Handling Liquefied Compressed Gas
液化压缩气体的操作

General
概述

A liquefied compressed gas can be defined as a gas, which when compressed in a container, becomes a liquid at ordinary temperatures and at pressures ranging from 25 to 2500 psig. Liquefied gases have boiling points that range from –130 to 30°F (–90 to –1°C). At 70°F the cylinder contains both liquid and gas. Cylinder pressure, or the “vapor pressure” of the gas, is directly affected by ambient temperature. Increases or decreases in the temperature will cause the vapor pressure to increase or decrease, respectively.

液化压缩气体可以定义为这样一种气体，当压缩在一个容器里时，在常温下它变成了液体，压力范围从25到2500 psig。液化气体的沸点在–130到30°F (–90到 –1°C)范围内。在70°F时，钢瓶内既有液体又有气体。钢瓶压力，或气体的“蒸气压”直接受到周围环境温度的影响。温度的增加或减少会导致蒸气压分别增加或减少。

Liquefied gases are packaged under their own vapor pressure and are shipped under rules that limit the maximum amount that can be put into a container to allow for liquid expansion with rising temperatures. The U. S. Department of Transportation (DOT) states in 49CFR 173.304 that the liquid portion of a liquefied gas must not completely fill the packaging at any temperature up to and including 130°F. The DOT sets the fill density for liquefied compressed gases to aid compliance to this requirement. Fill density is defined as the percent ratio of the weight of liquefied gas in a container to the weight of water that the container will hold at 60°F (1 pound of water =27.737 cubic inches at 60°F or 62.3 pounds of water per cubic foot of container volume).

液化气体包裹在它们自己的蒸气压下。按照规定，要限制装入容器的液化气体的最大数量，为温度上升时的液体膨胀留下余地。美国交通部(DOT)在49CFR 173.304中规定，在任何大于并包括130°F的温度时，液化气体的液体部分不能完全充满容器。DOT规定了液化压缩气体的灌装密度，以帮助执行这个要求。灌装密度定义为，容器中液化气体的重量对60°F时该容器能容纳的水的重量的百分比率（在60°F时，1磅水=27.737立方英寸，或者说每立方英尺容器容积等于62.3磅水）。

Containers
容器

Liquefied compressed gases come in a variety of containers.

液化压缩气体可以装在多种容器里。

Because the product exists in both the liquid and gas phases in the container, many containers are equipped to access both phases. This is accomplished by the use of

full-length eductor tubes (dip tubes) and gooseneck eductor tubes.
因为在容器里产品的液相和气相共存，许多容器装备得可以提取两种状态的产品。这是通过使用全长排放管（汲取管）和鹅颈排放管。

Cylinders with a full-length eductor tube, or what is sometimes called a full-length dip tube, have a tube that runs from the inlet of the cylinder valve to the bottom of the cylinder. When a cylinder with this valve configuration is in the upright position, the inlet of the tube is immersed in liquid and the liquid phase will be removed.
带有全长排放管，或者有时称为全长汲取管的钢瓶有一个从钢瓶入口一直伸到钢底部的管子。当带有这种阀门配置的钢瓶处在垂直位置时，管子的入口浸在液体中，就可以提取液相产品。

Some cylinders are equipped with two valves: one having a full-length eductor tube for liquid withdrawal and the other a valve without an eductor tube for gas withdrawal or inert gas padding (see Fig. 2 and section on liquid-phase withdrawal).
一些钢瓶配备了两个阀门：一个有全长排放管，用于液体提取；另一个没有排放管，用于气体提取或惰性气体填充。

Another type of valve configuration is called the gooseneck eductor tube. The gooseneck goes only a short distance into the cylinder and then bends to the cylinder side opposite the valve outlet. In the upright position, the gooseneck is above the liquid level and provides gas. To remove the liquid, the cylinder is placed on its side with the valve outlet facing up. This puts the gooseneck into the liquid.
另一种阀门结构称为鹅颈排放管。鹅颈管只伸入钢瓶内部较短的距离，弯曲到阀门排气口对面的钢瓶内侧。在钢瓶处于垂直位置时，鹅颈管处在液面以上提供气体。要提取液体的话，使钢瓶平躺，阀门排气口朝上。这样鹅颈管就伸到了液体里面。

In horizontal containers, such as “Y” cylinders,“ tonners,” and tube trailers, dip tubes are required to access both the liquid and gas phases.
在水平容器内，如”Y”钢瓶、“ tonners”、和管道拖车）里，要求汲取管既可以接近液体又可以接近气体。

