2012 台灣氧氣使用安全研討會

Oxygen Safety Seminar 2012 Taiwan

行政院勞工委員會

台灣區高壓氣體工業同業公會

Asia Industrial Gases Association

國立臺北科技大學

Introduction to Oxygen Safety
氧氣安全介紹

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Agenda
議程

1. **Introduction to Oxygen Safety**
2. **Materials and Oxygen Compatibility**
3. **Ignition Mechanism & Industry Incidents with Actual Cases in Asia**

1. 氧氣安全介紹
2. 材質及氧相容性
3. 引燃之機制 及 行業中的事故含亞洲真實案例

Agenda
議程

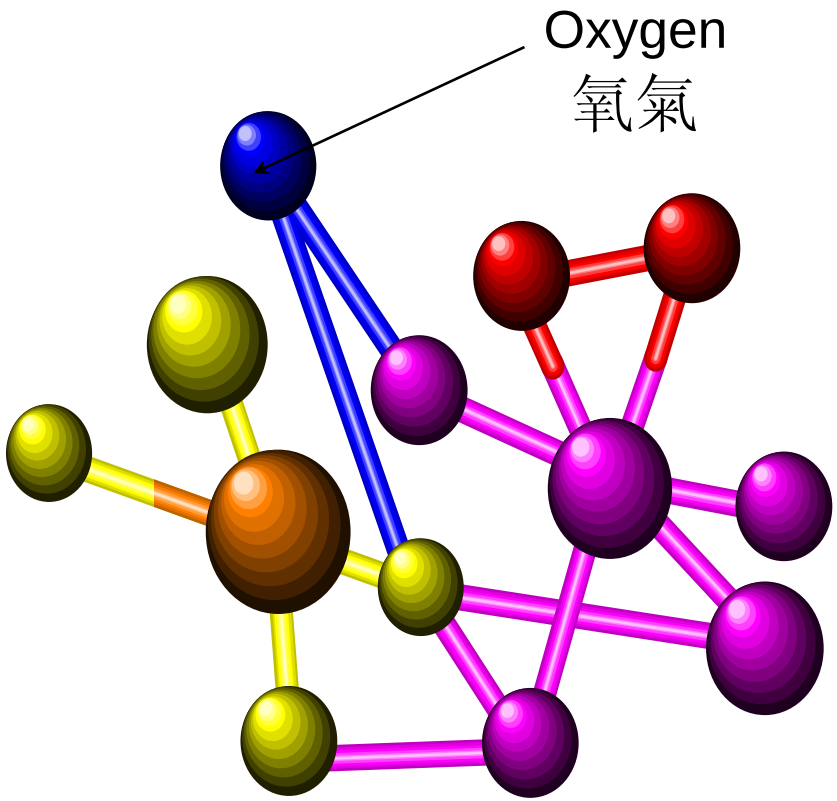
Part 1
第一部份

Introduction to Oxygen Safety

氧氣安全介紹

Properties & Hazards of Oxygen
氧氣的特性與危害

- **Oxygen is essential to the maintenance of life**
- **Oxygen is essential for combustion**
- **Oxygen is a reactive gas which will form oxides with most elements**
- 氧是維持生命的必須
- 氧亦是燃燒條件的必須
- 氧能夠與絕大多種分子發生作用，繼而產生氧化物



Properties & Hazards of Oxygen
氧氣的特性與危害

What are the hazards ?

- Oxygen enhances burning of materials
  - the material burns more aggressively
  - the fire cannot be extinguished
- All materials burn in oxygen except ceramics, gold and silver
- The energy required to start an ignition can be very small
- Oxygen enrichment gives no warning

Effect of adding LOX to a charcoal fire

Properties & Hazards of Oxygen
氧氣的特性與危害

有何種危害？

- 氧能促進物質燃燒
  - 有關物質會更強烈地燃燒
  - 有關的火不能夠被撲滅
- 除陶瓷、金和銀外，所有物質均可以與氧發生燃燒
- 引燃所需的能量可以很小
- 富氧的環境沒有警示

将液氧加进煤炭火的效果

Necessary Conditions For A Fire
火形成的所需條件

FUEL (COMBUSTIBLE MATERIAL)

- **Most Items are Combustible under Favourable Conditions**

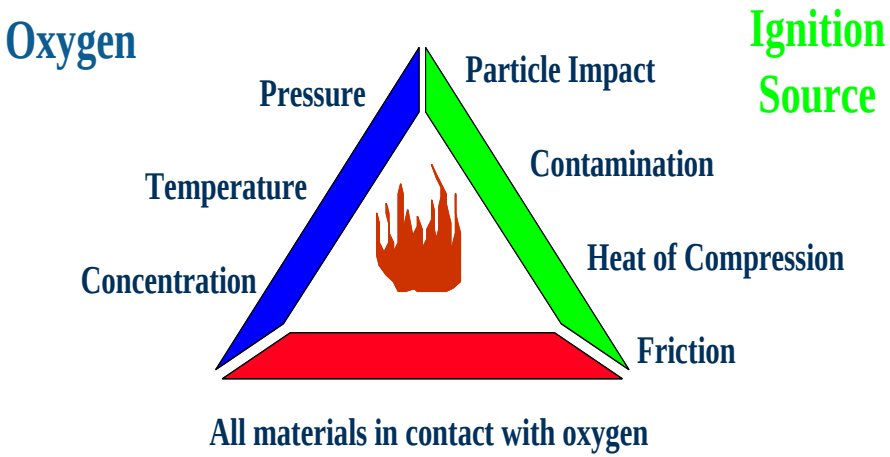
OXYGEN

- **From Air**
- **Enriched Air or Pure Oxygen**
  - **Liquid**
  - **Gas**

IGNITION SOURCE

- **Flame**
- **Sparks**
- **High Energy Particles**
- **Adiabatic Compression**
- **Friction**

Fire Triangle



No fire if any element is missing!

Necessary Conditions For A Fire
火形成的所需條件

燃料 （可以燃燒的物料）

- 大部分物質，在合適環境下，均可以燃燒

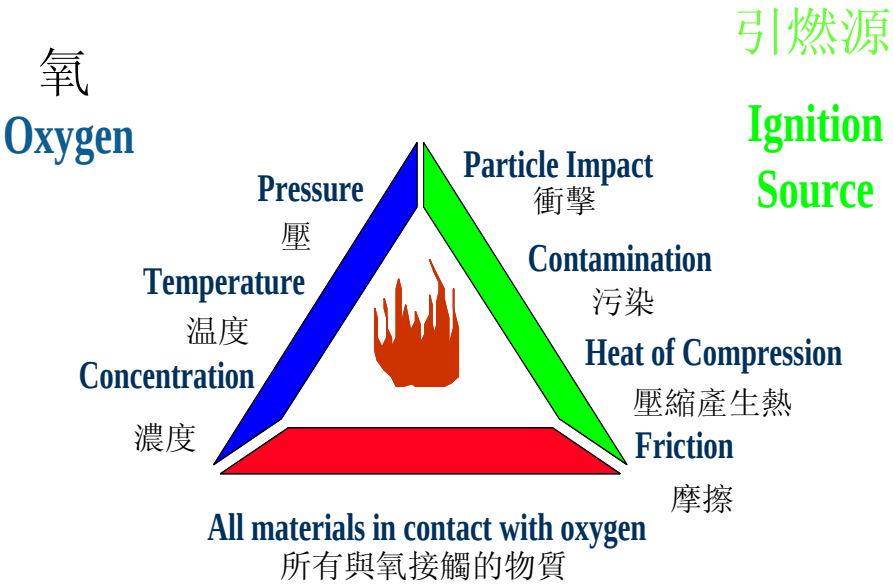
氧

- 空氣中
- 富氧空氣 或 純氧
  - 液體
  - 氣體

引燃源

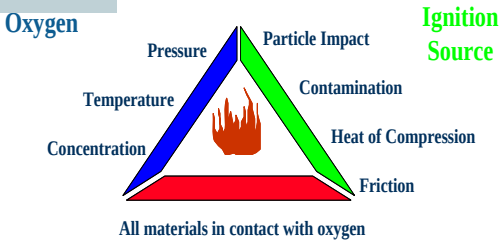
- 火焰
- 火花
- 高能量顆粒
- 絕熱壓縮
- 摩擦

火三角



缺乏其一，火均不能產生!

