Gas Safety
气体安全

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气体分类及特征概览

危险货物分类和品名编号（GB 6944-2025）

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Class 2: Compressed gases and liquefied gases

第2类：压缩气体和液化气体；

Class 3: Flammable liquids

第3类：易燃液体；

Class 4: Flammable solids, self-reactive materials, and substances that emit flammable gases upon contact with water

第4类：易燃固体、自燃物品和遇湿易燃物品；

Class 5: Oxidizers and organic peroxides

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Class 6: Toxic substances and infectious materials

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第7类：放射性物品；

Class 8: Corrosive substances

第8类：腐蚀品；

Class 9: Miscellaneous dangerous goods and articles

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Class 2 Compressed Gases and Liquefied Gases
第2类 压缩气体和液化气体

1) Compressed Gases: Gases that are entirely in a gaseous state at -50°C when packaged and transported under pressure; a mixture of one or more gases with one or more other categories of substances in vapor form; items filled with gas and aerosol products.

1) 压缩气体：在-50℃下加压包装运输时完全是气态的气体、一种或多种气体与一种或多种其他类别物质的蒸气混合物、充有气体的物品和气雾剂;

Class 2 Compressed Gases and Liquefied Gases
第2类 压缩气体和液化气体

2) Liquefied Gases: Gases that are partially in a liquid state when packaged and transported under pressure at temperatures above -50°C, which can be further classified as: a) High-Pressure Liquefied Gases: Gases with a critical temperature between -50°C and 65°C. b) Low-Pressure Liquefied Gases: Gases with a critical temperature greater than 65°C.

2) 液化气体：加压包装的气体,在-50 ℃以上温度时呈部分液态。分为以下两种情况：

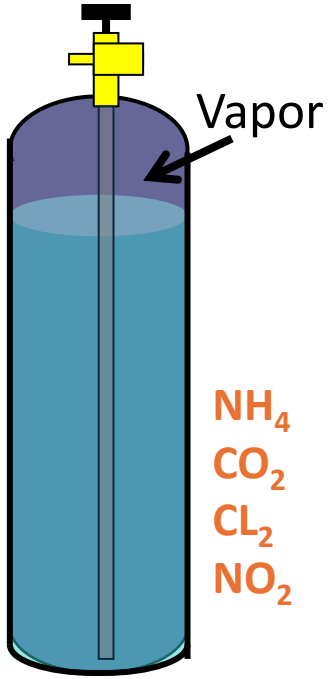
a）高压液化气体：临界温度在-50℃~65℃之间的气体

b）低压液化气体：临界温度大于65℃的气体

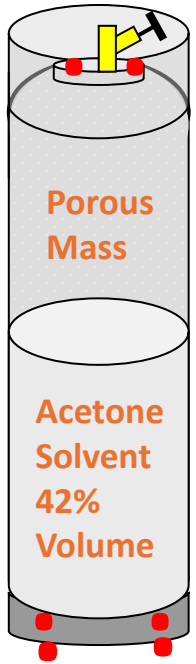
Categories of Compressed Gas Cylinders
压缩气瓶的类别

Classification of Gases by Physical State and Critical Temperature
按气体在瓶内的物理状态和临界温度的分类

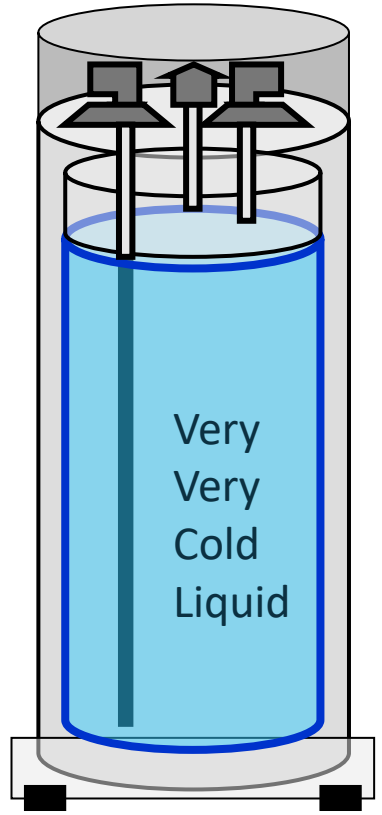
High-Pressure Gas
高压气体



High-Pressure and
Low-Pressure
Liquefied Gases
高、低压液化气体



Dissolved Gas
溶解气体
Acetylene
乙炔



Cryogenic Liquid
低温液体

气瓶安全技术规程（TSG 23-2021）

《化学品分类和标签规范 第1部分:通则》（GB 30000.1-2024）

Gases can be classified into three main categories: flammable gases, oxidizing gases, and gases under pressure.
将气体分为易燃气体、氧化性气体、压力下气体 3 大类

1) Flammable Gases: Gases that, at 20°C and standard atmospheric pressure of 101.3 kPa, can form a flammable mixture with air.
易燃气体是在20 ℃和标准大气压101.3kPa下,与空气混合有易燃范围的气体。

2) Oxidizing Gases: Any gas that can promote or enhance the combustion of other substances by providing oxygen, thus having a greater potential to cause or support combustion than air.
氧化性气体是一般通过提供氧气，比空气更能引起或促使其他物质燃烧的任何气体。

3) Gases Under Pressure: Gases that are stored in a container at a pressure of no less than 200 kPa (gauge pressure), including high-pressure gases, liquefied gases, or cryogenic liquefied gases. Gases under pressure include compressed gases, liquefied gases, dissolved gases, and cryogenic liquefied gases. The hazardous properties of most gases can be referenced through the "Classification Information Sheet for Hazardous Chemicals."
加压气体是指高压气体在压力不低于 200kPa（表压）下装入贮器的气体、液化气体或冷冻液化气体。压力下气体包括压缩气体、液化气体、溶解气体、冷冻液化气体。

Gases are classified into five main categories based on their chemical properties
根据化学性质，气体分为五大类气体

