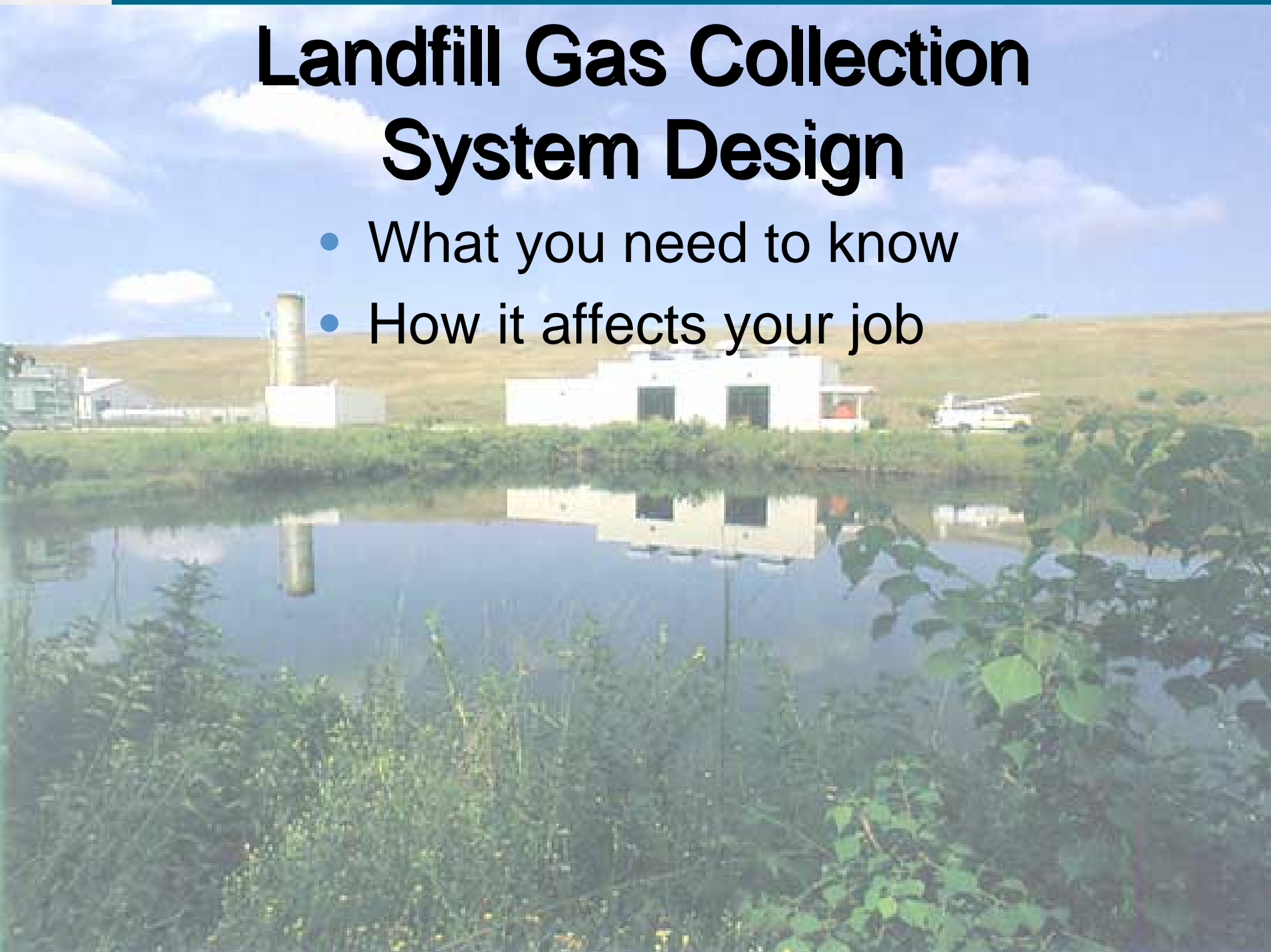


Landfill Gas Collection System Design

- What you need to know
- How it affects your job





Design Objectives

- Control migration
- Control emissions
- Control odors
- Maximize gas collection for energy recovery
- Comply with regulations

Designing to Accommodate the Variable Nature of Landfills

- MSW
- C&D
- Waste Age
- Method of Filling
- Location
- Climate



Types Of Systems

- Passive
- Active

Passive System

- System that relies on pressure or concentration gradients to function
 - ◆ Vertical vents, gravel trenches

Active System

- System that includes a prime mover that creates a vacuum on the landfill
 - ◆ Vertical gas wells
 - ◆ Horizontal collectors

Passive

- Pluses and Minuses
 - Low Operating cost
 - Low initial cost
 - Positive pressures
 - Gas collection inefficiencies
 - Condensate removal
 - Minimal capacity



Active

- Pluses and Minuses
 - ◆ Maximum capacity
 - ◆ Functions with various gas systems
 - ◆ Maintains vacuum on the landfill
 - ◆ Higher initial cost
 - ◆ Higher operating cost

What Goes into a Gas Collection System Design?

- Well Spacing
- Well Materials and Depth
- Non-Well Extraction Points
- Collection Piping
- Condensate
- Dual Gas/Leachate Extraction
- Flares



Well Spacing

- ROI equation
 - ◆ Limitations of
- Landfill design
- Permeability
- Waste type
- Operating pressure/vacuum

Well Spacing

- Typical ranges of ROI
 - ◆ Passive Wells
 - ◆ Active Wells



Well Spacing

- Gas venting layer beneath final cover
 - ◆ Waste Hauling and Bath Examples
 - ◆ Sand vs. Geosynthetic



Well Design

- Pipe vs. Pipeless vs. non-gravel pack wells
- Well diameter
- Materials of construction
- Well heads
- Well Lifecycle
- Design Limitations



Well Design

- Pipe vs. Pipeless vs. non-gravel pack wells
 - ◆ Depth
 - ◆ Packing
 - ◆ Surface seal
 - ◆ Geomembrane Boots
 - ◆ Connection to header
 - ◆ Header design



