ESA-023 Final Public Report

Introduction
The Rohm and Haas Texas Incorporated Deer Park plant near Houston, TX was the focus of a 3-day steam system Energy Savings Assessment (ESA). The Deer Park plant consists of several Rohm and Haas production units as well as third-party production plants. The steam distribution infrastructure at the Deer Park site is integrated across the production units. There is also a very high level of metering of utilities even within the battery limits of the production units. This allows Rohm and Haas personnel to understand, track and trend demand and usage of some of the larger energy consumers within different production units. The steam distribution system has several different pressure headers. The production units have waste heat and recovery boilers and are provided a credit for generating steam that is fed into the appropriate site header system. The Deer Park site utilities department also operates two natural gas fired boilers that provide the balance steam demand of the plant and provide for standby steam generation capacity and reliability in event of a production unit shutdown. Hence, any steam energy savings opportunities in the plant would directly reduce the steam production from these boilers.

Objectives of ESA
The main objectives of the ESA were as follows:

- Understand and identify steam system energy savings opportunities for the overall plant and focus on a couple of production units to estimate the magnitude of these opportunities
- Use the DOE Steam tools such as the Steam System Scoping Tool (SSST), Steam System Assessment Tool (SSAT) and the 3E Plus insulation software to model the steam system at the Rohm and Haas, Deer Park plant
- Assist Rohm and Haas Plant's Energy Cost Reduction Team (ECRT) to familiarize and have the ability to use all of the above mentioned tools to identify energy efficiency improvement opportunities at the plant and quantify the potential energy savings associated with the steam system

Focus of Assessment: Overall plant steam system

Approach for ESA
The ESA core plant team included Fred Fendt, Tony Dafft, Dave Anton and Peter Davy. These personnel belong to the Plant's Energy Cost Reduction Team (ECRT) and have varied responsibilities for the steam system ranging from Operations, Maintenance, Reliability and Control. Tony Dafft and Dave Anton completed the Steam System Scoping Tool (SSST) and sent it to the ESA expert prior to the start of the ESA. The steam system at the Deer Park plant is complex with multiple steam generating equipment and steam users at several different pressure levels. It is also highly integrated with the process. Hence, the plant team first decided to focus on the overall steam (energy) balance of the plant. After having a fair understanding of the overall plant, the team focused on a couple of areas to implement the SSAT and identify energy saving opportunities. Given just three days in the ESA, evaluation of each production unit was out of the scope of this Steam ESA. But the plant team did focus on the top two major users of steam at each pressure level to understand end-use and identify any opportunities that may exist there. Peter Davy downloaded the Steam System Assessment Tool (SSAT) from the DOE website to quantify potential steam system efficiency opportunities for natural gas and electrical energy savings. A 3-pressure header steam system was used to model the steam system at the plant. Data was collected from the historian system during the ESA.

General Observations of Potential Opportunities
There is a significant level of industry bestpractices in place at the Rohm and Haas, Deer Park plant, which is clearly reflected in the high score (88%) that the plant received on the SSST.

The steam system at the Deer Park plant is complex and highly integrated with the process. It has a central boiler house with two natural gas fired boilers, several waste heat boilers, reactor train heat recovery boilers, etc. The total annual natural gas usage for the plant is in excess of 10,000,000 MMBtu and annual electrical usage is almost in excess of 500,000 MWh. The total plant steam production averages between 1 and 2 MMlbs/hr, of which as much as 80% of the steam is produced from waste heat.

Based on the Steam ESA, steam savings opportunities exist in different areas and are described below. It has to be noted that due to the complexity of the steam balance and the constraints of proximity, headers, etc., some opportunities will need additional due diligence and that is out of the scope of this steam ESA. Secondly, some opportunities – though local within a particular production unit, may have global implications due to the highly integrated steam distribution system across the plant site. Currently, some of these energy saving opportunities are constrained due to the excess steam existing at the site. This is because there is no monetary incentive for the plant to pursue these opportunities in one production unit and then vent steam somewhere else. So a significant effort of the ESA was directed to come up with opportunities that would mitigate this situation and allow for economic and practical viability of these opportunities. Some

of these opportunities have also been previously identified by the plant's ECRT and have been documented in the project portfolio for the Deer Park plant.