Gas 气体	GHS	e.g.
Oxidizing gases 氧化性气体		O_2,NO_2
Flammable gases 可燃性气体		H_2,C_2H_2,CH_4, C_3H_8,H_2S
Asphyxiating gases (Neutral or Inert) 窒息性气体（中性或惰性）		N_2,Ar,CO_2
Toxic gases 有毒性气体		CO, H_2S
Corrosive gases 腐蚀性气体		Cl_2, NH_3

气瓶颜色标志 （GB/T 7144-2016）

Gas 充装气体	Chemical Formula 化学式	Bottle Color 体色	Text 字样	font color 字体颜色
氮	N_2	黑	氮	白
氧	O_2	淡（酞）蓝	氧	黑
氢	H_2	淡绿	氢	大红
空气	Air	黑	空气	白
氯	Cl_2	深绿	液氯	白
氨	NH_3	淡黄	液氨	黑
乙炔	C_2H_2	白	乙炔 不可近火	大红

The cylinder color for mixed gases is silver-gray, with the head color indicating the gas hazard characteristics:
混合气体的气瓶体色均为银灰色，头部的颜色按气体危险特性：

- Flammable: Red

  可燃性为大红色

- Toxic: Light Yellow

  毒性为淡黄色

- Oxidizing: Light (Phthalic) Blue

  氧化性为淡（酞）蓝色

- Non-flammable (General): Dark Green

  不燃性（一般性）为深绿色

Verification Required:
Label Information and Cylinder Barcode
需复核挂牌信息及气瓶条形码！！！

气体颜色标志GB/T 7144-2016

Liquefied Gas
液化气体

Gas Packaging Methods
气体包装形式

- Cylinder
  钢瓶
- Container rack
  集装格
- Dewar flask
  杜瓦瓶
- Storage tank
  储罐

Container
容器

Pressurized
带压

Non-pressurized
不带压

Dewar Flask
杜瓦瓶

Biological Container Tank
生物容器罐

Insulated Bottle
保温瓶

On-Site Filling of Liquefied Gases: Procedures and Precautions
现场分装液化气体时，如何分装，有哪些注意事项

◆Buddy system

双人作业

◆PPE, Site Ventilation, Oxygen Concentration Monitoring

个人防护装备，现场通风，氧气浓度探头

◆Post-Use Storage of Liquid Nitrogen Buckets

液氮罐提桶使用结束后的归置

Dewar Flask
杜瓦瓶

Cryogenic
低温

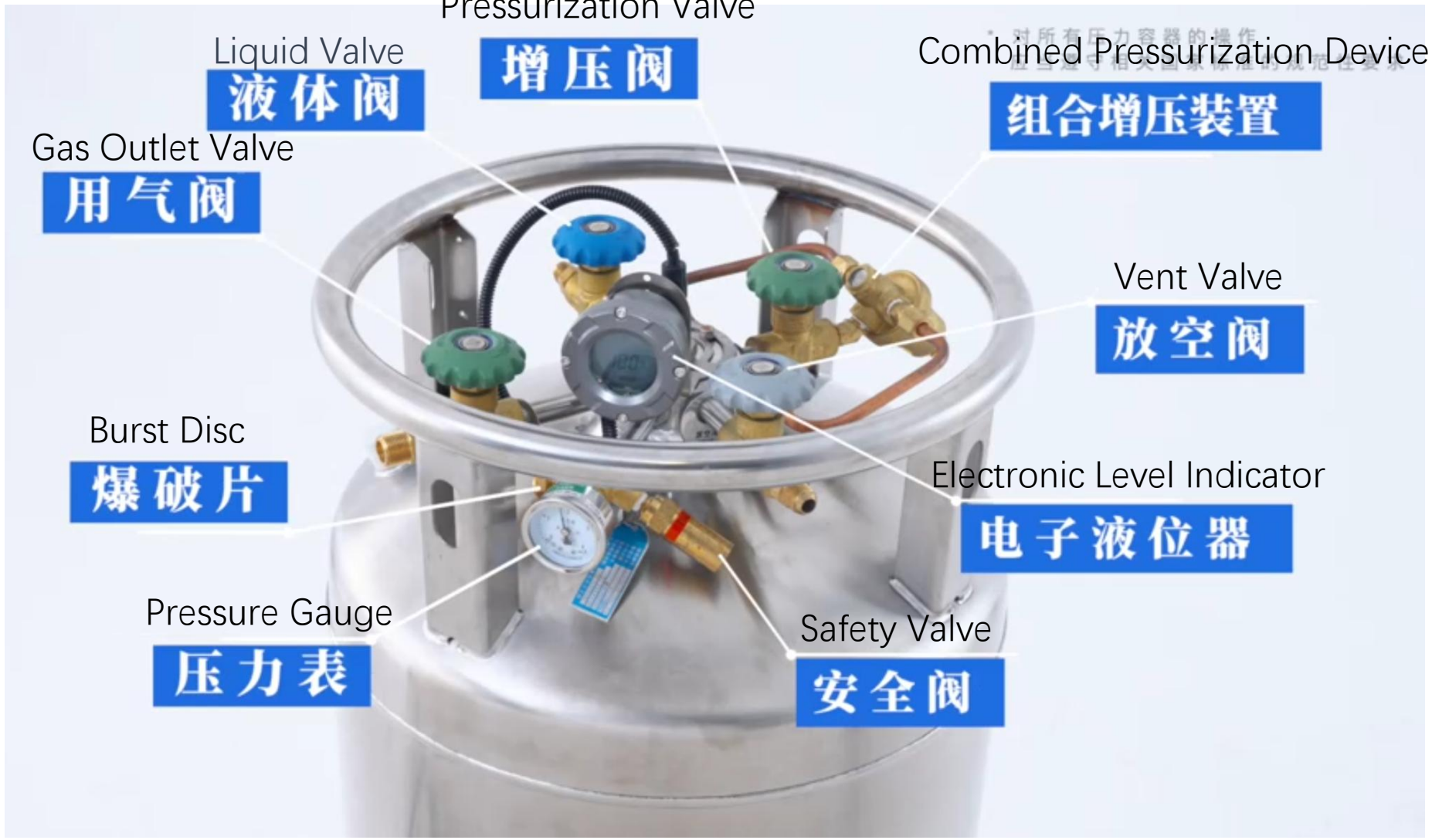
Also known as a welding insulated gas bottle, a Dewar flask is primarily used for the storage and transportation of liquefied gas products. It is a high-vacuum, multi-layer insulated, portable container designed for low-temperature liquids.

