# The New Abu Qir III Ammonia/Urea Complex Design and Start-Up Experiences

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## 1 Introduction

Abu Qir Fertiliser & Chemical Industries Company (AFC) was established in 1976 for producing nitrogen fertiliser to cover the local demands and to export the excess production. The company is located at the coast of Abu Qir bay, about 20 kilometres east of Alexandria, Egypt.

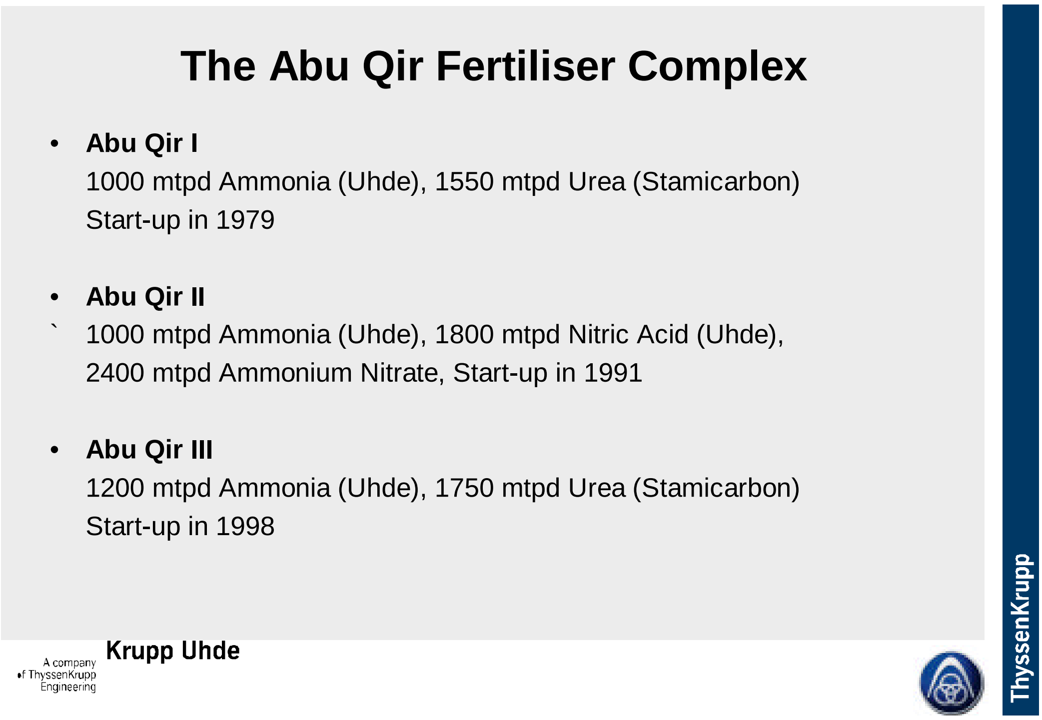


*Fig. 1: Abu Qir Fertiliser Complex*

The complex consists of:

- Abu Qir I, a 1000 mtpd ammonia plant (Uhde technology), a 1550 mtpd urea plant (Stamicarbon technology) and a urea prilling plant, general contractor was Uhde GmbH, financing via German Export Finance (Kreditanstalt für Wiederaufbau, KfW), the plant was commissioned in September 1979.

- Abu Qir II, a 1000 mtpd ammonia plant (Uhde technology), a 1800 mtpd nitric acid plant (Uhde technology) and a 2400 mtpd ammonium nitrate granulation plant (Uhde and Hydro Agri technology), general contractor was Uhde GmbH, financing also via KfW, this plant was commissioned in July, 1991.

- Abu Qir III, a 1200 mtpd ammonia plant (Uhde technology), a 1750 mtpd urea plant (Stamicarbon technology) and a 2000 mtpd granulation plant (Hydro Agri technology). The financing scheme was arranged by AFC via its shareholders and other Egyptian sources. Also for the third project Krupp Uhde was selected as the general contractor. The design details and start-up experiences will be subject of this paper.

All three plants have their own utilities, storage, bagging and loading units.

- A liquid ammonia marine export facility was established in April 1989.

Besides the whole complex covering an area of approximately 795000 m² a housing colony was establishing by AFC giving a home to approximately 30% of the employees with their families. This colony provides all services including nursery, schools, shops and recreational facilities.

## 2 Design Concept

### 2.1 Investment Optimisation

With a natural gas price of approximately 4 US$ / Gcal (1 US$ / MM BTU) it is obvious, that an ammonia plant design concept will be focussed on minimising the capital expenditure rather than aiming for the latest available design features to minimise the operational expen-ditures to the lowest possible limit. Nevertheless with the selected concept it was possible to achieve a reasonable expected consumption figure of 7.146 Gcal/t NH3, enabling Abu Qir Fertiliser an optimum return on investment.

