Chevron

DUMAI BASE OILS PROJECT FEASIBILITY STUDY

FINAL REPORT

Volume I of II

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This report was prepared by Fluor Daniel , Irvine, California with the cooperation of Pertamina, Chevron, Fluor Daniel & the process licensers.

The principal objective of the study were to

(A) Evaluate the feasibility of producing approximately 6000 BPSD of high quality lube base oils at Pertamina's existing UP-II refinery at Dumai, Sumatra using Chevron Research & Technology Co.'s hydroprocessing technology.
(B) Establish preliminary process configuration & definition for the new lube base oils complex, including utilities, & infrastructure.
(C) Provide estimate of capital & operating cost for the new facilities.
(D) Assess the economic viability of the alternatives under consideration to allow selection of the best process configuration
(E) Suggest execution plan & schedule.
(F) Identify potential U.S. sources for goods & services.
(G) Provide a list of technical issues for the next phase of the project

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The following companies have provided Information which is contained in these volumes:

Chevron Research & Technology Company
Pertamina
Universal Oil Products (UOP)
Kerr McGee
Fluor Daniel

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1.0 EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

1.1 Overview

This section of the Final Report summarizes the results of the Feasibility Study for the Dumai Base Oils Project (DBOP). The results of the study reflect and comply with the conceptual goals and objectives as stated in the Terms of Reference, kickoff meeting, conference notes, and other documents developed during the study.

The study work was performed in Fluor Daniel's office in Irvine, California from the end of July 1992 until July 1993 and was funded by Pertamina, the U.S. Trade and Development Agency (TDA), Chevron, and Fluor Daniel. The project team consisted of Fluor Daniel and Chevron personnel and a Pertamina representative. Valuable support was also provided by Pertamina's project and UP-II Refinery personnel. Chevron, UOP, and Kerr-McGee were the process licensors. Throughout the study there was a high degree of cooperation and exchange of information among Pertamina, Chevron, Fluor Daniel, and the process licensors.

The principal objectives of the DBOP Feasibility Study were to:

- Evaluate the feasibility of producing approximately 6,000 BPSD of high quality lube base oils at Pertamina's existing UP-II Refinery at Dumai, Sumatra, Indonesia using Chevron Research and Technology Company's hydroprocessing technology. The lube base oils were to be produced from feed stocks derived from Minas, Duri, and Pedada crude oils. Four cases were to be considered.

- Establish preliminary process configuration and definition for the new lube base oils complex, including utilities, offsites, and infrastructure.

- Provide estimates of capital and operating costs for the new facilities to allow economic assessment and selection of the best alternative case.

- Assess the economic viability of the alternatives under consideration to allow selection of the best process configuration.

- Suggest a probable scenario for implementing the project with an overall execution plan and schedule.

- Identify potential U.S. sources of supply for goods and services to satisfy a request from the U.S. Trade and Development Agency (TDA) in Washington D.C.

- Provide a list of critical technical and commercial issues that should be addressed during the next phase of the project.

All of the above study objectives have been achieved. The information contained in this Final Report can be used by the Consortium members as a:

- Basis for selecting the best process configuration alternative

- Reference document for additional technical and economic analyses of the proposed project

- Source for information to promote investment in the project from potential joint venture partners and commercial lenders

- Basis for planning the execution and further development of the project.

From August, 1992 through May, 1993 Chevron performed a pilot plant feasibility study, which is referred to as the Yield Confirmation Study (YCS) in this report. The YCS was undertaken to provide information on yields and product qualities from Chevron Lube Isocracker and Isodewaxer processes using heavy vacuum gas oil (HVGO) samples obtained from the UP-II Refinery as a feedstock. The YCS results were used to adjust the study basis. They are discussed in detail in Section 9.3.

Two versions of this Final Report have been prepared. The first, referred to as the "Consortium Version," contains the complete study information and findings. The second version (the "TDA Version") has been edited to remove all information considered to be confidential by the Consortium members and process licensors.

1.2 Project Description

High quality base oils will be produced at a new facility to be built within and integrated with Pertamina's existing UP-II Refinery, which is pictured on the following pages in Figures 1-A and 1-B. Feedstock for the new complex will be either virgin HVGO or a combination of HVGO and deasphalted oil (DAO) produced from High Vacuum Unit (HVU) residue. Incremental feed for the new facilities will be derived from additional low sulfur waxy residue (LSWR) from Pertamina's existing Sungai Pakning Refinery. The existing High Vacuum Unit will be debottlenecked, as required, to provide the required HVGO feedstock. In addition, the need for debottlenecking the existing Coker Unit and other ancillary systems was defined as part of this Feasibility Study.

The DBOP is currently envisioned to be a stand-alone, private investment, referred to in this study as "The ABC Lube Base Oils Company." To capitalize on its proximity to Pertamina's existing UP-II Refinery, DBOP will acquire feedstock, hydrogen, and certain utilities from Pertamina. It will return light products (mostly transportation fuels) generated in the base oil manufacturing process for integration into existing UP-II Refinery production. Product base oils will be exported by the DBOP Owners or its Offtakers.

Neither the identity of the initial DBOP Owners nor the commercial structure of their venture can be confirmed at this time. Therefore, the precise terms and conditions applicable to the acquisition of feedstock, hydrogen, and utilities from Pertamina are not known. The same circumstance is true regarding the return of light products from DBOP to the UP-II Refinery.

In contrast, the incremental change in the flow of LSWR into and products out of the UP-II Refinery resulting from the addition of DBOP can be accurately quantified and priced based on the available market prices.

Figure 1-A. Dumai Refinery: Looking North

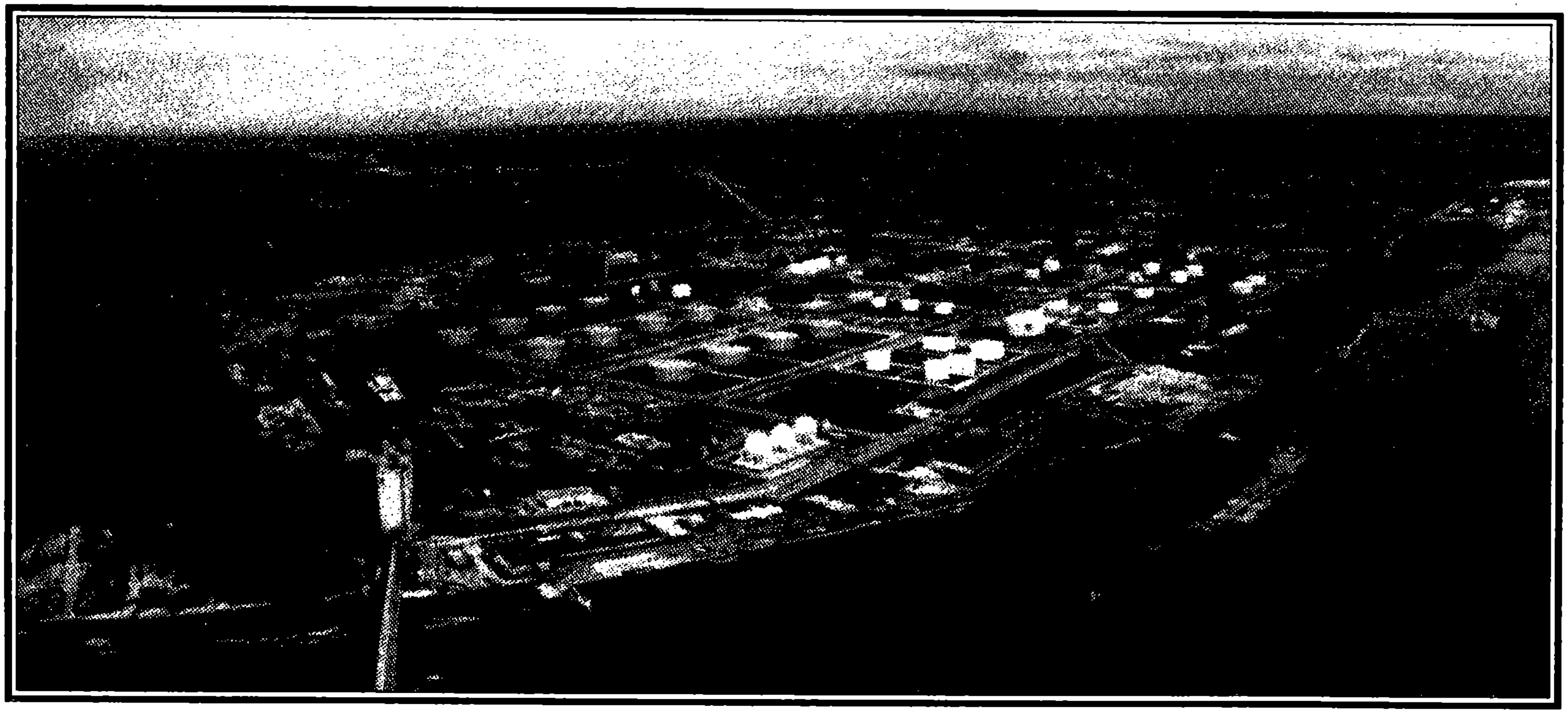

Figure 1-B. Dumai Refinery: Looking South

Therefore, DBOP can be evaluated financially by comparing the value of all DBOP products against the sum of the costs of incremental LSWR feed, plus additional capital equipment supplied by DBOP (to produce base oils and meet incremental hydrogen and utility requirements), plus incremental operating expenses paid by DBOP for new facilities. This simplified model has been selected for performing the DBOP financial evaluations.

1.3 Process Configuration

The scope of work of the DBOP Feasibility Study included four Cases, as summarized in the following Table 1.1. The objective is to produce about 6,000 BPSD of light, and heavy neutral base oils and bright stock in varying quantities, depending on the individual case. They include the following:

Case 1: Stand alone Lube Base Oils Complex, including Lube Isocracker, Isodewaxer, and Hydrofinisher Units and debottlenecked UP-II Refinery Coker and High Vacuum Units.

Case 2: A converted existing UP-II Refinery HC Unibon train, a new Lube Base Oils Complex, including Isodewaxer and Hydrofinisher Units, and debottlenecked UP-II Refinery Coker and High Vacuum Units.

Case 3: Stand alone Lube Base Oils Complex including Lube Isocracker, Solvent Deasphalting (SDA), Isodewaxer, and Hydrofinisher Units and debottlenecked UP-II Refinery Coker and High Vacuum Units.

Case 4: A converted existing UP-II Refinery HC Unibon train, a new Lube Base Oils Complex, including Solvent Deasphalting, Deasphalted Oil Hydrocracker, Isodewaxer, and Hydrofinisher Units and debottlenecked UP-II Refinery Coker and High Vacuum Units.

During the course of the study, Cases 1 and 2 were evaluated in detail, while Cases 3 and 4 were only evaluated at a conceptual level, as directed by the Consortium.

[The information contained on page 1-7 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

During the development of the study, it became apparent in Cases 1 and 3 that the existing UP-II Refinery HC Unibon units were not being fully utilized to produce incremental middle distillates over the Base Case rates. Therefore, a study was undertaken to further debottleneck the existing Hydrogen Plant and High Vacuum Unit to more fully utilize the existing HC Unibon Units to produce additional middle distillates. This study referred to as "UP-II Balanced Operations," is discussed in detail in Section 9.2.

In January/February 1993, UP-II plant performance tests were undertaken to determine the maximum capacity of the existing Hydrogen Plant and High Vacuum Unit and confirm bottlenecks identified during paper studies.

The following process information was developed by Fluor Daniel or the process licensors for the overall lube base oil complex for each study case:

- Preliminary material balances
- Simplified process flow diagrams or sketches
- Process Licensor data
- New utility requirements and summaries
- Effluent and emissions summaries
- Equipment lists and equipment descriptions
- Catalyst and chemical requirements
- Modifications required to the existing UP-II Refinery facilities.

Descriptions of the various process units, utilities, offsite systems, and infrastructure were also developed, along with preliminary plot plans of the new facilities.

1.4 Capital Cost Estimates

Capital Cost Estimates for the process, offsites, and utility units were prepared primarily by using Fluor Daniel's equipment-factored estimating program (EXPONE). A semi-detailed method was used for common facilities, such as infrastructure, interconnecting piping, etc. Vendor pricing information was obtained for most major equipment items. This approach achieved a level of confidence corresponding to a contingency level of 22% for Cases 1 and 2 and 25% for Cases 3 and 4. Chevron also engaged an outside consulting firm, Independent Project Analysis, Inc. (IPA), to perform an independent assessment of the cost risks for the project. Their results agreed quite closely with Fluor Daniel's recommended contingency levels.

The Total Project Costs included both traditional EPC Contractor's Costs and Owner's Costs, and covered the period from Feasibility Study completion through start-up of the facilities. The EPC Contractor's Costs included costs for activities ranging from the preparation of a project definition document (PDD) through to detailed engineering, procurement, and construction of the facilities. A 6% annual escalation factor was used throughout the life of the project. Owner's Costs included process licensor fees and royalties, start-up costs, land acquisition, governmental fees and permits, the initial charge of catalysts and chemicals, etc. A 3% annual escalation factor was applied to a portion of the Owner's Costs.

A summary of the total Project Costs for all four cases is presented in the following Table 1.2.

Two other, separate cost estimates were prepared in addition to the main Capital Cost Estimates. These rough-order-of-magnitude estimates were requested by Chevron and Pertamina for two alternate modifications under consideration. The first involves an alternate Lube Base Oils Complex facility site location, while the second assesses the cost of providing a new river water pipeline system in lieu of additional raw water storage facilities. These alternate Capital Cost Estimates are presented in Section 9.3.3.

1.5 Execution Plan

To support the capital cost estimate and financial evaluations, Fluor Daniel developed, with Chevron's assistance, an Overall Project Schedule (Figure 1-C on page 1-11). This schedule indicates that approximately ____ months will be required to execute the project, starting from Feasibility Study completion and continuing through start-up of the facilities and production of lube base oils. Twenty-four months of the schedule are allocated for Phase II (Project Definition) activities and for securing project financing for Phase III (EPC Contract Period).

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[The information contained on page 1-11 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

1.6 Financial Evaluation

A very important activity of the study was the development of a quantitative basis for understanding the project's ability to repay loans and provide suitable returns for equity investors. This activity included:

- Development of Preliminary Financing Structure with potential sources for debt funding and likely terms and conditions.
  - Based on available guarantees of debt repayment, it is planned that a limited recourse project finance structure would be employed.
  - *[This deleted information is considered confidential and proprietary.]*
  - Loan to equity ratio of 3:1 is assumed in the evaluation.
  - The terms and conditions under which debt would be provided for the commercial loan assumes a 5-year drawdown period and a 7-year repayment period at 12% interest per annum. The Export Credit Loan assumes a 5-year drawdown period with a 10-year repayment period at 8% interest per annum.
- Development of preliminary marketing data by Chevron and the joint agreement with reaction of world prices for the products produced by the complex.

The economic evaluation was based on a simplified financial model (UP-II Financial Model), described in detail in Section 6.2.1. The model assumes that the Lube Base Oils Complex is a part of the UP-II Refinery. The major parameters which enter into the model include incremental product revenues, incremental feedstock costs, incremental operating expenses, working capital, and DBOP capital costs.

For the financial analysis, a computer model was developed by Fluor Daniel which used a preliminary financing structure to calculate returns to investors and total investment, debt coverage ratios, and projected cash flow and income statements for the construction period and operating life of the project. The analysis also evaluated the sensitivity of the returns to changes in key factors such as feedstock prices, capital costs, construction delays, revenues, and operating days.

Key assumptions used in the financial analysis include:

- Five years of construction followed by twenty years of operation
- Production at 25% in first year and 100% thereafter
- General inflation escalation at 3% annually for feedstock prices, product prices, operating expenses and other owner's costs; 6% escalation on EPC and land costs
- 25% equity of Total Project Costs
- Tax rate 35%, 8-year, 25% declining balance depreciation
- 15% withholding tax on dividends
- Tax losses carried forward in the future years and offset against the profits when realized
- Financial Analysis - The information included in this analysis was developed during the study and includes:
  - Capital cost estimates for the complex
  - Estimated operating expenses
  - Current cost of feedstock
  - Current sale price of products
  - Annual escalation factors for the construction and operating life of the project

– Future feedstock cost and product sale prices calculated as the current cost or prices escalated by factors developed in the annual escalation factors.

1993 Feedstock and Product Prices

Feedstock	
LSWR	$15.00 per Barrel
Product Prices	
Lube Base Oils	____ per metric ton
Coke	$80 per metric ton

1.7 Conclusions and Analysis of Results

The information developed by the project team during the Feasibility Study confirmed many of the earlier technical assumptions developed by Chevron during their previous conceptual study: some of those earlier assumptions were modified during the course of the study particularly after the completion of the YCS. The major conclusions that resulted from the Feasibility Study are summarized below.

Technical Conclusions

- The Chevron YCS confirmed that a high quality lube base oil can be produced from HVGO derived from the Indonesian (Sumatra Light and Duri) crudes.
- The facilities will produce high quality lube base oils that can be marketed in the South East Asian, Western U.S., Japan, and European markets.
- The Lube Isodewaxer/Hydrofinisher produces high-quality light byproducts (diesel and kerosene) that meet or exceed the minimum specification requirements.

- The new facilities can be easily integrated into the existing UP-II Refinery. A Facilities Location Plan (Drawing 422700-AO-506; located at the end of this section) shows the proposed locations for the new facilities. An area of approximately 125 meters by 175 meters will be required for the new process units.

- Engineering and construction of the new facilities can be achieved with a minimum of disruption to the existing UP-II Refinery operations. However, close coordination and effective communications with the refinery will be essential.

- The project can be completed while complying with all current Indonesian laws and regulations including foreign ownership, environmental, and others.

- If further development of Cases 3 and 4 (SDA Cases) is deemed appropriate, additional feasibility study work will be required, as these cases essentially were not developed beyond the conceptual level.

- The processing facilities necessary to produce bright stock and heavy neutral oils as defined in Cases 3 and 4 can be added to the project at a later date.

- The project will require approximately ___ months to implement spanning the period from Feasibility Study completion to start-up and production.

- Test runs conducted at the UP-II Refinery confirm the High Vacuum Unit capacity developed during the study. In addition, test runs confirmed that the existing Hydrogen Plant capacity is adequate to meet the study requirements.

Financial Conclusions

The financial evaluation of the four complex configurations - Cases 1 through 4 - was based on a 100% equity and a 25% equity financial structure and an assumed financing plan.

In general, financial institutions look at the unleveraged 100% equity structure in order to determine the fundamental strength of a project, while potential equity participants or shareholders will assess project attractiveness based on the leveraged structure, i.e., 25% equity for this project.

It is also commonly recognized that potential returns tend to deteriorate as the financial analysis of a project develops from initial rough calculations towards more accurate and complete evaluations. In a preliminary feasibility study, financial institutions and potential investors will probably want to see returns in the 15%-20% range for the 100% equity case and between 20% and 25% in the case of 25% equity. Depending on their perception of risk, the acceptable returns will fall in the lower or higher end of the ranges. Given the preliminary nature of the data for the Dumai Base Oils Project and the current economic and political environment, we believe these entities will be conservative in their evaluation criteria.

- Case 2 has the least capital cost and is economically most attractive compared to the other three cases.

- For Cases 1 and 2, particularly Case 2, it would appear that the returns on the project would be satisfactory for financial institutions and an attractive investment for potential project participants. Cases 3 and 4 would be unacceptable under almost any circumstance. Presented below are the rate of returns and debt service cover ratios which favor Case 2 over the other cases.

[This deleted information is considered confidential and proprietary.]

- The rates of return are most sensitive to the product pricing. For example, in Case 2, a 15% increase in product price improves the ROE from ___% to ___%.

- The financial analysis uses a base price of $______ for lube base oils. From the sensitivity analysis it appears that only Case 2 could withstand lower prices. For example, in Case 2, a 15% lower base oils price will decrease the ROE from ____% to about ____%, which is still attractive.

- The impact of a 15% increase in capital cost on equity return is such that with lube base oil prices at $_____, Case 2 still remains attractive. As, historically, there is a tendency for project cost to increase, one might conclude that even with a moderate increase in plant cost, Case 1 would become less attractive.

- The assumed carry-forward of tax losses is a conservative approach that results in a lower rate of return. Absorbing tax losses in years incurred would improve returns and significantly help the debt-coverage ratios in the crucial early years of debt repayment.

- The impact of a 10% reduction in operating days on equity return is the most Case 2 could withstand before becoming unsatisfactory to investors and lenders. This amounts to 297 operating days per year for Cases 1 and 2.

- It appears that Case 2 would still be an attractive investment even if the LSWR price were to go as high as $19 per barrel.

- Equity returns appear to be relatively insensitive to the project schedule delays. For example, in Case 2, a schedule delay of six months will cause the ROE to drop marginally from _____% to _____%.

- Operating expenses have relatively small impact on returns.

- The financial results and profitability of the project will also depend on the extent of UP-II modifications DBOP would undertake and negotiated transfer prices of feedstock, byproducts, utilities, and services between the UP-II Refinery and DBOP.

1.8 Recommendations

There are several outstanding issues which must be addressed before the project can be successfully implemented. Not all issues are required to be addressed at the same time. To better plan for the next phase of the work, the near term issues and recommendations are segregated from other issues and are identified below.

Near Term Recommendations

The major near term issues associated with this project that should be addressed prior to commencement of the Phase II, Project Definition Document (PDD) development phase are summarized below.

- Investigate an enhanced Case 2 (referred to as Derivative Case 2), which should include additional Chevron pilot plant and capital cost optimization studies.

- Establish the optimum plant capacity.

- Develop a firm basis for the lube base oils product slate and product specifications.

- Evaluate the impact of other potential projects planned for the UP-II Refinery on the Dumai Base Oils Project.

- Reach agreement on the overall location for the new facilities.

- Establish the permitting requirements for the project.

- Identify and reach agreement on the potential Joint Venture partners for the DBOP.

- Identify the requirements of the financial institutions who may finance the DBOP.

- Identify all products, byproducts, feedstocks, effluent streams, utilities, and operating and maintenance services that are to be exchanged between the DBOP and the UP-II Refinery. Establish a basis for transfer pricing. The Feasibility Study project economic evaluation was based on a simplified overall "UP-II Financial Model." Confirm the project economic evaluation based on the agreed upon transfer prices.

The following major issues should be addressed in subsequent phases of the project are identified below:

Technical Issues

- Resolve any outstanding environmental issues (e.g., application of current and/or past regulations with respect to modified existing facilities).
- Review the need for reestablishing the Base Case definition.
- Opportunities exist to improve production of middle distillate products from the UP-II Refinery. This effort should be continued and extended further to optimize the integration of this project with UP-II Refinery operations.
- Firm-up the quality of waxy lube base stock from the existing HC Unibon Units, because the quality impacts the design of the downstream units. For example, the sulfur content dictates the metallurgy of the downstream lube units.
- Further review the operation and design modifications for all affected existing UP-II Refinery units, e.g., the Delayed Coker Unit, Vacuum Unit, Sour Water Treating Unit, etc.
- Determine what optimization studies are required (e.g., selection of steam turbine versus motor drivers for large power consumers, optimization of process unit heat integration, etc.).
- Confirm the lube base oil product shipping data (ship size, cargo size, ship frequency, etc.) used to determine product storage and shipping requirements
- Review the adequacy of the existing UP-II Refinery fire, safety, maintenance, laboratory, and other support facilities for meeting the DBOP needs.

Commercial Issues

- Project economics are dependent on the capital costs. Thorough review should be performed to reduce these costs to improve overall economics.

- The Ownership, financial structure, and governmental approval aspects of the project are key issues in developing the project. These issues will impact the capital costs and the economic viability of the project. These issues will begin to be addressed during the next phase of the project.

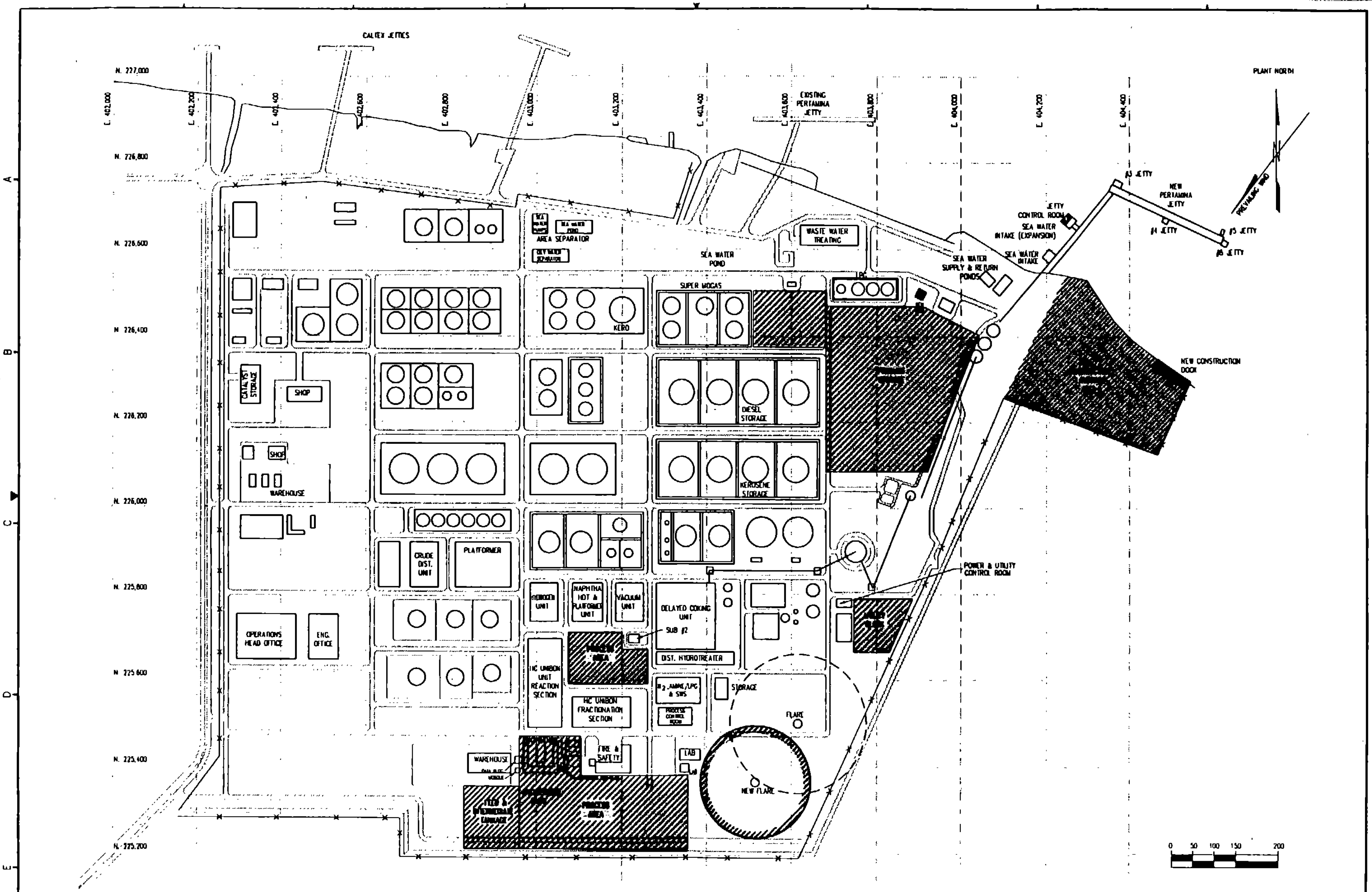
- An ongoing product market survey should be performed to confirm the product slate, location of markets, pricing, etc.

- The overall master schedule currently indicates a ___-month timeframe from Feasibility Study completion to the start of limited production of lube base oils. Emphasis should be placed on reducing the schedule to repay the debt earlier and further improve the profitability of the project.

- DBOP requires a significant amount of revamp work in the existing UP-II Refinery. Careful evaluation of any proposed upgrading of the existing facilities should be made to keep capital costs at a minimum.

1.9 Addendum

The Addendum (Section 9.0) is devoted to additional studies and adjustments including the "UP-II Balanced Operations" study, UP-II Plant Tests, and the results of Chevron's Yield Confirmation Study (YCS). This YCS was completed after the original Final Report was drafted. To help maintain consistency, the most appropriate way to include this information is in a separate section. Only Final Report Sections 1.0, 5.0, 6.0, 7.0, and 8.0 were updated to include adjustments due to the YCS. The other report sections were not modified or revised, instead, the YCS adjustments pertaining to those sections were incorporated into Section 9.3.



PERTAMINA/CHEVRON
DUMAI BASE OILS
PROJECT

FLUOR DANIEL

R. MANNING

FACILITIES LOCATION PLAN
DUMAI BASE OILS PROJECT

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PLOT-506

2.0 INTRODUCTION

2.0 INTRODUCTION

The writeup in this section was completed prior to the completion of the Yield Confirmation Study and may contain information which may not be totally accurate. However, the information presented here will assist the reader in understanding the Feasibility Study. The adjustments resulting from the Yield Confirmation Study are discussed in Section 9.3

Section 2.6 titled "Yield Confirmation Study" was completed after the issue of the Draft Final Report and completion of Chevron's pilot plant work in May, 1993.

2.1 General

Prior to preparation for the Feasibility Study, Chevron had completed a screening-level internal study for the Dumai Base Oils Project and approached Fluor Daniel for a Feasibility Study Proposal. On March 6, 1992, a meeting between Chevron and Fluor Daniel was held at Fluor Daniel's Irvine office to discuss the technical proposal with regard to scope of work and deliverables, along with the makeup and responsibilities of the study participants (comprised of the following Consortium members: Pertamina, Chevron, and Fluor Daniel). A document called the "Terms of Reference" was prepared by the study participants to define more clearly the scope and deliverables of the Feasibility Study. Subsequently, meetings were held in Indonesia among Pertamina, Chevron, Fluor Daniel, and Caltex to further define the Feasibility Study Project and assist Pertamina in obtaining a grant from the US Trade and Development Agency (TDA). In early May, 1992, the TDA tentatively approved a grant for the Feasibility Study, which, when supplemented with contributions from Chevron and Fluor Daniel, made up the available study budget. The formal Grant Agreement between TDA and Pertamina was executed on July 21, 1992.

The Feasibility Study kickoff meeting was held on July 28, 1992, at Fluor Daniel's office in Irvine. The meeting was attended by the representatives of Pertamina, Chevron, and Fluor Daniel. The participants signed the Study Agreement and the Terms of Reference document at this meeting.

Upon commencement of the work, a technical meeting was held in the first week of September, 1992 at the UP-II Refinery in Dumai, Indonesia for better understanding of the existing UP-II units operation, for gathering technical data on the existing units, and for establishing potential excess capacity available in the refinery process units, and the utility and offsite systems. On November 16, 1992, a mid-point project review meeting was held in Irvine to discuss the project progress and resolve several technical issues. All consortium members participated in this meeting. On December 18, 1992, Fluor Daniel presented the capital cost estimates to Chevron in a meeting at Irvine. The draft Study Report was presented to the consortium in a meeting during the first week of March 1993.

2.2 Scope of Work

The Dumai Base Oils Study required participation of all Consortium members and two process unit licensors. The scope of work for each participant is outlined below.

The following activities were included in the Chevron's scope of work:

- Confirm product yields for the new lube processing units
- Develop stock material balances for the study cases
- Develop process information on the new lube processing units including yield data, feed and product rates, major equipment data, process schematics, process description, finished product specifications, and utility, catalysts, and chemicals consumption summaries
- Define scope of work for UOP, coordinate and monitor UOP's work, establish secrecy agreement between UOP and a Chevron representative with respect to UOP technologies
- Establish secrecy agreement between Chevron and Pertamina with respect to Chevron's lube technology
- Provide input in development of the UP-II performance test program
- Provide input to the capital and operating costs estimates and also provide financial input data as necessary for the economic evaluation.

The following activities were included in the Pertamina's scope of work:

- Provide necessary drawings, equipment data sheets, and other documentation for the existing UP-II units
- Provide information on operating and maintenance philosophies
- Provide definition on supportive infrastructure and additional permanent housing requirements
- Provide UP-II utility and other operating cost data as appropriate
- Provide input and conduct performance tests on the selected UP-II units in accordance with test procedures from Fluor Daniel, Chevron, and UOP
- Assist the consortium members during the UP-II Refinery visits.

The following activities were included in Fluor Daniel's scope of work:

- Develop the four study cases as defined in the "Terms of Reference" document
- Use product yields for each new process unit as provided by Chevron/UOP
- Revise yields as necessary based on the pilot plant Yield Confirmation Study by Chevron
- Use stock material balances for the UP-II Refinery for all four study cases as well as the Base Case, as provided by Chevron
- Establish design basis for all licensed process units and assist Chevron in defining and evaluating UOP's work
- Identify process licensor and the process for the Solvent Deasphalting Unit (SDA) and obtain a technical proposal for the SDA Unit from the process licensor

- Modify design basis for the licensed lube units, if required, based on the results of the Yield Confirmation Study

- Define major equipment in the new process units

- Define modifications necessary to the existing UP-II Refinery process units for each study case

- Identify the existing UP-II Units that would require performance testing to establish existing maximum capacities and identify bottlenecks, develop procedures for the test runs, and witness and analyze the performance test run results

- Develop solutions to bottlenecks identified during performance testing of process units

- Establish utilities requirements for the new and modified process units

- Establish excess capacities in the existing UP-II Refinery utility systems

- Develop design for the new and modified or supplemental utility systems

- Develop offsite systems requirements and define the new equipment required in each offsite system

- Establish lube products shipping design basis for each study case

- Define infrastructure and support facilities for each study case

- Develop equipment lists and define major new and modified equipment for each case

- Develop plot plans for each case

- Develop an overall execution plan for PDD, engineering, procurement, and construction to support the cost estimates and financial evaluations

- Develop an overall master schedule for the purpose of planning and implementing the project

- Establish basis for the capital costs estimates including labor rates, contingencies, escalation, owner's costs, spare parts, bulk materials prices, home office costs, etc.

- Develop feasibility grade capital cost estimates for Cases 1 and 2. For Cases 3 and 4 develop conceptual level capital cost estimates

- Estimate operating and maintenance expenses for each case

- Establish basis for the financial evaluation including definition of financial evaluation model, feed and product pricing, preliminary financing structure, annual escalation, depreciation, taxation, funds draw-down schedule, etc.

- Carry out financial evaluation including estimation of rates of return and net present values (NPV) for each study case and conduct sensitivity analysis of the project returns to changes in key parameters, such as feed and product pricing, capital costs, operating expenses, etc.

- Generate information related to the potential opportunity for goods and services exports from the United States

- Present intermediate and final study results to the consortium

- Prepare a final Feasibility Study Report including recommendations for further work

- Evaluate the UP-II Balanced Operation scenario for the Case 1 configuration.

The following activities were included in UOP's scope of work:

- Establish secrecy agreement between a Chevron representative and UOP (licensor of the existing process units at UP-II).

- Provide yield estimates for HC Unibon Units for each case. Define modifications to the converted Unibon train associated with Cases 2 and 4; develop process schematics; estimate catalysts, chemicals and utility consumptions; and provide commercial proposal for their schedule "A" package described on Page 2-18.

- Provide a technical proposal for their licensed Deasphalted Oil (DAO) Hydrocracker associated with Case 4, including rough order of magnitude cost estimate.

- Additionally, UOP's scope of work included providing a copy of the schedule "A" revamp package for the existing Delayed Coker Unit completed in 1990, and providing a very preliminary assessment of the modifications necessary for increasing the capacity of the existing UP-II Hydrogen Plant.

- Assist in the UP-II Plant Tests.

The following activities were included in Kerr McGee's (process licensor of the SDA Unit) scope of work:

- Provide a proposal for the SDA Unit that would contain product yield data, product quality, process description and schematics, major equipment sizes, utility and chemical consumption, rough order of magnitude installed cost, and commercial data on licensing and basic process engineering package.

The scope of work for Caltex included providing data on lube product shipping.

2.3 Case Descriptions

Four cases have been evaluated for the Dumai Base Oils Project Feasibility Study. Cases 1 and 2 have been studied at a feasibility level, while Cases 3 and 4 have been evaluated at a conceptual level. The basic objective in each case is to produce approximately 6,000 BPSD of High Quality lube base oils. The primary feedstock to the lube oils complex is heavy vacuum gas oil (HVGO) in all four cases. Deasphalted oil (DAO) is an additional feedstock in Cases 3 and 4. The feedstocks are derived from mixtures of various Indonesian crudes, including Sumatran Light (SLC, also known as Minas), Duri, Pedada, and Lirik crudes. In addition to producing high quality lube base oils, each case is expected to maintain the quality and quantity of the middle distillate products at the current level in the UP-II Refinery. A tabular case summary that shows the major features of the four cases is presented in Table 2.1 on the following page.

A base case was established that served as the basis for comparing and evaluating the four study cases. The Base Case essentially represents the current mode of the UP-II Refinery operation. A detailed description of the Base Case with stock material balances and unit processing rates is included in Sections 3.1.2 and 3.3.1 of this report.

Case 1

Case 1 includes stand-alone Chevron licensed Lube Isocracker and catalytic Isodewaxer/ Hydrofinisher process units. The process units in this case require minimum integration with the existing UP-II Refinery. Figure 2-A on page 2-10 shows a simplified block diagram depicting the relationship among the new lube units and the existing refinery. The HVGO feed from the High Vacuum Unit (HVU) and make-up hydrogen from the Hydrogen unit are supplied from the existing UP-II Refinery. Unconverted VGO, light products, and sour water from the lube units are returned to the refinery for further processing.

