night and day typically doesn't vary widely here. This is because the high moisture content of the atmosphere tends to trap the infrared radiation emitted by objects at night, not allowing it to escape.

Both natural and fan-assisted draft ambient air vaporizers should be considered in tropical climates due to the available ambient air temperature driving force. Flow rates under 57,000 scfh (1500 Nm³/hr) are likely to perform more economically with natural convection units; flow rates over 152,000 scfh (4000 Nm³/

hr) with forced convection units. The main advantages of these systems is maximum vaporization capacity at minimal or no operation cost, coupled with maximum reliability.

In order to maintain maximum vaporizer capacity in this zone, both types of vaporizers should be switched quite often. Typical switching cycles would be about every four to eight hours. This is due to the high moisture content in the atmosphere and therefore rapid ice formation on the fins which rapidly reduces the overall heat transfer coefficient. Switching less than every two hours, to obtain even more vaporization capacity, is both unrealistic and dangerous. Both the natural and forced draft vaporizers will defrost adequately in this climate zone without any external energy source, as long as the off cycles are at least half the duration of the on cycles. The fan driven units will assist in this process.

A system can be designed with a larger approach temperature (approach temperature is defined as the difference between ambient temperature and discharge gas temperature), because of the consistently warm temperature both night and day. This results in greater capacity from a system rated for less in other climate zones.

Mediterranean Climate Zones

Mediterranean climate zones include areas such as the southern and central coast of California, Greece, the Algerian Coast, and other areas like Italy and Israel. These regions are characterized by precipitation periods of about four months per year. This climate zone, like the tropical climate zone, is well-suited to the ambient air temperature driving force available. The same rules generally apply regarding which vaporizers become economical choices.

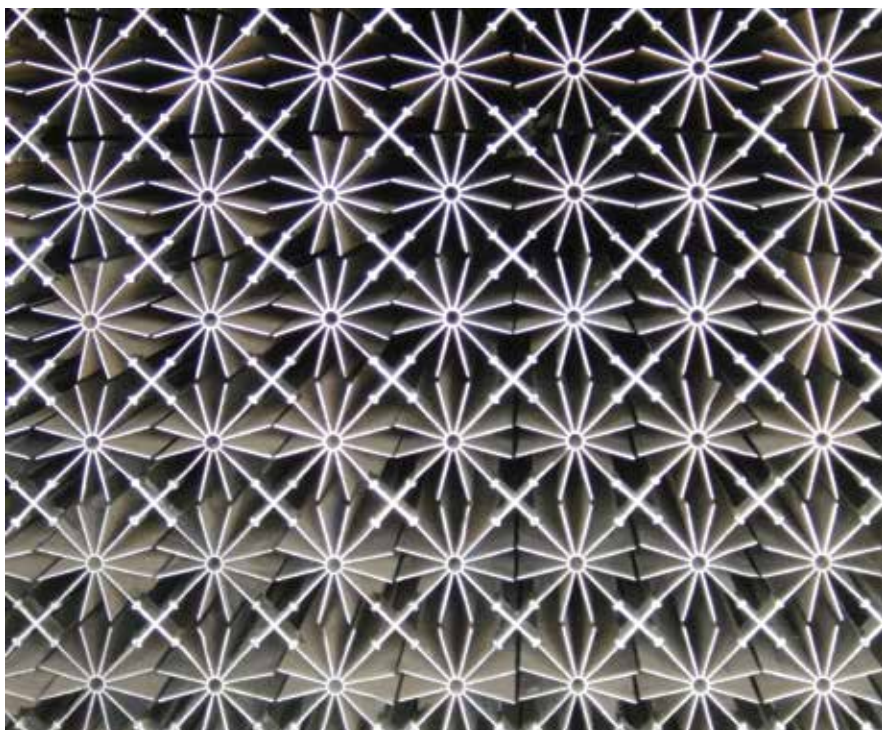


Figure 4

The main difference from the tropical zone is the low moisture content here can exist six to nine months of the year. Several unique weather characteristics result from this. Infrared radiation which escapes from the atmosphere at night often results in colder nighttime or early morning temperatures. This is a consideration when designing approach temperatures for this period and ensuring minimum temperatures remain above minimum values. The benefit of this drier climate is longer switching cycles. Switching less than every eight hours usually has little benefit, but switching in this zone should be done before 24 hours to obtain maximum efficiency from the units.