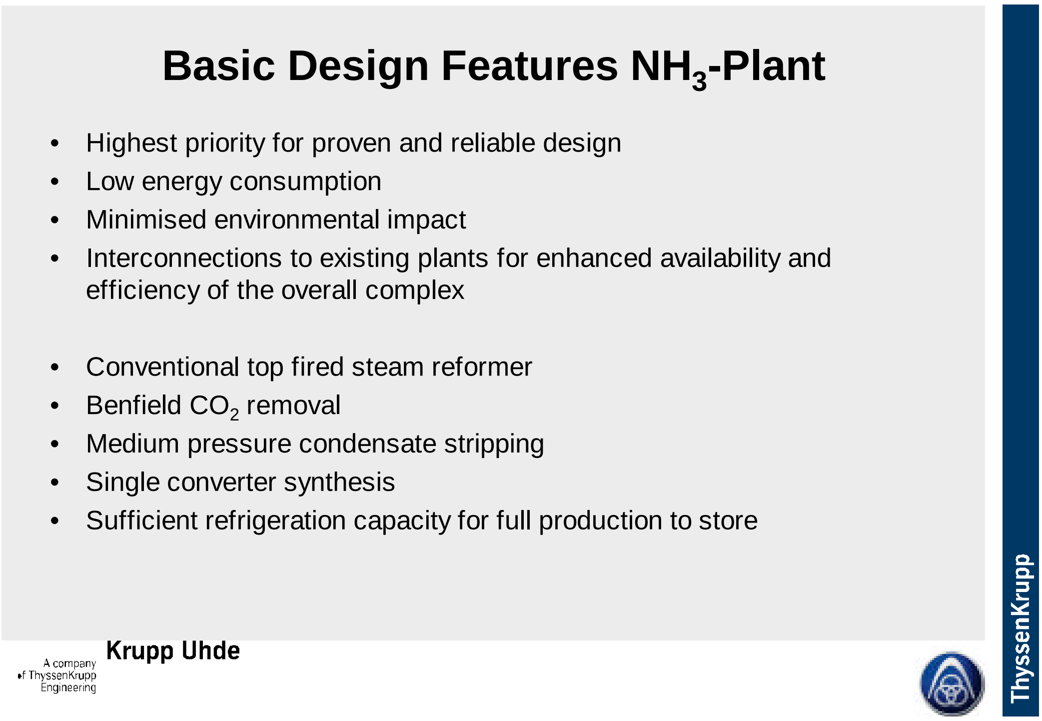


*Fig. 2: Basic Design Features of the Ammonia Plant*

The ammonia plant was designed according to the well proven and reliable Uhde ammonia process with a single converter synthesis loop. The conventional design was improved by several features from the recent Saskferco and Qafco plants, enabling increased operational flexibility, reduced environmental impact, and a reasonable consumption figure.

Also for the urea plant all efforts were taken to reduce the required investment and to optimise the concept according to AFC´s requirements. This was achieved especially in the synthesis by several measures:

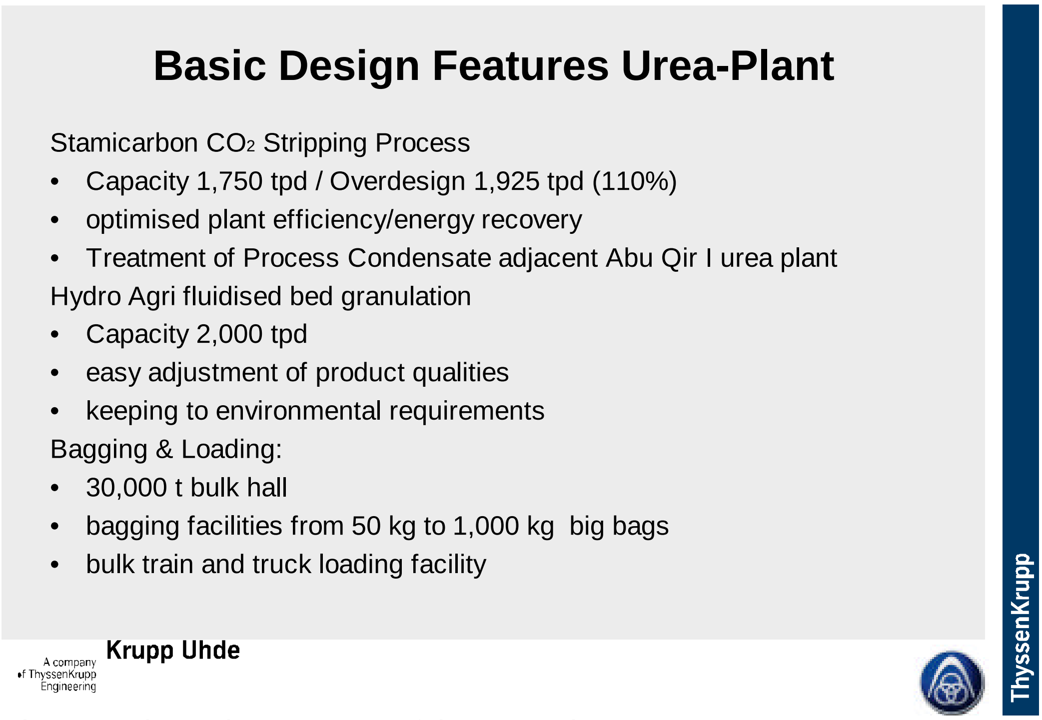


*Fig. 3: Basic Design Features of the Urea Plant*

1. For the first time in a Stamicarbon plant the urea reactor was equipped from the very beginning with high efficiency trays reducing the volume of the reactor in comparison to the old design.

2. The whole building was constructed more compact to reduce volume.

3. The Hydrolizer heat exchanger is another optimisation example. A new type of plate heat exchanger was used instead of 10-12 shell & tube heat exchangers. This cost savings was possible even though we had to cope with the world largest Desorption/Hydrolysis unit treating in addition the process condensate of the adjacent Abu Qir I urea plant.

Some of the process units and especially the offsites were designed to make maximum use of Abu Qir I/II effluent and blow down streams to optimise the overall efficiency and to minimise the raw water consumption and environmental impact of the whole complex.

