

Advisory Review of the Environmental Management  
Plan (EMP) for operation of the Temane Well-sites,  
Flowlines, Access Roads and a SASOL  
Petroleum Temane (SPT) Plant  
- Mozambique -

27 May 2004

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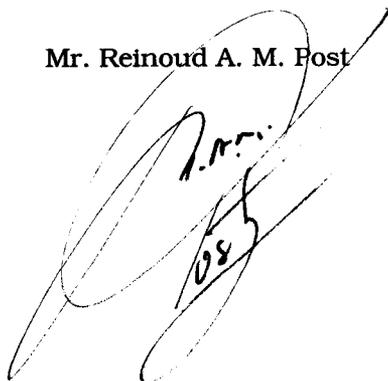
**Advisory Review of the Environmental Management Plan (EMP)  
for operation of the Temane Well-sites, Flowlines, Access Roads  
and a SASOL Petroleum Temane (SPT) Plant  
- Mozambique -**

Advice submitted to (MICOA), by a working group of the Commission for  
Environmental Impact Assessment in the Netherlands.

the technical secretary

the chairman

Mr. Reinoud A. M. Post

A large, stylized handwritten signature in black ink, appearing to be 'R.A.M. Post', written over the printed name.A handwritten signature in black ink, appearing to be 'M. J. J. J.', written in a cursive style.

Utrecht, 27 May 2004

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## APPENDICES

1. Letter from the Ministry for the Co-ordination of Environmental Affairs (MICOA) d.d. 29 December 2003 requesting the Netherlands Commission for EIA to advise on reviewing the Environmental Management Plan (EMP) for operation of the Temane Well-sites, Flowlines, Access Roads and a SA-SOL Petroleum Temane (SPT) Plant in Mozambique
2. Information on the Project

# **1. INTRODUCTION**

## **1.1 Description of the initiative**

In October 2000, Sasol Petroleum Temane Limitada (SASOL), Empresa Nacional de Hidrocarbonetos de Moçambique, E.P. (ENH), Companhia Moçambicana de Hidrocarbonetos S.A.R.L. (CMH) and the government of Mozambique signed a Petroleum Production Agreement for the production and processing of the Temane and Pande gas fields in Inhambane Province, Mozambique. The gas produced will be exported to Secunda in South Africa via an underground pipeline.

In Mozambique, the project develops the following activities:

- exploration activities over the life span of operations;
- development of a network of wells and flow lines in both gas fields;
- construction and operation of a Natural Gas Plant (STP) for cleaning and drying of the gas;
- construction and operation of a pipeline system to transport the gas to Maputo and Secunda.

Environmental Impact Statements have been produced for the various components of the project. These EISs have been submitted to MICOA for review and approval.

On January 8<sup>th</sup> 2004, pending formulation of the final environmental license, the Ministry for the Co-ordination of Environmental Affairs in Mozambique (MICOA) provided a temporary licence for all project components.

Specific and separate Environmental Management Plans (EMP) will govern environmental management of the various components. The final draft of the EMP for the STP plant, associated well sites, flow lines and access road infrastructure has now been submitted to MICOA for review.

## **1.2 Rationale and mandate for this advisory review**

By letter, dated 29 December 2003 (and received by e-mail on 27 January 2004 (see appendix 1)), MICOA requested the Commission to assist in reviewing this EMP, focussing on emissions. In order to respond to this request, the Commission composed a working group. Its composition is given in appendix 2. The working group acts on behalf of the Commission and is therefore referred to as 'the Commission'. The working group includes the following disciplines: Environmental Management Plans, gaseous, liquid and solid emissions of Gas exploitation and treatment and Environmental Licensing.

## **1.3 Justification of the approach**

Seen the character of the request, and the straightforwardness of the projected activities and their advanced stage of realisation, MICOA and the Commission agreed that a site visit would not be necessary and that a desk study of the documentation would suffice for the review requested.

This advisory review focuses on issues that may be problematic and may need regulation in the environmental license. It reviews the Environmental Management Plan (EMP) on basic concepts of the development of a new gasfield without extensive knowledge of the fields at the start of the project. The review takes general experiences from existing operations under similar conditions as a reference. It supports the EMPs on certain matters and indicates possible alternatives on other matters.

