Methane Emission Measurement Techniques

甲烷排放测量技术

Methane To Markets Partnership
International Workshop – Oil & Gas
April 17 and 18, 2008
Qingdao, China

Why Quantify Emission Rates?
为何要量化排放速度

- Justification for repair/control costs.
  调整修理/控制费用
- Prioritization and optimization of efforts?
  对各种减排方案/计划进行优先排序和优化？
- Objective performance monitoring.
  客观的动态监测
- Potential to generate marketable GHG credits. 产生有市场价值的GHG信贷的潜力

Key Measurement Parameters:
关键测量参数

- Temperature温度
- Pressure压力
- CH_4 Concentration甲烷浓度
- Volumetric Flow体积流量

Performance Requirements:
性能要求：

- Practical and safe to use in the field. 现场使用实用且安全
- Reasonable cost.费用合理
- Readily available.现成的技术
- Sufficient accuracy for economic evaluations (e.g., ±25% or better). 有足够精度，能满足经济评价要求（如± 25%或更好）
- Greater accuracy for carbon credit projects (e.g., ± 15% or better).有更高的精度，能满足碳信贷项目要求（如± 15%或更好）

Basic Options:基本选择方案

- Measurements at the source.在排放源处进行测量
- Remote measurement techniques.远程测量技术
- Engineering Calculations.工程计算

Measurements at the Source
在排放源处进行测量

- Typical Applications:典型应用
  - Equipment leaks, venting and flaring.
    设备泄漏、放空和点火炬
- Basic constraints:基本限制条件
  - Requires easy or supplied access to source.排放源要求容易接近
- Potential Issues:潜在问题
  - Safety concerns (H_2S or relief events).安全问题（H_2S或放空事件）
  - Backpressure limitations.回压限制
  - High or cold temperature surfaces.高温或低温表面
  - Fouling (e.g., condensing vapor or lube oil mist).
    污垢（如冷凝蒸汽或润滑油雾）

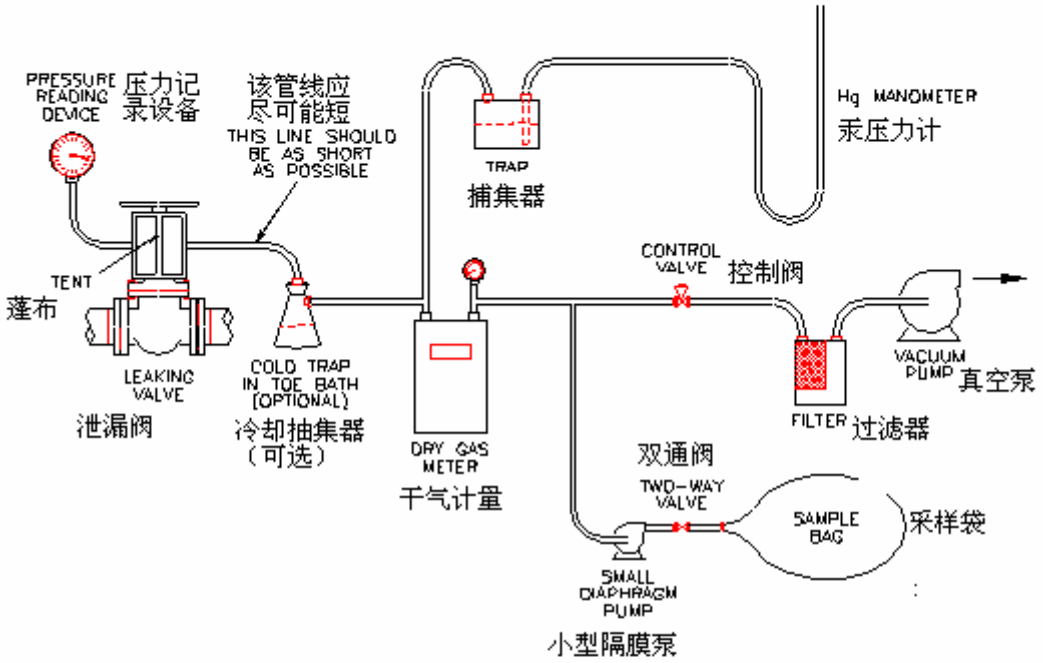
Measurements at the Source
在排放源处进行测量

- Methods:方法
  - Bagging装袋法
    - Time consuming and costly to apply.耗时、成本高
    - Applicable for small to moderate leak rates.适用于小到中等泄漏量的测量
  - Hi-Flow Sampler大容量采样器
    - Convenient approach for smaller to medium sized leaks (e.g., 8 to 10 scfm or $25,200 to $31,500/y at $6/mscf).
      用于较小规模到中等规模泄漏量测量的简便方法（如8～10标准立方英尺/分钟或25,200美元～31,500美元/年，6美元/标准立方英尺计算）

