Flare Minimization in Saudi Aramco a win-win story

Introduction

Saudi Aramco is an integrated global petroleum enterprise with operations across the globe including exploration, oil and gas production, refining, petrochemicals, crude and refined products shipping and national/international marketing and distribution network. For more than two decades Saudi Aramco ranked number one globally with respect to oil production with average daily oil production exceeding 9 million barrels in 2011. Saudi Aramco also has significant refining capacity exceeding 4 million barrels per day and has stewardship over the fourth largest natural gas reserve in the world (approximately 283 trillion standard cubic feet).

Since early 1970's, Saudi Aramco recognized the significant value of associated gas and the importance of capturing it for value added utilization to support Saudi Arabia's economy. Subsequently, Saudi Aramco embarked on an ambitious plan to establish a comprehensive integrated system to capture and distribute natural gas known as the Master Gas System (MGS) which represented one of the largest industrial projects in the world at that time and positioned Saudi Aramco as one of the earliest oil companies to establish infrastructure to capture and process associated gas four decades ago during a time when the prevailing practice worldwide was systematic flaring of such valuable resource and remain the case in several parts of the world.

1. Saudi Aramco Master Gas System (MGS)

Saudi Aramco MGS was established to recover associated gas produced from Saudi oil fields, process it and supply the gas to electric power plants and petrochemical facilities in Jubail Industrial City on the Arabian Gulf and Yanbu Industrial City on the Red Sea. The MGS first phase began operation in 1977 with the commissioning of Berri Gas Plant. Although the MGS first phase was dependent on associated gas from a limited number of oil fields, nevertheless, the recovered gas was enough to drive two large water desalination plants, seven power plants supplying most of eastern Saudi Arabia with electricity, a glass factory cement and other plants. Indeed, it was a most encouraging beginning.

The second phase of the MGS came on stream in 1980, through the commissioning of Shedgum and Ju'aymah Gas Plants followed by Uthmaniyah and Yanbu gas plants which were commissioned in 1981 and 1982 respectively enabling the recovery and processing of associated gas from additional oil fields. The MGS was expanded to supply 17 million cubic meters per day (cmd) of additional gas by 1987 from the new gas fields. By 1991, Saudi Aramco had added more than 56 million cmd of nonassociated gas-gathering capacity to the system, mostly from the Khuff strata beneath Ghawar.

Currently, the MGS consists of 55 Gas Oil Separation Plants (GOSPs) in Safaniya, Marjan, Zuluf, Berri, Qatif, Abqaiq and Ghawar fields; three gas-processing plants at Berri, Shedgum and 'Uthmaniyah; the East-West Natural Gas Liquids (NGL) Pipeline that feeds NGL cross-country from Shedgum to Yanbu'; and two gas fractionation plants at Yanbu' and Ju'aymah. Saudi Aramco also added about 90 million cmd of nonassociated gas-gathering capacity to the MGS at Hawiyah and Haradh gas plants which were commissioned in 2001 and 2003, respectively.

Furthermore, facilities capable of producing up to ~5 million cmd from the Abqaiq gas cap were installed to meet peak demand, and 2.5 million cmd from the Qatif storage reservoir for emergency use. Currently the system has the capacity to gather about 170 million cmd of unprocessed gas. Over the last 20 years, domestic demand for gas has grown rapidly at 10 percent per year in both the industrial and power generation sectors. The MGS capacity continues to grow to meet the rapid increase in domestic gas demand and recently Khurasaniayh Gas plant was commissioned enabling the MGS to reach a peak daily capacity exceeding 11 billion standard cubic feet and maintaining average gas supply of approximately 10 billion standard cubic feet per day during 2011. The MGS will be further expanded in the near future after commissioning of Wasit gas plant which is currently under construction and has the capacity of processing more than 2.5 billion standard cubic feet of gas per day.

Today, Saudi Arabia uses more gas per capita than the United Kingdom, Germany and Japan, and the demand for gas is expected to continue to grow at five percent per year over the next two decades as the country's domestic and industrial bases expand.

1.1 Key Challenges:

Designing, construction and operating a complex gas gathering, processing and distribution system of the scale of Saudi Aramco MGS involve a multitude of technical, engineering, logistical, construction and other challenges. Constructing mega facilities in remote areas of harsh desert environment represented a significant challenge. Similar challenges were faced while constructing thousands of kilometers of pipelines and distribution network across Saudi Arabia. Such facilities were constructed according to very high engineering standards and often subject to tight deadlines. Such challenges were met through careful planning, dedication and ingenuity of Saudi Aramco employees earning the company several prestigious international awards in project management. Another major challenge was the rapid expansion in domestic gas demand due to increase in power consumption and petrochemical industry which required rapid expansion in the MGS over relatively short period of time. One of the challenges was complying with environmental regulation specially while treating sour gas which required the utilization of state-of-art environmental control systems, such as Super Claus and Euro Clause sulfur recovery units to meet environmental standards. Also due to water scarcity in the Arabian Peninsula wastewater reuse was widely utilized in company facilities. Accordingly, approximately 80% of sanitary wastewater generated companywide is being reused with the target to exceed 90% reuse in the near future.