Humid Continental Climate Zones

The humid continental climate zone covers a vast area. In the Northern Hemisphere, typical areas include the interior United States, Southern Canada, Central Europe and Central Asia. These areas are characterized by somewhat tropical dew point temperatures in the summer and extended cold, dry periods in the winter, with a combination of the two in spring and fall.

In this zone, the point where forced draft ambient air vaporizers become more economical than natural draft vaporizers is much less apparent. It must be analyzed more rigorously due to the larger variations in ambient conditions. A phenomenon known as the freeze period (the period of time in which ambient temperatures remain below freezing) is one key to vaporizer specifications.

Fan-assisted vaporizers typically require an external energy source in order to defrost during their off period. Electrical heater assemblies, or gas fired external air heaters, can be used. Because of these additional requirements, the fan ambient vaporizers become less attractive over other vaporizers.

Natural draft vaporizers must be sized so each bank of on-stream and off-stream vaporizers is capable of operating for one-half the freeze period. This could be up to several months in parts of Canada or North Central Asia, thus requiring much more surface area (up to four times more) than in other climate zones. Due to the tropical nature that may exist in these areas during the summer, the switching cycles are typically based on summer conditions. Because of the potential for very low temperatures during winter months and depending on pipeline limitations, special equipment additions like gas super-heaters may be required downstream of the ambient units. Lower approach temperatures are often required during winter months. Fluids such as carbon dioxide and propane that may be vaporized in tropical zones by utilizing ambient units should not be considered in humid continental climates, since it is more likely you will be subcooling during winter periods.

Marine Climate Zones

Marine climate zones pose a unique challenge to ambient air vaporizer designers. Some areas included in this zone are Britain, the Northwest coast of the United States, British

Columbia, Canada, Maine and the far Northeast of the United States, Norway, New Zealand and the Southern coast of Argentina. Although ambient temperatures remain relatively mild throughout the year, usually between 23°F (-5°C) and 70°F (21°C), the climate is very moist. Dew point temperatures are commonly very close to the dry bulb temperatures as well as the freezing point of water. What tends to result is a substantial amount of condensation and added precipitation on vaporizer surfaces which quickly freeze into dense pockets of ice, reducing vaporizer capacity. Extra surface area must be added to reduce the effects of this atmospheric phenomenon. Likewise, the vaporizers need to be switched much more often to prevent the formation of very dense ice that will not defrost during off periods if levels get too substantial. Vaporizers must often be sized based on two to three day ratings, but switched every two to six hours to prevent ice buildup.

Micro Climate Zones

Micro climate zones exist in every one of the zones discussed. They are defined as zones that may result in substantially different weather conditions and may exist at distances as close as 31 miles (50 km) from one to the other. Micro climate zones may have unique wind or precipitation design requirements. The phenomenon of severe winds (caused by the venturi effects of local mountain canyons), may result in special mechanical design requirements or height limitations. One example is the area downwind of the Great Lakes region in the United States, where major snow fall accumulations can occur when dry cold winds move over warmer moist lake air, causing the air to become saturated and creating localized "lake effect" snow. Severe wind effects can also be found in the Chinook winds of Montana, the buran winds of Russia and Central Asia, the bora winds of the Northern Adriatic coast of Yugoslavia, and the Santa Ana winds of Southern California. Altitude effects also need to be considered, with appropriate capacity reduction applied to the vaporizer models.

For further information, visit www.Cryoquip.com

Upcoming Events

World LNG Fuels

Houston, Texas

Feb. 2-4, 2015

Exhibiting - LNG products for trucking, marine, rail and fracking

L-NGV

San Diego, California

April 27-29, 2015

Exhibiting - NGV and LNG applied to transportation

Offshore Technology Conference (OTC)

Houston, Texas

May 4-7, 2015

Exhibiting - LNG Pumps

Alternative Clean Transportation (ACT) Expo

Dallas, Texas

May 4-7, 2015

Exhibiting - LNG Pumps

The ACD Submerged Motor Pumps are Ideal for Many Applications

ACD'S Model AC/TC-34 and TC-34.2 submerged pumps are a sealess design with integral pump and motor vertically mounted in a sump or tank. The sealess design meets or exceeds all EPA and OSHA standards. The TC-34 is extremely durable and can handle tough pumping requirements, including methane (LNG) and other light-end applications, in addition to the more traditional fluids like nitrogen and argon.

