



Methane to Markets

Reduced Emissions Completions, Plunger Lifts, Smart Well Automation, and Other Solutions to Production Emissions 降低排放的完井、柱塞举升、智能的油井自动化以及其他生产排放的解决方法

Methane to Markets : International Workshop on Methane Emission Reduction Technologies in the Chinese Oil and Natural Gas Industry
Qingdao, China
甲烷市场化：中国油气行业甲烷排放降低技术国际研讨会 青岛，中国

17-18 April, 2008

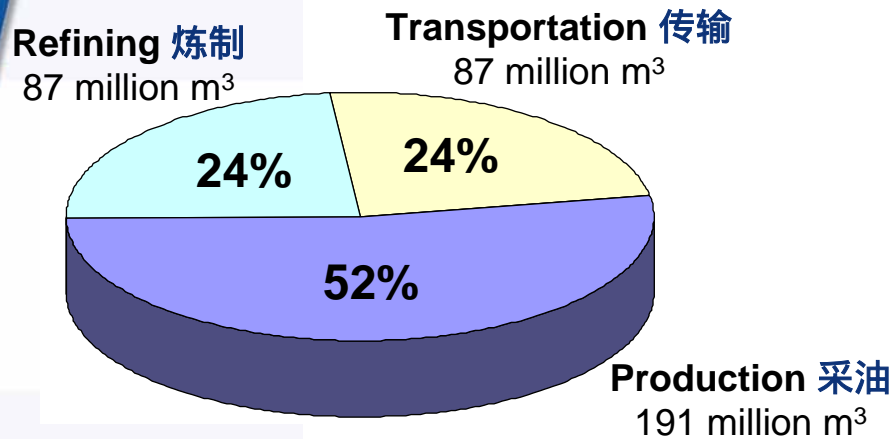
Agenda 目录

- China Oil & Gas Methane Emissions 中国油气甲烷排放
- Well Venting 井孔放喷
 - Methane Losses 甲烷损失
 - Methane Recovery 甲烷回收
 - Is Recovery Profitable? 回收有利吗？
 - Industry Experience 工业经验
- Other Wellhead Emission Solutions 其他的井口排放解决方法