“Y” cylinders use what is referred to as a “C” configuration. This configuration is very similar to the gooseneck, but the inlet to the gooseneck is oriented in the same direction as the valve outlet. The product flows into the dip tube and out the valve outlet in a flow path shaped like the letter “C”. This means when the valve outlet is pointed up, the gas phase is accessed, and when the valve outlet is pointed down, the liquid phase is accessed.
“Y”钢瓶采用称为”C”的结构。这种结构同鹅颈管很相似，但鹅颈管的入口与阀门排气口的方向一致。产品流进从汲取管，从阀门排气口流出，流程形状象字母”C”一样。这意味着，当阀门排气口朝上时，汲取管接触气相；当阀门排气口朝下时，汲取管接触液相。

Tonner containers have two valves. The container is oriented so the valves are one above the other. The valves are connected to dip tubes that run to the cylinder sides. The top valve will have the dip tube in the vapor and the bottom valve will have the

dip tube in the liquid.
Tonner容器有两个阀门。让容器朝向一定方向，使一个阀门在另一个阀门的上面。阀门上连接着汲取管，汲取管伸入到钢瓶内侧。上面的阀门的汲取管处在蒸气里，下面的阀门的汲取管处在液体里。

On tube trailers with liquefied compressed gases, gooseneck dip tubes are used, but the dip tube orientation is determined by the end of the tube trailer which is being accessed. Typically all valve outlets will be aimed downward on a tube trailer. Normally, gas can be withdrawn from the rear of the trailer with all dip tubes oriented upward (to the vapor phase). Liquid can be withdrawn from the front of the trailer where the dip tubes will be oriented downward into the liquid phase.
在装液化压缩气体的管道拖车上,使用鹅颈汲取管,但汲取管的方位由要接近的拖车的终端决定。在管道拖车上，所有阀门排气口一般都朝下。通常所有汲取管朝上（以接触气相），从拖车的后部提取气体。可以从拖车的前部提取液体。在前部，汲取管向下伸入到液相里。

The most common type of liquefied gas container uses a standard cylinder valve. In the upright position the liquid level is well below the valve inlet, preventing liquid from being removed. If liquefied gas is to be withdrawn, the bottom of the cylinder must be elevated above the valve to allow the liquid phase to be in contact with the valve inlet. Special inversion racks are usually used to provide a safe method for cylinder inversion.
最普通类型的液化气体容器使用标准钢瓶阀门。在垂直位置时,液体水平线在阀门入口以下很多,防止了液体的提取。如果要提取液化气体，必须把钢瓶底部提高到阀门以上，使液相同阀门入口相接触。通常使用专门的倒置架来安全地倒置钢瓶。

Table 1. Some Common Liquefied Gases*
表1 一些普通液化气体

Gas气体	Vapor Pressure @ 70°F 在70°F时地蒸气压
Ammonia氨	114 psig
Carbon Dioxide二氧化碳	830 psig
Chlorine氯	86 psig
Hydrogen Chloride氯化氢	613 psig
Hydrogen Sulfide硫化氢	247 psig
Methyl Chloride氯甲烷	59 psig
Monomethylamine单甲胺	44 psig
Nitrous Oxide一氧化二氮	745 psig
Sulfur Dioxide二氧化硫	34 psig
Sulfur Hexafluoride六氟化硫	298 psig
Tungsten Hexafluoride六氟化钨	2.5 psig

*Liquefied petroleum gases, such as propane and butane, have not been included as they are too numerous to mention.由于它们数量众多，无法一一提及，液化石油气体，如丙烷和丁烷没有包括在这里。

Special Warnings Regarding Vapor-Phase Withdrawal

关于气相提取的特别警告

CAUTION! EXCESSIVE TEMPERATURE CONSIDERATIONS:
警告！过分考虑温度:
Any enhanced vapor withdrawal method listed here that involves heating should be controlled to prevent exposure of the container to temperatures exceeding 125°F.
应该控制这里列出的有关加热的任何促进蒸气提取的方法，防止容器暴露于125°F以上的温度。

DANGER: Never heat an aluminum cylinder with electrical resistance elements. Only cylinders made of steel should be electrically heated. Aluminum cylinders can be severely damaged by excessive temperature exposure.
危险: 禁止用电阻元件加热铝瓶。只有钢制容器才能用电加热。暴露于过高的温度会严重损坏铝瓶。

