The Biocatalytic Desulfurization Project

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ABSTRACT

The material in this report summarizes the Diversa technical effort in development of a biocatalyst for the biodesulfurization of Petro Star diesel as well as an economic report of standalone and combined desulfurization options, prepared by Pelorus and Anvil, to support and inform the development of a commercially viable process. We will discuss goals of the projected as originally stated and their modification as guided by parallel efforts to evaluate commercialization economics and process parameters. We describe efforts to identify novel genes and hosts for the generation of an optimal biocatalyst, analysis of diesel fuels (untreated, chemically oxidized and hydrotreated) for organosulfur compound composition and directed evolution of enzymes central to the biodesulfurization pathway to optimize properties important for their use in a biocatalyst. Finally we will summarize the challenges and issues that are central to successful development of a viable biodesulfurization process.

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1.0 EXECUTIVE SUMMARY

In this report we present a summary and overview of the studies carried out to evaluate and develop a biocatalyst for the removal of organosulfur compounds from diesel fuel.

We will describe our original proposed goals to develop a biocatalyst for standalone use or in combination with Conversion-Extraction Desulfurization technology and the reasons for revision to, instead examine the possibilities of using a biocatalyst in combination with established hydrodesulfurization technologies.

Analytical studies to determine the organosulfur composition of chemically oxidized, as well as partially hydrotreated, diesel fuel are presented. This work defines the extreme heterogeneity of organosulfur compounds found in diesel fuel and highlights the challenges of achieving EPA ULSD targets with a biocatalyst.

Efforts to characterize known biodesulfurization enzymes and discover new enzymes to address the challenge of the highly heterogeneous substrates that must be acted upon are described. These include both sequence-based and functional discovery efforts and the development of new screening strains for this purpose.

Directed evolution of the DszA and DszC proteins of IGTS8 to meet the challenges of a combined BDS/HDS process are described. This effort resulted in the identification of novel DszA variants with improved activity on relevant substrates as well as a more thorough understanding of the structure-function of both of these important enzymes.

The importance of the biocatalyst host is demonstrated by a number of different studies presented here and we describe our efforts to identify new potential hosts for the expression of the biodesulfurization phenotype. Strains with improved growth characteristics and biocatalytic properties have been identified and might serve as the basis for further development of a host for whole cell oxidations of organosulfur compounds as well as other economically important biotransformations.

Because of the need for a robust recombinant biodesulfurization biocatalyst that is able to maintain its desirable properties without the need for the addition of antibiotics to maintain stability, we describe our efforts to generate an antibiotic-free selection system and demonstration of its viability for the introduction,expression and maintenance of improved dsz genes.

Finally, we present a comprehensive economic study of the cost of biodesulfurization as a standalone process as well as in combination with hydrotreatment and compare the costs to the current hydrotreatment process. This work serves as a basis for any additional studies in this area and describes the performance and economic challenges to successful commercial implementation of this novel technology.

2.0 INTRODUCTION

Overview

This proposal responds to the U.S. Department of Energy's solicitation announcement "Development of Technologies and Capabilities of Fossil Energy-wide Coal, Natural Gas, and Oil R&D Programs", Area of Interest #15: Oil Technology – Emerging Process Technology. Petro Star Inc. is proposing a project to improve existing biodesulfurization (BDS) technology for commercially desulfurizing diesel fuel.

2.1 Regulations

Sulfur in diesel fuel is not only a source of air pollution, but also plays a significant role in determining the tailpipe emissions of other pollutants, such as nitrogen oxides, carbon monoxide, and particulate matter because if its inhibitory effect on current catalytic systems. The Environmental Protection Agency and associated government agencies have mandated the reduction of sulfur in on-road diesel fuels to 15ppm by June, 2006 and 10ppm by 2010. As most of the current and known reserves of petroleum in the world have increasingly higher levels of organosulfur compounds (sour vs. sweet), this will require greater cost and infrastructure to meet these new ultra-low sulfur in diesel (ULSD) requirements using exist hydro-desulfurization technology.

2.2 Alternative Desulfurization technologies

Hydrotreatment

Hydrodesulfurization (HDS) is the current refinery standard for removing sulfur from diesel fuel. HDS is an expensive and energy-intensive process, requiring high temperature and pressure. It also requires expensive collateral processes to generate hydrogen for the HDS process and to convert the hydrogen sulfide by-product from a poisonous, odorous gas into elemental sulfur. For small refiners HDS is not cost-effective because of the high capital and energy costs.

Adsorption

Another method reported for removal of sulfur compounds from fuel is the use of a catalyst/adsorbent primarily as developed by Phillips Petroleum (S-Zorb). A proprietary adsorbent material is used to bind the reduced sulfur compounds resulting from a mild hydrotreatment process. Originally promoted for the removal of sulfur from gasoline, it has also been proposed for use with diesel, although capital costs appear to be prohibitive and plans for a demonstration unit appear to be on hold.