## 2.2 Interconnections

A variety of interconnections to the existing complex was foreseen to enhance the overall flexibility and availability of the complex and to enable the use of blow down streams. The following split can be made:

## Interconnections

**Enhanced Availability**

- Demineralised Water
- Nitrogen
- Instrument Air
- Plant Air
- HP-Steam
- $CO_2$
- Synthesis Gas
- Liquid Ammonia
- Urea Solution
- Urea Product

**Enhanced Efficiency**

- Process Condensate
- Cooling Water Blowdown
- LP - Steam (AQ I/II Excess)

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*Fig. 4: Interconnections*

With these interconnections a variety of scenarios is possible, for example:

- AQ III ammonia plant shut down, AQ III urea plant running with ammonia from storage and $CO_2$ from AQ II
- Transfer of synthesis gas from AQ II front-end to AQ III synthesis and vice versa
- Urea solution of AQ I sent to AQ III granulation to produce granules instead of prills
- Urea product exchange between AQ I and AQ III to optimise storage capacity

Besides the increased operational flexibility and availability the start-up of the new plant can be significantly speeded up, by having all the necessary feedstock for pre-commissioning and commissioning at hand. Moreover, already existing laboratories, workshops and experienced operational staff contributed to construction and commissioning.

## 3 Ammonia Plant & Offsites

The selected design with a single converter synthesis concept basically reflects the optimisation of capital and operational costs (ref. to 3.1). The design will be described in detail unit by unit.

## Design Details $NH_3$ - Plant

- Feed Gas: Natural gas via natural gas compressor
- Desulphurization: CoMo/ZnO, single vessel
- Primary Reformer: top-fired, Uhde proprietary cold outlet, Steam/Carbon - Ratio 3.0
- Secondary Reformer: Burner with external radial nozzles
- CO-Shift: Conventional HT & LT, separate vessels
- $CO_2$-Removal: Benfield LO-Heat Process
- Condensate Stripping: with MP-Steam, added to Process Steam
- Synthesis Gas Compression: 3stage, 2 casings, internal circulator
- Synthesis Loop: Single Converter, Magnetite Catalyst, 187 bar
- Refrigeration: Turbo Compressor with Booster compressors at storage tank, sufficient for 100% production to store
- Hydrogen Recovery: Membrane System

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*Fig. 5: Design Details of the Ammonia Plant*

**Feed gas** is natural gas from Abu Qir offshore field which is considered to be a stable and long term supply as can be seen from the 20 years supply contract. In case of upsets from this gas field the supply is switched to Badredine gas with a very similar composition.

A **natural gas compressor** was provided to compensate the occasionally low pipeline pressure of down to 37 bar. Most of the time the supply pressure is high enough so that the compressor is not in operation. It is only used as a nitrogen circulator for start-up. Due to the low sulphur content of both natural gases a standard CoMo/ZnO **desulphurization** was chosen.

The top fired **primary reformer** was throughout designed by Krupp Uhde. The furnace is set up with 192 tubes of 5”, arranged in 4 rows and heated by 105 low $NO_x$ burners. The feed/steam mixture is preheated in the reformer waste heat section to 540°C, the steam/carbon ratio chosen is 3.0. The waste heat section is also used for HP steam superheating, process air preheating, feed preheating and combustion air preheating.

From the primary reformer the process gas enters the **secondary reformer** via the Uhde proprietary cold outlet manifold. The process air is injected to the combustion chamber radially via a set of nozzles connected by an external annular manifold. This burner type was already used in the Saskferco and Qafco plant and shows excellent performance and long term reliability.

**Process air** is supplied by a GHH-Borsig four-stage centrifugal air compressor. Before entering the secondary reformer the process air is preheated in the waste heat section of the primary reformer to a moderate temperature of 450°C. Passivation air for the urea plant and instrument air for the complex are extracted at the appropriate interstages.
Downstream of the secondary reformer HP steam is generated and subsequently superheated together with the steam produced in the synthesis. The HP steam header was set with 115 bar and 510°C to the same conditions as Abu Qir II to enable a steam exchange via the interconnection. The Abu Qir III HP header feeds the turbines of syngas and $CO_2$ compressor and the alternator. MP steam is extracted from the syngas compressor turbine at 48 bar and

is used as process and stripping steam and to drive the process air compressor turbine, the refrigeration compressor turbine and the BFW pump turbine.

The **CO shift** is of conventional design with HT and LT in separate vessels, cooling is accomplished by BFW preheating after both reactors. The further cooling of the process gas up to the inlet of the absorber is achieved by a LP-steam generator, a reboiler for the Benfield solution and a demineralized water preheater. For the **$CO_2$ removal** system the Benfield LO-Heat process was chosen, mainly due to the Abu Qir operator experience and the simplified chemicals stock with only one type of scrubbing system for all three plants. The columns were filled with standard packing material and also for the activator diethanolamine was preferred over the new generation activators. Even with this conventional design a $CO_2$ slip of 0.1% could be kept at approximately 106% plant load. The solution pump power is partly recovered by a hydraulic expansion turbine.

The condensates are purified by a MP steam **condensate stripper** and routed back to the demineralization plant. The stripper steam containing the stripped components contributes to the process steam for the primary reformer. The stripping section has enough capacity to purify additional 50 t/h of process condensates from Abu Qir I plant via the interconnection.

Following a standard **methanation** section the synthesis gas is chilled down to 6°C before entering the 3 stage synthesis gas compression. The single shaft syngas compressor by Nuovo Pignone is arranged in two casings including the loop circulator and driven by an ABB extraction / condensing turbine. Hydrogenation gas for the desulphurization is extracted after the first stage.

The **synthesis loop** pressure was selected with 187 bar and is based on Krupp Uhde's single converter with three radial beds with internal heat exchangers. The make-up gas enters the loop via a combined chiller upstream of the ammonia separator. Separation temperature was set to -10°C. Downstream of the ammonia converter HP steam is generated and routed to the superheater upstream of the HT-Shift. Purge gas and flash gas from the let down vessel are scrubbed in the **ammonia recovery** unit. The hydrogen is furthermore recovered in a membrane **hydrogen recovery** unit and routed back to the syngas compressor suction.