The TC-34 is designed to endure thousands of starts per year without requiring an overhaul. The submerged pump's design, unlike conventional trailer pumps, does not include a mechanical seal, which is a major cause of wear and maintenance. Instead, the pump and motor are completely immersed in fluid, allowing the unit to operate for longer periods between overhauls.

ACD has more than 30 years experience designing and manufacturing submerged pumps, from dockside loading pumps to truck mounted units. A larger capacity model is also available for significantly higher flows and pressures.

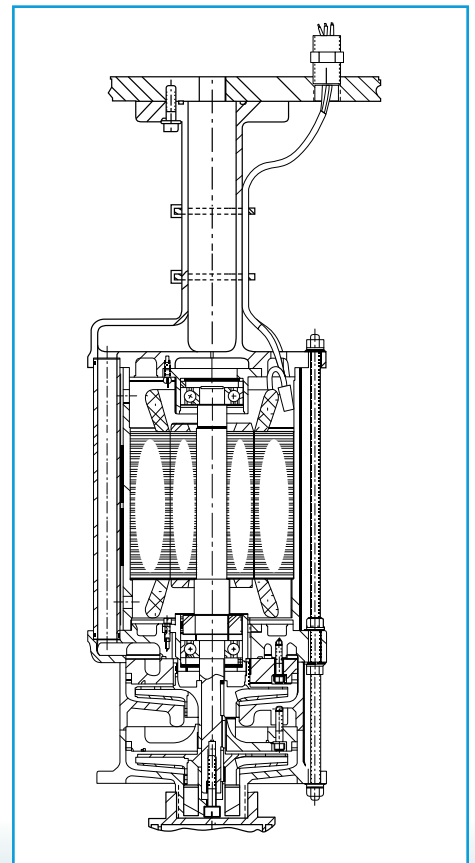
The AC/TC-34 has many uses in filling applications and the customer benefits from the pump's ability for multiple instantaneous quick starts. Because the pump is immersed in a vacuum-jacketed sump where it is continuously flooded in a liquid, the traditional waiting period for the pump to cool down is eliminated,

providing more deliveries per day with lower product losses results in maximized profits.

The AC/TC-34 in argon service provides the most benefits to the customer by eliminating cool down time of the pump without product loss. When coupled with the proper tank system and with resources saved by not venting expensive argon, the pump will provide a valuable return on investment.

Among other key features of the AC/TC-34 are the product-lubricated bearings and motor, which benefit from immersion in the cryogen. Diverting and filtering a portion of the pumped product flow through the bearings provides longer bearing life and pump operation. At the same time, the cooling effect of the cryogen makes it possible to reduce the motor's physical size. The pump is also fitted with a state-of-the-art inducer to provide minimal NPSH required for the pump to operate without cavitation. The AC/TC-34 is normally driven by a variable frequency drive controller for greater flexibility as it relates to variable flows and differential pressures as well as reducing speed to obtain a positive flow in extremely low NPSH conditions.

For more information, visit www.acdllc.com.



Heat Exchanger Research

Heat exchanger fouling due to scale formation is a common problem. A particularly severe application is heat transfer from brine flows. Generation of power from low temperature geothermal resources requires the transfer of heat from the brine to a binary power system. Conventional binary power systems are limited in the amount of heat that can be transferred for conversion by the boiling process. Advanced power cycles such as Energent's Variable Phase Cycle or the Kalina cycle are able to capture more heat from the geothermal resource and produce more power. The only limitation to these advanced cycles is the extent to which the brine temperature can be lowered in the heat exchanger without producing scaling. These advanced cycles have the potential of producing 20 – 30% more power than a conventional binary power system.

To determine the best method of scale reduction, a research program was carried out at a geothermal resource having a high scaling potential. The primary source of scaling was silica which was found in the brine at a level of 528 ppm.