杜瓦瓶，又称焊接绝热气瓶，主要用于贮存、运输液化气体产品的高真空多层绝热可移动式低温液体容器。

- Liquid Nitrogen液氮(LN_2)
- Liquid Argon液氩(LAr)
- Liquid Oxygen液氧(LO_2)

Dewar Flask Valve Assembly
杜瓦瓶的阀门组件

Cryogenic
低温



Risk: Cryogenic Frostbite
风险：低温冻伤

- Phenomena of Cryogenic Frostbite
  低温冻伤的现象
- Characteristics of Cryogenic Frostbite
  低温冻伤的特点
  - Burning Sensation
    灼伤
  - Numbness
    麻木
  - Difficult to Detect
    不易察觉

当心低温

Risk: Cryogenic Frostbite
风险：低温冻伤

- Cryogenic Products That May Cause Frostbite

  可能导致低温冻伤的低温产品

  - 液氮-196°C, 液氧-183°C, 液氩-186°C
  - Liquid Nitrogen-196°C, Liquid Oxygen-183°C, Liquid Argon-186°C
  - 其他 **CO_2, N_2O**…

    Other Cryogenic Gases **CO_2, N_2O**…
- Operations at Risk of Cryogenic Frostbite

  可能接触到低温冻伤的风险的操作

  - 钢瓶搬运，液体充装…

    Cylinder Handling, Liquid Filling…

当心低温

First Aid for Cryogenic Burns
低温冻伤的急救

- First Aid Measures: Same as for Burns急救措施，与处理烧伤同样的方法：
  - ✓ Rinse the affected area with warm water
    用温水冲洗受伤部位
  - X Do NOT rub the area
    不要揉搓
  - ✓Cover with sterile gauze
    用消毒纱布覆盖
  - X Do NOT use powders or ointments
    不能使用粉剂或乳剂
  - ✓ Seek medical attention promptly
    尽快就医

First Aid
急救

Compressed Gas
压缩气体

The Cylinder
气瓶

- Regular inspection

  定期检查
- Marking

  记录
- Labeling -- type of gas

  《气瓶安全技术规程》（TSG 23-2021）
- Colours

  《气瓶颜色标志》（GB/T 7144-2016）

表 9-1　气瓶定期检验周期

气瓶品种		介质、环境		检验周期(年)
钢质无缝气瓶、钢质焊接气瓶(不含液化石油气钢瓶、液化二甲醚钢瓶)、铝合金无缝气瓶		腐蚀性气体、海水等腐蚀性环境		2
		氮、六氟化硫、四氟甲烷及惰性气体		5
		纯度大于或者等于 99.999%的高纯气体(气瓶内表面经防腐蚀处理且内表面粗糙度达到 *Ra*0.4 以上)	剧毒	5
			其他	8
		混合气体		按混合气体中检验周期最短的气体特性确定(微量组分除外)
		其他气体		3
液化石油气钢瓶、液化二甲醚钢瓶	民用	液化石油气、液化二甲醚		4
	车用			5
车用压缩天然气瓶		压缩天然气、氢气、空气、氧气		3
车用氢气气瓶				
气体储运用纤维缠绕气瓶				
呼吸器用复合气瓶				
低温绝热气瓶(含车用气瓶)		液氧、液氮、液氩、液化二氧化碳、液化氧化亚氮、液化天然气		3
溶解乙炔气瓶		溶解乙炔		3

The Cylinder
气瓶

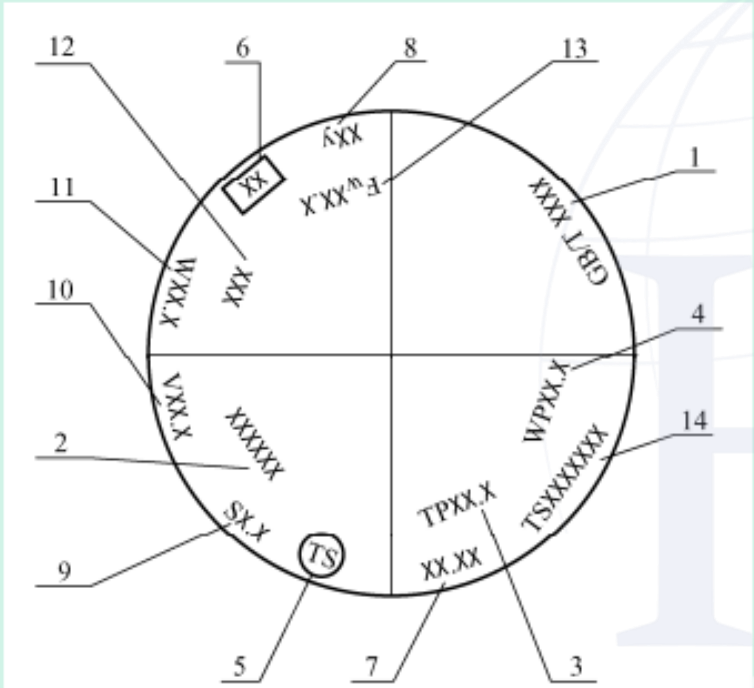


图 D-3　气瓶制造钢印的项目和排列

表 D-1　气瓶制造钢印标志的项目和含义(注 D-3、注 D-4)

编号	钢印项目(例)	含义
1	GB/T ××××	产品标准号(注 D-5，下同)
2	××××××	气瓶编号
3	TP××.×	水压试验压力，MPa
4	WP××.×	公称工作压力，MPa
5	TS	监检标记
6	××	制造单位代号
7	××.××	制造日期

表 D-1(续)

编号	钢印项目(例)	含义
8	××y	设计使用年限，y
9	S××.×	瓶体设计壁厚，mm
10	V××.×	实际容积，L
11	W××.×	实际重量，kg
12	×××	充装气体名称或者化学分子式
13	Fw××.×	液化气体最大充装量，kg
14	TS××××××	气瓶制造许可证编号

注 D-3：溶解乙炔气瓶及焊接绝热气瓶除外。

Hazards and Risks Associated with High-Pressure Gas Cylinders
与高压气瓶有关的危害和隐患

- Gas Properties: Flammable, Self-igniting, Toxic, Corrosive, Reactive, Asphyxiating.