**Refrigeration** is achieved at two levels of +1°C and –15°C, the evaporated ammonia is recompressed in a GHH Borsig single casing centrifugal compressor driven by an ABB MP condensing turbine. The capacity of the refrigeration system is sufficient to cool 100% production to –33°C for the atmospheric **ammonia storage**. The storage tank is located close to the Abu Qir I & II ammonia tanks and has a storage capacity of 15000 mt. Interconnections to the existing tanks and the marine export line are provided.

The further **offsites and utility** units worth mentioning are a 146 t/h Babcock HP steam package boiler, a cryogenic **nitrogen generation** unit, a **raw water treatment** unit and a **demineralization** unit with a maximum continuous output of 300 $m^3$/h.

### 3.1 Krupp Uhde Synthesis Concepts

The design of the new Abu Qir III plant differs from plants recently built by Krupp Uhde especially with respect to the ammonia synthesis section. The previous plants like BASF, Saskferco and Qafco were all based on a two converter three bed synthesis while Abu Qir uses only a single converter, still with three beds. The two different synthesis concepts are shown in the following figures:

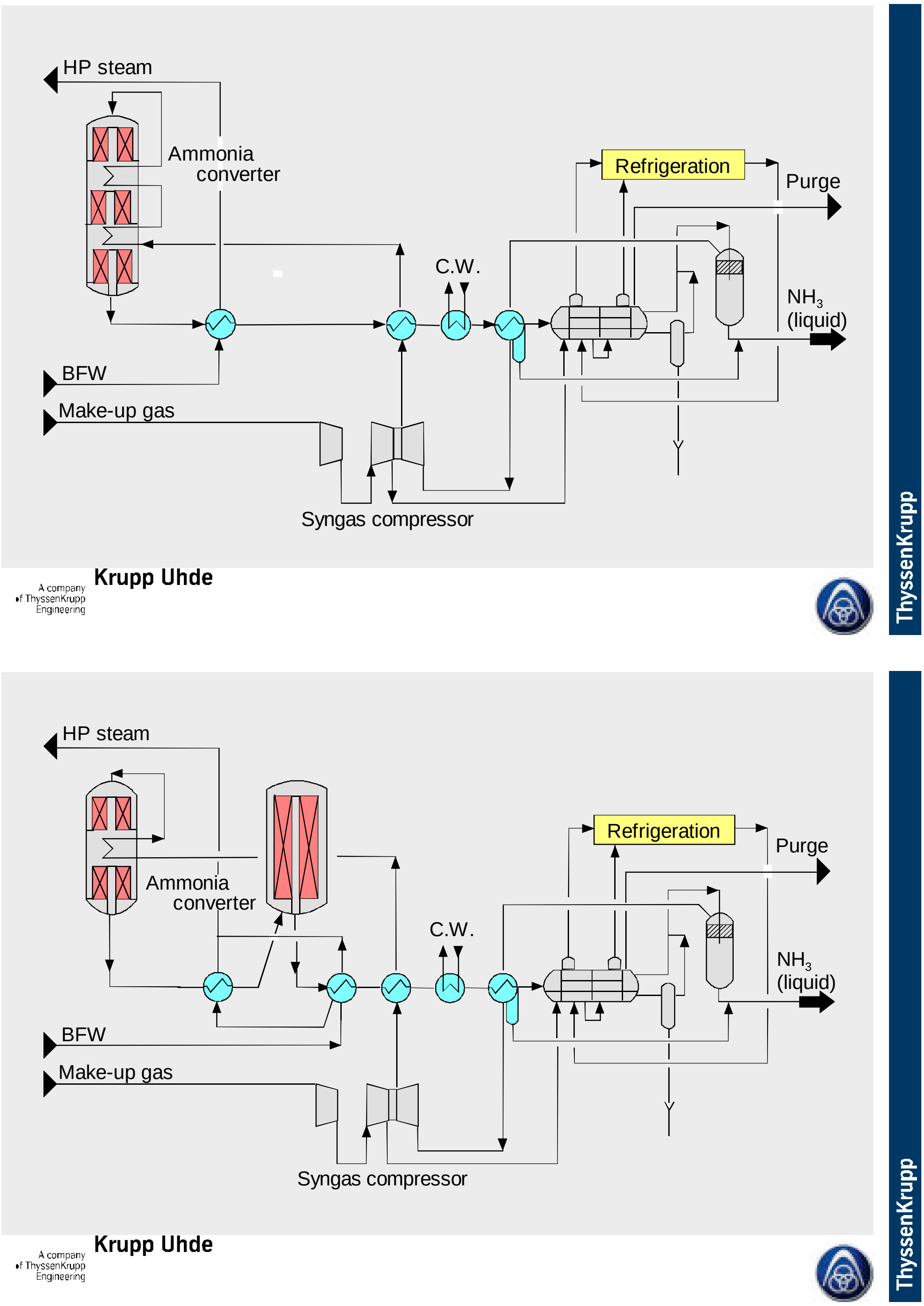


*Fig. 6: Flowsheet One/Two Converter Synthesis*

While the one converter synthesis combines all three beds and two internal heat exchangers in one vessel the first reactor of the two converter synthesis contains only two beds and one internal heat exchanger. The cooling of the synthesis gas between the second and the third bed is accomplished by a HP steam generator. Downstream of the third bed a HP steam boiler similar to the one converter synthesis is implemented. The main difference is that this boiler also preheats the BFW for the first boiler between the reactors. Due to the fact that the two converter synthesis uses two vessels the total catalyst volume and conversion rate was increased and therefore the recycle flow reduced leading to less heat losses. The separation temperature has to be adjusted as well, the one converter synthesis requires –10°C to achieve a good conversion while the two converter synthesis can be kept at 0°C.  From these process requirements the characteristics for both concepts can be summarised as follows:

**Single Converter Concept**
- lower specific investment
- reasonable energy efficiency
- suitable for up to 1800 mtpd

**Two Converter Concept**
- higher specific investment
- best energy efficiency
- suitable for very large capacities

Besides the given fact that for large capacities the two converter concept is generally preferred for economical reasons there would be a location dependent limitation for the single converter concept at around 1800 mtpd with respect to available crane lifting capacity for inserting the internals into the reactor.
The key to the appropriate selection can be derived from the following diagram:

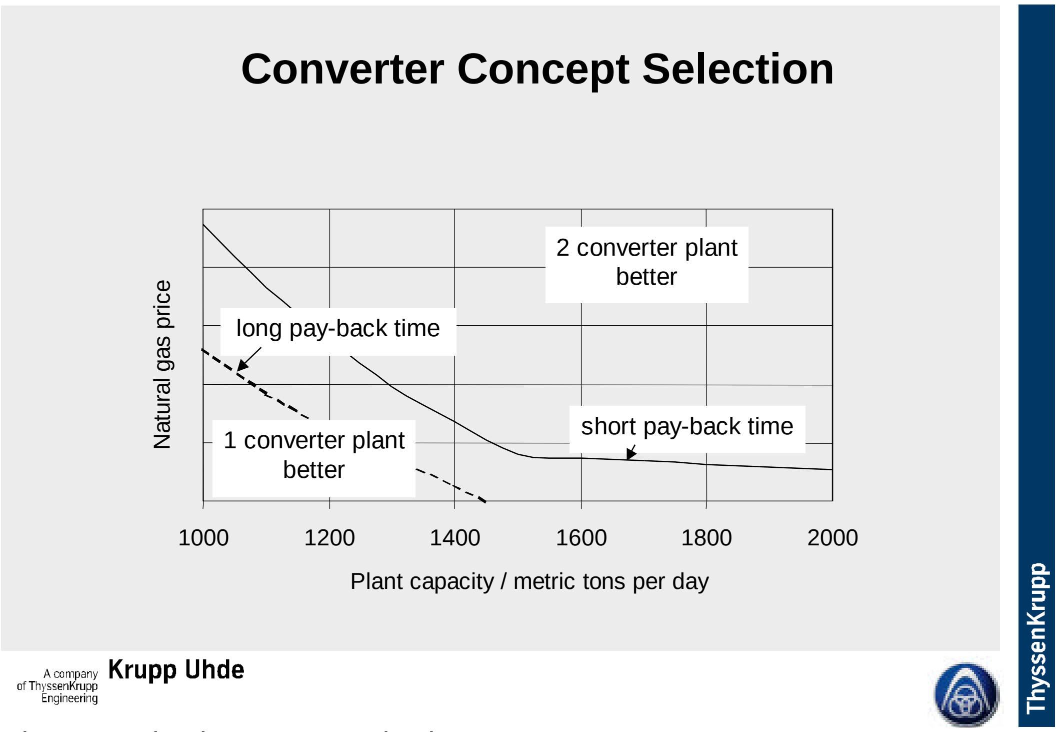


*Fig. 7: Synthesis Concept Selection*

Based on the anticipated pay back time and the natural gas price the optimum synthesis concept can be derived for the required plant capacity. Consequently for the Abu Qir III plant with a name plate capacity of 1200 mtpd and a very low natural gas price the single converter concept was selected.

# 4 Urea Plant

The new design of the Abu Qir III urea plant is another good example for the optimisation of operational aspects as product quality and variety, excellent consumption and environmental figures combined with minimum investment figures.

## 4.1 Overall Design philosophy

Before going into more detail of the urea plant, it is necessary to introduce its overall design philosophy. As can be seen in the table below Abu Qir Fertiliser Co. decided to fix the capacities of the synthesis and granulation at different levels. The capacity of granulation plant designed by Hydro Agri is higher than the synthesis of Stamicarbon design.

By this excess capacity of the granulation advantage can be taken to process the inventory of the urea solution storage tank, which was used as an intermediate storage of the urea solution, after shutdown of the granulation plant for cleaning of the granulator
In addition, in case of normal operation use can be made of the urea solution interconnection to the Abu Qir I plant to increase the output of granular urea.

Consequently, also the evaporation unit was equipped with 20% over-capacity.
This overall design philosophy was applied to even more equipment. Starting with the $CO_2$ Compressor, followed by the HP-$NH_3$ and Carbamate pumps, heat exchangers in all parts of the plant etc. most of the items were designed with over-capacity from the very beginning.

| Plant/Item | Capacity in % | Capacity in MTPD |
|---|---|---|
| Urea Synthesis | 100% | 1750 |
| incl. Over-design | 110% | 1925 |
| Urea Granulation | 100% | 2000 |

## 4.2 Urea Synthesis / Granulation

The urea synthesis plant with its nameplate capacity of 1,750 mtpd is of Stamicarbon design is based on the $CO_2$ stripping process. With a design capacity of 1,925 mtpd it ranks among the larger urea plants in the world recently commissioned.