A scaling test system with several experiments was designed and operated at Coso geothermal resource with brine having a high scaling potential. Several methods were investigated at the brine temperature of 235°F. The experiments involved injection of four potential anti-scaling chemicals; operation of an electromagnetic device; and the circulation of abradable balls through the brine passages. The test apparatus is shown in Figure 1. Brine from a power plant separator flowed through tubes which had the scale reduction methods introduced. The tubes were immersed in a cooling water bath to reduce the temperature. The temperature of the brine was reduced to an average temperature of 125°F.

The most promising method was found to be circulation of the abradable balls through the brine passage. Abradable balls are routinely used for the scaling of condenser tubes. The balls used for the brine descaling had a special high temperature rubber formulation with hard particles inserted in a sponge matrix. Table 1 shows the results of operation for 30 days of flowing brine. As can be seen, the abradable balls resulted in the lowest scale buildup at the tube exit. Two of the chemicals had a low scale buildup at the inlet of the tube, but resulted in a buildup of more than three times that of the abradable balls at the exit. A probable reason is the recommended injection rate was too low. Future tests will be done increasing the vendor's recommendation for the injection rate. However, chemical injection is costly and has environmental consequences. Increasing the rate can substantially increase the operating cost.

The key result is the ability to operate at the low-temperature 125°F with only a moderate buildup of scale. For advanced low-temperature cycles, such as the Variable Phase Cycle or Kalina Cycle, the lower brine temperature will result in a 20-30% increase in power production from low temperature resources.

A preliminary design of an abradable ball system ("ABS") was done for the heat exchanger of the 1 megawatt VPC system at Coso resource. The ABS will be installed and demonstrated in Phase 2 of this project, increasing the power production above that which is possible with the present 175°F brine outlet limit.

A hermetic turbine generator (TGH) was designed for the next phase of the project. This unit will use the working fluid (R134a) to lubricate the bearings and cool the generator. The 200 kW turbine directly drives the generator, eliminating a gearbox and lube oil system. Elimination of external seals eliminates the potential of leakage of the refrigerant or hydrocarbon working fluids resulting in environmental improvement. A similar design has been demonstrated by Energent in a binary waste heat recovery system.

Operation in Phase 2 of the TGH with and without the ABS system will demonstrate an increase in geothermal resource productivity for the Variable Phase Cycle (VPC) from 1 MW from 1 MW/million pounds of brine to 1.75 MW/million pounds of brine; a 75% increase.

For additional information, visit www.Energent.net.

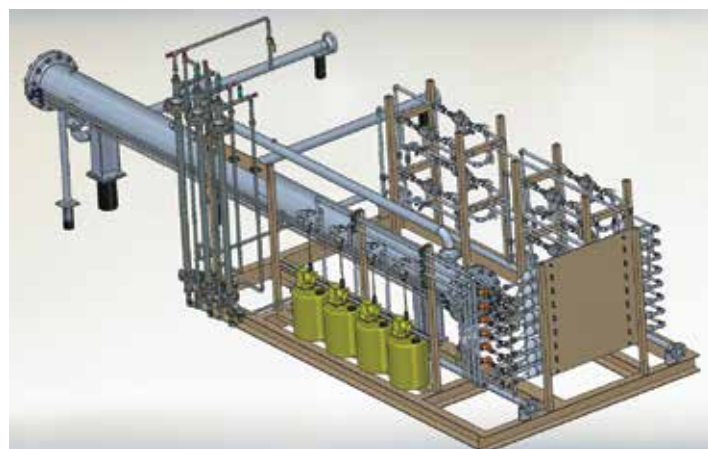


Figure 1 - Heat Exchanger Test System for De-Scaling Experiments

	INLET (mils)	OUTLET (mils)
Insulated pipe	N/A	N/A
Control heat exchanger	17.12	29.59
Chemical injection: MX 2-3628	9.79	27.38
Chemical injection: GS8464	19.35	34.22
Chemical injection: CL4700	18.40	40.23
Chemical injection: PDC9486	34.10	41.03
Electromagnetic scale device	25.90	38.57
Abradable ball heat exchanger	29.61	10.16

Table 1 - Scale Thickness Measurements for Heat Exchanger Inlets and Outlets.