Chemical Oxidation/Extraction

In contrast to the previous methods, chemical oxidation of sulfur-containing diesel fuels through the action of peroxides results in the production of sulfones that can be selectively removed by extraction due to their reduced hydrophobicity. Of particular interest is the ability of the process to act on the highly alkylated dibenzothiophenes that are particularly difficult for removal by current hydrotreatment catalysts. This method however suffers from a major disadvantage of yield losses due to the removal of carbon-containing sulfur compounds as well as some proportion of the fuel because of incomplete selectivity in the extraction process. As of yet, pilot scale performance of the process has yet to be convincingly demonstrated.

2.3 Biodesulfurization

Similarly to chemical oxidation, the biological removal of sulfur from organic sulfur compounds in diesel fuel involves its oxidation to more hydrophilic, water soluble species that can be separated from the oil phase.

2.3.1 Microbiology

The ability to oxidize organic sulfur compounds from fossil fuels such as coal and petroleum in order to utilize the sulfur as a nutrient is widespread amongst fungi and bacterial species. Many bacterial have been reported to oxidize organic sulfur compounds including *Sphingomonas*, *Tsukamarella*, *Bacillus*, *Mycobacterium*, *Nocardia*, and *Rhodococcus* sp..

The first organism with this ability was identified and characterized by the Institute of Gas Technology and was called *Rhodococcus* sp. IGTS8 (1). Rhodococci are members of the Actinomycetes and are characterized by their high G+C content and their relatively hydrophobic cell was, consisting of wax-like mycolate esters. Other members of the Actinomycetes include *Mycobacterium* and *Streptomyces*. This hydrophobic nature of the cells enables their association with hydrophobic oil and organic compounds and utilization of these compounds as growth substrates.

2.3.2 Enzymology

Two main enzymatic pathways have been described for the oxidation of organic sulfur compounds in fossil fuels.

1) The so-called destructive pathway results in ring-opening reactions of the aromatic sulfur-containing compounds and the subsequent utilization of both the carbon skeleton and sulfur. Since this pathway would result in the degradation of the hydrocarbon components of fuel it is not a major focus of research in the industrial use of biodesulfurization.

2) The non-destructive, or 4S oxidation pathway **(Figure 1**), in contrast, results in the specific removal of the sulfur without degradation of the hydrocarbon skeleton and is therefore the preferred pathway for commercial biodesulfurization technology.

Three enzymes are directly involved in the four oxidation steps (hence 4S pathway) and conversion of insoluble sulfur compounds in diesel fuel, mainly dibenzothiophenes and benzothiophenes, to water-soluble species.

The first enzyme in the 4S pathway in DszC, dibenzothiophene monooxygenase, which carries out two sequential oxidation steps, converting the model compound dibenzothiophene to the transient intermediate DBT sulfoxide and finally to DBT sulfone. The oxidation requires two mole equivalents of the reduced flavin $FMNH_2$, regenerated by the flavin reductase DszD from the cellular reductant NADH.

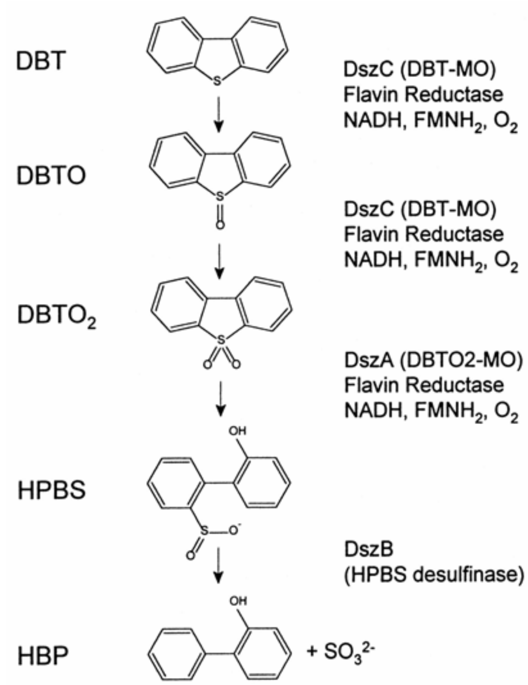


Figure 1. *Dsz enzymes and the 4S pathway of DBT oxidation.*

The second enzyme in the pathway, DszA (DBT sulfone monooxygenase), carries out the oxidation of DBT sulfone to hydroxy-biphenyl sulfinate (HBPS), the first water soluble organosulfur compound generated. DszA also requires reduced $FMNH_2$ to affect the oxidation step.