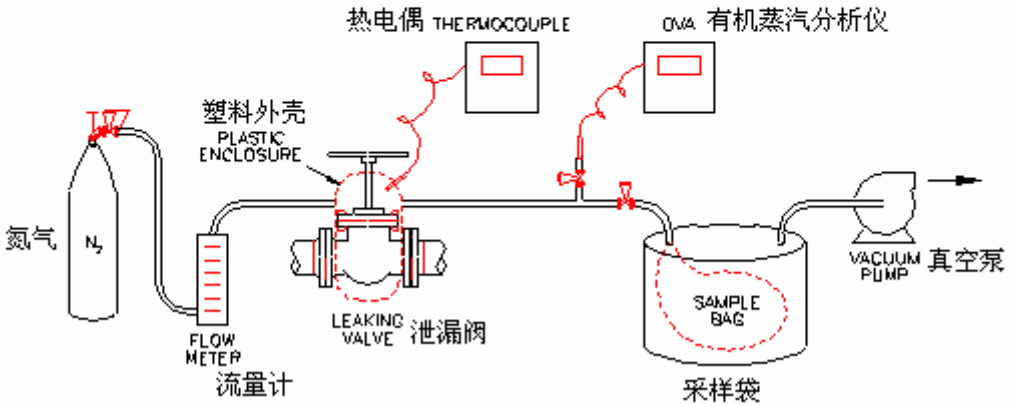
Measurements at the Source
在排放源处进行测量

- Methods:方法
  - End-of-Pipe Capture & Measurement Techniques
    管线终端捕集&测量技术
    - Calibrated Bag标准袋子
    - Full-flow flow meters.全流式流量计
    - Velocity Traverses速度导线测量
  - Inline Measurements在线测量
    - Velocity Traverses速度导线测量
    - Tracer Techniques示踪剂技术