  气体本质 - 易燃、自燃、有毒、腐蚀、反应性、窒息

- Cylinder Integrity: High Pressure, Potential Damage.

  瓶体本体 - 高压、有损

- Gas Line: Poor Connections, Leakage (Lack of Marking, Emergency or Maintenance Valve Switches).

  气路 - 接驳、固定不良漏气（缺乏标识，紧急或维护开关阀）

- Cylinder Tipping (Not Secured).

  气瓶翻倒（没有被固定）

- Treatment of Waste Gas and Exhaust Emissions

  废气和尾气的处理

Precautions for Purchasing Gas Cylinders
气瓶的采购注意事项

- Purchase from the on-campus framework supplier

  在校内框架供应商采购
- Procurement must be initiated through the laboratory safety management platform

  必须在实验室安全管理平台发起采购
- Only gases should be procured, not gas cylinders

  只采购气体，不采购气瓶
- Upon delivery of the cylinders, label and bind the information

  气瓶到货后贴码绑定信息

Limit the Number of Gas Cylinders in the Laboratory
限制实验室气瓶数量

◆In general, each laboratory should have a maximum of 5 gas cylinders in total. No more than one cylinder of each type is allowed, except for inert gases.

一般来说，每个实验室最多总共有 5 个气瓶 。每类不可超过一瓶，惰性气体除外。

◆Do not store spare cylinders in the laboratory solely for convenience.

不要仅仅为了方便而将备用气瓶存放在实验室中。

◆Empty cylinders, as well as those that are inactive or not in use for an extended period, should be returned to the gas storage facility or supplier.

空瓶、停用、长时间不使用气瓶应退回气瓶仓库或供应商。

◆Consider utilizing gas generators as an alternative.

考虑使用气体发生器。

Considerations for Receiving Gas Cylinders
气瓶的接收注意事项

◆ **Confirmation of Ordered Product Information**

确认订货产品信息

- Verify details including product medium type, grade, quantity, etc

  送货单的产品信息（包括产品介质类型、等级、数量等）

Considerations for Receiving Gas Cylinders
气瓶的接收注意事项

◆ Product Attributes Confirmation

确认产品属性

- Confirm that all cylinders are fitted with intact caps

  所有的气瓶均佩戴有完好的瓶帽

- Check for any damage, leaks, or oil contamination on the valves of cylinders or Dewar flasks

  气瓶或杜瓦瓶的阀门有无损坏泄露或粘有油污

- Barcode Presence

  是否有条形码

- Inspection Stamp Validity

  气瓶检验钢印是否在合格期内

- Legibility of Paint and Markings

  气瓶漆膜和其上的文字符号是否清晰可辨

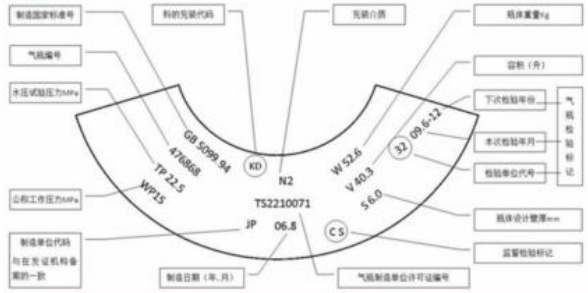
- Additional Safety and Quality Checks

  其他涉及安全或质量因素的检查项

Inspect the appearance of the cylinder (the gas inside matches the color of the cylinder, the cylinder outlet is sealed with a plastic film or plug, no deformation, crack, abrasion, corrosion of the cylinder and oxygen cylinders are free from grease) and verify the integrity of safety accessories (shock-absorbing rubber ring, cylinder protective cover, valve).

Scan the electronic identification symbol on the cylinder shoulder (such as a QR code) using a mobile phone to view basic information about the cylinder, including cylinder status and specific expiration date of the inspection.

Check the manufacturer's certificate of compliance (including gas name, purity, volume, filling date, expiration date, manufacturer's name, etc.) and labeling.