The final enzyme in the complete 4S pathway is DszB, HBPS sulfinolyase, which converts HBPS to sulfite and hydroxybiphenyl. The sulfite is then assimilated by the microorganism, releasing the hydroxybiphenyl hydrocarbon skeleton to repartition into the oil phase. Although required for organisms to use the sulfite as a source of sulfur, DszB is dispensable to a commercial BDS process as the HBPS is sufficiently water soluble to affect its removal from the oil matrix. It does however lead to a loss of the hydroxybiphenyl skeleton and its contribution to the total hydrocarbon pool available**.**

As mentioned above, another enzyme, DszD (or equivalent) flavin reductase is required for recycling reduced $FMNH_2$ as cofactor for DszC and DszD but is not directly involved in oxidation of the organosulfur compounds.

Among those organisms characterized at the molecular level for biodesulfurization ability, the amino acid sequences of their Dsz proteins are reasonably well conserved. A number of diverse genera possess Dsz proteins whose sequences are very similar to those of the prototype organism *Rhodococcus sp.* IGTS8, suggesting a potential common origin. In addition, the majority of *dsz* genes (with the exception of the flavin reductase component) have been found on large extrachromosomal plasmids, in a similar gene order, further suggesting the possibility of their horizontal transmission.

The range of thiophenic substrates that are oxidized by various bacteria is often diverse and is, at least in some measure, determined by the diversity of Dsz sequences. Recent evidence, however, has suggested that the host (and additional genes) contributes significantly to the overall substrate range as well as other phenotypic differences including temperature optima and stability. For example, it has recently been shown that the introduction of a defined *dszABCD* operon (within an artificially constructed transposon) into a number of *Rhodococcus* and *Mycobacterium* strains results in a variety of substrate ranges (2). In another example of the contribution of the host to phenotype, it has been shown that the *dsz* genes of *Mycobacterium phlei*, while identical to those of *Rhodococcus erythropolis* IGTS8, display a moderate thermostability (active at 55^{o}C) not seen in IGTS8 (3). Clearly, the contribution of the host physiology and morphology are important to biological removal of sulfur as well as the desulfurization enzymes themselves

2.3.3 Issues and Challenges to Commercialization

Although organisms that can oxidize petroleum organosulfur compound naturally do so at an efficiency required to support their biological sulfur demand, their effectiveness at removing sulfur compounds at a commercially relevant rate falls far short (estimated to require >1mM DBT/gram of biocatalyst DCW/hour). A number of limitations and issues must be overcome in order to develop a viable biocatalyst and are described briefly here.

Mass transfer

Because of the relatively insoluble nature of the organosulfur compounds in petroleum and the high molecular weights of their alkylated structures, access of the desulfurization enzymes to their substrates is limited. This requires both the intimate interaction of the organism to oil droplets containing the substrates as well as intracellular solubilization of the substrates into aqueous solvent in order to be acted upon by the DszC enzyme, the first step in the conversion of the very hydrophobic BT and DBT substrates to more water-soluble oxidized molecules (**Figure 2).**

This is a significant issue for the development of a commercial biodesulfurization process and must be dealt with through a combination of process engineering, to generate efficient oil/water emulsions, and appropriate choice of biocatalyst organism. A number of different organisms have been considered as biocatalysts but vary greatly in their ability to interact with relevant substrates dissolved in an oil matrix. For instance, although *Pseudomonas* sp. have been investigated as biodesulfurization hosts (by introduction of non-native *dsz* genes) and shown very high levels of activity on substrates presented in aqueous phases, they fall short in their ability to oxidize the same substrates directly from the oil matrix. This is likely due to the relatively hydrophilic nature of these organisms and their tendency to partition to the water phase in separated oil/water emulsions. In contrast, *Rhodococcus* and *Mycobacterium* sp., which have a relatively hydrophobic, waxy cell wall associate more readily with the oil phase and have better activity on substrates dissolved in the oil.

Substrate range and extent

Although dibenzothiophene and benzothiophene are typically used as model compounds in the development of biodesulfurization strains, the true composition of organosulfur compounds in petroleum feedstocks is much more diverse. In addition to the highly alkylated derivatives of these compounds there are also a broad range of minor alkyl and aryl sulfide species that must be removed in order to meet EPA specification for ultra-low sulfur products. This requires not only a broad substrate range for each of the three Dsz enzymes as individuals but their coordinated ability to completely oxidize organosulfur compounds to avoid bottlenecks and accumulation of intermediate compounds. Although the contribution of any given organosulfur species to the total sulfur content may be small, the ability of the biocatalyst to completely remove all species is essential to commercial viability.

