Nitrogen Rejection Unit Optimization

Technology/Practice Overview

Description

Cryogenic nitrogen rejection units (NRUs) in gas processing plants are used to remove inert components from the sales gas to meet transmission pipeline standards. The separated nitrogen, plus a small percentage of methane, are often vented to the atmosphere through a reject stream. Control enhancement, process optimization, exchanger cleaning, and tracking procedures combine to reduce the amount of methane in the nitrogen reject stream.

The goal of NRU optimization is to improve the separation process and thus reduce the methane content in the nitrogen that is vented or sold. The addition of monitoring and tracking equipment, such as a gas chromatograph to measure the methane content of the reject stream, will indicate when the NRU is in need of tuning. A unit-specific process model of the NRU can help optimize process variables to increase methane recovery and minimize operating costs. Routine process optimization coupled with cleaning and maintenance of heat exchangers increase the process efficiency. These practices reduce the methane content in the nitrogen reject stream, which saves saleable gas and increases revenue.

- [ ] Compressors/Engines
- [ ] Dehydrators
- [ ] Directed Inspection & Maintenance
- [ ] Pipelines
- [ ] Pneumatics/Controls
- [ ] Tanks
- [ ] Valves
- [ ] Wells
- [x] Other

Applicable Sector(s)

- [ ] Production
- [x] Processing
- [ ] Transmission
- [ ] Distribution

Other Related Documents:

Require Improvements in Quality of Gas Received from Producers, PRO No. 903

NRU at Cryogenic Gas Plant

Source: Natural Gas STAR

Economic and Environmental Benefits

Methane Savings

Estimated annual methane emission reductions	*246 MMcf – 364 MMcf per nitrogen rejection unit*

Economic Evaluation

Estimated Gas Price	Annual Methane Savings	Value of Annual Whole Gas Savings*	Estimated Implementation Cost	Estimated Incremental Operating Cost	Approx. Payback (months)
$7.00/Mcf	246 MMcf	$1,831,900	$75,000	included	< 1 Month
$7.00/Mcf	364 MMcf	$2,710,600	$300,000	$0	2 Months
$5.00/Mcf	246 MMcf	$1,308,500	$75,000	included	< 1 Month
$5.00/Mcf	364 MMcf	$1,936,000	$300,000	$0	2 Months
$3.00/Mcf	246 MMcf	$785,100	$75,000	included	2 Months
$3.00/Mcf	364 MMcf	$1,161,700	$300,000	$0	4 Months

* *Whole gas savings are calculated using a conversion factor of 94% methane in pipeline quality natural gas.*

Additional Benefits:

- Continuous Monitoring
- Improved Efficiency
- Operations and maintenance cost savings

Nitrogen Rejection Unit Optimization (Cont'd)

One Natural Gas STAR Partner's approach to reduce methane emissions from a nitrogen rejection unit involved a unit optimization process and a planned three-phase upgrade of the NRU. The operator's objective was to reduce methane emissions from the NRU to 1 percent of the total gas stream. The operator began with a process optimization review and upgrades to the monitoring equipment. Pressure and temperature were optimized, heat exchangers were cleaned, and a continuous monitoring gas chromatograph was added. The optimization resulted in a 46 percent reduction in the volume of methane vented to the atmosphere from the NRU.

Phase I upgrades to the nitrogen rejection unit began with replacing trays in the low pressure tower with more efficient tray designs. The new trays allowed a reduction in operating pressure for the tower, which further reduced vented methane from 3 percent to 1 percent of the total gas stream.

Plans for Phase II and Phase III included re-cylindering the compressors used for nitrogen injection and installing an overhead de-methanizer for stripping gas entering the low pressure tower. Phases II and III were expected to contribute a 16 percent improvement in methane emissions at a projected cost of several million dollars. Instead, the combined NRU optimization and initial Phase I equipment upgrades reduced methane emissions by 70 percent over a six year period, at a significantly lower cost. The Phase I improvements were so effective in achieving the emission reduction goals of the project that the planned Phase II and III upgrades were not implemented.

Operating Requirements

Routine optimization, maintenance and cleaning have been shown to significantly improve NRU operations. However, continuous monitoring of the process is needed to determine the optimal time for required maintenance and tuning of the system. Monitoring and tracking equipment include electronic gas metering, remote transmitting units (RTUs) for data storage and transmission, and gas chromatographs to continuously monitor the composition of the discharge stream. Optimization of a nitrogen rejection unit can be further refined by applying process analysis software and a specific process model tailored to an individual NRU.

Applicability

Optimization techniques and cleaning and maintenance routines can be applied to any NRU with elevated methane emissions in the nitrogen reject stream. A process model developed for an individual NRU provides a basis from which a unit–specific process model can be adapted for any NRU. Equipment upgrades will be similarly unit-specific.

Methane Content of Natural Gas

The average methane content of natural gas varies by natural gas industry sector. The Natural Gas STAR Program assumes the following methane content of natural gas when estimating methane savings for Partner Reported Opportunities.

Production	79 %
Processing	87 %
Transmission and Distribution	94 %

Methane Emissions

Methane emissions reductions are the result of a continuous improvement approach to system operations implemented over a period of several years. Installing constant monitoring equipment and establishing routine cleaning and maintenance procedures provide the starting point. These practices together with process optimization efficiently identify equipment in the system needing upgrade or replacement.