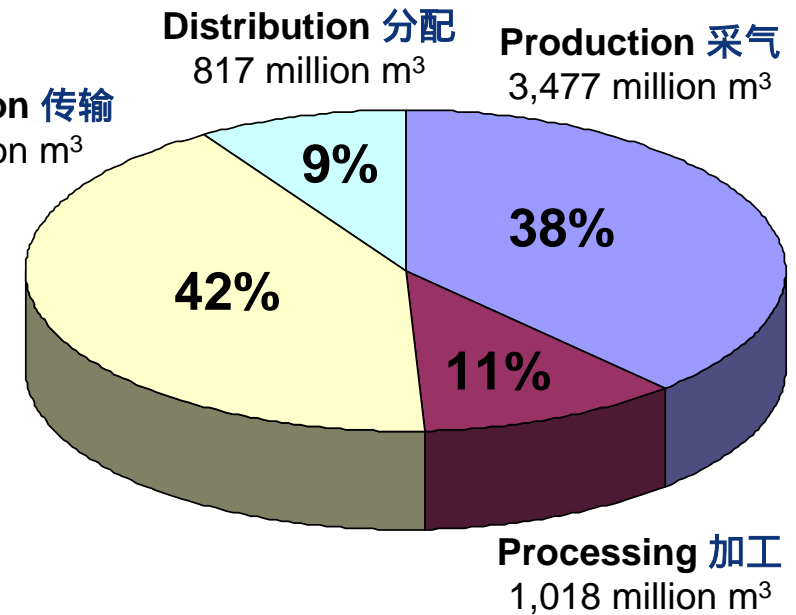
Source: Williams

China Oil and Gas Methane Emissions in 2005 中国油气2005年甲烷排放



Petroleum Systems Emissions

石油系统排放



Natural Gas Systems Emissions

天然气系统排放

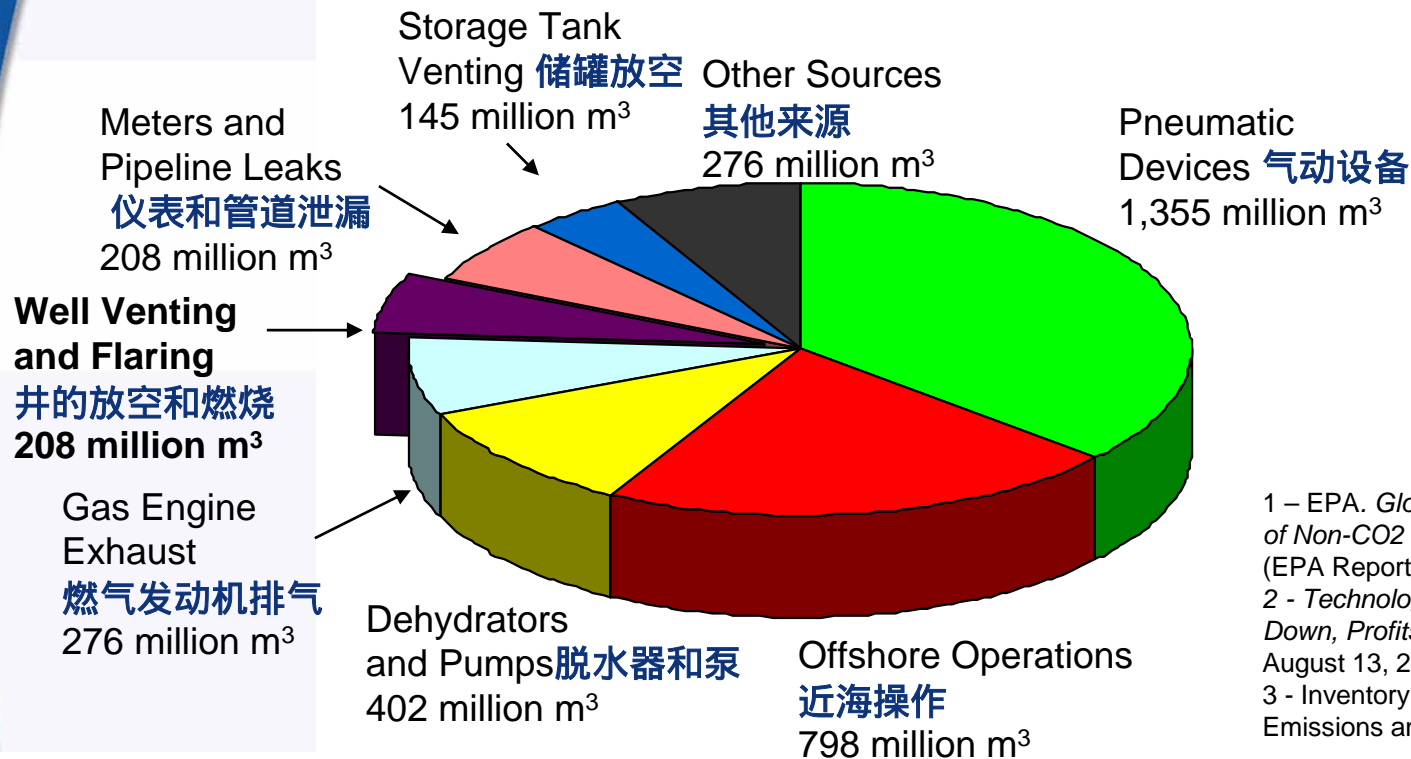
m³ = cubic meters 立方米

Sources: 1 – EPA. *Global Anthropogenic Emissions of Non-CO2 Greenhouse Gases 1990-2020* (EPA Report 430-R-06-003). China emissions.
 资料来源: 2 – *Technology Drives Methane Emissions Down, Profits Up*, Oil and Gas Journal, August 13, 2007

Note: It is assumed that all natural gas produced, goes through gas processing.

Estimated Methane Losses from China Production/ Workovers 中国生产/修井过程中甲烷损失估计

- Well venting and flaring is responsible for 6% of methane emissions in the natural gas and oil production sectors 在天然气和石油开采部门，井的放空和燃烧占甲烷损失量的6%。
 - Anecdotal evidence suggests it could be significantly more 轶事证据证明此值可能更大
 - Total emissions from Production Sectors = 3,668 million m³ 采油部门总排放量等于3,668,000,000方



1 - EPA. *Global Anthropogenic Emissions of Non-CO₂ Greenhouse Gases 1990-2020* (EPA Report 430-R-06-003)
 2 - *Technology Drives Methane Emissions Down, Profits Up*, Oil and Gas Journal, August 13, 2007
 3 - *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*

Methane Losses During Well Completions/ Workovers 完井和修井过程中甲烷的损失

- Gas wells in tight formations and coal beds require hydraulic fracture 渗透率低的气井和煤层需要水力压裂
- It is necessary to clean out the well bore and formation 清除井眼和地层是必须的
 - After new well completion 新井完井后
 - After well workovers 修井完毕后
- Operators produce the well to an open pit or tank to collect sand, cuttings, and reservoir fluids for disposal 操作人员在一个开放的矿井施工，或者用一个罐来收集砂子、岩屑和油藏流体以备后续处理。
- Vent or flare the natural gas produced 生产出的天然气进行放空或者燃烧



Source: Williams

Methane Recovery: Reduced Emissions Completions Completions 甲烷回收：减少排放的完井

- Reduced Emissions Completions (RECs) or “Green Completions” recover natural gas and condensate produced during well completions or workovers 减少排放的完井（RECs）或者“绿色完井”回收完井或修井过程中的天然气和凝析液
- Use portable equipment to process well clean-out fluids suitable for gas and condensate sales 使用便携设备处理井的清除流体，以适合于天然气和凝析液的销售。
- Send recovered gas through permanent dehydrator and meter to sales line, reducing venting and flaring 通过永久脱水器和仪表向销售管道发送回收的天然气，减少放空和燃烧。



Source: Williams

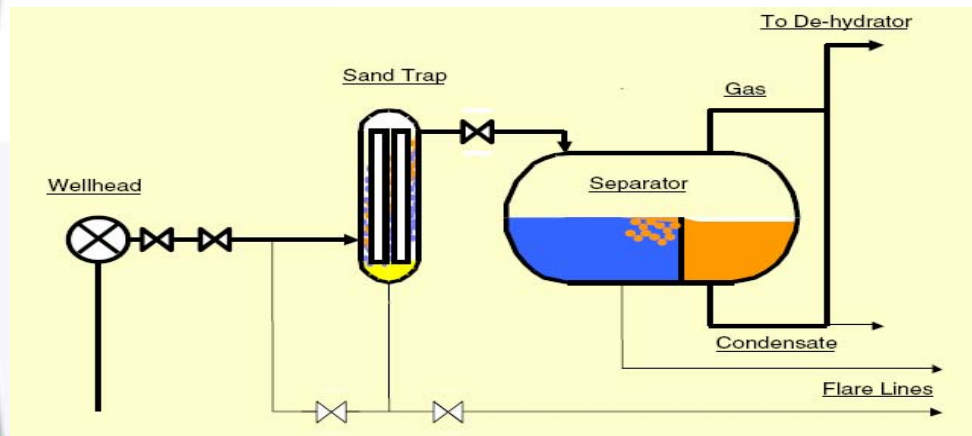
Methane Recovery: Reduced Emissions Completions 甲烷回收：减少排放的完井

- Technical document available in Chinese 可以获得中文技术文献资料

绿色完井	
Green Completion	
合作伙伴推荐的甲烷减排机会 (PRO) NO. 703	
<p>适用领域:</p> <p><input checked="" type="checkbox"/> 生产部门 <input type="checkbox"/> 处理加工部门 <input type="checkbox"/> 输气和配气部门</p> <p>报道 PRO 的合作伙伴:</p> <p>BP, ConocoPhillips Company</p> <p>其他相关的 PRO:</p> <p>安装井下分离泵, 将套管连接到蒸汽回收装置上, 安装压缩机收集套管气</p>	<p>压缩机/发动机 <input type="checkbox"/></p> <p>脱水器 <input type="checkbox"/></p> <p>管线 <input type="checkbox"/></p> <p>气动/控制 <input type="checkbox"/></p> <p>储罐 <input type="checkbox"/></p> <p>阀门 <input type="checkbox"/></p> <p>井 <input checked="" type="checkbox"/></p> <p>其他 <input type="checkbox"/></p>
<p>技术/实践概况</p> <p>描述</p> <p>当气井完钻后, 在向销售管线生产天然气前的最后一步是立即“清洗”井筒和气井周围</p>	<p>甲烷节省量: 7 000 千立方英尺/年</p> <p>费用</p> <p>投资费用 (包括安装费用)</p> <p><input type="checkbox"/> <1 000 美元 <input checked="" type="checkbox"/> 1 000~10 000 美元</p> <p><input type="checkbox"/> >10 000 美元</p>