[The information contained on page 2-8 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

Two grades of lube base oils are produced: light neutral ____ and medium neutral ____. Sufficient intermediate waxy lube base oil and final product lube base oil storage capacity is provided to permit operation of the Isodewaxer/Hydrofinisher Unit in a blocked mode. This case also requires modifications to several UP-II Refinery units, including the HVU, the Sour Water Treating and the Delayed Coker Units. Most utilities and offsites requirements for the process units are supplied by new utility generating equipment and offsites systems, which are integrated with the existing UP-II Refinery utility and offsite systems.

Case 2

Figure 2-B on page 2-11 depicts the proposed Case 2 configuration, which, like Case 1, also produces a total of about 6,000 BPSD of two ______________ lube base oil products. However, instead of a new stand-alone lube Isocracker, one of the two existing HC Unibon Unit trains (Train No. 2) is converted to a lube isocracker mode of operation for this case. The HC Unibon Unit is licensed by UOP. This case was included in the study because it was felt that by eliminating a stand-alone lube hydrocracker, substantial capital costs savings could be realized, even though one train of the existing HC Unibon Unit must be modified.

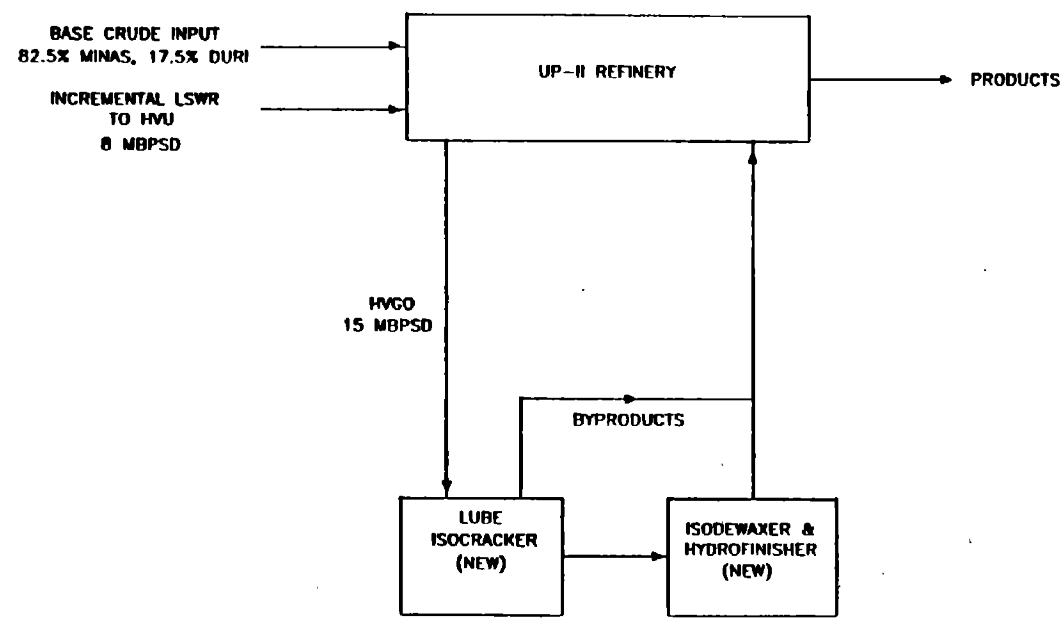

Figure 2-A. UP-II/Lube Base Oils Complex Schematic
Case 1

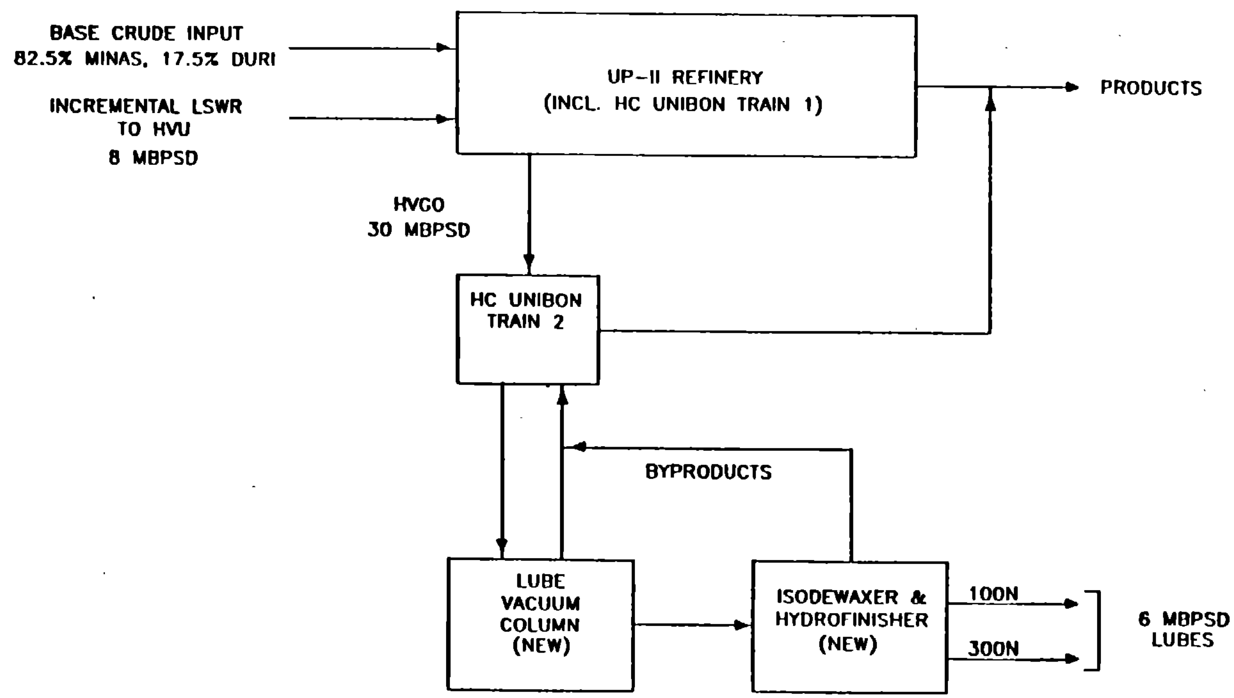

Figure 2-B. UP-II/Lube Base Oils Complex Schematic
Case 2

The converted HC Unibon Unit Train 2 processes only heavy vacuum gas oil (HVGO), while the HC Unibon Unit Train 1 receives a mixture of HVGO and heavy coker gas oil (HCGO). The HC Unibon Unit Train 2 will require substantial modifications, including replacement of catalyst and reconfiguring some of the existing equipment along with additional new equipment into a new distillate hydrotreating unit. A new lube vacuum column unit is included in this case to fractionate the 680°F+ waxy lube material from the HC Unibon Unit Train 2 into light and medium neutral waxy cuts. As in Case 1, these waxy cuts are dewaxed and finished in a new Chevron-licensed Isodewaxer/Hydrofinisher Unit. The incremental feed and the need for debottlenecking existing UP-II Refinery units are the same as in Case 1. All non-lube materials are returned to the UP-II Refinery for further processing. The utility, tankage, and offsite facilities requirements for this case are similar to the Case 1 requirements.

Case 3

A simplified conceptual schematic of Case 3 is presented in Figure 2-C on page 2-13. This case produces a total of about 6,000 BPSD of four separate lube base oil products. It is similar to Case 1 in that it contains a new, stand-alone Chevron-licensed Lube Isocracker Unit and Isodewaxer/Hydrofinisher Unit. However, to produce the heavier lube base oil products, a new Solvent Deasphalting (SDA) Unit, licensed by Kerr-McGee, is included in this case. The SDA Unit design is based on the ROSE® process, which uses mixed LPG solvent to extract deasphalted oil (DAO) from vacuum residue. Residual pitch from the SDA Unit is routed to the existing Delayed Coker Unit (DCU) for further processing.

The DAO and HVGO are fed to the new Lube Isocracker Unit in a blocked operation mode to produce a full slate (four products) of waxy lube base oils. The Lube Isodewaxer/Hydrofinisher Unit in this case processes all four products in a blocked operation mode. In addition to light and medium base oils, this case also produces heavy neutral and bright stock base oil products. Incremental feed and the extent of debottlenecking of the existing UP-II Refinery units required for this case are similar to the Case 1 requirements. The tankage and utility requirements are higher for Case 3 (compared to Case 1) because four products are produced and an additional processing unit is required.

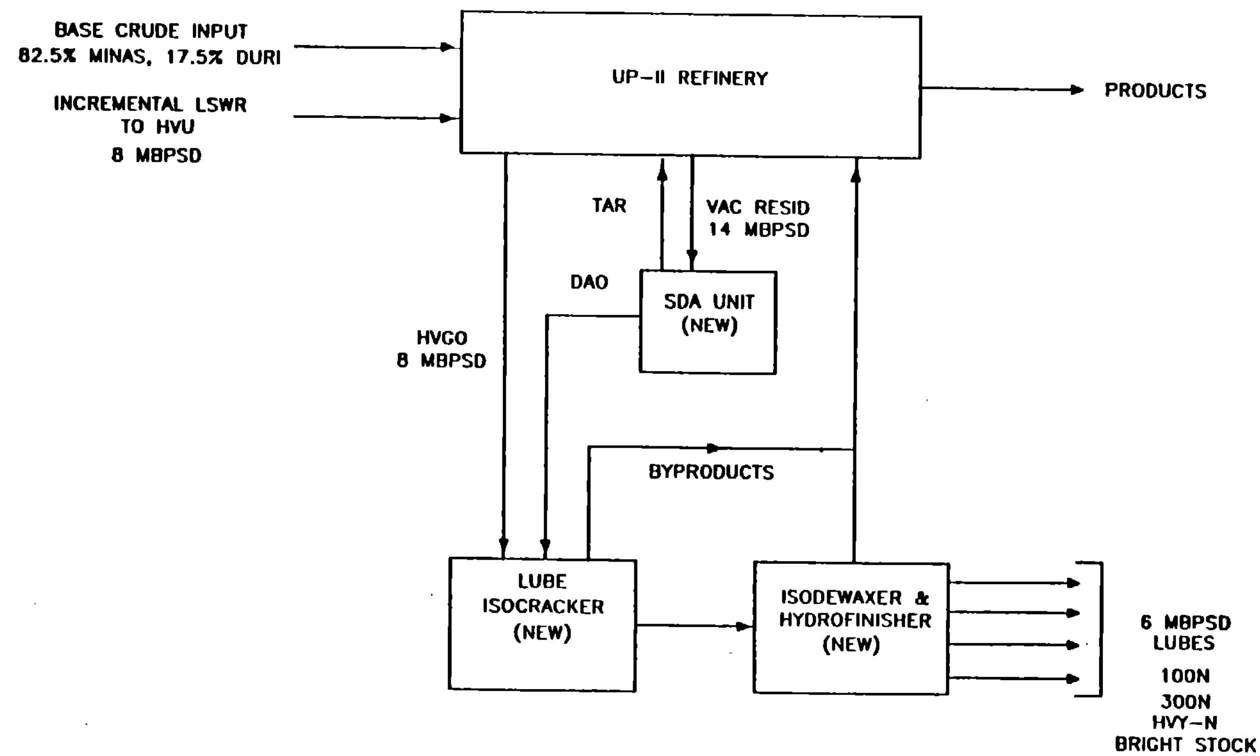

Figure 2-C. UP-II/Lube Base Oils Complex Schematic
Case 3

Case 4

A simplified conceptual schematic of Case 4 is presented in Figure 2-D on page 2-15. Case 4 is a hybrid of Case 2 and Case 3. As with Case 3, four separate lube base oil products (________) are produced in Case 4. This case is similar to Case 2 because it uses a converted HC Unibon Unit Train 2 in place of a stand-alone Chevron-licensed Lube Isocracker, and includes a new Lube Vacuum Column Unit. A Lube Isodewaxer/Hydrofinisher Unit is also included in this case. Case 4 also includes an SDA Unit, identical to the Case 3 SDA Unit, to supply the DAO required for producing heavier base oils and bright stock. Case 4 differs from Case 3 in that it includes a stand-alone UOP-licensed DAO Hydrocracker Unit. UOP has proposed continuous, separate processing (non-blocked operation) of DAO in the DAO Hydrocracker Unit and HVGO in the Converted HC Unibon Unit Train 2.

Incremental feed and the extent of debottlenecking required to the existing UP-II Refinery units for this case are similar to the other cases. As expected, with an increased number of processing units and lube base oil products, this case requires more tankage.

2.4 Study Methodology

At the kickoff meeting the Consortium members agreed to a Terms of Reference document outlining the study project objectives, study structure, scope of work, deliverables, and responsibilities of the study participants. It also defined the four study cases and outlined the study procedures. During this meeting, Chevron presented the stock material balances for the Base Case (current refinery operation) and the four study cases. These balances, which Chevron updated during the course of the study, served as the basis for Fluor Daniel's work.

Due to the aggressive feasibility study schedule requirements, a parallel approach to completing activities was adopted. Preliminary information and reasonable assumptions, where required, were used to generate the data to complete a task. When more complete information became available, the previously generated data was appropriately adjusted. This approach helped to significantly compress the overall study schedule.

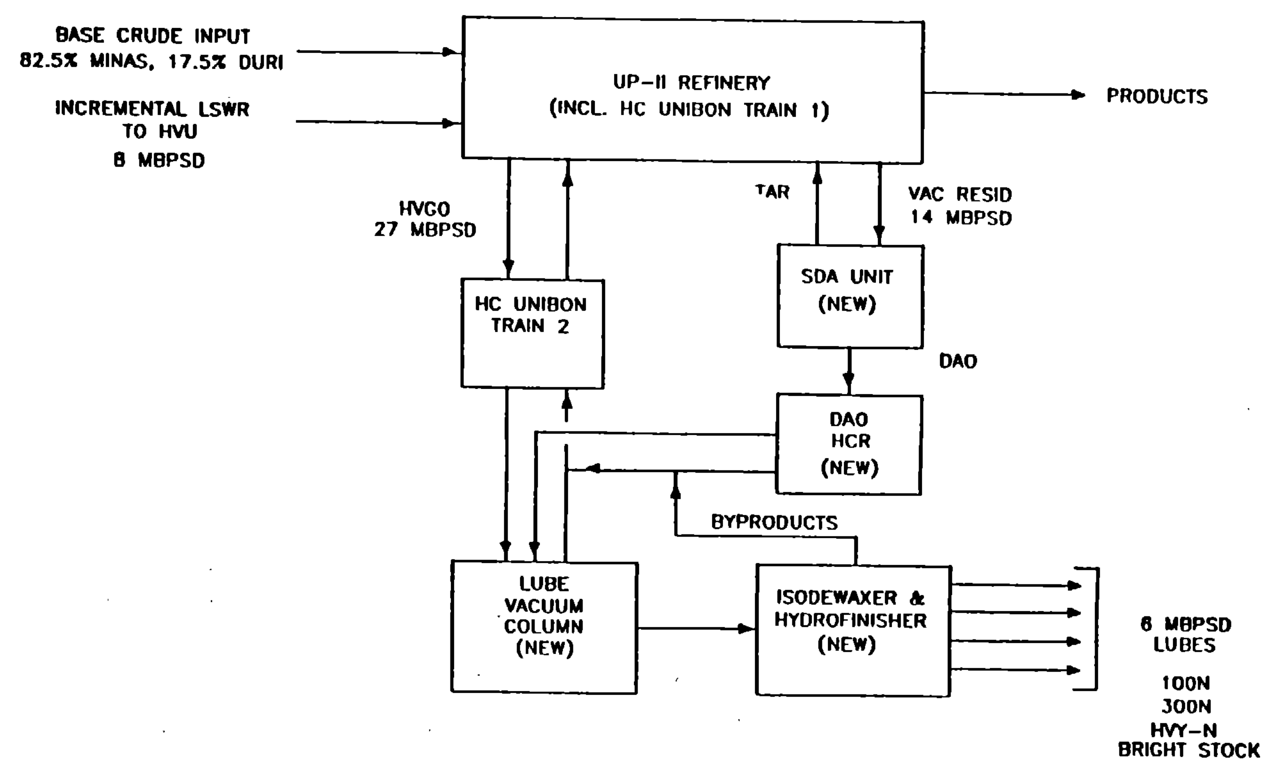

Figure 2-D. UP-II/Lube Base Oils Complex Schematic
Case 4

To ensure that the study proceeded efficiently and in a timely manner, methods were implemented to help the individual contributors work as a more effective team. As an example, Fluor Daniel used information from various Consortium sources to complete specific tasks, as dictated by the study schedule. However, when the required source information was not readily available, to avoid delay, Fluor Daniel generated preliminary information (based on in-house knowledge and other information sources) to complete the task. This preliminary information was sent to the appropriate source for review, and the source-provided adjustments, if any, were then incorporated into the specific task deliverables.

The project team held weekly status meetings to report on progress and address outstanding issues. The close working relationship fostered through these meetings helped keep the study on schedule. A project mid-point review meeting was held on November 16, 1992, in Fluor Daniel's Irvine office to review the progress of the process design work and plan for future activities. Fluor Daniel raised several technical issues at this meeting, which the Consortium Members resolved.

A "Technical Data Notebook" was compiled during the initial stages of the study. The data in this book was assembled from various sources including that gathered during visits to the UP-II Refinery. The data book also provided an exhaustive listing of the technical documents (drawings, equipment data, etc.) which were collected during UP-II Refinery visits. The Technical Data Notebook served as a valuable source of information for executing the study. In addition to the data book, Fluor Daniel prepared a two-hour video and a photo album of the UP-II Refinery and surrounding facilities. The video tape and photos provided valuable visual perspective of the facility.

Fluor Daniel used data from various sources (Consortium members, UP-II Refinery, licensors, vendors, etc.) to complete the study. Dumai UP-II Refinery personnel supplied information on the existing refinery systems and equipment during a site visit by Chevron and Fluor Daniel representatives in late August/early September 1992. In addition, during the site visit information was collected on the existing common facilities (laboratories, maintenance, warehouses, fire/safety, etc.). Discussions were also held to assess the need for additional common facilities to support the new lube processing facilities. A Pertamina representative, Ir. Bambang Rispandriyo, was assigned to the Fluor Daniel Irvine office for a six-week period in November/December

1992. He provided valuable, timely assistance to the project team during his stay, and was able to review many aspects of the study development and conclusions.

Chevron supplied a process scope package for their licensed units, including the Lube Isocracker Unit, Lube Isodewaxer/Hydrofinisher Unit, Lube Vacuum Column Unit, and associated support systems, such as tempered water and wash water injection systems. The Chevron package included process flow diagrams, process descriptions, stock material balances, equipment lists (including duties/sizes and design conditions for major equipment items), metallurgy requirements, and utility summaries. Various parts of the package were provided to Fluor Daniel at different points in the study schedule to facilitate the timely completion of various study deliverables.

The study was performed using a flexible approach that permitted making adjustments in the scope of work based on interim results. An example of this is an opportunity identified during the course of the study that involves modifying the refinery operation in Case 1 to supply additional feed to the HC Unibon Unit, which operates below its design capacity in Case 1. These sub-cases, which are referred to as "UP-II Balanced Operation," involve feeding incremental SPK LSWR to the High Vacuum Unit and changing the vacuum residue cutpoint. Their net effect is to produce more middle distillate products by using idle hydrocracker capacity. This subject is discussed in detail in the Addendum section of this report (Section 9.2).

Based on the results of the Yield Confirmation Study, which is scheduled to be completed in April 1993, the Terms of Reference included a provision for reexamining, and possibly modifying the stock balances and the lube processing units operation and design. This Chevron study involves pilot plant work to determine lube processing unit yields and product quality data. Based on the pilot plant yield data, changes may be required to each of the four study cases. These potential changes will be incorporated by Fluor Daniel into the configurations established for the original study scope once they have been supplied by Chevron. The Yield Confirmation Study adjustments will be addressed in the Addendum Section of this report (Section 9.3).

The refinery configurations and operating modes proposed for the four original study cases, the UP-II Balanced Operation cases, and any modified cases arising from the Yield Confirmation Study may dictate that the HVU and the Hydrogen Unit operate beyond their original design capacities. Therefore, Chevron, Fluor Daniel, and UOP, with assistance from Pertamina, conducted performance test runs for these existing UP-II Refinery units in late January 1993. The results of the plant tests are discussed in the addendum section of this report (Section 9.4).

UOP, the original licensor of the UP-II Refinery HC Unibon Unit, provided a revamp feasibility process design package for the Converted HC Unibon Unit Train 2 including their proposed new Distillate Hydrotreater Unit, and the associated stand-alone DAO Hydrocracker Unit. UOP developed this package under directions from Chevron and Fluor Daniel. A step approach was adopted, whereby interim results were thoroughly examined before developing the scope of work for subsequent steps. The UOP package, which underwent a preliminary and a final issue during the course of the study, contained the same type of information as that in the Chevron package.

UOP also supplied Fluor Daniel with a copy of the existing UP-II Refinery Delayed Coker Unit (DCU) Revamp Schedule "A" package which was developed prior to this study for Pertamina. This package contained drawings and equipment specifications for modifications required to permit operation of the DCU at its original design capacity under new operating conditions. Fluor Daniel used this information to develop capital cost estimates for revamping the DCU.

In addition, UOP performed an evaluation of the existing UP-II Refinery Hydrogen Plant to determine what modifications would be required to operate the unit at 10% and 25% above its original design capacity. UOP identified modifications to major equipment items only. This information, with cost allowances developed by Fluor Daniel for minor equipment modifications, was used to develop a capital cost estimate for revamping the Hydrogen Plant.

Kerr-McGee, the licensor for the ROSE® process, supplied a sales proposal-type package that defined the new Solvent Deasphalting (SDA) Unit. This package included process flow schemes, an overall material balance, a process description, an equipment list of major equipment (with some size information), and a utility summary. Fluor Daniel used this information, along with supplemental in-house equipment size estimates, to determine the capital cost of the new SDA Unit.

Caltex supplied preliminary lube base oil product shipping data, including expected cargo and parcel sizes, the number of ship loadings per year, and a frequency versus ship size distribution. Fluor Daniel used this information to estimate the required lube base oil product shipping facilities, including product storage, loading pumps and loading arms. In addition, Fluor Daniel used this data to perform a preliminary evaluation of the existing Pertamina jetties to determine if they can be used for loading the lube base oil products. However, Fluor Daniel did not perform a detailed jetty occupancy study, nor a marine survey, as these activities are beyond the scope of this feasibility study phase.

Fluor Daniel was responsible for evaluating the existing High Vacuum Unit, Sour Water Treating Unit, and Amine Treating/LPG Recovery Unit to determine the scope of modifications required to support the new Dumai Base Oils Project. Fluor Daniel used information collected from the various licensors and Pertamina, as well as in-house data, to estimate required unit capacities, perform computer simulations, checkrate existing equipment, and propose modifications, if required. Process flow schemes, process descriptions, equipment lists (with size information), and utility summaries were generated in support of the capital cost estimate activity.

Fluor Daniel also defined the utility and offsite systems required to support the new lube oil processing facilities. Utility summaries and offsite requirements were collected from the various licensors and supplemented with in-house estimates, as required. The overall utility and offsite requirements were then analyzed to determine the best methods of supplying the required facilities to supplement the existing UP-II Refinery utility and offsite facilities.

During the site visit in August-September 1992, and in subsequent meetings, Pertamina, Chevron, and Fluor Daniel agreed on the scope of supply for infrastructure and common facilities to be used in developing the capital cost estimates.

During the project kickoff meeting, the Consortium members agreed on a primary and an alternate site location for the Dumai Base Oils Project facilities. Fluor Daniel developed unit plot plans based on the primary location. However, during the August-September 1992 site visit, Pertamina refinery personnel expressed concerns over the viability of the primary location. Subsequently, after the project mid-point review meeting, the alternate location plans were developed in conjunction with the primary location, and cost estimates were developed for both locations.

Fluor Daniel used the information supplied from the above mentioned sources to prepare data required to generate the capital cost estimates. As previously mentioned, Fluor Daniel had to supplement some of the licensor information to produce a sufficiently accurate estimate. Vendor quotes were obtained for selected major equipment items, and Fluor Daniel's in-house estimating methods were used. The methodology used for generating the capital cost estimates is discussed in more detail in Section 4.0.

Chevron contracted the services of Independent Project Analysis, Inc. (IPA), to analyze the cost and schedule risks associated with feasibility study project estimates. The IPA representative interviewed the project team members to obtain information on the following subjects: general project information, project schedule, technical description, technical problem areas, project execution plans, and cost estimate. Using this information along with historical project data, IPA provided Chevron with various cost estimate contingency factors and expected schedule durations.

Fluor Daniel, with input from Chevron and Pertamina, developed operating cost estimates. These estimates, as well as estimates of owners' costs, feed and product costs, and other financial data were used by Fluor Daniel to perform a financial and sensitivity analysis of the Dumai Base Oils Project. Much of the financial input data, such as tax structure, depreciation, commercial loan terms, and working capital were provided by Chevron. The economic analysis of the Dumai Base Oils Project was based on incremental feedstock costs and incremental product revenues for the UP-II Refinery. All feedstock and utilities delivered to the Lube Base Oils Complex by UP-II are a result of the increased LSWR. For each study case, incremental feed and products flows over the Base Case were defined based on the stock balances. These incremental flow quantities were priced and used along with capital costs and other operating expenses for input into the financial evaluation model. In addition, a preliminary project financing plan was developed. The financial evaluation program is discussed in detail in Section 6.0.

A Brainstorming Session was held on April 15, 1992 to generate ideas for improving the viability of the project. The session participants included representatives of Chevron International Oil Co., Chevron Research and Technology Co., and Fluor Daniel. An outside facilitator was used for the meeting. The meeting participants came up with several ideas. Some of these ideas were implemented in the adjustments to the Yield Confirmation Study and subsequent development of a derivative Case 2. The meetings memory notes were issued by the facilitator.

2.5 Information Sources

Fluor Daniel used information from many sources to complete the Dumai Base Oils Feasibility Study. This section lists those sources and the information that was obtained from them, and where the information is located.

Pertamina

Information Item	Location
Crude Assays	Terms of Reference
Existing Refinery Technical Data	Appendix
Existing Equipment Data Sheets	Dumai Base Oils Project Files
Existing Refinery Utility Data	Dumai Base Oils Project Files
Existing Utility Cost Data	Dumai Base Oils Project Files
Existing Refinery Product Specifications	Terms of Reference
Existing Process Flow Diagrams	Dumai Base Oils Project Files
Existing P&ID's (selected units and systems)	Dumai Base Oils Project Files
Test Run Reports for HVU and HC Unibon Unit	Dumai Base Oils Project Files
Existing Plot Plans	Dumai Base Oils Project Files
Existing Tankage Data	Terms of Reference
Existing Jetty Occupancy Data	Terms of Reference
Existing Unit Operating Guideline Manual	Dumai Base Oils Project Files
Operating Manpower Data	Section 6.2.7
Labor Rates	Appendix
Housing Data	Dumai Base Oils Project Files
Land Costs	Dumai Base Oils Project Files

Chevron

Information Item	Location
Minas and Duri Crude Assays	Terms of Reference
Stock Material Balances	Dumai Base Oils Project Files
Lube Complex Design Package	Appendix
Lube Base Oil Product Properties/Specifications	Terms of Reference
Plant Operating Cost Data	Section 6.2.7
Owner's Costs Data	Appendix

Feeds/Products Pricing Data	Section 6.2.7
Financial Evaluation Input Data	Appendix

UOP

Information Item	**Location**
Hydrocracker Study	Appendix
Coker Revamp Schedule A Package	Appendix (excerpts); Dumai Base Oils Project Files (entire document)
Hydrogen Plant Study	Appendix
UP-II Plant Test	Appendix

Kerr-McGee

Information Item	**Location**
SDA Plant Design Package	Appendix

Caltex

Information Item	**Location**
Lube Base Oil Product Shipping Data	Section 3.2.4

Fluor Daniel

Information Item	**Location**
UP-II Refinery Site Data	EXOR IV Project Files
Cost Data	Fluor Daniel EXPONE Cost Estimating Program, Cilacap Debottlenecking Project Files, EXOR IV Project Files
Financial Evaluation Input Data	Appendix

Independent Project Analysis, Inc.

Information Item	**Location**
Project Cost Analysis Curves Schedule	Section 4.4

Equipment Vendors

Information Item	**Location**
Major Equipment Cost Data	Appendix

2.6 Yield Confirmation Study

Chevron Research and Technology Company (CRTC) executed the Yield Confirmation Study undertaken by in Richmond, California from August 1992 through May 1993. The study involved pilot plant work in the area of Chevron licensed Lube Isocracker, Lube Isodewaxer, and Hydrofinisher units. A copy of the report, "Dumai Pilot Plant Tests Summary and Discussion," is included in Appendix C-2. The purpose of the Yield Confirmation Study was to develop the required information which would support the process design basis presented in the Chevron process package ("Lube Base Oils Complex" dated May 26, 1993). The Chevron process package is included in Appendix C-1.

In January 1993 Chevron prepared a process package to support the Feasibility Study based on the best available information. The package included the design basis for the Chevron Isocracker and Isodewaxer/Hydrofinisher units, which Fluor Daniel used to complete the draft version of the Final Feasibility Study Report. Subsequently, as a result of the pilot plant Yield Confirmation Study, revisions were made to the Chevron process package which required adjustments to the Feasibility Study. The necessary adjustments resulting from the revised Chevron process package are summarized and discussed in Section 9.3.

CRTC used HVGO samples from the UP-II Refinery for performing the pilot plant test program. HVGO was fed to the several Isocracker pilot plant tests to determine the ways to enhance the waxy viscosity index (VI) and the solvent dewaxed oil VI at various levels of conversions. The distilled Isocracked product from the Isocracker pilot plant was used as feed to the Isodewaxer/Hydrofinisher pilot plant. During the tests, several parameters were noted, including product yields, pour point, volatility, VI, etc. In addition, the light byproducts' (jet and diesel) properties and their sensitivity to process conditions were determined. The results of the pilot plant test indicate that high quality base oils in the VI range of ___ to ___ can be produced with varying yields. Light byproducts from Isodewaxing are of high quality, with diesel cetane index and jet smoke point well above normal specifications.

2.7 UP-II Plant Tests

During the feasibility study, it became clear that the HC Unibon units were not being fully utilized in Cases 1 and 3. Opportunity existed to run these units at their respective design throughputs to produce additional amounts of middle distillates for the domestic Indonesian market. However, the ability to run these units at higher throughputs beyond the capacities required by Cases 1 and 3 greatly depended on the ability of the High Vacuum Unit (HVU) and Hydrogen Plant to produce additional HVGO and hydrogen feedstocks respectively.

Paper studies conducted by Fluor Daniel for the HVU and UOP for the existing Hydrogen Plant revealed that while no major bottlenecks surfaced for the HVU, the Hydrogen Plant may require major debottlenecking to increase the capacity much in excess of 110% of the design capacity. The hydrogen plant study also concluded that hydrogen product purity will be compromised to 95%, should the Hydrogen Plant need to operate in excess of 117% of the design capacity.

It was decided to have Pertamina, Chevron, UOP, and Fluor Daniel conduct plant tests to verify paper studies for the HVU and Hydrogen Plant. Although HC Unibon units were not among the candidate units to be tested for study Cases 1 and 3, it was considered desirable to conduct a short test on these units with a makeup hydrogen purity of 95% to assess its effect on product specifications. The team recognized that the units had been originally designed to operate with 95% purity hydrogen. However, the plans to test the HC Unibon units were shelved when it was discovered that Pertamina had tested these units with low-purity hydrogen in the past and that no adverse effect on product specifications had been observed.

The testing program, which was undertaken by the team during the last week of January 1993, was successfully completed in the first week of February 1993. The governing guidelines overriding the test objectives were to safeguard the plant and personnel, and not to impede the current refinery operations.

The HVU was tested at a throughput of 102,000 BPSD. Higher LVGO and HVGO recoveries were achieved by varying TBP cutpoints, higher heater outlet temperatures (higher lift), pumparound and wash oil rates, and lower flash zone pressure while maintaining color and pour points specification of these products within acceptable limits. The unit operated well with minor problems with heater skin temperatures, HVGO pumparound circuit, slopwax pumps and control valves (an existing problem), and the vacuum jet ejector system.

One of the two Hydrogen Units (Unit 702) was tested at a throughput of approximately 110% of design hydrogen product rate. The unit operated well with the exception of higher than allowable maximum temperature for the reformer furnace tubes. The test was, therefore, terminated at this throughput. Pressure surveys done in the plant with a single calibrated pressure gauge were very encouraging.

UOP's report on the test runs is provided in the Appendix Section C-7 of this study.

2.8 Study Limitations and Assumptions

This study report documents the Consortium (Pertamina, Chevron, and Fluor Daniel) assessment of the technical and economic feasibility of implementing the Dumai Base Oils Project. The study was performed over several months, and much effort has gone into it. However, this study is not, nor was it intended to be, a complete definition of the Dumai Base Oils Project. Several assumptions and limitations necessarily were imposed in order to assess the feasibility in a way that gave meaningful results, yet met the overall project objective and schedule requirements. The major study limitations and assumptions are listed below.

- The UP-II crude feed is derived from a mixture of minimum 80 vol% Minas and maximum 20 vol% of Duri crudes. The present UP-II crude throughput rate will not be increased.

- Incremental LSWR from Sungai Pakning derived from local Sumatran crude will be processed in UP-II for the lube base oils production. The minimum required LSWR rate is the one that prevents a reduction in UP-II middle distillate production relative to the present production. The proportion of Minas in the crude feed to Sungai Pakning refinery will be at least 70 vol%, with the remainder being Pedada and other crudes, limited to a maximum of 30% by volume.

[This deleted information is considered confidential and proprietary.]

- The current UP-II unit design capacities, as summarized in section 3.3.1 of this report, are the basis for the study. The stock balances, as developed by Chevron, utilize the appropriate unit design capacities except where existing unit capacity evaluations and/or modifications result in a capacity greater than the design capacity.

- The present UP-II middle distillate production rates and quality will not be adversely affected by this project.

- Only those UP-II Refinery process units are being debottlenecked that are required to support the new Lube Base Oils Complex.

- The utility and offsite systems required to support the new Lube Base Oils Complex will be either stand-alone systems or integrated with the existing systems by the addition of new equipment. No new facility will be provided where there is sufficient excess capacity in the existing systems. The excess system capacities are summarized in Section 3.2.4 of this report. Sufficient utilities will be provided for operations as well as for new infrastructure needs including additional Pertamina housing.

- Optimization with respect to equipment selection, energy integration, hydraulics, etc. has not been closely examined.

- The current Indonesian environmental rules and regulations, appended with the Terms of Reference, Attachment 8, will be applicable only to new facilities. Modifications to the existing UP-II facilities will be governed by the environmental design criteria used for the design of the original units.

- Instrumentation for the new facilities will be electronic with a distributed control system (DCS). The modified UP-II units and equipment will retain the same control system as presently exists for these units.

- Additional housing and other infrastructure will be added to the existing facilities for the supplemental personnel needed to operate and maintain the new facilities.

- Additional common facilities such as laboratory, warehouse, maintenance shop, administration office, control room, communication equipment, electrical distribution, and fire and safety equipment, will be added appropriately to the existing facilities to support the new lube facility.

- The assumptions and basis used in developing the capital cost estimate are described in detail in Section 4.1 of this report. Cases 1 and 2 have been developed and estimated to a higher level of accuracy compared to Cases 3 and 4.

- For the financial evaluation of the cases, it is assumed that the new lube facility is a part of the UP-II Refinery. All utilities except raw water are internally generated. The economic evaluation of each case will be performed based on differential costs and revenues over the Base Case operation. The Base Case is defined as the current UP-II operation in the Terms of Reference. Section 6.2 of this report describes the basis and assumptions for the financial evaluation.

- It is recognized that eventually the Lube Base Oil Complex will be owned by an independent company, although it will be located within the boundaries of the UP-II Refinery and it will be integrated with the existing refinery.

- Minimum effort has been spent on identifying and developing markets for the new lube base oils product for the purpose of this study. It should be noted that Chevron has undertaken an extensive market survey which is not finished at this time.

3.0 PROCESS CONFIGURATION

3.0 PROCESS CONFIGURATION

The information contained in Sections 3.1 through 3.6 were generated prior to the completion of the Yield Confirmation Study and as such, may not be totally accurate. However, the detailed write-up in this section will assist reader in better understanding the study design basis, new and existing processing units, utility and offsites systems, common facilities, and other aspects of the study. Please refer to Section 9.3 which describes the adjustments to the Feasibility Study as a result of the Yield Confirmation Study.

3.1 Overview

3.1.1 Site Location and Considerations

The Dumai Lube Base Oils Complex will be located inside the battery limits of Pertamina UP-II Refinery at Dumai, Sumatra, Indonesia. The existing UP-II Refinery has facilities for importing and exporting raw materials and products. The existing refinery is self sufficient in terms of all utilities, with the exception of raw water, which is delivered to the refinery via a 55 km long pipeline from the Rokan River.

The primary feedstock to the Lube Base Oils Complex is straight-run heavy vacuum gas oil, which is obtained by processing additional low sulfur waxy residue (LSWR) in the existing High Vacuum Unit (HVU). The existing UP II Refinery has adequate facilities to import the additional LSWR from Pertamina's existing Sungai Pakning Refinery.

The new Lube Base Oils Complex will share most of the existing common facilities, infrastructure (both onsite and offsite), and other offsites with the existing UP-II Refinery. Where necessary, the existing facilities will be expanded or revamped to serve the new Lube Base Oils Complex. The new complex is expected to benefit from sharing and integration with the existing facilities in terms of lower capital cost relative to a grass roots complex. At the same time, the existing UP-II Refinery will benefit from more effective utilization of any idle capacity in the existing processing and support units. For example, in the processing units area the existing hydrogen plant has excess capacity, which may be effectively utilized for supplying hydrogen to the new lube processing units. Similarly, in the support facilities area, the existing jetties have spare capacity and/or space for future loading arms, which may be used for shipping the lube products.