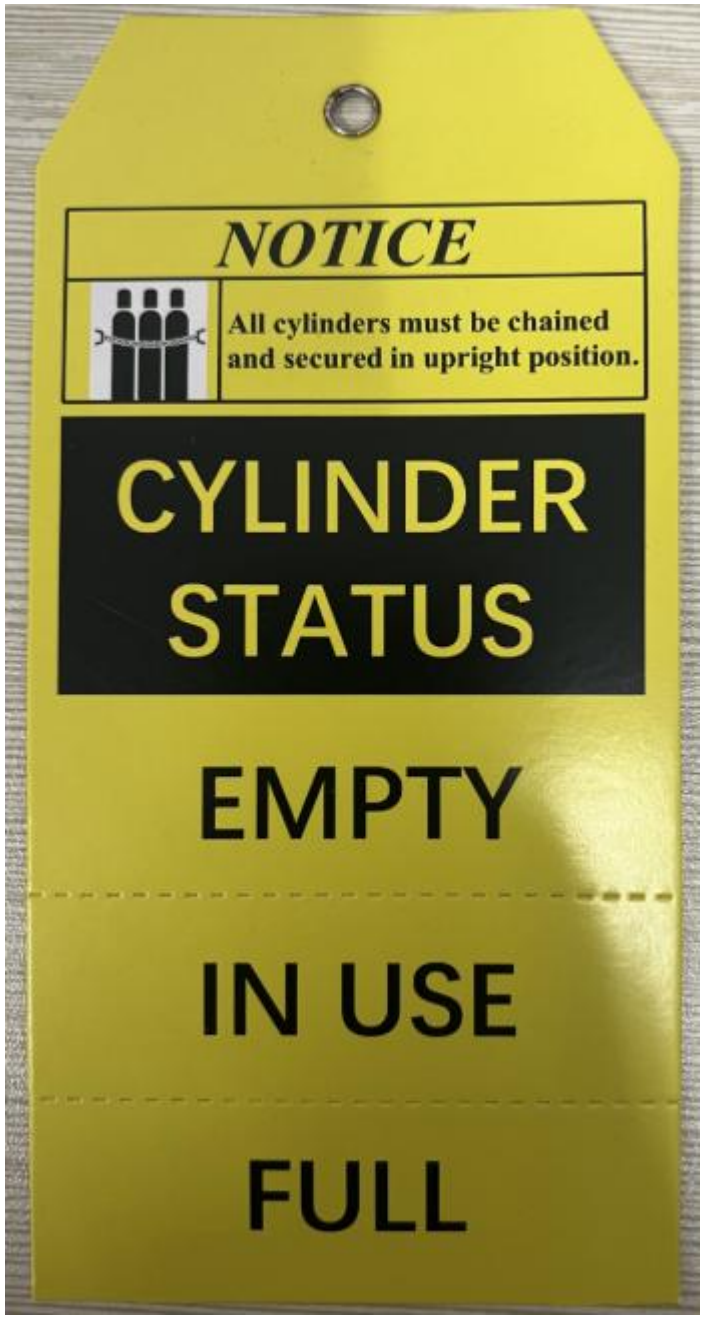


Check the steel mark on the shoulder of the cylinder (including the manufacture date, the designed service life, the name or the chemical formula of the filled gas, etc.).

** If there are any problems or concerns in the above four steps, please contact the cylinder supplier or feedback to LSMD in time. Make sure there is no any problem before accepting the cylinder.

Attach a gas usage status label to the cylinder, indicating the manager and date, and keep the status updated

在气瓶上悬挂气体使用状态标识卡，注明管理人和时间，并保持更新气瓶状态



The neck and valve of the bottle are the most vulnerable parts and must be well protected

瓶颈与瓶阀是最容易受损的部位必须好好保护

Transporting Gas Cylinders
运输气瓶

General Precautions:
一般注意事项:

- Always shut off the valve before moving

  确保在移动之前关闭阀门
- Do not drag, roll or slide cylinders

  不可以拖、滚或滑动气瓶
- Use proper trolleys or carts for transporting cylinders for long distances

  在长距离运输气瓶时，请使用适当的手推车或小车

Transporting Gas Cylinders
运输气瓶

General Precautions:
一般注意事项:

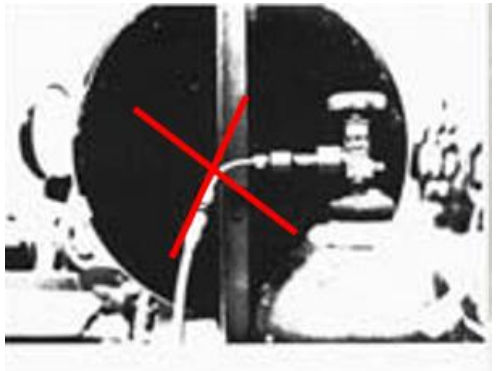
- When moved by crane, hoist or forklift, cylinders must be securely placed inside a cradle or platform and securely tied with chains or ropes
  通过起重机、吊钩或叉车移动时，气瓶必须安全放置在托架或平台上，并用链条或绳索牢固固定
- Cylinder valves should be protected with caps (if provided) during transportation
  在运输过程中，气瓶阀门应使用保护帽（如提供）保护
- Never drop a cylinder or permit cylinders to strike each other violently
  切勿掉落气瓶或允许气瓶猛烈撞击
- Wear proper personal protective equipment (e.g. gloves, safety shoes) when moving cylinders
  搬运气瓶时请穿戴适当的个人防护装备（例如手套、安全鞋）

Cylinder Stabilization Methods
不同的气瓶固定（防倾倒）方式

Laboratory bench clamps are not recommended for this purpose
不建议使用实验室桌夹

Before Using Cylinder
使用气瓶前

- Never accept or use a leaking cylinder
  切勿接受或使用泄漏的气瓶
- Check the label to make sure the gas is the one you want
  检查标签以确保所用气体是您需要的气体
- Do not rely only on the colour of cylinder, if in doubt-ask
  不要仅依赖气瓶的颜色，如果有疑问，请询问
- Never use gas without label of type of gas
  切勿在没有气体类型标签的情况下使用气体



Before Using Cylinder
使用气瓶前

- Know the SDS of gas you use

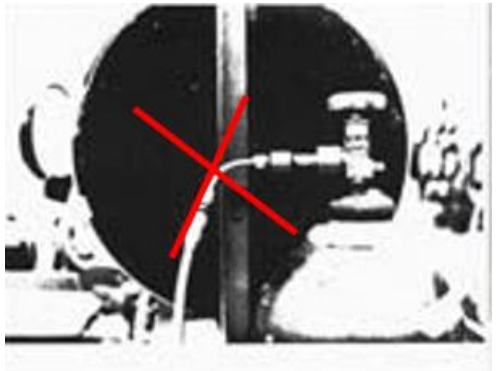
  了解您使用的气体的SDS

- Check to ensure the regulator and pressure gauges are of the proper types. Cylinders must not be used without an appropriate regulator

  检查以确保调节器和压力表是适当类型。气瓶在没有适当调节器的情况下不得使用

- Check to ensure hoses/ tubes are appropriate types of sufficient pressure ratings and securely connected