REC Equipment 减少排放的完井设备

- Truck or trailer mounted equipment to capture produced gas during cleanup 放喷洗井过程中使用装在拖车或卡车上的设备捕获采出的气
 - Sand trap 除砂器
 - Three-phase separator 三相分离器
- Use portable desiccant dehydrator for workovers requiring glycol dehydrator maintenance 修井作业中需要乙二醇脱水器的维持时，使用便携式干燥剂除水器。



Mobile Surface Facilities 地面移动设备
Source: British Petroleum 资料来源：英国石油



Source: Williams

REC Preconditions REC 前提条件

- Must have permanent equipment on site before cleanup 放喷洗井前在井场必须要有固定设备
 - Piping from wellhead to sales line 连接从井口到销售管线的管道
 - Dehydrator 脱水器
 - Gas meter 天然气流量计
 - Stock tank 油库油罐
- Sales line gas can be used for fuel and/ or gaslift in low pressure wells 可供燃料和/或低压气举井使用的销售管道



Permanent Dehydrators
固定脱水器

Source: Williams

REC for Low Pressure Wells 低压井REC

- Can use portable compressors to start-up the well when reservoir pressure is low 当油藏压力很低时，可以使用便携式压缩机启动油井。
 - Artificial gas lift to clear fluids 人工气举至干净流体
 - Boost gas to sales line 给天然气加压至销售管线
- Higher cost with portable compressor 便携式压缩机具有较高的成本



JERRY McBRIDE / Herald
Portable compressors, separator and other equipment on a trailer 挂车上的便携式压缩机、分离器和其他设备

Methane Savings 甲烷节省

- Operators report recovering an average of 53% (but up to 90%) of total gas produced during well completions and workovers 操作人员报道，在完井和修井过程中，平均节省天然气总产量的53%（最高为90%）。
- Estimate an average of 85 thousand m³ of natural gas can be recovered from each cleanup¹ 据估计，每次放喷洗井操作平均可以回收85千立方天然气。
 - Estimate up to 65 tonnes (580 barrels) of condensate can be recovered from each cleanup 据估计，每次放喷洗井作最高可以回收65吨桶）凝析油。

¹ Value for high pressure wells 高压井数据



Portable Three Phase Separator, Source: BP
便携式三相分离器，来源：英国石油 11

Is Recovery Profitable? 回收有无经济价值？

Economics for 25 Well Annual REC Program with Purchased Equipment 购买设备的25口井每年的REC项目经济分析						
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Volume of Natural Gas Savings 天然气节省 (thousand m ³ /year)		7,646	7,646	7,646	7,646	7,646
Value of Natural Gas Savings (\$/year) 节省天然气价值@\$0.25/ thousand m ³		1,890,000	1,890,000	1,890,000	1,890,000	1,890,000
Additional Savings 额外节省(\$/year)		110,000	110,000	110,000	110,000	110,000
Set-up Costs (\$/year) 准备工作花费		-15,000	-15,000	-15,000	-15,000	-15,000
Equipment Costs (\$) 设备费用	-500,000					
Labor Costs (\$/year) 劳务费		-106,250	-106,250	-106,250	-106,250	-106,250
Annual Cash Flow (\$) 年度现金流	-500,000	1,878,750	1,878,750	1,878,750	1,878,750	1,878,750
Internal Rate of Return 内部收益率						376%
Payback 投资回收期						4 months

Source: Natural Gas STAR Recommended Technologies and Practices;*Economics have been updated using the Nelson-Farrar Index and \$7per cubic feet of Natural Gas

Note: All costs and revenues are represented in U.S economics

REC Benefits REC效益

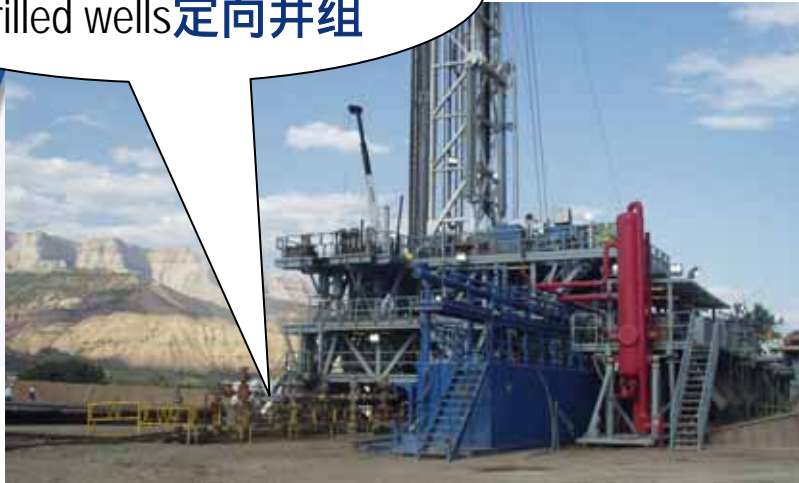
- Reduced methane emissions during completions and workovers 降低完井和修井过程中的甲烷排放
- Sales revenue from recovered gas and condensate 回收的天然气和凝析油可获得销售收入
- Improved safety 安全性提高
- Reduced disposal costs 处理费用降低
- Improved air quality 空气质量提高



