

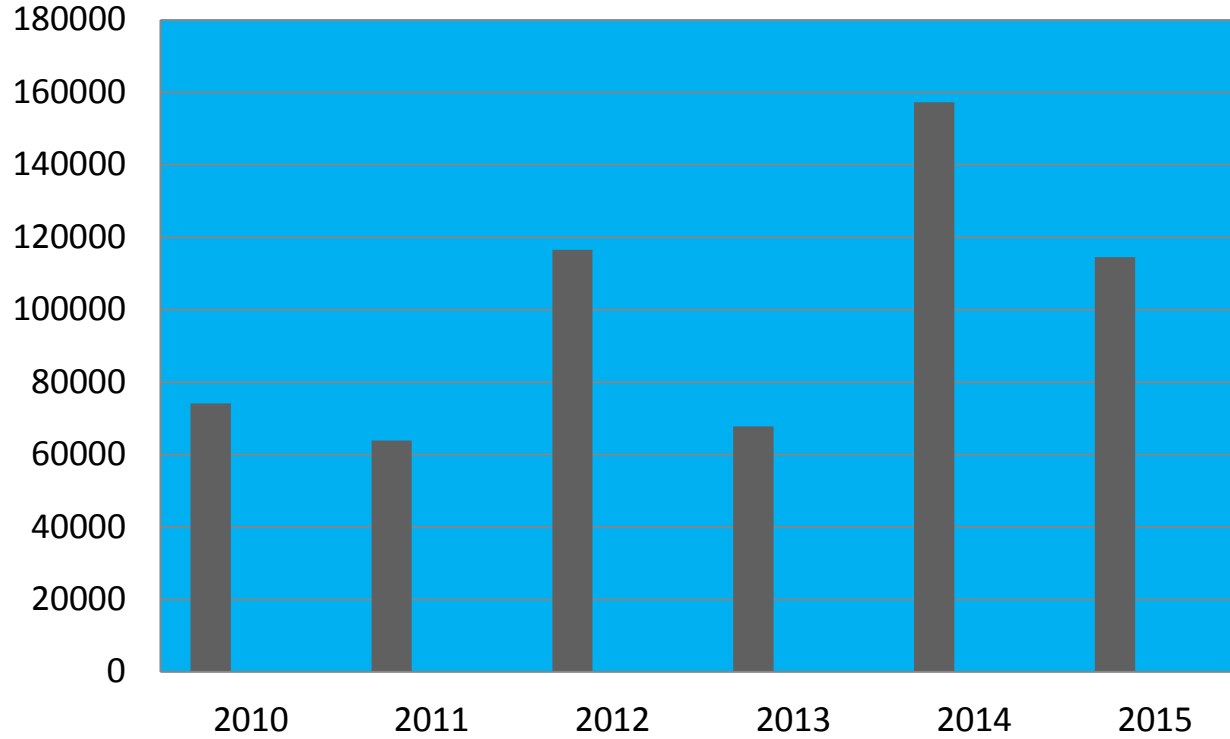
State Regulator Perspective on Existing Peak Shavers

DP Peak Shaving Plant

State Regulator LNG (Peak Shaver) Perspective

- Purpose of LNG Liquefaction and Peak Shaving Facility in Wilmington, DE: liquefy pipeline natural gas during periods of low consumer demand, storage of the LNG and re-vaporization during periods of peak consumer demand. Decision to vaporize is based on latest day ahead forecast- if forecast low is 15 or less.
 - Feed Flow (MMSCFD) 2.85
Press. (PSIG) 150
 - Liquefaction (MMSCFD) 1.50 167 days to fill tank.
 - Vaporization (MMSCFD) 51
 - Holding Operations
Boiloff Gas (MMSCFD) 0.15
- Discharge Pressure (PSIG) 30
- Liquefaction in 2014 7/14/14 @ 27.4 ' and ending 11/15/14@ 90+'
Liquefaction in 2015 8/6/15@36'-7" and on 8/21/15 @ 44'-10" * ended 12/11/15
- *LNG had to be trucked in daily in order to reach a 90 foot liquid level

Liquefaction in MCF



State Regulator LNG (Peak Shaver) Perspective

General Safety Aspects of Inspection of LNG Facilities

- Inspection of plant's Operating procedures, and Maintenance plan
- Inspection of plant's Monthly Preventative Maintenance schedule to verify that operator is scheduling the maintenance activities and maintaining a record of their completion.
- Component Preventative Maintenance inspection completion (PM Cards). A record is maintained for the maintenance items identifying the component, date and type maintenance activity performed on the component.
- LNG Liquefaction Daily Log, Vaporization Log and Daily Plant Operations Checklist
- Checking of Pressure, Temperature and Flow Instrumentation on the Control Room Panel and inspection of readings on the Local Control Panels for Molecular Sieves, Nitrogen Cycle compressor, Nitrogen Expansion Turbine/Booster Compressor and Coldbox and Boiloff Compressors
- Visual inspection of compressor room, compressor motor starter and Motor Control Center, instrument air system, nitrogen supply system, fire protection and control system, storage tank, molecular sieves system, expansion turbine/booster compressor and coldbox, LNG pump area, vaporizers, chromatograph room, Boiloff Gas System, natural gas sendout area and cooling water system.
- Inspection for verification that the safety relief valves have been inspected, tested and that the valve lifting pressure and reseating in compliance with 193.2607, 193.2619 and 193.2639.