CAUTION! ELECTRICAL REQUIREMENTS: All electrical systems for indirect heating and monitoring for a flammable gas supply system should be designed to comply with the applicable national or local electrical code requirements. Typical electrical code requirements include classification for instruments and/or limiting the surface temperature of heated resistance elements to a specified fraction of the autoignition temperature for the flammable gas.
警告！有关电的要求: 应该按照可适用的国家或地方的电力法规的要求来设计用于间接加热和易燃气体供应系统的监测的所有电力系统。典型的电力法规要求包括器具的分类，和/或把热电阻元件的表面温度限制在易燃气体的自燃温度的一个指定的分数。

Various national and/or local codes prohibit the general direct heating of containers. However, these codes are interpreted as only pertaining to heating systems that apply heat energy directly onto the containers. This interpretation is based on the examples of prohibited heating methods cited in various code references: radiant flame, steam impingement on the container, immersion in a heated water bath or electrical resistance heater elements in direct contact with the container.
各种各样的国家和/或地方法规禁止容器的一般直接加热。但是，这些法规被解释为只适用于把热能直接施加到容器上的加热系统这种解释是基于在许多法规参考书目里引用的被禁止的加热方法的例子: 辐射火焰、容器上的蒸汽冲击、热水槽中的浸泡或直接接触容器的电阻加热元件。

Nonheated, flow-enhancing options should be evaluated as a first preference. If none are suitable, a properly engineered and approved **INDIRECT** heating system is acceptable for liquefied compressed gas containers. Direct heating methods such as flames, steam impingement, electrical resistance elements, water bath immersion, hot plates, and ovens should not be used.
非加热提高流速的选项应该是首选。如果没有合适的，适当设计和得到认可的**间接**加热系统对

于液化压缩气体容器是可以接受的。不能使用直接加热系统，如火焰、蒸汽冲击、电阻元件、水槽浸泡、轻便电炉和烤箱。

Water-bath immersion is not recommended
不推荐水槽浸泡:

The direct immersion of a cylinder into a water bath is **NOT RECOMMENDED** as a heating method, since repeated or prolonged exposure to heated and agitated water can degrade the cylinder's external surface and can eventually compromise the cylinder's mechanical integrity. Use of acidic or alkaline water or the use of conditioning salts and other materials has caused cylinder failures when used in water baths.
因为重复或长时间暴露在热水或沸水中会使钢瓶外表面退化，最终危及钢瓶的机械完整性。**不推荐**把在水槽中直接浸泡钢瓶作为加热方法。在水槽中使用酸或碱水，或使用调节盐和其它物质已经导致了钢瓶的失效。

How to Withdraw Product Safely
如何安全地提取产品？
Product withdrawal should be carefully supervised by qualified people with the proper equipment. Personnel should be aware of the associated hazards of the product and equipment and thoroughly understand applicable safety regulations and emergency procedures.
应该由有资格的人使用合适的设备来仔细监督产品的提取。人员应该知道同产品和设备相关的危险，完全理解可应用的安全规范和紧急程序。

There are two different methods of product withdrawal from a liquefied compressed gas container: as a vapor (gas) or as a liquid (liquefied gas).
从液化压缩气体容器内提取产品有两种不同的方法: 作为蒸气（气体）或作为液体（液化气体）。

Vapor-Phase Withdrawal
气相提取
Liquefied compressed gases in a cylinder or any container exist in liquid and gaseous form at a pressure equal to the vapor pressure of the particular gas (see Table 1 for specific vapor pressures). The cylinder pressure will remain constant at the vapor pressure of the material as long as there is any liquid remaining in the cylinder. When the contents of the cylinder are withdrawn to the point that no liquid remains, the pressure in the cylinder will begin to diminish as the remaining vapor is used.
钢瓶或任何容器内的液化压缩气体以液态和气态形式存在，压力等于特定气体的蒸气压（具体的蒸气压见表1）。只要在钢瓶内还有液体，钢瓶的压力就会保持在材料的蒸气压。当钢瓶内的液体被全部提取之后，钢瓶内的压力会因为剩余蒸气的使用而开始下降。