Source: Weatherford 来源：威德福公司

REC Field Setup REC野外装置

Group of directionally drilled wells 定向井组



Temporary water tanks 临时水罐



Proppant 支撑剂

Sand trap, gas/ liquids separator 沉砂池、气液分离器

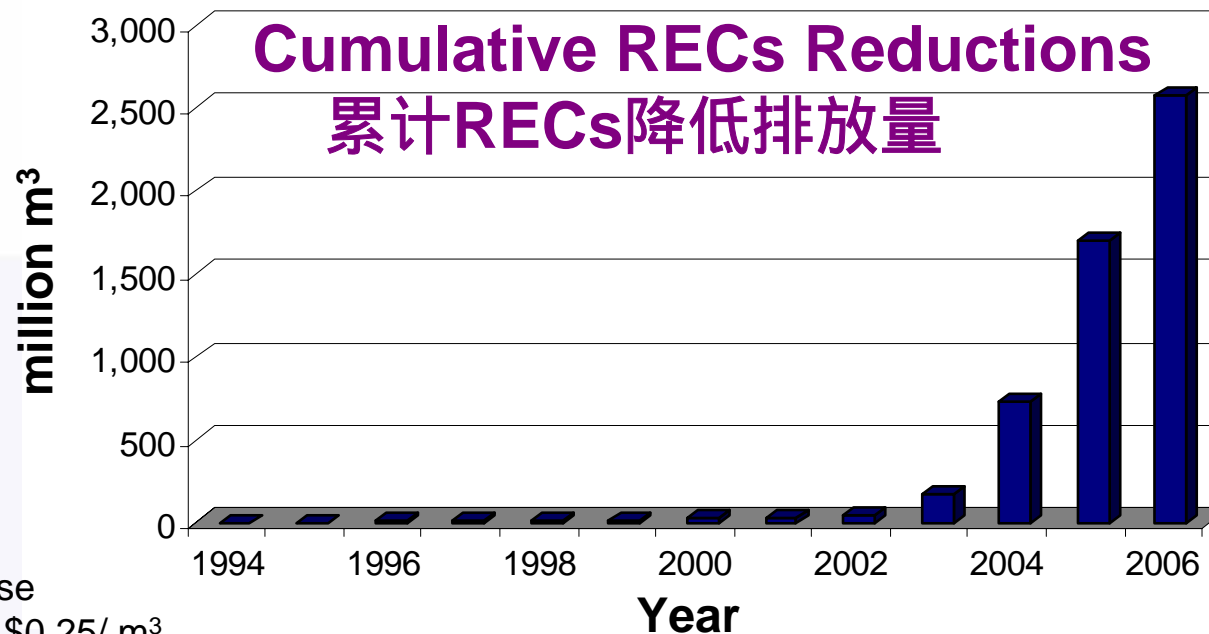


Permanent dehydrators 固定脱水器



Industry Experience 行业经验

- 12 companies have reported using RECs since 1994 自从1994年，有12家公司报道使用了RECs技术。
 - saving nearly 2,575 million m³ of methane¹ 节省甲烷近2,575百万方
 - worth nearly \$643 million² 价值近6亿4千3百万美元



¹ iSTAR database

² Gas valued at \$0.25/ m³

Methane Losses from Liquids Unloading 由液体卸载引起的甲烷损失

- Completion venting is not the only type of well venting 完井放空并不是油井放空的唯一途径
- Accumulation of liquid hydrocarbons or water in aging wells reduces, and can halt, production 在老井中累积的液态烃或水会降低产量或者使油井停产。
- Well is revived by closing it off to build up pressure, then opening it and venting to unload liquids 通过关闭油井以增加井底压力，然后开井排液，可以使油井恢复原来的生产能力。
 - This may vent 2,265 to 16,990 m³/year¹ to the atmosphere per well 每口井每年要向大气中排放2,265到16,990方气体。

1 – Installing Plunger Lift Systems in Gas Wells Lessons Learned 在气井中安装柱塞
举升系统文献资料

http://www.epa.gov/gasstar/pdf/pro_pdfs_chi/lessons/plunger_lift.pdf

Methane Recovery: Plunger Lift

甲烷回收：柱塞举升

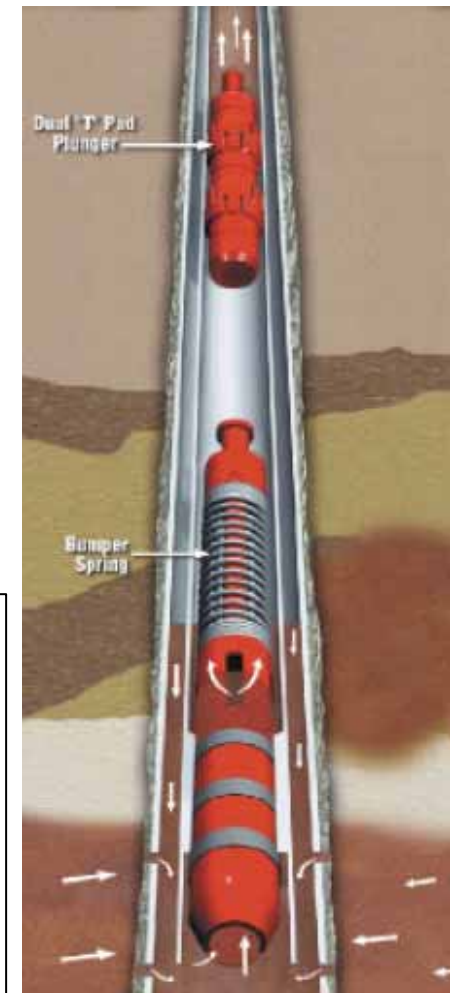
- Plunger lifts remove liquids 柱塞举升移除液体
 - Well is shut-in with plunger at the bottom 当柱塞在井底时关井
 - Well pressure builds up in casing 套管中井压增加
 - Plunger and liquids are pushed to surface 柱塞和液体被推向地面
 - Plunger dropped to bottom 柱塞落回井底
- Benefits include 经济效益包括：
 - Continuous production 不间断连续生产
 - Lower maintenance 较低的维修保养费
 - Increased efficiency 效率增加
 - Reduced methane emissions 减少甲烷排放

在气井上安装柱塞举升系统

INSTALLING PLUNGER LIFT SYSTEMS IN GAS WELLS

1 内容提要

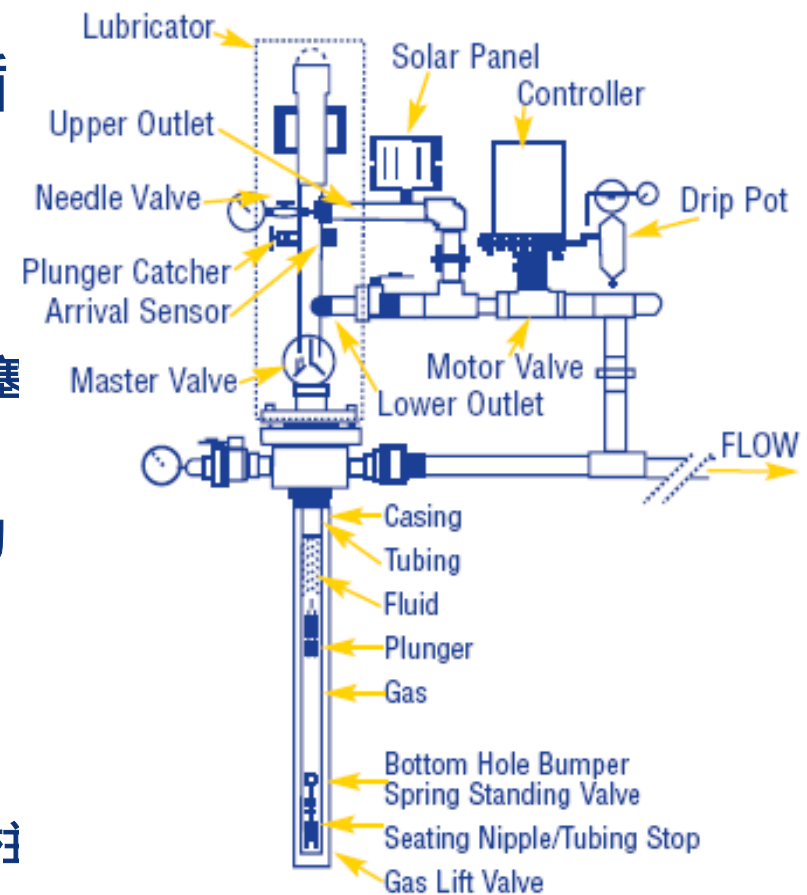
在进入开采中后期的气井中，井内积液能阻碍甚至有时会停止气体生产。当出现这种情况时，一般通过使用有杆泵或采用诸如抽汲、泡排或者将气井排放至大气压（称作气井“放空”）等补救措施来除去积液，以此来维持气体流动。除液作业，特别是气井放空作业，会造成大量甲烷排放到大气中。