It is anticipated that this site can provide adequate qualified labor to support the operation and maintenance of the new Lube Base Oils Complex. The new lube hydroprocessing units require specially trained operation and maintenance personnel. The existing UP-II Refinery staff has been operating similar hydroprocessing units (HC Unibon and hydrotreaters) for a decade and have the potential to operate effectively and maintain the new lube processing units.

There are other non-technical, marketing, and financial considerations that enter into the site location selection that are beyond the scope of this feasibility study.

A map of the Dumai UP-II Refinery and the surrounding area is presented in Figure 3.1.1-A on the following page.

3.1.2 Overall Block Flow Diagrams and Stock Material Balances

The overall processing schemes for the Base Case (current UP-II Refinery configuration) and each of the four study cases are described in this section. In generating the stock material balances for the four cases, the prime objective was to maintain the quantity and quality of the middle distillate (diesel and light/heavy kerosene) products at the current UP-II Refinery levels, as represented by the Base Case.

Base Case

The current UP-II Refinery process configuration is represented in Figure 3.1.2-A on page 3.1-4. A summary of the Base Case feeds, products, and internal processing rates for major units are presented in Table 3.1.2-A on page 3.1-5.

Currently, the UP-II Refinery processes 120,000 BPSD of crude oil consisting of 82.5 volume percent Sumatra Light crude (SLC, also known as Minas), and 17.5 volume percent Duri crude. In addition to the crude, the refinery also processes 8,000 BPSD of Low Sulfur Waxy Residue (LSWR) imported from Pertamina's existing Sungai Pakning (SPK) Refinery. The SPK Refinery feed is comprised of 70 volume percent Minas, 15 volume percent Pedada and 15 volume percent Lirik crudes.

The refinery currently operates under a maximum diesel production mode. The refinery diesel pool consists of straight-run diesel from the Crude Distillation Unit (CDU), light

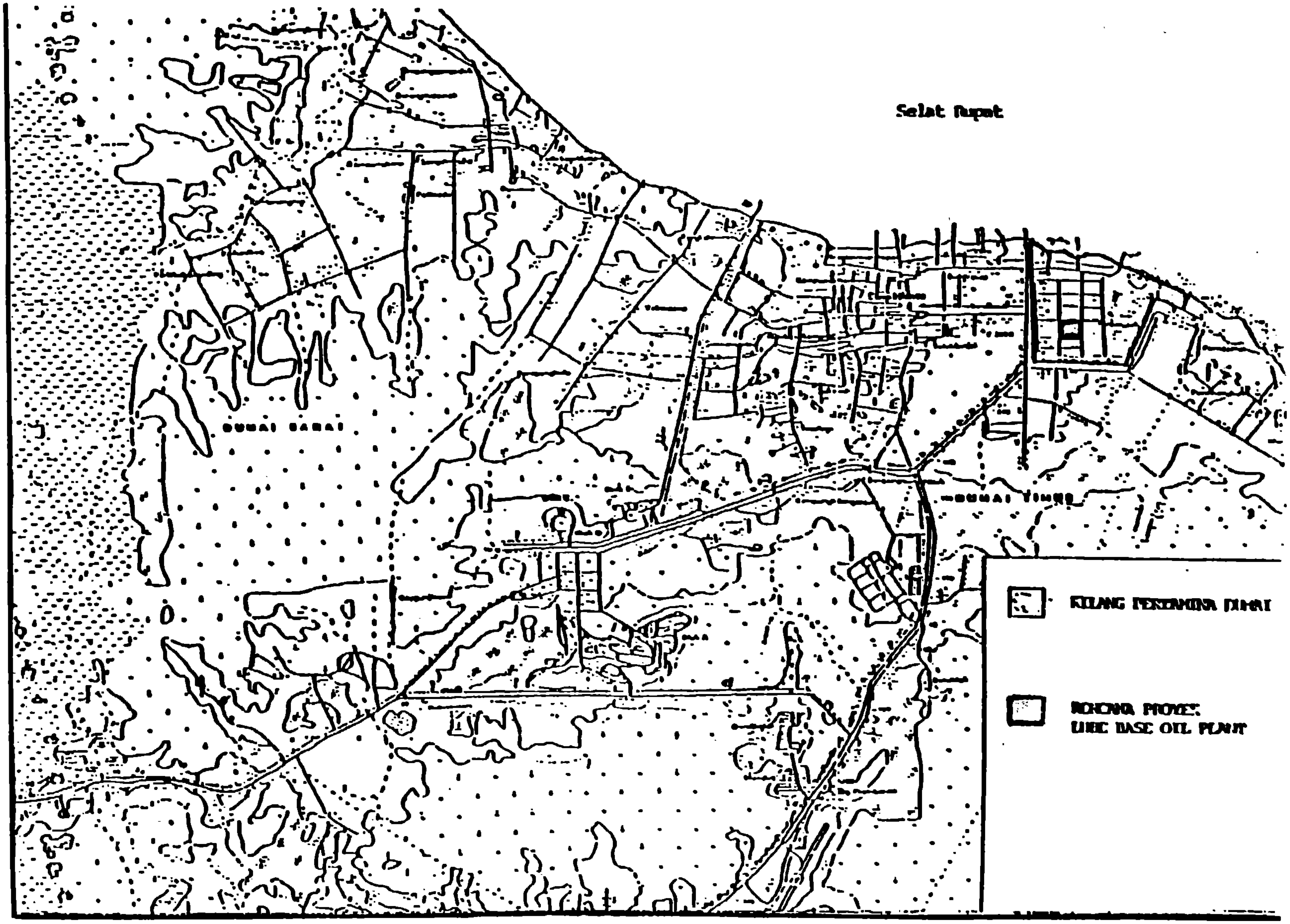
Selat Rupat
DUMAI BARAT
DUMAI TIMUR
KILANG PERTAMINA DUMAI
RENCANA PROYEK
LUBE BASE OIL PLANT

Figure 3.1.1-A

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vacuum gas oil from the High Vacuum Unit (HVU), hydrocracker diesel from the HC Unibon Unit and hydrotreated light coker gas oil from the Distillate Hydrotreater (DHDT) Unit. The kerosene pool includes straight-run kerosene from the CDU and hydrocracker kerosene from the HC Unibon Unit. In addition to middle distillate products, the refinery also produces motor gasoline, LPG and fuel and anode grade coke. The fuel oil for the refinery's internal consumption is produced by blending diesel and/or naphtha cutter stock into vacuum residue.

Case 1

The Case 1 configuration is represented in Figure 3.1.2-B on the following page. In this case, a new lube base oil production facility is incorporated into the existing refinery. The new lube facility consists of a lube isocracker unit, a lube dewaxing and finishing unit, and associated tankage and offsite facilities. The stock material balances for Case 1 are developed based on maintaining the production levels of middle distillate (diesel and kerosene) products at the Base Case levels while producing about 6,000 BPSD of lube base oils. The overall feeds, products, and internal processing rates for the major units are summarized in Table 3.1.2-A.

In order to produce about 6,000 BPSD of lube base oils, LSWR feed to the UP-II Refinery is increased by 8,000 BPSD over the Base Case operation. The CDU throughput is identical to the Base Case operation. The additional LSWR is obtained from the SPK Refinery. It is combined with the Base Case LSWR from the CDU and processed in the HVU. The total HVU feed in Case 1 is 94,000 BPSD. The HVU production rates for light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO) and vacuum residue are 8,200 BPSD (8.7 LV%), 44,500 BPSD (47.3 LV%) and 41,300 BPSD (44.0 LV%), respectively. These yields are based on a nominal cut-point range of 357°C-521°C for HVGO and 521°C+ for vacuum residue.

The new Lube Isocracker Unit, licensed by Chevron, receives _____ BPSD of HVGO feed from the HVU. This unit produces _____ BPSD of waxy lube base oils, along with unconverted vacuum gas oil (VGO) and hydrocracked lighter products (diesel and lighter),

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which are returned to the existing HC Unibon Unit for further processing. The waxy lube base oils are further processed in a new Chevron-licensed Lube Isodewaxer/Hydrofinisher (IDW/HF) Unit in a blocked mode of operation. *[This deleted information is considered confidential and proprietary.]* The lighter products (diesel minus) from the Lube IDW/HF Unit are returned to the existing HC Unibon Unit.

The other UP-II Refinery units are only slightly impacted by the Case 1 operation. The feed to the existing Delayed Coker Unit (DCU), and the resulting coke make, are increased over the Base Case operation. Similarly, the existing Hydrogen Unit production requirement is increased to support the new lube processing units.

Case 2

The Case 2 configuration is represented in Figure 3.1.2-C on the following page. This case is identical to Case 1 with respect to overall feed rates and lube product slate. In Case 2, one of the two existing HC Unibon Unit trains is converted from fuels to lube base oils production mode, eliminating the need for a new lube hydrocracker unit. The overall stock material balance rates are summarized in the previous Table 3.1.2-A. Note that the required Case 2 HC Unibon Unit throughput for Train 1 (fuels hydrocracker) exceeds its original design capacity. UOP, the HC Unibon Unit licensor, evaluated this train and stated that the Case 2 (as well as Case 4) throughput can be handled by the existing train without modification.

The converted HC Unibon Unit train (Train No. 2), licensed by UOP, is fed straight-run HVGO only, while the fuels HC Unibon Unit train (Train No. 1) receives a blend of HVGO and heavy coker gas oil (HCGO). The converted HC Unibon Unit Train 2 produces 12,000 BPSD of 360°C+ waxy lube cut, which is fractionated in a new vacuum column into light and medium waxy cuts. *[This deleted information is considered confidential and proprietary.]*

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Case 3

The Case 3 configuration is represented in the following Figure 3.1.2-D. This case is similar to Case 1, except that it produces a full slate of lube base oils. This is accomplished by adding a Solvent Deasphalting (SDA) Unit to the processing configuration. The stock material balances for Case 3 are summarized in Table 3.1.2-A on page 3.1-5. The Case 3 crude and LSWR feed rates to the UP-II Refinery are identical to those in Case 1.

[This deleted information is considered confidential and proprietary.]

As in Case 1, the unconverted VGO and light products from the Lube Isocracker Unit are returned to the existing HC Unibon Unit for further processing. Four waxy lube base oils are produced by the Lube Isocracker Unit, which are further processed in the new Lube IDW/HF Unit in a blocked operation mode. The average production rate for each of the four products is as follows:

- Light Neutral ______
- Medium Neutral ______
- Heavy Neutral ______
- Bright Stock ______

The SDA Unit has a relatively minor impact on the other existing refining units, with the exception of the DCU. The Case 3 volumetric feed rate to the DCU is reduced considerably compared to the Case 1 rate. However, the feed Conradson Carbon Residue is higher due to DAO extraction in the SDA Unit. The net effect is slightly reduced coke

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make and a corresponding reduction in light and heavy coker gas oil production when compared to the Case 1 rates.

Case 4

The Case 4 configuration is represented in the following Figure 3.1.2-E. This case is a hybrid of Case 2, which converts one of the existing HC Unibon Unit trains to lube oil production mode, and Case 3, which produces a full slate of lube base oils by incorporating an SDA Unit. The stock material balance for this case is summarized in Table 3.1.2-A.

Case 4 also includes a UOP-licensed DAO Hydrocracker Unit designed to process ____ BPSD of DAO. As in Case 2, the converted HC Unibon Unit Train 2 processes only straight-run HVGO and supplies approximately ____ BPSD of 360°C+ waxy stock to the new Lube Vacuum Column Unit. The new DAO Hydrocracker Unit produces approximately ____ BPSD of waxy lube stock. The two waxy lube stocks are processed in the Lube Vacuum Column Unit in a blocked operation mode. The waxy cuts from the new Lube Vacuum Column Unit are further processed in the Lube IDW/HF Unit in blocked operation mode for producing the full slate of lube base oils. The lube base oil product rates and slates for Case 4 are identical to those in Case 3.

3.1.3 Process Units

An overall description of the proposed refinery configurations for each of the four study cases was presented in the previous section, including feed and product flowrates, qualities, and sources/destinations for the major process units. This section provides a summary of the function of each of these units and how they are interconnected in each of the four study cases. A matrix showing which particular process units are included in each case is presented in Table 3.1.3-A on page 3.1-14. It lists two groups of units: 1) existing UP-II Refinery units that have been evaluated and/or recommended for modification to support the Dumai Base Oils Project; and 2) new units that are part of the Lube Base Oils Complex.

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Table 3.1.3-A
Process Units Case Matrix

Evaluated/Modified UP-II Process Units	Unit Number	Case 1	Case 2	Case 3	Case 4
High Vacuum Unit	110	X	X	X	X
Delayed Coker Unit	140	X	X	X	X
Converted HC Unibon Unit Train 2	212	--	X	--	X
Distillate Hydrotreater Unit	013	--	X	--	X
Hydrogen System	---	--	--	--	--
Sour Water Treating Unit	840	X	X	X	X
Amine Treating/LPG Recovery Unit	410	--	--	--	--
New Lube Base Oil Complex Process Units	**Unit Number**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Lube Isocracker Unit	010	X	--	X	--
Solvent Deasphalting Unit	016	--	--	X	X
DAO Hydrocracker Unit	014	--	--	--	X
Lube Vacuum Column Unit	011	--	X	--	X
Lube Isodewaxer/Hydrofinisher Unit	012	X	X	X	X
Make-up Hydrogen Booster Compression Unit	015	X	X	X	X
Tempered Water System	017	X	X	X	X
Wash Water Injection System	018	X	X	X	X

Note: An "X" indicates that either a new unit is required, or that an existing unit must be modified for a given case. A dash (--) indicates that a new unit is not required, or that existing unit modifications are not required.

High Vacuum Unit (Unit 110) - This existing unit fractionates low sulfur waxy residue (LSWR) from both the UP-II Refinery Crude Distillation Unit and the Sungai Pakning Refinery Crude Distillation Unit under high vacuum conditions to produce light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO), and vacuum residue. LVGO is routed directly to the refinery diesel pool. HVGO is used as feedstock by the existing HC Unibon Unit (fuels hydrocracker), and the lube hydrocracker facility (either a new stand-alone unit or a modified train of the existing HC Unibon Unit). Vacuum residue is used as Delayed Coker Unit (DCU) feedstock, as refinery fuel oil, and as feedstock to the new Solvent Deasphalting Unit. The High Vacuum Unit feed rate is increased in all four study cases; however, only minimal modifications are required.

Delayed Coker Unit (Unit 140) - The feed to this existing unit is vacuum residue from the HVU, along with (in Cases 3 and 4 only) Tar (asphaltenes) from the SDA Unit. The feed is thermally cracked to produce green coke, heavy coker gas oil (HCGO), light coker gas oil (LCGO), naphtha and LPG. Green coke is either sold directly as fuel-grade coke, or processed in the existing Coke Calciner Unit to produce anode-grade coke product. HCGO is used as feedstock to the existing fuels hydrocracker (HC Unibon Unit). LCGO, naphtha and LPG are processed in various existing units prior to being combined into the refinery diesel, mogas, and LPG product pools, respectively. Modifications are required to the Delayed Coker Unit in all four study cases to bring it to its original design capacity in order to meet the increased throughput rates or coke make requirements.

Lube Isocracker Unit (Unit 010) - This new Lube Base Oil Complex unit catalytically processes either straight-run HVGO (Case 1), or HVGO and Deasphalted Oil (from the SDA Unit) in a blocked mode of operation (Case 3), to produce waxy lube base oil stocks. The lube isocracking catalyst selectively converts feed components into high viscosity index lube base oils and premium-quality distillate fuels. The unit includes a vacuum column that separates the combined lube stock into separate waxy lube base oils, which are routed to the Lube Isodewaxer/Hydrofinisher Unit for further processing. Two waxy lube base oils are produced in Case 1 and 2, while four products are produced in Case 3 and 4.

Solvent Deasphalting Unit (Unit 016) - A new Solvent Deasphalting Unit (using a Kerr-McGee ROSE® licensed process) is provided in Cases 3 and 4 to extract a paraffin-rich, low- metals-content heavy oil from a portion of the HVU vacuum residue using mixed LPG solvent. The resulting deasphalted oil (DAO) is processed in either the Lube Isocracker Unit (Case 3) or the DAO Hydrocracker Unit (Case 4) to produce a waxy bright stock lube base oil. The asphaltene byproduct (Tar) is combined with the remaining vacuum residue and processed in the Delayed Coker Unit.

Converted HC Unibon Unit Train 2 (Unit 212) - In Cases 2 and 4, Train 2 of the existing HC Unibon Unit is converted to dual lube/fuels hydrocracking operation. This converted unit, in combination with the Distillate Hydrotreater Unit (Unit 013) and the Lube Vacuum Column Unit (Unit 011), performs a similar function to the stand-alone Lube Isocracker Unit. The HVGO feed is catalytically processed to produce lube base oil stock (sent to the new Lube Vacuum Column Unit for separation), and distillate products (processed in the new Distillate Hydrotreater Unit and then blended into the refinery distillate product pools).

DAO Hydrocracker Unit (Unit 014) - This new unit is used in Case 4 only to catalytically process DAO from the SDA Unit to produce bright stock lube base oils. It performs a function comparable to the Lube Isocracker Unit in Case 3, which periodically operates in a blocked DAO processing mode. The DAO Hydrocracker Unit is licensed by UOP/Unocal.

Distillate Hydrotreater Unit (Unit 013) - The kerosene and diesel products produced in Cases 2 and 4 by the Converted HC Unibon Unit Train 2, along with additional products produced in Case 4 by the DAO Hydrocracker Unit, must be hydrotreated to improve their quality prior to being blended into the refinery product pools. The new Distillate Hydrotreater Unit, which is configured to include both existing, surplus HC Unibon Unit Train 2 equipment and new equipment, performs the required hydrotreating function. light kerosene, heavy kerosene and diesel are routed from Unit 212 to Unit 013, processed to improve the kerosene smoke point and the diesel cetane index, and sent to the refinery kerosene and diesel product pools.

Lube Vacuum Column Unit (Unit 011) - This new unit is required in Cases 2 and 4 to fractionate lube base oil stock from the Converted HC Unibon Train 2 (along with stock from the DAO Hydrocracker in Case 4) into waxy lube base oil intermediate products and unconverted vacuum gas oil. This unit performs the same function as the vacuum column section of the Lube Isocracker Unit in Cases 1 and 3. The waxy lube base oils are routed via intermediate storage to the Lube Isodewaxer/Hydrofinisher Unit. Unconverted vacuum gas oil is combined with straight-run HVGO for reprocessing in the hydrocracking units.

Lube Isodewaxer/Hydrofinisher Unit (Unit 012) - The waxy lube base oil intermediate products from the various lube hydrocracking processes utilized in all four study cases are processed in the new Lube Isodewaxer/Hydrofinisher Unit to produce marketable lube base oils. This unit utilizes two separate catalytic reactor systems. The Isodewaxing catalyst isomerizes waxy material to increase the finished product Viscosity Index and reduce its pour point. The hydrofinishing process removes residual amounts of nitrogen and sulfur and saturates aromatics, thereby enhancing the finished product color and oxidation stability. The Lube Isodewaxer/Hydrofinisher Unit is operated in a blocked mode to allow selection of the optimum operating conditions which best preserve the quality and characteristics of the various specific lube base oil products.

Hydrogen System - The Hydrogen System includes the existing UP-II Refinery hydrogen production, distribution, and compression systems. The existing Hydrogen Plant consists of two identical production trains which produce 97 volume % purity hydrogen for use at the selected hydroprocessing and all hydrocracking units. Offgas from the various hydroprocessing units is processed in the Amine Treating/LPG Recovery Unit, combined with a portion of the platformer offgases, and fed to the Hydrogen Plant. LPG is used as supplemental feed as required.

The existing hydrogen make-up gas compression system, which is located within the HC Unibon Unit, compresses gas from the Hydrogen Plant and routes it to both HC Unibon Unit trains, the new Lube Isocracker Unit (Cases 1 and 3), the new Distillate Hydrotreater Unit (Cases 2 and 4), the new DAO Hydrocracker Unit (Case 4), and the new Lube Isodewaxer/Hydrofinisher Unit (all Cases). Make-up hydrogen for some of the new lube processing units must be routed through a new make-up hydrogen booster compression unit to meet the specific unit supply pressure requirements. The existing hydrogen system has adequate excess capacity in all four study cases to handle the new lube processing unit hydrogen requirements with only minor modifications (new distribution piping is required).

Make-up Hydrogen Booster Compression Unit (Unit 015) - Although the existing HC Unibon Unit make-up hydrogen compression system has adequate capacity, new booster compressors are required in all four study cases to boost the supply pressure of the make-up hydrogen to the new Lube Isocracker and DAO Hydrocracker Units and the hydrofinishing portion of the new Lube Isodewaxer/Hydrofinisher Unit. Two 100 percent capacity, motor-driven, reciprocating machines are provided in the make-up hydrogen booster compression unit for this purpose.

Tempered Water System (Unit 017) - Due to pour point and viscosity considerations, tempered water must be used (instead of sea cooling water) to cool waxy lube base oils and lube base oil products before they are sent to storage. The new Tempered Water System is a closed-loop system designed to supply, depending upon the case, the new Lube Isocracker, DAO Hydrocracker, Lube Vacuum Column and Lube Isodewaxer/ Hydrofinisher Units.

Wash Water Injection System (Unit 018) - The new Wash Water Injection System injects water upstream of reactor effluent condensers in the Lube Isocracker and Lube Isodewaxer/Hydrofinisher Units to prevent the accumulation of ammonium bisulfide salts, which may cause excessive fouling of air cooler tubes.

Sour Water Treating Unit (Unit 840) - This existing unit is designed to process sour water from various sources to produce stripped sour water with a maximum H_2S concentration of 37.5 ppm(w). The stripped sour water is routed to the refinery waste water system for further treatment and disposal. Sour offgas is sent to the existing refinery sour gas flares for disposal. In each of the four study cases, additional sour water is produced by the new lube processing units. This incremental sour water stream is processed in the existing Sour Water Treating Unit, although some equipment must be modified to adequately handle the additional load.

Amine Treating/LPG Recovery Unit (Unit 410) - Sour, hydrogen-rich gas from the various refinery hydroprocessing units is processed in this unit to remove H_2S, and then is routed to the Hydrogen Plant. In addition, this unit removes H_2S from sour LPG produced by the HC Unibon Unit, which is then combined with Platforming Unit LPG, stabilized in a deethanizer, and routed to final product storage. The new lube processing units produce both sour gas and sour LPG. Overall, however, the total sour LPG rate is lower than the original design in all cases. The total sour gas rate has increased for some of the study cases, but the existing Amine Treating/LPG Recovery Unit is adequate to process this increased load without modifications.

3.1.4 Utilities, Offsites, and Tankage

The utility and offsite facilities required to support the Dumai Base Oils Project are provided by addition of several new utility and offsite systems as well as by modifying the existing UP-II utility and offsite systems. The study has also evaluated the available excess capacity in the existing utility and offsite systems and utilized those excess capacities where sufficient margins exist. The UP-II refinery operation personnel were consulted prior to arriving at the available excess capacities in the existing systems. A tabular summary of the available excess capacity in the existing systems is included in the design basis section of this report.

For the most part, new parallel equipment is added to the existing utility systems to meet the requirements of the Dumai Base Oils Project. Rather than adding systems or equipment sized to exactly match the new requirements of each study case, equipment sizes are selected that match the existing equipment sizes. This approach provides for greater compatibility (maintenance, spare parts, etc.) between new and existing systems, while providing conservatively sized systems to meet the new facility requirements.

In general, most of the new utility and offsite systems required for this project are integrated to the existing UP-II refinery systems, except those systems that are dedicated to the lube base oil complex (e.g., flare system, intermediate and product tankage, jacket water system, etc.).

New loading arms are added to the existing UP-II refinery "New" Jetty to allow export of the lube base oil products. The existing jetties are modified to accommodate these new loading arms. Completely new product tankage and product transfer pumps and associated equipment are provided to facilitate storage and loading of base oils.

Table 3.1.4-A on the following page presents an overall summary of the utility consumptions. The summary includes utility requirements for (a) new Lube Base Oils Complex Units, (b) differential over the Base Case for the modified UP-II process units, and (c) additional utility/offsite equipment systems.

The values in the table are based on the information supplied by process unit licensors, supplemented by Fluor Daniel-developed information. In addition, the data for the modified process units was generated internally and supplemented in some cases by licensor data (e.g., UOP information on the Delayed Coker Unit and the converted HC Unibon Unit Train 2). It was assumed that the existing utility systems can adequately support the Base Case UP-II refinery operation. Therefore, for the existing modified units, only the differential utility values over the Base Case are included in the table. Also included in the table are the utilities required to support the new utility and offsite equipment/systems. The values reported in this table serve as the basis for the design of the new equipment for supplementing the existing or new utility/offsite systems.

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A matrix showing which particular systems are included in each of the study cases is presented in Table 3.1.4-B on the following page. It lists three groups of systems: utility systems, offsite systems, and tankage and loading systems. A detailed discussion of each system is provided in Section 3.4. The following provides a summary for the systems. The presentation of information is arranged sequentially by unit number.

Utility Systems

The River Water Intake and Pipeline System (Unit 020) is used to transport water from the Rokan River to the offplot water treating facility located near the Pertamina housing area. The system consists of a water intake facility and diesel-engine driven water supply pumps. The river water is transported by an existing 45 km long 24" pipeline. The proposed design does not require changes to this system to support the base oils project. An alternate proposed design does require some additions to this system (new intake pumps and a new 45 km long 10" pipeline).

The Water Treatment (Offplot) (Unit 021) is used to treat the river water to produce potable water for the Pertamina housing area and to provide raw water to the UP-II Refinery. This system is composed of clarifiers, reservoirs, pumps, and filters. The proposed design adds a new 5000 m^3 capacity storage tank for balancing the varying water demand from the Pertamina housing area. The alternate design requires significant modifications to the existing system.

The Raw/Plant/Potable Water system (Unit 022) is the water treating system inside the UP-II refinery. The system filters the raw clarified water for use as feed to the various refinery systems. Chlorination is carried out on the portion of the water used for potable services. The system is modified by the addition of a sand filter and pumps in potable and raw water service.

The Demineralized Water/BFW/Condensate System (Unit 023) is used to produce high purity water for boiler feedwater and other services. Makeup demineralized water is blended with return condensate to produce the deaerator feed. A new deaerator and associated boiler feedwater pumps are added for supplying water to the new boilers and new process steam generators.

Table 3.1.4-B
Utility/Offsite/Tankage System Case Matrix

Utility Systems	Unit Number	Case 1	Case 2	Case 3	Case 4
River Water Intake & Pipeline	020	NC	NC	NC	NC
Water Treatment (off-plot)	021	X	X	X	X
Raw/Plant/Potable Water	022	X	X	X	X
Demineralized Water, BFW, Condensate, Steam Generation	023	X	X	X	X
Power Generation	024	X	X	X	X
Instrument/Plant Air	025	X	X	X	X
Sea Cooling Water	026	X	X	X	X
Firewater (Sea Water)	027	X	X	X	X
Fuel Oil	028	X	X	X	X
Jacket Water System	029	X	X	X	X
Fuel Gas	030	X	X	X	X
Offsite Systems					
Flare System	040	X	X	X	X
Nitrogen Storage/Vaporizer	041	X	X	X	X
Oily Water Treatment	042	X	X	X	X
Sanitary System	043	X	X	X	X
Tankage & Shipping					
Intermediate Storage	045	X	X	X	X
Product Lube Storage	046	X	X	X	X
Product Shipping	050	X	X	X	X

Note:
- An "X" indicates that either a new system is required or that new equipment is added to the existing system.
- "NC" - No change

The Steam Generation System (Unit 023) produces the high pressure steam (42 kg/cm^2g) for process users and power generator turbines. The system is modified to include two new boilers and accessories.

The Power Generation System (Unit 024) is used to produce power required to operate the refinery as well as an allotment of power for the Pertamina housing facility. The new system adds a new steam turbine power generator and associated equipment. The new equipment can meet the demand of the Lube Base Oils Complex and the additional requirements of the modified process units, the Pertamina housing area, and other infrastructure being provided for this project.

The Plant/Instrument Air System (Unit 025) is used to supply compressed dry air for the plant instruments and controls and compressed air for the refinery maintenance and process requirements. The air flow to the plant air header is automatically cutoff should the instrument air header pressure drop. A new air system is added that includes an air compressor, air receiver, and a dryer package.

The Sea Cooling Water System (Unit 026) is modified to provide water to the new equipment in sea cooling water service. New pumps, strainers, and basins are added to the system to satisfy the process requirement.

The Firewater System (Unit 027) is used as a source of fire-fighting water. No new equipment is added to the system other than piping, valves, monitors, and fire hydrants as required for the additions in the following areas: process units, tankage and loading systems, and the utility plant.

The Fuel Oil System (Unit 028) and the Fuel Gas System (Unit 030) supply fuel to the process area fired heaters, utility area steam generators, and to other small users. The existing systems are not modified except to make piping tie-ins where required.

The Jacket Water System (Unit 029) is used to cool process equipment where use of sea water is considered unacceptable. This system supplies water to the lube oil complex and new utilities and offsites equipment.

Offsite Systems

The Flare System (Unit 040) is used to collect and dispose of waste gas from the refinery. The Lube Base Oils Complex is provided with a stand-alone elevated flare. There is no modification required to any of the existing refinery flare systems except to make the necessary piping tie-ins for the modified process units.

The Nitrogen Storage/Vaporizer System (Unit 041) is used to distribute inert gas. The existing system is modified by adding a storage tank and a vaporizer. The primary new users of nitrogen are lubes storage tanks and process units during unit turnaround.

The Oily Water Treatment System (Unit 042) is used to collect and process oily water so that it may be discharged from the refinery. The existing system is modified by addition of an oily water collection and transfer facility. A new, dedicated TPI separator is added for treating the oily water from the new facility.

The Sanitary Sewer System (Unit 043) will be a closed, gravity flow sewer system that collects and routes waste to septic tanks located in the new lube complex area. The septic tank effluent will be pumped to the existing stabilization basin for biological treatment.

Tankage and Shipping Systems

The Intermediate Storage (Unit 045) and the Product Lube Storage (Unit 046) systems consist of storage tanks and transfer pumps to allow for smooth operation of process units and shipping of products. The tankage is added as required to support the new Lube Base Oils Complex and its support facilities. The tankage requirements for each study case vary with the number of lube products and the processing unit configuration. A summary of storage capacities for each study case is presented in the following Table 3.1.4-C. The Product Shipping System (Unit 050) is used to transfer products from tankage to ships or barges at the jetties. The loading requirements vary with the number of lube products, parcel size, loading frequency, etc. Cases 1 and 2 require three loading arms each, while Cases 3 and 4 need five loading arms each. The marine loading facilities will require modifications to allow for shipping the lube products. These modifications will include

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new loading arms, revamping of existing jetties, new product transfer lines, and new controls.

3.1.5 Infrastructure and Common Facilities

The Dumai Base Oils Project requires the addition of infrastructure and common facilities to the existing UP-II Refinery facilities. The following summarizes the facilities that are included in the project scope of work and capital cost estimates.

Infrastructure

Additional housing (a total of 80 houses) is added to the existing Pertamina Housing Area, which is located approximately 12 km from the refinery. The number and type of housing, which is identical for all four study cases, was determined by the Pertamina in-house client representative. Utilities to support the new housing are obtained via tie-in to the existing utility systems.

Common Facilities

The Common Facilities provided to support the Dumai Base Oils Project are divided into four major areas, as follows:

Offsite Common Facilities

The following Offsite Common Facilities (designated as CF) are added to the existing refinery facilities:

- New laboratory equipment and furnishings in the existing laboratory buildings
- Additional communications equipment
- Additional cathodic protection, as required

- Miscellaneous steam and electric tracing not associated with the new and modified process units

- Miscellaneous fire and safety equipment

- Structural modifications to existing jetties to accommodate new product loading arms

- Additional maintenance equipment and vehicles, the existing maintenance buildings are adequate

- General civil site development

- New construction dock and laydown area, including a customs bonding area, batching plant, materials receiving and stockpiling area, and field fabrication area, as required.

Electrical Substations/Distribution Facilities

The new Electrical Substation/Distribution (EL) facilities include systems to distribute electrical power from the new power generation facility (Unit 024) to the new process units, and two new electrical substations located at the new lube oil complex. Electrical distribution within process units is included in the process unit design and cost estimate.

Control Rooms/DCS/Analyzers Facilities

The new Control Rooms/DCS/Analyzers (CR) facilities include the following:

- A new main process control room and change room for the new lube complex process units. This control room houses the new Distributed Control System (DCS).

- Addition to the existing Utilities Control Room to support the new utility equipment.

- Addition to the existing Power Generation Building to house the new power generator.

- Addition to the existing instrument air supply building.

- A new tank gauging system for the new intermediate and final lube base oil product tanks.

- Allowances in the capital cost estimate to cover miscellaneous process analyzers, shelters, detectors, fire and gas monitoring systems, etc., using EXOR IV as a basis.

Interconnecting Pipeways Facilities

The new Interconnecting Pipeways (IP) facilities include all new pipeways and sleeper ways required to connect process units with other process units and tankage. In addition, modifications are made to existing interconnecting pipeways and sleeper ways to support modified existing facilities, as required.

3.1.6 Environmental Considerations

The Dumai Base Oils Project feasibility study considers current and past Indonesian environmental regulations and standards in the design of the lube processing facilities. The current Indonesian environmental standards on effluent water quality and air emission, as outlined in Table 3.1.6-A and 3.1.6-B on the following two pages, are applicable only to new units and equipment. Modifications to the existing UP-II Refinery units or systems are governed by the environmental standards or criteria used for the design of the original units or systems. This approach was agreed upon by all consortium members during the Mid-Point Review meeting, which was held on the November 16, 1992.

In the existing UP-II Refinery, the major effluent streams leaving the refinery battery limit include waste water and sea cooling water. The major sources contributing to the waste-water stream are oily water from various units, contaminated storm water, cooling tower and boiler blowdown streams, sour water from process units, sanitary water, and miscellaneous streams from water treatment units. The sea cooling water is used as a once-through cooling medium for various exchangers within the refinery.

The major sources of emissions in the refinery originate from fired boilers, fired heaters, flare stacks, equipment and tankage vents, process unit vents (e.g., CO_2 from the Hydrogen Unit), and miscellaneous other sources.

The Dumai Base Oils Project will require the addition of several new process units, as well as modifications to certain existing units in the refinery. All new equipment, whether located in a new unit or in an existing unit, will be designed to meet the current environmental standards. For example, a new fired heater will be designed to meet the current SO_X, NO_X and CO emission standards.

The lube facility is expected to generate additional sour water and oily water. The additional sour water will increase the load on the existing Sour Water Treating Unit by 20 to 30 percent. The existing unit will be debottlenecked on the basis of meeting the original design H_2S and NH_3 concentration levels in the stripped sour water. Also, sour gas generated by additional feed to the existing Amine Treating/LPG Recovery Unit and the Sour Water Treating Unit will be flared in the existing sour gas flares, under the assumption that emissions from the existing flare stacks will be exempt from the current standards.

A similar approach has been adopted for oily water and sea-cooling water systems. The new lube facility will generate additional oily water and increase the load on the existing sea-cooling water system. Again, these systems have been debottlenecked based on meeting the original effluent water standards.