  检查以确保软管/管道是适当类型且具有足够的压力等级，并且连接牢固



- Never force fit regulators or fittings to cylinders

  切勿强行将调节器或配件安装到气瓶上

Before Using Cylinder
使用气瓶前

- Do not force open cylinder valve. Return cylinder if valve cannot be opened by turning hand wheel or using valve key

  切勿强行打开气瓶阀门。如果无法通过转动手轮或使用阀门钥匙打开阀门，请退还气瓶

- Gases must never be mixed inside cylinder

  气体绝不可在气瓶内混合

- "Reverse flow check valves" and "flashback arresters" must be fitted for each gas cylinder whenever an oxidizer and a flammable gas are used

  每个气瓶在使用氧化剂和可燃气体时必须安装“单向阀”和“回火阀”

- Never strike an electric arc or direct a flame at a cylinder, or make a cylinder as part of an electric circuit

  切勿对气瓶打电弧或将火焰直接指向气瓶，也不得将气瓶作为电路的一部分

After Using Cylinder
使用气瓶后

- Close cylinder valves when not in active use

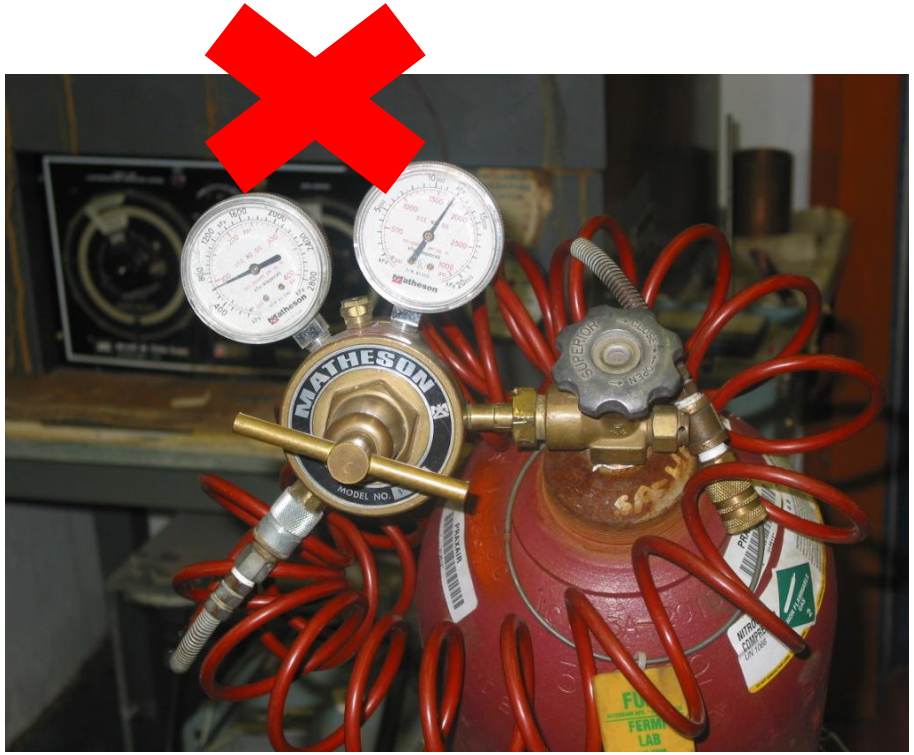
  使用结束后关闭气瓶阀门
- The gas in the bottle should not be used up, excess pressure should be left

  气瓶中的气体不应被完全用尽，应留有多余的压力
- Empty cylinders should be labeled

  空气瓶应贴上标签

使用后的调节器还是处于加压状态

应该清空，泄压



使用完毕的气瓶

Leak test
检验气密性

Bubble-free= Leak-free
无气泡 = 无泄漏

8068 型气体泄漏检测仪

Gas Leak Detector
气体泄漏检测仪

Safe Storage of Compressed Gas Cylinders
压缩气瓶的安全存储

◆Store only in designated gas rooms or specified laboratory areas

只能将气瓶存放在指定气瓶房、仓库，或实验室指定的位置

◆Display safety signs for hazardous gases

展示特殊危险气体的安全标志

◆Implement access control to prevent unauthorized entry

气瓶房或存储间应设门禁安防，防止未经授权的进入

Safe Storage of Compressed Gas Cylinders
压缩气瓶的安全存储

◆**Storage and Installation Requirements**

存储和安装的房间和地面应

- Keep rooms cool, dry, well-ventilated, and fire-resistant
  凉爽、干燥、通风良好，房间防火
- Position away from ignition sources and unprotected electrical circuits
  位置远离火源、热源、火花或电路 （没有保护）
- Ensure level flooring
  地面平整
- Maintain temperatures below 51.7 ^{o}C (56 ^{o}C)
  温度低于51.7 ^{o}C (56 ^{o}C)
- Avoid direct sunlight exposure
  远离太阳的直晒（长时间）

◆**Assess environmental monitoring needs for low oxygen or hazardous gases**

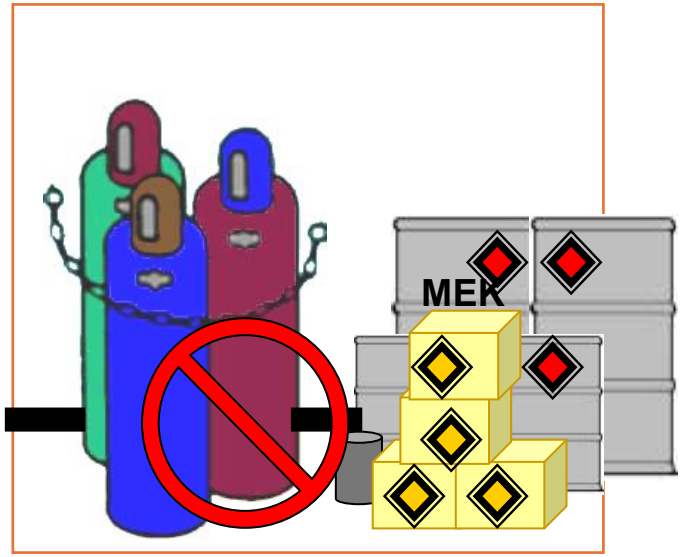
评估对可能贫氧，使用高易燃或有毒等气体环境监测的需要

Consider Cylinder Compatibility During Storage to Avoid Mixing
存储时同时考虑气瓶的兼容性，避免混存