Source: Weatherford 17

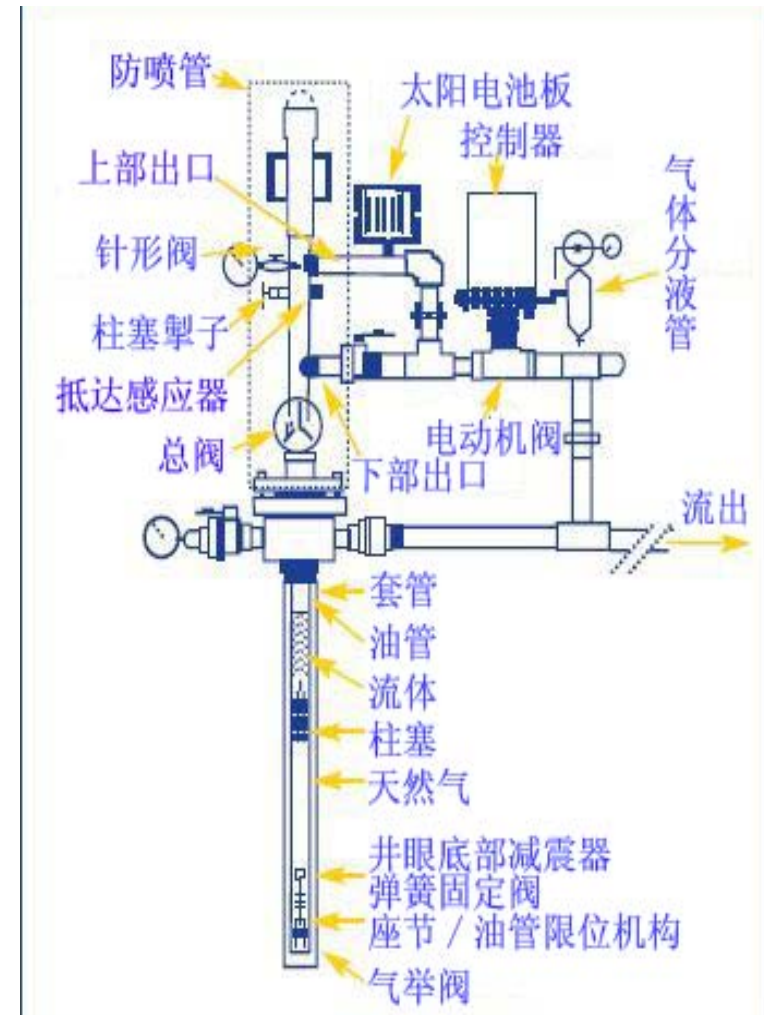
What is the Problem? 问题？

- Fixed timer cycles may not match reservoir performance 固定时间的循环可能与油藏性能不匹配
 - Cycle too frequently (high plunger velocity) 循环频率太大 (高的柱塞速率)
 - Plunger not fully loaded 柱塞不能完全加载
 - Cycle too late (low plunger velocity) 循环频率太小 (低的柱塞速率)
 - Shut-in pressure can't lift fluid to top 关井压力不能举升液体到地面
 - Plunger stalls; vent to atmosphere to lift plunger 柱塞失速；举升柱塞通向大气



What is the Problem? 问题？

- Does not account for gathering line pressure fluctuations, declining well performance, or plunger wear 不能说明集输管线的压力波动、井的性能的衰退或者柱塞的磨损
- Results in manual venting to atmosphere when over or under loaded 当超过或低于加载时，导致手动放空。



Methane Recovery: Smart Automation

甲烷回收：智能自动化

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters such as: **自动化技术可以通过检测井口参数而提高柱塞举升的能力：**
 - Tubing and casing pressure **油压和套压**
 - Flow rate **流速**
 - Plunger travel time **柱塞循环时间**
- Using this information, the system is able to optimize plunger operations **使用这些信息，系统可以优化柱塞操作。**
 - To minimize well venting to atmosphere **使油井向大气放空次数减到最少**
 - Recover more gas **回收更多的天然气**
 - Further reduce methane emissions **进一步减少甲烷排放**