1. **Low pressure steam distribution system reconfiguration (Medium term)**
   This opportunity identifies strategic production units that are proximally located and serving them with a common low pressure (35 psig) distribution loop. This low pressure steam loop would be a sink for all the vented steam and serve as a supplier for the steam required by the deaerators in those units. The thermal pinch analysis study that was recently completed by the plant ECRT can be used as a reference to identify these strategic sources of low pressure steam production in the plant and connecting them with a common loop.

2. **Reduce excess steam venting with use of a condensing steam turbine (Near term)**
   This opportunity collects all the excess steam in the plant and runs it through a condensing turbine to generate shaft horsepower. It allows for power and water savings since it condenses instead of venting live steam. From the plant perspective, it would be most preferred to operate the condensing turbine inlet at the lowest header level (35 psig) and thereby capture all the excess steam possible. The East Water Treatment Plant (EWTP) blower is an ideal candidate for using the condensing turbine drive since all the components are already in place. Note that this opportunity is not economically viable if natural gas is used to generate the steam for the condensing turbine.

3. **Use of excess steam to provide refrigeration and/or process cooling (Long term)**
   An ammonia water absorption refrigeration unit (ARU) can be powered by using the excess steam that is currently vented. The ARU would use the thermal energy from the steam in its generator and provide refrigeration capacity at the required temperature. This would help to save electrical energy that is currently used to operate mechanical vapor compression refrigeration units and/or help to debottleneck summer operations when refrigeration capacity is severely limited. Current state-of-the-art ammonia-water absorption equipment can be customized to produce electrical power and/or refrigeration.

4. **Use of superheat from C-Train TO waste heat boilers for turbines (Near term)**
   The steam rate (lb/hp-hr) of turbines is very sensitive to superheat and turbine performance improves as the superheat increases for fixed inlet and exit pressure conditions. The C-train thermal oxidizer (TO) waste heat boilers generate 600 psig superheated steam (~750°F) but this steam enters the common 600 psig plant header that is at saturated (or wet) conditions. Hence, the steam looses its availability. The net effect being that the steam rate of the C-train condensing turbine is ~7% higher. This results in more steam flow for the same horsepower generated. By reconfiguring the piping of the 600 psig header in the C-train TO area, the condensing turbine can be supplied with high superheat steam and thereby operate at lower steam rates and less steam flow.

5. **Improve condensate return (Medium term)**
   All throughout the plant there is less than 10% steam usage as direct contact or steam injection with process. Hence, 90% of the condensate can be recovered ideally. But there are several places where condensate is not returned because there is no incentive to return it. This is due to the excess steam availability leading to venting if the deaerator steam demand reduces. Nevertheless, deionized water is expensive and returning condensate reduces water treatment costs and also debottlenecks the water treatment plant. Secondly, all this condensate ends up in the cooling tower since it cannot be sent to the sewer before cooling it down. This increases the cooling tower load that may severely limit operations and production rates during the summer months. This opportunity evaluates increasing the current condensate return by 5% of the available condensate.

6. **Utilize blowdown flash tank and blowdown heat recovery exchanger (Near term)**
   The plant has tried both manual and automatic blowdown controls. After monitoring blowdown closely, it has decided to go with manual control on blowdown and currently averages ~2-3% of feedwater flow. In some production areas, blowdown does go to a flash tank and steam is captured. But in other areas (HR acid recovery) there exists an opportunity to capture flash steam from the blowdown to supply the deaerator steam as well as add a blowdown heat recovery exchanger to pre-heat the make-up deionized water going into the deaerator. Secondly, this opportunity would also reduce the overall cooling tower load and save water costs.