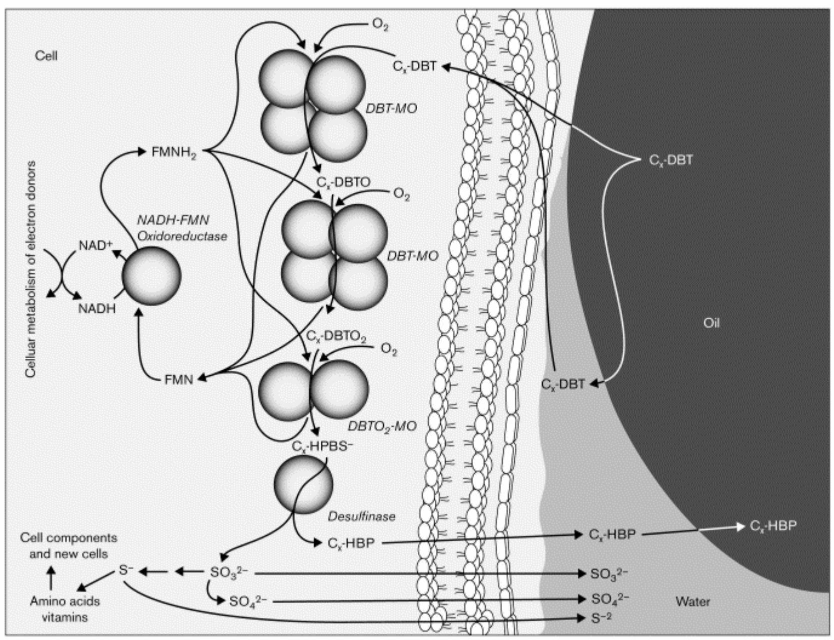


Figure 2. *Physiology of DBT oxidation from an oil matrix. This figure was taken from the following reference:* Monticello, D,J. (2000). Biodesulfurization and the upgrading of petroleum distillates. *Curr. Opin. Biotechnol.*, **11**:540-546

Enzyme rates and affinities

In order to meet the requirements for a viable commercial process, with limited residence times for the biocatalyst and petroleum feedstock to act, it is essential to oxidize the substrates as quickly as possible for their removal from the oil phase. Additionally, as mentioned above, it is important for the activities of the three enzymes to be as closely coordinated as possible, both in terms of substrate affinity and relative abundance, in order to avoid bottlenecks in the conversion of substrates to a water-soluble form that can be separated and removed. Finally, because of the highly diverse organosulfur compounds and their relatively small individual contribution to the total sulfur content, the affinity of the enzymes must be extremely high in order to act on the substrates without extended periods of time being required for their complete conversion.

Reductant supply

The biological oxidation of organosulfur compounds by DszC and DszA requires reducing equivalents in the form of the reduced flavin $FMNH_2$, via the action of the flavin reductase DszD, at the expense of NADH. It is this requirement that precludes the development of an *in vitro* process due to the extremely high expense of redox recycling and impracticalities at the scale required for commercial biodesulfurization.

Even an *in vivo* system requires input in the form of a co-oxidizable substrate to provide reducing equivalents. A number of different substrates have been proposed but their utility is a function of their economic and metabolic costs. For instance, glucose is a common substrate for commercial fermentations but its cost is prohibitive in a commercial biodesulfurization process. Cheaper substrates like acetate, ethanol or methanol have been proposed but their energetic value to the biocatalyst is somewhat limited and significantly more must be used to provide sufficient reducing equivalents to the process. Alkanes such as octane or hexadecane have also been suggested as they have a relatively high energy value and could be provided as a side stream in a petroleum refining operation but an organism's ability to metabolize these compounds would have implications for the fate of the bulk alkane phase of the petroleum feedstock to be desulfurized.

The intracellular machinery providing reductant to Dsz enzymes is also critical in order to maintain a proper redox balance in the cell as a whole. Properly coordinated expression and activity of the flavin reductase component with the Dsz enzymes will be essential in order to avoid either an undersupply or oversupply of reduced flavin. Reduced flavins, in particular, $FMNH_2$, can auto-oxidize and produce oxygen free radicals that can poison the cell by attacking sensitive enzymes and metabolic pathways, reducing the stability and longevity of a viable biocatalyst.

Extent

Directly related to the issues described above, the extent of biodesulfurization and removal of organosulfur compounds is critical to the commercial viability of the process. In order to fully remove these compounds will require a biocatalyst with sufficient rates and affinities for the diverse substrates present in the feedstock. As the majority of the sulfur compounds are removed, it will take increasingly longer periods of time for their full removal, particularly as the K_m for the individual species is approached. In addition, the organism must retain viability during the process and be able to efficiently carry out the oxidation of organosulfur compounds and metabolism of substrates to provide the necessary for extended periods of time and cycles before the need to regenerate the biocatalyst by fermentation.

Recycling, robustness and biocatalyst supply

In order to achieve the economics of a biocatalyst for desulfurization it will be necessary to not only prepare large enough quantities of cells for initial but also to recharge the biocatalyst between rounds of feedstock treatment. This is required to allow the cell to rebuild the cellular enzymes and structure to carry out additional rounds of biodesulfurization. For this to be an effective process will require that the biocatalyst be very robust, not only to constituents of the petroleum feedstock that might otherwise be inhibitory or toxic to growth but be relatively robust to contaminants that often plague bacterial fermentations at industrial scale.