Fire Triangle: Fuel Leg
火三角：燃料端



Contamination:

- **Such as oil, grease, particles or fine debris from assembly are often easy to ignite and can initiate the kindling chain. Ease of contamination removal should be considered in the design**

Thermal conductivity:

- **Metals with low thermal conductivity are more easy to ignite, as hot spots cannot be dissipated before ignition occurs**

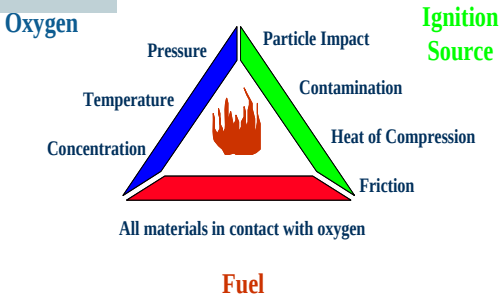
Thickness:

- **Sharp corners and thin sections promote easier ignition, as they are heated more quickly than thicker sections**

Higher heat of combustion provide more energy to promote propagation

Successful Experience with the metal in same or similar service provides a good basis for material selection

Fire Triangle: Fuel Leg
火三角：燃料端



污染:

— 例如油、油脂、微粒、從組裝體所鬆脫之碎片是普遍較容易引燃，從而引起燃燒的連鎖。在設計上應考慮該等污染物容易被清除

熱傳導:

— 低熱傳導的金屬是較為容易被引燃，那是由於該熱點是不容易在其引燃發生前所散發

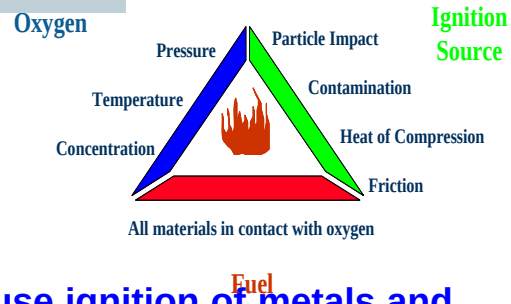
厚度:

— 尖角與薄片較為容易促進引燃，那是由於其熱傳導較其他厚片快

較高 燃燒熱熔 可提供較多能量來促進蔓延

相同或相似金屬的成功 經驗 可以作為日後選擇材质的基礎

Fire Triangle: Ignition Leg
火三角：引燃端



Particle impact:

- Impact from particles in a high velocity flowing oxygen stream can cause ignition of metals and non metals, particularly in impingement sites such as tees, elbows, etc.

Friction:

- The rubbing together of components generates heat that can cause ignition. Friction may also generate particles

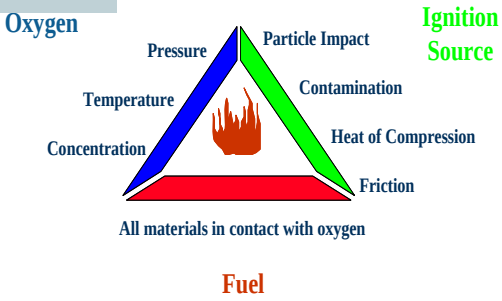
Electrical energy:

- Electrical discharge from static energy generated by gas flow in the presence of particles can cause ignition. Similarly, electrical discharge from shorts in motors or heating elements can result in ignition

Kindling chain:

- Combustion of particles or polymers may release enough energy to ignite an adjacent metal component. Ignition of a less compatible metal such as carbon steel may cause ignition of a more compatible metal such as brass

Fire Triangle: Ignition Leg
火三角：引燃端



微粒撞擊:

— 在高流速氧氣中微粒的撞擊可以將金屬和非金屬引燃，尤其是於三通、彎頭等的地方

阻力:

— 組件間的摩擦會發放熱從而引發引燃。摩擦同時產生微粒

電能量:

— 氣流中的微粒帶有靜電從而發放電能量從而引發引燃。同樣地，馬達或發熱體也可以發放電能量從而引發引燃

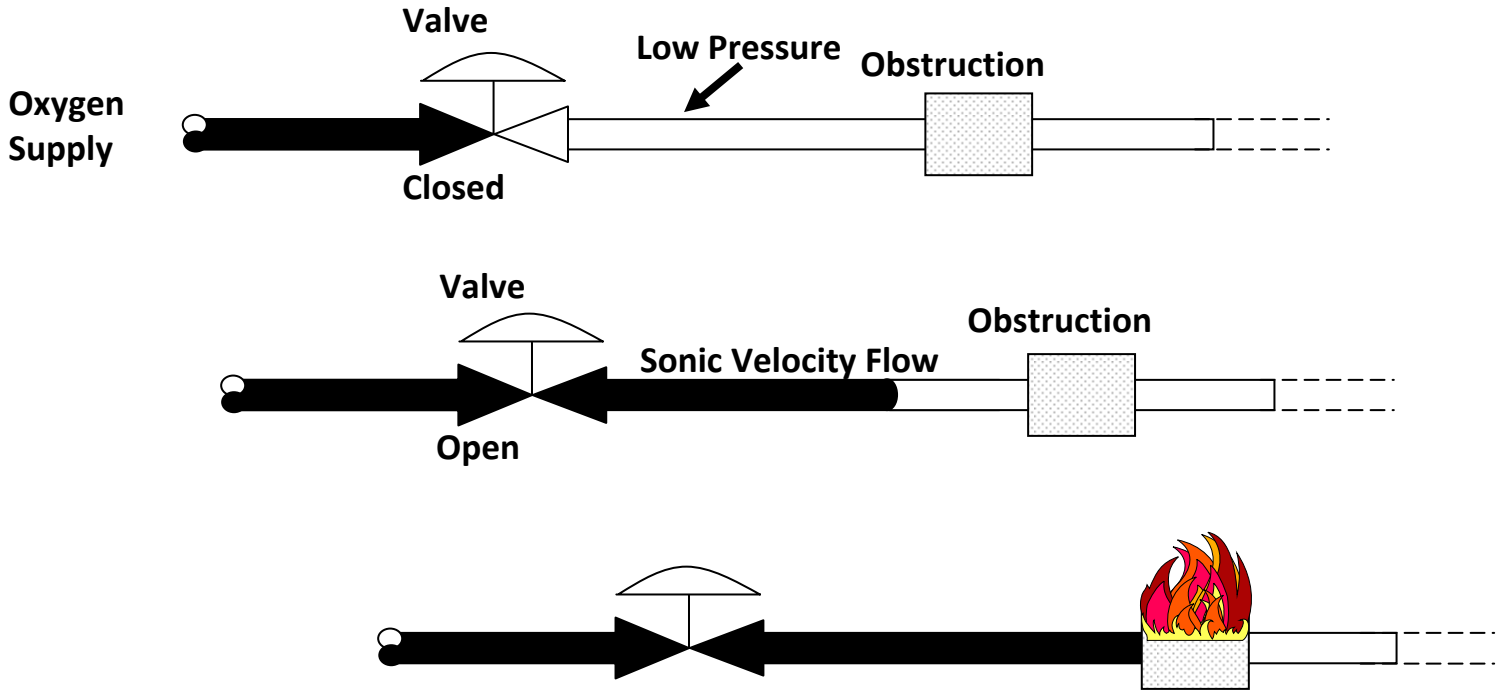
點燃連鎖:

— 微粒或聚合物的燃燒可能發放足夠的能量來引燃旁邊的金屬元件，低兼容金屬，例如碳鋼，在被引燃後，可能引發高兼容金屬發生引燃，例如黃銅，

Fire Triangle: Ignition Leg
火三角：引燃端

Adiabatic compression:

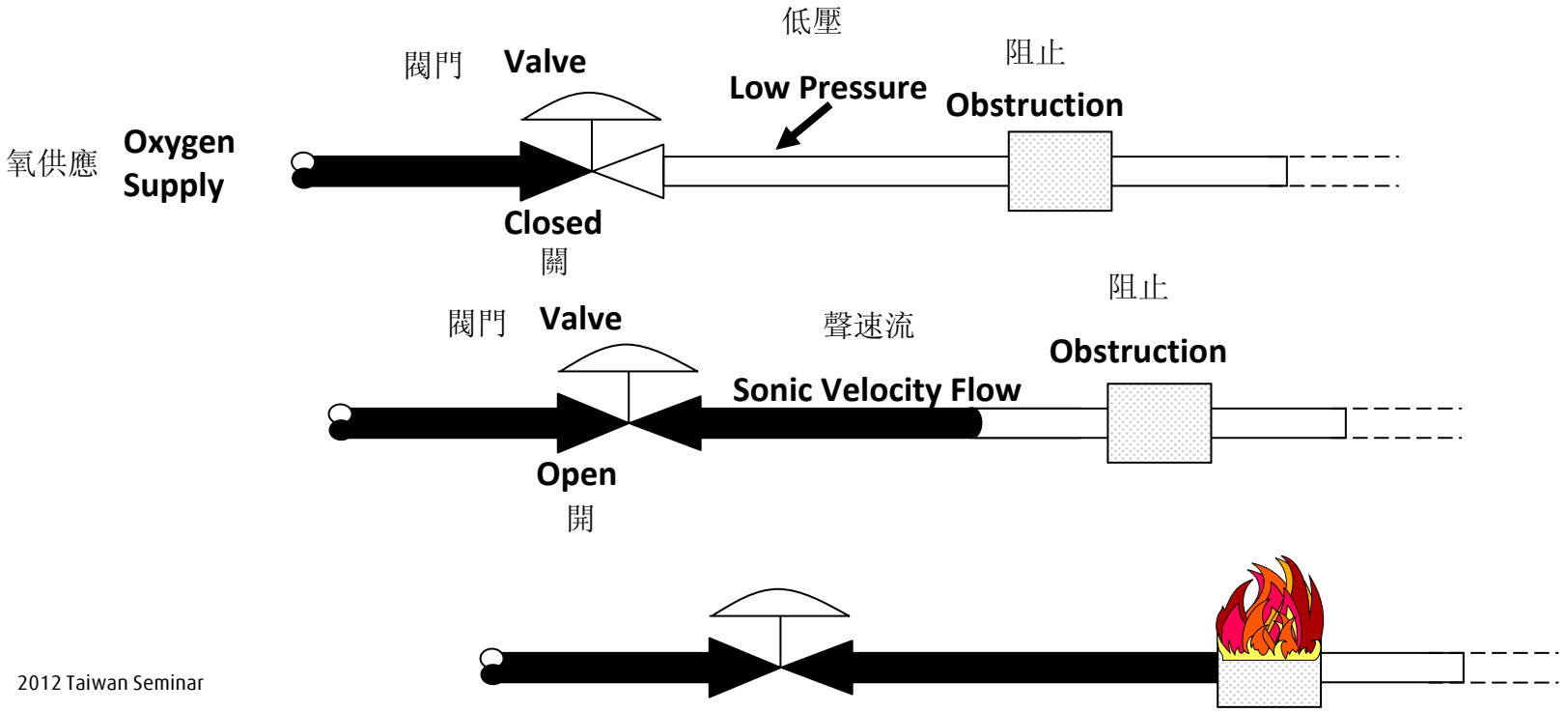
- **When a valve is suddenly opened, with more than 20 bar upstream, the gas downstream is compressed and the temperature in the trapped gas rises instantaneously (over 400°C)**
- **Polymers may be ignited when situated at dead ends. Fast opening/closing valves and dead ends must be avoided by design**
- **Energy adsorbing, fire resistant piping sections where temperature rise may occur is usually effective in controlling this mechanism**



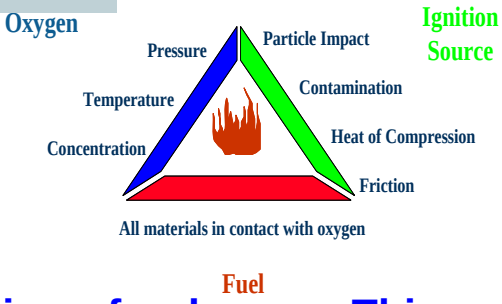
Fire Triangle: Ignition Leg
火三角：引燃端

絕熱壓縮:

- 當一個上游壓力高於20公斤的閥門突然被打開，氣體於下游會被壓縮，那麼被困的氣體之溫度會快速地提高（高於400° C）
- 如果聚合物處於盡頭可能被引燃，“閥門快速的開 / 關” 與 “死角”應在設計上避免。
- 在那些有可能產生高溫的地方，安排能量吸收，耐火管道是一個有效的控制機制



Fire Triangle: Oxygen Leg
火三角：氧氣端



Temperature: High oxygen temperatures increase the risk of ignition of polymers. This may lead to ignition of a metal component

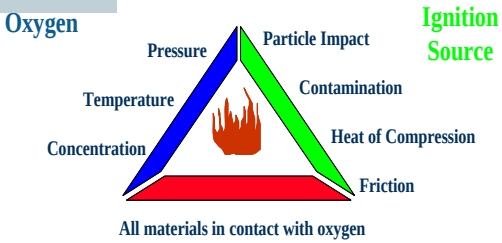
Pressure: Higher the pressure, higher is the ignition risk and propagation faster. Certain piping configurations provide possibilities for organ pipe heating of gases

Velocity: High velocities increase the risk of ignition from particle impact, such as in valves, restrictions, pressure regulators, filters, …

Concentration: Risks of ignition are diminished with lower oxygen concentration. Carbon steel is considered as non combustible in lower than 40% Oxygen enriched air

Phase: Gaseous form or liquid form. Fire in LOX may be explosive

Fire Triangle: Oxygen Leg
火三角：氧氣端



溫度: 高溫氧增加聚合物引燃的風險，這也可能將金屬件引燃

壓力: 壓力越高，引燃的風險越大及蔓延的速度越快，某些管路的配置提供管道內氣體加熱的機會

速度: 高速提高微粒衝擊後引燃的風險，例如閥門、阻力、調壓閥，過濾網等。。。

濃度: 低濃度氧可減低引燃的風險，碳鋼於低於40%氧成分的空氣中，被視為不能燃燒

態　: 氣態或液態，火於液氧可能產生爆炸

Agenda 議程

Part 2 第二部份

Materials and Oxygen Compatibility

材質及氧相容性

What is Oxygen Compatibility?
什麼是氧氣兼容性？

The ability of a material to coexist with both oxygen and a potential source(s) of ignition within the acceptable risk parameter of the user

— At an expected temperature, pressure and composition

As the material will most likely burn in oxygen, the level of risk that one is willing to accept must be taken into account.

某一種物質，能夠與氧和潛在引燃源共同存在的能力，並處於使用者可接受的風險參數

— 於某一個期望的溫度，壓力和成分

由於大部分物質均有可能在氧中燃燒，故此一定要清楚我們準備去接受的其風險之程度

Why is Oxygen Compatibility Important?
氧氣兼容性 – 為何重要?