Due to absence of locally enacted environmental standards, the Commission will, as indication, compare emission levels with Dutch and EU standards.

This review is based on the documentation that MICOA has provided:

1. Environmental Management Plan. Operation of the Temane Well-sites, Flowlines, Access roads and a SASOL Petroleum Temane (STP) plant. Report no. 7 Final Draft – English, version 4, December 2003.
2. Documents requested at meeting held on 15 December 2003 for Environmental Management Plan. Operation of the Temane Well-sites, Flowlines, Access roads and a SASOL Petroleum Temane (STP) plant.

As the documentation did not include information on a number of topics in the project (such as the well-site drilling, operation and well maintenance, flow lines, the landfill construction, soil management, the pipeline and general infrastructure), this advisory review specifically addresses the licensing of the STP plant.

#### 1.4 Reading instruction

Chapter 2 provides major observations and recommendations. In general, each paragraph in chapter 2 provides observations and considerations and ends with suggesting issues to be addressed in the license. Chapter 3 provides some additional suggestions for licensing conditions.

## **2. OBSERVATIONS AND RECOMMENDATIONS**

### 2.1 General

The EMP and the additional documentation indicate that the natural gas is relatively clean, which means that it has low levels of sulphur, mercury and other contaminating components. In addition, the EMP indicates that:

- the central processing plant separates condensate from gas and water and dries the gas with glycol to export qualification;
- consecutively, the gas is exported via a pipeline system to South Africa;
- the production water generated by the process is disposed via dedicated injection wells;
- the plant uses part of separated hydrocarbons as energy source in a gas turbine and in compressor stations;
- the remainder is removed by road tankers or re-injected in the Temane-23 well, flared or burnt in an open pit;
- an incinerator furnished with flue gas treatment systems incinerates the solid and liquid waste;
- all installations comply with international standards; and
- all processes are manageable and controllable.

The Commission holds the opinion that the EMP provides a good basis for developing management of the environmental impact by SASOL and the Mozambican government. In the following paragraphs, the Commission provides some points which need special attention.

The Commission fully supports the overall strategy of the company to the management of waste related to the entire project. The company demonstrates to take first line responsibilities for this critical issue and presents an operational approach that is in accordance with this strategy. The circumstance of having available a low level of external services for waste management and other industrial services, imposes a responsibility upon the company, which the company seems prepared to take up. From the documentation, however, the Commission is unable to judge whether this is the case for all elements of the project (e.g. the landfill).

## 2.2 Gas Composition

The Commission also observes, that several of the current proposals for plant design, waste treatment and water treatment are based on limited information on the gas composition of only one well in one gas-field (Temane), while also a second gas-field (Pande field) will be taken into production, be it at some later stage. In addition, the Commission observes that this project can clearly not build on historical experience (information) from existing operations.

This implies that there are considerable uncertainties that have not been adequately addressed in the EMP, whereas they have a significant effect on the selection of alternative options.

Also, the uncertainty in relation to the gas composition of the Pande field has not been addressed in the EMP.

- The Commission recommends to address the likelihood of deviating gas compositions and the consequences thereof for plant design and waste management.

### 2.2.1 Mercury in natural gas

In the reports submitted with the EMP, mercury has been observed as a contaminant in the well-stream samples. The concentration found was relatively low. However, in early stages of gas exploitation projects the accuracy of gas-sample analyses with respect to mercury is generally not very reliable and experience shows that actual levels prove to be usually higher. The impact of mercury on the design of the plant is significant, which has been experienced in other areas (e.g North-West Europe, Thailand, Oman, Algeria). This implies that a special treatment step will have to be included in case mercury proves to be present in higher quantities. In all cases mentioned, the operations were caught by surprise shortly after start-up, because the mercury issue was not recognised in an early stage of the project.