One Partner operating a 50 MMcf/day gas processing plant reduced total annual methane emissions from the nitrogen rejection unit by more than 70 percent, from 539 MMscf/year to 175 MMscf/year. Implementation of a continuous monitoring chromatograph plus maintenance and control process improvements reduced vented methane emissions by 246 MMscf/year during the first five years. The Partner also implemented a maintenance schedule to clean the heat exchangers and upgrade the low pressure tower trays, which further improved the operation bringing total emission reductions to 364 MMscf/year. The methane removed from the nitrogen reject stream was added to sales gas thus boosting the saleable gas output of the plant.

Basis for Costs and Savings

Installation of a continuous monitoring gas chromatograph established baseline methane emissions. The reduction in daily methane emissions was quantified as the optimization process progressed. Initial monitoring, maintenance and process optimization costs

Nitrogen Rejection Unit Optimization (Cont'd)

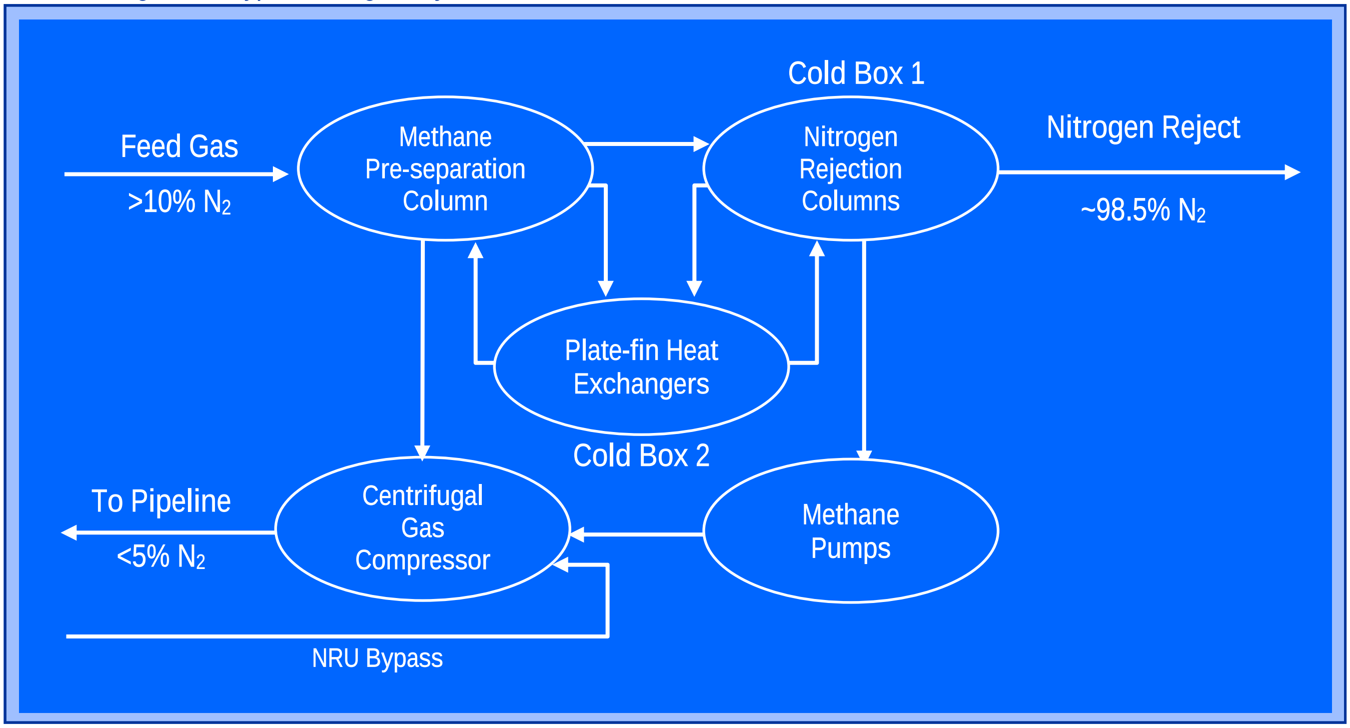
totaled approximately $75,000. These costs would be paid back in less than a month assuming a gas price of $5.00/Mcf and initial methane emissions savings of 246 MMscf/yr.

The Phase I upgrade of the low pressure tower trays incurred a capital cost of $300,000, netted incremental methane savings of 118 MMscf/yr, and prevented total natural gas losses of 364 MMscf/yr. Assuming a gas price of $5.00 Mcf and increased revenue of $1,820,000/yr, payback of the capital investment occurs in approximately two months.

Discussion

Transmission pipelines set standards for the heat content and inert composition of the gas that is delivered. When nitrogen rejection units remove nitrogen from the sales gas stream, a small volume of methane is carried with the reject stream. This methane is generally vented to the atmosphere. Optimization of NRUs often improves gas composition above transmission pipeline standards, reduces emissions and increases profits. When optimized, most NRUs are capable of achieving methane content in the reject stream of 1 percent or less. The economics of NRU optimization are attractive because significant methane emissions savings can be achieved without major capital expenditures on new equipment. The incremental costs of added maintenance and process model development are similar for most NRUs regardless of size, making optimization especially attractive for large capacity units.

Process Diagram for Typical Nitrogen Rejection Unit



Source: U.S. EPA Natural Gas STAR Program