The first step for removing vapor is to orient the package to access the vapor phase of the product. When vapor is removed from the cylinder, the temperature and

pressure equilibrium is disturbed and both will decrease. Liquid will vaporize to replace the gas that was removed, absorbing the heat of vaporization from the remaining liquid and the container. This heat can usually be recovered from the ambient air surrounding the cylinder. If the withdrawal rate of the gas is such that the energy required to vaporize the liquid cannot be recovered from the surrounding air, the liquid phase will begin to cool.
提取蒸气的第一步是调整钢瓶的方位，使可以接触产品的气相。在蒸气被提取后，温度和压力的平衡被破坏，两者都要下降。液体会从剩余液体和容器吸收蒸发热，蒸发来代替被提取的气体。这个热量通常可以从钢瓶周围的空气中得到补充。如果气体提取速度太快，使得蒸发液体所需要的能量不能从周围空气中得到补充，液相会开始冷却。

The phase equilibrium is a function of the system temperature. As the temperature of the liquid phase increases, so will the vapor pressure; the converse is also true. If the liquid cannot recover enough heat from its surroundings to keep up with the demand for gas, the liquid will cool. This is called “sub-cooling” or“ auto-refrigeration”. It is common for vapor withdrawal to cool the cylinder to the point where moisture condenses on the external cylinder, valve, and piping surfaces. If the surfaces are chilled below water’s freezing point, the condensed moisture can solidify into ice.
相平衡使系统温度的一个功能。当液相温度上升时，蒸气压也会上升; 反过来也是如此。如果液体无法从周围环境补充足够的热量来满足气体的要求，液体会冷却。这称为“次冷却”或“自动冷却”。对于蒸气提取来说，钢瓶冷却到使水蒸汽浓缩到钢瓶外部、阀门和管道表面的程度是很普通的。如果表面被冷却到水的凝固点以下，浓缩的水蒸汽会凝固成冰。

If the rate of withdrawal of vapor is excessive, serious safety problems can arise. Sub-cooling can cause the vapor pressure to collapse to the point where the cylinder pressure is below that of the process. This pressure inversion can cause back flow of the process materials into the cylinder, or “suck back”. It is also possible to cool a cylinder enough to actually embrittle the metal, potentially leading to a cylinder failure. Ice formation on the cylinder and especially on the valve and piping, coupled with the decrease in flow as the cylinder pressure drops, is sometimes misinterpreted as blockage in the valve. This can lead to users applying excessive heat to the valve, possibly creating leakage at the outlet connection, the valve packing, and especially from a fusible metal relief device if the valve is so equipped.
如果蒸气提取率过大，会出现严重的安全问题。次冷却会导致蒸气压下降到钢瓶压力小于过程压力的程度。这种压力倒置会引起过程物质回流入钢瓶，或“吸回”。还有可能使钢瓶温度下降到足以使金属变脆的程度，从而可能导致钢瓶故障。在钢瓶上，特别是在阀门和管道上结冰，加上因为钢瓶压力下降引起的流速下降，有时候会被误认作阀门内的阻塞物。这会导致用户过度加热阀门，可能造成排气口接头和阀门衬垫处泄露，特别是从易熔金属减压装置处泄露，如果阀门装有易熔金属减压装置的话。

How Can One Improve the Gas-Phase Withdrawal Rate?
如何改善气相提取率？

Depending on the cylinder or container geometry and ambient conditions, some

method might be necessary to enhance product withdrawal from liquefied compressed gas cylinders to maintain required flow rates. This is especially true with small cylinders and nearly empty larger containers.
根据钢瓶或容器的几何尺寸和周围条件,可能有必要采取一些方法来加强从液化压缩气体钢瓶内的产品提取，以维持要求的流速。对于小钢瓶和快空了的大钢瓶更是如此。
Product withdrawal enhancement methods have a definite preference of selection based on inherent safety considerations and consequences of system failure. This Safetygram presents the recommended methods in order of preference and their associated requirements.
根据固有的安全考虑和系统故障的后果，促进产品提取的方法有一定的优先选择。按照优先选择和它们的相关要求的顺序，本安全程序介绍推荐的方法。
1. Use a Larger Container: This will increase the outer surface area of the container to allow more heat transfer from the environment.
使用更大的容器: 这会增加容器的外表面，使更多的热量从外界转移过来。