*If the mercury levels are indeed as low as the gas-sample indicates, no extra measures will have to be taken. However, it is better to have the situation of occurrence of higher mercury levels addressed in the EMP.*

- *Proposed license condition:*  
*In the license a special monitoring programme on mercury will have to be included with the objective to clarify this critical aspect during the initial phase of the project. The company will have to submit periodic (on a weekly to monthly basis) analyses of samples of a number of selected emission outlet for gas, liquids and solid waste, such as:*
  - *Produced water*
  - *Condensate*
  - *Export gas*
  - *Filters from glycol regenerator**Once a more conclusive decision can be made on the basis of this initial monitoring programme concerning the possible occurrence of mercury in the gas-stream the frequency of analysis can be reduced to a monthly or quarterly analysis. A reporting system on the mercury issue will have to be specified in the permit for the period until the time that the absence of mercury has been positively identified.*
  
- *Proposed license condition:*  
*In the license a specific regulation will have to be included in which the following matters are covered:*
  - *the company will be required to submit a plan for the modification of the plant in case mercury is positively identified;*
  - *how the mercury waste will be handled in that case;*
  - *the conditions that will lead to temporarily closure of the wells in order to make the identified plant changes.*

### **2.2.2 Production water**

Another important uncertainty is the quantity of production water. The production of this water may increase considerably during the lifetime of the project due to the influx of formation water. This will impact on the volume of water to be handled and on the composition of the produced water, in particular on the salinity. No specific information in the submitted documents is presented on this matter and in the way it will be handled. Such information will have to be communicated via the sub-surface specialists to the production engineers in order to be able to size the treatment facilities. In the documents submitted only a very general reference is made to the gas/condensate and the gas/water ratio, but no additional discussion of the topic has been presented.

- *Proposed license condition:*  
*In order to be prepared for these gradual changes in the production water management it is recommended that MICOA addresses this issue in the permit by specifying the reporting of key information on a regular basis. It is noted that the production organisation will collect this information anyhow for management of the gas-field. The permit should therefore include a provision that information is submitted on a monthly basis on:*
  - *Volume of production water in relation to the gas-production;*
  - *Composition of the production water (salinity and other standard parameters);*
  - *Any anomalies observed in the pattern.*

## 2.3 Specifics on emissions to the atmosphere

### 2.3.1 The Gas Treatment Facility (STP)

- The natural gas to be processed and conditioned in the gas treatment facility (STP) is relatively “clean” according to the Air Quality EIA table 1.1.

According to this table, the gas contains low amounts of sulphur components (H<sub>2</sub>S), Hg and metals. Emissions to atmosphere are directly related to the gas quality. This quality can vary over time during the whole production period. Therefore, the composition of the gas should be monitored and in case of deviations appropriate measures should be implemented to limit air pollution. Especially H<sub>2</sub>S and Hg are important in this respect.

- *Proposed license condition:*

- See 2.2 for the proposed condition on the monitoring of the gas composition

- The emission from the TEG regenerator is either emitted in the atmosphere or sent to the flare. The regenerator outlet contains BTX (Benzene, Toluene and Xylene). Benzene (C<sub>6</sub>H<sub>6</sub>) emissions require special attention as Benzene is a carcinogenic agent. The emission limit value for benzene in the Netherlands is at the moment 1 mg/m<sup>3</sup>. Neither the proposed emission of these gases in the atmosphere, nor their introduction in the flare can be regarded as best available technology (BAT).

- *Proposed license condition :*

- The emission from the TEG regenerator and other substantial process emissions must be re-routed in the process (fuel-gas system), adsorbed (by activated carbon technology) or incinerated in a dedicated thermal or catalytic incinerator. The flare system may only be used incidentally for upset conditions and for cases mentioned in 2.1.2 of the Air Quality EIA and not for the regular incineration of process emissions. A report must be sent to MICOA within 6 months after start-up on the technical measures needed to implement (retrofit) in order to fulfil this requirement.*

- The Commission suggests the use of low-NO<sub>x</sub> technology, especially for the “significant amounts of NO emitted by the gas-turbines” mentioned in the EIA. For gas-turbines a maximum of 45 g/GJ is set in license conditions in the Netherlands and 65 g/GJ in the European Large Combustion Plant (LCP) Directive. Most gas-turbine suppliers (amongst others General Electric and Siemens) guarantee a maximum level of 45g/GJ.