Well Design

- Well diameter
 - ◆ Implications
 - Flow
 - Pressure
 - ◆ Cost



Well Design

- Well Design / Materials of construction
- Typically HDPE or PVC
- Stainless Steel
 - ◆ (rarely)



Well Design

- PVC
 - ◆ Rigid
 - ◆ Higher temperature
 - ◆ Structurally functional when slotted
 - ◆ Easy to extend
 - ◆ Higher cost
 - ◆ Variety of manufactured fittings



Well Design

- HDPE
 - ◆ Low cost
 - ◆ Very flexible
 - ◆ Temperature affects
- Stainless Steel
- Other materials

Geomembrane Boot Around Well

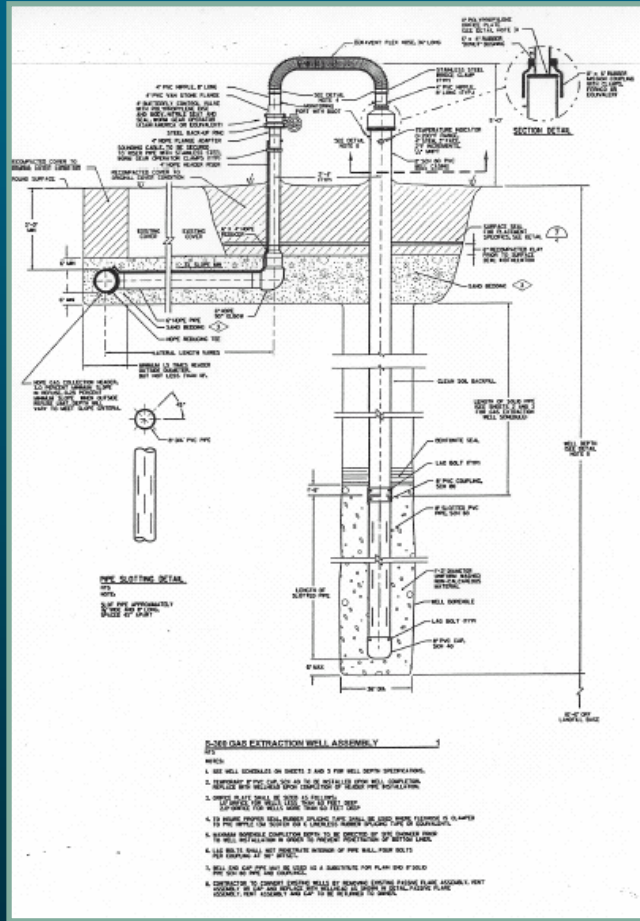




Well Design

- Well heads
 - ◆ Monitoring capability
 - ◆ Liquid level accessibility
 - ◆ Resistance to environmental affects
 - ◆ Versatility after installation

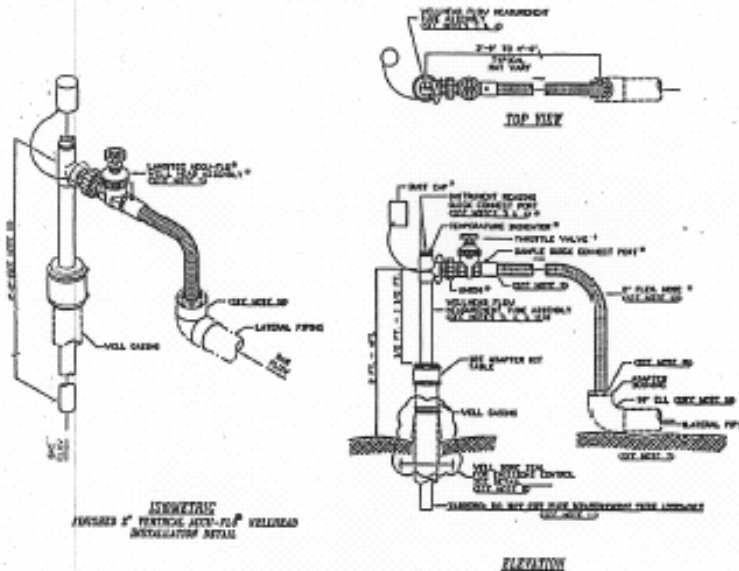
Well Design - A



Accu-flo Model

LANDTEC
 800-390-7745
 301-391-6545
 301-391-6546 FAX

ACCU-FLO MODEL 200V



- INSTALLATION NOTES**
- 1 - REFER TO LANDTEC ACCU-FLO® WELLSHEAD INSTALLATION INSTRUCTIONS MANUAL AND PROJECT OR SPECIFICATION, AS PER INSTRUCTIONS THROUGHOUT TO OBTAIN ADDITIONAL ASSEMBLY AND INSTALLATION OF WELLSHEAD AND WELL CASING.
 - 2 - WELLSHEAD CASING SHOULD BE AN APPROPRIATE GRADE OR FIELD EQUIVALENT AND THE CORROSION PROTECTION.
 - 3 - WELLSHEAD AND FLUID HEAD ASSEMBLY SHALL BE SUPPORTED AND STABILIZED TO PREVENT LATERAL GAS MIGRATION AND BEARING UNDESIRABLE LOADS.
 - 4 - WELLSHEAD SHALL BE SUPPORTED WITH LANDTEC'S CERTIFIED FLUID HEAD SUPPORT SYSTEMS (FSS).
 - 5 - LANDTEC CONTROL TECHNOLOGIES' ELASTIC ACCU-FLO® WELLSHEAD ASSEMBLY & ACCESSORIES INCLUDING BEARING MANAGEMENT SOFTWARE AND WELLSHEAD SEAL AVAILABLE FROM LANDTEC (PHONE 301-391-6545).
 - 6 - WELLSHEAD SHALL BE RIGGED FOR A FLUID FORCE OF 10000 LBS.
 - 7 - LATERAL FLOWING GAS IS SUPPORTED BY GRAVITY AND/OR PRESSURE TO FLOW THROUGH WELLSHEAD SEAL.
 - 8 - HOW TO SEAL - THE WELLS HEAD SEAL INSTALLATION SHALL BE PERFORMED AS PER THE WELLS HEAD SEAL INSTALLATION MANUAL. INITIAL CHECKING FOR WELLS HEAD SEALING SHALL BE PERFORMED AS PER THE WELLS HEAD SEALING MANUAL.
 - 9 - THE FLOW CONTROL VALVE AND THE 2\"/>

OPTIONS BY TABLE

| TABLE NO. | DESCRIPTION |
|-----------|----------------|
| 1 | ACCU-FLO 2\"/> |

ACCU-FLO®
 2\"/>

LANDTEC ELASTIC GAS WELLSHEAD INSTALLATION
 ACCU-FLO® 2\"/>

This unit should be stored in an upright position. Do not store in a horizontal position. Do not store in a position where the unit is subjected to vibration or shock. Do not store in a position where the unit is subjected to moisture or other environmental conditions.