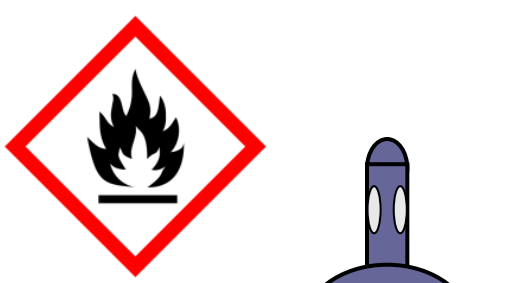
◆**Gas cylinders should be stored in compatible category groups, keeping them isolated from incompatible types**

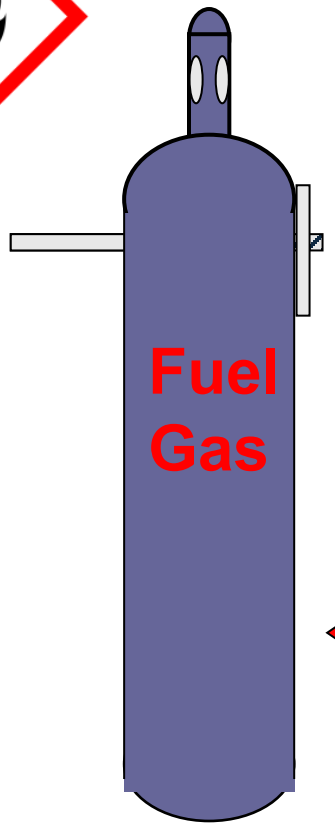
气瓶应存放在兼容的类别组，与有禁忌的种类隔离分开

- Oxidizing gases must be stored separately from flammable gases
  氧化气体与易燃气体要分开存放
- Flammable gases should be kept away from combustible materials
  易燃气体与可燃物品分隔



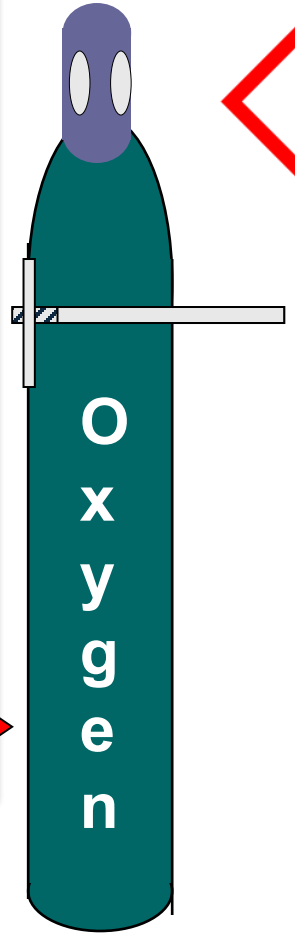
Separation of Flammable Gases from Oxygen (Oxidizers)
易燃气体与氧气（氧化）的分隔





Storage and Use in Laboratory Indoor Environment
实验室室内的存储使用

- Ensure good ventilation
  良好通风
- Maintain a minimum distance of 20 feet/ 6m, or use a non-combustible barrier with a 30-minute fire rating (minimum height of 5 feet)
  分开20 英尺/6米最小距离 或以防火等级为半小时的不燃屏障分隔（至少 5 英尺高）



Cylinders Storage Location
气瓶存放位置

◆Keep cylinders away from emergency exits, main entrances, and high-traffic areas

远离逃生通道、大楼主要出入口、实验室主门口、大量人流的路径和区域

◆Avoid storage near elevators or areas prone to collisions or falling objects

避免存放在电梯附近，或在大型移动物体可能撞击气瓶或有物品掉落到气瓶的位置

◆Store away from open flames, heat sources, and electrical hazards (above 56°C)

气瓶远离明火、热源或点火源 (56 °C) 或可能对瓶体的完整性产生不利影响的来源（电击等）

For toxic and corrosive gases, conduct risk assessment and develop emergency response plans
对于毒腐气体，做好风险评估 与 应急预案

Prioritize the use of small gas cylinders
优先使用小气瓶

For toxic and corrosive gases, installation and use must be in gas cabinets, fume hoods, or ventilated enclosures

对于毒腐气体，安装和使用是在气瓶柜，抽风装置或通风柜内

Safety Configuration for Flammable and Toxic Gas Piping Design
易燃气体 与 有毒气体的气路设计安全配置