Waste disposal and value-added products

As with any desulfurization process, there is a need for the economic disposal of the sulfur that results, in whatever form it may take. Since the goal of biodesulfurization is to convert sulfur compounds to a water-soluble form that can be separated from the bulk oil, the combined actions of DszC and DszA are enough to convert hydrophobic organosulfur compounds to the corresponding water-soluble organosulfinates. This class of compounds can be chemically converted to potential value-added surfactants for use in the detergent and structural materials industries although significant effort to create commercial interest by Energy Biosystems was unsuccessful. Another issue with terminating the process at this point is the loss of the hydrocarbon backbone which will affect the overall yield of the treated petroleum. The addition of DszB to the biocatalyst results in the conversion of the organosulfinates to sulfite and the corresponding hydrocarbon backbone. The hydrocarbon backbone can then repartition back to the bulk oil phase and reduce the overall yield loss. The sulfite that results however has no value-added properties and must somehow be economically disposed of.

Project Engineering

Critical to the success of a commercially viable biodesulfurization process is the design and implementation of the process engineering and supporting infrastructure. As the ultimate design parameters are highly dependent on biocatalyst performance and properties, mutually inclusive assumptions about each must be made during the course of development of the overall process**.** Although described in more detail in the Economic Report in **Appendix 4**, many processes must be developed and interconnected to create an operational unit. These include fermentation facilities, oil/water emulsion generation, separation methods, product and waste-stream management, cooling, heating and recirculation equipment and sterilization.

2.4 Original focus of research plan

The original objective of this proposal consisted of two distinct overlapping efforts:

The first was to develop a standalone biocatalyst that could effectively remove a large portion of sulfur from diesel fuel at commercially acceptable rates. The original performance requirements were to achieve reduction of sulfur levels from ~3500ppm in Petro Star diesel to <500pmm S, the original EPA standards set for low sulfur diesel. If successful, the team, consisting of Petro Star, Pelorus and Anvil were to develop design parameters and cost estimates for a biocatalytic desulfurization demonstration unit to produce about 5,000 barrels per day (bpd) of low-sulfur diesel.

The second effort, to be carried out in parallel to the first, was to develop a biocatalyst for use in a combined process with a Conversion Extraction Desulfurization (CED) technology being developed by Petro Star in collaboration with Degussa. The CED process was designed to produce an ultra-low diesel fuel by converting organosulfur compounds in the diesel to their sulfone derivatives using a chemical oxidation procedure. The more hydrophobic sulfones could then be selectively extracted to remove from the diesel bulk phase. An issue with the process was the loss of fuel to the sulfur-concentrated extract in both the form of the lost hydrocarbon backbone and entrained alkane bulk phase. It was proposed that a biocatalyst could work synergistically with the CED process, as it would require only the activity of the DszA and B enzymes since the chemical conversion process generated the sulfone derivatives normally created by DszC. In addition, as the CED-derived sulfones were more hydrophilic, mass transfer issues of the biocatalyst might be more efficiently addressed. If successful, this would increase the yield of marketable fuel and raise the economical viability of the CED process.

2.5 Revised focus of research plan

In the course of carrying out the original objectives of the proposal, work on the CED process by Petro Star and Degussa was coming to completion. A conclusion of this work was that the economics of the process at scale would prove cost-prohibitive either as a standalone process or in combination with BDS. Only incremental gains in cost-savings would be achieved in the combined process and would require the introduction of two untested novel technologies simultaneously.

In addition, new EPA requirements for ULSD were introduced during the course of our initial work that precluded the use of BDS as a standalone process. Although the original goal of achieving reductions of sulfur from 3500ppm to <500ppm were challenging in itself, the ability of a biocatalyst to reduce sulfur to <15ppm were felt to be unattainable within reasonable economic and performance parameter.

For this reason, we revised our goals to develop a biocatalyst that could be used in combination with conventional hydrotreatment to help reduce the high capital and recurrent costs that would be incurred by the industry with new ULSD requirements.

With this mind, we set out to develop a biocatalyst that could act on organosulfur substrates that are known to be problematic for HDS, namely 4-methyl and 4, 6–

dimethyl DBT. If these compounds could be reduced by a biocatalyst, either before or after hydrotreatment, lesser amounts of hydrogen, temperature and pressure could be used to finally produce an ULSD that would meet EPA requirements at reduced cost.