- *Proposed license condition:*

- The NO<sub>x</sub> emission from the gas-turbines at full-load is not allowed to be higher than 45 g/GJ. A continuous NO<sub>x</sub> stack monitoring and registration must be implemented.*

- The fugitive emissions of Volatile Organic Compounds (VOC) due to leakage of flanges, valves and seals can be significant, if not controlled in an adequate manner. This is also stated in the 2001 Environmental Impact Statement made for SASOL, however not addressed in the EMP. In the Netherlands, a structural yearly leakage measurement and repair program is part of the license conditions. This program is based on a detailed national “protocol”, that at the moment is regrettably not available in English. Similar programs however are established by the US Environmental Protection Agency (EPA) and probably available from the EPA.

- *Proposed license condition:*  
*Within 6 months after start-up a plan for structural yearly leakage measurement and repair program for flanges, valves and pump-compressor seals must be sent for approval to MICOA. This plan must contain an inventory of emission points and emissions according EPA-453/R.93-0206.*
- The considerable VOC emission from the condensate storage tanks TK 9201A/B of 85 tons/year should be eliminated. This could be done, for instance, by recompressing and re-routing them in the process (fuel-gas system). The Commission could not find data on the composition of this emission in the reports submitted for review.

Equally, the Commission could not find data for the emission caused by loading 1500 barrels/day of condensate into road tankers for export. In the Netherlands, application of vapour recovery or a vapour return system is a standard part of the license conditions for both storage tanks and truck-loading.

Furthermore, the breathing and working losses from floating roof tanks are reduced by double seals for substances with a vapour pressure superior to 14kPa, according the Air Quality EIA. In the Netherlands double seals are already required for substances with a vapour pressure above 1kPa.

- *Proposed license condition:*  
*Within 6 months after start-up, a report must be sent to MICOA containing:*
    - *Quantification of emissions from the condensate storage tanks and the truck-loading facilities;*
    - *Engineered technical measures, notably vapour return or vapour recovery systems, to be implemented (retrofitted) in order to limit the emissions with best available technology.*
- The Marpol and IMO standards mentioned in the EMP, are not relevant for truck-loading (see section 2.1.1. in the EMS/Metago report on air Quality Impact Assessment).

### **2.3.2 The waste incinerator**

For the proposed Solid Waste Incinerator, the Air Quality EIA provides only limited information on emission/immission. The EMP claims compliance of the “SPT agreement” with World Bank requirements. It includes only limited information on monitoring. In the EU, the Directive 2000/76/EG<sup>1</sup> on Waste Incineration is in force. This directive sets, amongst others, emission concentration limits for all the substances emitted. In the Netherlands, this Directive is considered to represent Best Available Technology (BAT) at this moment.

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<sup>1</sup> (dated December 4th 2000)

- *Proposed license condition:*  
*Within 6 months after start-up a report must be sent to MICOA in which is worked out the compliance with the emission standards given in the EU Directive 2000/76/EG on Waste Incineration. Furthermore a comparison must be made between this Directive and the standards in the "SPT agreement", mentioned in the EMP.*

## 2.4 Effluent management

- The documents indicate that production water will be re-injected into dedicated injection wells. These wells are completed in a sandstone rock below the gas bearing reservoir. The Commission considers it important to discuss this disposal option in more detail, because it is crucial to the continuity of the gas treatment process. Typical issues to be discussed are the design of the injection well(s), the availability of the well(s) at start of the project, the back-up options, the injectivity of the well in relation to water composition, treatment of the water to prevent corrosion, a monitoring programme for the well, etc.

It should be noted that injection of production water as described in the EMP, i.e. in a rock formation below the gas-bearing layer, is considered an environmentally sound option, because the risk of surface contamination is avoided. This is particularly the case if the production water is saline and contaminated with hydrocarbons. It is also an option to consider other effluent streams for injection instead of disposal via a surface outlet, in particular the industrial effluents from closed and open drain systems and from well maintenance activities. The EMP proposes to treat these effluents from the gas treatment plant in a dedicated facility based on a Dissolved Air Flotation (DAF) unit with an average flow of 2-3 m<sup>3</sup>/day and with a fluctuating rate. The Commission notes that a DAF system is not designed to handle strongly fluctuating flowrates and streams that have varying compositions and contaminations. It is common practice to add these effluents to the produced water and prepare that mixed stream for re-injection.