1.2 Benefits Realized:

The development of the Master Gas System resulted in eliminating systematic flaring of associated gas and its environmental impacts and conserved natural gas resources. Additionally, gas utilization domestically made possible by the MGS, is supplying much of the Kingdom's electric power and freeing additional oil for export. Furthermore, the use of natural gas as a feedstock supported the Saudi Arabia's rapidly growing petrochemical sector, positioning Saudi Arabia as a global supplier of petrochemicals and supporting the Saudi Arabian economy.

2. Saudi Aramco Flaring Minimization Program

With the development of the Master Gas System, regular daily flaring from Saudi Aramco facilities has been limited to purge gas, necessary to prevent air ingress into flare headers, the daily leakages from flare header isolation valves, and any emergency operational requirements.

To facilitate flare minimization companywide, Saudi Aramco established a flare minimization roadmap which calls for:

- Establishing effective, reliable and consistent flare monitoring companywide through installing real-time Flare Monitoring Systems (FMS) in company facilities
- Tracking flaring as one of the corporate environmental Key Performance Indicators (KPIs) and setting quantitative targets for flare minimization
- Establishing a Saudi Aramco Engineering Procedure (SAEP) to specify internal guidelines for flare minimization and ensure consistency in implementing flare minimization measures companywide
- Developing and implementing facility specific Flare Minimization Plans (FMPs) for company facilities.

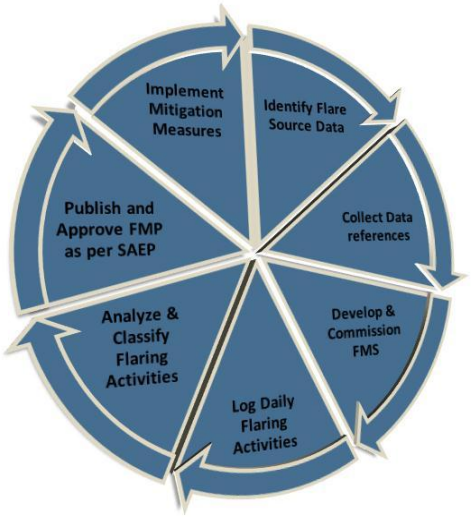


Figure illustrates FMP work flow

2.1 Flare Monitoring System (FMS)

Flare monitoring using the FMS is playing a fundamental role in Saudi Aramco flare minimization strategy through providing the necessary database on which facility specific flare minimization plans are established and the most effective flare minimization measures are identified. The technology employed for the development of FMS was in-house propriety Saudi Aramco methodology utilizing existing automation technologies. The salient features of FMS are:

- Real time site specific flaring losses recording system.
- Plant and equipment flaring on a real time basis.
- Analysis and classification of recorded flare losses.
- Periodic reporting and forecasting of flare losses.
- Comprehensive database used for periodic FMP reports.

Based on the data provided by the FMS, a facility specific flare minimization plan (FMP) is developed for each facility identifying the operational and capital measures required to minimize flaring for each facility. FMS and FMP have been successfully commissioned at all Saudi Aramco Refineries, Gas Plants and NGL Fractioning plants and will be competed in remaining company facilities by 2012 year end.

2.2 Fare Gas Recovery Systems and Other Mitigation Measures

One of the main technologies leveraged by Saudi Aramco to minimize flaring is installation of Flare Gas Recovery (FGR) systems in several company facilities. Since installing large capacity FGR systems require multimillion dollars investments a criteria was developed to install FGR systems in company facilities. Accordingly FGR systems are being installed in several major facilities such as 'Uthmaniyah Gas Plant (UGP), Shedgum Gas Plants (ShdGP) and the Safaniyah Onshore Producing Facilities (SOPD). The total capacity of FGR systems under construction is 23 million standard cubic feet per day. Additionally, four new FGRS plants with a total capacity of 10 million standard cubic feet per day are being planned.

In addition to the benefits achieved in flare reduction by the commissioning of FGR systems, Saudi Aramco's flare minimization program has identified many short, medium and long-term mitigation measures, which when implemented in a phased manner over time, will further reduce gas flaring. Some typical mitigation measures are:

- Flare purge optimization.
- Annual control valves leakage survey/leak rectification.
- Optimization of sulfur recovery units.
- Synchronization of maintenance and annual turnaround activities.

- Optimization of cooling requirements in distillation facilities at the operating facilities to avoid flaring of light hydrocarbons.
- Optimization of hydrogen supply and demand at refineries to avoid flaring.

2.3 Key Challenges:

There were several challenges faced in successful implementation of the program, such as:

- Large, complex and diverse infrastructure throughout the value chain.
- The need to raise awareness about flare minimization.
- Difficulty in measuring, recording, analyzing, classifying and reporting of flare losses.
- Soft business cases for flare minimization CAPEX compared to other investments.
- Integration of multiple flare headers at the upstream and gas processing facilities and linking the same to a common FGRS.
- Determining a practical, economical and value added usage of the recovered gas as valuable fuel to generate electrical power or feedstock.
- Operational challenges related to integration of operating facilities with the FGR systems.