3.0 EXPERIMENTAL

3.1 Chemical analysis

Analyses of benzothiophenes and dibenzothiophene sulfone derivatives, either synthesized as standards or experimentally determined from chemically or biologically oxidized diesel were carried out using HPLC-MS-MS and GC-MS. HPLC-MS-MS for the determination BT and DBT sulfone substrates and products was carried out by injecting samples from 96-well plates using a CTCPAL autosampler (Leap Technologies, Carrboro, N.C.) into an LC mobile phase of various mixtures of H_2O/ACN (0.1% formic acid) provided by LC-10ADvp pumps (Shimadzu, Kyoto, Japan) at 1.0 mL/min through an Agilent Zorbax C8 column (4.6 x 150 mm) (Agilent Technologies, Palo Alto, CA) to an API 4000 TurboIon spray triple-quadrupole mass spectrometer (Applied Biosystems, Foster City, CA). Ion spray and Multiple Reaction Monitoring (MRM) were performed for analytes in the positive ion mode. Initial ionization produces parent ions, fragments of which are observed and quantified. Instrumentation control and data generation was accomplished using Analyst 1.2 software (Applied Biosystems, Foster City, CA). A detailed description of the gradient conditions and parent/fragment ion relationships for MS/MS are described in **Figure 3**.

Substrate:	**Parent ion/fragment ion**
$DBTO_2$:	217.269/152.104
HBPS:	217.265/168.097
0.0 50%A	H_2O/ACN gradient @1200 uL/min for 3 minutes
2.0 10%A	
2.1 50%A	
3.0 50%A	
4-MeDBBTO$_2$:	231.155/152.138
4,6-DiMeDBTO$_2$:	245.194/165.235
4-EtDBTO$_2$:	245.207/165.091
4,6-DiEtDBTO$_2$:	273.224/181.004
2,8-DiMeDBTO$_2$	245.057/165.255
H_2O/ACN	25/75 isocratic mixture @ 1200 uL/min for 3 minutes
2,4,6 TriMeDBTO$_2$:	259.032/165.082
BTO_2:	167.127/103.149
2-MeBTO$_2$:	181.145/91.035
3-MeBTO$_2$:	181.108/91.051
5-MeBTO$_2$:	181.119/91.133
7-MeBTO$_2$:	181.152/91.025
H_2O/ACN	20/80 isocratic mixture @ 1000 uL/min for 3 minutes
DBT:	184.085/152.107
DBTO:	201.116/183.971
4,6-DiMeDBT:	213.163/184.153
4-MeDBT:	198.137/165.170
ACN	100% @ 1000 uL/min for 3 minutes

Figure 3. *Gradient conditions and parent ion/fragment ion relationships for analysis of BT and DBT compounds.*

For high-throughput screening of DszA GSSM variants, activity was determined on $DBTO_2$ and 4, 6-dimethyl$DBTO_2$, analyzing resultant HBPS derivatives. For high-throughput screening of DszC GSSM variants, activity on DBT and 4, 6-dimethylDBT was determined, analyzing resultant sulfone derivatives.

For analyses of single- and two-phase biodesulfurization assays, hexadecane/diesel and/or water samples for the biocatalytic reactions were initially diluted 10-fold into ethanol, and then further diluted 10-fold in acetonitrile before separation and analysis by LC/MS/MS. Cells from the reactions were isolated from the oil and water phase by centrifugation, extracted with methanol and diluted into acetonitrile for analyses. In the above examples, all relevant compounds (dibenzothiophenes, -sulfoxides, -sulfones and -sulfinates), with the exception of hydroxybiphenyl derivatives, could be determined in a single run. Hydroxybiphenyls were determined by using the negative ion mode in a separate separation. For analysis of total sulfur, samples from the initial 10-fold dilution in ethanol were further diluted in ethanol before analysis on the Antek 9000 sulfur analyzer.

For GC separations, 1ul samples were injected onto a DB-1 column (30m x 0.25mm x 0.25um) with helium carrier gas at a flow rate of 1.5ml/min. Oven temperature ranged from 100^{o}C to 240^{o}C with a gradient of 4^{o}C/min (injection/detection temp. 290^{o}C/320^{o}C) and a run time of 35 minutes. Sample streams were split into two for detection by either MS for total ion composition or SCD for sulfur-containing ion determination.

3.2 Microbiological methods

Microbiological culture and media. Standard microbiological procedures were used for the isolation and cultivation of bacterial strains. All strains were cultivated on either nutrient or Luria broth (4), with appropriate additions of vitamin supplements and antibiotics when necessary. A basal salts medium was used for preparation and testing of biocatalyst strains, using DMSO as sole source of sulfur when preparing cells for *in vivo* activity determination. Basal salts media was composed of the following per liter: Na_2HP04, 5.11g; KH_2P04, 1.90g; NH_4CI, 1g; $MgCl_2$*6H_2O), 0.2g, Hutner's minerals, 5ml; 50% glucose, 10ml; pH7.2.

3.3 Molecular biology

Molecular biology. Generation of PCR products was carried out using established procedures with varying incubation temperatures and cycling conditions according to experimental requirements. Recombinant DNA procedures were carried out according to methods previously described (4). Nucleotide sequencing was carried out using the method of Sanger and dye termination chemistry and analysis by the ABI 3700 DNA Analyzer.