One special highlight of the Urea Plant is the Desorption & Hydrolysis, which can be considered as the largest in the world.
In this section most of the remaining ammonia, carbon dioxide and urea is removed from the process condensate. This treatment protects the environment and recovers valuable reactants and consists of four steps. After ammonia and carbon dioxide have been desorbed in the first step, urea is decomposed in a hydrolyser to its reactants in the second step, which are then recovered by desorption in the third step. In the fourth step the off-gases will be condensed in a reflux condenser.
The huge capacity is based on the fact that the Desorption & Hydrolysis is processing not only the ammonia water from the Abu Qir III plant but in addition the process condensate from Abu Qir I urea plant, which amounts to 45 to 50 $m^3$/h. Hence, during the test run up to 90 $m^3$/h were fed to this section compared to a 'normal' capacity of a Desorption of approximately 40 to 45$m^3$/h.

To get an idea of the dimensions of this unit, which is normally integrated in the urea synthesis building, some technical comparison with the Qafco III plant, also built by Krupp Uhde in Qatar, with a name plate capacity of 2000 mtpd.

| | Abu Qir III | Qafco III |
|---|---|---|
| HYDROLYSER | | |
| Height (mm) | 25,450 | 19,150 |
| Diameter (mm) | 2,850 | 2,150 |
| DESORPTION COLUMN | | |
| Height (mm)<br>(Qafco two separate columns) | 23,180 | 9,800<br>12,500 |
| Diameter (mm) | 1,800 | 1,400 |

For the hydrolyser heat exchanger, where the feed to the hydrolyser is heated to about 190 C by the hydrolyser liquid outlet, this over-design requirement would have resulted in 10-12 shell and tube heat exchangers. As this would have led to a substantial cost increase, a single plate heat exchanger designed for 25 barg and 230°C was chosen with a fully welded design (but totally accessible from both sides) that combines performance, safety, maintenance and capital/maintenance cost.

Although the quantity of treated process condensate is high; the quality is excellent allowing the water to be used again as cooling water make-up.

The urea granulation plant is of the Hydro Agri process a has a design capacity of 2000 mtpd. In the Hydro Agri process granular urea is produced by spraying liquid urea onto seed material in the fluidized state.

The basic characteristics of this process are:
- the liquid urea is a concentrated solution not a melt;
- the spraying occurs in the core of a fluidized layer by means of a large number of spray heads;
- the particle size enlargement is achieved by accretion;
- formaldehyde (in the form of urea/formaldehyde pre-condensate) is added to the urea solution before spraying, as a process aid and anti-caking agent.

Some technical details about the urea plant are presented in the following figure:

## Design Details Urea - Plant

- capacities of the synthesis and granulation at different levels:

| Plant | Capacity | |
|---|---|---|
| Synthesis | 100% | 1750 tpd |
| incl. Over-design | 110% | 1925 tpd |
| Granulation | 100% | 2000 tpd |

- urea reactor equipped from very beginning with high efficiency trays reducing the volume significantly

- hydrolizer heat exchanger: new type of plate heat exchanger was used instead of 10-12 shell & tube heat exchangers

  (world largest Desorption/Hydrolysis unit)

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*Fig. 8: Technical Details of the Abu Qir III Urea Plant*

### 4.3 Bulk Hall / Bagging and Loading

The urea plant is also equipped with a 30,000-t bulk storage hall in order to have a storage capacity. The automatic scraper/reclaimer can adapt its scraping arms from 18 m maximum to the diminishing height of the heap and is able to travel the full length of the storage hall unattended. Moreover, it has a capacity of 250 t/hour corresponding to a handling capacity of 2,000 t/day with an utilisation factor of 50 %, that means 4,000 t/day in 16 hours/day.

The Bagging and Loading unit is located adjacent to the Urea plant. It consists of bagging facilities from 50 kg bags up 1,000 kg big-bags. With these bags mainly the local market in Egypt is supplied. In addition there is a bulk loading facility for train and truck loading to serve the exports interests.

## 5 Commissioning, Start-Up and Performance Test

### 5.1 Schedules

The key milestones of the whole project can be summarised as follows:

- Effective Date of contract - the day of the award of contract to Krupp Uhde – (12.04.1996)
- Mechanical Completion Certificate of the entire complex within 30 months;
- Take Over Certificate, which includes the semi-commercial operation and the test-run of the plant as a whole, after 33 months;

### 5.2 Precommissioning

Precommissioning activities for the offsites started in March/April '98, i.e. 23-24 month after effective date with the preparation of the instrument air and cooling water system. Despite having the interconnections as a back up, the start up was tried as far as possible independent from the existing complex to minimise the influence on the running plants. After the package boiler was started up, steam blowing started mid of July and was finished within only two weeks, mainly due to the fact, that the MP steam lines had been pickled before. The LT-Shift Reduction was finished by the mid of August, i.e. within 28 month after effective date. By the end of August the reformer was lit for dry out and the $CO_2$ removal section was prepared by chemical cleaning.

Due to a delayed delivery of equipment for the urea plant the precommissioning activities started very late for this plant, the steam blowing was performed at the end of August i.e. in the 29th month from contract award. During the next month the Granulation unit performed its Dry Test Run. At this stage, the mechanical product flow was checked, so that any necessary adjustments could be made before urea solution was fed to the granulation unit.

### 5.3 Commissioning

Commissioning of the ammonia plant started on the 2nd of September by introducing the feed gas to the reformer. Two weeks later the process air was introduced to the secondary reformer and the $CO_2$ removal and methanation unit were put in operation. After having finished the leak test the synthesis gas compressor was started up. Meanwhile the leak test for the synthesis loop was continued and the refrigeration system tested. With the reduction of the synthesis catalyst the first ammonia was sent to store in the beginning of October, i.e. four weeks after the first introduction of feed gas to the reformer.

Before starting up the urea synthesis the evaporation unit was already started up with urea solution imported from Abu Qir I. With this urea solution, the first urea granules were produced. All the downstream urea handling facilities up – especially the bagging and loading unit – were also tested using the urea granules produced.