Table 3.1.6-A
Air Emission Standards

LAMPIRAN XV : SURAT KEPUTUSAN
MENTERI NEGARA KEPENDUDUKAN
DAN LINGKUNGAN

BAKU MUTU UDARA EMISI
1. SUMBER TAK BERGERAK

NOMOR : KEP-03/MENKLH/II/1991
TANGGAL : 19 January 1991

No. Urut	Parameter	Baku Mutu Emisi	Keterangan
		B	
1.	Kabut asam sulfat atau sulfur trioksida atau keduanya	0.25	1. g SO_3/Nm^3 dari buangan gas 2. buangan gas bebas dan kabut yang persisten.
2.	Oksida nitrogen (NO_X)	4.60	Buangan gas tak berwarna g/Nm^3
3.	Karbon monoksida (CO)	1.00	g/Nm^3
4.	Partikel padat (operasi lainnya)	0.50	g/Nm^3
5.	Hidrogen sulfida (H_2S)	5.00	ppm (v/v)
6.	Metil merkaptan (CH_3SH)		ppm
7.	Amonia (NH_3)		ppm
8.	Gas klorin	0.25	g HCl/Nm^3
9.	Hidrogen klorida (HCl)	0.50	gm HCl/Nm^3
10.	Fluor, asam hidrofluorida atau senyawa inorganik fluor	0.02	gm asam hidrofluorida/Nm^3 dari buangan gas
11.	Timah hitam (Pb)	0.025	gm/Nm^3
12.	Gas-gas asam	6.00	gm SO_3/Nm^3 dari buangan gas
13.	Seng (Zn)	0.10	gm/Nm^3
14.	Air raksa (Hg)	0.01	gm/Nm^3
15.	Kadmium (Cd)	0.015	gm/Nm^3
16.	Arsen (As)	0.025	gm/Nm^3
17.	Antimon (Sb)	0.025	gm/Nm^3
18.	Radio nuklida		
19.	Asap		* = Ringlemann no. 2

Keterangan B = baku mutu sedang

Table 3.1.6-B
Effluent Water Standards

LAMPIRAN XV : SURAT KEPUTUSAN MENTERI NEGARA KEPENDUDUKAN DAN LINGKUNGAN
NOMOR : KEP-03/MENKLH/II/1991
TANGGAL : 19 January 1991

BAKU MUTU AIR LIMBAH *)

No. Urut	Parameter		Satuan	Golongan Baku Mutu Air Limbah
				II
	FISIKA			
1.	Temperature		°C	38
2.	Zat padat terlarut		mg/L	2,000
3.	Zat padat tersuspensi		mg/L	200
	KIMIA			
1.	pH			
2.	Besi terlarut	(Fe)	mg/L	6 - 9
3.	Mangan terlarut	(Mn)	mg/L	5
4.	Barium	(Ba)	mg/L	2
5.	Tembaga	(Cu)	mg/L	2
6.	Seng	(Zn)	mg/L	2
7.	Krom Heksavalen	(Cr^{6+})	mg/L	5
8.	Krom total	(Cr)	mg/L	0.1
9.	Cadmium	(Cd)	mg/L	0.5
10.	Raksa	(Hg)	mg/L	0.05
11.	Timbal	(Pb)	mg/L	0.002
12.	Stanum	(Sn)	mg/L	0.1
13.	Arsen	(As)	mg/L	2
14.	Selenium	(Se)	mg/L	0.1
15.	Nikel	(Ni)	mg/L	0.05
16.	Kobalt	(Co)	mg/L	0.2
17.	Sianida	(CN)	mg/L	0.4
18.	Sulfida	(H_2S)	mg/L	0.05
19.	Flourida	(F^2)	mg/L	0.05
20.	Klorin bebas	(C_2)	mg/L	.2
21.	Amoniak bebas	(NH_3-N)	mg/L	1
22.	Nitrat	(NO_3-N)	mg/L	1
23.	Nitrat	(NO_3-N)	mg/L	20
24.	BOD_5		mg/L	1
25.	COD		mg/L	50
26.	Senyawa aktif biru metilen		mg/L	100
27.	Fenol		mg/L	5
28.	Minyak nabati		mg/L	0.5
29.	Minyak mineral		mg/L	5
30.	Radioaktifitas **)			10
31.	Pestisida termasuk PCB ***)			

Catatan:

*) Kadar bahan limbah yang memenuhi persyaratan baku mutu air limbah tersebut tidak diperbolehkan dengan cara pengeceran yang airnya secara langsung di ambil dari sumber air

The following list summarizes the specific environmental measures taken for each emission. In general, all new furnaces in the lube oil complex are fuel-oil fired. The refinery fuel oil consists of the vacuum residue from the HVU with coker naphtha and/or diesel as cutter stocks. The fuel oil is expected to contain 0.2 wt% of sulfur and 0.37 wt% of nitrogen.

Air Emissions	Environmental Measures
Sulfur Oxides:	
All New Fired Heaters and Boilers	No specific measures required based on sulfur content of fuel oil
Nitrogen Oxides:	
All New Fired Heaters and Boilers	Low NOx burners
Hydrocarbon Vapors:	
New Oily Water Sewer	Sealed drain hubs
Process Vents	Elevated flares, safe venting
Storage Tanks	RVP>1.5 psi: Double seal floating roof RVP<1.5 psi: Cone roof
Effluent:	
Oily Water	TPI separator and biological treatment
Sanitary Server	Septic tanks, biological treatment
Sour Water	Revamp existing sour water stripper to remove H_2S and NH_3

The Lube Base Oils Complex will increase the overall emissions and effluents from the UP-II Refinery. Table 3.1.6-C on the following page provides a summary of the overall atmospheric emissions from the additional facilities provided by this project only. The second following Table 3.1.6-D provides a summary for the effluents from the additional facilities.

Table 3.1.6-C
Atmospheric Emissions Summary
(Incremental Over Base Case)

	Class B Air Standard	Case 1			Case 2			Case 3			Case 4		
		Boilers & Heaters(1)	Sour Gas Flare(2)	Total	Boilers & Heaters(1)	Sour Gas Flare(2)	Total	Boilers & Heaters(1)	Sour Gas Flare(2)	Total	Boilers & Heaters(1)	Sour Gas Flare(2)	Total
Duty, MM Kcal/h	-	93.4	NC	-	109.2	NC	-	139.4	NC	-	163.3	NC	-
Flue Gas, Nm^3/h		131,800	3,100	134,900	154,100	3,700	157,800	196,700	3,700	200,400	230,400	4,200	234,600
NOx, kg/h	-	94	NC	-	110	NC	-	141	NC	-	165	NC	-
NOx, g/Nm^3	4.6	0.72	NC	-	0.72	NC	-	0.72	NC	-	0.72	NC	-
CO, kg/h	-	6	NC	-	7	NC	-	9	NC	-	10	NC	-
CO, g/Nm^3	1.0	0.05	NC	-	0.05	NC	-	0.05	NC	-	0.05	NC	-
SO_2, kg/h	-	35	309	343	41	340	381	52	375	427	61	422	483
SO_2, g/Nm^3	N/A	0.26	100	2.54	0.26	92	2.41	0.26	101	2.13	0.26	101	2.06
SO_3, kg/h	-	0.9	3.9	4.8	1.0	4.3	5.3	1.3	4.7	6.0	1.5	5.3	6.8
SO_3, g/Nm^3	0.25	0.01	1.25	0.036	0.01	1.18	0.034	0.01	1.27	0.030	0.01	1.26	0.029
H_2S, kg/h	-	Trace	0.17	0.17	Trace	0.18	0.18	Trace	0.20	0.20	Trace	0.23	0.23
H_2S, g/Nm^3	5.0	Trace	0.05	0.05	Trace	0.05	0.05	Trace	0.05	0.05	Trace	0.05	0.05

Notes:
(1) All boilers and heaters are new and comply with new Class B air standards
(2) New air standards are not applicable to the sour gas flare emission since the flare is existing in UP-II
(3) NC - Not calculated

Table 3.1.6-D
Effluent Summary
(Incremental Over Base Case)

	Case 1	Case 2	Case 3	Case 4
Effluent Water				
Average, m^3/h	50	57	64	69
Maximum, m^3/h	150	150	150	150
Sea Cooling Water				
From Sea Water Return Retention Pond, m^3/h	703	664	803	929
Return Temperature, °C	<38	<38	<38	<38

Note: New effluent standards are not applicable since the existing or revamped existing facilities are used for treating the effluent streams.

3.2 Study Design Basis

3.2.1 General Design Criteria

The purpose of this study is to determine the technical and economic feasibility of producing approximately 6,000 BPSD of high quality lube base oils at a new facility located within the existing Dumai UP-II Refinery. The feedstock for lube base oil production will be straight-run heavy vacuum gas oil (HVGO) produced by the existing UP-II Refinery processing Minas (Sumatran Light) and Duri crudes, and deasphalted oil (DAO) produced from straight-run UP-II Refinery vacuum residue. Incremental feed required to produce the lube base oils will be supplied by processing additional low sulfur waxy residue (LSWR) obtained from Pertamina's existing Sungai Pakning Refinery, which processes Minas, Pedada and Lirik crudes, in the UP-II High Vacuum Unit.

The general design criteria used to complete this study are summarized as follows:

- Lube hydrocracking capability is supplied as follows:

Cases 1 and 3:	New stand-alone Lube Isocracker Unit.
Case 2:	Conversion of one of the existing HC Unibon Unit fuels trains to lube hydrocracking mode.
Case 4:	Conversion of one HC Unibon Unit train, plus the addition of a new DAO Hydrocracker Unit.

- Base lube oils are produced using Chevron lube hydroprocessing technology. For this study UOP catalyst technology is used for the cases where one train of the existing HC Unibon Unit is modified.

- The lube processing facilities are designed for an operating on-stream factor of 330 days per year.

- Some of the lube processing units (e.g., the Lube Isodewaxer/Hydrofinisher Unit) must be operated in a blocked mode to produce the desired lube base oils.

[This deleted information is considered confidential and proprietary.]

- The operation of the new lube base oil facilities must not impact the current UP-II Refinery middle distillate product (kerosene and diesel) rates and qualities, as defined in the study Base Case. As a result, some of the existing UP-II Refinery units must be debottlenecked, including the Delayed Coker Unit, High Vacuum Unit.

- Current UP-II Refinery unit capacities, as reported by Pertamina and included in the Terms of Reference, are used as one of the criteria for deciding if a given existing unit must be evaluated as a part of this study.

- The new Lube Base Oils Complex will be located within the existing Dumai UP-II Refinery. As agreed to by the Consortium members, a primary and an alternate site location, both near the existing process units, are considered.

- Current Indonesian environmental rules and regulations (as specified in the Terms of Reference) apply only to new facilities. Any modifications to existing units are governed by rules and regulations in existence at the time the unit was originally designed and installed.

- The use of air cooled exchangers is maximized, while the use of sea water cooling services is minimized.

- Only a minimal degree of heat integration is incorporated into the design of the new and modified lube processing units.

- Spare equipment items are provided for all pumps and reciprocating compressors. No spares are provided for centrifugal compressors.

- Instrumentation supplied for new facilities is electronic, including a distributed control system (DCS). Modified UP-II facilities retain their current control system design.

3.2.2 Feed and Product Quality

The criteria used to establish the study feed and product quantities are discussed separately in Section 3.1.2. The following feed and product quality criteria were used to design the new lube oil processing facilities and to recommend necessary modifications to existing facilities:

- The UP-II Refinery crude feed slate is comprised of 82.5 volume percent Minas crude and 17.5 volume percent Duri crude. For the Sungai Pakning Refinery, which supplies incremental LSWR feedstock to UP-II, the crude feed slate is 70 volume percent Minas, 15 volume percent Pedada and 15 volume percent Lirik crudes.

- The assays for the crude oils processed in both the Dumai UP-II and the Sungai Pakning Refineries are contained in the Terms of Reference (Attachment 6). The assays originally included in the Terms of Reference were performed by SIPM, BP, and Pertamina, depending upon the crude. During the course of the study, Chevron assays for Minas and Duri crudes taken from the EXOR IV project files were substituted to maintain the Chevron and Fluor Daniel study work on a consistent basis.

[This deleted information is considered confidential and proprietary.]

[This deleted information is considered confidential and proprietary.]

- The existing UP-II Refinery distillate product specifications supplied by Pertamina (Attachment 7 of the Terms of Reference) are used.

- The hydrogen gas feed to the lube processing units will have a minimum hydrogen purity of ___ volume percent.

3.2.3 Process Units

Each of the study cases include both new process units and modified existing UP-II Refinery process units. The following design criteria are used in the design and/or evaluation of these units:

- None of the new lube processing units are integrated (e.g., heat integrated) with the existing UP-II Refinery process units.

- The UP-II Crude Distillation Unit throughput is not increased beyond its Base Case capacity of 120,000 BPSD. Sungai Pakning LSWR is used to supply the additional refinery feed required to produce the lube base oils.

- Only those existing UP-II Refinery units that are impacted by the Dumai Base Oils Project are evaluated for potential bottlenecks. All other units are assumed to be capable of operating at their capacities, as defined by Pertamina in the Terms of Reference (Attachment 5).

3.2.4 Utilities, Offsites and Infrastructure

The Dumai Base Oils Project will supply additional facilities and/or modify the existing UP-II Refinery facilities to provide adequate Utilities, Offsites and Infrastructure systems to support the new Lube Base Oils Complex. The following criteria are used in the design of these new and/or modified systems:

- For the most part, new equipment and/or systems are supplied to meet the utility and offsite system requirements of the Lube Base Oils Complex. Minimal effort is made during the study phase of the project to determine the optimum level of integration between the new facilities and the existing UP-II Refinery utility and offsite systems. In fact, integration is incorporated only in those systems where it is obviously practical and effective (e.g., the firewater system).

- In general, rather than adding systems or equipment sized to exactly match the Lube Base Oils Complex requirements, equipment sizes are selected that match the existing equipment sizes. This procedure provides for greater compatibility (maintenance, spare parts) between new and existing systems, while providing conservatively-sized systems to meet the new facility requirements. Where practical, existing equipment provides spare capacity for new facilities.

- The utility generation conditions (pressure, temperature, electrical power level) for new equipment are identical to the existing system generation conditions.

- The existing UP-II Refinery utility systems capacities and current operating loads, as provided to Fluor Daniel by Pertamina, are listed in Table 3.2.4-A on the following page.

- A new, dedicated flare system is provided for the new Lube Base Oils Complex. Integration with the existing refinery flare systems is not considered during this study phase.

- Adequate storm water drainage and sewer facilities are provided to support the new lube processing facilities.

- Lube base oil product shipping design criteria developed jointly by Caltex, Chevron, Pertamina, and Fluor Daniel are summarized in Table 3.2.4-B on page 3.2-8 following Table 3.2.4-A.

- In order to help minimize the cost of the Dumai Base Oils Project, a new, dedicated lube base oil product shipping jetty is not provided. Instead, new loading arms are added to the existing UP-II Refinery "New" Jetty to allow the export of the new lube base oil products. The existing jetty must be modified to accommodate these new loading arms. However, completely new product tankage and product transfer pumps are provided.

- Adequate feed storage capacity and intermediate/final product storage capacity is provided to safely operate the new lube processing facilities and the existing refinery with minimal disruption.

- The utilization of existing common facilities is maximized where excess capacity exists (e.g., laboratories, maintenance buildings, warehouses, etc.).

- Housing is provided outside the refinery boundaries for the new Lube Base Oils Complex staff. Additional utilities (water and power) are supplied to support the new housing.

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3.3 Process Units

3.3.1 Overall Refinery Process Description

a. ***Base Case Refinery Configuration***

A block flow diagram for the current configuration of the Dumai UP-II Refinery is presented in Figure 3.3.1-A on the following page. (The block flow diagrams presented in this section were presented in Section 3.1.2 as Figures 3.1.2-A through 3.1.2-E.) The refinery processes a mixture of crude oils (82.5 vol% Sumatra light crude/ 17.5 vol% Duri crude) and low sulfur waxy residue (LSWR) from the Sungai Pakning (SPK) refinery to produce the following products: Mixed LPG, mogas, kerosene, diesel, and fuel-grade and anode-grade coke. In addition, the refinery internally produces sufficient fuel gas and fuel oil to meet its fuel requirements.

The original UP-II Refinery, a simple topping refinery, was built in the early 1970s, and included the Crude Distillation Unit (CDU) and associated naphtha processing units. This topping refinery produced LPG, mogas, and straight-run kerosene and diesel products, as well as atmospheric residue (LSWR). In the early 1980s, the refinery underwent a major expansion to enable processing of the heavy crude cuts to produce additional mogas, kerosene, diesel, fuel, and anode grade coke. The following processing units and associated treating units were added: High Vacuum Unit (HVU), Naphtha Hydrotreater Unit, CCR Platformer Unit, HC Unibon Unit, Delayed Coker Unit (DCU), Coke Calciner Unit, Distillate Hydrotreater Unit, Hydrogen Plant, Amine Treating/LPG Recovery and Sour Water Treating Unit.

The design capacities of the individual units in the UP-II and SPK Refineries are presented in Table 3.3.1-A on page 3.3-3. The capacities listed in the table are taken from Attachment 5 of the Terms of Reference, and were compiled by Pertamina.

In addition to the configuration presented above, Figure 3.3.1-A also shows three existing support process units that are affected by this study. They are: the Hydrogen Unit, the Sour Water Treating Unit and the Amine Treating/LPG Recovery Unit.

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b. ***Case 1 Refinery Configuration***

The proposed revised refinery configuration for Case 1 is presented as a block flow diagram in Figure 3.3.1-B on the following page. This diagram, as well as the diagrams for the other three study cases, indicates which units currently exist in the refinery, which existing units are recommended for revamp, and which new units are required for lube base oils production. Case 1 produces a total of about 6,000 BPSD of two separate lube base oil products while maintaining refinery middle distillate production at the base case levels.

The first new unit, a Lube Isocracker Unit, processes straight-run HVGO to produce waxy lube stocks which are further processed in the new Lube Isodewaxer/Hydrofinisher Unit to produce lube base oil products for export. These new units also produce unconverted vacuum gas oil and a mixture of light by-products that are routed to the existing HC Unibon Unit for further processing into middle distillates and lighter products.

Several existing refinery units must be modified, including the HVU, which must process additional SPK LSWR to supply adequate feedstock to the new Lube Isocracker Unit. In addition, the Delayed Coking Unit must be revamped in order to handle the increased vacuum residue from the HVU. The increased sour water loads generated by the new units also necessitate revamping of the existing Sour Water Treating Unit.

c. ***Case 2 Refinery Configuration***

Figure 3.3.1-C on page 3.3-6 depicts the proposed refinery configuration for Case 2, which also produces a total of about 6,000 BPSD of two separate lube base oil products. However, instead of a new stand-alone lube isocracker, one of the two existing HC Unibon trains (Train 2) is converted to a lube hydrocracker mode of operation in this case. The lube stocks produced from this modified unit are routed to a new Lube Vacuum Column Unit and Lube Isodewaxer/Hydrofinisher Unit for separation and further processing. As with Case 1, byproducts from the new units are routed to the existing HC Unibon Unit (Train 1) for further processing.

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The same existing units that are recommended for modification in Case 1 also must be modified for Case 2.

d. ***Case 3 Refinery Configuration***

The proposed refinery configuration for Case 3 is presented in the following Figure 3.3.1-D. This case produces a total of about 6,000 BPSD of four separate lube base oil products. It is similar to Case 1 in that it contains a new, stand-alone Lube Isocracker Unit and Lube Isodewaxer/Hydrofinisher Unit. Also, the existing HVU, Delayed Coker Unit and Sour Water Treating Unit must be modified. However, in order to produce the heavier lube base oil products, a new Solvent Deasphalting (SDA) Unit must be added. This unit processes vacuum residue to produce deasphalted oil that is fed to the Lube Oil Isocracker to produce the heavier lube base oil products. Residual pitch from the SDA Unit is routed to the Delayed Coker Unit for further processing.

e. ***Case 4 Refinery Configuration***

A block flow diagram for the Case 4 refinery configuration is depicted in Figure 3.3.1-E on page 3.3-9. As with Case 3, four separate lube base oil products (______________) are produced in Case 4. This case is similar to Case 2 in that it utilizes a converted HC Unibon Unit train (Train 2), and includes a new Lube Vacuum Column Unit and Lube Isodewaxer/Hydrofinisher Unit. Also, because UOP does not recommend operating the modified HC Unibon Unit train in a blocked mode of operation, a new Deasphalted Oil Hydrocracker is required downstream of the new SDA Unit. The existing unit modifications presented for the other three cases are also required for this case.

[The information contained on pages 3.3-8 through 3.3-9 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

3.3.2 Evaluated/Modified UP-II Process Units

Several existing UP-II Refinery process units were evaluated to decide if modifications are required for operation under each of the four study cases. The following is a list of those units, along with the study cases in which they require modification:

a.	***Converted HC Unibon Unit Train 2 (Unit 212)***	Cases 2 and 4
b.	***Distillate Hydrotreater Unit (Unit 013)***	Cases 2 and 4
c.	***Delayed Coker Unit (Unit 140)***	All Cases
d.	***High Vacuum Unit (Unit 110)***	All Cases
e.	***Sour Water Treating Unit (Unit 840)***	All Cases
f.	***Amine Treating/LPG Recovery Unit (Unit 410)***	No Modifications Required
g.	***Hydrogen System***	No Modifications Required

Both new equipment and reused equipment from existing Unit 212 make up the Distillate Hydrotreater Unit. For the purposes of this study, it is categorized as an existing UP-II Refinery process unit.

These units are discussed in detail below.

a. ***Converted HC Unibon Unit Train 2 (Unit 212)***

1. Introduction

In Study Cases 2 and 4, the second train (Train 2) of the two existing HC Unibon Unit trains (licensed by UOP) is converted to enable production of lube stocks from straight-run HVGO feedstock. A new Deasphalted Oil (DAO) Hydrocracker is provided in Case 4 to simultaneously supply heavier lube stocks. The proposed modified configuration for Train 2 is identical for both study cases. The other HC Unibon Unit train (Train 1) is not modified, and would continue to produce middle distillates and lighter products from a combination of straight-run HVGO and HCGO feedstock. The required Train 1 throughput of _______ BPSD in Cases 2 and 4 exceeds the original train design capacity of _______ BPSD. However, UOP stated that Train 1 can handle the increased throughput without modifications. A new Distillate Hydrotreater Unit is required to process byproducts such as light kerosene, heavy kerosene, and diesel produced by the converted Train 2 to meet the existing product quality specifications.

The capacity of reconfigured Train 2 is _______ BPSD of fresh feed for Case 2, and ______ BPSD of fresh feed for Case 4 (the original Train 2 design capacity is ______ BPSD). The existing Hydrogen Unit supplies makeup hydrogen gas (97% purity) requirements via the existing HC Unibon Unit makeup hydrogen compression system. *[This deleted information is considered confidential and proprietary.]*

The existing train is reconfigured to handle the increased throughput (____________) while minimizing modifications and maximizing the reuse of existing equipment. UOP performed a process review of all major equipment items in Train 2, including the reactor circuit, the makeup hydrogen compression section, the debutanizer, the product fractionator (with product strippers), the naphtha splitter and the light naphtha stripper. Data from the original UOP Project Specifications for the HC Unibon Unit was used for evaluating the existing equipment. All catalyst recommendations are based on using UOP catalyst systems.

[The information contained on pages 3.3-12 through 3.3-24 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/ or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

d. ***High Vacuum Unit (HVU - Unit 110)***

1. *Introduction*

The existing High Vacuum Unit was originally designed to process 92,612 BPSD of low sulfur waxy residue (LSWR - atmospheric column bottoms). The unit feed was a mixture of LSWR from the UP-II Crude Distillation Unit and LSWR from the Sungai Pakning (SPK) Refinery. The unit is designed to produce light vacuum gas oil (LVGO), which is sent directly to the diesel product pool, heavy vacuum gas oil (HVGO), which is routed to the HC Unibon Unit, and vacuum residue, which is sent to the Delayed Coker Unit.

As depicted in the stock balances presented in Section 3.1.2, the feasibility study HVU feed rate is 94,000 BPSD for all four study cases, which represents only a 1.5% increase over original design. The study feed consists of 78,000 BPSD of UP-II LSWR and 16,000 BPSD of SPK LSWR. The required study production rates for LVGO, HVGO and vacuum residue are 8,200 BPSD, 44,500 BPSD and 41,300 BPSD, respectively.

2. *Process Description*

A simplified schematic of the HVU is shown in the following Figure 3.3.2-D1. LSWR produced in the UP-II Crude Distillation Unit is normally fed directly to the HVU, bypassing LSWR storage. SPK LSWR is routed from storage to the HVU, where it is preheated with HVGO, and then mixed with the UP-II LSWR in the feed surge drum. Next, the two-stage desalter removes salts and other impurities from the feed. The desalted LSWR is further preheated via heat exchange with HVGO and vacuum residue, and then heated to the required operating temperature in the feed heaters.

The partially vaporized feed stream is routed from the heaters to the vacuum column. The three HVU products (LVGO, HVGO and vacuum residue) are drawn from the vacuum column, which contains three separate packed sections. The column overhead vapors are routed to the vacuum producing equipment, which includes a three-stage

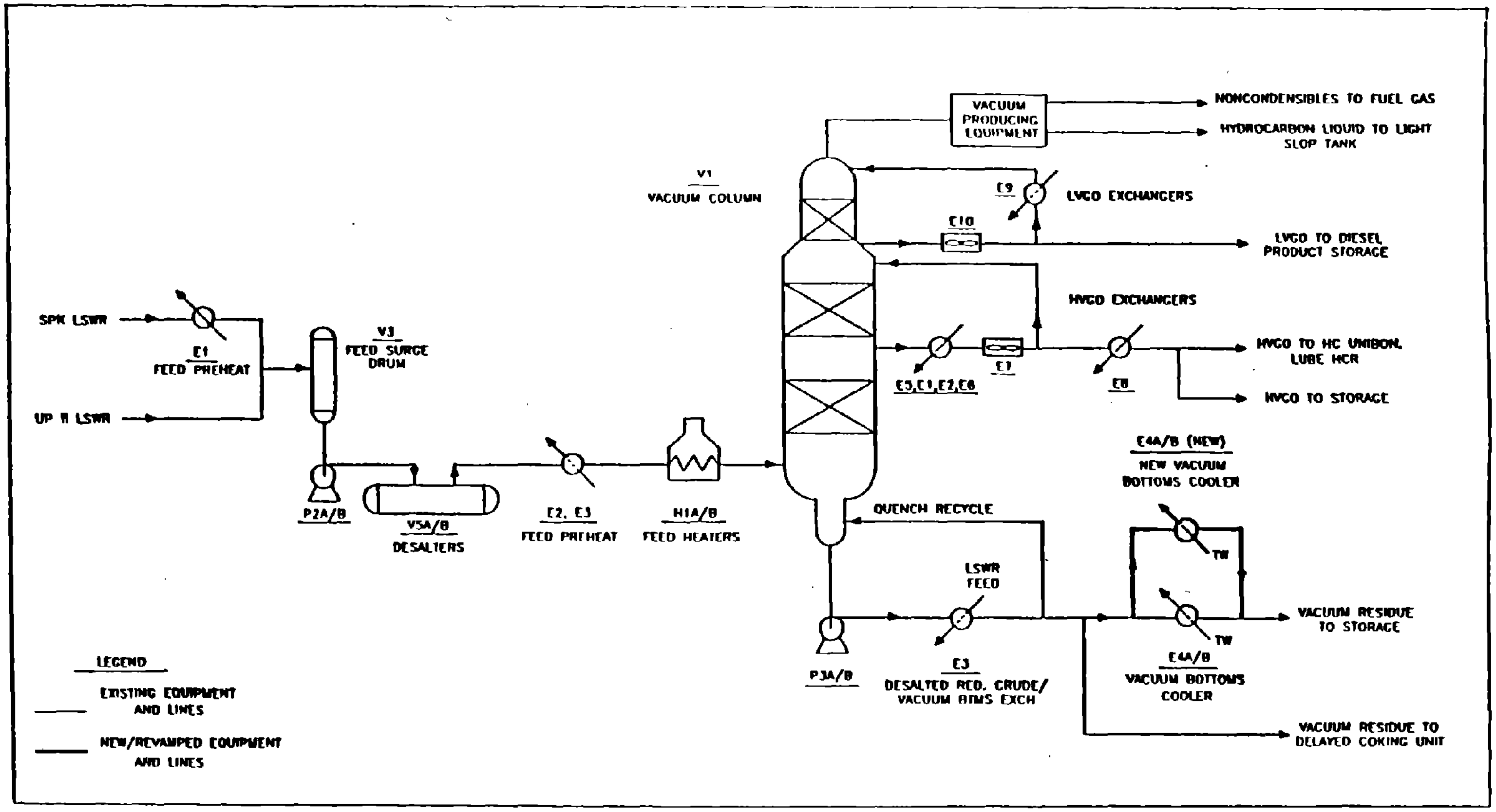

Figure 3.3.2-D1. High Vacuum Unit (Unit 110)
Unit Schematic (With Proposed Modifications)

ejector system and a liquid-ring vacuum pump. Any condensed hydrocarbon liquid is routed to the existing light slop tank, while noncondensible gases are sent to the refinery fuel gas system.

A combined LVGO product and circulating reflux stream is drawn below the uppermost packed section. After it is partially cooled in an air cooler, the LVGO product is routed to the diesel pool. The LVGO circulating reflux stream is further cooled using sea cooling water and returned to the column above the top packed section.

Similarly, the combined HVGO product/circulating reflux stream is drawn below the packed section located in the middle of the vacuum column. This stream is partially cooled in several heat exchangers to produce steam and to preheat LSWR feed, and finally is cooled to the required reflux temperature in an air cooler. The HVGO circulating reflux stream is then returned to the column above the middle packed section. The HVGO product is cooled to the required battery limit temperature in a tempered water cooler, and routed either directly to the HC Unibon Unit or to storage. For study Cases 1 and 3, HVGO will also be routed directly to the new Lube Isocracker Unit.

The vacuum residue product is drawn from the bottom of the vacuum column and partially cooled via heat exchange with LSWR feed. A portion of this cooled stream is routed back to the bottom of the vacuum column as a quench stream, which is used to maintain the vacuum residue surge volume temperature below the level where excessive cracking and/or coking may occur (366°C). Typically, the product stream is then routed directly to the Delayed Coker Unit. Alternately, the vacuum residue product can be further cooled in a tempered water cooler and sent to storage.

3. *Unit Simulation*

Initially, simplified UP-II and SPK crude unit simulations were made to estimate the HVU LSWR feed composition. These simulation models are represented in the following Figure 3.3.2-D2. The crude unit feeds and required product rates were taken from the Stock Balances (refer to Section 3.1.2), and the crude assays were taken from the Terms of Reference.

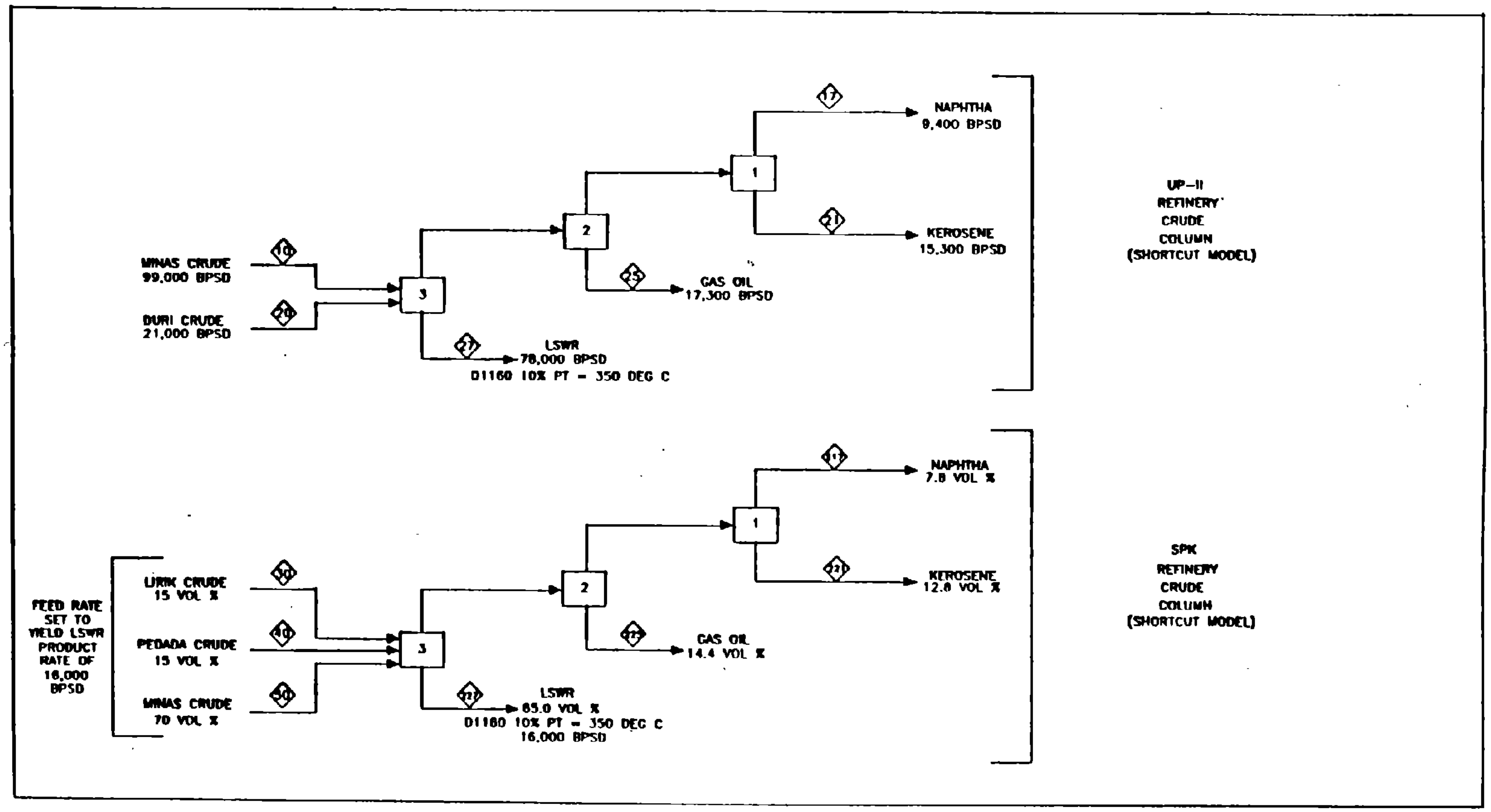

**Figure 3.3.2-D2. Crude Columns (UP-II and SPK)
Simulation Sketch**

A sketch of the HVU simulation model, was configured to include all major equipment items, is shown in Figure 3.3.2-D3 on the following page. The total study LSWR feed rate of 94,000 BPSD is 1.5 percent greater than the original design feed rate. The simulation model feed also includes estimates of water carryover from the feed desalter, the condensible and non-condensible cracked hydrocarbon material produced in the vacuum charge heater, and air that leaks into the vacuum column. These streams are typically added to the simulation model feed to provide an estimate of the load on the vacuum column overhead ejector system.

The vacuum column model pressure profile was selected to provide conservative results, and was based on original design data and data from a unit test run conducted by Pertamina from December 29, 1991, to January 1, 1992. In addition, most of the operating temperatures used in the model were generally set to match the original design values. In particular, the LVGO pumparound duty was adjusted to achieve the original design operating temperature of 49°C at the top of the column.

The number of theoretical stages used in the model to represent each of the fractionation column packed sections was estimated based on past Fluor Daniel experience. In general, the fractionation efficiency in a vacuum column is relatively insensitive to the number of theoretical trays used in the model. The column heat balances were set to achieve the desired product specifications, which are discussed below.

The simulation model was adjusted to give the product yields specified in the Stock Balances provided by Chevron. In addition, product specifications obtained from Attachment 5 of the Terms of Reference were also met. The crude and vacuum unit product cut point ranges, Stock Balance yields, and specifications are presented in the following Table 3.3.2-D1 on page 3.3-31.

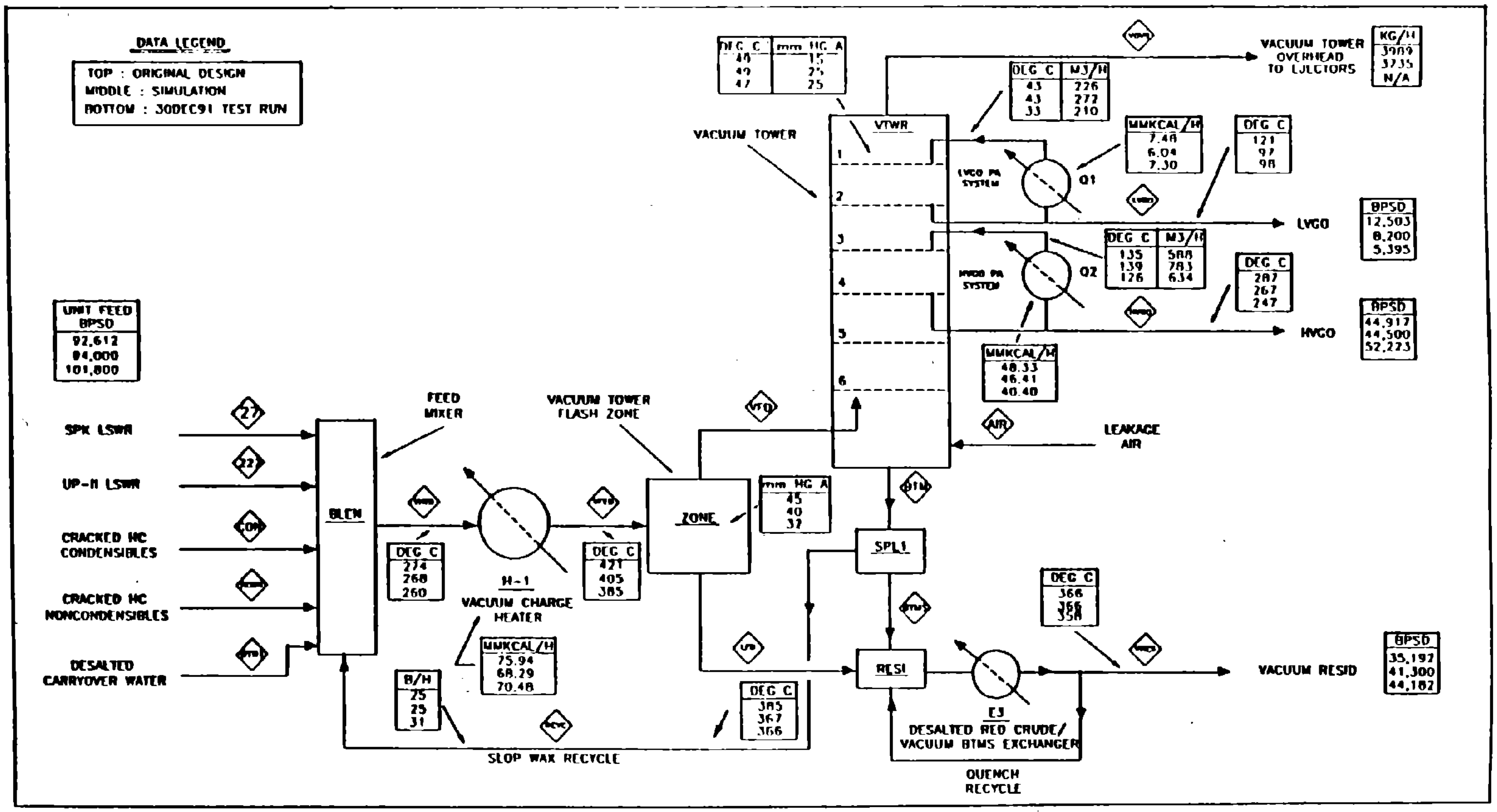

Figure 3.3.2-D3. High Vacuum Unit Simulation Sketch. Comparison of Simulation Results with Design and Test Run Data

Table 3.3.2-D1
Crude Distillation and High Vacuum Units
Product Cut Points, Yields and Specifications

Product	Nominal Cut Point Range (°C)	Stock Balance Yield (BPSD)	Specifications
Naphtha	-141	9,200	—
Kerosene	141-238	15,500	—
SR Diesel + LVGO	238-357	17,300 8,200	Flash Point = 150°F (min)
HVGO	357-521	44,500	—
Vacuum Residue	521+	41,300	—

The Vacuum Distillation Unit product yields and properties for the simulated operation are presented in Table 3.3.2-D2 on page 3.3-32. For comparison, this table also shows similar information from the original design and the Pertamina test run. In addition, Figure 3.3.2-D3, presented previously on page 3.3-30, also shows product yields, and other operating conditions, for the original design, simulation, and test run. An analysis of this data indicates that the vacuum residue cut point is currently significantly lower than the original design, and as a result the required heater outlet temperature is also much lower. Also, for all three sets of data the LVGO product flash point specification (150°F minimum) is met.