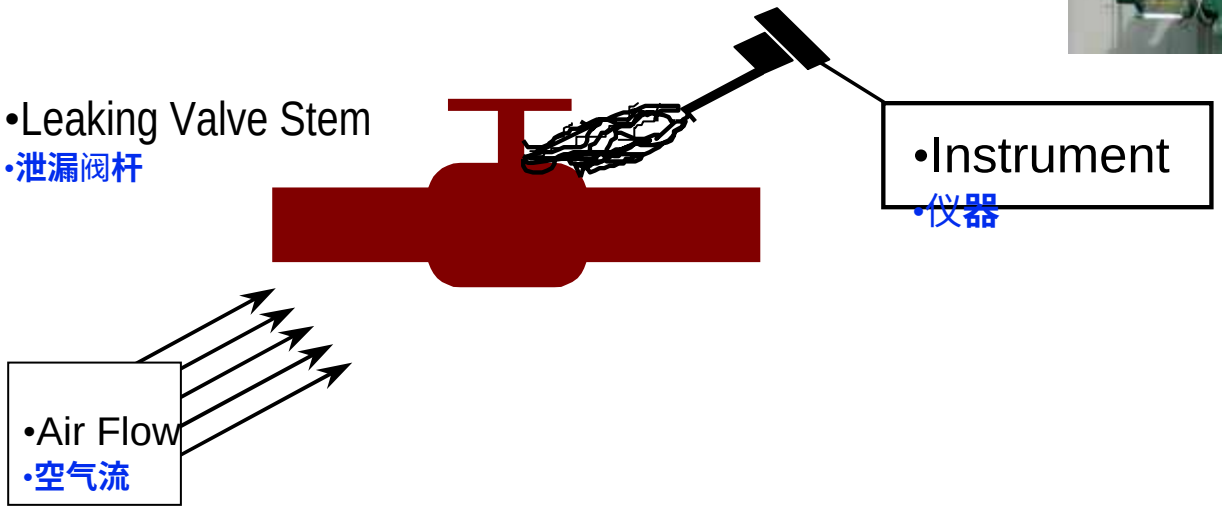
VACUUM METHOD 真空法



BLOW-THROUGH METHOD 漏气法



HiFlow Sampler大容量采样器



Remote Measurements:远程测量

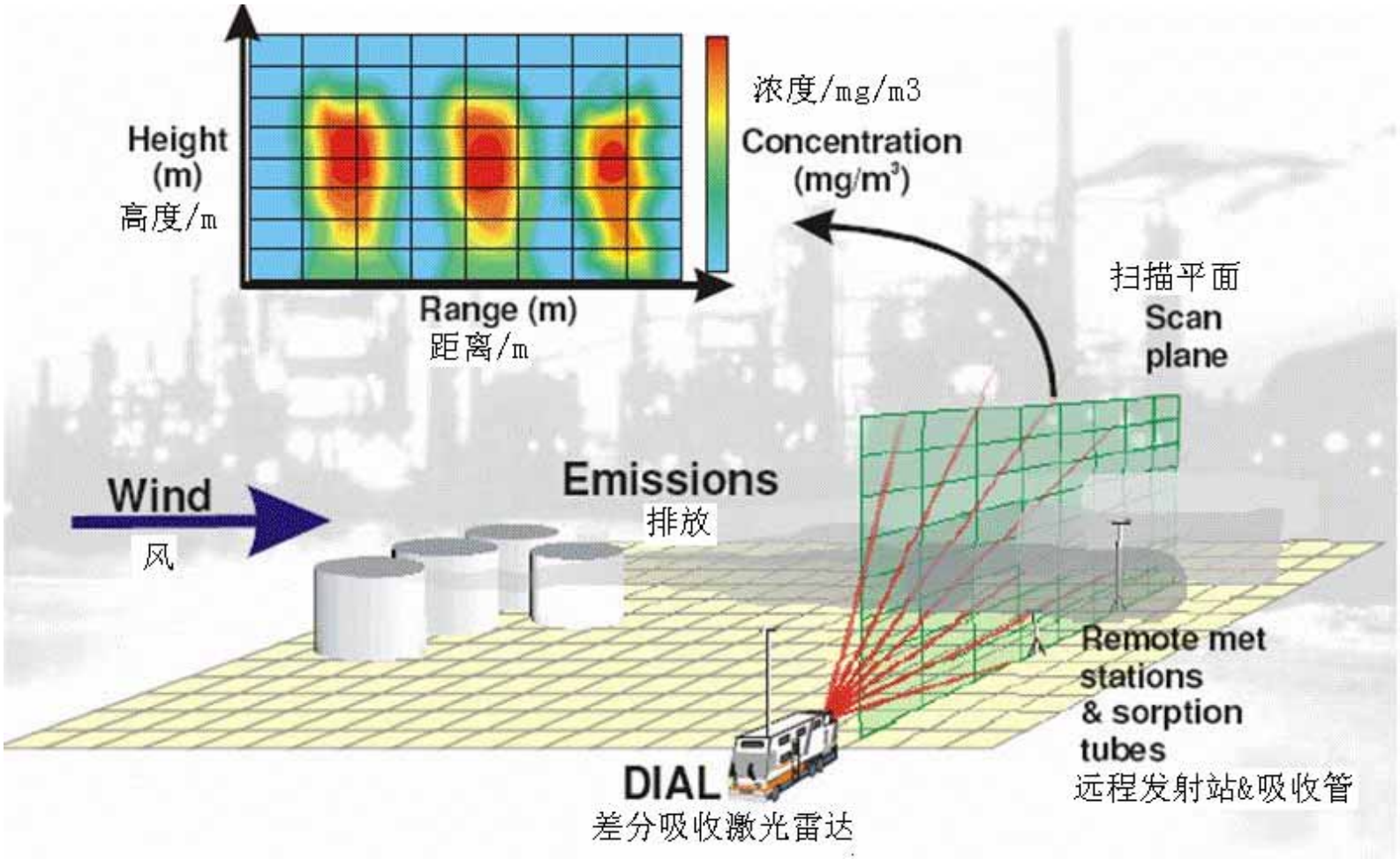
- Typical Applications:典型应用
  - Area and volume sources.面（泄漏）源和体（泄漏）源
  - Inaccessible or unsafe to access sources.接近泄漏源不方便或不安全
- Basic Constraints:基本限制
  - Generally more costly and complicated to use.通常使用起来费用更高、更复杂
- Potential Issues:潜在的问题
  - Weather dependent.测量与天气有关
  - Susceptible to interferences.易受干扰
  - Require suitable downwind access.需要有适当的顺风
  - Potentially reduced resolution and accuracy.可能降低分辨率和精度