For cloning of Dsz and Dsz-homologues for expression and characterization, PCR products of the coding regions were amplified and cloned into pASK5 plasmid between *Nco*I and *Bgl*II sites to create a plasmid that expresses native or carboxy-terminal hexahistidine-tagged oxidoreductases. For amino-terminal hexahistidine-tagged proteins, the PCR product was cloned into pASK1 between *Bgl*II and *Hind*III sites

For preparation of the *Rhodococcus* IGTS8 plasmids for sequence characterization, a procedure for the isolation of plasmids from this organism was developed. A single colony was inoculated into 200mls of 2xYT medium in a 2L flask and incubated for 48 hours at 30^{o}C, 250 RPM. Fifty mls of culture was then inoculated into each of four flasks containing 400ml 2xYT with 2% glycine and further incubated for 8 hours. Cells were harvested, washed with 0.5X volume of 50mM EDTA, pH8.0, and the cell pellet resuspended in 80 ml Qiagen solution I (Qiagen, Valencia, CA). Mutanolysin (100U/ml) and lysozyme (2mg/ml) was then added and the cells incubated for 1 hour at 37^{o}C. From this point, directions for the Qiagen Large Construct Kit were followed.

To construct an ordered cosmid library of the IGTS8 plasmids, DNA was randomly sheared to obtain 30-45kb fragments. After treating digested DNA to repair ends, these fragments were then ligated into *Eco72*I-digested pCC1FOS (Epicentre, Madison, WI). Ligated DNA was packaged and transfected into *E. coli* cells. Recombinants were selected by plating transfected cells on L-agar with chloramphenicol (12.5ug/ml). Plasmid DNA was prepared and clones characterized by restriction digest.

To construct a small insert library for sequencing, DNA was randomly sheared and end repaired followed by ligation into pCR4TopoBlunt (Invitrogen, Carlsbad, CA). Individual clones were grown in 96-well microtiter plates and plasmid DNA was prepared for nucleotide sequencing with dye termination chemistry. Nucleotide sequences obtained in this manner were assembled using Sequencher^{TM} software (Gene Codes Corp., Ann Arbor, MI).

3.4 Expression and purification of enzymes

Expression and Purification. *E. coli* TOP10 (Invitrogen, Carlsbad, CA) were used as host for the expression of recombinant oxidoreductases. Freshly transformed colonies were inoculated into LB medium with kanamycin (50ug/ml). 1 L cultures were grown until OD_{600}~1 and expression was induced with anhydrotetracycline (10-100 µg/l) and carried on overnight at 30^{o}C. Cells were lysed in buffer I (50 mM sodium phosphate; 100mM NaCl supplemented with lysozyme (EpiCentre, Madison, WI) by French-pressure treatment. Cell lysates were clarified by centrifugation at 15,000 x g for 30 min and recombinant protein was bound to pre-equilibrated Ni^{+2}-NTA resins at 4^{o}C for 1 hr. Resins were washed with buffer I containing imidazole (20 to 80 mM) and eluted with 0.5 M imidazole in buffer I. The eluted protein was dialyzed against buffer II (50 mM Tris pH 7.5, 100 mM NaCl) and than against buffer II containing 40% glycerol. Protein was stored at –20^{o}C in buffer II with 40% glycerol and 1mM DTT.

3.5 Enzymatic assays

In vitro DszA, DszC assays were carried out as described previously (5) with slight modifications. Purified proteins (200pmols of protein and 450pmols of reductase) as well as crude lysates were incubated with substrates in the presence of 10µM FMN, 4mM NADH, 100mM NaCl, and 25mM sodium phosphate buffer (pH 7.5). For DszA assays, $DBTO_2$, 4-Me$DBTO_2$, BTO_2, 3-MeBTO_2, 5-MeBTO_2; 7-MeBTO_2 were used at 100µM concentration; 4, 6-diMe$DBTO_2$ was used at 30µM concentration, and 2, 4, 8-triMe$DBTO_2$ was used at 50uM concentration. For DszC assays DBTs and BTs were used at 100µM concentration. The reaction mixtures were shaken at 230 rpm at 30°C. At designated time points, reactions were quenched with equal volume of acetonitrile. Substrate and product concentrations were determined by LC/MS analysis.

In vitro reductase assays were carried out as described previously (5). The reductase activity was measured by the FMN-dependent oxidation of NADH monitored at 340nm. Reactions were carried out at 30°C in 50mM phosphate buffer, in the presence of 0.1mM NADH and 20µM FMN. Five to twenty pmols of enzyme was used.

High throughput screening of the DszA and DszC GSSM and GeneReassembly libraries and variants was carried out using modifications of the assays as described above, described in more detail in the respective sections below.