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The liquefaction log lists the components, lines, valves or instrument number and description for which temperatures, pressures and flows are physically checked and recorded by plant operators every 2 hours and via field devices (RTUs) automatically to a data storage device. This information is inspected/reviewed during the Standard inspection.

The liquefaction log is reviewed during the standard inspection of the LNG facility.

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General Plant Safety prior to and after startup of Liquefaction - Records reviewed of these processes.

- Vessels into which natural gas or other hydrocarbons are introduced must be purged with nitrogen to remove any air in the system (molecular sieves, coldbox, and lines to storage) if they have been opened to the atmosphere. Purging done by pressurizing with nitrogen and then depressurized through all available purge points until an oxygen content of less than 6% is obtained.
- Cooldown: LNG must enter warm piping systems at a controlled rate to avoid high thermal stress and over pressurization. Any lines with LNG in them must not be blocked off for any appreciable length of time because the pressure can buildup to a point where the pressure relief valves can be actuated.
- During cooldown plant operators must visually monitor LNG piping, equipment and components during the cooldown in order to detect any unusual movements or lack of support of piping, equipment and components; leaks that may develop at flanges, valves, valve packing and seals as a result of cooldown. The person performing the inspection is in communication with the operator responsible for controlling cooldown so that necessary changes in the rate of cooldown can be made to avoid excessive stresses on piping, equipment and components.

State Regulator LNG (Peak Shaver) Perspective

Upgrades Made to Plant To Reduce Interruptions

- Natural Gas Purification and Refrigeration System Repairs/Upgrades
- Replacement of original three transformers that are power source for the 2-stage closed cycle compressor with new 2000KVA transformer
- Repairs to one of the Molecular Sieve Adsorption Vessels that developed a crack in the bottom.
- Replacement of molecular sieve process valves which open/close during adsorption, depressurizing/heating and cooling/pressurizing. Some of the piping and insulation had also been replaced.
- Sensitivity of existing auto-transfer switch between two electrical circuits that provide the power to LNG facility resulted in replacement of Auto-Transfer Switch with new one (resulted in shutdowns and subsequent replacement on 12/16/09)
- Replacement of Motor Starter for motor that drives 2-stage Nitrogen Compressor

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Electric motor driven Centrifugal Compressor

Equipment issues which resulted in shutdowns:

- Broken compressor rotor bar and replacement (10/30/09) New rotor was balanced and bearings were determined to be OK.
- Outboard end journal bearing requiring replacement. Also motor stator rebuilt including dipping and baking of stator/windings.
- Thrust bearing collar had loosened causing electric motor and or gear unit vibration/shaking and the need for replacement of thrust and journal bearings and shaft alignment using laser equipment in June, 2010.
- Compressor removed from bedplate for complete overhaul primarily due to problems with seals. Overhauled by Houston Dynamic Services in Houston, TX. Teardown revealed shaft damage – a helicoid score on the shaft, so repairs and replacement of worn/damaged components were made (03/25/15 inspection).

State Regulator LNG (Peak Shaver) Perspective

Expansion Turbine/Booster Compressor

Equipment issues which resulted in shutdowns:

- August 12, 2013 Axial Thrust bearing Issues required sending turbine/booster compressor to LA Turbine for repairs.
- July 2, 2014 Operator preparing to re-install the turbo expander/boost compressor the Week of July 7th, 2014.
- 03/25/15 Nitrogen expansion turbine and it's housing were removed and the expansion turbine sent out so bearing housing could be drilled and tapped to accept new vibration probes (vibration detection requirement). The nitrogen expansion turbine needed to be disassembled (turbine and compressor wheels removed) and the shaft burnished in area where then vibration probes view the shaft.
- October, 2015 a new *Fisher* booster compressor bypass anti-surge control valve had to be installed with *Masoneilan* positioner unit (upgraded from an electronic Siemens unit). This resulted in a 2-week shutdown.

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Molecular Sieve System

05/25/11 Upgrade of Molecular Sieve system by replacing original pneumatic operated valve actuators and associated solenoid valves. During liquefaction on the morning of May 25, 2011 one of the solenoid valves had temporarily stuck, but self corrected. Solenoid valves have a brief alarm delay and should a solenoid valve remain stuck it would shut down liquefaction. Plant operators would sometimes use a rubber mallet to gently tap a sticking solenoid valve.