NEVER BORE OR PLACE IN LATERAL POSITIONS. The Accu-Flo wellhead assembly is designed to be used in a vertical position. It is not designed to be used in a lateral position. It is not designed to be used in a horizontal position. It is not designed to be used in a position where the unit is subjected to vibration or shock. It is not designed to be used in a position where the unit is subjected to moisture or other environmental conditions.

LANDTEC
 LANDTEC CONTROL TECHNOLOGIES
 OILTON, CA

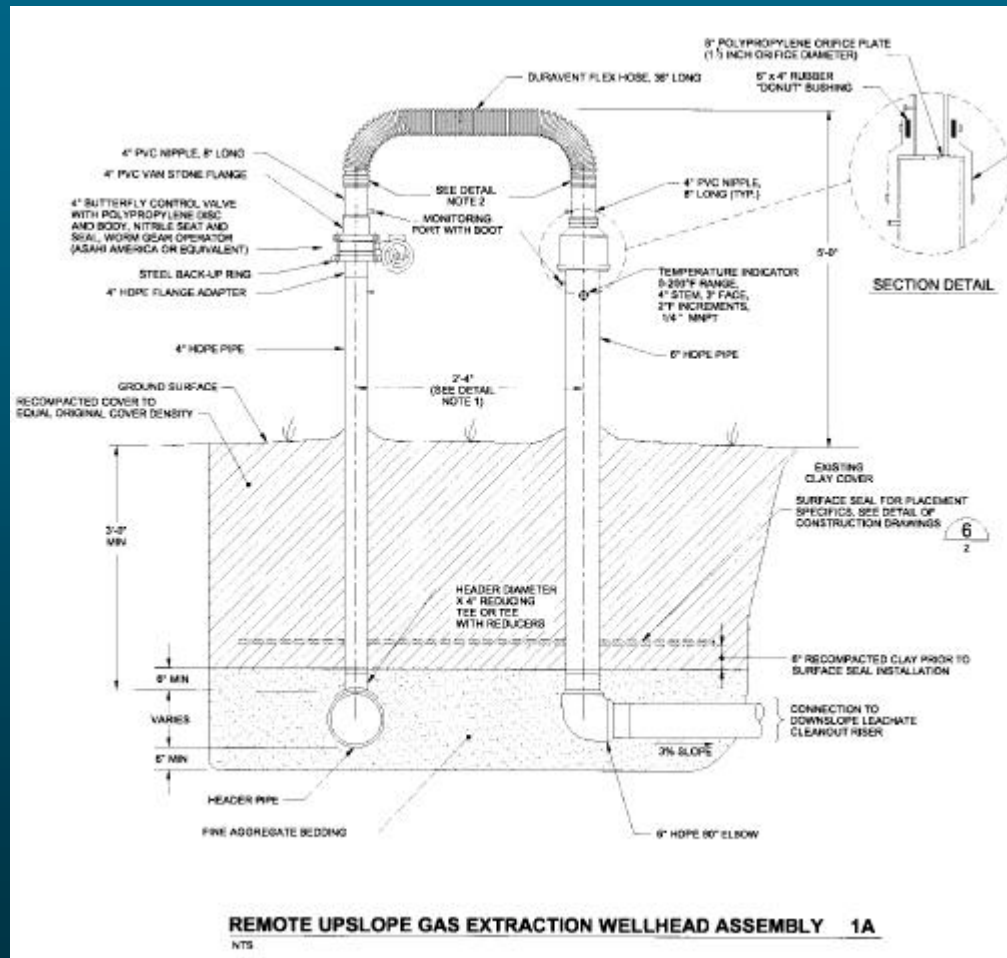
ACCU-FLO®
 ELASTIC GAS WELLSHEAD

| TABLE NO. | DESCRIPTION | TABLE NO. | DESCRIPTION |
|-----------|----------------|-----------|----------------|
| 1 | ACCU-FLO 2\"/> | 2 | ACCU-FLO 2\"/> |

Remote Up-slope Wellhead

- Used when header is upslope of well
- Prevents lateral from filling with condensate
- Typical lateral/wellhead will become blocked with condensate in this configuration