气井“智能型”自动化系统

Gas Well “Smart” Automation System

合作伙伴推荐的甲烷减排机会（PRO） NO. 709

适用领域：

生产部门
 处理加工部门
 输气和配气部门

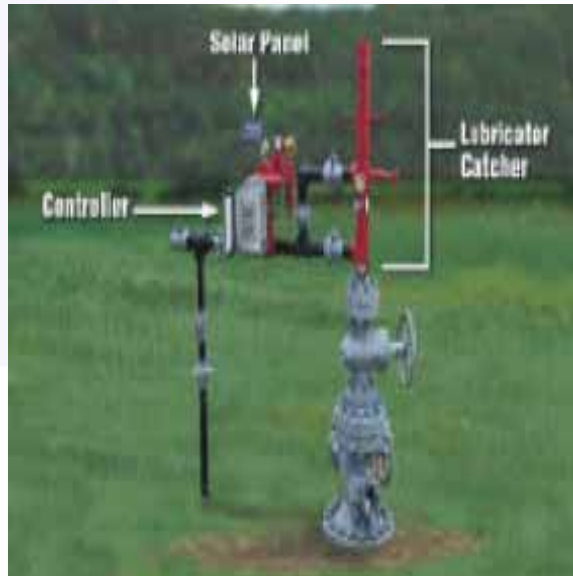
报道 PRO 的合作伙伴：

压缩机/发动机

脱水器

管线

Automated Controllers 自动化控制器



Source: Weatherford

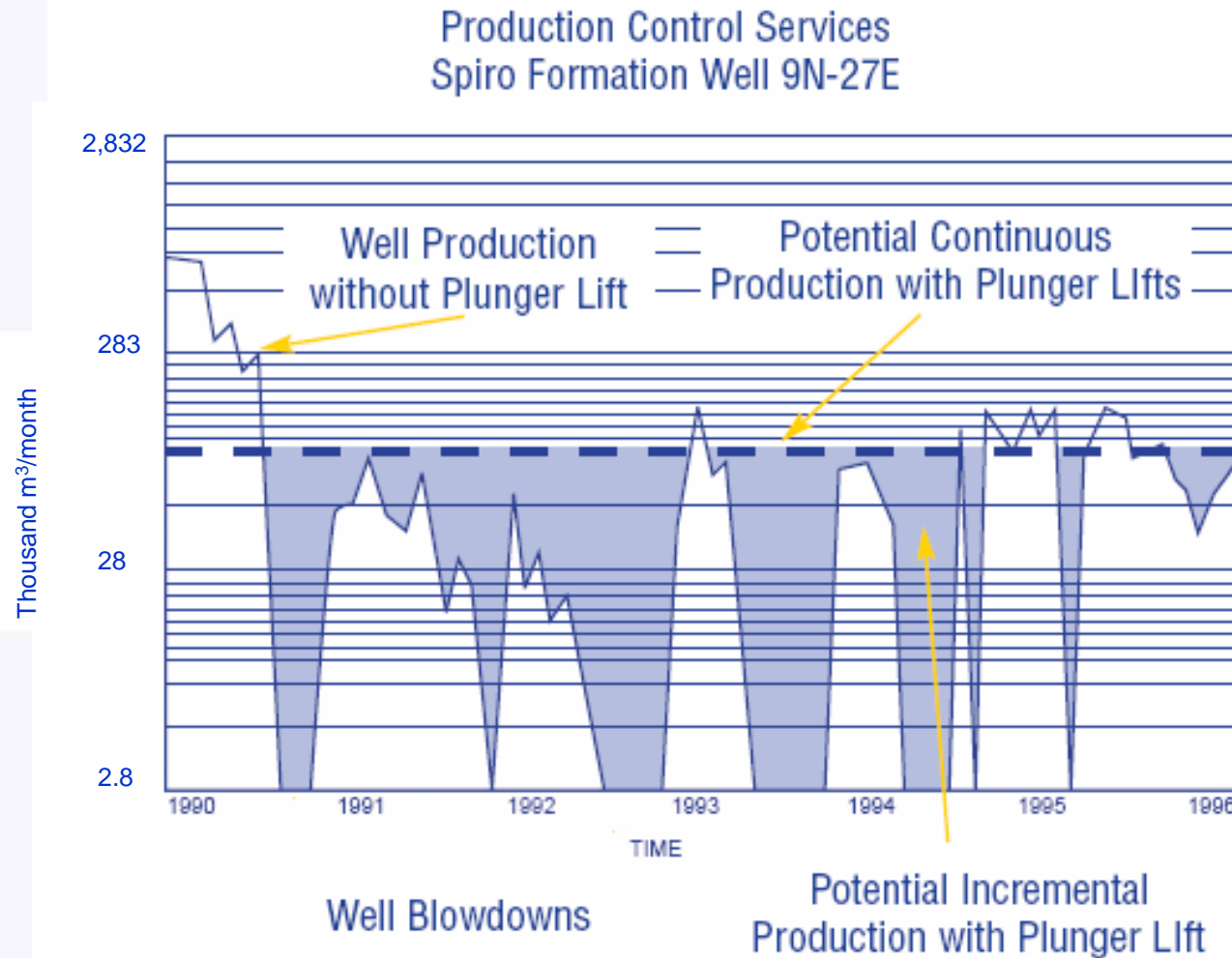
- Remote well management 油井远程管理
 - Continuous data logging 连续测井数据采集
 - Remote data transmission 远程数据传输
 - Receive remote instructions 远程指令接收
 - Monitor other equipment 监测其他设备

- Low-voltage; solar recharged battery power 低电压；太阳能充电电池
- Monitor well parameters 监测井参数
- Adjust plunger cycling 调整柱塞周期变化