From the available documentation, the Commission is unable to identify reasons to deny the option of re-injecting these liquid waste streams as well, a solution that for environmental reasons is to be preferred. In addition, the EMP states that TEG contaminated water will be kept separate, collected and incinerated. Also this effluent stream should be considered for injection as an alternative to incineration.

- *Proposed license condition:*  
*The Commission recommends to address in the license the following items to monitor the performance of water injection and to report on a monthly basis:*
  - *Analysis of the well-performance in terms to injectivity index, and wellhead pressure versus flowrate;*
  - *Composition of the injection water in terms of suspended matter, salinity and organic components (e.g. hydrocarbons, TEG);*
  - *Consumption of water conditioning chemicals;*
  - *Reporting of the volume of injection of effluent streams other than production water;*
  - *Reporting of up-set conditions;*
  - *Any well-maintenance activities carried out.*

- The Effluent treatment Plant is not meant to treat production water with subsequent surface disposal of this water-source. It is therefore essential that the production water is always injected and that the operator will have to arrange for a back-up injection option in case the injection well can not handle the water. Availability of sufficient injection capacity at any time is considered essential to the project.
  - *Proposed license condition:*  
 The Commission recommends to include in the licence such conditions that will guarantee the re-injection of production water at any time. These conditions would have to impose the shutdown of operations in case production-water cannot be re-injected or stored in the Produced Water Storage system.
- If re-injection of effluents from the closed or open drain system is technically not an option, then these streams will be routed via the Industrial Effluent Treatment Plant mentioned in the EMP. The composition of these effluents is dependent on the substances in the natural gas to be treated, which can vary over the whole production period. Therefore, the July 2002 Metago report on the “Management of Effluent” recommends<sup>2</sup> the development of a contingency plan in case inorganic contaminants (salts and heavy metals) become contaminants of concern. This advice is not worked out in the EMP, although a good online monitoring protocol on various parameters, including metals, for every effluent release is provided on page 55 of the EMP.
  - *Proposed license condition:*  
 A contingency plan on the Management of effluent, as mentioned in the 2000 Metago report must be submitted for approval to MICOA.

## 2.5 Condensate Management

- The condensate separated from the raw gas will be stored at the location and trucked away to Beira. The storage capacity is limited to about 8 days. The first back-up option for removal of condensate in case of interruption in the logistics will be re-injection in a dedicated well (Temane-23 well). It is not specified how this will take place and how this has been incorporated in the design of the plant. Furthermore, storage in an open pit and subsequently burning it in the open air is mentioned in case no other options are available. It has been calculated that the risk of reaching this situation is very remote. The Commission is of the opinion that more specific background information to support that conclusion should be presented.
  - *Proposed license condition:*  
 Burning of condensate in the open air pit is not allowed. At all times enough storage capacity must be available to store condensate in case of upsets, for instance disruption in the re-injection system. If needed the production must be interrupted to fulfill this requirement.

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<sup>2</sup> on page 15

- The EMP does not present information on condensate management in sufficient detail, whereas it has an important environmental impact both in relation to plant operations and downstream logistics (transfer, trucking and storage at Beira).
  - *Proposed license condition:*  
Because of the inter-linking with the plant operations, the Commission recommends to present the situation at Beira in more detail, before making a final assessment on the condensate matter.

## 2.6 Waste management

### 2.6.1 Overall analysis

The EMP includes a detailed overview of the different types of waste and effluents that will be produced during operations and maintenance activities. No obvious waste streams have been missed in the overall analysis. Also, a good distinction has been made between so-called “general waste” categories and “industry specific waste” categories. This second category requires special attention from the operator, even in countries where a high level of industrial services is available to the oil & gas production industry. Attempts have been made to find solutions for all types of identified waste streams.