Remote Up-slope Wellhead





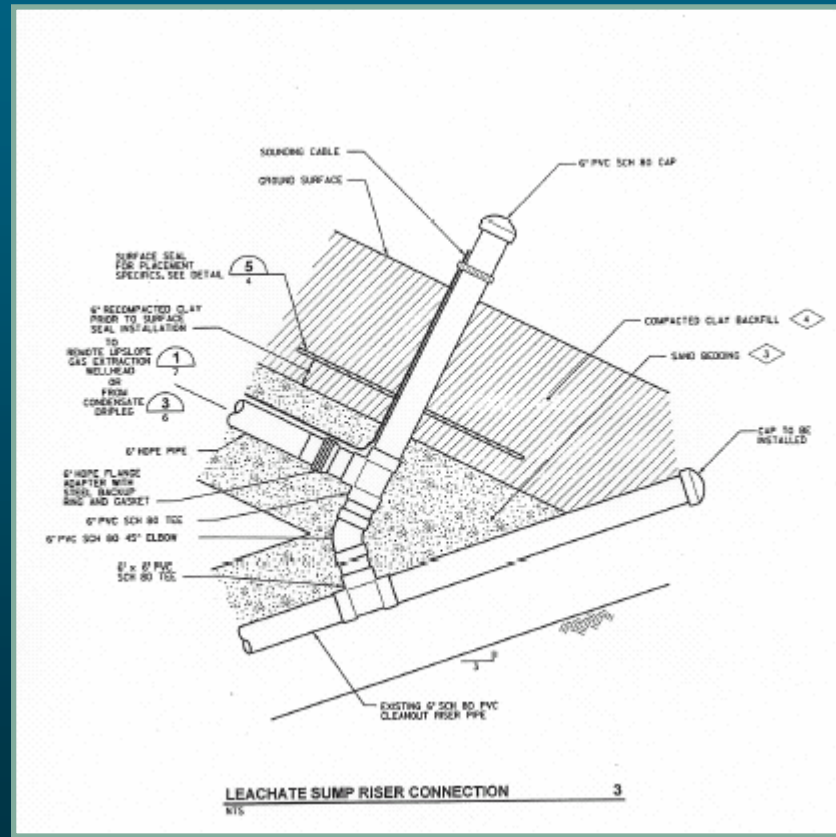
Well Design

- Well Life Cycle
 - ◆ Life expectancy
 - ◆ Causes for decline in well performance
 - liquids
 - silt
 - pipe crushing
- Design Limitations

Non-Well Extraction Points

- Leachate collection risers
- Trench systems
- Regulatory Implications

Leachate Sump Riser Connection



Sump Tie-in





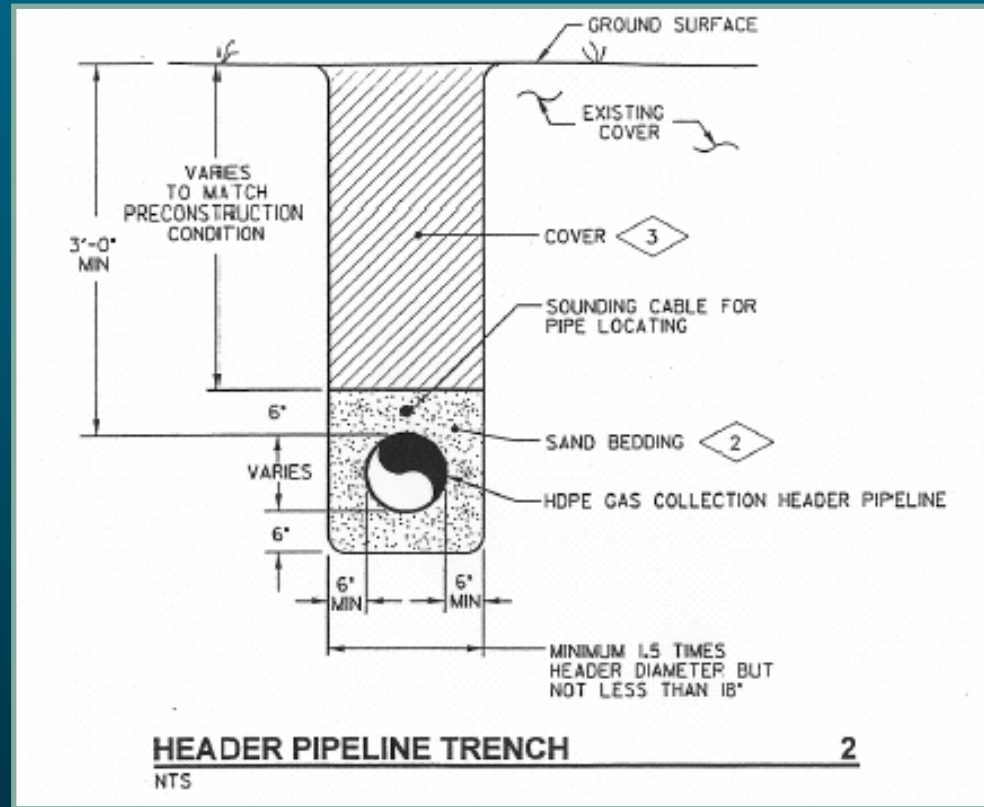
Collection Piping

- How to:
 - ◆ Get the vacuum to the wells
 - ◆ Get the gas from the well to the flare
 - Or the power plant

Collection Piping

- Looping systems
- Pipe slope
- Pipe diameter
- Valves
- Pipe Lifecycle
- Condensate

Header Pipe Trench



Collection Piping

- Looping systems
 - ◆ Benefits vs. costs
 - ◆ Designed to be redundant
 - ◆ Accepts expansions

Collection Piping

- Pipe slope
 - ◆ Implications associated with settlement
 - Bellies
 - Sedimentation
 - Shearing
 - ◆ Design Options
 - ◆ Design Limitations