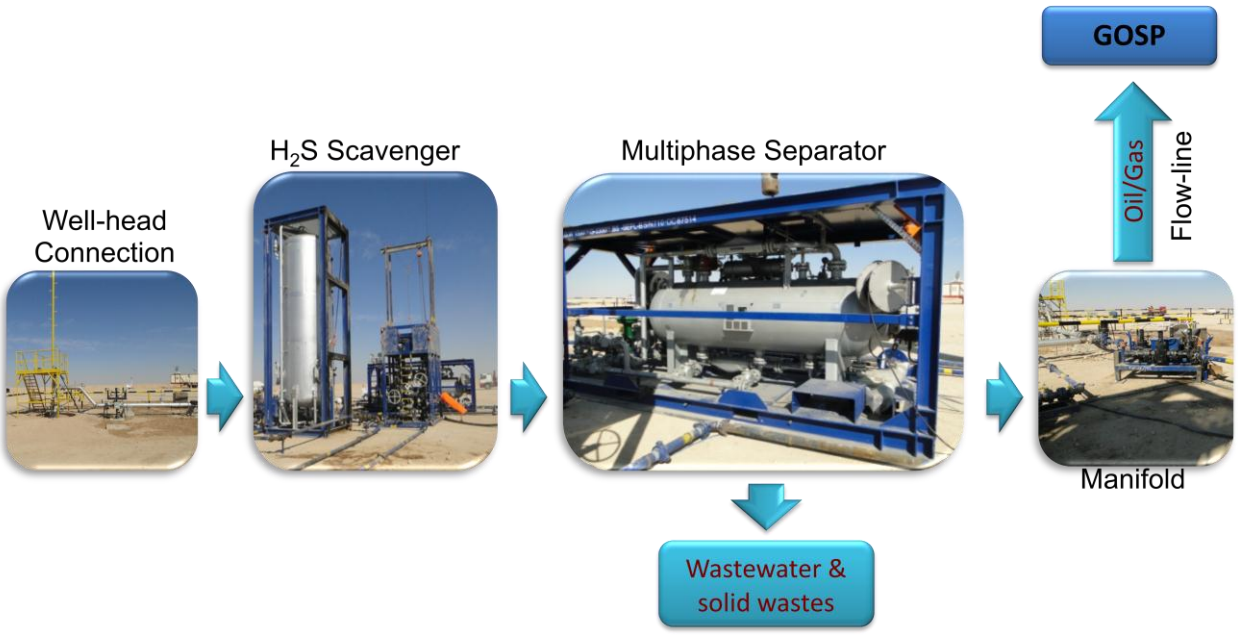
2.4 Benefits Realized

Establishment of the Saudi Aramco flare minimization program and rallying corporate management support behind created a significant momentum which was essential for implementing flare minimization measures in a very large company such as Saudi Aramco. Another important benefit is the development and implementation of the FMS which significantly improved the effectiveness and reliability of monitoring and reporting of facilities' flaring losses. Further, the facility specific FMPs identified the short- and long-term mitigation measures to reduce facility flaring. Implementation of mitigation measures identified in the developed FMPs such as replacing passing isolation valves on flare headers with tight isolation valves (class IV or above) has resulted in noticeable reduction of flaring losses. A typical example of the success story of FMP implementation at the gas plants resulted in more than 30% reduction in flaring in 2011 compared to 2010. In addition to conserving valuable natural gas resources, the flare minimization resulted in significant reduction in emissions of air pollutants such as SO_2 and NOx. Further, implementing flare minimization measures such as FGR systems reduce CO_2 emissions which is a recognized methodology by the Clean Development Mechanism under Kyoto protocol.

3. Implementing Zero Discharge Technologies

Oil and gas well site operations such as drilling, well testing, well stimulation and well backflow operations often involve flaring of hydrocarbons resulting from such operations. One common approach utilized by the oil and gas industry to reduce environmental impact from flaring at oil/gas well is to utilize smokeless flares. Nevertheless, smokeless flares do not conserve hydrocarbon recourses nor eliminate emissions of CO_2 and air pollutants such as SO_2 and NOx. Therefore and as part of its efforts to minimize flaring, Saudi Aramco implemented internal measures to promote the utilization of zero discharge technologies at its onshore and offshore oil/gas well site operations.

The zero discharge process is connected to the well head where H_2S is chemically neutralized and well fluids are segregated using a multi-phase separator. Oil and gas are recovered, separated and sent to the nearest GOSP through a manifold connected to a flowline where it become part of the production meanwhile wastewater and solid wastes are collected and disposed properly. This technology recovered gas and crude oil, resulting in zero flaring and conserving hydrocarbon resources. On average 600 barrels of oil and 120 thousand cubic feet of gas are recovered for every well meanwhile solid waste were reduced to few kilograms for each well. The below figure illustrates the zero discharge process implemented at one of Saudi Aramco on shore oil/gas wells.



The same concept is implemented in offshore wells as shown in the figure below which illustrates the zero discharge process implemented at one Saudi Aramco offshore platforms.