The Use Of SF₆ to Assure Reliable Delivery of Power to Home and Industry

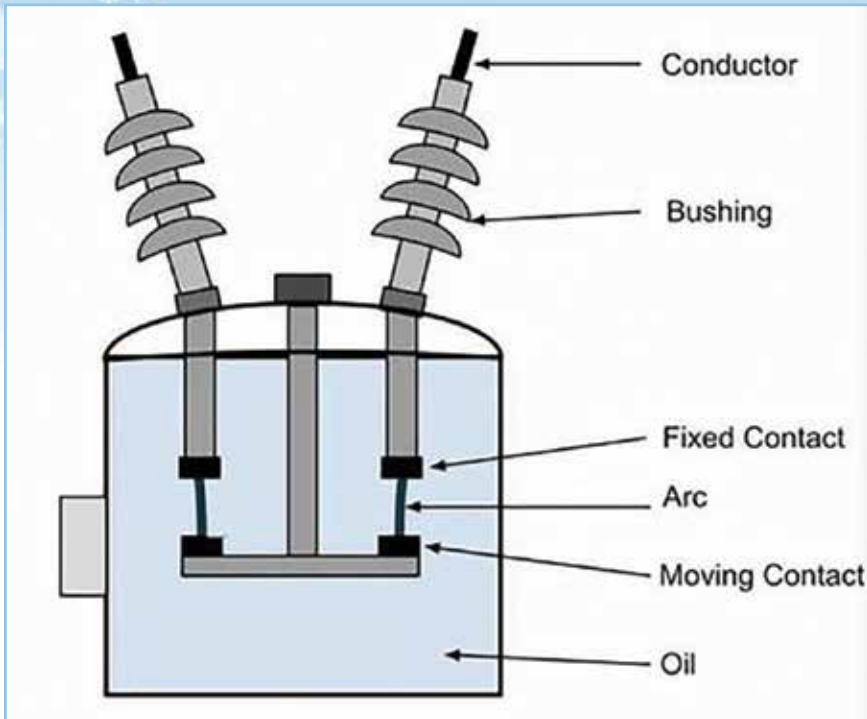


Figure 1 - Bulk Oil Type Circuit Interrupt Switch

Moving vast amounts of electrical energy over many miles from electrical generating plants to the end user requires the power to be “stepped up” to 230kV, 345kV, 500kV (thousand volts), and higher. It is then sent along transmission lines to many local sub-station distribution centers where the power is “stepped down” to customer usable levels. It is necessary for the sub-station to be able to turn these high voltage levels of power off and on as needed. Furthermore, power may arrive at the sub-station from more than one source and because of price or availability, it may become necessary to switch from one source to another. When power is interrupted at such high voltage levels, an arc forms between the switch contacts. This can produce temperatures in excess of 4700° C (8500° F). At these temperatures, it does not take long for the metal contact surfaces to melt and fuse. Therefore, it is necessary to quench and cool the arc as rapidly as possible. For many years this was accomplished by the use of oil-filled switches [Figure 1] referred to as “circuit breakers”. These switches submerge the contact surfaces in oil, and then when the switch opens, the arc is quenched and cooled by the oil and by the “hydrogen” gas bubble which is formed around the arc. Flammable oil, hydrogen gas, and high arc temperatures create potentially hazardous conditions. Therefore a safer and more reliable method was needed.

In 1956, Westinghouse Corporation developed what is still considered today as the safe alternative to oil-filled switches [Figure 2]. They did so by placing the switch in a vessel purged with SF₆ (sulphur hexafluoride) gas. SF₆ is a very strong dielectric man-made compound which resists the formation of arcs in high voltage interrupts. As the SF₆ gas-immersed contact surfaces open, a high pressure shot of SF₆ gas is blown into the area, further cooling and blowing out the arc [Figure 3]. SF₆ purged circuit breakers are the most commonly used in the high voltage power industry today, and have been for many years.

As with any other type of equipment, it occasionally becomes necessary to maintain gas-filled breakers. The gas needs to be safely removed, stored, filtered, dried and returned to the circuit breaker. This requires special equipment, designed not only to remove the gas, but to compress it and liquefy it, without introducing any air, moisture or other contaminants.