BECAUSE
因為

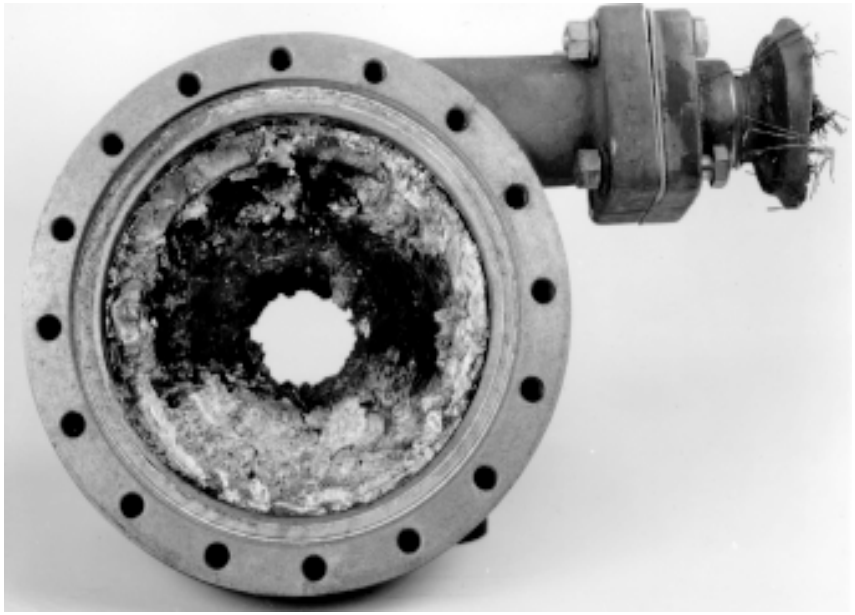
FIRES
火

OCCUR
發生

Why is Oxygen Compatibility Important?
氧氣兼容性 – 為何重要?

During the 1970's there were numerous LOX pump fires. By replacing the aluminium bronze impeller and casing with a tin bronze material these ignitions were eliminated

在70年代曾經有很多液氧泵着火；在將葉輪和外殼的物料從鋁青銅合金替換為錫青銅後，引燃就沒有再發生



ALUMINIUM PUMP 鋁泵

Why is Oxygen Compatibility Important?
氧气兼容性 – 为何重要?

Where do incidents occur?

- Air Separation Plants
- Cylinder filling
- Liquid oxygen pumps
- Oxygen compressors
- Oxygen pipelines & valve systems
- LOX piping and valve systems
- In areas where exposure to oxygen can occur

事故一般在那裏發生?

- 空分
- 氣瓶充裝
- 液氧泵
- 氧氣壓縮機
- 氧氣管道和閥門系統
- 液氧管道和閥門系統
- 在該些有機會與氧接觸的地方

Agenda
議程

Part 3
第三部份

Ignition Mechanism & Industry Incidents with Actual Cases in Asia

引燃之機制 及

行業中的事故含亞洲真實案例

So Where do Oxygen Hazards Exist?

- In atmospheric air enriched (23.5%) with oxygen
  - Venting and leaks
  - Oxygen is denser than air and so can collect in pits, ducts, trenches, etc.
  - LOX may form on contact of air with LIN, LHe etc.
- In pressurised systems containing pure oxygen greater than 1 bar
- Air compression – 30 bar partial pressure of oxygen is the limit

Hazard of Oxygen
氧气的危害

那麼，氧危害在那裏存在?

- 在大氣中富氧程度大於 (23.5%)
  - 排放與洩漏
  - 氧氣的密度較空氣大，可以在坑、管道、地溝等聚集
  - 液氧可能在空氣與液氮或液氦等接觸後產生
- 其系統壓力大於1公斤之純氧
- 空氣壓縮 – 氧之部分壓力，30公斤為上限

Hazard of Oxygen in Air
氧氣在空氣中的危害

How much oxygen does it take to create a hazard?

多少氧氣才會產生危害?

Oxygen concentration (% in Air)	氧濃度（空氣中%）	25	30	35	40
Probability of igniting clothing % Based on time to ignite denim overalls with a cigarette	與衣服引燃的機率% 基於香煙引燃外衣所需的時間	5	30	50	90
Probability of a fatal or serious injury % Based on the burning rate of the material and reaction time of the victim	死亡或嚴重傷害的機率% 基於物料燃燒的速度和受害人的反應時間	10	16	29	90
Combined probability of a fatal or serious injury %	組合死亡或嚴重傷害的機率%	0.5	4,8	14.5	81

From EIGA Position Paper PP-14 由歐洲工業氣體協會**PP-14**號檔提供

Managing Risks in Oxygen Systems
氧系统中的风险管理

- **Oxygen systems will always have oxygen and fuel (metals, gaskets, seals, lubricants etc.)**
- **So how do we Avoid Fires in Oxygen Systems?**
- **By:**
  - **Avoiding Ignition**
  - **Avoiding Propagation**
  - **Mitigating Consequences – (barriers)**
- 氧系統一般都有氧和燃料（金屬、墊片、密封、潤滑油等）
- 那麼我們如何在氧系統中避免着火**?**
- 從**:**
  - 避免引燃
  - 避免蔓延
  - 減輕後果 **–**（隔離）

Avoid Ignition

- Careful selection of system materials - avoid fuels with low ignition temperatures
- Good system/equipment design - avoid ignition sources
  - Good piping designs to reduce particle impact sites and using exempt materials at impingement points
- Good standards of cleanliness during construction and maintenance - avoid fuels and ignition sources
  - Absence of particulate matter and hydrocarbon oils and greases
- Good system commissioning - avoid ignition sources
- Good system maintenance - avoid fuels and ignition sources
- Operation within the system's declared safe operating limits - avoid ignition sources

Managing Risks in Oxygen Systems
氧系统中的风险管理

避免引燃

- 小心選擇系統的物料 - 避免低燃點的燃料
- 良好系統 / 硬體之設計 - 避免引燃源
  - 良好管道設計以減低粒子碰撞的地方，在容易受到撞擊位置採用獲得豁免的材料
- 在建設及維修時採用良好的清潔標準 - 避免燃料和引燃源
  - 杜絕微粒物體和碳氫油和油脂
- 良好的系統調試 - 避免引燃源
- 良好的系統維修 - 避免燃料和引燃源
- 於系統承諾的操作範圍內 - 避免引燃源

Managing Risks in Oxygen Systems
氧系统中的风险管理

Avoid Propagation

Oxygen materials compatibility is dependent on many factors, so materials compatibility in oxygen is application specific. In general acceptance criteria depends on two key factors

- **Flammability – factors that determine flammability include material composition, thickness and operating conditions**
- **Ignitability – Ignition mechanisms include particle impact, adiabatic compression, mechanical friction, mechanical impact, thermal ignition etc.**

Mitigating consequences

- **In some cases the best material for oxygen compatibility can not be used because there may be issues with galling, friction, high cost etc. In such cases a risk assessment should be undertaken to ensure other mitigation measures are in place to make the system as safe as possible. This could include**
  - **Barriers around equipment and valves**
  - **Additional cleaning of piping and equipment**

Managing Risks in Oxygen Systems
氧系统中的风险管理

避免蔓延

— 氧兼容物質是取決於多項因素， 因此在氧環境中的物料的兼容性是按其應用而特定的。一般來講，接受條件是取決於兩個重要的因素

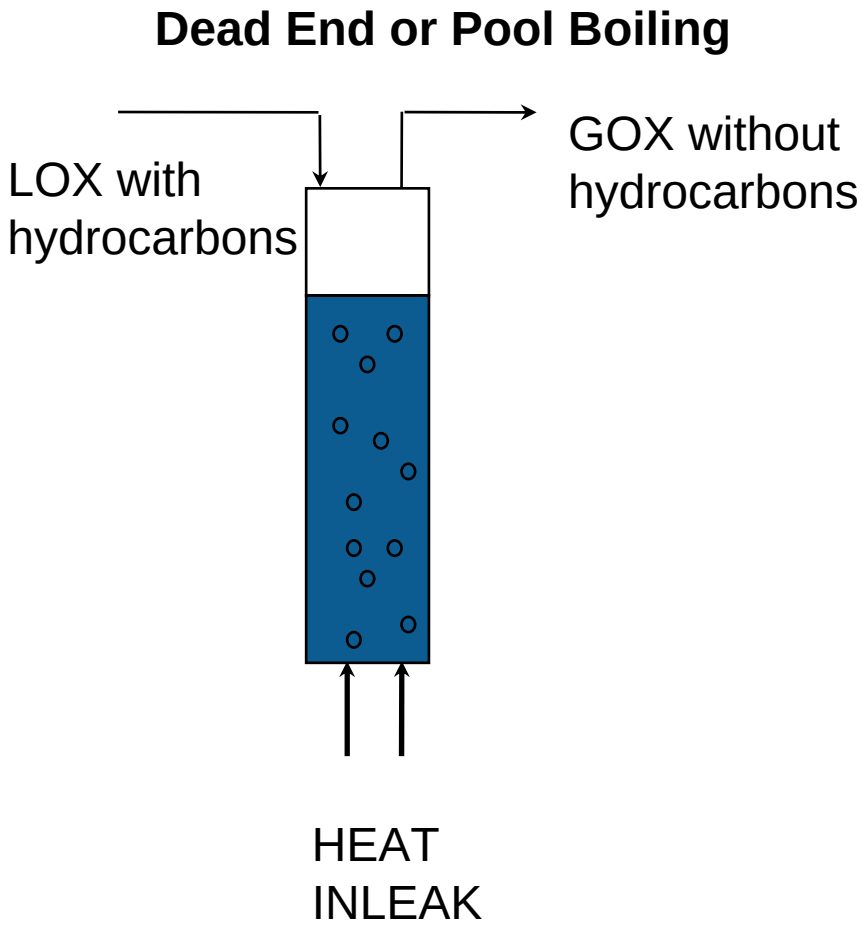
- 可燃性 – 決定可燃性的因素包括物料的成份，厚度及操作狀態
- 引燃性 – 引燃機制包括粒子的衝擊，絕熱壓縮，機械的阻力，機械撞擊及熱點燃等.