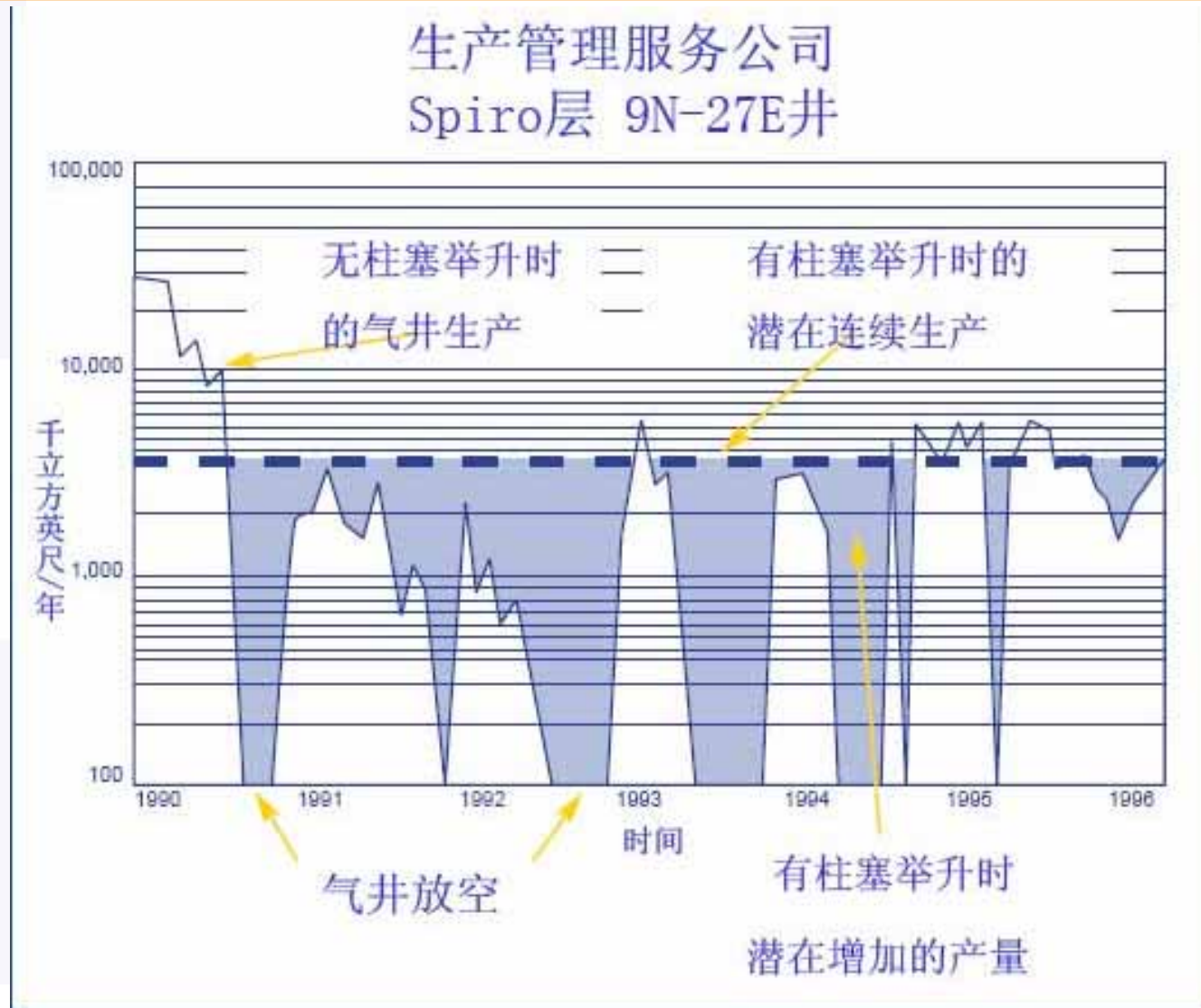


Source: Weatherford

How much production is lost? 损失掉了多少产量？



How much production is lost? 损失掉了多少产量？



Methane Savings: Plunger Lift and Smart Automation 甲烷节省：柱塞举升和智能自动化

- Methane emissions savings a secondary benefit 节省的甲烷排放属于二次获益
 - Optimized plunger cycling to remove liquids increases well production by 10 to 20%¹ 优化柱塞循环周期、清除液体可以增加油井产量**10-20%**。
 - Additional 10%¹ production increase from avoided venting 由于避免放空可以再增加**10%**的产量
- 14,150 m³/year methane emissions savings on average per mature well 每口老井每年平均减少甲烷排放**14,150方**
- Other benefits include: 其他的经济效益包括：
 - Continuously optimized production conditions 连续优化生产条件
 - Remotely identify potential unsafe operating conditions 远程识别潜在的不安全生产操作条件
 - Monitor and log other well site equipment (i.e dehydrator, compressor, vapor recovery units) 监测和记录其他井场设备（如：脱水器、压缩机、蒸汽回收设备）

¹Reported by Weatherford 威德福报道

Is Recovery Profitable? 回收有无效益？

- Plunger lift installed cost: ~\$2,500 to \$10,000 per well¹ 柱塞举升安装费用：每口井2,500-10,000美元
 - Reported savings of ~50% less venting² 比放空节省可达50%
 - Reported paybacks of 2 to 14 months¹ 投资回收期为2-14个月
- Smart automation controller installed cost: ~\$11,000³ 智能井控制器安装费用：最高为11,000美元
 - Reported savings of additional ~25% less venting (for a total of ~75% reduction in original blowdown venting)⁴ 与放空相比，最多可以额外节省25%
 - Reported paybacks of 1 to 3 years⁵ 投资回收期为1-3年

¹ EPA. Installing Plunger Lift Systems in Gas Wells Lessons Learned
在气井上安装柱塞举升系统

² British Petroleum. Houston Natural Gas STAR Annual Implementation Workshop, 2007
英国石油：休斯敦天然气STAR年度实施交流会，2007

³ Phone conversation with vendor 与卖主电话交流

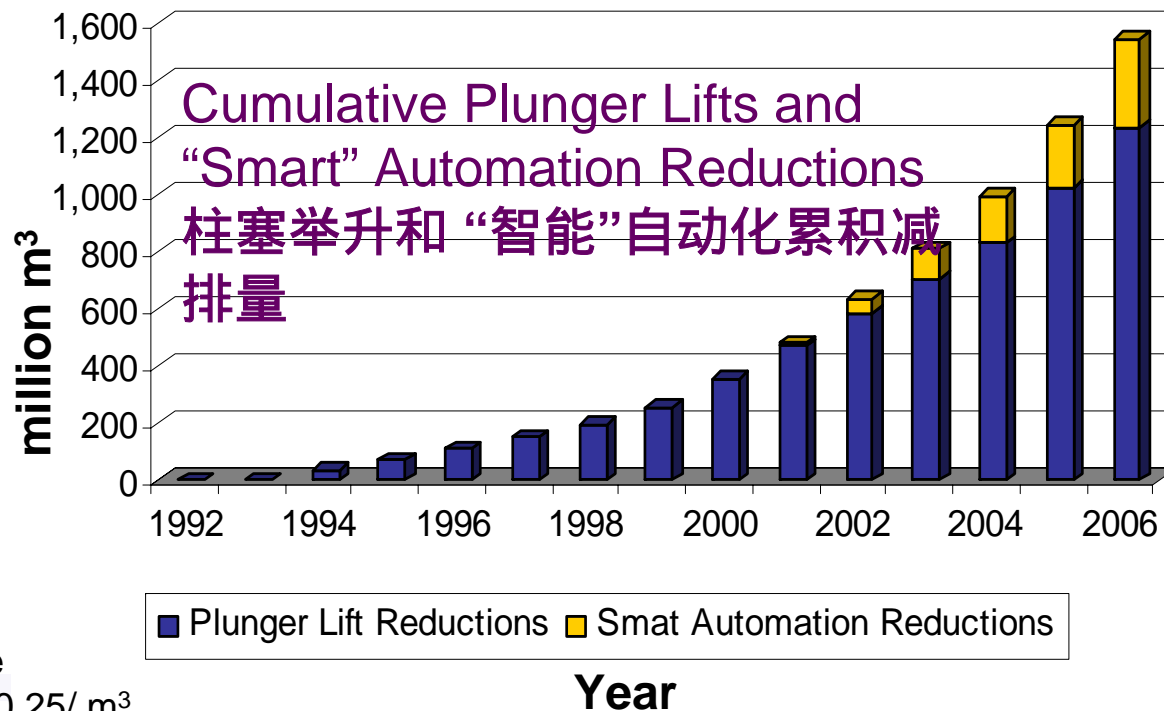
⁴ EPA. Spring 2004 Partner Update 2004年春季，合作者更新

⁵ EPA. Gas Well “Smart” Automation System PRO 气井“智能”自动化系统

Note: All costs and revenues are represented in U.S. economics
所有的花费和收益以美元计算

Industry Experience 行业经验

- 13 companies have reported using plunger lifts since 1992 (2 automated) 自从1992年开始，有13家公司相继报道使用了柱塞举升技术（2个自动化）
 - saving over 1,500 million m³ of methane¹ 节省甲烷15亿方
 - worth nearly \$387 million² 总价值将近3亿8千7百万元



¹ iSTAR database

² Gas valued at \$0.25/ m³

Leak Detection – Infrared Camera 泄露探测-红外摄像机

- Flowlines often leak 流体流动
管线经常发生泄露
 - Inspect with infrared camera to identify leaks 使用红外摄像机进行泄露的识别
 - Creates real-time images of gas plumes from leaks 对泄露源的气体热流可以产生实时图像



Source: Leak Surveys Inc.