7. **Increase exhaust pressure of 600-35 psig steam turbine (Near term)**
   This opportunity is not an energy saving opportunity per se, but it will allow for better steam load balancing in the plant headers such that all of the above mentioned heat recovery and energy saving opportunities can become financially viable. Current design and operating conditions indicate that the plant has excess 35 psig steam whereas it is short on 75 psig steam. This opportunity will modify the back-pressure turbines (600-35) by increasing the exhaust pressure to 75 psig. Hence, higher steam flow will be needed for the same shaft power. But that is not detrimental, since the plant is short on 75 psig steam and hence, has a continuous pressure letdown from 150-75 psig. Reconfiguring the turbine will eliminate steam venting at 35 psig. From an operations

perspective, it allows for decoupling some of the loads. One example is operating the atomizing air compressor in the HR acid recovery area either with steam turbine or electric motor without jeopardizing the steam balance.

8. Other opportunities & BestPractices

- **Upgrade low pressure steam using a thermo compressor (Medium term)**
  Based on investigations of two of the major steam users in the plant, it was found that their current steam usage was not necessarily at the pressure level at which steam entered their battery limits. The production units used pressure letdown valves to get steam to their actual usage pressure. This presents an opportunity for the use of a thermocompressor. For example, in the ammonia recycle production unit, excess flash steam at 35 psig, which is currently vented, can be upgraded to the usage pressure (50 psig) using 150 psig steam. Another similar opportunity exists in the MMA (Methyl MethAcrylate) production unit, where currently 150 psig steam is reduced to 110 psig before process use. Using a thermocompressor would allow steam from the 75 psig header to make 110 psig steam by using 600 or 150 psig as the motive steam.

- **Heat recovery in acrylate monomers thermal oxidizer unit (Medium term)**
  As per discussions with plant ECRT, stack temperatures from the thermal oxidizer unit are in excess of 350°F and this provides a very good opportunity to recover thermal energy. This thermal energy can be used in one of the several different configurations:
  - Preheat combustion air for the thermal oxidizer - will need to ensure NOx issues and permits
  - Preheat boiler feedwater (economizer)
  - Use it in a waste-heat fired ammonia water absorption refrigeration unit (similar to Opportunity 3)

- **Monitor and trend real-time utility equipment efficiency (BestPractice)**
  The steam system utility equipment such as powerhouse boilers, waste heat recovery boilers, back-pressure turbines, etc. can be monitored and trended for real-time operating efficiency. This will ensure that the plant operates at its optimum efficiency. Secondly, it will serve as a very effective tool for predictive maintenance and planning for shutdowns. This BestPractice can also be extended to pumps, compressors, chillers, etc.

Management Support and Comments

There is the ECRT at the plant level and an “Energy Best Practices” group at the corporate level. Rohm and Haas management has set defined energy reduction goals for each business company wide. The Monomers business and the Deer Park plant management have provided full support to the ECRT to capture any and every economically justifiable opportunity. Beginning in 1997, the ECRT has maintained a large project portfolio that has captured every project idea that has been developed so far. Based on capital availability, energy projects from this portfolio are included in each year’s capital budget. Plant personnel spent three days working with the ESA Specialist and will continue to work on identifying projects site-wide thereby re-affirming their goals, strategy and energy saving opportunities. Additionally, Management’s commitment and support was clearly evident with the participation of Robert Brinly, President, Rohm and Haas Texas Incorporated at the Steam ESA wrap up meeting.

DOE Contact at Plant/Company: Tony Dafft
Distinguished Engineer
Rohm and Haas Company
6519 La Porte Freeway
Deer Park, TX 77536
Phone: (281) 228 8685
Email: tdafft@rohmhaas.com

The definitions for Near Term, Medium Term and Long Term opportunities are as follows:

- Near term opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
- Medium term opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
- Long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.