In the beginning of month 31 on the 19./20. October 1998 the water run was executed in the Urea Synthesis. During the water run, the feeds to the synthesis unit were simulated with $CO_2$ from the $CO_2$ compressor and water from the HP ammonia pump. This was an excellent opportunity to acquaint the operators with the start-up procedures and the peculiarities of the plant. In addition, one was sure that the radioactive level measurements and the important control valves, especially those in the high-pressure section, were working in accordance with the requirements. As a result, the urea plant was now ready for production.

The urea synthesis was first time started up on the 24th of October, i.e. in the 31st month after effective date.
Within only one week all plant units were in operation and the period of semi-commercial operation was started on the 1st of November.
A summary of the precommisioning and commissioning highlights is given in the table below:

**Commissioning Highlights**

- After 25 months — Instrument air & cooling water in operation
- After 26 months — Package Boiler started up
- After 27 months — Steam blowing of the ammonia plant finished
- After 28 months — LT-Reduction finished
- After 29 months — Reformer in operation
- After 30 months — Mechanical Completion<br>First ammonia to store,<br>Pressure Test of Urea HP equipment<br>Granulation Dry run performed
- After 31 months — Semi-commercial operation (30 days) started
- After 32 months — Short maintenance shutdown
- After 33 months — Performance Test (7 + 10 days) finished,<br>Hand over of plant

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*Fig. 9: Commissioning Highlights*

## 5.4 Semi-Commercial Operation

A peculiarity of this contract was the requirement of a very long period of semi-commercial operation before the performance test run. A total period of thirty cumulative days of operation was required before the plant performance test could be started. For the first twenty-eight days of semi-commercial operation, a day was defined as any period of twenty-four consecutive hours in which the total output of the unit equalled or exceeded 75% of the daily design rate for ammonia and urea.
The final two days were required as a readiness demonstration to show that the plant is fit for the plant performance test. Therefore, the plant had to operate continuously for a period of forty-eight consecutive hours during which the total output of the unit equalled or exceeded the daily minimum penaltiable rate for the ammonia and urea plant.

With this long period of semi-commercial operation Abu Qir ensured that the plant can be operated continuously under commercial conditions immediately after the test run and no further shutdown is required until the next turnaround.
The major advantage for the contractor was that the client´s personnel received an extensive training and knowledge of the plant peculiarities before entering the test run.

From the first day of commissioning the plant was operated by Abu Qir staff under the supervision and responsibility of Krupp Uhde’s commissioning team. Due to the profound operating experience gained in the existing two plants the operating staff had no difficulties in starting up and running the new plant and the required training had just to be focussed on the DCS operation itself.

## 5.5 Performance Test Run

According to the contract a simultaneous plant performance test on all the process plants and on all wholly related offsite facilities had to be carried out for seven consecutive days.

The plant performance test should prove that ammonia, urea synthesis and granulation plants and all offsite facilities can operate simultaneously and continuously and produce final and intermediate products and by-products to specification and at the guaranteed production rate and that consumptions of raw materials, utilities, chemicals, etc., are not higher than the guaranteed figures.

Moreover, in additional ten consecutive days separate tests for individual units and items had to be carried out. During this period also the maximum turn down rate and the 110% capacity of the urea plant had to be demonstrated.
The overall plant testing procedure where the whole plant with all units had to be in operation sums up to a total of 49 days minimum.

The performance test run was performed from the 2nd to the 9th of January. Some extracts of the performance and consumption figures are given below:

**Ammonia Plant:**

| | | |
|---|---|---|
| Average Production: | 1274.5 mtpd | (106.2 %) |
| Average Consumption Figure: | 6.917 | Gcal/t $NH_3$ |
| Average NH3 Concentration: | 99.92 | wt.-% |

**Urea Plant:**

| | | |
|---|---|---|
| Average Production: | 1848.4 mtpd | (105.6 %) |
| Average Biuret Content: | 0.75 | wt.-% |
| Crushing Strength: | > 4 | kg |

All gaseous and liquid effluents were well below contractual limits. For further details refer to the Annex.

## 5.6 Start-Up Difficulties

Generally the overall start-up went very smooth without any major problems. A typical start-up problem in many plants are sticking or not smoothly operating valves which also caused some trouble in the Abu Qir III start-up. Affected were the first process gas vent downstream of LT-Shift and a motor driven Benfield solution pump discharge valve. The problems were solved by providing a new type with more piston rings for the vent valve and an overhaul in the AFC workshop for the solution valve.

A tricky problem occurred in the combination of the ABB Distributed Control System / Emergency Shut Down System (DCS/ESD system) and the Woodward turbine control which caused several trips for the generator turbine. The bug was finally identified as being the self-test of the ESD system, recognised only by the generator turbine Woodward as an external trip input signal. This problem was finally solved with a kind of electronic filter for the Woodward input.

Another start-up problem which turned out to be quite simple after once having been identified was a slow increase of syngas compressor turbine bearing vibration and temperature after each start-up which limited the operation after 2-3 days. It was finally identified as being oil mist, entering the coupling, coalescing there and causing a slowly increasing unbalance. Unfortunately the identification of this problem took some time, otherwise the test-run could have been started earlier. The problem was easily solved with some drain holes at the coupling, preventing an oil accumulation.

For the urea plant problems worth mentioning during start up refer to the hydrolyser heat exchanger and the carbamate pumps.
The plate heat exchanger showed a leakage shortly after start up. Together with the manufacturer this mechanical problem was solved. Furthermore, to minimise the process impact on this equipment, the level control valve of the first desorption column was shifted downstream the exchanger. With this measure the pressure of the ammonia water coming from the first desorber was kept high inside the heat exchanger. Thus, any boil off of the liquid causing vibrations was avoided.