Feed and product distillation data for the original design, simulation, and test run are presented in Table 3.3.2-D3 on page 3.3-32. The distillation data from the simulation model match fairly well with the test run distillation data.

4. *Proposed Modifications*

All of the existing HVU equipment is listed in Table 3.3.2-D4 on page 3.3-33. This table also shows if an equipment item was found adequate by inspection or was checkrated.

Table 3.3.2–D2
High Vacuum Unit
Product Yields and Properties

	Original Design			Simulation			Test Run Average		
	LVGO	HVGO	Vac. Resid.	LVGO	HVGO	Vac. Resid.	LVGO	HVGO	Vac. Resid.
Nominal TBP Cut Point (Deg. C)	343–382	382–565	565+	---	357–521	521+	---	---	---
Yield (LV%)	13.5	48.5	38.0	8.7	47.3	44.0	5.3	51.3	43.4
Flash Point (Deg. F)	315	---	---	216	---	---	217	---	---

Table 3.3.2–D3
High Vacuum Unit
Feed and Product Distillation Data

	Original Design				Simulation				Test Run Average		
LV%	LSWR (1) Feed (Deg. C)	LVGO (1) Product (Deg. C)	HVGO(1) Product (Deg. C)	LV%	LSWR (2) Feed (Deg. C)	LVGO (3) Product (Deg. C)	HVGO (2) Product (Deg. C)	LV%	LSWR (2) Feed (Deg. C)	LVGO (3) Product (Deg. C)	HVGO (2) Product (Deg. C)
IBP	254	243	365	IBP	157	180	322	IBP	256	206	272
10	389	354	415	10	350	250	365	10	350	255	348
30	446	360	438	30	425	283	406	30	417	280	396
50	505	365	468	50	486	303	431	50	474	297	427
70	590	368	488	70	549	316	464	70	539	317	453
90	---	382	582	90	---	348	506	90	---	354	496

Notes: (1) Type of distillation unknown.
(2) ASTM D–1160 Distillation.
(3) ASTM D–86 Distillation.

Table 3.3.2-D4
High Vacuum Unit
Checkrating Equipment List

ITEM NO	DESCRIPTION	O.K. BY INSPECTION?	REMARKS
110-E1A/B	Cold Reduced Crude/HVGO Exchanger	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E2	Desalted Reduced Crude/HVGO Exchanger	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E3	Desalted Reduced Crude/Vacuum Bottoms Exchanger	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E4A/B	Vacuum Bottoms Cooler	CHECKRATE	ADD 2 NEW SHELLS IN PARALLEL TO EXISTING SHELLS.
110-E5A/B	HVGO Steam Generator	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E6A/B	HVGO/BFW Exchanger	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E7A/D	Circulating HVGO Cooler	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E8A/B	HVGO Product Cooler	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E9A[illegible]	LVGO Cooler	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E10	Circulating LVGO Cooler	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
110-E11A/D	Desalter Water/Desalter Brine Exchanger	YES	
110-E12A/B	Desalter Brine Cooler	YES	
110-E13A/J	Tempered Water Cooler	YES	
110-E15	Compressor Sealant Cooler	YES	
110-E16	Desalter Brine Trim Cooler	YES	
110-P-1A/B	Reduced Crude Booster	YES	
110-P-2A/B	Reduced Crude	YES	
110-P-3A/B	Vacuum Bottoms	YES	
110-P-4A/B	Heavy Vacuum Gas Oil Wash	YES	
110-P-5A/B	Slop Wax Recycle	YES	
110-P-6A/B/C	Circulation Heavy Vacuum Gas Oil	YES	
110-P-7	Slop Wax	NOT USED	
110-P-8A/B	Heavy Vacuum Gas Oil Product	YES	
110-P-9A/B	Light Vacuum Gas Oil	YES	
110-P-10	Hydrocarbon Slop	YES	
110-P-11A/B	Ejector Condensate	YES	
110-P-12A/B	Boiler Feedwater Circulation	YES	
110-P-13A/B	Desalting Water	YES	
110-P-14A/B	Second Stage Desalting Water	YES	
110-P-15A/B	Tempered Water	YES	
110-P-16	Ram & Flush	YES	
110-P-51	Phosphate Injection	YES	
110-P-52	Desalting Unit Demulsifier	YES	
110-H1A/B	Vacuum Heater	YES	
110-V1	Vacuum Column	YES	
110-C1A/B/C	Offgas Compressor	YES	
110-J1	Vacuum Producing Equipment	YES	
110-J51A/B/C	First Stage Steam Jet Ejector	YES	
110-J52A/B	Second Stage Steam Jet Ejector	YES	
110-J53A/B	Third Stage Steam Jet Ejector	YES	
110-E52A/B/C	First Stage Vacuum Intercondenser	YES	
110-E53	Second Stage Vacuum Intercondenser	YES	
110-E54	Third Stage Vacuum Aftercondenser	YES	
110-V5A/B	Desalting Unit	YES	
110-ME1	Phosphate Injection System	YES	

Most of the HVU systems are adequate for the proposed operation, including:

- feed preheat
- feed fired heaters
- vacuum column internals
- pumparound heat removal systems
- vacuum producing equipment (ejectors and liquid-ring pump)
- all pumps.

However, based on the study stock balances, the vacuum residue product rate is 17% higher than the original design. Therefore, it is recommended that additional surface area be added to the vacuum residue product cooling system to cool the entire product stream before it is routed to storage (note, however, that typically most or all of the vacuum residue is bypassed around the product cooling system and is routed directly to the Delayed Coker Unit). In particular, Fluor Daniel recommends adding a parallel tempered water-cooled exchanger (2 shells in series) in parallel to the existing exchanger (110-E4A/B). The tempered water system was evaluated and found to have adequate capacity to service this new exchanger.

The proposed HVU modifications are shown in Figure 3.3.2-D1, presented previously on page 3.3-31. A detailed equipment list for the new and/or modified equipment is presented in Section 3.3.4.

b. ***Sour Water Treating Unit (Unit 840)***

1. <u>Introduction</u>

The Sour Water Treating Unit was originally designed to process 68.7 m^3/h of sour water produced by the following units:

- Naphtha Hydrotreater Unit
- Distillate Hydrotreater Unit
- Delayed Coker Unit
- High Vacuum Unit
- HC Unibon Unit

For the purposes of this study it was assumed that the sour water production rate is unchanged for all of the units listed above, except the HC Unibon Unit. For Study Cases 1 and 3, where the HC Unibon Unit is not modified, the HC Unibon Unit sour water production rate was adjusted based on the specific unit feed rate. In Cases 2 and 4, where HC Unibon Unit Train 2 is modified, an estimate of the sour water production rate for Train 2 was obtained from UOP. The sour water production rate for the new Lube Isocracker and Lube Vacuum Column Units was estimated based on the EXOR IV rates for similar units. UOP provided the DAO Hydrocracker Unit sour water production rate. A summary of the estimated Sour Water Treating Unit feed rates for each case is presented in Table 3.3.2-E1 on the following page. The study unit feed rate varies between 18% and 28% above the original design rate, depending upon the case.

2. *Process Description*

A simplified schematic of the Sour Water Treating Unit is shown in Figure 3.3.2-E1 on page 3.3-37. Sour water is routed from the various producers to a degassing drum, heated in a feed/bottoms exchanger, and routed to the sour water stripper, which has 26 valve trays. The stripper reboiler utilizes low pressure steam to supply sufficient heat input to the column to meet the required stripped sour water specifications. A pumparound air cooler circuit, located at the column top section, maintains the column overhead temperature.

Sour gas is taken overhead from the sour water stripper on pressure control, combined with flashed gas from the degassing drum, and routed to the refinery Sour Gas Flares for disposal. Stripped sour water is pumped from the column bottom, through the feed/bottoms exchanger, and partially cooled in an air cooler. A portion of this stream is normally routed to the High Vacuum Unit desalter system. The remaining stripped sour water is cooled in a sea cooling water trim cooler, and sent to the refinery waste water system for further treatment and disposal.

TABLE 3.3.2–E1
SOUR WATER TREATING UNIT LIQUID FEED RATES

	M3/HR				
SOURCE	ORIGINAL DESIGN	CASE 1	CASE 2	CASE 3	CASE 4
COMBINED EXISTING STREAMS	45.08	45.08	45.08	45.08	45.08
HC UNIBON TRAIN 1	11.81	9.59	12.70	10.48	12.70
HC UNIBON TRAIN 2 (1)	11.81	9.59	19.98	10.48	18.32
LUBE ISOCRACKER	---	17.71	---	17.71	---
LUBE VACUUM COLUMN	---	---	7.72	---	7.72
DAO HYDROCRACKER	---	---	---	---	4.18
TOTAL	68.70	81.97	85.48	83.74	88.00
PERCENT OF ORIGINAL DESIGN	---	119.3%	124.4%	121.9%	128.1%

RATIO VALUES

	CASE 1	CASE 2	CASE 3	CASE 4
HC UNIBON TRAIN 1				
ORIGINAL CAPACITY (MBPSD)	27.90	27.90	27.90	27.90
NEW CASE CAPACITY (MBPSD)	22.65	30.00	24.75	30.00
RATIO (NEW/ORIGINAL)	0.81	1.08	0.89	1.08
HC UNIBON TRAIN 2				
ORIGINAL CAPACITY (MBPSD)	27.90	27.90	27.90	27.90
NEW CASE CAPACITY (MBPSD)	22.65	30.00	24.75	27.50
RATIO (NEW/ORIGINAL)	0.81	1.08	0.89	0.99
LUBE ISOCRACKER				
EXOR IV CAPACITY (MBPSD)	27.00	---	27.00	---
DUMAI CAPACITY (MBPSD)	15.00	---	15.00	---
RATIO (DUMAI/EXOR IV)	0.56	---	0.56	---

NOTE: (1) AS REPORTED BY UOP, FOR CASE 2 RATE IS 88 GPM (19.98 M3/HR). CASE 4 RATE OBTAINED BY RATIONING UNIT CAPACITIES (27.5/30.0).

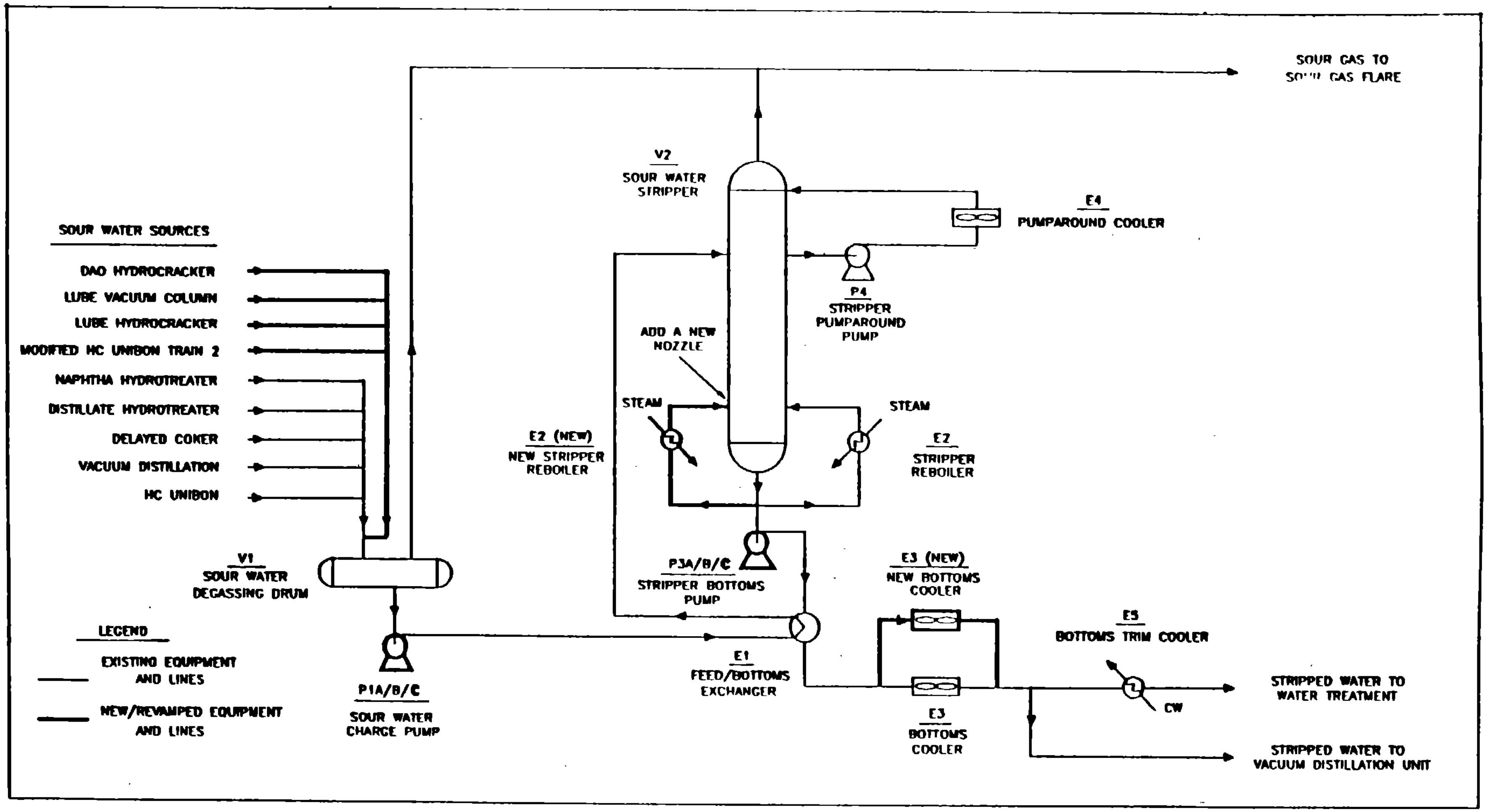

Figure 3.3.2-E1. Sour Water Treating Unit (Unit 840)
Unit Schematic (With Proposed Modifications)

3. *Unit Simulation*

The Sour Water Treating Unit was modelled using Simulation Sciences, Inc., PROCESS® simulation program. The unit feed rate was set at the estimated Case 4 rate of 88.0 m^3/h. It was assumed that the feed composition is unchanged from the original design value. Although the sour water production rate varies somewhat among the four cases, this variation did not warrant evaluating the Sour Water Treating Unit in detail for each case.

A sketch of the Sour Water Treating Unit model, configured to include all major equipment items, is shown in Figure 3.3.2-E2 on the following page. This sketch shows the unit product rates and properties and operating conditions for both the original design and the simulated operation. Generally, the original unit pressure and temperature profiles were used in the simulation model. However, some temperatures were based on the estimated performance of existing equipment.

The number of theoretical stages used to model the sour water stripper column was selected using a conservative tray efficiency of 20%. The stripper operating conditions were set to meet the original design stripped sour water H_2S concentration of 37.5 ppm(w). (See Section 3.1.7 for further discussion of effluent environmental considerations.)

4. *Proposed Modifications*

All of the existing Sour Water Treating Unit equipment is listed on page 3.3-40 in Table 3.3.2-E2. This table also shows if an equipment item was found adequate by inspection or was checkrated. The following equipment items are adequate for the proposed operation:

- Sour water stripper column and internals
- Top pumparound pump and air cooler.

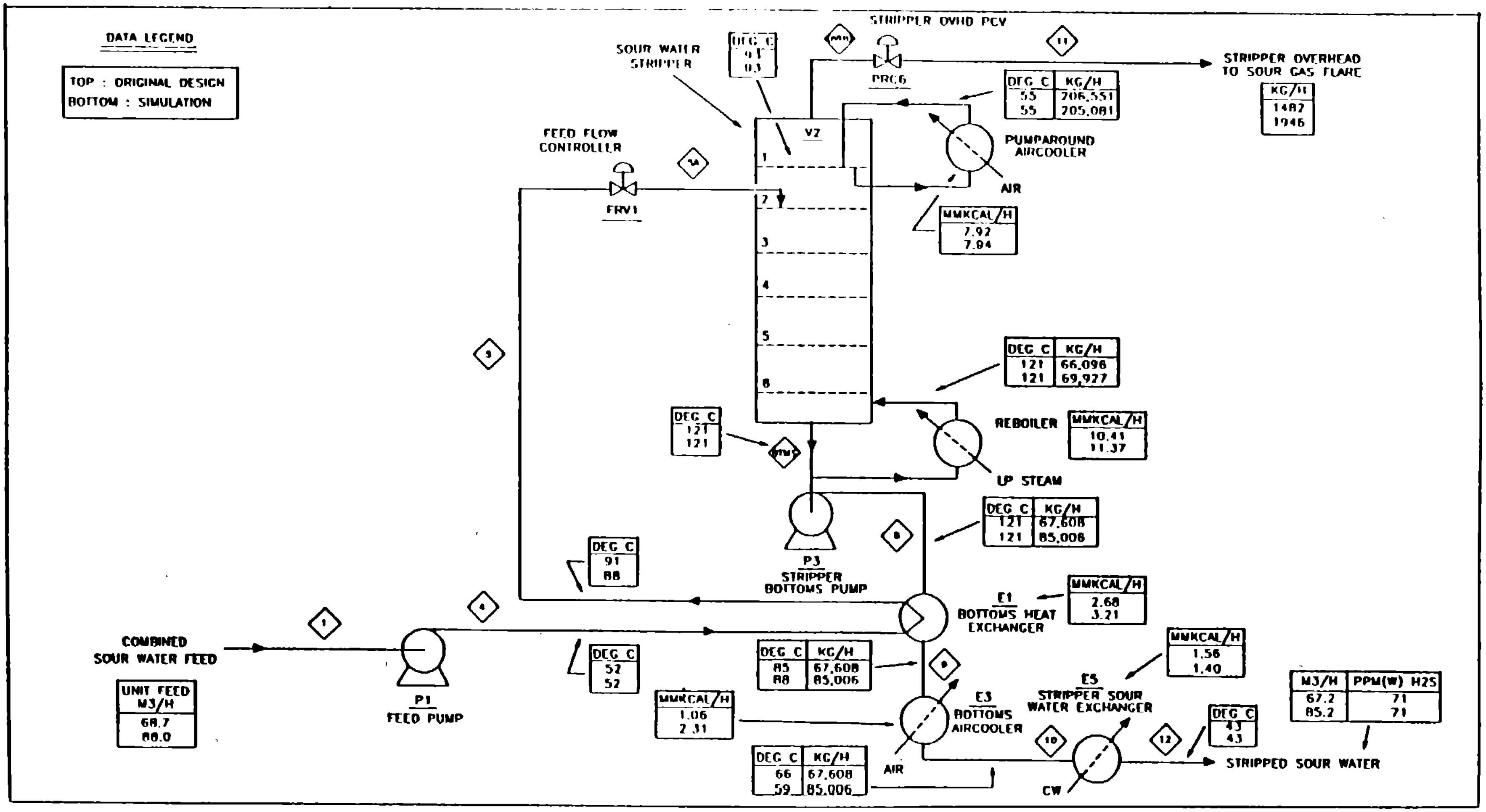

Figure 3.3.2-E2. Sour Water Treating Unit Simulation Sketch Comparison of Simulation Results with Design Data

TABLE 3.3.2-E2
SOUR WATER TREATING UNIT
CHECKRATING EQUIPMENT LIST

ITEM NO.	DESCRIPTION	O.K. BY INSPECTION?	REMARKS
840-E-1A/B	FEED/BOTTOMS EXCHANGER	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
840-E-2	STRIPPER REBOILER	CHECKRATE	ADD NEW REBOILER IN PARALLEL TO EXISTING REBOILER.
840-E-3	BOTTOMS COOLER	CHECKRATE	ADD NEW AIR COOLER BAY IN PARALLEL WITH EXISTING BAY.
840-E-4A/E	PUMPAROUND COOLER	YES	
840-E-5A/B	BOTTOMS TRIM COOLER	CHECKRATE	CHECKRATE INDICATES EQUIPMENT IS O.K.
840-P-1A/B	SOUR WATER CHARGE PUMP	CHECKRATE	ADD IDENTICAL NEW PUMP IN PARALLEL WITH 2 EXISTING PUMPS.
840-P-2	SLOP OIL PUMP	YES	
840-P-3A/B	STRIPPER BOTTOMS PUMP	CHECKRATE	ADD IDENTICAL NEW PUMP IN PARALLEL WITH 2 EXISTING PUMPS.
840-P-4A/B	STRIPPER PUMPAROUND PUMP	YES	
840-P-5	CAUSTIC INJECTION PUMP	YES	
840-V-1	SOUR WATER DEGASSING DRUM	YES	
840-V-2	SOUR WATER STRIPPER	CHECKRATE	CHECKRATE INDICATES TRAYS ARE O.K. ADD NEW 8" NOZZLE FOR NEW REBOILER.
840-T-1	CAUSTIC STORAGE TANK	YES	
840-F-51	SEA WATER SUPPLY STRAINER	YES	

Due to the increased unit feed rate, it is recommended that the following areas be modified:

- Add one identical pump in parallel to the two existing sour water charge pumps, and simultaneously operate two, with one as spare standby.

- Similarly, add one identical pump in parallel to the two existing sour water stripper bottoms pumps, and simultaneously operate two, with one as spare standby.

- Approximately 10% more stripper reboiler capacity is required. Therefore, add a new reboiler to operate in parallel with the existing reboiler. A new 8" nozzle must be added to the sour water stripper column to accommodate the new reboiler.

- The stripped sour water cooling requirement has increased by approximately 40% (the sour water stripper feed/bottoms exchanger was not modified). Therefore, add one identical air cooler bay in parallel with the one existing bottoms cooler air cooler bay.

The proposed modifications to the Sour Water Treating Unit are depicted in Figure 3.3.2-E1, presented previously on page 3.3-37.

Section 3.3.4. presents a detailed equipment list for the new and/or modified equipment.

c. ***Amine Treating/LPG Recovery Unit (Unit 410)***

1. <u>Introduction</u>

The Amine Treating/LPG Recovery Unit includes both a vapor amine absorber and an LPG amine absorber, an amine regeneration system, and an LPG product deethanizer. The vapor amine absorber was originally designed to process 20,638 Nm^3/h (920.8 kgmol/h) of sour gas produced by the following units:

- Naphtha Hydrotreater Unit
- Distillate Hydrotreater Unit
- Platforming Unit
- HC Unibon Units

The LPG amine absorber was designed to treat 1,468 BPSD of sour LPG produced by the HC Unibon Unit. The treated LPG is combined with an additional 797 BPSD of LPG from the Platforming Unit, and then routed to the deethanizer for stabilization.

For the purposes of this study it was assumed that the sour vapor and LPG production rates remain unchanged for all of the units listed above, except for the HC Unibon Unit. For Study Cases 1 and 3, where the HC Unibon Unit is not modified, the HC Unibon Unit sour vapor and LPG production rates were adjusted based on the specific unit feed rate. In Cases 2 and 4, where HC Unibon Unit Train 2 is modified, the estimated sour vapor and LPG production rates were obtained from UOP. The sour vapor and LPG production rates for the new Lube Isocracker Unit were estimated based on EXOR IV rates for similar units. The DAO Hydrocracker Unit sour vapor production rate was provided by UOP.

A summary of the estimated sour vapor feed rates for each of the four study cases is presented in the following Table 3.3.2-F1. The vapor amine absorber feed rate varies between 98% and 114% of the original design rate, depending upon the case. The LPG feed rates are presented in Table 3.3.2-F2 on page 3.3-44. The study feed rates to the LPG amine absorber and the deethanizer are below their respective original design rates for all cases. Therefore, these columns and their associated equipment were considered adequate by inspection and were not evaluated in detail.

2. *Process Description*

A simplified schematic of the vapor amine absorber and amine stripper sections of the Amine Treating/LPG Recovery Unit is shown in Figure 3.3.2-F1 on page 3.3-45. Low pressure sour gas is routed from the various producers to a knockout drum, and then to

TABLE 3.3.2–F1
AMINE TREATING/LPG RECOVERY UNIT
VAPOR FEED RATES

VAPOR SOURCE		SOURCE PRESSURE	KGMOL/HR ORIGINAL DESIGN	CASE 1	CASE 2	CASE 3	CASE 4
INTERNAL RECYCLE FROM DEETHANIZER		HIGH	24.5	24.5	24.5	24.5	24.5
PLATFORMER UNIT		LOW	19.6	19.6	19.6	19.6	19.6
NAPHTHA HYDROTREATER		LOW	55.5	55.5	55.5	55.5	55.5
DISTILLATE HYDROTREATER (EXISTING)		LOW	46.7	46.7	46.7	46.7	46.7
HC UNIBON DEBUTANIZER	TRAIN 1	LOW	91.8	74.5	98.7	81.4	98.7
HC UNIBON DEBUTANIZER	TRAIN 2	LOW	91.8	74.5	---	81.4	---
HC UNIBON LP FLASH GAS	TRAIN 1	LOW	48.1	39.1	51.8	42.7	51.8
HC UNIBON LP FLASH GAS	TRAIN 2	LOW	48.1	39.1	---	42.7	---
HC UNIBON MP FLASH GAS	TRAIN 1	HIGH	247.2	200.7	265.8	219.3	265.8
HC UNIBON MP FLASH GAS	TRAIN 2	HIGH	247.2	200.7	---	219.3	---
MOD. HC UNIBON TRAIN 2 (TOTAL) (1)		LOW/HIGH	---	---	343.5	---	314.9
DAO HYDROCRACKER OFFGAS		HIGH	---	---	---	---	101.0
LUBE ICR CLPS OFFGAS		HIGH	---	153.2	---	153.2	---
LUBE ICR ATMOS COL OFFGAS (2)		VERY LOW	---	63.2	---	63.2	---
TOTAL FEED STREAMS (KGMOL/HR)			920.8	991.5	906.2	1049.8	978.6
TOTAL FEED STREAMS (NM3/HR)			20638	22223	20312	23530	21935
PERCENT OF ORIGINAL DESIGN				107.7%	98.4%	114.0%	106.3%
TOTAL LOW PRESSURE FEED STREAMS (KGMOL/HR)			401.8	412.3	396.5	433.4	386.1
TOTAL LOW PRESSURE FEED STREAMS (NM3/HR)			9005	9242	8887	9714	8655
PERCENT OF ORIGINAL DESIGN				102.6%	98.7%	107.9%	96.1%

NOTE: (1) AS REPORTED BY UOP, FOR CASE 2 COMBINED RATE IS 6.9 MMSCFD. THIS INCLUDES VAPOR FROM THE DEBUTANIZER, LP DRUM, MP DRUM AND NEW DISTILLATE HDT STRIPPER. CASE 4 RATE OBTAINED BY RATIOING UNIT CAPACITIES.
(2) STREAM PRESSURE TOO LOW TO FEED INTO EXISTING AMINE UNIT BOOSTER COMPRESSOR. NEW BOOSTER COMPRESSOR IS REQUIRED IN LUBE ICR UNIT.

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TABLE 3.3.2–F2
AMINE TREATING/LPG RECOVERY UNIT
LIQUID FEED RATES

		BPSD				
FEEDS TO LPG AMINE ABSORBER		ORIGINAL DESIGN	CASE 1	CASE 2	CASE 3	CASE 4
HC UNIBON DEBUTANIZER	TRAIN 1	388	315	417	344	417
HC UNIBON DEBUTANIZER	TRAIN 2	388	315	---	344	---
HC UNIBON NAPHTHA STRIPR	TRAIN 1	346	281	372	307	372
HC UNIBON NAPHTHA STRIPR	TRAIN 2	346	281	---	307	---
MODIFIED HC UNIBON TRAIN 2 (TOTAL) (1)		---	---	450	---	413
LUBE ISOCRACKER		---	135	45	138	51
TOTAL FEEDS TO ABSORBER (BPSD)		1468	1326	1284	1440	1253
PERCENT OF ORIGINAL DESIGN			90.4%	87.5%	98.1%	85.3%
ADDITIONAL FEEDS TO DEETHANIZER (BPSD)						
PLATFORMER DEBUTANIZER		797	797	797	797	797
TOTAL FEEDS TO DEETHANIZER (BPSD)		2265	2124	2081	2237	2050
PERCENT OF ORIGINAL DESIGN			93.8%	91.9%	98.8%	90.5%

NOTE: (1) AS REPORTED BY UOP, FOR CASE 2 COMBINED RATE IS 450 BPD. CASE 4 RATE OBTAINED BY RATIOING UNIT CAPACITIES (27.5/30.0).

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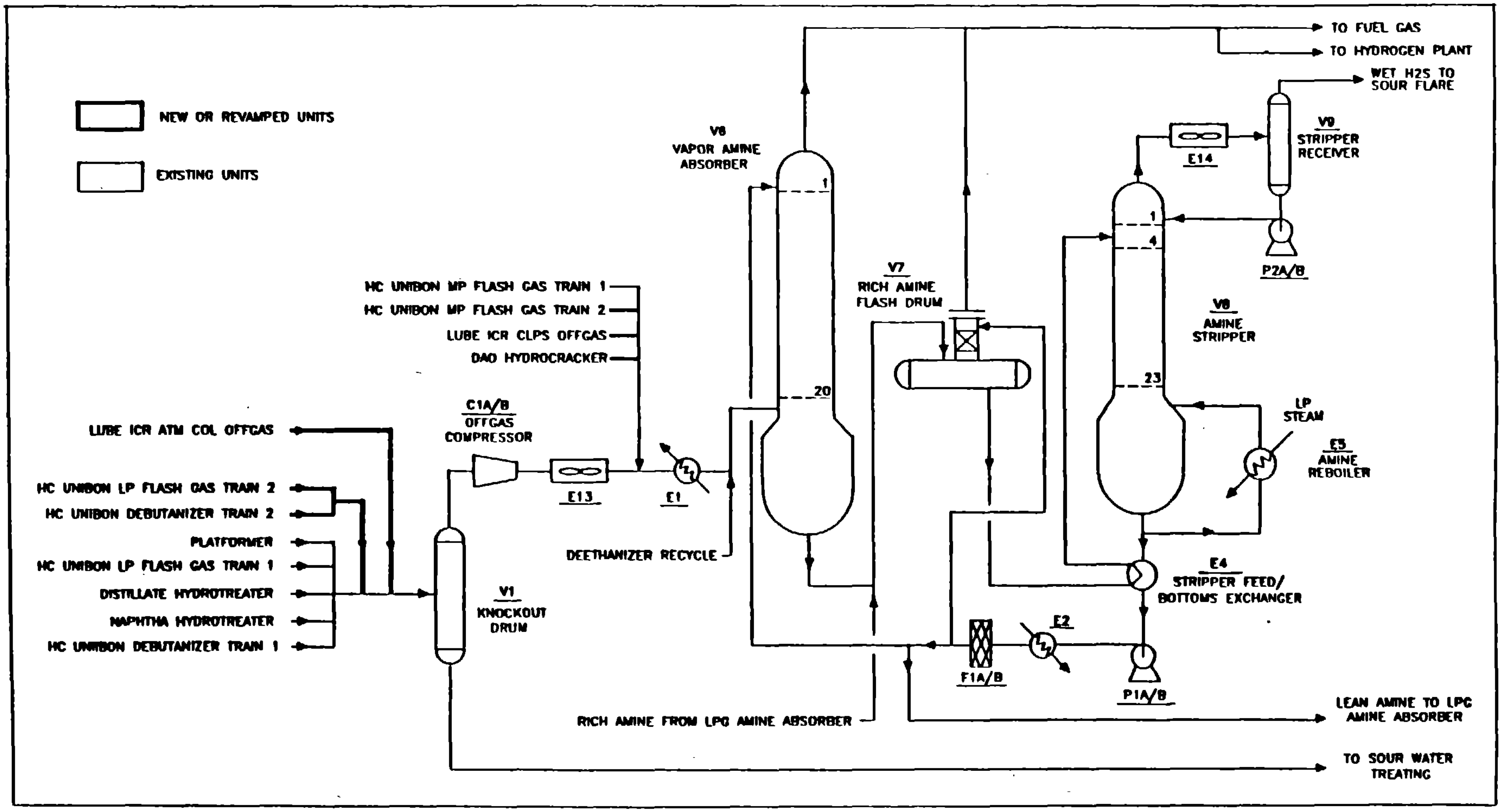

Figure 3.3.2-F1. Amine Treating/LPG Recovery Unit (Unit 410) Partial Unit Schematic (With Proposed Tie-Ins)

the suction of the offgas compressor, where the stream pressure is boosted up to the required absorber operating pressure. The compressed stream is partially cooled in an air cooler, and then combined with the high pressure sour gas sources. The combined stream is further cooled to the required absorber operating temperature in a sea water cooled exchanger, and then is routed, along with the deethanizer offgas stream, to the vapor amine absorber.

The sour vapor is contacted with lean amine in the vapor amine absorber, which contains 20 valve trays. The treated vapor is routed from the top of the absorber to either to the Hydrogen Plant feed system or to the refinery fuel gas system. The rich amine from the bottom of the vapor amine absorber is combined with the rich amine produced by the LPG amine absorber, and then routed to the rich amine flash drum, and then on to the amine stripper. The offgas is contacted with a slipstream of lean amine in a packed bed located at the top of the rich amine flash drum, and is then combined with the vapor amine absorber offgas.

The combined rich amine is fed to the amine stripper, which contains 23 valve trays, via a feed/bottoms exchanger. A low pressure steam reboiler supplies heat to the stripper, and an air cooler is used as a condenser. The hydrogen sulfide that is removed from the rich amine is routed from the stripper overhead receiver to the refinery Sour Gas Flare system for disposal. The stripped (lean) amine is routed through the feed/bottoms exchanger, and then pumped through a sea water cooler and a filter, and recirculated back to the two absorbers and the rich amine flash drum.

3. *Unit Simulation*

The vapor amine absorber and amine stripper were modelled using Hyprotech's HYSIM® simulation program. The study case with the highest feed rate (Case 3) was simulated, with the rates taken directly from Table 3.3.2-F1 on page 3.3-45. It was assumed that the sour vapor feed compositions from the existing Platforming, Naphtha Hydrotreater, Distillate Hydrotreater and HC Unibon Units are unchanged from the original design values. The Lube Isocracker offgas compositions were assumed to be the same as similar streams in the EXOR IV Lube Isocracker.

The absorber and stripper models, configured to include all associated equipment items, are shown in the following Figures 3.3.2-F2 and 3.3.2-F3, respectively. These simulation sketches include the stream flows and properties and operating conditions for both the original design and the simulated operation. Generally, the original unit pressure and temperature profiles were used in the simulation model. The number of theoretical stages used to model the absorber and stripper columns was selected based on 30% and 50% tray efficiencies, respectively.

The lean amine feed rate to the vapor amine absorber was set at the original design rate. The lean amine residual H_2S level was set at a conservative level of 350 grains/gallon of amine solution. The simulation showed that the treated vapor H_2S concentration will be approximately 48 ppm(w), which is below the original design concentration limit of 50 ppm(w). (See Section 3.1.7 for a discussion of effluent environmental considerations).

The simulated rich amine stream from the vapor amine absorber was combined with the rich amine streams from the LPG amine absorber and the rich amine flash drum (at original design rate and composition) to provide an estimated amine stripper feed rate and composition. The stripper condenser duty was varied to achieve a stripper receiver temperature of 55°C, which matches the original design value. The stripper reboiler duty was set at its original design value. The resulting lean amine H_2S concentration was approximately 212 grains/gallon of amine solution, as compared to a typical specification of 250 grains/gallon of amine solution.

4. *Proposed Modifications*

All of the existing Amine Treating/LPG Recovery Unit equipment items were found to be adequate for the proposed operation by inspection. Therefore, no modifications are required.