Collection Piping

- Pipe diameter
 - ◆ sizing for gas and condensate flow

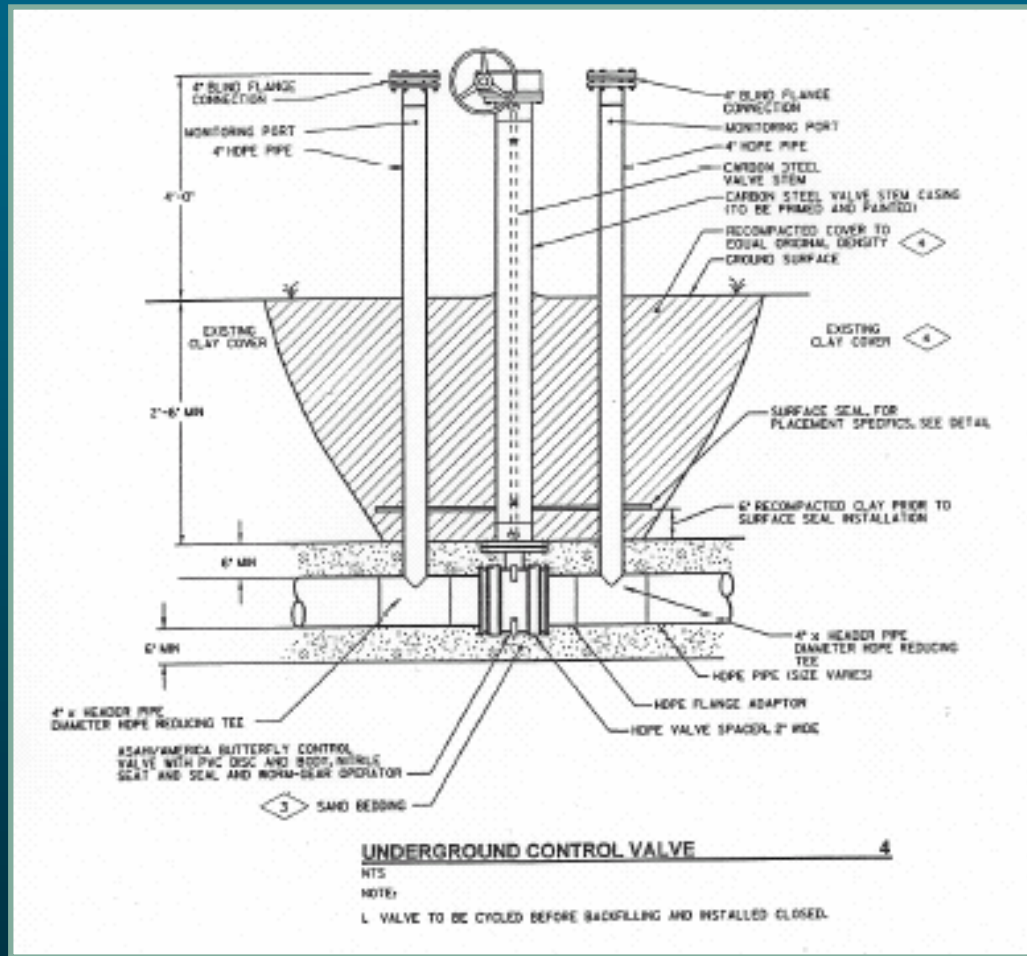
Collection Piping - Valves

- Control valves at strategic locations in header system
- Purpose
 - ◆ Isolation portions of the system for maintenance, etc
- Not used for balancing the wellfield
 - ◆ Use valves at wellheads for that

Collection Piping - Valves

- Types
 - ◆ Butterfly
 - ◆ Gate
 - ◆ Others
- Materials of construction

Underground Control Valve



Collection Piping - Valves

- Monitoring ports on both sides of valve for troubleshooting





Collection Piping

- Pipe Life Cycle
 - ◆ Life expectancy
 - ◆ Causes for decline in flow capacity
 - Landfill settlement
 - Pipe crushing
 - ◆ Design Limitations

Condensate

- HOW DID ALL THIS LIQUID GET IN MY GAS HEADER PIPES?



Condensate

- What is it?
- Where does it come from?
- Can't we make it go away?
 - ◆ No!
- How do we manage it?
- What if we don't manage it?

Condensate

- What is it?
 - ◆ Warm gas from within the landfill
 - ◆ Saturated with water vapor
 - ◆ Flows into a cooler area
 - Wellhead above ground at ambient temperature
 - ◆ Voila - Condensate!



Condensate

- Managing it
- Need to size headers to carry it, along with the gas

Condensate

- Headers need to be sloped so condensate doesn't pool in them!
- **NEED TO MAKE SURE HEADERS DON'T HAVE UNDRAINED LOW POINTS!!!**

Condensate

- Estimating quantities of condensate
 - ◆ Gas flow estimates
 - ◆ Humidity change
 - ◆ System design and gas temperature



Condensate

- Condensate Management Structures
 - ◆ Knock-outs
 - ◆ Lift stations
 - ◆ Barometric drip legs
 - ◆ Transfer stations
 - ◆ Drip legs
 - Potential for air intrusion
 - ◆ Pneumatic vs. Electric

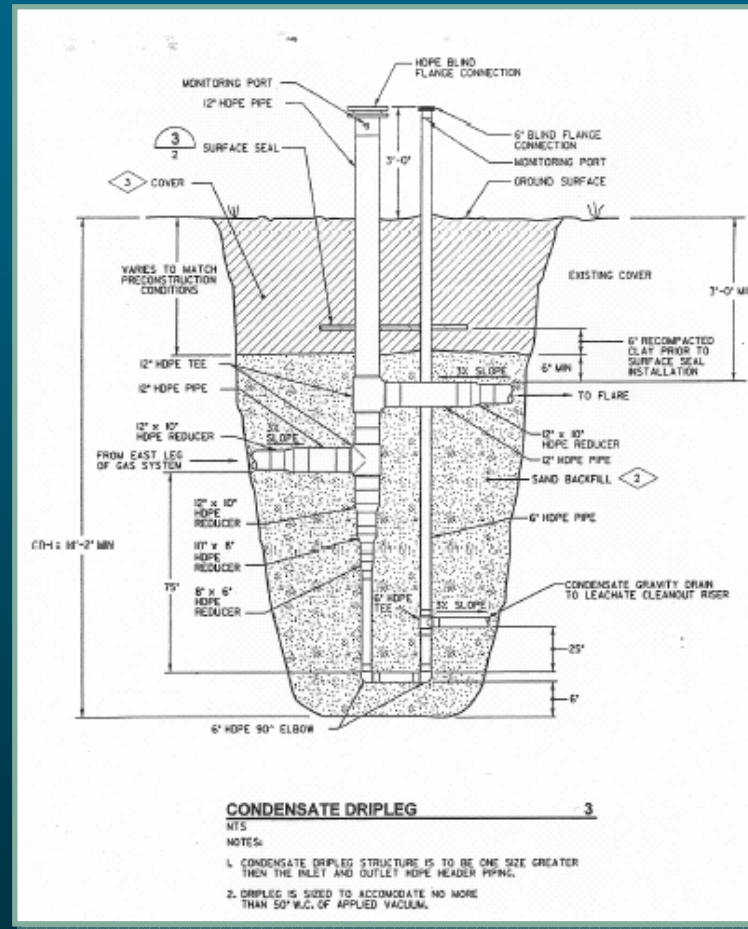
Sump



Drip Legs



Condensate Drip Leg





Condensate

- Consequences of inadequate condensate management
 - ◆ Flooded headers
 - ◆ Low vacuum at well heads
 - ◆ Effectively reduces pipe diameter
 - ◆ Increased operating cost

Condensate Knock-out and Pump



Condensate Knock-out and Pump



Dual Leachate/Gas Extraction



Flares

- What do we do with the gas once we collect it?