### 2.6.2 Integrated assessment of waste streams

The EMP presents a strong emphasis on the treatment plant during the construction and operation phase. The Commission observes that the entire project includes also an ongoing exploration activity with the drilling of some 35 wells during the lifetime of the project.

The drilling and the maintenance activities of these wells will generate large volumes of additional waste streams with an industry specific character and also much more general waste at a more or less constant level. In general, the drilling activities will even produce substantially more waste than the gas-plant during normal operations. The waste generated will require a dedicated waste treatment location where drilling mud and cuttings can be collected and treated. Such a site will also need an infrastructure to store other types of drilling related waste.

- *Proposed license condition:*  
The Commission recommends to cover in the license the following elements:
  - A standard reporting system for all categories of produced waste will have to be in operation at the start of the project. This system will have to specify the type of waste, volume of waste, the disposal destination and the period of time covered in relation to these data;
  - The reporting system has to be agreed upon by the competent authority and will have to be submitted on a quarterly basis;
  - Efforts to minimise the impact of waste will have to be highlighted;
  - The system should be integrated with other waste streams reported for other parts of the project.

### 2.6.3

#### Waste incinerator

Detailed efforts have been made in the EMP to select the preferred method of waste disposal for a number of possible waste streams. The final conclusion has been reached that a dedicated waste incinerator, operated by the company itself, is the first choice. Given the local circumstances, the Commission supports this conclusion. It should be realised, however, that the operation of a small-scale waste incinerator in an oil & gasfield environment is not a standard situation. It will require a dedicated effort to incorporate this type of activity into the routine operations. In order to be prepared to operate this type of activity in a reliable way, special contractual arrangements with the supplier will be required and the unit costs for treatment will be high.

There is relatively little practical information on the application of small-scale waste incinerators in oilfield operations in areas with a limited infrastructure or general services. However, in various current projects this type of waste treatment is being considered.

Selection criteria are e.g.:

- The supplier, the record of experiences elsewhere with thorough analysis of the performance statistics (down-time, repairs, services, etc).
- Inclusion in the contract of a service and maintenance package from the supplier. Offers without such a package should not be taken into consideration.

For the selection of the incinerator, also the supply of waste from drilling and well maintenance operations should be taken into account.

■ *Proposed license condition:*

*Given the sensitive situation of waste disposal via incineration with a stand-alone small-scale incinerator, the Commission considers it important to cover this subject in the permit with a number of regulations. These include:*

- *The contract with the supplier must include a service package that guarantees repairs at short notice after breakdowns. The proof must be demonstrated via contract submission;*
- *The operator must have a fall-back option developed in case of failure to operate the incinerator as designed;*
- *The incinerator must be made available to other parts of the Sasol facilities producing waste that can best be handled in the same way (e.g. drilling related calorific waste streams);*
- *The performance statistics of the incinerator must be reported separately. Information must include:*
  1. *Operating period;*
  2. *Volume of waste treated;*
  3. *Operating conditions, such as temperature readings, fuel consumption, etc.;*
  4. *Volume of inert material to be disposed off.*

### **3. ADDITIONAL SUGGESTIONS FOR LICENSING CONDITIONS**

The Commission recommends to address the following issues in the license conditions:

- Compliance to legislation, including results of audits (EMP 3.3.2/page 29)
- Bringing the Environmental Management System in line with ISO 14001; Approval of the Environmental System Manual by MICOA (EMP 3.3.4/page 29);
- Reporting: the Commission recommends that the license specifies what should be reported annually and what should be reported on a more frequent basis (at least one would think of an obligation of direct reporting on major spills and upsets) (EMP 3.5.7/page 33);
- Government liaison: The Commission recommends working out effective governmental inspection/enforcement arrangements(EMP 3.5.9/page 33);
- Emergency response: The Commission thinks it is of crucial importance that MICOA approves the emergency response plan (EMP 3.17.12/page 49);
- Minimum audit requirements: The Commission thinks that the annual independent auditing mentioned in the EMP is a good practice and in line with EU standards, especially during the first 3 years of operation. It is also suggested that MICOA be involved in auditing (EMP table 4 page 66).