2. Vaporization: The user can withdraw liquid phase through an external vaporizer, thereby converting the liquid to gaseous product. This is the preferred method for high flow requirements. This method requires liquid-phase withdrawal from the container using an eductor tube. The liquid is then vaporized via a standard vaporizer, tubing coil, or other vaporization means. This method can provide the highest withdrawal rates, but may not be suitable for high-purity applications. It also creates the highest release flow rate potential due to downstream leakage or operator error, which should be adequately addressed for hazardous products. Overpressure protection should be provided on any lines, including the vaporizer circuit, in which liquid product can be trapped by isolation valves, check valves, or other system components.
蒸发: 用户可以通过一个外蒸发器来提取液相，从而把液体转变为气体产品。对于要求高流速的情况，这是首选的方法。这种方法要求使用排放管来从容器中提取液相。接着液体通过一个标准蒸发器、蛇管或其它的手段蒸发。这种方法能够提供最高的提取速度，但可能不适用于高纯度应用。如果由于回流或操作者的错误引起泄露的话，它还可能造成最高的泄露流速。对于危险产品，这一点须充分考虑到。应该为任何管道提供过压保护，包括液体产品可能被隔离阀堵在里面的蒸发器回路、止回阀或其它系统组件。

3. Container Switching: This method uses two or more identical containers or banks of containers that can be switched to the online position either manually or automatically. When the primary, active container vapor pressure drops below the threshold capable of supplying the desired gaseous flow rates, the secondary, alternate container is brought on-line in place of the previously active container. This permits the first container to re-warm by absorbing ambient heat. The switching sequence is repeated throughout the high flow demand. This method may not be feasible if the ambient temperature conditions do not provide adequate heat to rewarm the off-line container within an acceptable period of time.
容器转换: 这个方法使用两个或更多的同样的容器或容器组，这些容器可以被手动或自动地转换到在线位置。当初级主容器蒸气压下降到能够供给需要的气体流速以下时，二级备用容器切换到

先前主容器的位置。这就允许第一个容器通过吸收周围的热量来重新升温。在整个高流量要求过程中，重复转换顺序。如果在可接受的时间间隔内，周围温度条件不足以提供充分的热量来加热离线容器，这种方法就不可行了。

4. Container Manifolding: Manifolding a number of liquefied, compressed gas containers in parallel permits the user to achieve the required gaseous flow rate by withdrawing product from all containers simultaneously. This method benefits from the larger thermal mass of the manifolded cylinders and product and provides additional container surface area for ambient heat transfer, thus enhancing total gaseous withdrawal capability. However, manifolding may not be adequate if ambient temperature conditions do not yield sufficient heat flow or product vapor pressures within the containers.

容器并联: 把许多液化压缩气体容器并联在一起，通过同时从所有容器中提取产品，用户就可以得到要求的气体流速。这种方法受益于并联容器和产品的更大的热容量，为周围热量转移提供了额外的容器表面积，因此提高了总的气体提取能力。但是，如果周围温度条件不能产生足够的热流或容器内的蒸气压，并联就没有作用了。

CAUTION, Cylinder Heating Considerations: Any equipment used to heat a cylinder of liquefied compressed gas must include redundant over-temperature protection, such as a system temperature controller (thermostat) with a maximum set point of 125°F along with a separate, independent over-temperature shutdown device, such as a fusible link, in the power supply to the heater. The over-temperature shutdown must be installed between the heat source and the cylinder.

警告，钢瓶加热的考虑：任何用于加热液化压缩气体钢瓶的装置必须包括过压保护，如一个最大设定温度为125°F的系统温度控制器（自动调温器）。还要在加热器的电源里包括一个分离的独立过温切断装置，如熔线。过温切断必须安装在热源和钢瓶之间。

5. Convective Conditioning: Gas withdrawal can be enhanced by heating the atmosphere surrounding the container to provide additional thermal convective heating of the containers and their contents to increase product vapor pressure. This approach is best accomplished if the container is held within an enclosure or small room and it provides gradual, controlled heating of the container contents. However, this system may not prove feasible for containers located out-doors, within a large room, or in a highly ventilated/exhausted enclosure.

对流调节: 可以这样促进气体提取：加热容器周围的空气，提供额外热量对流来加热容器和它们的内容物，以增加产品蒸气压。如果容器处在一个封闭或小房间里，它可以提供对容器内容物的逐渐的受控的加热，那么这种方法就可以达到最好的效果。但是，对于坐落在室外的、大房间内的、或非常通风的/排气良好的房间内的容器来说，这个系统不能证明是可行的。

6. Radiant Conditioning: Heat lamps (or equal) can be used to provide radiant heating of the container contents to increase container pressure for enhanced gas withdrawal capability. The heat source must not directly heat the container valve since the valve, connection, and relief device components can be damaged by

excessive temperatures. This method is best utilized for indoors systems with no obstructions around the containers and provides gradual heating of the container contents. The system may not be feasible for containers located outdoors or in congested areas.