Flares

- Enclosed vs. open
- Sizing
- Capacity ranges
- Interconnection with gas recovery project

Flares

- Enclosed vs. open
 - ◆ Destruction efficiency
 - ◆ Cost
 - ◆ Simplicity of operation

Flares

- Sizing
 - ◆ Gas rate
 - ◆ Operating temperature
 - ◆ Ignition source

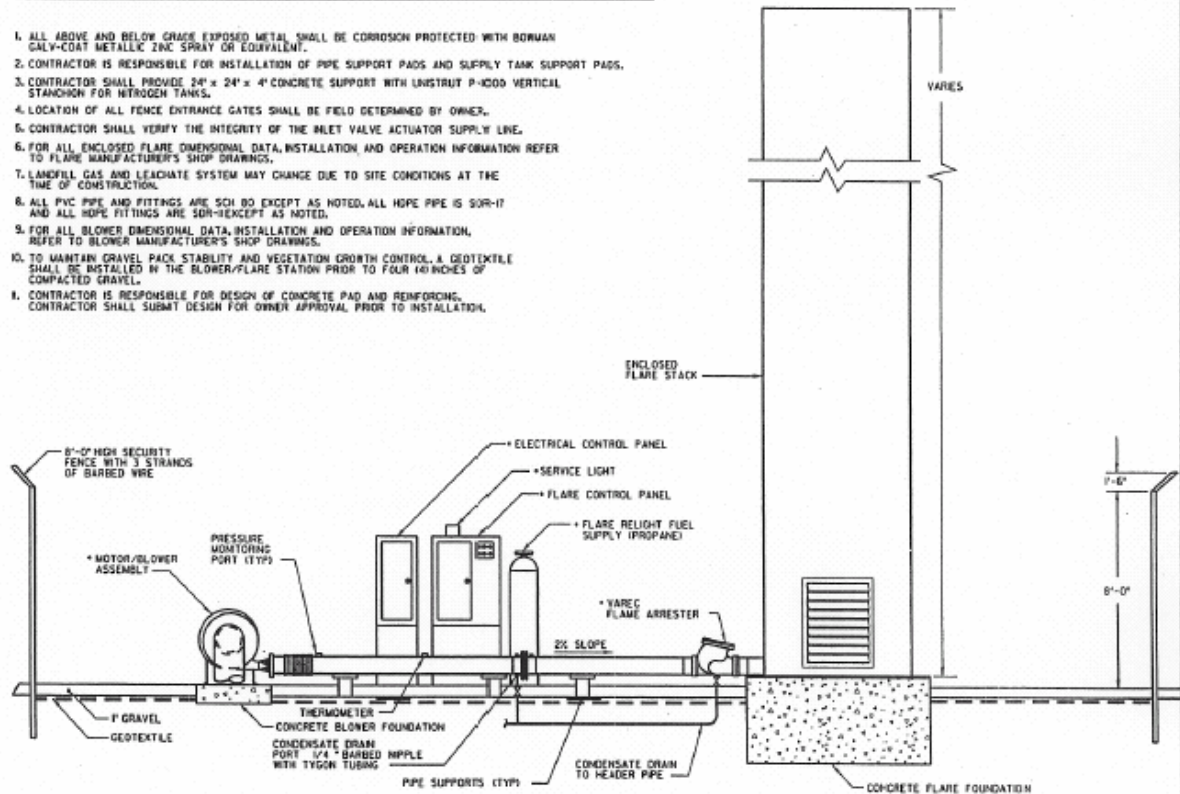
Flares

- Capacity ranges (turndown capability)
 - ◆ May be important for some of the closed sites with very little gas