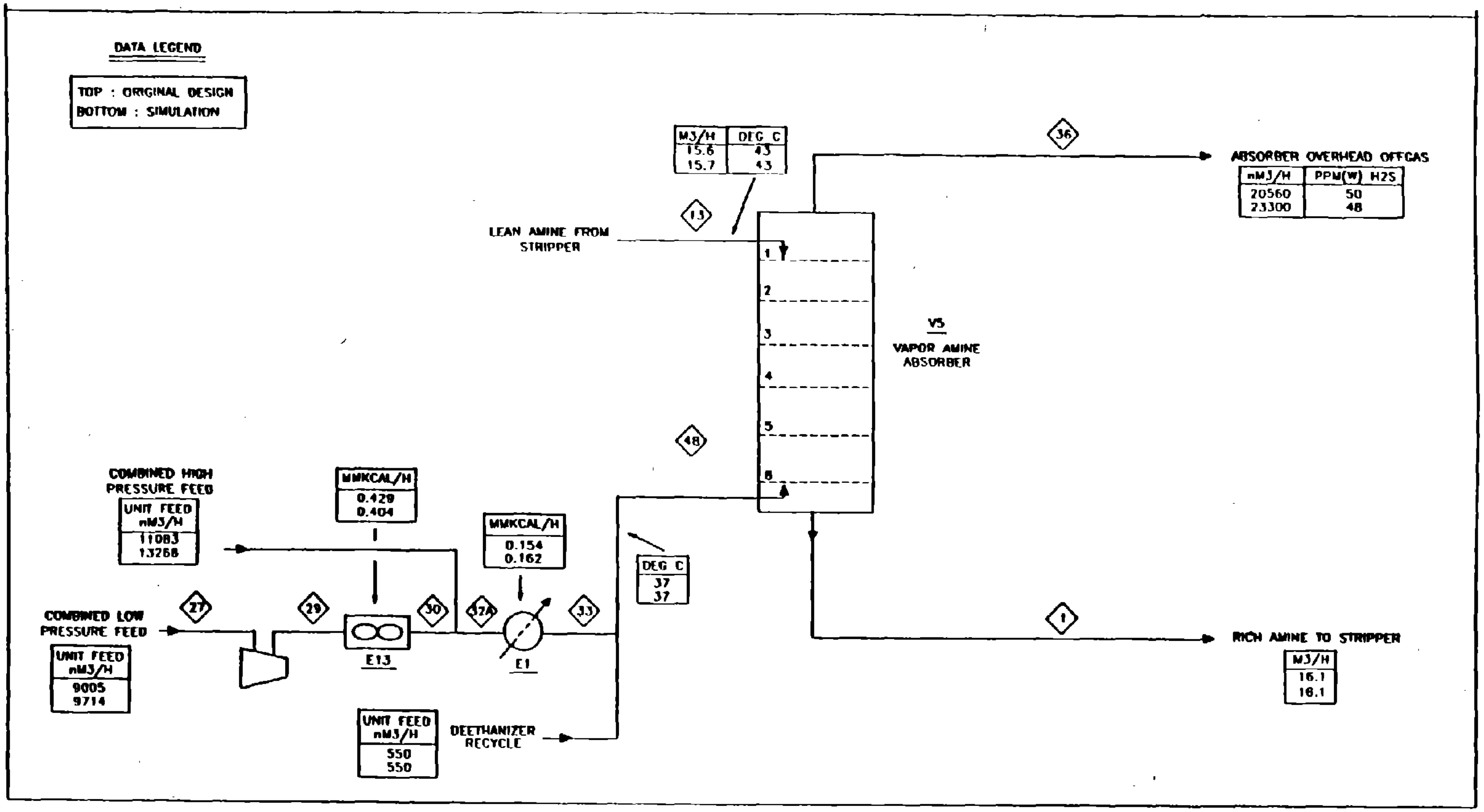

**Figure 3.3.2-F2. Amine Treating/LPG Recovery Unit
Simulation Sketch - Absorber Section
Comparison of Simulation Results with Design Data**

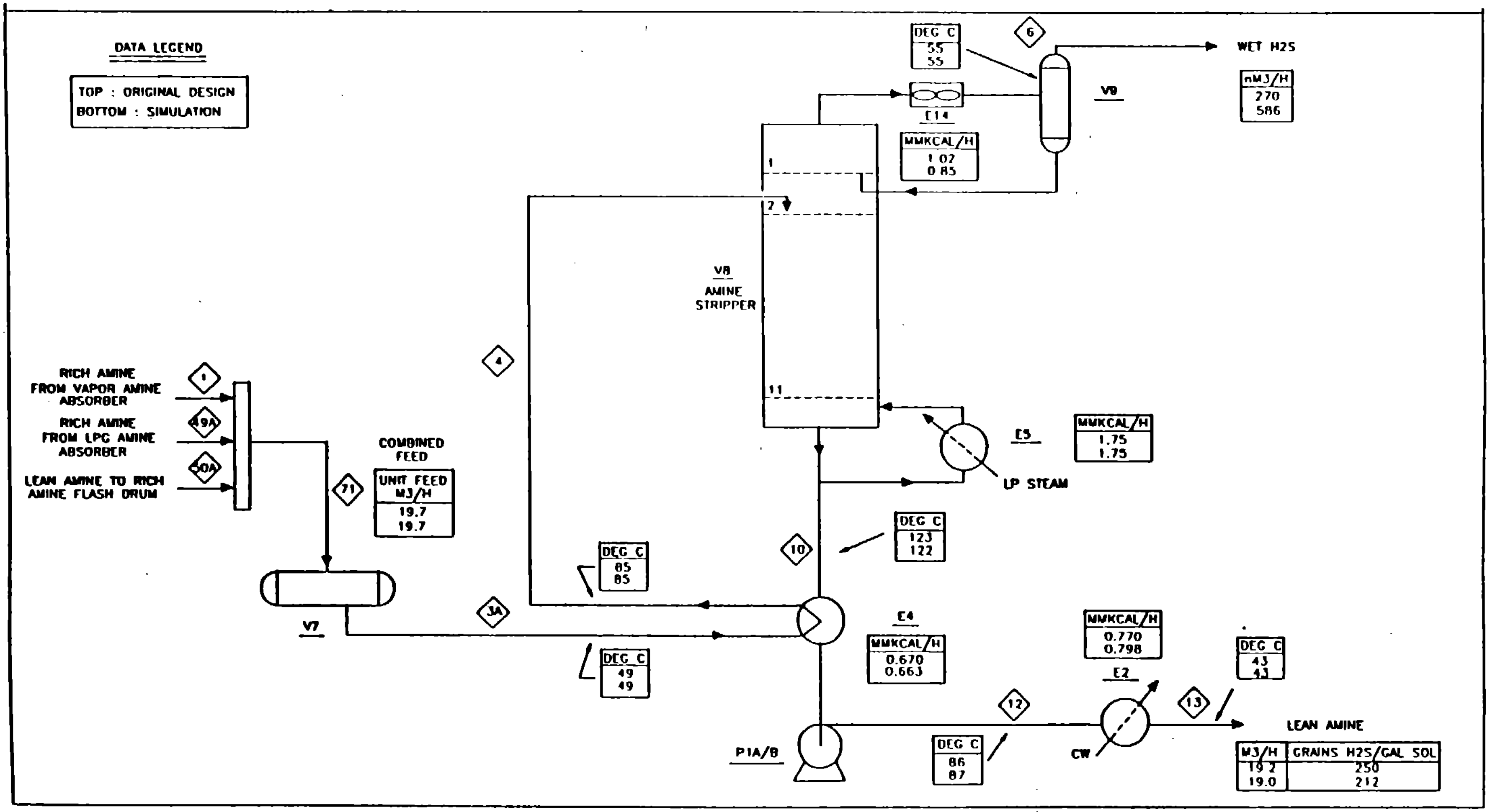

**Figure 3.3.2-F3. Amine Treating/LPG Recovery Unit
Simulation Sketch - Stripper Section
Comparison of Simulation Results with Design Data**

g. *Hydrogen System*

1. Introduction

As defined for this study, the Hydrogen System consists of existing UP-II Refinery hydrogen production, distribution, and compression systems. Hydrogen is required in all hydroprocessing units within the UP-II Refinery. Typically, higher purity make-up hydrogen is supplied to the high pressure hydrogen consumer units (e.g., the HC Unibon Unit), while lower purity hydrogen-rich gas is either supplied to low pressure hydroprocessing units (e.g., the Naphtha Hydrotreating Unit), or returned to the Amine Treating/LPG Recovery Unit for reprocessing.

The existing UP-II Refinery Hydrogen Plant consists of two identical production units with a combined design capacity of 90,500 Nm^3/h of 97 vol% purity hydrogen. The UP-II Refinery hydrogen requirement will increase with the addition of the Lube Base Oils Complex. However, the existing Hydrogen Plant and make-up hydrogen compression system (located in the HC Unibon Unit) have adequate capacity for each of the four study cases. Additional make-up hydrogen booster compression capability must be added to supply hydrogen at higher pressures to some of the new Lube Base Oils Complex units.

Table 3.3.2-G1 on page 3.3-51 summarizes the existing Hydrogen Plant production and make-up hydrogen compression capacities and make-up hydrogen requirements for the various study cases.

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3.3.3 Lube Base Oils Complex Process Units

The new Lube Base Oils Complex will include several new process units for each of the four study cases. The following is a list of these new units, along with the corresponding cases in which they are utilized:

a.	***Lube Isocracker Unit (Unit 010)***	Cases 1 and 3
b.	***Lube Vacuum Column Unit (Unit 011)***	Cases 2 and 4
c.	***Lube Isodewaxer/Hydrofinisher Unit (Unit 012)***	All Cases
d.	***Solvent Deasphalting Unit (Unit 016)***	Cases 3 and 4
e.	***DAO Hydrocracker Unit (Unit 014)***	Case 4
f.	***Make-up Hydrogen Booster Compression Unit (Unit 015)***	All Cases
g.	***Tempered Water System (Unit 017)***	All Cases
h.	***Wash Water Injection System (Unit 018)***	All Cases

These units are discussed in detail below. Detailed equipment lists for each of these units are presented in Section 3.3.4.

a. ***Lube Isocracker Unit (Unit 010)***

1. *Introduction*

The Lube Isocracker Unit is used in Case 1 to process straight-run heavy vacuum gas oil (HVGO), and in Case 3 to process either HVGO or deasphalted oil (DAO) in a blocked mode of operation to produce waxy lube base oil stocks. The unit is comprised of a catalytic reactor section and a fractionation section, which includes both an atmospheric column and a lube vacuum column.

The lube isocracking catalyst selectively converts unrefined lube feedstocks into high Viscosity Index lube base oils and premium-quality distillate fuels. In addition, most sulfur and nitrogen is removed from the feed, and the aromatic content is reduced significantly.

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f. ***Make-Up Hydrogen Booster Compression Unit (Unit 015)***

1. *Introduction*

Make-up hydrogen requirements for the new lube processing units are supplied from the existing Hydrogen Plant. Adequate excess capacity is available in the existing HC Unibon Unit make-up hydrogen compression system; however, the hydrogen gas must be further compressed via a new booster compressor to supply the new Lube Isocracker and DAO Hydrocracker Units and the hydrofinishing portion of the new Lube Isodewaxer/ Hydrofinisher Unit at the required pressure level. The entire hydrogen system is discussed in detail in Section 3.3.2.

2. *Process Description*

Schematics of the makeup Hydrogen Booster Compression Unit are shown on the following consecutive pages in Figures 3.3.3-F1 through 3.3.3-F4 for Cases 1 through 4, respectively. The surplus hydrogen from the existing HC Unibon Unit make-up hydrogen compression system is cooled in a new make-up hydrogen booster compressor suction air cooler, and then routed to a new booster compressor suction knockout drum. After removal of free water, the hydrogen stream is compressed in the new makeup hydrogen booster compressor. Two 100 percent capacity, motor-driven, reciprocating machines (one operating, one spare) are provided. Makeup hydrogen is then routed to the new lube processing units.

g. ***Tempered Water System (Unit 017)***

1. *Introduction*

Tempered Water System is a closed-loop, stand-alone unit which supplies tempered cooling water to the new lube processing units. Tempered water is used for cooling waxy lube base oils and lube products prior to storage. It is used in place of sea cooling water to prevent the temperature of the product streams from falling below their pour points and possibly plugging heat exchangers and lines. It also maintains the process side fluid viscosity in a range where heat exchanger heat transfer coefficients remain reasonable. The system supplies tempered water at 66°C, while the return stream temperature is approximately 140°C.

2. *Process Description*

A schematic of the Tempered Water System is shown in Figure 3.3.3-G1 on page 3.3-85. Tempered water is pumped from the tempered water surge drum to the various process unit consumers. For Cases 1 and 3, the users include the Lube Isocracker Unit and the Lube Isodewaxer/Hydrofinisher Unit. The Lube Vacuum Column and Lube Isodewaxer/Hydrofinisher Units require tempered water in Cases 2 and 4. The Case 4 DAO Hydrocracker Unit also uses tempered water. The hot tempered water is returned from the process units to the tempered water air cooler, where it is cooled and then routed back to the tempered water surge drum.

h. ***Wash Water Injection System (Unit 018)***

1. *Introduction*

The Wash Water Injection System provides condensate-quality water to wash out ammonium bisulfide salts that can cause fouling in the fin fan coolers as the temperature of hydroprocessing reactor effluent is reduced. Wash water injection points include the following: upstream of the Lube Isocracker Unit reactor effluent air cool exchanger, upstream of the Lube Isodewaxer/Hydrofinisher Unit dewaxer reactor effluent cooler, and, in Case 4, upstream of the DAO Hydrocracker Unit reactor effluent air cooled exchanger. For Cases 2 and 4 it is assumed that the Converted HC Unibon Unit Train 2 receives wash water from the existing injection system. Polysulfide is added into the wash water system as a water treatment.

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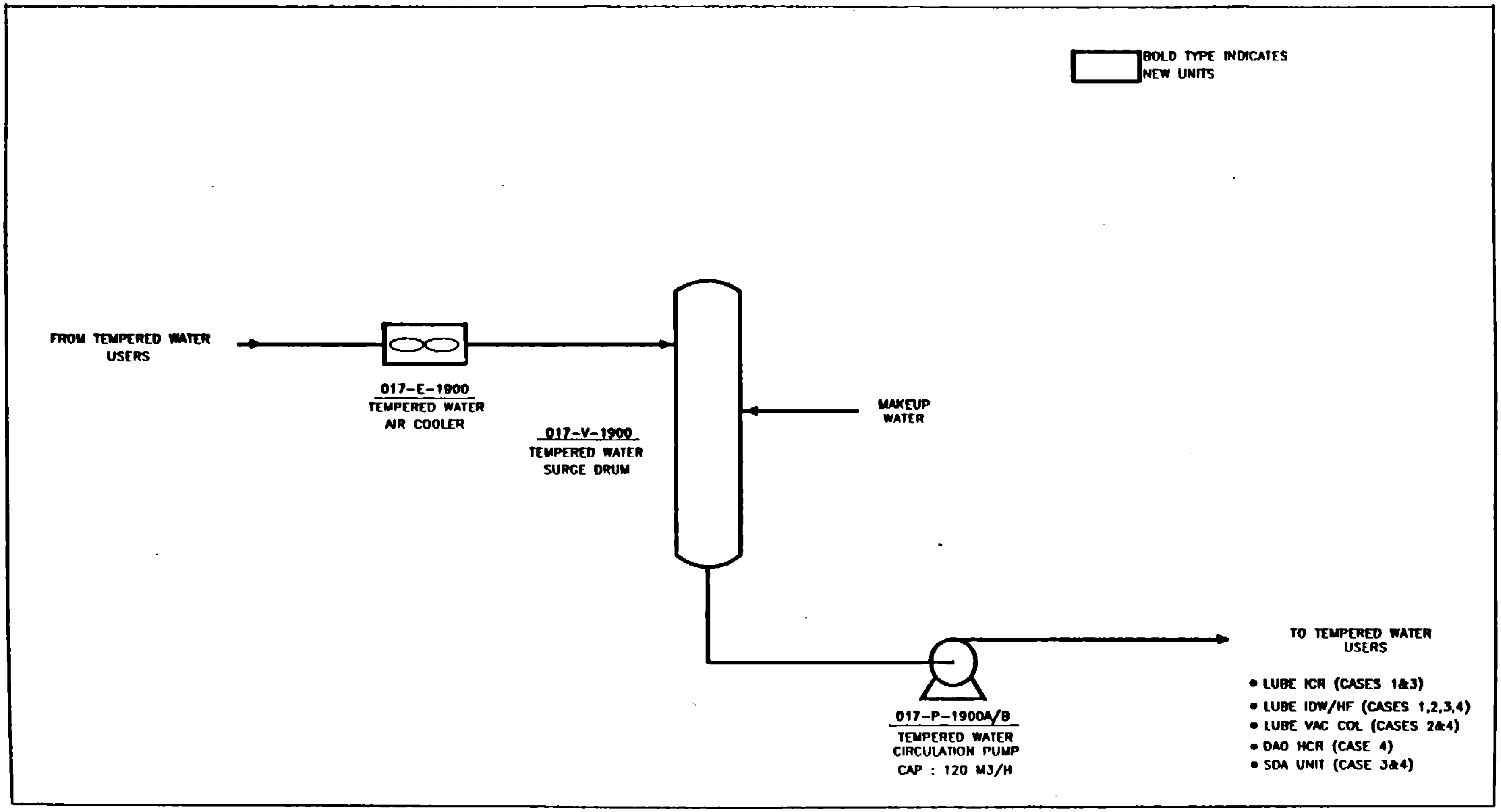

Figure 3.3.3-G1. Tempered Water System (Unit 017) Unit Schematic

The wash water injection requirements will vary from case to case. The differences in the injection rate are relatively small among cases and are unlikely to impact the study case evaluations. Therefore, for this study, an identical design is used for all cases. The wash water is supplied at a rate of approximately 11.4 m^3/h and at a maximum temperature of 93°C.

2. *Process Description*

A schematic of the Wash Water Injection System is shown in Figure 3.3.3-H1 on the following page. Make-up Wash Water (condensate or boiler feed water) and recycle water from the Lube Isocracker Unit atmospheric column reflux drum and the Lube Isodewaxer/Hydrofinisher Unit stripper reflux drum is routed to a new wash water drum. Polysulfide is injected into the wash water pump suction, and the treated wash water is routed to the various process unit consumers.

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3.3.4 Equipment Lists

The equipment lists for all the new and modified process units for the four study cases are included in this section. The lists are presented sequentially by unit number. The equipment list titles at the top of each page indicate for which study case or cases a given unit is required.

Within each unit, equipment is listed by cost estimating account number (e.g., Account 42 is Shop Fabricated Vessels/Tanks). Along with equipment item tag numbers and descriptions, the lists also show sizes, capacities, metallurgy, design conditions, insulation requirements, and miscellaneous additional information, all of which is used to generate equipment capital costs and plot plans.

Note:

The equipment list and descriptions presented in this section were done before the completion of the Chevron Yield Confirmation Study. Some of the equipment and/or descriptions have changed as a result of necessary adjustments. These changes are not reflected in this section but they are discussed in Section 9.3.

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3.4 Utilities, Offsites, and Tankage

This section contains an overall discussion of the Utility and Offsite Facilities followed by a discussion of each system. Finally, this section presents an equipment list for all of the Utility and Offsite Systems for all four study cases.

3.4.1 Overall Description

A convenient philosophy adopted for this study at the beginning of the project was to provide stand-alone utility and offsite systems. However, early in the study it was realized that potential cost savings could be achieved by integrating with the existing utility systems where practical, either by adding parallel equipment or by using any excess capacity. For most systems that were integrated to the existing UP-II systems, parallel equipment was selected to duplicate the existing equipment to minimize the time required to gain familiarity with the new equipment and investment in spares. In some systems, this approach led to equipment with more excess capacity than required for the Lube Base Oils Complex. There are a few new stand-alone systems dedicated to the new units. This approach will be further evaluated and optimized during the next phase of this project.

3.4.2 Utility Systems

River Water Intake and Pipeline and Water Treatment (Offplot) Systems (Units 020 and 021)

The River Water Intake and Pipeline and Water Treatment systems are provided with two suggested designs. The proposed design represents minimum investment. See Figure 3.4.2-A on the following page for a representation of these systems.

The proposed systems utilize the existing equipment to the maximum extent. They use existing capacity that may be present in these systems as a result of the intermittent delivery of water to the Pertamina housing area. For this study, the river water intake facilities that are currently existing are not modified. Also not modified is the majority

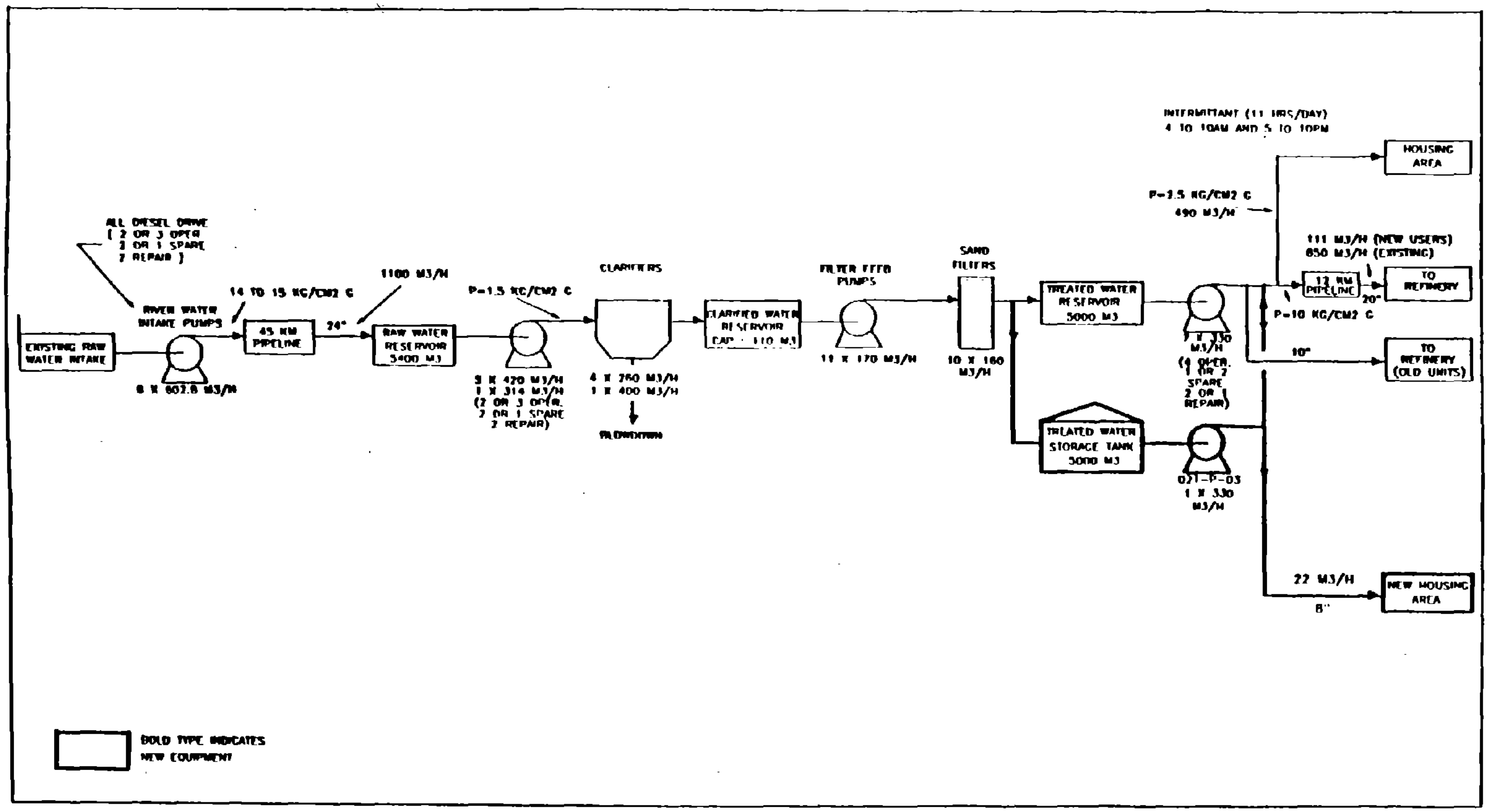

Figure 3.4.2-A River Water Intake, Pipeline & Water Treatment Systems
Block Flow Diagram

of equipment of the offplot water treating system located near the Pertamina housing area. A 5,000 m^3 treated water storage tank and one new 330 m^3/h water pump that operates in parallel with the seven existing 330 m^3/h pumps are proposed additions. The new pump discharges into the existing facilities so that it is able to work as a spare for, or be spared by the existing pumps. A new section of 8" diameter pipe is added to allow delivery of approximately 22 m^3/h (average) of treated water to the new housing area. Two tube wells are also added in the housing area as backup water supply sources.

The alternate design is cost intensive, but it provides additional flexibility for the water supply since the existing 24", 45 km long pipeline appears to be heavily scaled internally with organic sediment. See Figure 3.4.2-B on the following page for a representation of the alternate design systems. The alternate scheme requires modifications to the raw water intake structure at the Rokan River. Two new 170 m^3/h capacity pumps are added to supply water to a new 10", 45 km long pipeline, which would run parallel to the existing 24" pipeline and deliver water to the offplot water treating system. At the offplot water treating system, the new line is tied to the existing water reservoir. A new raw water pump sized at 170 m^3/h is added to operate in parallel with the existing five 420 m^3/h pumps and the one 314 m^3/h pump. A new clarifier with the capacity of 260 m^3/h is added to operate in parallel with the currently installed four clarifiers at 260 m^3/h and one at 400 m^3/h. The clarified water from all of these clarifiers is sent to the existing clarified water reservoir. A new pump of 170 m^3/h capacity is added to provide clarified water to a new sand filter. The filter feed pump works in parallel with the currently installed 11 pumps of 170 m^3/h capacity each. The new sand filter is designed for a capacity of 160 m^3/h and operates in parallel with the existing ten sand filters of 160 m^3/h capacity each. The filtered water is sent to the existing 5000 m^3 capacity treated water reservoir. A new treated water pump with a capacity of 330 m^3/h is provided to operate in parallel with the existing seven pumps of 330 m^3/h capacity each. Cross ties are provided to allow the new pump to feed the existing supply to the UP-II refinery and the housing area. Cross ties are provided so that the existing pumps may be used as spares for the new pump. A new 8" pipeline delivers 22 m^3/h (average) treated water to the new Pertamina housing area.

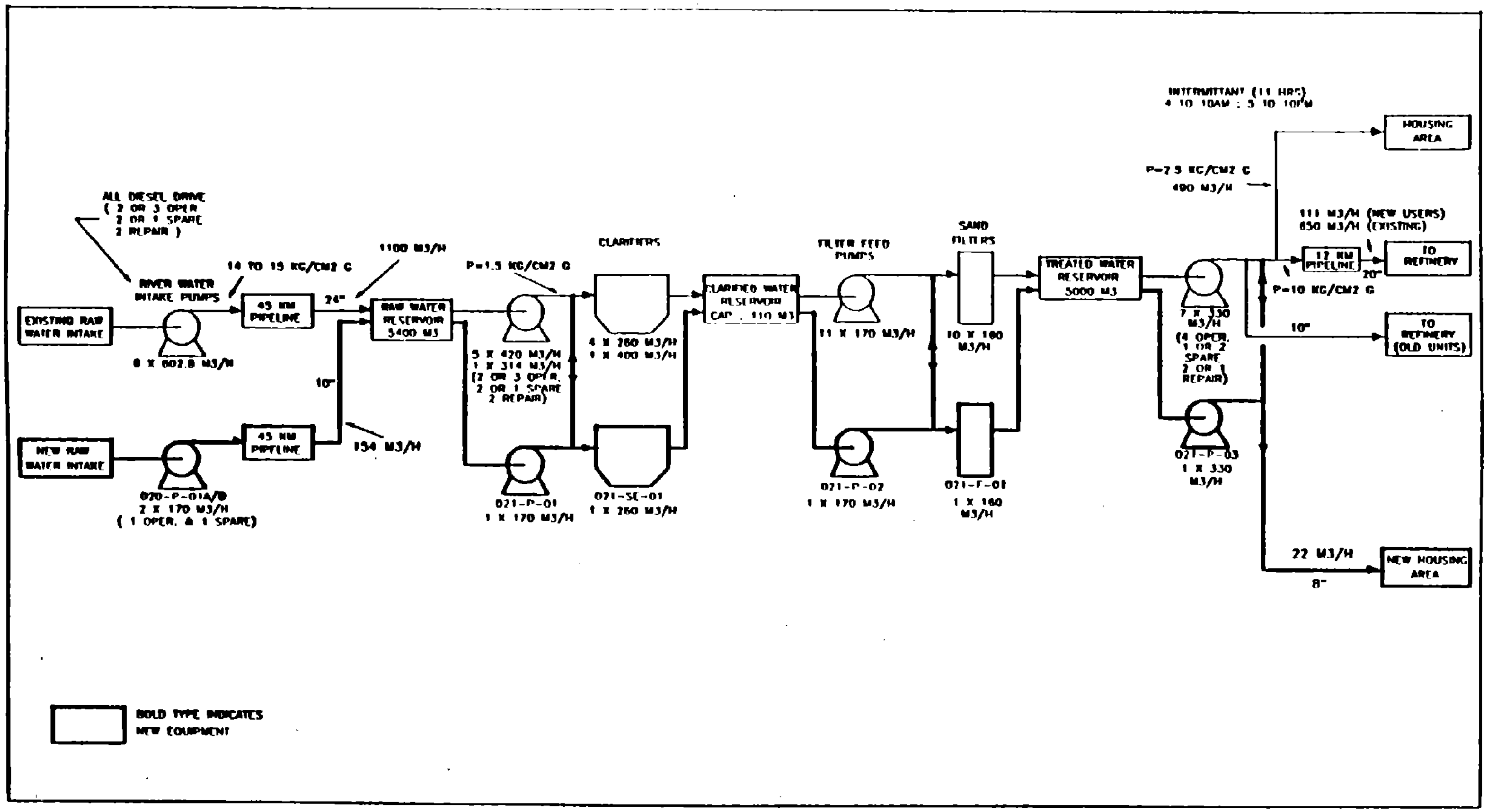

Figure 3.4.2-B River Water Intake, Pipeline & Water Treatment (Offplot) Systems
Alternate Design
Block Flow Diagram

Raw/Plant/Potable Water System
(Unit 022)

The raw water, plant water, and potable water system is being supplemented by the addition of a new sand filter and two new pumps to increase the capacity of the existing system. Refer to Figure 3.4.2-C on the following page for a sketch of the system. The new sand filter is fed through a branch line from the existing header. The sand filter is designed for a capacity of 150 m^3/h and works in parallel with the existing eight sand filters each of 150 m^3/h capacity. Water from the sand filters is directed to one or the other of the two existing raw water storage tanks of 39,700 m^3 capacity each. Two new pumps of 140 m^3/h capacity each are added to this system. These pumps operate in parallel with the existing pumps. The new pumps supply water to the plant water users, existing potable water treatment area and to the existing demineralizers. Cross ties are provided such that the two existing raw water pumps with a capacity of 681.3 m^3/h each can serve as the backup for the new pumps. A new pump with capacity of 10 m^3/h is added to deliver potable water to the new users. A tie-in is provided so that this pump may operate in parallel with the two existing potable water pumps. The additional potable water requirements within the refinery are estimated at 3 m^3/h (average) while the new lube base oils complex plant water requirements are 23 m^3/h (average). The balance of water being delivered from the new raw water pumps is directed to the existing demineralizers.

Demineralizer Water/BFW/Condensate/Steam Generation System
(Unit 023)

The Demineralizer Water/BFW/Condensate System processes raw water to produce demineralized water, which is blended with return condensate and further treated to produce boiler feedwater (BFW). The system configuration is presented in Figure 3.4.2-D on page 3.4-7. Raw water from storage is delivered to the four existing demineralizer units, each of which has a demineralized water capacity of 180 m^3/h. The treated (demineralized) water is routed to the two existing demineralized water tanks (7,589 m^3 capacity each). A new treated water pump, identical in size (272.5 m^3/h) to the two existing pumps, is added in parallel to the existing pumps to deliver treated water to the new facilities. The existing spare pumps also provide the necessary spare capacity for the new pump.

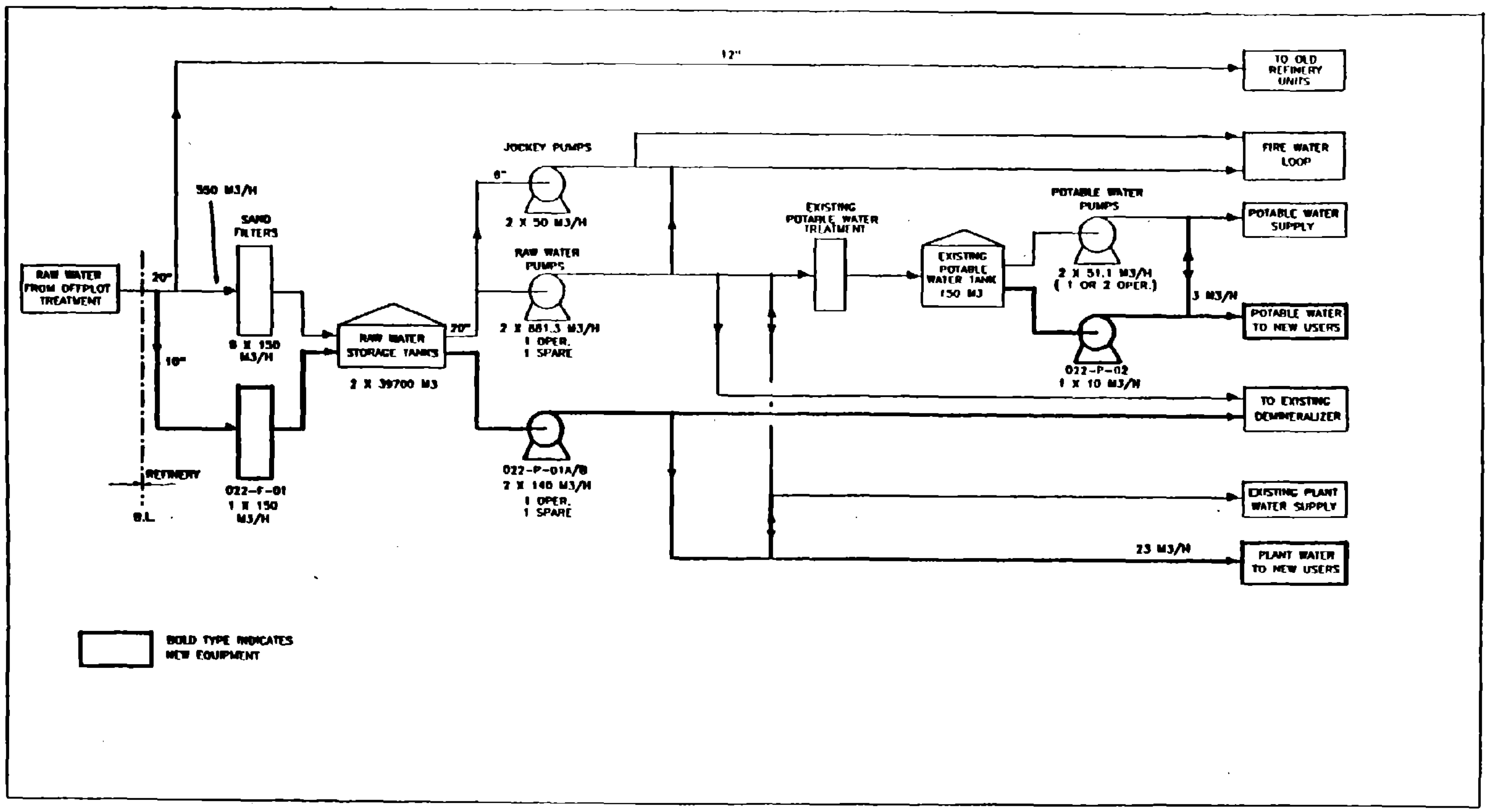

Figure 3.4.2-C Raw/Plant/Potable Water System Block Flow Diagram

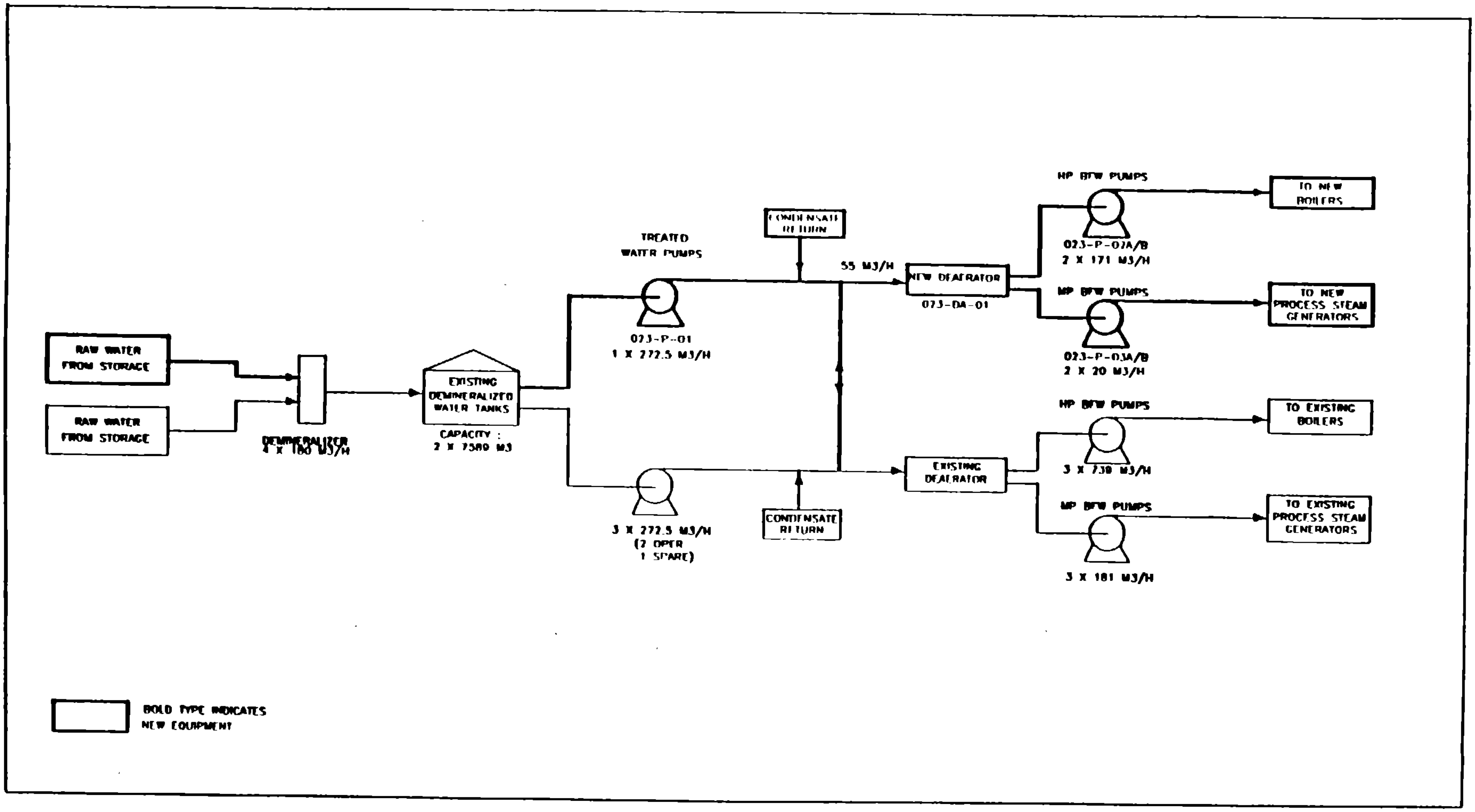

Figure 3.4.2-D. Demineralized Water/BFW/Condensate Steam Block Flow Diagram

Condensate is returned from the existing facilities as well as from the new facilities. Return condensate is mixed with treated makeup water and routed to both the existing deaerator and a new deaerator. Two new high pressure BFW pumps (170 m^3/h capacity each), and two new medium pressure BFW pumps (20 m^3/h capacity each) are added to supply BFW to the new boilers and process steam generators.