辐射调节: 可以用热灯（或等效物）来为容器内容物提供辐射加热，提高容器压力，增强气体提取能力。由于过高的温度会损坏阀门、接头和减压装置组件，热源不能直接加热容器阀门。对于在容器周围没有障碍物的室内系统，这种方法被利用得最好，而且为容器内容物提供了逐渐的加热。对于处在室外或拥挤区域的容器，这个系统是不可行的。

7. Temperature-Controlled Jacket: This method encloses the container in a removable, temperature-controlled jacket that contains a "closed-loop," recirculated heat transfer fluid connected to a separate electric heater unit. This design separates the heating element from the container and also allows for heating or cooling the containers, depending on the process pressure requirements. The electric heater should have a heat output rated for the maximum product withdrawal rate requirements, without excessive over-capacity. This design is widely used for multiple container systems where there is sufficient space to locate the heating unit adjacent to the containers.

温度受控封套: 这个方法把容器装入一个活动的温度受控的封套内。封套内装有一个"闭环"，循环热流连接到一个分离的电加热器。这种设计把发热元件和容器隔离开来，同样允许根据过程压力要求来加热或冷却容器。电加热器的热输出应该由要求的最大产品提取率来确定，不能有过剩能力。这种设计广泛用于多容器系统。在该系统内有足够的空间来在容器附近放置加热器。

8. Electrically Heated Blanket: The container can be encased in a removable blanket that contains electrically heated resistance elements operated by a temperature controller. Blankets should have an integral covering permanently attached to their inner surface to prevent direct contact of the heating elements with the container. The power input to the blanket should be limited, based on maximum withdrawal rate requirements to restrict worst-case heat input to the container during temperature controller runaway.

电热毯: 容器可以包裹在一个活动的毯子里面。毯子内装有温度控制器操作的加热电阻元件。毯子应该带有永久附在它们的内表面的完整的遮盖物，以防止加热元件和容器的直接接触。毯子的输入功率应该是有限的，根据要求的最大提取率，在温度控制器失控的时候限制容器的最坏情况热量输入。

Liquid-Phase Withdrawal

液相提取

Just as in vapor-phase removal, the first step in liquid-phase removal is to orient the package to gain access to the liquid phase. The liquid is pushed from the cylinder by the vapor pressure of the product. As the liquid is removed, it increases the volume of the vapor space of the cylinder. Some liquid will vaporize to fill the additional space, but usually not enough to excessively sub-cool the cylinder.

正象在气相提取中那样，液相提取的第一步是调整钢瓶的方位，使可以接触产品的液相。产品的蒸气压把液体推出钢瓶。在液体被提取后，它增加了钢瓶蒸气空间的体积。一些液体会蒸发，以

填充额外的空间，但通常不足以过分次冷却钢瓶。

Sometimes the vapor pressure of the product is not high enough to push the liquid out at the required rate. When this is the case, a method called padding can be used to pressurize the liquid. This enhances the rate at which the liquid can be pushed from the cylinder. Padding is the addition of an inert gas to the vapor space in the cylinder to raise the cylinder pressure. When adding the inert gas to the cylinder, the cylinder pressure rating must never be exceeded. This pressure rating is part of the DOT stamping on the cylinder. For example, if the stamping reads DOT 3AA480, this cylinder has a working pressure of 480 psig. Furthermore, certain cylinder relief devices may vent the cylinder contents at pressures below the pressure rating of the cylinder. If you are not sure how to interpret the DOT stamping, or for guidance concerning padding a cylinder, contact supplier for assistance.
有时候，产品的蒸气压没有高到足以把液体以要求的速度推出。在这种时候，可以使用一种称为填料的方法来对液体加压。这提高了液体被推出钢瓶的速度。填料就是把惰性气体补充到钢瓶的蒸气空间，以提高钢瓶的压力。当增添惰性气体到钢瓶时，决不能超过钢瓶的额定压力。这个额定压力是钢瓶上的DOT压印的一部分。例如，如果压印是DOT 3AA480，这个钢瓶的工作压力是480 psig。此外，某些钢瓶的减压装置可以在低于钢瓶额定值的压力下排出钢瓶内容物。如果你不能确定如何解释DOT压印，或者需要关于钢瓶填料的指导，同供应商联系，寻求帮助。

