Case 1: Successful treatment of lean gas containing BTX

Qatar Liquefied Gas Company Limited (Qatargas) has executed a major debottlenecking of its existing facilities at Qatargas 1 in order to maintain the LNG production, while coping with increased levels of H_2S and CO_2 in the inlet feed gas streams. As part of this plateau maintenance project (PMP), a new pretreatment acid gas removal unit (AGRU), upstream of the existing gas sweetening facilities, an additional sulphur recovery unit (SRU) and a tail gas treatment unit (TGTU) have been added to existing facilities.

One of the challenges to be addressed for the design of the AGRU, the SRU and the TGTU of the PMP project was to treat 1,100 million std ft^3/d of a lean gas containing BTX and to recover 880 t/d sulphur within the SRU + TGTU and incinerator within a limited surface area allocated to the project. This challenge was successively met thanks to the integration of the enrichment section and the TGTU absorber with the AGRU. The proposed scheme is based on a patented process of the AdvAmine™ technology licensed by Prosernat.

The main design features of the 1,100 million std ft^3/d single train AGRU which treats lean gas with BTX within an integrated AGRU + low BTX enrichment section + TGTU absorber are highlighted below.

Feed gas and outlet specifications

The new gas treatment unit is designed to cover the complete range of feed gas flow rates and compositions given in Table 1, with a H_2S:CO_2 ratio down to 1: 2.51.

The main outlet guaranteed specifications are reported in Table 2 along with the performance test results.

AGRU + enrichment + TGTU absorber + common regenerator

The use of selective acid gas removal technology with MDEA was an obvious choice. However, the acid gas sent to the SRU in some cases contains less than 50% H_2S contaminated by up to 1200 ppmv of aromatics and mercaptans, which can adversely affect the good operation of the SRU unit. Therefore, the question of whether to use acid gas enrichment was raised. An independent acid gas enrichment unit (AGEU) could not be considered

Table 1: **Operating cases of new gas treatment plant**

	Design case P90 Summer/ winter	Normal case P50 Winter 2011	Turndown case 1% mol H_2S
Feed gas flow rate, million std ft^3/d	1 100	975	620
Feed gas temperature, °C	40.0	22.4	40.0
CO_2 content, % mole dry basis	3.2874	3.117	2.5136
H_2S content, % mole dry basis	2.0741	1.8273	1
H_2S in acid gas to SRU, mol-%	54 / 60	60	54
$H_2S:CO_2$	1:1.58	1:1.71	1:2.51
$CycloC_5$+ (ppmv)	395	286	496
Aromatics (ppmv)	401	400	400
COS (ppmv)	30	30	30
Mercaptans (ppmv)	270	270	270

Source: Prosernat

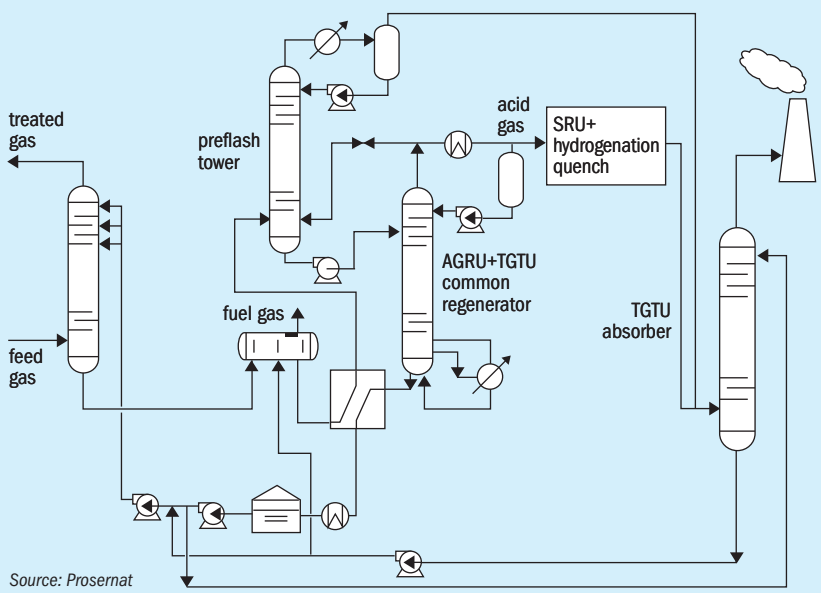
because of the limited plot area allocated to the new plant as well as the increase in capex and opex associated with the addition of an AGEU.

Different solutions were studied by Prosernat. After an international bidding phase Qatargas selected the AdvAmine™ MDEAmax technology, based on open market MDEA solvent, and integration of the AGRU + preflash low BTX acid gas enrichment section + TGTU absorber + common regenerator (see Fig. 3).

HP absorber

In the high pressure section, all treated gas specifications are achieved by contacting the raw feed gas with an amine solvent that is a mix of a very lean solvent and of "semi-lean amine solvent" already used in TGTU absorber. The fraction of each amine solvent can be adjusted to be as close as possible to the required H_2S specification, and the number of trays in the absorber is adjustable to control the CO_2 slippage.