The new Steam Generation system produces high pressure (42 kg/cm^2g) steam required for the lube base oils complex as well as for the new steam turbine power generator. Refer to Figure 3.4.2-E on the following page for a sketch of the new system and the tie-ins to the existing system. Two new boilers are added to supply high pressure steam requirements of the lube base oils complex. These boilers of 68 t/h capacity each, identical to existing boilers in capacity, operate in parallel with the existing four boilers and two new boilers currently being installed. The high pressure steam is supplied from the new and existing systems via a cross connection so that steam may be delivered either from the new or from the existing boilers at the 42 kg/cm^2g. The new facilities are provided with a distribution system and controls to deliver the 42 kg/cm^2g high pressure steam to the new steam turbine drivers. The facility also includes a 10.5 kg/cm^2g medium pressure steam header and a 3.5 kg/cm^2g low pressure steam header.

Power Generation System
(Unit 024)

A new steam turbine generator rated at 14 megawatts at a power output of 11 kv is proposed for addition to the existing system. Refer to Figure 3.4.2-F on page 3.4-10 for an arrangement of the new and existing generators. The present system is comprised of four steam turbine generators, each rated at 14 megawatts at 11 kv. Normally, three of these are in service at approximately 9 megawatts each. The new steam turbine generator operates in parallel with the existing four steam turbine generators. In addition to these steam turbine generators, the existing system has two AEG-Kanis gas turbine generators each rated at 17.5 megawatts at 10.5 kv. One of these two operates at 7 megawatts while the other, a spare, has not been in operation for several months. The system also has two small diesel generators as well as an additional gas turbine-driven generator. These three

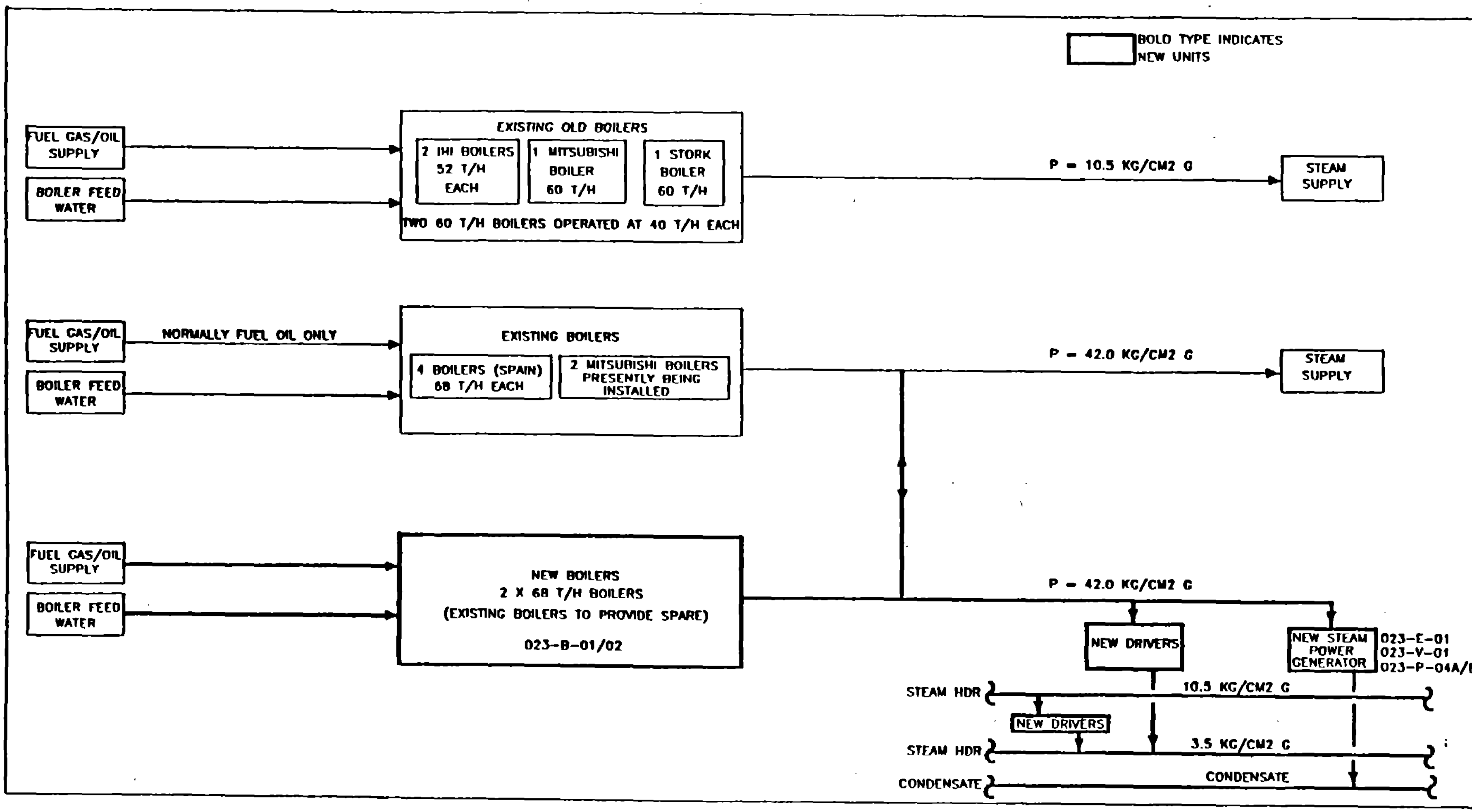

Figure 3.4.2-E Steam Generation System Block Flow Diagram

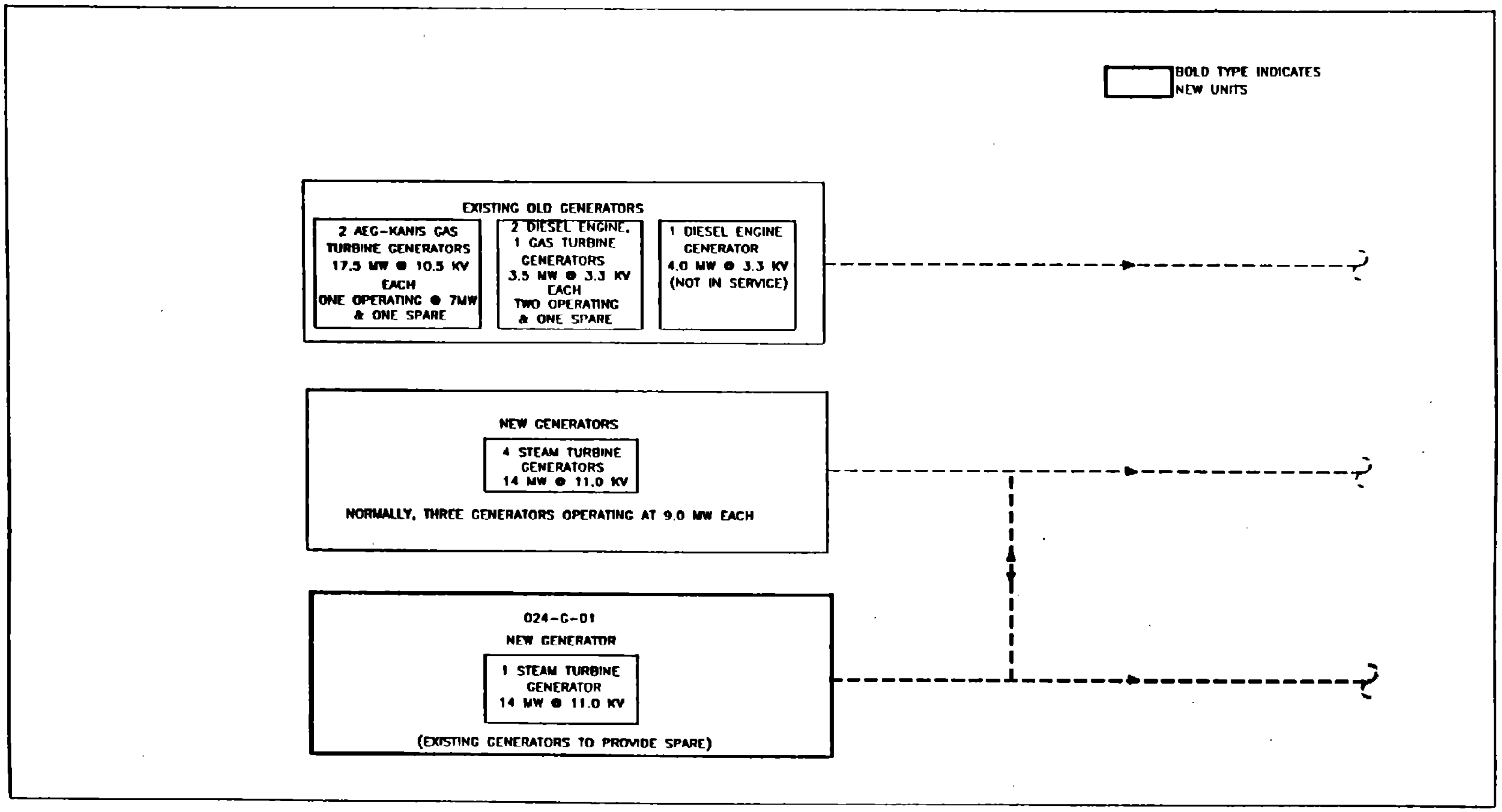

Figure 3.4.2-F Power Generation System Block Flow Diagram

generators are rated at 3.5 megawatts each at 3.3 kv. Two of these are normally operated while the third is kept in a standby condition. There is also a diesel engine driven generator rated at 4 megawatts at 3.3 kv which is not in service at this time.

A dedicated emergency power generator is not provided by this project due to the availability of existing spare generators.

The generator turbine has provision for induction of low pressure steam to help balance the refinery steam system. The new turbine exhaust steam at 0.25 kg/cm^2 absolute is condensed in an air-cooled surface condenser. The vacuum condensate is collected in a surge drum and pumped to the condensate return system.

The existing power generation building is extended for housing the new power generation equipment. The size of the building extension is 20 m x 60 m.

Plant/Instrument Air System
(Unit 025)

A new air compressor package complete with inter and after coolers, an air receiver, and an instrument dryer package are provided for the new lube base oils complex. Refer to Figure 3.4.2-G on the following page for an overview of the new and existing air systems. The new compressor is designed for a capacity of 3,300 Nm^3/h. The compressor discharges into a new air receiver. The operation of this system is integrated with the existing system which is comprised of four package compressors of 3,300 Nm^3/h capacity each. Three of the four existing compressors normally operate for the UP-II air requirements. The existing compressors discharge to their own receivers. The volume of the new receiver is identical to the volume of the existing receivers. The refinery also has in operation an old air compressor system. This system has three air compressors of 250 Nm^3/h capacity each, two of which are normally in service. In addition to the compressor and receiver, a new air dryer package complete with pre- and after-filters is included in the design. The new dryer package with a capacity of 2000 Nm^3/h operates in parallel with the existing installed two trains of dryers, each of 4000 Nm3/h capacity.

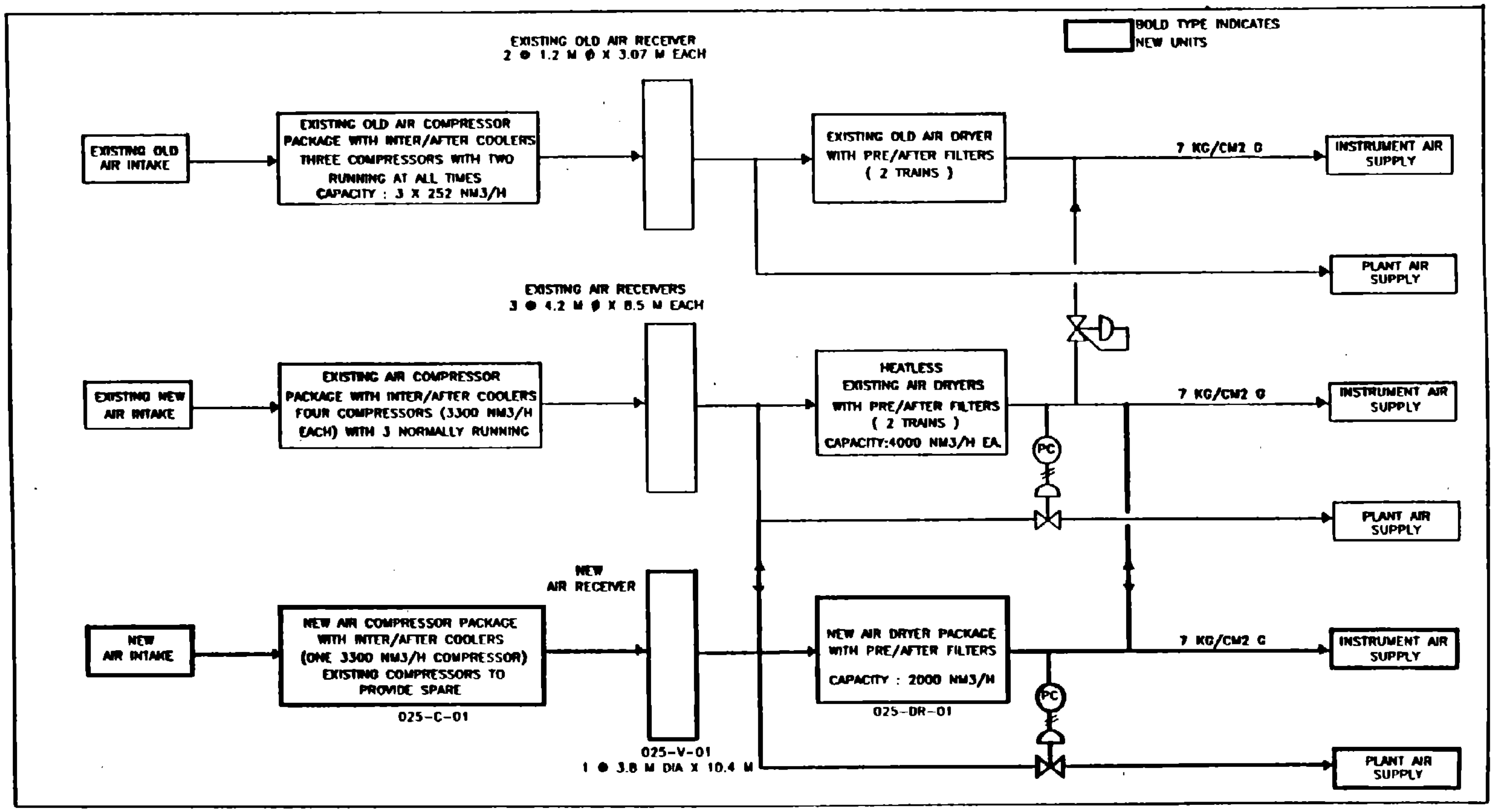

Figure 3.4.2-G Plant/Instrument Air System Block Flow Diagram

Cross ties are provided such that the existing air system and the new air system can serve as backup for each other. The instrument air system is provided with controls to ensure that the instrument air system has preference over the plant air system. Therefore, on low instrument air pressure the flow of air to the plant air system is reduced to ensure adequate supply of the instrument air.

The existing air compressor building is extended for housing the new air compressor. The size of the building extension is 10 m x 20 m.

Sea Cooling Water System
(Unit 026)

The existing sea cooling water system is expanded to supply water to the new lube base oils complex. Refer to Figure 3.4.2-H on the following page for the arrangement of the sea cooling water system. A new sea water intake system is incorporated into the existing intake structure to allow an additional pump to be provided for the system. This pump is identical to the four existing pumps of 3,250 m^3/h capacity each and operates in parallel with those pumps. The suction line for this pump is provided with chlorine injection from a new feeder which receives chlorine from the existing chlorine injection system. The sea water from the intake pumps is delivered to the existing collection basins (5,800 m^3 capacity total) or to a new basin of 2,900 m^3 capacity. A new pump is installed at the new basin for supplying water to the new users. The new supply pump is identical to the existing four supply pumps of 3,250 m^3/h capacity each and operates in parallel with those pumps. The existing supply pumps take their suction from the existing basin. Crossover piping between the basins as well as between the pump discharge headers allows any pump within these facilities to operate as the spare while the balance of the pumps can operate to supply the demand of the facility.

A new strainer identical to the existing four strainers of 5,920 m^3/h capacity each is added to meet the additional sea water filtering requirements. The new and the existing sea cooling water supply headers are cross connected to provide full integration. Modifications are also required in the sea water return system. The new water return is cross tied to the two existing water return circuits.

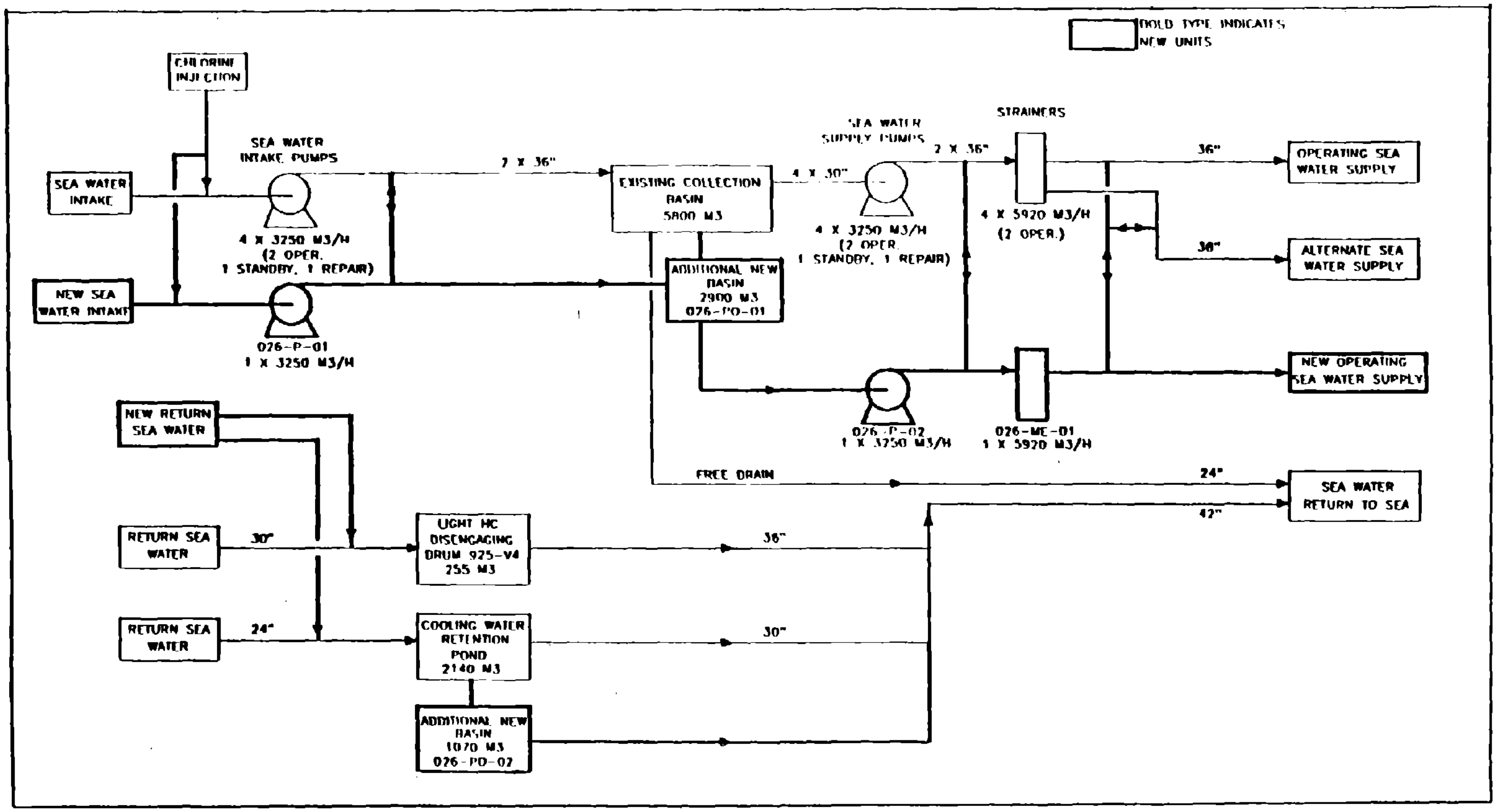

Figure 3.4.2-H Sea Cooling Water System Block Flow Diagram

These two circuits discharge to different holding locations depending on process side service of the exchangers. Cooling water return from lighter hydrocarbon cooling services is routed to the existing light hydrocarbon disengaging drum with a capacity of 255 m^3. The return from heavier hydrocarbon cooling services is sent to the cooling water retention pond of 2,140 m^3 capacity. An additional basin with capacity of 1070 m^3 is added to augment the current retention system. The returned cooling water, after checking and approval for discharge, is directed to the ocean.

Firewater System
(Unit 027)

The firewater system provides sea water to be used in an emergency to fight fires. Refer to Figure 3.4.2-I on the following page, which presents the design philosophy for this system. The firewater system for the lube base oils complex utilizes the existing facilities for its requirements. The amount of water available for delivery to the new facilities is sufficient based on the existing refinery equipment demand and the extent of new facilities being added. Therefore, only new piping is provided from the existing firewater loops to provide distribution headers around the new lubes process area, the new lube oil intermediate and product tankage area, and the new lubes utilities area. The existing firewater system has four 568 m^3/h capacity pumps that deliver the required water to the new and existing services.

In addition to the header piping, the new system includes network valves, monitors, and fire hydrants as required by the tankage, the utilities or the process areas.

Fuel Oil and Fuel Gas Systems
(Units 028 and 030)

The existing refinery fuel oil and fuel gas systems have sufficient capacity to allow utilization of existing equipment for the fuel oil and fuel gas requirements of the lube base oils complex. Therefore, additional equipment is not provided. Refer to Figure 3.4.2-J on page 3.4-17 for an overview of the Fuel Oil System. Tie-in connections are provided from the distribution system to allow connection of fuel oil to the new facilities.

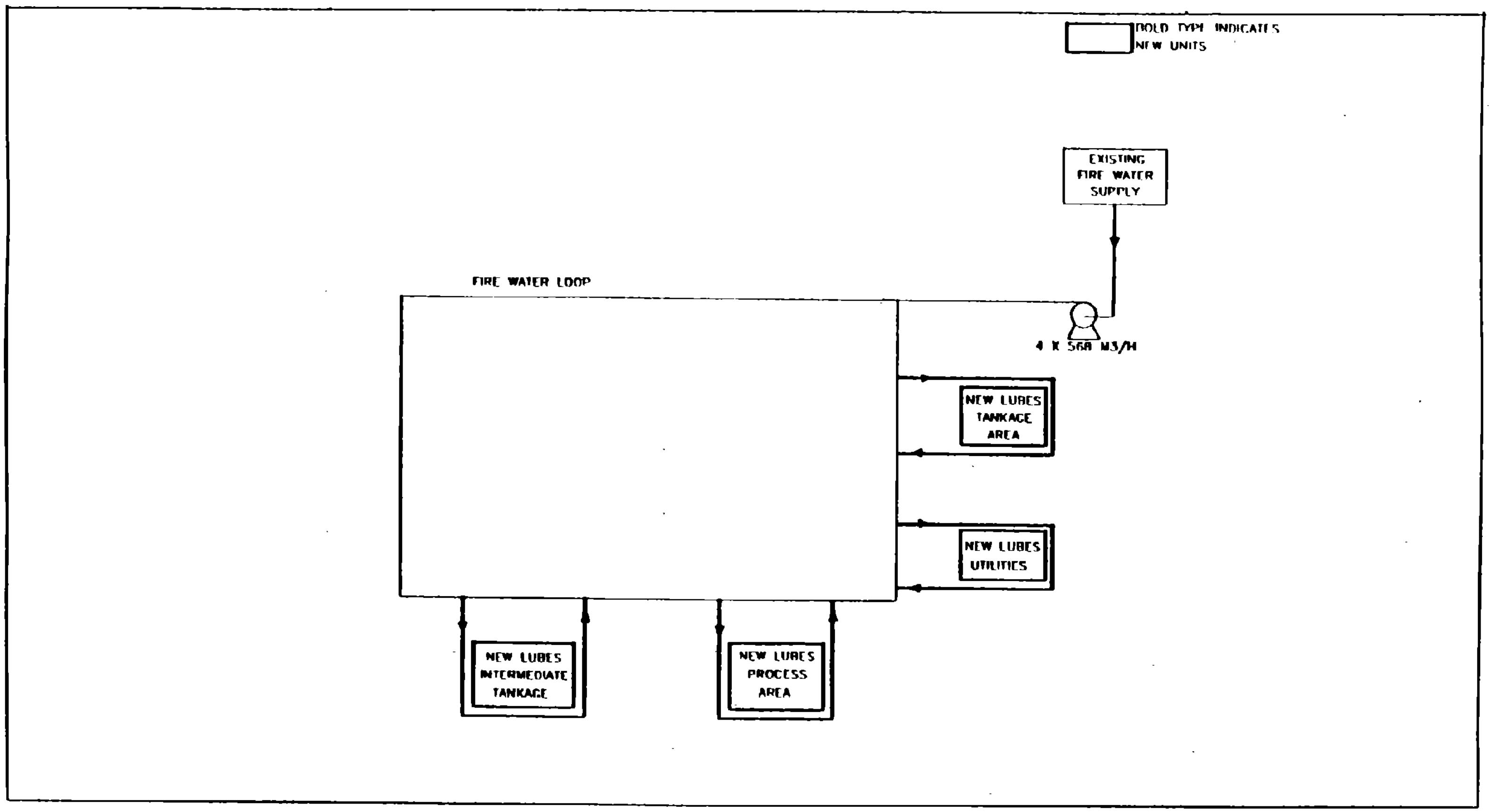

**Figure 3.4.2-1 Firewater Systems
Block Flow Diagram**

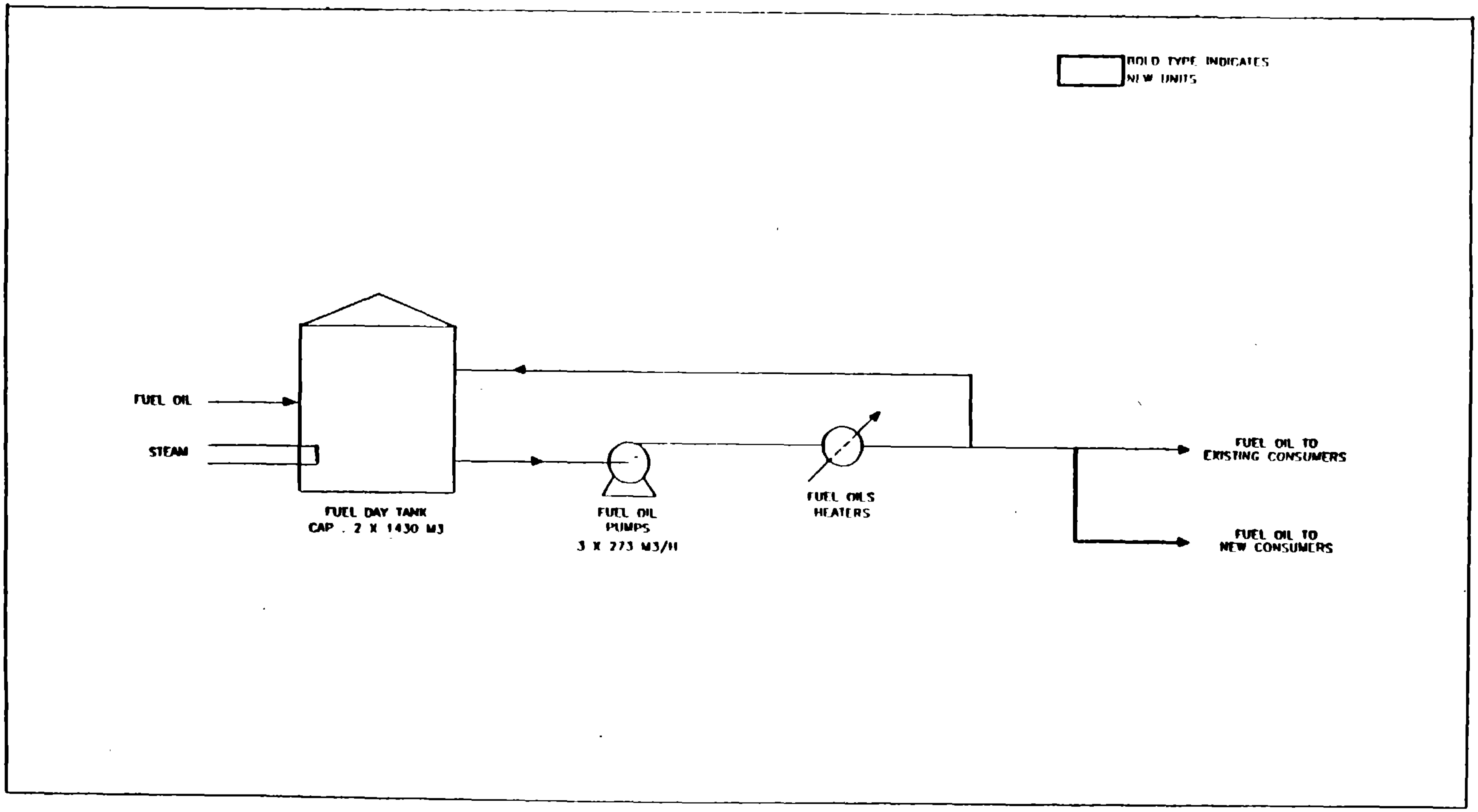

Figure 3.4.2-J Fuel Oil System
Block Flow Diagram

The fuel gas system is treated exactly like the fuel oil system. A separate system sketch is not provided.

Jacket Water System
(Unit 029)

The jacket water system is a totally new system dedicated to support the requirements of the new equipment associated with the new lube base oils complex. Refer to the following Figure 3.4.2-K for a sketch of the system. The system is a closed loop cooling water system. Corrosion inhibitor is added to the water in the surge tank. The jacket water pumps deliver water via the distribution piping system to various equipment items requiring jacket water. In general, the jacket cooling water is supplied to all those new users that cannot accept sea water for cooling. A collection header system returns the heated water to the air cooler where the absorbed heat from the equipment is dissipated. The water from the air cooler is returned to the water storage tank.

3.4.3 Offsite Systems

Flare System
(Unit 040)

New flare facilities are provided for the lube base oils complex. Refer to Figure 3.4.3-A on page 3.4-20 for an overview of the new and existing flare systems. The new flare system consists of a new knockout drum, and a new flare stack with tip and a pilot ignition system. The new knockout drum is provided with an operating and spare pump to remove any liquids that may be separated from the gas to the knockout drum. The new flare is sized for 110,000 kg/h of vapor flow. The basis for this rate is relief from new process units under a power failure scenario. The new flare system is not connected to any of the existing flare system. Any liquid collected is transferred to the existing slops tanks by way of a new header.

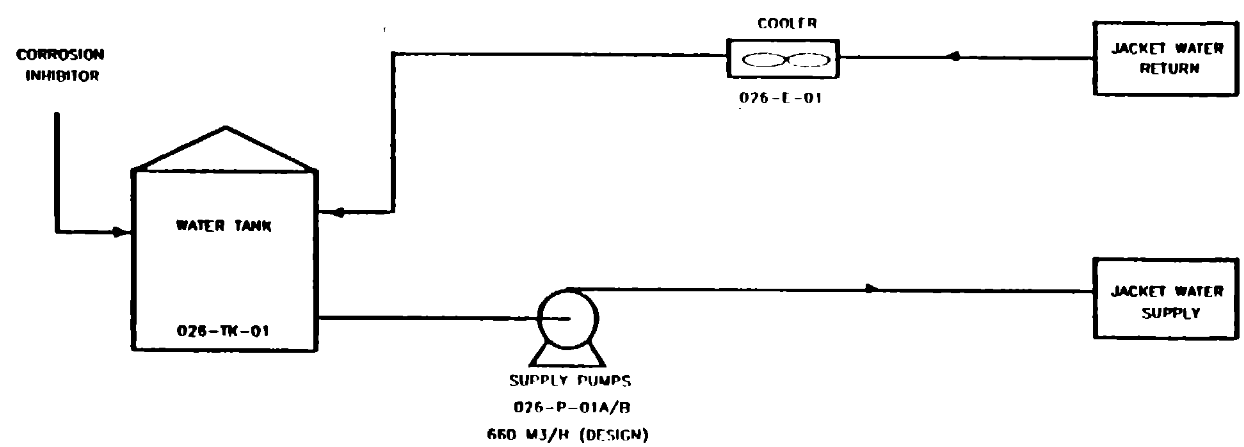

**Figure 3.4.2-K Jacket Water System
Block Flow Diagram**

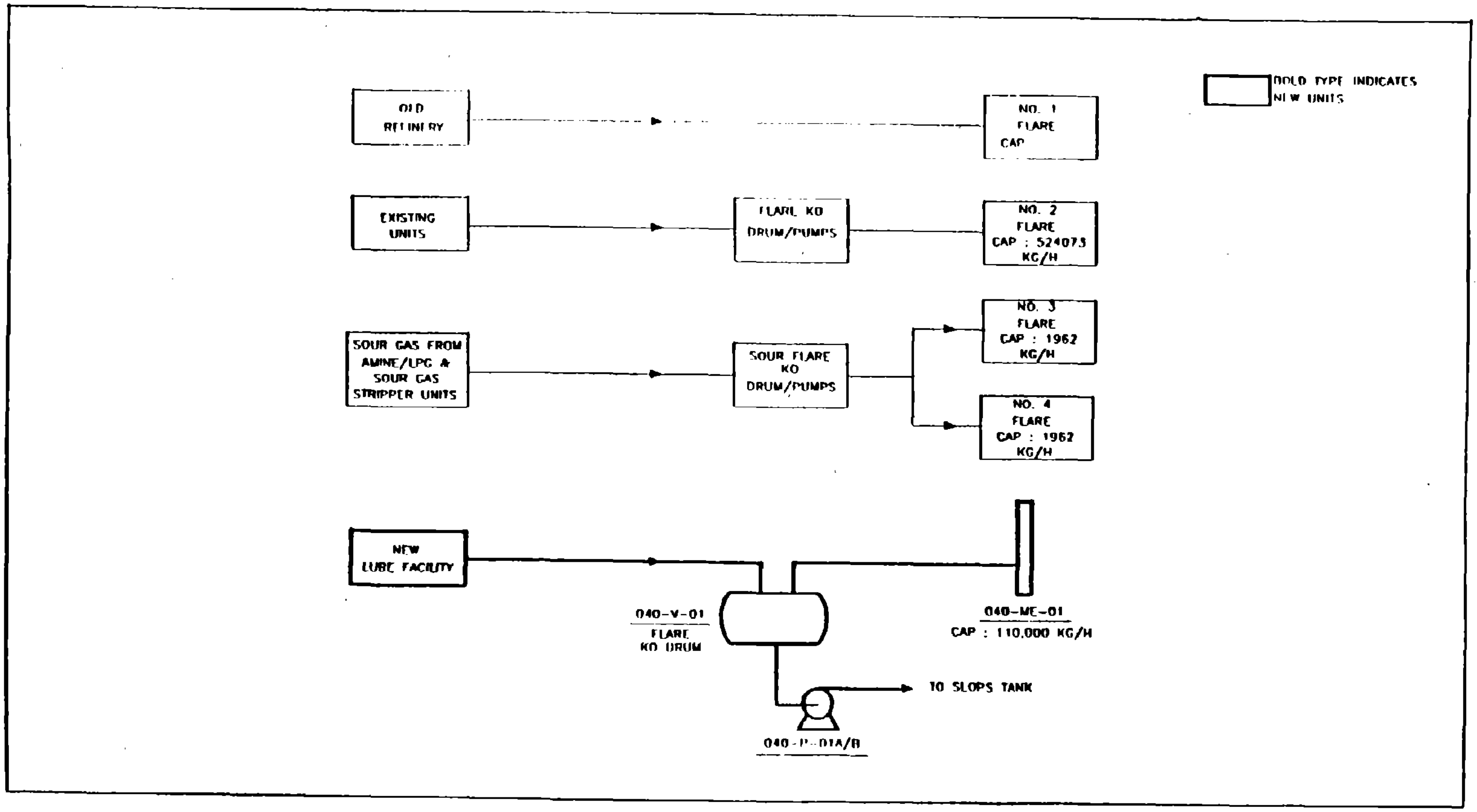

Figure 3.4.3-A Flare System
Block Flow Diagram

Nitrogen Storage/Vaporizer System
(Unit 041)

The nitrogen system is provided with additional facilities to store and vaporize nitrogen. Refer to the following page for Figure 3.4.3-B for a sketch presenting the concept for the nitrogen system. The new liquid nitrogen storage drum is designed to store 100 m^3 of liquid and receives its supply from the existing air separation plant, which is rated to produce 400 Nm^3/h of nitrogen. The average normal usage of nitrogen is only 100 Nm^3/h. The proposed scheme utilizes excess capacity by storing liquid nitrogen in the new drum to meet the lube base oils complex shipping and transfer requirements, the normal tank breathing demands, and other maintenance or shutdown requirements of the new facility. The liquid nitrogen is vaporized in a new nitrogen vaporizer, which has a capacity of 1,900 Nm^3/h of gas. The gaseous nitrogen from the vaporizer is supplied to the new user via a new distribution header. Cross piping connections are provided between the new and the existing vaporizers and distribution piping such that the overall system reliability is not compromised.