How the inert gas pressure is added depends upon the cylinder. If the cylinder has dual valves, the inert gas can be added through the gas-phase valve. Be sure the inert gas source is regulated to not exceed the pressure rating of the cylinder and is protected from back flow minimally by a check valve. If the cylinder has one valve, the inert gas can be added while the cylinder valve is oriented to the vapor phase, then the inert gas source can be disconnected before orienting to the liquid phase. Again, care must be taken not to exceed the pressure rating of the cylinder. Some applications use air in place of the inert gas for padding. For some products, unloading with air padding may be prohibited by regulations.**NEVER USE AIR TO PAD FLAMMABLE PRODUCTS.** When air padding is allowed and appropriate, it is imperative that clean, oil-free, cooled, dry compressed air be introduced into the vapor space through its vapor valve to transfer the liquid. **NEVER** use a plant air system for air padding since vapors may backflow into the plant air system.
惰性气体如何加入依赖于钢瓶。如果钢瓶有两个阀门，惰性气体可以通过气相阀门加入。要确定惰性气体源调整得不超过钢瓶的额定压力，而且至少受到一个止回阀的回流保护。如果钢瓶有一个阀门，当钢瓶阀门导向气相时可以加入惰性气体，接着在阀门导向液相之前，必须断开惰性气体源。同上一样，必须小心，不能超过钢瓶的额定压力。一些应用使用空气来代替惰性气体作为填料。对于某些产品，用空气填料来排出液体是被规范禁止的。**禁止用空气来填充易燃产品。**当空气填料被允许而且是适当的时候，所引入的空气必须是洁净的、无油的、冷却的、干燥的压缩空气。压缩空气通过蒸气阀门进入蒸气空间，来转移液体。由于蒸气可能回流入工厂用压缩空气系统，**禁止**使用工厂用压缩空气作为填料。

Extreme care must be taken when handling the liquid phase of any liquefied compressed gas. Unlike gas, the liquid does not compress. Therefore, the liquid

must always have a space to expand, especially as it warms. In the cylinder this expansion space is provided by the vapor space or head space.
当操作任何液化压缩气体的液相时，必须十分小心。同气体不一样，液体没有压缩。因此，液体总是有膨胀的空间，特别是当它升温的时候。在钢瓶内，这种膨胀空间由蒸气空间或排出空间提供。

The DOT filling limits/fill density for liquefied compressed gases were described earlier. These limits were set to prevent the cylinder from becoming liquid full at normal storage and use temperatures. If a vessel or system becomes liquid full, any increase in temperature would cause the liquid to try to expand with no space for the expansion. The liquid's incompressibility would result in a rapid increase of hydrostatic pressure. These pressures can build very rapidly and can quickly cause over pressurization of the equipment. Over pressurization of a system takes place when its pressure rating is exceeded. This can result in a rupture of the system. Systems using liquefied gases as liquids should be adequately protected by pressure relief devices, especially where there is a chance to trap liquid between valves or in other components that can be isolated.
以前已经说明了对于液化压缩气体的DOT灌装限度/灌装密度。这些限度是设定来防止在正常的储存和使用温度下钢瓶被液体充满。如果容器或系统被液体充满，温度的任何增长都会导致液体试图在没有空间的情况下膨胀。液体的不可压缩性会导致流体静力学压力的迅速增长。这些压力可以非常迅速地积累，很快导致设备的过压。当它的额定压力被超过时，系统就发生了过压。这会导致系统的破裂。把液化气体作为液体使用的系统应该受到减压装置的充分保护，特别是在有可能积累液体的阀门之间或在可以隔离的其它组件内。

Important Considerations
需要考虑的重要事项

1. NEVER allow any part of a liquefied gas container to be exposed to temperatures greater than 125°F (51°C).
禁止允许液化气体容器的任何部分暴露在大于125°F (51°C)的温度中。

2. NEVER fill any cylinders without the owners written consent.
禁止在没有所有者的书面同意的情况下灌装任何钢瓶。

3. NEVER heat an aluminum cylinder with electrical resistance heaters.
禁止用电阻加热器加热铝瓶。

4. ALWAYS refer to the Material Safety Data Sheet for specific chemical properties.
总是查阅材料安全数据表来得到准确的化学性质。