Fig 3: **General AdvAmine™ process scheme of integrated AGRU + preflash low BTX acid gas enrichment section with acid gas recycle to TGTU + TGTU amine section + common regenerator**



Source: Prosernat

The recycling of semi-lean MDEA from the TGTU in the HP absorber allows the overall solvent flow rate to be reduced by re-using the semi-lean solvent, which is not fully loaded, in order to be above 0.67 mole of acid gas per mole of amine in solvent. In addition, it contributes to acid gas enrichment by increasing the quantity of H_2S in the solvent sent to the thermal regeneration.

Preflash for low BTX and acid gas enrichment

After the rich amine recovered at the bottom of the MDEA absorber is released to 7 barg through a level control valve in the MP flash drum, the rich solvent is preheated with the lean solvent from the bottom of the regenerator through the rich/lean MDEA exchangers. The hot rich solvent then feeds the preflash column at reduced pressure. The advantages of this new system are:

- the low pressure flash of a rich amine solvent preferentially vaporises CO_2, which is a simple way to enrich the rich solvent in H_2S, then the acid gas from the regenerator;
- the flash of the rich amine solvent also releases a large fraction of aromatics, which are sent to the absorber of the TGTU and then on to the incinerator.

The operating pressure can be adjusted by the operators. It controls the differential ratio of CO_2 and BTX released versus H_2S in respect of the composition and flow of sour feed gas to the HP AGRU. The lower the operating pressure of the preflash column, the higher the content of H_2S in the acid gas to the SRU will be. The configuration allows the concentration of the acid gas to be adjusted between 54 mol-% (when the operating pressure of the preflash column is 4 barg) to 60 mol-% or more, at lower operating pressures.

The new AGRU is equipped with an acid gas line that allows the acid gas to be recycled from the top of the regenerator to the preflash column. This facility is used to meet minimum H_2S content of the acid gas even when the feed gas contains only 1% of H_2S. The line can also be used during turndown conditions.

TGTU absorber

The LP flash gas from the preflash column is mixed with the tail gas from the SRU hydrogenation section and feeds the TGT absorber, where it is contacted with fresh

Table 2: **Guaranteed and measured performances test results**

	Licensor guaranteed values	Measured performances during tests
AGRU design capacity, million std ft^3/d	1,100	1,100
Treated HP gas H_2S content, ppmv (dry basis)	< 600	463
Treated HP gas CO_2 content, mol-% (dry basis)	< 1.8	< 1.5
Treated tail gas H_2S content, ppmv (wet basis)	< 250	219
Flash gas H_2S content, ppmv (wet basis)	< 50	< 25
Flash gas pressure (upstream of PCV), barg	7	7.24
Acid gas pressure (upstream of PCV), barg	1.2	1.22
H_2S content in acid gas, mol-% (wet basis)	> 54	57.2
BTX in acid gas, ppmv	< 300 expected	< 80
Maximum reboiler duty, MW	≤ 115	< 10

Source: Prosernat

solvent from the regenerator to achieve the 250 ppmv H_2S specification and further sulphur emissions at stack.

Thermal regenerator

The rich amine from the preflash column is sent to one common regenerator where H_2S and CO_2 are stripped by the vapour generated in the reboiler. Finally, this single regenerator treats all the solvent flow used to remove acid gases in the HP absorber, in the MP flash absorber and in the TGTU.

Cooled lean amine solvent feeds the HP absorber, the MP absorber on the MP flash (in order to achieve 50 ppmv H_2S in the flash gas) and the TGTU absorber.

The plant is also equipped with a direct condensing section and vertical direct cooler with recycled water wash, on acid gas and treated gas in order to limit the pressure drop and also minimise the solvent losses. Filtration of the inlet gas and part of the solvent is also performed based on operational feedback from the licensor in order to achieve smooth operation of the unit.

Improved flexibility and operability

Depending on the feed gas composition (H_2S/CO_2 ratio and feed gas flow), the operating conditions of the AGRU are adjusted to achieve the required specifications, especially the concentration of H_2S in the acid gas. Two parameters are essential and specific to the good operation of the unit: the recycle rate of semi-lean amine in the solvent feed to the HP absorber and the operating pressure of the preflash column.

Performance tests

Performance tests took place at the beginning of 2015. Results measured during the performance tests are reported in Table 2.

The AdvAmine™ design meets the multiple process requirements with high operational flexibility: it meets the H_2S and CO_2 removal specifications in the treated gas, the high capacity plant cleans up the H_2S from the tail gas from the 880 t/d SRU to meet environmental emissions regulations and it secures the H_2S, RSH and BTX content in the acid gas (by a dedicated preflash column) in order to satisfy the design of the SRU furnace section. An additional acknowledged benefit of this giant unit is the decrease of the solvent circulation and of the solvent regeneration duty achieved by the recycle of semi lean solvent from the TGT column to the HP absorber.

All guarantees associated with the AdvAmine™ license of the integrated AGRU and TGT amine section at design and turndown capacities have been demonstrated without operational issues. In addition, operators have reported the simple and efficient management of the H_2S and BTX content of acid gas by the preflash column.

References

3. Normand L, Perdu G, Loborie G. Streicher C. (Prosernat) and Al-Hatou O.I. (Qatargas): "Successful treatment for the 1100 MMSCFD single train AGRU in Qatar", prepared for Sulphur (Oct 2015).