The carbamate pumps faced a cavitation problem. Therefore, the whole suction piping assembly was recalculated by several pulsation-studies, resulting in the implementation of gas filled suction stabilisers. After that recently executed modification from fluid-dynamic point of view this problem is solved.

Before entering the test run the whole plant was shut down for some maintenance. Flow meters were calibrated, maintenance was executed and for instance in the Urea plant this period was also used for further intensive cleaning of some equipment, e.g. the stripper to improve the overall efficiency.

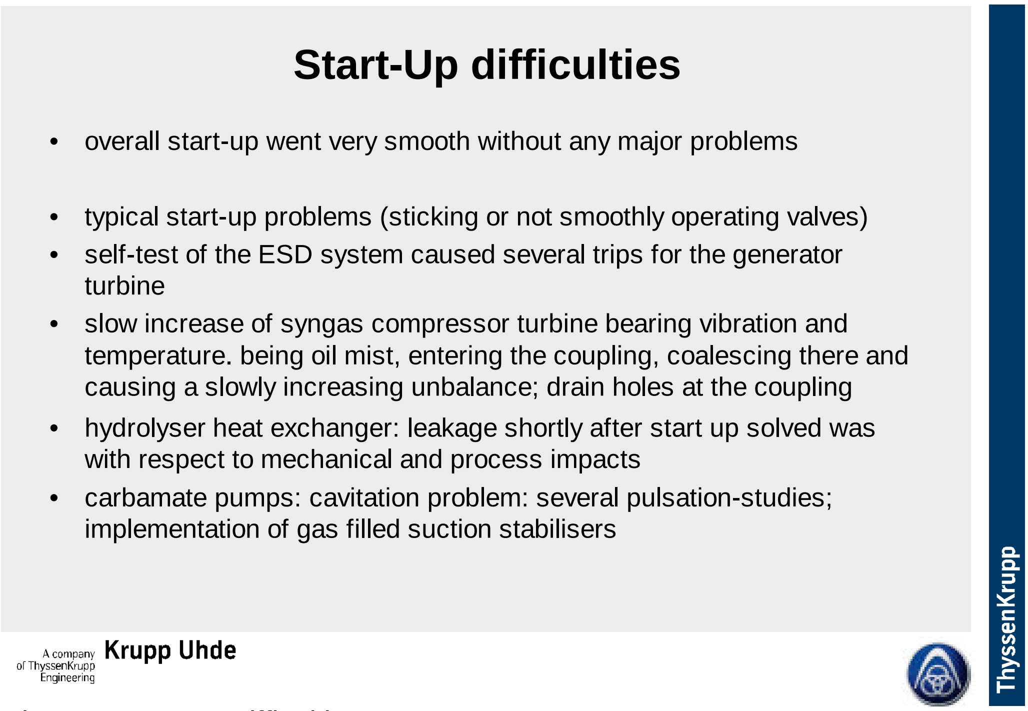


*Fig. 10: Start-Up Difficulties*

## 6 Conclusion

The third fertiliser project for Abu Qir Fertilisers, engineered, constructed and commissioned by Krupp Uhde was handled within the contractual time of 33 month and showed excellent performance by exceeding the design capacities at low energy consumption.
The plant design compared to recent designs of BASF and Saskferco reflects Krupp Uhde's flexibility and experience to tailor a plant layout to clients requirements and to optimise the required investment with respect to the operational costs at a specific location. Furthermore the environmental impacts of the old Abu Qir I plant were eliminated by shifting the treatment duties to the new Abu Qir III plant.

Some usual start-up difficulties were solved within short time together with the experienced maintenance and operating team of Abu Qir Fertiliser. The project proved again the benefit of starting up a new plant within an existing fertiliser complex by having experienced manpower and well equipped workshops at hand.
The excellent performance of the new plant was demonstrated by achieving an overall production rate of 102% in the first half year after take over of the plant.

**ANNEX.:**

| Results of Performance Test Abu Qir III (extract) | | | |
|---|---|---|---|
| **Description** | **Unit** | **Guarantee Value** | **Test Average** |
| **Ammonia Plant** | | | |
| Ammonia Plant Capacity | mtpd | 1,200 | 1,274.5 |
| Energy Consumption | Gcal/t $NH_3$ | 7.285 | 6.917 |
| Ammonia Concentration | wt.-% (min.) | 99.80 | 99.92 |
| $H_2O$ in Product | wt.-% (max.) | 0.20 | 0.08 |
| Oil in Product | ppm (max.) | 5.0 | 2.0 |
| **Urea Plant** | | | |
| Urea plant capacity | t/d min.<br>(melt to produce granules) | 1,750.0 | 1,848.4 |
| *Urea quality*: | | | |
| Biuret | wt % max. | 1.00 | 0.75 |
| Moisture | wt % max. | 0.30 | 0.26 |
| Crushing strength | kg min. for 3.15 mm fraction | 3.00 | 4.05 |
| *Screen analysis of final product[1])* | | | |
| Medium size | % min. (2 <= x <= 4 mm) | 90.00 | 90.97 |
| Undersize | % max. (<1 mm) | 1.00 | 0.64 |
| Urea dust in effluent air | mg/$Nm^3$ air max. | 50.00 | 30.07 |
| $NH_3$ loss granulation scrubber | mg/$Nm^3$ air max. | 155.00 | 87.24 |
| Urea granulation plant capacity | t/d min. granules (46.2%N) | 2,000 | 2,231 |
| [1)] screen cloth was changed on request of AFC before test run to achieve bigger granules | | | |