Blower and Flare Station

GENERAL NOTES

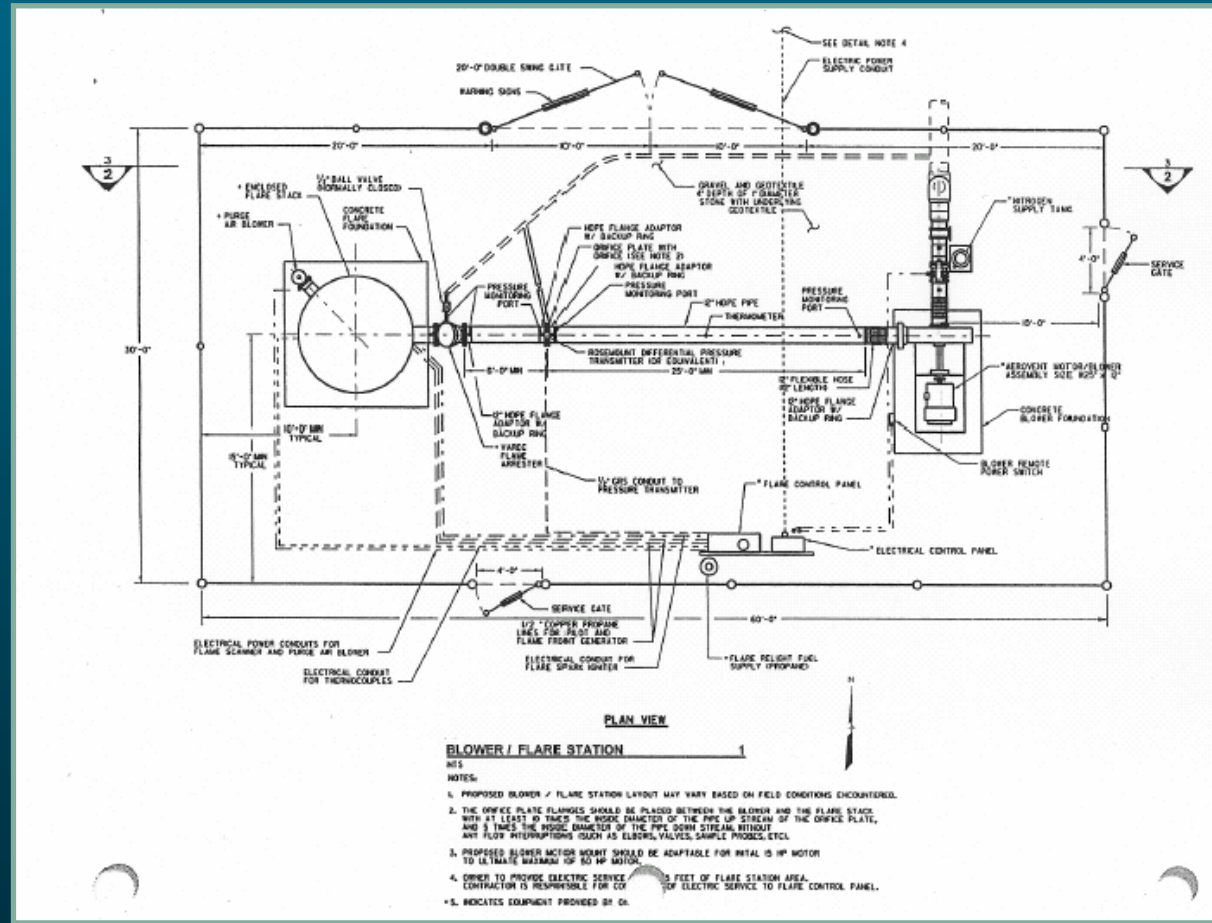
1. ALL ABOVE AND BELOW GRADE EXPOSED METAL SHALL BE CORROSION PROTECTED WITH BORWAN GALV-COAT METALLIC ZINC SPRAY OR EQUIVALENT.
2. CONTRACTOR IS RESPONSIBLE FOR INSTALLATION OF PIPE SUPPORT PADS AND SUPPLY TANK SUPPORT PADS.
3. CONTRACTOR SHALL PROVIDE 24" x 24" x 4" CONCRETE SUPPORT WITH UNISTRUT P-1000 VERTICAL STANCHION FOR NITROGEN TANKS.
4. LOCATION OF ALL FENCE ENTRANCE GATES SHALL BE FIELD DETERMINED BY OWNER.
5. CONTRACTOR SHALL VERIFY THE INTEGRITY OF THE INLET VALVE ACTUATOR SUPPLY LINE.
6. FOR ALL ENCLOSED FLARE DIMENSIONAL DATA, INSTALLATION AND OPERATION INFORMATION REFER TO FLARE MANUFACTURER'S SHOP DRAWINGS.
7. LANDFILL GAS AND LEACHATE SYSTEM MAY CHANGE DUE TO SITE CONDITIONS AT THE TIME OF CONSTRUCTION.
8. ALL PVC PIPE AND FITTINGS ARE SCH 80 EXCEPT AS NOTED. ALL HDPE PIPE IS SDR-17 AND ALL HDPE FITTINGS ARE SDR-18 EXCEPT AS NOTED.
9. FOR ALL BLOWER DIMENSIONAL DATA, INSTALLATION AND OPERATION INFORMATION, REFER TO BLOWER MANUFACTURER'S SHOP DRAWINGS.
10. TO MAINTAIN GRAVEL PACK STABILITY AND VEGETATION GROWTH CONTROL, A GEOTEXTILE SHALL BE INSTALLED IN THE BLOWER/FLARE STATION PRIOR TO FOUR (4) INCHES OF COMPACTED GRAVEL.
11. CONTRACTOR IS RESPONSIBLE FOR DESIGN OF CONCRETE PAD AND REINFORCING. CONTRACTOR SHALL SUBMIT DESIGN FOR OWNER APPROVAL PRIOR TO INSTALLATION.



ELEVATION VIEW

BLOWER / FLARE STATION

Blower and Flare Station



Flare Drain



Open Flare





Controls

- Emission safety interlock
 - ◆ Flare Off
 - Blower Off
 - Valve Closes
- Pneumatic Valves
- PLC