在偏远现场进行针对性检修

Conduct DI&M at Remote Sites

合作伙伴推荐的甲烷减排机会 (PRO) NO. 902

适用领域:

■生产部门 ■处理加工部门 ■输气和配气部门

报道 PRO 的合作伙伴:

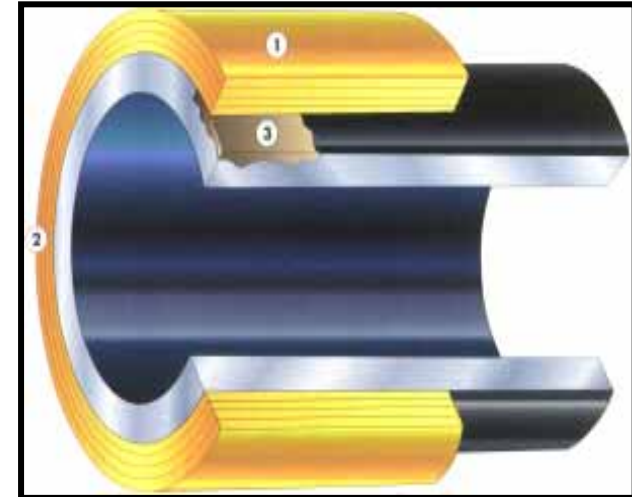
压缩机/发动机

脱水器

管线

Pipeline Defect Emissions Solution- Composite Wrap 管线损伤泄露解决方法-复合管套

- Flowline damage or corrosion leads to leaks 流动管线损坏或者腐蚀导致的泄露
 - Identify defects in pipeline and use composite wrap to avoid leaks 监测管线上的故障点，使用复合管套以避免泄露
 - Consists of composite sleeve wrapped around the defect and bonded to the pipeline 复合套筒卷绕泄漏点，连接到管线上



Source: Clock Spring® Company L. P.

用于非泄漏管线损伤的复合管套

COMPOSITE WRAP FOR NON-LEAKING PIPELINE DEFECTS

1 内容提要

复合管套是一种永久性的、经济有效的管线修复技术，适用于诸如凹槽、凹痕、凿缝和外部腐蚀等非泄漏损伤。复合管套可直接在运行管线上安装，无须将损坏部分取出进行修复。这种修理技

Blowdown Emissions Solutions

泄压排放解决方案

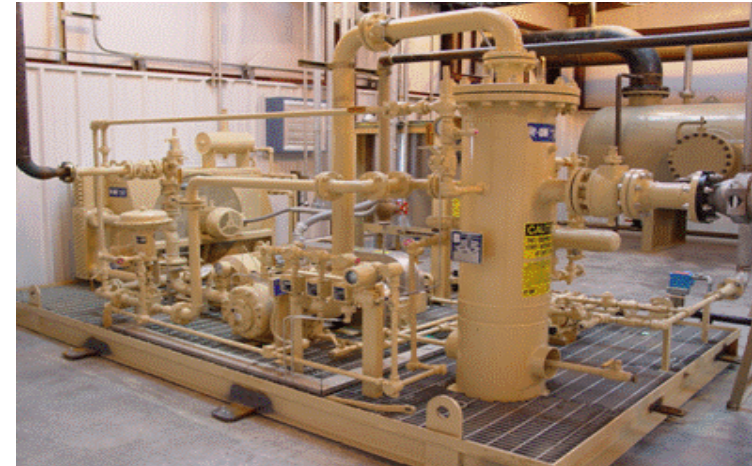
Blowdowns 泄压

- **Velocity tubing strings** - reduces the cross-sectional area of flow, increasing the flow velocity, allowing liquid removal without methane emissions **速度油管柱---减少流动横截面积，增加流动速率，使得流体清除过程中没有甲烷排放。**
- **Foaming agents (soap)** - gas bubbling through the soap-water solution creates gas-water foam that is easily lifted to the surface for water removal, preventing emissions **发泡剂---气体经过肥皂水溶液时会产生气水泡沫，泡沫可以轻易地举升水至地面，防止了甲烷的排放。**
- **Downhole separator pumps** -separates gas from water below the surface, preventing methane emission **井下分离泵---在地面以下从水中分离气体，阻止甲烷的排放。**

安装井下分离泵	
使用发泡剂	
安装速度油管柱	
Install Velocity Tubing Strings	
合作伙伴推荐的甲烷减排机会 (PRO) NO. 704	
适用领域: <input checked="" type="checkbox"/> 生产部门 <input type="checkbox"/> 处理加工部门 <input type="checkbox"/> 输气和配气部门	压缩机/发动机 <input type="checkbox"/> 脱水器 <input type="checkbox"/> 管线 <input type="checkbox"/> 气动/控制 <input type="checkbox"/>
报道 PRO 的合作伙伴: TotalFinaElf (现在的 Total)	

Wellhead Emissions Solutions – Vapor Recovery Unit (VRU) 井口排放解决方法---蒸汽回收装置

- Casing head gas venting 套管头天然气放空
 - Recover vapors with compressor or VRU 使用压缩机或者蒸汽回收装置回收蒸汽



Source: Hy-bon Engineering

将套管连接到蒸汽回收装置上

安装压缩机收集套管气

Install Compressors to Capture Casinghead Gas

合作伙伴推荐的甲烷减排机会 (PRO) NO. 702

适用领域:

■ 生产部门

报道 PRO

Marathon

其他相关的

用管线将乙

适用领域:

■ 生产部门

□ 处理加工部门

□ 输气和配气部门

报道 PRO 的合作伙伴:

Pioneer Natural Resources USA, Inc.

其他相关的 PRO.

压缩机/发动机

脱水器

管线

气动/控制

储罐

Discussion Questions 问题讨论

- To what extent do you have opportunities to implement these technologies? 你有多大机会实施这些技术？
- How could these opportunities be improved upon or altered for use in your operation? 在你的操作过程中，如何改进或改变这些机会以应用这些技术？
- What are the barriers (technological, economic, lack of information, regulatory, focus, labor, etc.) that are preventing you from implementing these practices? 应用这些技术的障碍（技术、经济、缺少信息、调整、重点、劳动力等）是什么？