Remote Measurements:远程测量

- Methods:方法
  - Tracer techniques:示踪剂技术
    - Pollutant-to-tracer ratio technique.污染物－示踪剂比例技术
  - Remote plume sensing methods.远程羽流检测方法
    - US EPA (2006): ORS Protocol光学远程检测协议文本 (www.epa.gov/ttn/emc/prelim/otm10.pdf).
    - DIAL (ftp://public:access@ts.clearstone.ca).差分吸收激光雷达（differential absorption lidar）
    - Back-calculation using atmospheric dispersion models and upwind/downwind monitoring data.利用大气污染扩散模型和逆风/顺风监测数据反算
    - AIRDAR.（AIR Detection and Ranging空气探测和测距）

Storage Tanks – Remote Emissions Measurement

储罐－远程排放测量



Engineering Calculations工程计算

- Typical Applications:典型应用
  - Process Venting工艺过程排气
- Basic Constraints:基本限制
  - Requires detailed and accurate process data.需要详细、精确的工艺过程数据
- Potential Issues:潜在的问题
  - Requires expert knowledge.需要具备专门知识
- Methods:方法
  - Mass balance and energy balance techniques.质量平衡和能量平衡方法
  - Process simulators.工艺过程模拟器

Compressor Seal Vents: 压缩机密封排气口

- Causes of Emissions:引起排放的原因
  - Seal wear.密封磨损
- Typical Measurement Problems:典型测量问题
  - Potentially multiple leakage points:可能存在多个泄漏点
    - Centrifugal compressors :离心式压缩机
      - Lube oil degassing reservoir.润滑油脱气室
      - Seal Vent.密封排气口
    - Reciprocating compressors:往复式压缩机
      - Distance piece and packing case vents. 隔片和密封箱排气口
      - Lube oil drain tank vent.润滑油排放罐排气口
      - Crank case vent.曲轴箱排气口

  - Potentially large flows.存在大流量问题
  - Minimal tolerance to any back-pressure.承受回压的能力很小
  - Fouling due to lube oil mist.由于润滑油雾而受到污染

Compressor Seal Vents:
压缩机密封排气口

- Typical Measurement Problems:典型测量问题
  - Oily roof-tops and limited roof-top access.油沟箱顶，限制从箱顶进入测量
  - Lack of ports on vent lines.放空管线上无测量端口
  - Possibly weather caps on vent outlets.在放空出口处可能有风帽

Compressor Seal Vents:
压缩机密封排气口

- Measurement Approaches.测量方法
  - Vane anemometers.叶轮风速计
  - Diaphragm meters or calibrated bags where some backpressure can be tolerated.在可以承受回压的地方使用膜片计量器或标准装气袋
  - Hi-Flow Sampler大流量采样器
  - Quantitative remote sensing methods.定量的远程检测方法
  - Permanent Solutions:永久性的解决方法
    - Flow switches.流量开关
    - Rotameters.转子流量计

Blowdown and Vent/Flare Systems:泄压和放空/火炬系统

- Causes of Emissions (During Passive Periods):引起排放的原因
  - Purge gas.吹扫气
  - Leakage past the seats of blowdown/relief valves (5 to 10% leak and 1 to 2% of these contribute over 75% of the emissions).通过泄压阀/放空阀阀座发生泄漏（5~10%的阀发生泄漏，其中1~2%的泄漏阀的泄漏量占总泄漏量的比例超过75%。）
  - Blowdown or drain valves not fully closed. 泄压阀或排放阀为完全关闭严实
  - Compressor seals.压缩机密封