減輕後果

— 在一些情況下，氧兼容最好的材料並不能使用，因為有可能有摩擦、阻力的問題，可能價錢也高。在該情況下，必須進行風險評估以確保後果減輕之措施存在，以期達到儘量達到安全，這可以包含

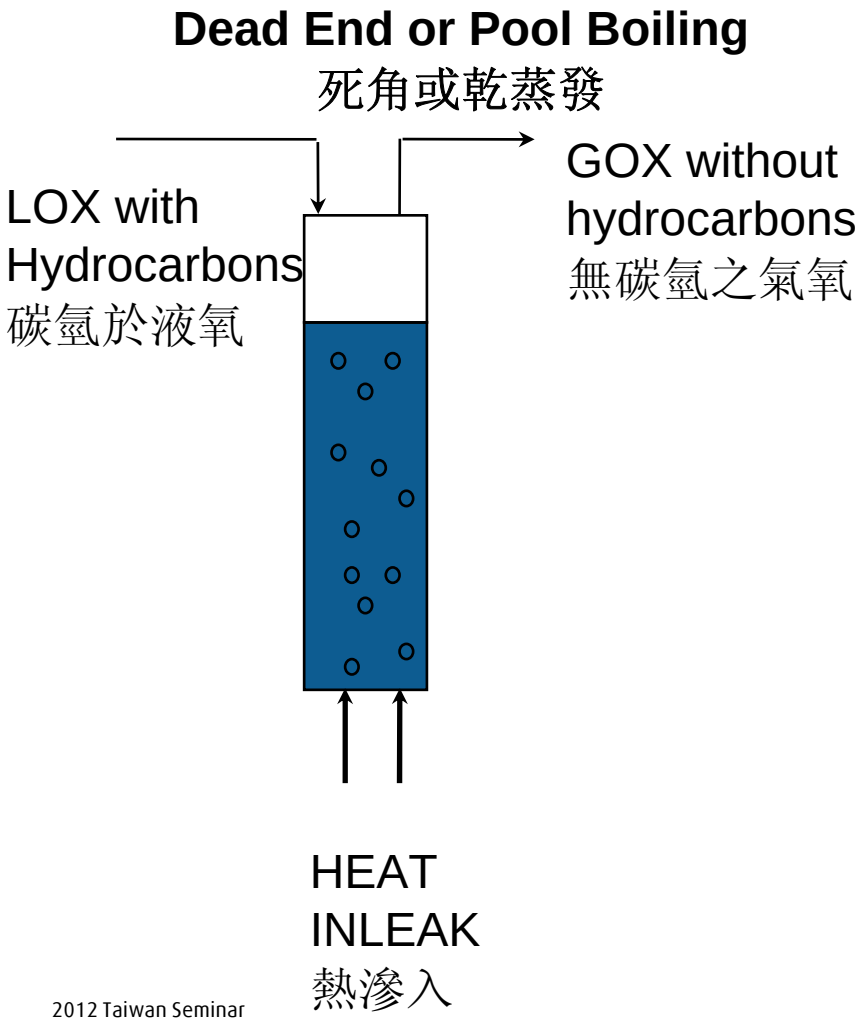
- 在設備和閥門周邊的隔離防護
- 對管道的設備的額外清潔措施

Managing Risks in LOX Systems
液氧系统中的风险管理



- Hydrocarbons and other contaminants will accumulate over time if liquid is not purged
- Solubility and flammability limits of contaminants will be exceeded
- Once Hydrocarbon levels exceed allowable limits the risk of ignition is significantly increased
- Accumulation of Hydrocarbons and other plugging contaminants must be prevented in LOX, by continuous purging of reboilers and proper routing of liquid lines to avoid low points and pockets where liquid can accumulate and boil off

Managing Risks in LOX Systems
液氧系统中的风险管理



- 假如液體沒有被吹掃，碳氫及其它污染物會隨著時間而積聚
- 污染物的溶解度和其燃燒範圍會被超過
- 一旦碳氫水平超出其可接受的範圍，引燃的風險會大大的增加
- 液氧中的碳氫及其它堵塞物的積聚一定要防止，再沸器不斷的吹除及液體管線的適當路徑以避免於低點和死角處之液體乾蒸發

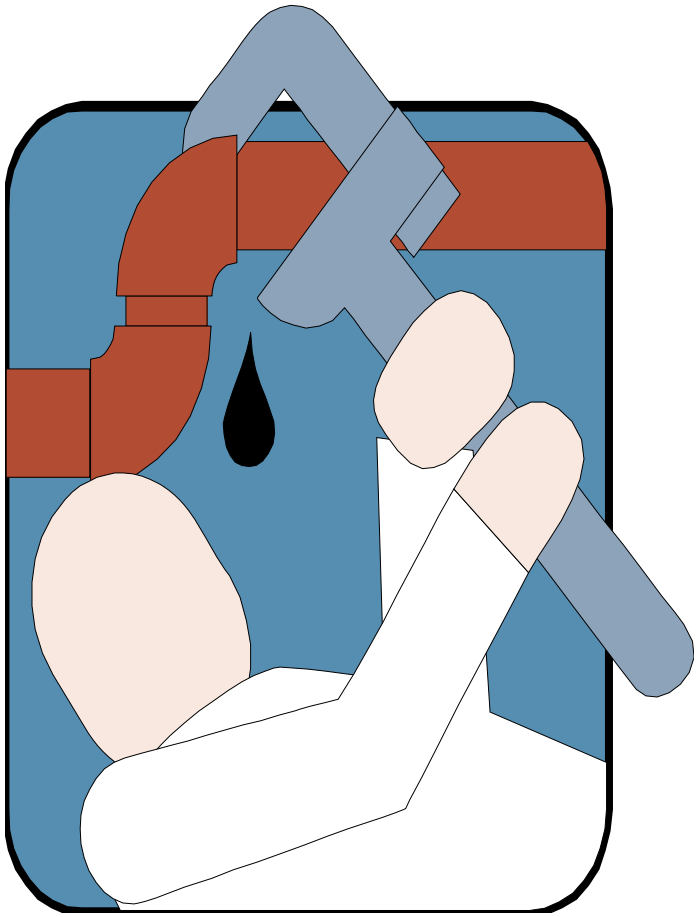
The Importance of Cleanliness
整潔的重要性

What is Oxygen Clean?

- No visible evidence of:
  - Moisture
  - Cleaning agents
  - Flux residues / weld splatter
  - Particulate matter
  - Organic materials e.g. oil, grease, paint etc.

甚麼是氧清潔?