Excess Flow Shut-Off Valves
过流截止阀

Reverse-flow Check Valve
止回阀

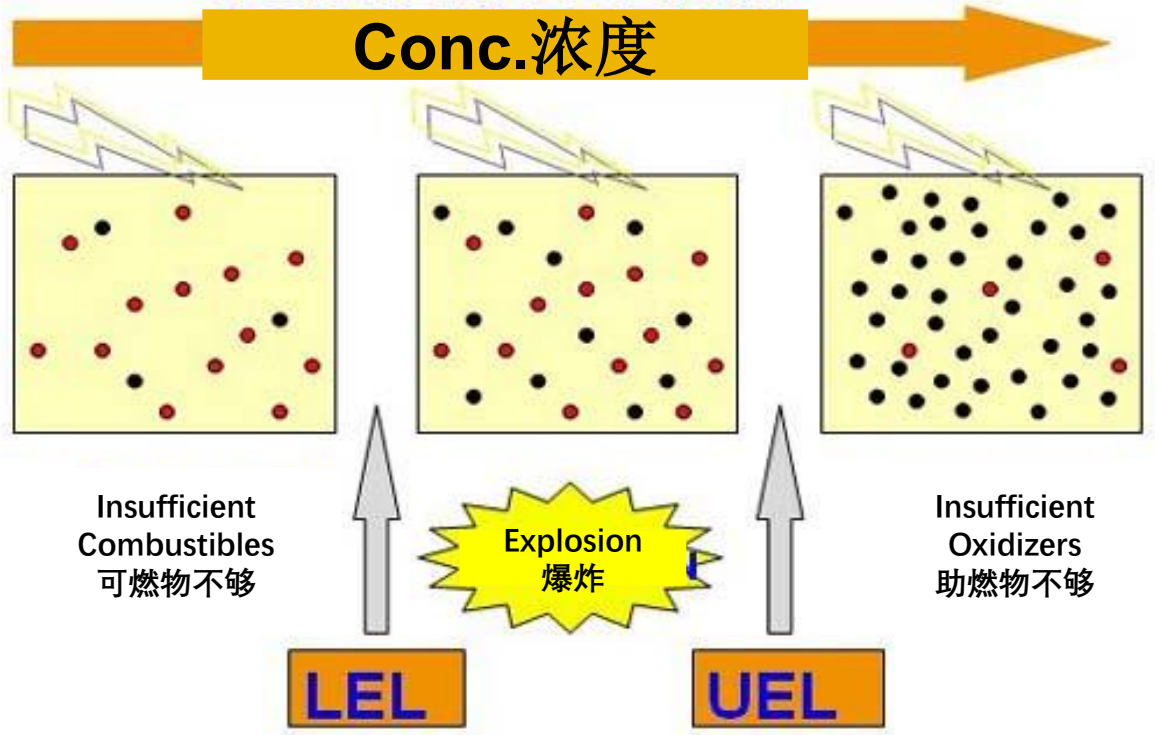
flashback arrestor
易燃气体气瓶安装回火断路器

Industrial gas-related risks: combustion and explosion
工业气体导致的风险：燃烧和爆炸

Explosive limit
爆炸极限

(LEL)Lower Explosivity Limit
爆炸下限

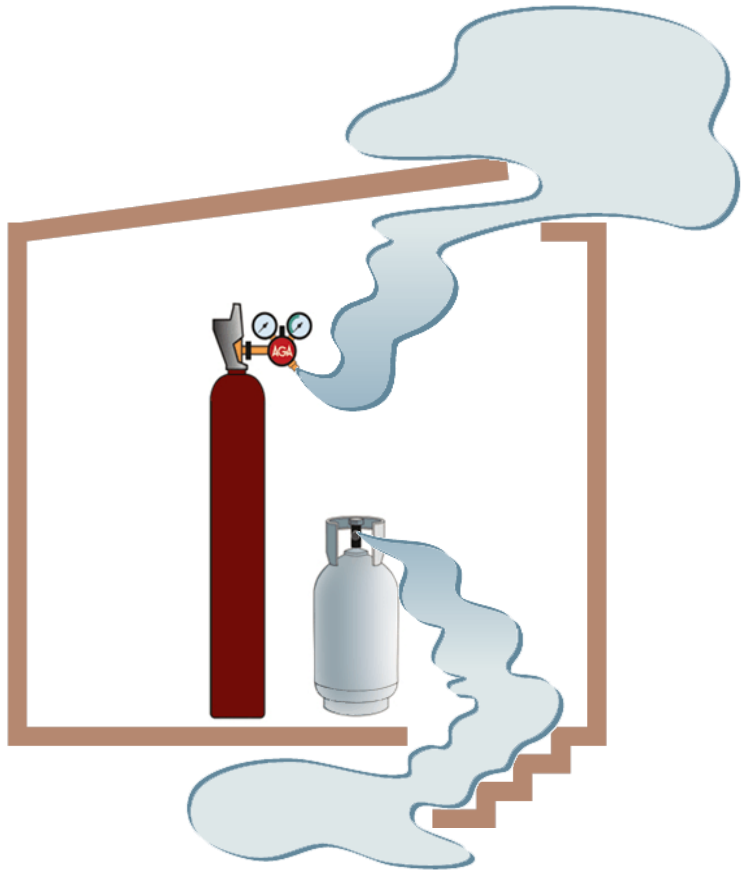
(UEL)Upper Explosivity Limit
爆炸上限



LEL and UEL vary depending on pressure, temperature, and oxygen content
LEL 和UEL 会根据压力、温度及氧气含量的不同而有所不同

Install gas concentration detectors
安装气体浓度检测仪

Gas	Relative Density
氢气H_2	0.07
氦气He	0.14
乙炔C_2H_2	0.91
氮气N_2	0.97
空气Air	1.0
氧气O_2	1.11
氩气Ar	1.38
二氧化碳CO_2	1.53
丙烷C_3H_8	1.56



Gas Concentration Detectors
气体浓度检测仪

A device that detects gas concentration, displays the value, and triggers an alarm when the concentration exceeds a preset limit

探测部件探测气体浓度,通过显示部件显示气体浓度值,并在达到报警设定值时由报警部件发出报警信号的设备。

Sampling Method 采样方式	Operating Principle 工作原理	Image 图片
Diffusion 扩散式	Gas naturally diffuses 气体自然扩散	
Pumping 泵吸式	Gas is drawn in using a built-in pump 通过内置泵	

Gas Emergency Response Procedure
气体应急响应程序

Gas Emergency Response Procedures
气体应急处置流程

The gas concentration detector alarms
气体浓度检测仪报警

→

Notify personnel to evacuate, secure the area
通知周围人员疏散，封锁现场

→

Report to all levels of management
电话上报各层级负责人

↓

Wear PPE based on gas type and leak size; initiate emergency response
结合气体性质、泄漏量，穿戴不同个人防护装置，开展应急

Note: After the environment reopens, notify professionals to check cylinders and gas lines before use.
注意：环境解封后，需通知专业人员排查气瓶和气路问题，待确认没问题后再启用

Reference
参考

- 危险货物分类和品名编号（GB 6944-2025）
- 气瓶安全技术规程（TSG 23-2021）
- 化学品分类和标签规范 第1部分:通则（GB 30000.1-2024）
- 气瓶颜色标志 （GB/T 7144-2016）

谢谢！！！