Blowdown and Vent/Flare Systems:泄压和放空/火炬系统

- Typical Measurement Problems:典型的测量问题
  - Potentially large flows.存在大流量问题
  - Difficulty accessing end of pipe.很难接近管线末端
  - Limited or no suitable ports for insertion of velocity probes.可供插入速度探针的端口有限，或者没有合适的端口
  - Low flow velocities.低流速
  - Potentially wet or fouling environment inside pipe. 管线内部环境可能潮湿或受到污染
  - Safety concerns (relief episodes). 安全考虑（放空偶发事件）

Blowdown and Vent/Flare Systems:泄压和放空/火炬系统

- Measurement Approaches.测量方法
  - Micro-tip vane and thermal dispersion anemometers.叶轮和热分散速度计
  - In-line tracer tests.在线示踪剂测试
  - Ultrasonic sensors (portable & online). 超声波检测气（便携式&在线式）
  - Remote sensing methods.远程检测方法
  - Permanent Solutions:永久性解决方法
    - Ultrasonic transient-time flow meters.超声波瞬时流量计
    - Flow switches.流动开关

Storage Tanks:储罐

- Causes of Emissions:引起排放的原因
  - Working and breathing losses.操作损耗和呼吸损耗
  - Flashing losses.闪蒸损耗
  - Unaccounted for contributions:
    未计及的其他损耗贡献
    - Unintentional Gas carry-through.
      无意的气体泄漏
      - Leaking drain and dump valves.漏失的排泄阀和放卸阀/调压阀
      - Malfunctioning level controllers.功能失常的液位调节器
      - Inefficient upstream gas/liquid separation.低效的上游气液分离
      - Piping changes resulting in storage of unstablized product.管道变化导致存储不稳定的产品
      - Non-routine storage of unstabilized product in atmospheric tanks.在常压罐中非常规/不定期存储不稳定的产品

Storage Tanks:储罐

- Causes of Emissions:引起排放的原因
  - Unaccounted for contributions:
    未计及的其他损耗贡献
    - Malfunctioning vapor recovery systems:
      功能失常的蒸汽回收系统
      - Faulty blanket gas regulators or pressure controllers.
        缓冲层气体调节器或压力控制器出现故障
      - Fouled vapor collection lines.蒸汽回收管线受到污染
      - Leaking roof fittings and seals.顶部装置和密封发生泄漏

Storage Tanks:储罐

- Typical Measurement Problems: 典型测量问题
  - Multiple roof openings. 顶部存在多个开口
  - Edge-of-roof access only.仅能接近顶部边缘
  - Dependence on pump in/out activity and meteorological conditions. 取决于泵入/泵出作业和气象条件
  - Fall protection and potentially confined space training required. 防护不到位，可能需要密闭的导流空间
  - Interpretation and extrapolation of results.结果解释和外推
- Measurement Approaches:测量方法
  - Velocity profiles across openings.沿着开口的速度剖面
    - Vane anemometers.叶轮风速计
  - Tracer techniques.示踪剂技术
  - DIAL差分吸收激光雷达

- Engineering Calculations工程计算
  - API E & P TANKS Model (Flashing, working and breathing losses). API E&P储罐模型（闪蒸损耗、操作损耗和呼吸损耗）

Best options by source:

测量各种排放源的最佳选择方案

Source 排放源	Hi-Flow 大容量采样器	End-of-Pipe Flow Meters 管端流量计	Velocity Probes 速度探针	Tracer Methods 示踪剂方法	Quantitative Remote Sensing 定量远程检测	Flow/Leak Sensors 流动/泄漏传感器
Connectors 接头	X					
Valves 阀	X					
PRVs 减压阀	X	X				
OELs 末端开口管线	X	X	X			
Blowdown Systems 放空系统		X	X	X		X
Compressor Seals 压缩机密封	X	X	X			X
Flare Systems 火炬系统			X	X	X	X
Tanks 储罐		X	X	X	X	X
Non-point Sources 非点式泄漏源				X	X	

Conclusions on Leak Measurement:
泄漏测量结论：

- A selection of measurement technologies is usually required.通常需要选择测量技术
- Instrumented solutions are the best choice for large potential emitters:对于大的潜在的排放源来讲，仪器测量方法是最佳选择
  - Compressor seals.压缩机密封
  - Flare and vent systems.火炬和放空系统
  - Metering of gas blanketing systems.气体覆盖层/缓冲层计量系统