- 沒有明顯的象徵:
  - 濕度
  - 清潔劑
  - 殘餘清洗液體 / 焊接
  - 微細物體
  - 有機物，例如：油、油脂，油漆等



Cleaning for Oxygen Service
對氧作業的清潔

Solvent degreasing

- **Wiping with a lint free cloth**
- **Immersion in a solvent tank**
- **Cold washing**
- **Spraying/brushing**

溶解液除油法

- 利用乾淨的布塊抹乾淨
- 浸於溶解液桶中
- 冷清洗
- 噴霧 / 洗擦

Detergent cleaning 洗潔精清洗

- **Immersion** 沉浸
- **Re-circulation** 迴圈（循環）
- **Spraying / brushing** 噴霧 / 洗擦

Steam/Hot Water Cleaning

- **Pressurised cleaning of major plant parts and pipes**
- **With or without detergent**

蒸汽 / 熱水清洗

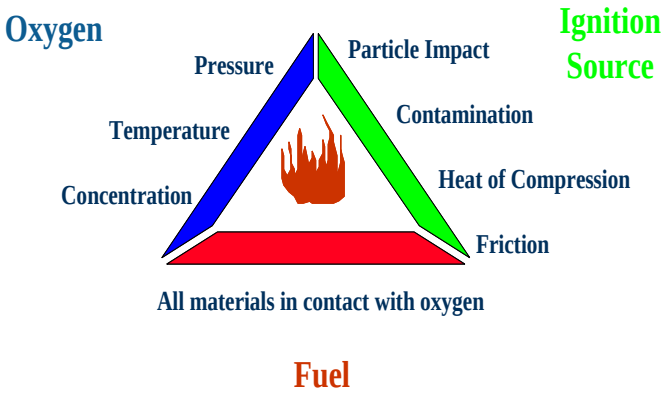
- 對主要部件及管道作加壓清洗
- 可含或不含洗潔精

When You Get Oxygen Compatibility Wrong

當氧兼容出錯

ASU Separation Unit (ASU) – Reboiler Explosion
空分再沸器爆炸

An ASU reboiler exploded – why?
空分再沸器爆炸 – 為何



India - Vizag Steel Plant Blasted (13 June 2012)
印度 Vizag 鋼廠爆炸（2012年6月13日）

1. **19 people died including the General Manager**
2. **Newly extended Steel Plant under commissioning**
3. **Explosion at O2 Pressure Reducing Station**

1. 19人死亡，含總經理
2. 新擴建的鋼廠正在調試中
3. 爆炸發生在氧氣降壓車間

An injured employee of a steel plant is being rushed to a hospital in Visakhapatnam. (AP Photo)

hindustantimes
Mon, 18 Jun 2012
South India

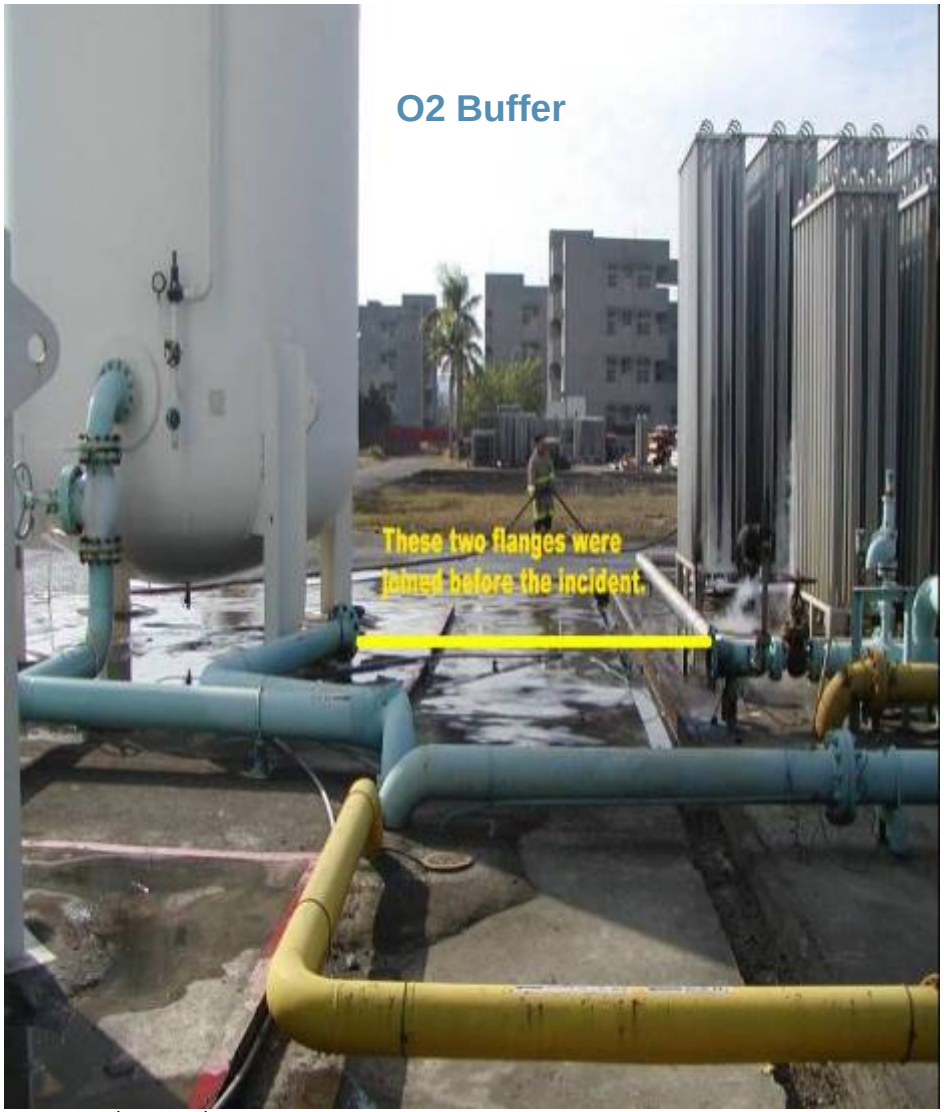
Investigation still underway
but what could be the issues?
調查仍然在進行中
但有什麼可能的問題？

O2 Safety Incident in Asia – ASU Pipeline Burnt
在亞洲關於氧安全的事故 – 空分管道燃燒

1. **Control Valve material not ideally Oxygen Compatible**
2. **Flow Rate too high**
3. **Pipeline also burnt**

1. 調壓閥材質並非最理想的氧兼容
2. 流速過高
3. 管道也受到影響

O2 Safety Incident in Asia – O2 Pipeline Caught Fire
洲關在亞於氧安全的事故 – 氧氣管道着火



1. **Flange inner gasket irregular in shape**
2. **Minor leakage via gasket after 7 years**
3. **Incompatible grease was used on bolts & nuts**
4. **O2 leaked via gasket and caught fire with grease**

1. 法蘭墊片的內圓形狀不均勻
2. 墊片在7年後有微漏
3. 不兼容潤滑油用於螺姆上
4. 氧氣先從墊片漏出，繼而與潤滑油接觸而着火

O2 Safety Incident in Asia – O2 Strainer Caught Fire
在亞洲關於氧安全的事故 – 氧氣濾網着火

1. **28 Bar working pressure**
2. **Stainless Steel**

1. 28 公斤工作壓力
2. 不銹鋼

O2 Safety Incident in Asia – O2 Regulator On Fire
在亞洲關於氧安全的事故 – 氧氣調壓閥着火

1. **150 Bar working pressure**
2. **Incompatible material of the Control Valve – Aluminum Bronze**

1. 150 公斤工作壓力
2. 控制閥材質不兼容 – 鋁青銅

O2 Safety Incident in Asia – 200 Bar O2 Hose On Fire
在亞洲關於氧安全的事故 – 200公斤软管着火

Pin to open valve
插針作打開閥門

1. **Incompatible Material – Stainless Steel Pin vs. Monel**
2. **Vent Valve wrongly opened first before Main Stop Valve leading to too high velocity**
3. **Stainless Steel Pin on fire**