Oily Water Treatment System
(Unit 042)

Waste water comprises the following four major types of waste streams:

- Sour water
- Process oily waste water from equipment collected via raised hubs.
- Potentially contaminated storm water from paved process areas of the lube base oils complex.
- Sanitary sewage

Sour water treatment is discussed in Sections 3.3.2 of the report.

Figure 3.4.3-C on page 3.4-23 shows the conceptual scheme for the oily water system. The performance of the existing TPI oily water separator is known to be poor due to greater-than-design flow and concentration of oil in the feed to the separator.

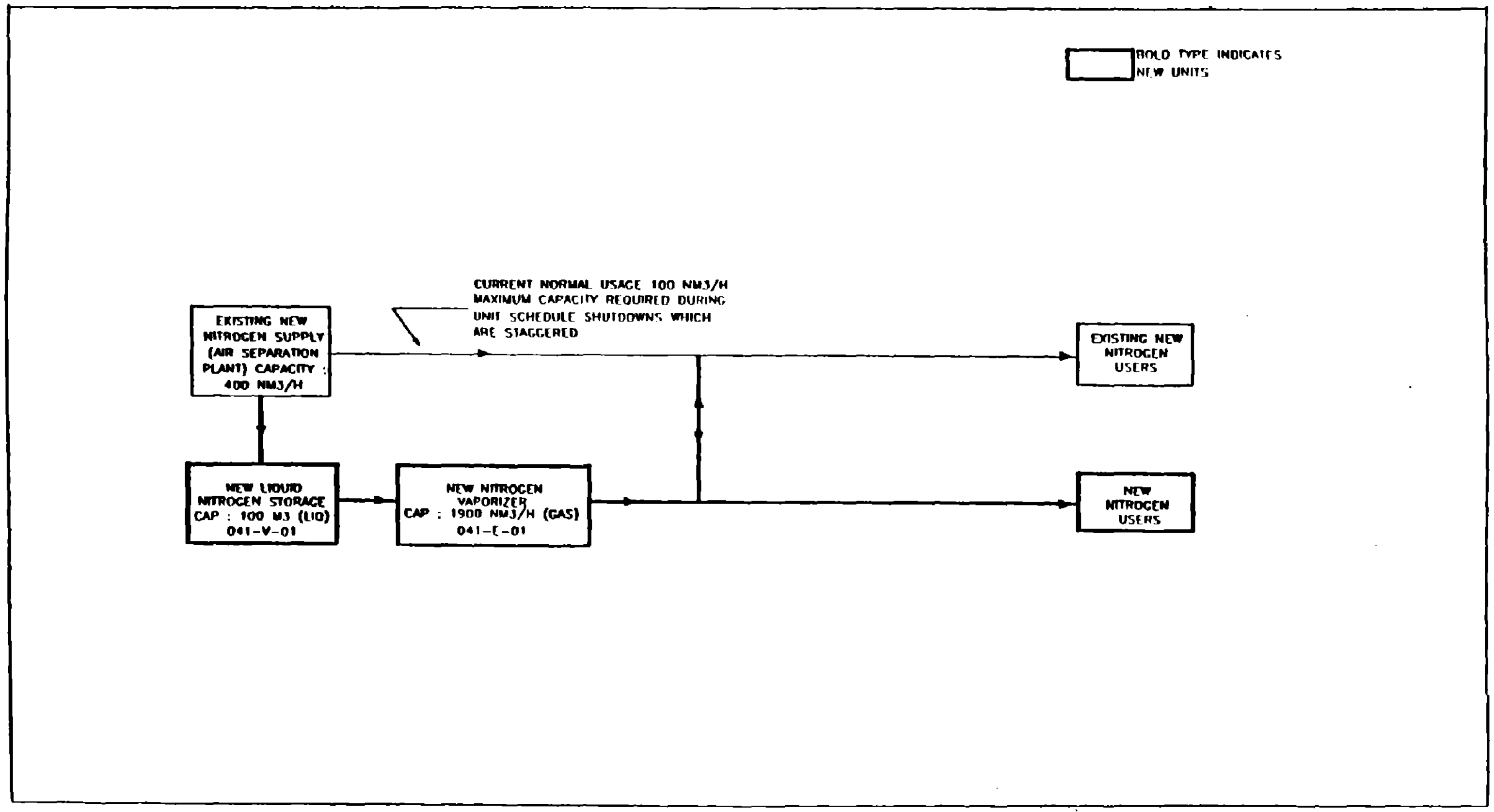

Figure 3.4.3-B Nitrogen Storage/Vaporizer System
Block Flow Diagram

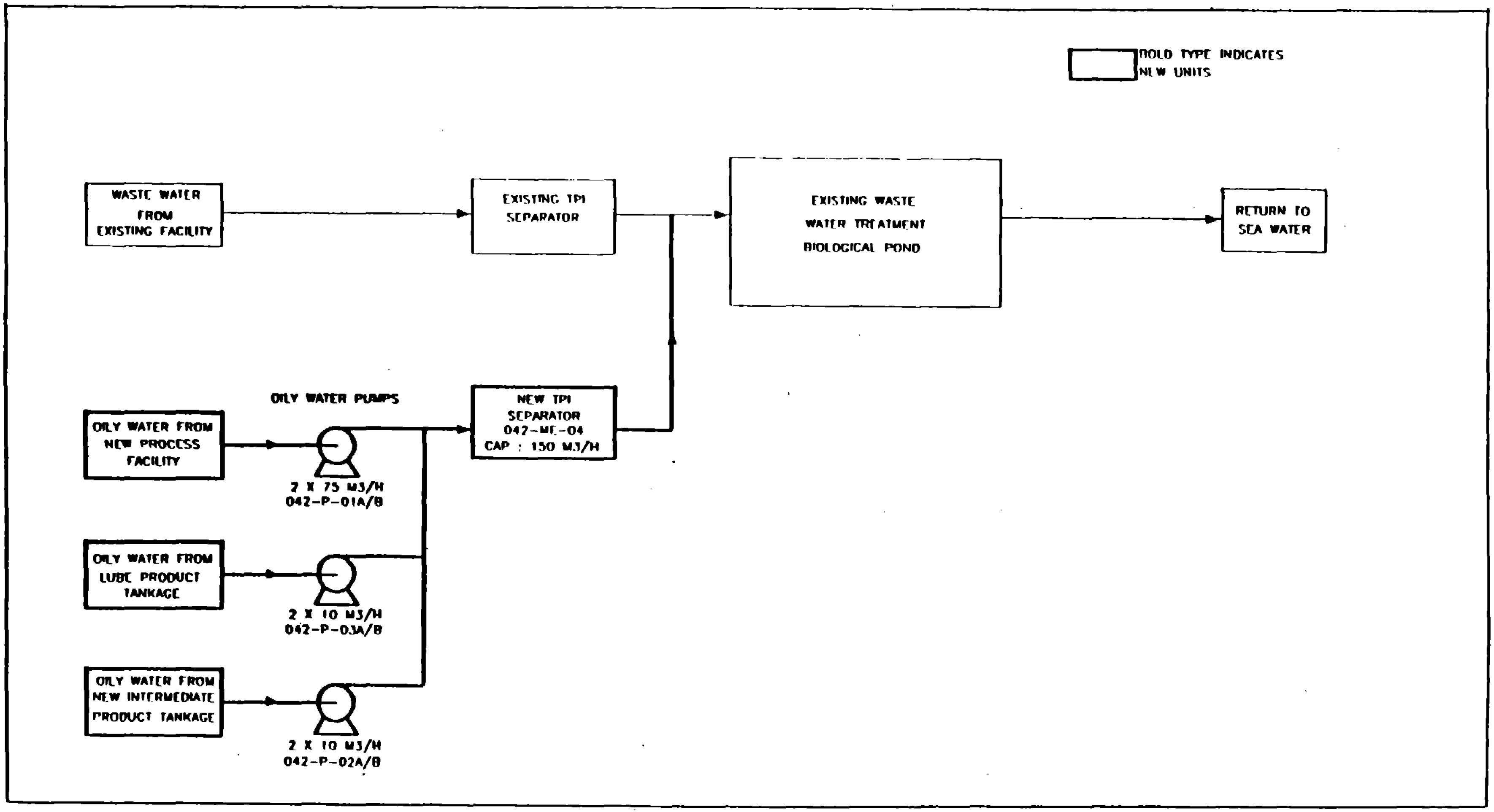

Figure 3.4.3-C Oily Water Treatment System
Block Flow Diagram

Therefore, a new oily wastewater pretreatment system is planned for the lube base oils complex. The process oily wastewater from equipment drains is collected through a raised drain hub sewer system to a new below ground surge tank located near the lube base oils complex. This oily wastewater is pumped to a new TPI oily wastewater separator located above ground near the existing TPI separator and stabilization basin. The new separator is designed to process 150 m^3/h of oily wastewater with an oil gravity of 0.95. The 150 m^3/h separator size is based on increased raw water consumption by about 120 m^3/h.

The treated water from the TPI separator is discharged to the existing stabilization basin. It is assumed that sufficient capacity exists in the separator downstream equipment to meet the regulatory requirements. A more detailed evaluation of the existing biological treatment system must be performed during the project design definition phase.

Oil recovered in the new separator is pumped to the existing slop oil tanks. Sludge from the bottom of the separator is pumped to the existing oily sludge disposal location.

Water draws from intermediate and finished product storage tanks flow through a gravity sewer to a below ground storage sump. The water is pumped to the new TPI oily water separator for treatment.

The storm water system include runoff from all paved areas in the lube base oils complex. It is a closed, gravity flow system, except where lift stations may be required, discharging to the existing storm water pond.

Sanitary System
(Unit 043)

The Sanitary Sewer system is provided to collect waste from the buildings associated with the Lube Base Oils Complex. The system is composed of collection header directed to a septic tank. The effluent from the septic tank is pumped to the existing stabilization basin for biological treatment by use of a packaged lift station.

[The information contained on page 3.4-25 through 3.4-35 is considered confidential and proprietary to the Dumai Base Oils Project or to the licensors who have provided the information under a secrecy and/ or licensor agreements. This information has been removed from this Study Report in order to comply with the required agreements.]

3.4.5 Equipment List

The equipment lists for all required utility and offsite systems in all four study cases are included in this section. The lists are presented sequentially by system (unit) number. The equipment list titles at the top of each page indicate which study case or cases is required for a given system.

Within each system, equipment is listed by cost estimating account number (e.g., Account 42 is Shop Fabricated Vessels/Tanks). Along with equipment item tag numbers and descriptions, the lists also show sizes, capacities, metallurgy, design conditions, insulation requirements, and miscellaneous additional information, all of which is used to generate equipment capital costs and plot plans.

Note:

The equipment list and descriptions presented in this section were done before the completion of the Chevron Yield Confirmation Study. Some of the equipment and descriptions have changed as a result of necessary adjustments. These changes are not reflected in this section but they are discussed in Section 4.3.

River Water Intake System and Pipeline (Unit 020)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 020	RIVER WATER INTAKE										

ALTERNATE River Water Intake System and Pipeline (Unit 020)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS: TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 020	RIVER WATER INTAKE										
44		PUMPS & DRIVERS										
	020-P-01A	RIVER WATER INTAKE PUMP	NEW	PUMP		HD=15 KG/CM2 ; 170 M3/H	REV 3	CS	20	AMB		
	020-P-01AEN	RIVER WATER INTAKE PUMP DRIVER	NEW	ENGINE	150 HP OUTPUT		REV 3					
	020-P-01B	RIVER WATER INTAKE PUMP (SPARE)	NEW	PUMP		HD=15 KG/CM2 ; 170 M3/H	REV 3	CS	20	AMB		
	020-P-01BEN	RIVER WATER INTAKE PUMP DRIVER (SPARE)	NEW	ENGINE	150 HP OUTPUT		REV 3					
50		PIPING										
	020-	RAW WATER PIPELINE	NEW	PIPE	10" (NOM.) X 45 KM LONG		REV 3	CS	20	AMB		

PERTAMINA/CHEVRON
DUMAI BASE OILS PROJECT

FLUOR DANIEL
CONTRACT NO. 422700

Water Treatment System (Off Plot) (Unit 021)

Equipment List

All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 021	WTR TREATMT (OFF PLOT)										
42		SHOP FAB VSL/TKS										
	021-TK-01	TREATED WATER STORAGE TANK	NEW	TANK		5000 M3	REV 2	SEE RMK	ATM			CS TANK OR CONCRETE RESERVOIR
44		PUMPS & DRIVERS										
	021-P-03	TREATED WATER PUMP	NEW	PUMP		HD=10 KG/CM2 ; 330 M3/H		CS	14	AMB		
	021-P-03M	TREATED WATER PUMP MOTOR	NEW	MOTOR	125 KW							
47		MATL PROCESSING										
	021-F-02A	WATER FILTERS	NEW	FILTER		25 M3/H	REV 3					
	021-F-02B	WATER FILTERS	NEW	FILTER		25 M3/H	REV 3					
	021-ME-02	CHLORINATOR	NEW	MISC.			REV 3					SIZE TO TREAT 25 M3/H WATER
50		PIPING										
	021-	TREATED WATER PIPELINE TO HOUSING	NEW	PIPE	8" (NOM.) X 2 KM		REV 3	CS	13	AMB		

ALTERNATE Water Treatment System (Off Plot) (Unit 021)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS: TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 021	WTR TREATMT (OFFPLOT)										
46		PUMPS & DRIVERS										
	021-P-01	CLARIFIER FEED PUMP	NEW	PUMP		HD=2 KG/CM2 ; 170 M3/H	REV 3	CS	5	AMB		
	021-P-01M	CLARIFIER FEED PUMP MOTOR	NEW	MOTOR	18.5 KW		REV 3					
	021-P-02	FILTER FEED PUMP	NEW	PUMP		HD=3 KG/CM2 ; 170 M3/H	REV 3	CS	5	AMB		
	021-P-02M	FILTER FEED PUMP MOTOR	NEW	MOTOR	30 KW		REV 3					
	021-P-03	TREATED WATER PUMP	NEW	PUMP		HD=10 KG/CM2 ; 330 M3/H	REV 3	CS	14	AMB		
	021-P-03M	TREATED WATER PUMP MOTOR	NEW	MOTOR	125 KW		REV 3					
47		MATL PROCESSING										
	021-F-01	CLARIFIED WATER FILTER	NEW	FILTER	5.5 M DIA X 5 M HIGH	160 M3/H	REV 3	CS	ATM	AMB		IDENTICAL TO EXISTING SYSTEM
	021-F-02A	WATER FILTERS	NEW	FILTER		25 M3/H	REV 3					
	021-F-02B	WATER FILTERS	NEW	FILTER		25 M3/H	REV 3					
	021-ME-01	TUBEWELLS TO HOUSING AREA	NEW	MISC.			REV 3					ADD ALLOWANCE FOR COST ESTIMATE - TWO WELLS ADDED TO HOUSING AREA
	021-ME-01	CLARIFIER	NEW	MISC.	14 M DIA X 5.3 M HIGH		REV 3		ATM	AMB		IDENTICAL TO EXISTING SYSTEM
	021-ME-01AG	CLARIFIER AGITATOR	NEW	AGIT.			REV 3		ATM	AMB		IDENTICAL TO EXISTING SYSTEM
	021-ME-01M	CLARIFIER AGITATOR MOTOR	NEW	MOTOR	3.7 KW		REV 3					
50		PIPING										
	021-	TREATED WATER PIPELINE TO HOUSING	NEW	PIPE	8" (NOM.) X 2 KM		REV 3	CS	13	AMB		

Raw/Plant/Potable Water Systems (On Plot) (Unit 022)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS: TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 022	RAW/POTBL/PLANT WTR										
46		PUMPS & DRIVERS										
	022-P-01A	RAW WATER PUMP	NEW	PUMP		HD=7 KG/CM2 ; 140 M3/H		CS	10	AMB		IMPELLER : 304 SS
	022-P-01AM	RAW WATER PUMP MOTOR	NEW	MOTOR	45 KW							
	022-P-01B	RAW WATER PUMP	NEW	PUMP		HD=7 KG/CM2 ; 140 M3/H		CS	10	AMB		IMPELLER : 304 SS
	022-P-01BM	RAW WATER PUMP TURBINE	NEW	TURBINE	60 HP		REV 2					STEAM : IN 10.2/OUT 1.2 KG/CM2G
	022-P-02	POTABLE WATER PUMP	NEW	PUMP		HD=7 KG/CM2 ; 10 M3/H		CS/CI	10	AMB		
	022-P-02M	POTABLE WATER PUMP MOTOR	NEW	MOTOR	4 KW							
	022-P-03	POLYELECTROLITE INJECTION PUMP	NEW	PUMP		HD=5 KG/CM2; 33.5 L/H		SS	10	AMB		
	022-P-03M	POLYELECTROLITE INJECTION PUMP MOTOR	NEW	MOTOR	0.5 KW							
47		MATL PROCESSING										
	022-F-01	RAW WATER FILTER	NEW	FILTER	3830 MM OD X 1900 MM	150 M3/H		CS	10	AMB		IDENTICAL TO EXISTING 925-F-1
50		PIPING										
	022-	TREATED WATER TBL PIPELINE	NEW	PIPE	10" (NOM) X 2 KM		REV 3	CS	13	AMB		

Demineralized Water,BFW,Condensate,Steam Generation Systems (Unit 023)

Equipment List

All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS: TYPE	EQUIPMENT SPECIFICATIONS: SIZE	EQUIPMENT SPECIFICATIONS: CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 023	BFW,COND,STM SYSTEM										
42		SHOP FAB VSL/TKS										
	023-V-01	VACUUM CONDENSATE SURGE DRUM	NEW	VESSEL	1.5 M OD X 4.7 M T/T			CS	3.5/FV	150		
	023-V-02	CONTINUOUS BLOWDOWN DRUM	NEW	VESSEL	1.0 M OD X 1.9 M			CS	5.6	162	IH	
	023-V-03	INTERMITTANT BLOWDOWN DRUM	NEW	VESSEL	1.0 M OD X 1.9 M			CS	ATM	100	IH	
	023-V-04	CONDENSATE FLASH DRUM	NEW	VESSEL	1.5 M OD X 4.7 M T/T		REV 3	CS	5.6	162	IH	
44		EXCHANGERS										
	023-E-01	STG STEAM AIR CONDENSER	NEW	AIR	72320 M2 (EXTENDED)		REV 2	CS	0.35/FV	150		ROOF TYPE ; SEE 940-E-1 ; PLOT : 560 M2
	023-E-01M	STG STEAM CONDENSER FAN MOTORS (10)	NEW	MOTOR	75 KW (EACH)							
	023-E-02	EXCESS STEAM CONDENSER	NEW	AIR	14130 M2 (EXTENDED)		REV 3	CS	3.5	150		PLOT : 110 M2
	023-E-02M	EXCESS STEAM CONDENSER MOTORS (8)	NEW	MOTOR	11 KW (EACH)		REV 3					
45		FIRED HTRS/BLRS										
	023-B-01	BOILER	NEW	BOILER		68 TONS/H			49.5	425	IH	IDENTICAL TO 940-B-1
	023-B-01M	BOILER FAN MOTOR	NEW	MOTOR	150 KW		REV 2					
	023-B-02	BOILER	NEW	BOILER		68 TONS/H			49.5	425	IH	IDENTICAL TO 940-B-1
	023-B-02M	BOILER FAN MOTOR	NEW	MOTOR	150 KW		REV 2					
46		PUMPS & DRIVERS										
	023-P-01	TREATED WATER MAKE-UP PUMP	NEW	PUMP		HD=6.8 KG/CM2; 272.5 M3/H		316SS	10	70		IDENTICAL TO 940-P-1
	023-P-01M	TREATED WATER MAKE-UP PUMP MOTOR	NEW	MOTOR	75 KW							
	023-P-02A	H.P.BFW PUMP	NEW	PUMP		HD=58 KG/CM2; 171 M3/H	REV 3	SEE RMK	82	150	IH	MULTISTAGE PUMP SEE 940-P2 ; MATRL : A296-CA15
	023-P-02AT	H.P.BFW PUMP TURBINE	NEW	TURBINE	500 HP		REV 3					STEAM- IN:42/OUT:1.2 KG/CM2 G
	023-P-02B	H.P.BFW PUMP	NEW	PUMP		HD=58 KG/CM2; 171 M3/H	REV 3	SEE RMK	82	150	IH	MULTISTAGE PUMP SEE 940-P2 ; MATRL : A296-CA15
	023-P-02BM	H.P.BFW PUMP MOTOR	NEW	MOTOR	375 KW							
	023-P-03A	H.P.BFW PUMP	NEW	PUMP		HD=20 KG/CM2; 20 M3/H		CS	40	150	IH	SEE 940-P3
	023-P-03AT	H.P.BFW PUMP TURBINE	NEW	TURBINE	30 HP							STEAM- IN:10.2/OUT:1.2 KG/CM2 G
	023-P-03B	H.P.BFW PUMP	NEW	PUMP		HD=20 KG/CM2; 20 M3/H		CS	40	150	IH	SEE 940-P3
	023-P-03BM	H.P.BFW PUMP MOTOR	NEW	MOTOR	22 KW							

Demineralized Water,BFW,Condensate,Steam Generation Systems (Unit 023)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	023-P-04A	STEAM CONDENSER CONDENSATE PUMP	NEW	PUMP		HD=8.6 KG/CM2; 100 M3/H		CS	40	150		SEE 940-P5 ; IMPELLER: 13 CR
	023-P-04AT	STEAM COND. CONDENSATE PUMP TURBINE	NEW	TURBINE	60 HP							STEAM- IN:10.2/OUT:1.2 KG/CM2 G
	023-P-04B	STEAM CONDENSER CONDENSATE PUMP	NEW	PUMP		HD=8.6 KG/CM2; 100 M3/H		CS	40	150.		SEE 940-P5 ; IMPELLER: 13 CR
	023-P-04BM	STEAM COND. CONDENSATE PUMP MOTOR	NEW	MOTOR	45 KW							
	023-P-05A	CONDENSATE PUMP	NEW	PUMP		HD=5.6 KG/CM2; 60 M3/H	REV 2	CS	10	150		STEAM IN : 10.2/OUT : 1.2 KG/CM2
	023-P-05AT	CONDENSATE PUMP TURBINE	NEW	TURBINE	20 HP		REV 2					
	023-P-05B	CONDENSATE PUMP	NEW	PUMP		HD=5.6 KG/CM2; 60 M3/H	REV 2	CS	10	150		STEAM IN : 10.2/OUT : 1.2 KG/CM2
	023-P-05BM	CONDENSATE PUMP MOTOR	NEW	MOTOR	15 KW		REV 2					
	023-P-06A	PHOSPHATE INJECTION PUMP	NEW	PUMP		HD=42.2 KG/CM2; 18.9 L/H	REV 3	SS	55	AMB		METERING : SEE 940-P53
	023-P-06AM	PHOSPHATE INJECTION PUMP MOTOR	NEW	MOTOR	0.4 KW							
	023-P-06B	PHOSPHATE INJECTION PUMP	NEW	PUMP		HD=42.2 KG/CM2; 18.9 L/H	REV 3	SS	55	AMB		METERING : SEE 940-P53
	023-P-06BM	PHOSPHATE INJECTION PUMP MOTOR	NEW	MOTOR	0.4 KW							
	023-P-07A	AMINE INJECTION PUMP	NEW	PUMP		HD=42.2 KG/CM2; 18.9 L/H	REV 3	SS	55	AMB		METERING : SEE 940-P54
	023-P-07AM	AMINE INJECTION PUMP MOTOR	NEW	MOTOR	0.4 KW							
	023-P-07B	AMINE INJECTION PUMP	NEW	PUMP		HD=42.2 KG/CM2; 18.9 L/H	REV 3	SS	55	AMB		METERING : SEE 940-P54
	023-P-07BM	AMINE INJECTION PUMP MOTOR	NEW	MOTOR	0.4 KW							
	023-P-08	HYDRAZINE INJECTION PUMP	NEW	PUMP		HD=3.5 KG/CM2 ; 1.5 L/H	REV 3	SS	5	AMB		METERING : SEE 940-P52
	023-P-08M	HYDRAZINE INJECTINO PUMP MOTOR	NEW	MOTOR	0.2 KW							
	023-P-09	LP BFW AMINE INJECTION PUMP	NEW	PUMP		HD=19.3 KG/CM2; 37.8 L/H	REV 3	SS	25	AMB		METERING : SEE 940-P51
	023-P-09M	LP BFW AMINE INJECTION PUMP MOTOR	NEW	MOTOR	0.4 KW							
47		MATL PROCESSING										
	023-DA-01	DEAERATOR	NEW	MISC	STORAGE 2.5 M OD X 7.7 M	OUTLET CAP: 150 M3/H		CS	5.6	210	Ih	
	023-EJ-01	STG CONDENSER EJECTOR SYSTEM	NEW	MISC								

Power Generation System (Unit 024)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 024	POWER GENERATION										
43		COMPRESSORS/DRVRS										
	024-G-01	POWER GENERATOR	NEW	GENERATOR		14 MW						IDENTICAL TO 905-G-1
	024-G-01T	POWER GENERATOR STEAM TURBINE	NEW	TURBINE								IDENTICAL TO 905-GT-1

Instrument and Plant Air Systems (Unit 025)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 025	INSTRUMENT/PLANT AIR										
42		SHOP FAB VSL/TKS										
	025-V-01	AIR RECEIVER	NEW	VESSEL	3800 MM OD X 10384 MM		REV 3	CS	9.84	185		IDENTICAL TO 910-V-11
43		COMPRESSORS/DRVRS										
	025-C-01	AIR COMPRESSOR	NEW	COMPRESSO		3300 NM3/H		CS				IDENTICAL TO 910-C-1A
	025-C-01E1	FIRST STAGE INTERCOOLER	NEW	SHELL				CS				
	025-C-01E1	FIRST STAGE INTERCOOLER	NEW	TUBE				CS				
	025-C-01E2	SECOND STAGE INTERCOOLER	NEW	SHELL				CS				
	025-C-01E2	SECOND STAGE INTERCOOLER	NEW	TUBE				CS				
	025-C-01E3	AFTERCOOLER	NEW	SHELL				CS				
	025-C-01E3	AFTERCOOLER	NEW	TUBE				CS				
	025-C-01F	INTAKE FILTER	NEW	FILTER				CS				
	025-C-01M	AIR COMPRESSOR MOTOR	NEW	MOTOR	375 KW			CS				
	025-C-01V1	MOISTURE SEPARATOR	NEW	VESSEL				CS				
47		MATL PROCESSING										
	025-DR-01	AIR DRYER PACKAGE	NEW	MISC		DRY AIR : 2000 NM3/H		CS	10			
	025-DR-01F1	PREFILTER	NEW	FILTER				CS				
	025-DR-01F2	AFTER FILTER	NEW	FILTER				CS				
	025-DR-01V1	AIR DRYER TOWER	NEW	VESSEL				CS				
	025-DR-01V2	AIR DRYER TOWER	NEW	VESSEL				CS				

Sea Water Cooling System (Unit 026)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 026	SEA COOLING WATER										
46		PUMPS & DRIVERS										
	026-P-01	SEA WATER INTAKE PUMP	NEW	PUMP		HD=2.2 KG/CM2 ; 3250 M3/H	REV 3	SEE RMK	4.0	40		IDENTICAL TO 925-P-6 ; MATRL : CASE:NI RESIST., IMPELLER:316 SS
	026-P-01M	SEA WATER INTAKE PUMP MOTOR	NEW	MOTOR	280 KW							
	026-P-02	SEA WATER SUPPLY PUMP	NEW	PUMP		HD=7.3 KG/CM2 ; 3250 M3/H	REV 3	SEE RMK	10.5	40		IDENTICAL TO 925-P-7 ; MATRL : CASE:NI RESIST., IMPELLER:316 SS
	026-P-02M	SEA WATER SUPPLY PUMP MOTOR	NEW	MOTOR	850 KW							
47		MATL PROCESSING										
	026-ME-01	SEA WATER STRAINER	NEW	MISC		5920 M3/H		316SS	8.5	65		IDENTICAL TO 925-ME-8A
	026-PO-01	SEA COOLING WATER SUPPLY BASIN	NEW	POND		2700 M3						CONCRETE BASIN ; 40 M LONG X 11 M WIDE X 6.6 M DEEP
	026-PO-02	SEA COOLING WATER RETURN BASIN	NEW	POND		1135 M3						CONCRETE BASIN ; 76 M LONG X 6.1 M WIDE X 2.5 M DEEP
	925-ME-4	SEA WATER INTAKE STATION	REV	MISC			REV 2					REVAMP EXISTING INTAKE STATION

Fire Water System (Sea Water) (Unit 027)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REV	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 027	FIRE WATER (SEA WTR)										

Fuel Oil System (Unit 028)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS			TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
				TYPE	SIZE	CAPACITY						
	UNIT : 028	FUEL OIL(PIPING ONLY)										

Jacket Water System (Unit 029)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 029	JACKET WATER SYSTEM										
42		SHOP FAB VSL/TKS										
	029-TK-01	JACKET WATER SURGE TANK	NEW	TANK	4.6 M DIA X 5 M HEIGHT	83 M3	REV 2	CS	ATM	85		
44		EXCHANGERS										
	029-E-01	JACKET WATER COOLER	NEW	AIR	29330 M2 (EXTENDED)		REV 3	CS	10	85		PLOT : 18.0 M X 12.2 M
	029-E-01M	JACKET WATER COOLER MOTORS (10)	NEW	MOTOR	22.0 KW (EACH)		REV 3					
46		PUMPS & DRIVERS										
	029-P-01A	JACKET WATER SUPPLY PUMP	NEW	PUMP		HD=7 KG/CM2 ; 660 M3/H	REV 3	CS	10	85		
	029-P-01AM	JACKET WATER SUPPLY PUMP MOTOR	NEW	MOTOR	225 KW		REV 3					
	029-P-01B	JACKET WATER SUPPLY PUMP	NEW	PUMP		HD=7 KG/CM2 ; 660 M3/H	REV 3	CS	10	85		
	029-P-01BM	JACKET WATER SUPPLY PUMP MOTOR	NEW	MOTOR	225 KW		REV 3					
47		MATL PROCESSING										
	029-ME-01	CORROSION INHIBITOR INJECTION	NEW	MISC			REV 2					INCLUDES 0.3 M3 PLASTIC TANK & TWO 50 L/H INJECTION PUMPS

Flare System (Unit 040)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 040	FLARE SYSTEM										
42		SHOP FAB VSL/TKS										
	040-V-01	FLARE KNOCKOUT DRUM	NEW	VESSEL	2.8 M ID X 8 M T/T		REV 2	CS	3.5	315		
46		PUMPS & DRIVERS										
	040-P-01A	FLARE KO DRUM PUMP	NEW	PUMP		HD=5 KG/CM2 ; 10 M3/H	REV 2	CS	7.0	315		
	040-P-01AM	FLARE KO DRUM PUMP MOTOR	NEW	MOTOR	3 KW		REV 3					
	040-P-01B	FLARE KO DRUM PUMP	NEW	PUMP		HD=5 KG/CM2 ; 10 M3/H	REV 2	CS	7.0	315		
	040-P-01BM	FLARE KO DRUM PUMP MOTOR	NEW	MOTOR	3 KW		REV 2					
47		MATL PROCESSING										
	040-ME-01	FLARE TIP INCL. SEAL & STACK	NEW	MISC	24"DIA X 46 M HIGH STACK	110000 KG/H	REV 3	CS	3.5	315		TIP IS SS

Nitrogen Storage System/Vaporizer (Unit 041)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 041	NITROGEN STORAGE/VAPORIZER										
42		SHOP FAB VSL/TKS										
	041-V-01	NITROGEN STORAGE TANK	NEW	VESSEL	3.5 M ID X 10.5 M T/T	100 M3	REV 2	SS	10.2	-196	Ic	DOUBLE WALL TANK ; OUTER SHELL CS, INSULATION PERLITE
44		EXCHANGERS										
	041-E-01	NITROGEN VAPORIZER	NEW	BATH	3.47 MM KCAL/H		REV 3	CS	ATM			
	041-E-01	NITROGEN VAPORIZER	NEW	TUBE		32600 NM3/H N2 GAS	REV 3	SS	10.2	-196		

Oily Water Treatment System (Unit 042)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS TYPE	SIZE	CAPACITY	TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
	UNIT : 042	OILY WATER TREATMENT										
46		PUMPS & DRIVERS										
	042-P-01A	OILY WATER PUMP (PROCESS)	NEW	PUMP		HD=3.5 KG/CM2 ; 75 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-01AM	OILY WATER PUMP MOTOR	NEW	MOTOR	11 KW							
	042-P-01B	OILY WATER PUMP (PROCESS)	NEW	PUMP		HD=3.5 KG/CM2 ; 75 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-01BM	OILY WATER PUMP MOTOR	NEW	MOTOR	11KW							
	042-P-02A	OILY WATER PUMP (INT. TANKAGE)	NEW	PUMP		HD=3.5 KG/CM2 ; 10 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-02AM	OILY WATER PUMP MOTOR	NEW	MOTOR	2.2 KW							
	042-P-02B	OILY WATER PUMP (INT. TANKAGE)	NEW	PUMP		HD=3.5 KG/CM2 ; 10 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-02BM	OILY WATER PUMP MOTOR	NEW	MOTOR	2.2 KW							
	042-P-03A	OILY WATER PUMP (PROD. TANKAGE)	NEW	PUMP		HD=3.5 KG/CM2 ; 10 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-03AM	OILY WATER PUMP MOTOR	NEW	MOTOR	2.2 KW							
	042-P-03B	OILY WATER PUMP (PROD. TANKAGE)	NEW	PUMP		HD=3.5 KG/CM2 ; 10 M3/H	REV 2	CS	5	100		VERTICAL SUMP PUMP
	042-P-03BM	OILY WATER PUMP MOTOR	NEW	MOTOR	2.2 KW							
	042-P-04A	OIL PUMP	NEW	PUMP		HD=4 KG/CM2 ; 5 M3/H	REV 2	CS	7	150		
	042-P-04AM	OIL PUMP MOTOR	NEW	MOTOR	1.5 KW							
	042-P-04B	OIL PUMP	NEW	PUMP		HD=4 KG/CM2 ; 5 M3/H	REV 2	CS	7	150		
	042-P-04BM	OIL PUMP MOTOR	NEW	MOTOR	1.5 KW							
	042-P-05	AIR DIAPHRAM PUMP	NEW	PUMP		5 M3/H	REV 2	CS	10	AMB		
	042-P-05M	AIR DIAPHRAM PUMP MOTOR	NEW	MOTOR								
47		MATL PROCESSING										
	042-ME-01	OILY WATER SUMP FLAME ARRESTOR	NEW	MISC	3"			CS	ATM	AMB		
	042-ME-02	OILY WATER SUMP FLAME ARRESTOR	NEW	MISC	3"			CS	ATM	AMB		
	042-ME-03	OILY WATER SUMP FLAME ARRESTOR	NEW	MISC	3"			CS	ATM	AMB		
	042-ME-04	OILY WATER SEPARATOR	NEW	MISC	(SEE REMARKS)			CS	ATM			3.0 M LONG X 5.7 M WIDE X 2.5 M DEEP
	042-SU-01	OILY WATER SUMP (PROCESS)	NEW	MISC	(SEE REMARKS)				ATM	100		CONCRETE WITH COVER ; 5 M LONG X 4 M WIDE X 3 M DEEP
	042-SU-02	OILY WATER SUMP (INT. TANKAGE)	NEW	MISC	(SEE REMARKS)				ATM	100		CONCRETE WITH COVER ; 2.5 M LONG X 2 M WIDE X 2 M DEEP
	042-SU-03	OILY WATER SUMP (PROD. TANKAGE)	NEW	MISC	(SEE REMARKS)				ATM	100		CONCRETE WITH COVER ; 2.5 M LONG X 2 M WIDE X 2 M DEEP

Sanitary System (Unit 043)
Equipment List
All Cases

A/C	TAG NO.	EQUIPMENT DESCRIPTION	NEW / REU	EQUIPMENT SPECIFICATIONS			TOTAL WEIGHT (K Kg)	MATERL OF CONSTRN	DESIGN PRESS Kg/cm2	DESIGN TEMP DEG C	INSUL REQMT	REMARKS
				TYPE	SIZE	CAPACITY						
	UNIT : 043	SANITARY SYSTEM										

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