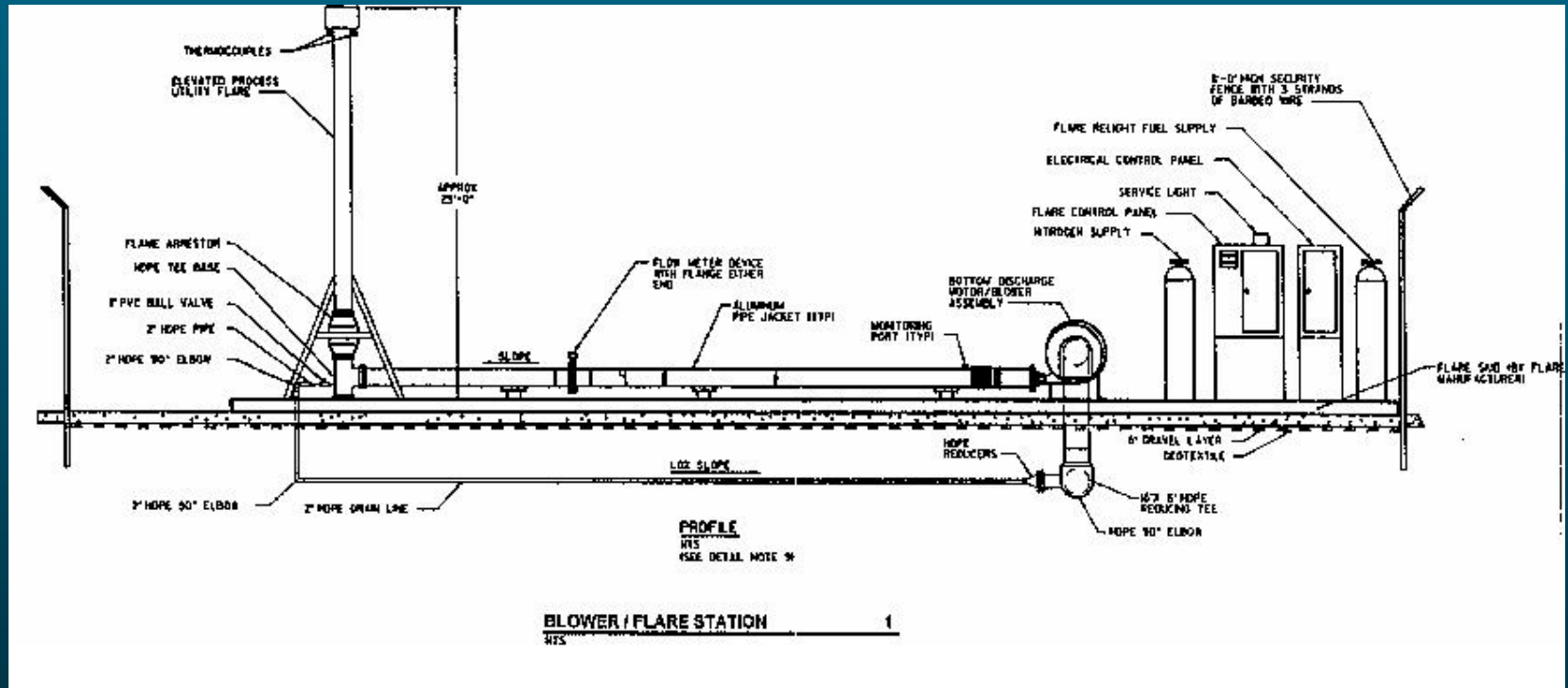
Flare Valve



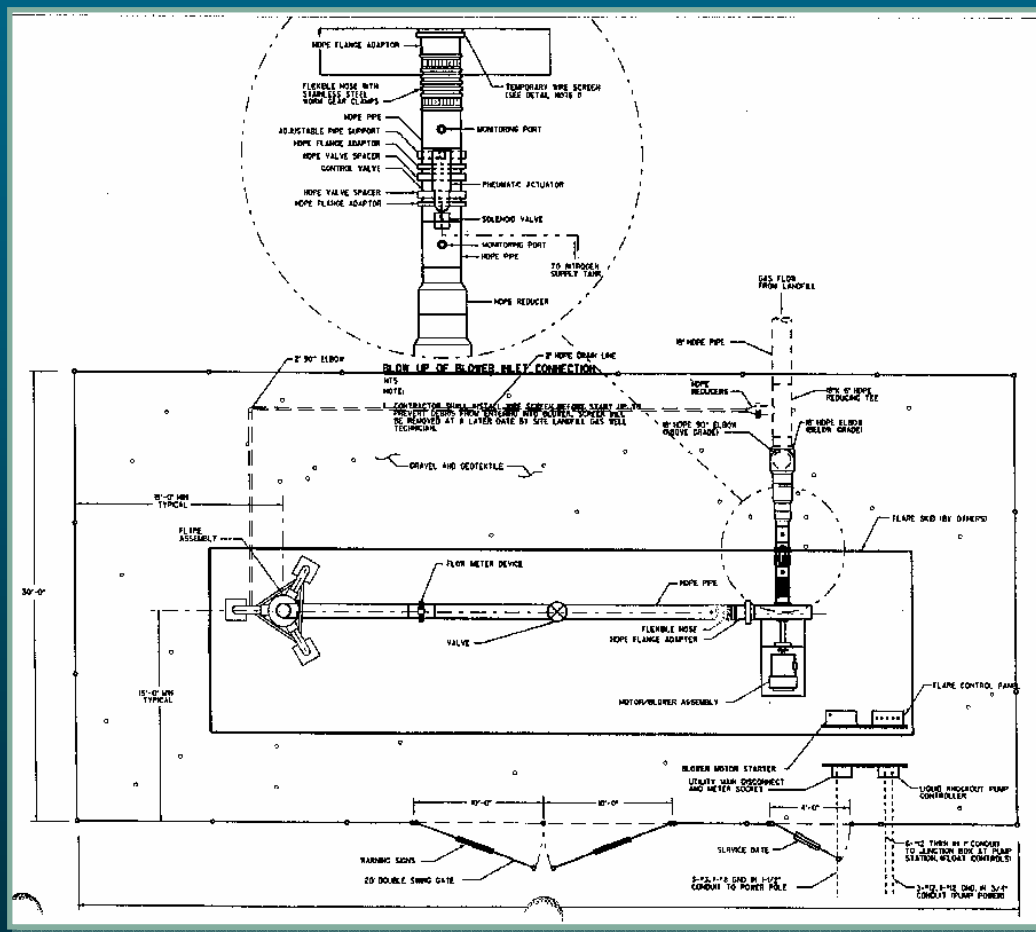
Actuator



Flare Diagram



Blower Inlet



Propane Tank



Flame Arrestors



Control Panel



Nitrogen Supply



Flares

- Interconnection with power plant operations
- Implications for NSPS/EG compliance



Construction Quality Assurance

- Documenting that the constructed system resembles the permitted system



CQA

- Critical elements
- Well construction
 - ◆ Depth
 - ◆ Slotted pipe
 - ◆ Backfill
 - ◆ Seal and boots



CQA

- Critical elements
- Header
 - ◆ Slope
 - ◆ Pipe size
 - ◆ Air tight
- Condensate Management
 - ◆ Pipe connections
 - ◆ Dripleg dimensions



CQA

- Critical elements
- Document what gets buried and can't be seen after the fact

Collection System Cost Comparison

- Active vs. passive
- Typical 1-10 well system
- Typical 10 – 20 well system
- Typical 20 – 50 well system