1. 不兼容材質 – 不銹鋼插針替代了蒙内爾
2. 排放閥被錯誤地先行打開，繼而關閉主閥，因而引致高流速
3. 不銹鋼插針着火

O2 Safety Incident in Asia – Air Filter Buffer Burst
在亞洲關於氧安全的事故 – 空氣濾器緩衝罐爆破

1. **Newly used system - only 4 months**
2. **11 out of 12 Paper Filters choked leading to too high a velocity via the only one in service condition**
3. **Paper Filter on fire first then Stainless Steel buffer tank**

1. 剛投入使用4個月
2. 12根紙濾芯中，11根堵塞，引致餘下的一根流速過高
3. 紙濾芯先着火，再而引致不銹鋼緩衝罐爆破

Oxygen Valve Fire
氧氣閥門着火

- The valve (operating at 27 barg) had a carbon steel body with a stainless steel shaft
- It is believed that the fire started in the stem packing area, through adiabatic compression and contamination
- The kindling chain then ignited the packing and valve stem
- The valve was cleaned to an inadequate standard
- EIGA publication Doc 13* would have required exempt material for the wetted parts

- 閥門工作壓力為27公斤，殼體為碳鋼，軸為不銹鋼
- 相信火於軸的密封處開始，通過絕熱壓縮及污染物
- 連鎖反應繼而引燃軸的密封
- 閥門沒有按足夠的標準來清潔
- 歐洲工業氣體協會檔 13 有提到某些材質可以豁免

*** EIGA 13 equivalent to AIGA 21/012**

The Application Determines the Material
“應用”決定“物質”

Liquid Oxygen - Aluminium Valve Fire

Aluminium dust is one of the most highly reactive (explosive) metal dusts with oxygen

Materials need to be selected for the application

- Aluminium is suitable for ASU vessels, columns and trays. It can be used for high pressure cylinders
- Lubricants should not be applied to the internals of valves where they can collect debris
- Aluminium is not suitable for rotating machinery and valves
- Aluminium burns explosively in oxygen

The Application Determines the Material
“應用”決定“物質”

液氧 – 鋁閥門着火

鋁塵粒是其中之一與氧有
高反應（爆炸）的金屬

物質需按其應用而作適當的選擇

- 鋁是適合於空分的儲罐、冷箱及其蒸餾隔板，同時可用于高壓氣瓶
- 潤滑油不應該應用於閥門之內部，由於其可積聚鬆脫物
- 鋁並不合適於轉動的機器及閥門
- 鋁與氧可以有爆炸性的燃燒

Oxygen Compressor Fire
氧壓縮機着火

- **Aluminum bronze greater than 2.5% is not allowed by modern piping standards in HP GOX system**
- **Aluminum content is considered flammable and is not classed as a bronze from an oxygen standpoint. It is believed that the casing inserts were aluminum bronze**
- 在新的高壓氧氣管道設計標準是不可以使用高於**2.5%** 鋁青銅
- 鋁成分被視為可燃，而非如青銅與氧的一般。相信殼體的物料為鋁青銅

Oxygen Pump Fire
液氧泵着火

- **Inadequate purge to the gearbox allowed oxygen to enter the gearbox, resulting in a fire**
- 對齒輪箱的吹掃不足夠，從而引致氧氣進入了齒輪箱，結果引發火警

Oxygen Barrier After Fire
氧防爆在着火後

— **An oxygen compressor fire is contained by the barrier**

— 氧壓機火被防護牆所包圍起來

Oxygen Compressor Fire
氧壓縮機着火

- **A particle impact on a carbon steel pipe bend resulted in a burn out at a reciprocating compressor**
- 微粒於碳鋼管彎頭內的撞擊引致活塞壓縮機燃燒

The Importance of Cleanliness
整潔的重要性

- **Silicone grease found in the threads of this cylinder**
- **When the cylinder was dropped the valve rubbed on the cylinder threads igniting the silicone grease in the presence of O_2 at 2000psig**
- 有機矽油脂被發現於瓶牙
- 當氣瓶被拋落地時，閥門與瓶閥的牙摩擦，從而引燃有機矽油脂與138公斤壓力之氧氣

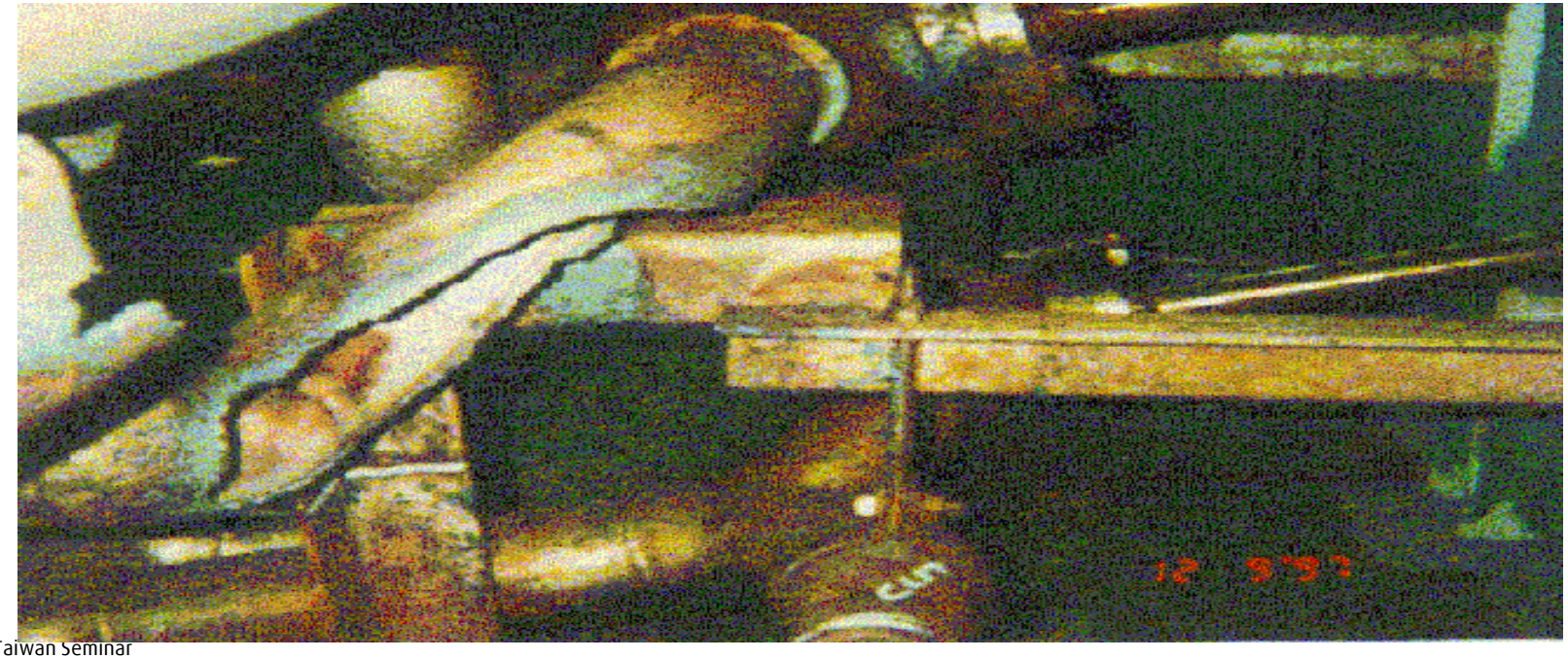
The Importance of Cleanliness
整潔的重要性

Valve Ignition Causes:

- **Inadequate degreasing & blow through procedures**
- **Debris in the valve cage and filter**
- **High velocity impact or friction caused by valve movement**
- **thin sections in the valve cage**

閥門引燃的原因:

- 不足夠的除油和吹除程式
- 碎體於閥門閥體內和過濾網
- 高壓衝擊或閥門移動時的摩擦
- 閥體內的薄件

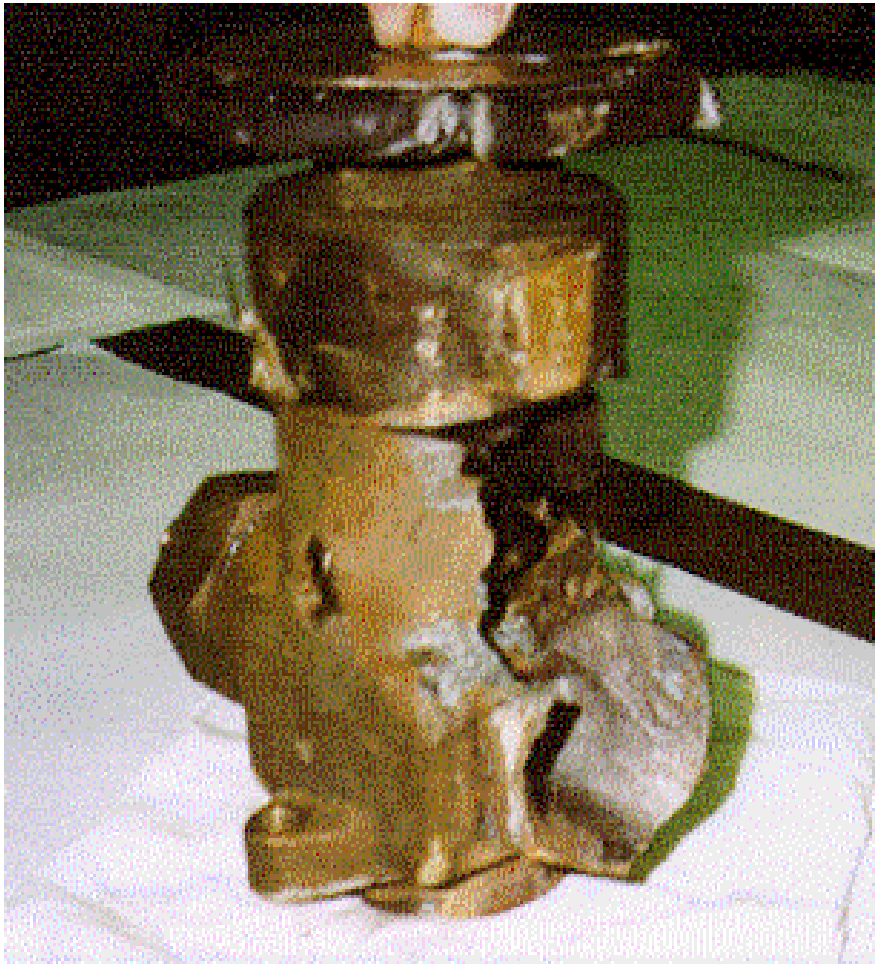


Using Improper Materials
採用不恰當的物料

A stainless steel filter was used in the suction line to a ground mounted LOX pump. A piece of the filter became detached and went into the pump causing an ignition

一個安裝於“座地液氧泵”的不銹鋼的過濾網，其中一小塊鬆脫從而進入泵的泵體，繼而做成引燃

Lack of Maintenance
缺乏維修



The non-metallics (O-rings, seals etc) of this manifold cylinder filling valve had never been replaced since the date of installation

瓶組中的該些軟體（**O-**型圈，密封等），在最初期組裝後就從來沒有再被替換

Improper Cleaning
不恰當的清洗

This is the assorted debris that can be collected on a filter during blow through of a “clean” oxygen system

這是在經過“氧等級清洗”的過濾網，所收集到的各種雜物。

Brief Summary from the above Incidents
以上事故的簡單歸納

		Design	Installation	Maintenance	Operation
		設計	安裝	維修	操作
ASU Reboiler Explosion	再沸器爆炸	1			1
Iron Steel Plant Explosion	鋼鐵廠爆炸	1	1		1
Al Bronze at ASU	空分中的鋁青銅	1			1
O2 Pipeline Bended	氧氣管道被屈曲		1	1	
HP Strainer Fire	高壓過濾器著火	1			1
HP Cyl Filling Control Vlv	高壓充瓶閥	1			
HP Cyl Filling SS Pin	高壓不銹鋼針	1		1	1
Air Filter	空氣過濾器	1	1	1	1
CS Valve Packing Leaked	碳鋼閥門墊片漏	1		1	
Grease inside ASU	空分中的油脂	1	1		
Al Bronze Parts at ASU	空分中的鋁青銅	1			
Gear Box Purging	齒輪箱吹掃				1
Particle in O2 Compressor	氧壓機內的微粒	1		1	
Oil at Cyl Valve O Ring	瓶閥O型圈有油		1	1	1
Valve Strainer with Grease	閥門過濾器有油		1	1	
Particle in O2 Valve	氧閥門內的微粒	1	1		
Manifolded Cylinder Valve	匯流排閥門			1	
Strainer's Devris	過濾器的雜物		1	1	
Sub Total	分類總數	12	8	9	8

Do's and don'ts of oxygen safety
氧安全方面 – "?應該" 與 "不應該"做的事情

DO's

☑ use approved materials
☑ use "oxygen cleaned" materials to the appropriate level of cleanliness
☑ leave the bottom two threads free of PTFE tape when sealing joints
☑ open valves slowly to avoid sudden pressurisation
☑ wear clean clothes free of oil or grease
☑ ventilate clothing after working in oxygen enriched atmosphere

☑ remove all cleaning fluids from oxygen systems even where they are described as 'oxygen compatible'
☑ ensure that appropriate component testing is performed where required
☑ remember that oxygen compatibility is not a 'science'
☑ remember that oxygen enrichment of clothing is hazardous and clothing must be ventilated for approx. 30 minutes before approaching ignition sources

DON'Ts

☒ tighten leaking joints under pressure
☒ use oil or grease to lubricate components

☒ introduce contaminants into an oxygen system

☒ smoke in an oxygen enriched atmosphere

☒ misuse oxygen
☒ assume that below 21% oxygen there is no hazard of ignition-the environment dictates the safe concentration
☒ perform repairs on a 'live' oxygen system

☒ substitute one material for another without performing a proper review
☒ increase the temperature or pressure within a system without validating the materials
☒ assume an approved material can be used under the same operating conditions in a different configuration or thickness

Do's and don'ts of oxygen safety
氧安全方面 – "應該" 與 "不應該" 做的事情

應該做	不應該做
使用已被審批的材質	在有壓力的情況下把洩漏收緊
使用已經達到某水準的"氧清潔"的材料	使用油或油脂作部件的潤滑
在使用潤滑帶作密封時，把螺紋的最低兩層牙留空	把污染物帶進氧系統
在打開閥門的時候要慢，以防止壓力突然提高	在富氧環境內吸煙
穿著的工作服要沒有油或油脂	錯誤地使用氧氣
在富氧環境工作以後，要把衣服徹底通風	假設氧成分低於21%就沒有什麼危害 - 環境決定安全的濃度
就是某些除油劑是"氧相容"，也要徹底的把該些在氧系統的液體弄乾淨	在仍然帶壓的氧系統進行維修
確保在需要時，進行適當的部件測試	在正規評估前，以另外一種材質代替原來的一種
記住"氧相容"並不是一種"科學"	在印證以前，提高系統的溫度或壓力
記住衣服富氧是危險的，一定要在吹風30分鐘後才好接近引燃源	假設某一種已經於某一個運行條件被審批的材質，就是不同形狀也沒有問題

Related AIGA Publications
AIGA相關文件

AIGA Website: www.asiaiga.org

- AIGA 021/12 – Oxygen pipelines and piping system
- AIGA 048/08 – Reciprocating compressors for oxygen service
- AIGA 055/08 – Installation guide for stationary, electric motor driven centrifugal oxygen pumps
- AIGA 071/11 – Centrifugal compressors for oxygen service

中言版

- AIGA 012/04 - 供氧设备的清洁
  Cleaning of equipment for oxygen service
- AIGA 056/08 - 低温空分装置安全
  Safe practice guide for cryogenic air separation plants

Thanks for your attention

Except for section on incidents in Asia, the presentation was originally given by Sudhir Phakey (Linde) at the EIGA 2012 Meeting

感謝各位的關注

除亞洲案例外，大部分是參照 Sudhir Phakey（林德）於2012年歐洲工業氣體協會會議上之發表

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