4th Quarter 2012 and 1st Quarter 2013 Change out of 25 original molecular sieve system valves, Valve actuators and valve positioner assemblies as well as the associated tubing (replaced with stainless steel tubing) to *Siemens Moore* solenoid valve panel in Chromatograph Building.

7/2/14 Some machining was required on the larger size (3") valves due to internal operating clearance issues in order to enable them to operate properly.

10/24/15 Crack in the bottom of Molecular Sieve Absorption vessel shutdown liquefaction for one week (10/24 through 10/30). Vessel was welded and radiographed using ultrasonic shear wave.

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Upgrades to Improve Efficiency of LNG Plant

- New Allen Bradley 2100 Series Motor Control Center replaced original Square D Circuit Breaker Power Panels (vintage 1972) in 1st Quarter 2013. This improves the integrity and reliability of the plant.
- New Local Control Panels for the Molecular Sieve System, Nitrogen Expansion Turbine/Booster Compressor and Coldbox, and Boiloff Compressors. In addition, new pressure, temperature indicating (TI) and flow indicating/measuring instrumentation has replaced older instrumentation in the main control room panel.
- Tank Leveling System. Honeywell–enraff system which uses an egg shaped sensor of known weight. The sensor gets lowered down into the LNG, stopping every foot or two feet, determined how it is programmed. The built-in strain gauge then calculates the level and determines any differences in density while the sensor descends to the bottom of the tank (02/16/12 - 03/13/13). Tank leveling system is a requirement of Chapter 7 of NFPA 59, Liquid Level Gauging of LNG containers.

State Regulator LNG (Peak Shaver) Perspective

Upgrades to Improve Efficiency of LNG Plant

- Overhaul and upgrades to the boiloff gas compressor system (2 compressors) to ensure more reliability— included new Dresser Rand Controls w/feedback sensors to measure temperatures and pressures at key/critical compressor system locations) and Dresser Rand lubrication systems for both boil-off compressors (before 2010)
- Rebuild/repair of the single cell cooling tower that included replacing the honeycomb material in the water curtain, replacement of cooling tower outer plates and relocating the motor outside of the airflow to protect it from corrosion.

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Other Upgrades at DP Peak Shaving Plant

- Spring, 2015 New piping supports (slides) for the piping lines in the molecular sieve area, Vaporizer area, for the LNG (liquid lines) to the vaporizer area
- Installation of 12 high resolution digital safety cameras (09/02/10), New security guard house (11/26/12) and installation of LED lighting along the perimeter fencing (12/2013)
- New Local Siemens Control panel for the Molecular Sieve System
- New Allen Bradley Local Control Panel for Nitrogen Expansion Turbine/Booster Compressor (December 2014 and 1st Quarter 2015)
- 2015 Vibration probes installed on the expansion turbine to monitor for abnormal vibration. A valve was installed across the Nitrogen Expansion Turbine to ensure that the Front Bearing Thrust and Back Bearing Thrust remain close to being equal.
- Testing functionality of the Ansul Portable Purple K automatic extinguishing systems to verify it 's ability operate (05/25/11).
- New LED perimeter lighting along the perimeter fencing to improve security's ability to detect any encroachment.

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Vaporization

04/26/11 Masoneilan 3502 Series Camflex II Rotary Control Valve actuator installed on the LNG line valves located near the LNG pumps due to previous original valve actuators icing up

02/16/12 Additional jacketing installed on ethylene glycol solution lines of vaporizers

08/12/13 One of two vaporizer pumps required bearing repairs. Vertical shaft was spray welded and machined.

08/2014 Original equipment pneumatic *Foxboro* pressure control loop

(transmitter, controller and positioner) on each of two vaporizers was replaced with Siemens digital controller, electronic pressure transmitter and digital positioner. Configured in August'14 and functionally tested in December, 2014 under normal vaporization operating conditions.

03/25/15 Wafer type emergency valve for Vaporization Emergency Shutdown (VES) installed later in year prior to vaporization (Winter 2015/2016)

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Remaining Electrical Issues—Peak Shaving Facility

- The reliability due to external power issues has been improved , but the transformer upgrades will not rule out the possibility of electrical momentaries, surges, dips, overcurrent, under voltage, phase imbalance or lightening strike issues from the feeder substation.

State Regulator LNG (Peak Shaver) Perspective

Future Peak Shaving Projects Planned

- Update/Upgrade of Fire Alarm system including replacement of high temperature detectors for fire detection alarm and combustible gas detection monitoring system with state-of-the-art system. An evaluation was performed in 2015. Delmarva is looking at replacing the *Delphian* (Old technology) Methane detection system with a UV/IR (visual) by 2020.
- Future repair or replacement of “micarta” insulation for the booster compressor due to micro cracks developing in the insulation.
- Installation of a splash shield at the base of the LNG tank.
- Miscellaneous projects to upgrade various transmitters, controllers and valves