Figure 2 - Typical SF₆ Circuit Breaker

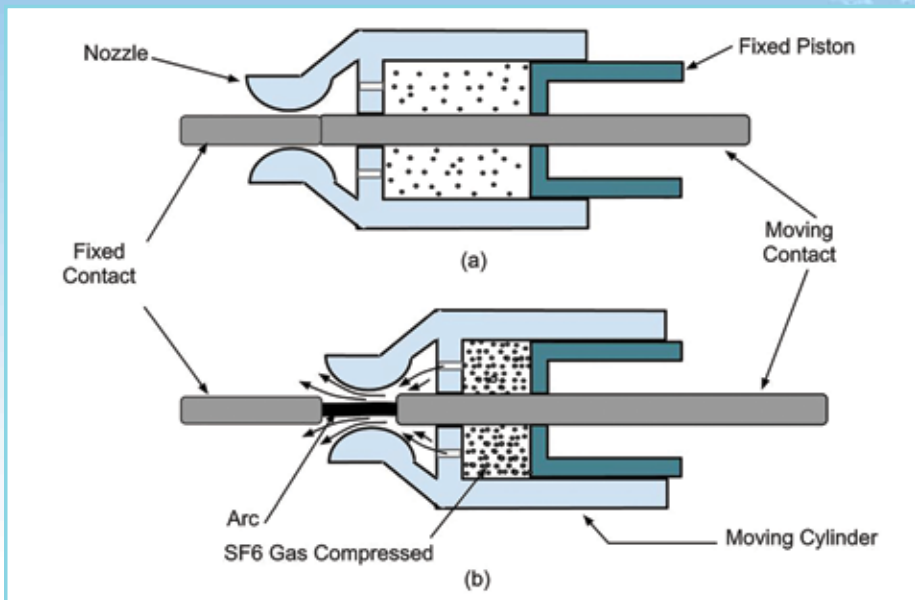


Figure 3 - Puffer Type SF₆ Circuit Breaker

One method of liquefying SF₆ for storage is by “High Pressure Liquefaction”, which is accomplished by compressing the gas up to 700 psig then liquefying into cylinders or a vessel. The advantage of this method is that it does not require an oil removal system or refrigeration condensing unit to cool the gas. The disadvantage is that it requires frequent compressor maintenance and retains the inherent problems and dangers associated with higher pressures.

Another method is “Low Pressure Cooled Liquefaction”. This employs a more reliable and higher speed oil lubricated compressor, oil removal system, and a refrigerated vessel to store the SF₆. Cryoquip has used this low pressure method in its design and manufacturing of SF₆ recycling equipment since 1984.

In addition to the standard oil removal coalescing filters, Cryoquip also uses an oil absorber filter designed to trap oil vapor prior to entering the storage vessel. The SF₆ compressed gas is next chilled and liquefied in the storage vessel, where it will remain until it is needed. When the SF₆ is returned to the circuit breaker it will return as a vapor from the top of the storage vessel. The gas passes through a dryer, by-product filter, and a fine particle filter, before being returned to the circuit breaker, thereby removing arc byproducts, moisture, and particle contaminants from the gas.

SF₆ gas is a green house gas and is declared to have a global warming potential almost 24,000 times that of CO₂. The National Oceanic and Atmospheric Association (NOAA) has monitored levels of SF₆ gas in the atmosphere since 1995. To date, SF₆ trace gas levels in the atmosphere have increased from 2ppt (parts per trillion) to 8ppt. This increase is driving rules and legislation concerning the inventory, tracking, usage and disposal of SF₆, and is especially relevant as it relates to SF₆ recovery and recycling equipment.

In order to meet these demands, Cryoquip has added several enhancements to its SF₆ recovery and recycling equipment. One is a magnetically driven SF₆ vacuum pump capable of recovering gas from a circuit breaker down to 100 mTorr (millitorr) of pressure. This, combined with the high speed semi-hermetic compressor, allows for removal, compression, and liquefaction of SF₆ without loss of gas to the atmosphere, and accomplishes this at high speed and relatively safe and low pressure.

For further information, visit www.Cryoquip.com



Figure 4 - Cryoquip 375TM Mobile SF₆ Service cart



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