3.6 Whole cell biocatalysis assays

To test whole cell activity of biocatalyst strains on either model substrates or diesel fuel, strains were streaked out on BSM-glucose minimal agar to obtain single colonies. A single colony was then inoculated into 1ml of BSM-glucose liquid media containing appropriate antibiotics, incubated overnight at 30°C, and then used to inoculate 50ml of BSMS-glucose-DMSO and further incubated for 2 days at 30°C. This culture was then used to inoculate an 800ml culture of BSMS-glucose-DMSO which was grown to OD_{600} of ~10 before harvesting. Pelleted cells were then resuspended in 15-20ml of phosphate buffer and an aliquot removed to determine dry cell weight/ml. To carry out the reaction for model compounds, a 3:1 phosphate buffer-hexadecane emulsion was prepared to which substrate, previously dissolved in hexadecane, was added at the appropriate concentration to be tested. For assays on diesel fuel (either straight-run or partially hydrotreated), 3:1 phosphate buffer-diesel emulsions were directly prepared. Following generation of an emulsion, a source of co-oxidizable substrate, such as glucose, ethanol or acetate, was added to provide cellular reductant. The reaction was incubated by shaking in a baffled flask at 200 rpm and aliquots were removed at various time points. Reactions were terminated and analyzed for reaction products and total sulfur as described above.

4.0 RESULTS AND DISCUSSION

4.1 Analysis of organosulfur compounds in diesel fuel

Two analytical efforts were carried out in the course of this work; 1) the determination of organosulfur compounds in chemically oxidized Petro Star diesel and 2) the determination of organosulfur compound in partially hydrotreated Petro Star diesel.

4.1.1 Determination of organosulfur compounds in chemically oxidized Petro Star diesel

Since the objective of the original research proposal was to develop a biocatalyst that would work in combination with a chemical oxidation/extraction step, it was imperative to determine the composition of the sulfur-containing chemical oxidation products that would need to be acted upon by the biocatalyst for their removal.

Petro Star middle distillate diesel was received and characterized initially for total sulfur content, and determined to be 0.339% sulfur, in close agreement with results provided by Petro Star (0.342% sulfur). A strategy for analyzing Petro Star diesel was developed which incorporates a fractionation step of diesel polar compounds on reverse phase-HPLC (RP-HPLC) before analysis and ion assignments by GC-MS-SCD. The basic assumption of the separation strategy is that sulfur-containing compounds are most likely present in diesel as series of homologues. As each series is separated on RP-HPLC, less alkylated (and thus more polar) representatives are eluted first, followed by more highly alkylated homologues. Subsequent GC analysis of these fractions should result in less alkylated homologues appearing at lower retention times. Better-separated peaks should also result from fractionation due to the smaller number of possible isomers in each GC analysis.

Appendix 1 describes in detail the results of these analyses. The origin and nature of the samples, their handling, methodology of analysis and detailed procedures are explained. Qualitative and quantitative results of analysis are discussed.

4.1.2 Determination of organosulfur compounds in partially hydrotreated Petro Star diesel.

As described above, during the course of this work our objectives were modified to develop a biocatalyst to be used in combination with HDS. To determine the nature of the organosulfur compounds that remain after partial hydrotreatment that must be acted upon by the BDS biocatalyst, we obtained partially hydrotreated diesel fuel from Petro Star (provided by a separate subcontractor).

Three samples of diesel fuels with varying degrees of hydrotreatment (1746ppm, 418ppm and 43ppm residual sulfur) were analyzed, in addition to the a new batch of straight-run fuel (4130ppm). A GC/MS method was developed to identify organosulfur compounds that remained following hydrotreatment. **Appendix 2** details these analyses and concludes that, as expected, the majority of identifiable organosulfur remaining after hydrotreatment is 4-methyl and 4, 6-dimethyl DBT but a substantial amount of extremely heterogeneous unidentified organosulfur compounds remain that contribute significantly to the total sulfur composition of hydrotreated diesel. It is this "hump" of diverse organosulfur compounds that represents the major challenge to development a biocatalyst that can achieve the ULSD mandated by the EPA

4.2 Synthesis of standards

To provide as many standards for subsequent analysis of the biological oxidation products of Petro Star diesel, a number of methods were used for the synthesis of alkylated benzothiophenes and dibenzothiophenes as well as sulfone and sulfinate derivatives. Products were evaluated for structure and purity using nuclear magnetic resonance procedures.

We have acquired parent benzothiophene and three monomethyl derivatives (2-, 3-, and 5-MeBTs, C_1BTs) commercially (various sources). From these we have produced three pure sulfones by standard oxidation with peracetic acid. The 2-methylbenzothiophene sulfone, however, proved to be unstable and was not prepared.

A number of DBT derivatives were synthesized, including 4-MeDBT (C_1DBT), 4,6-diMeDBT (C_2DBT), 4-EtDBT (C_2DBT), 4,6-diEtDBT (C_4DBT), 4-PrDBT (C_3DBT), 4,6-diPrDBT (C_4DBT), 2,8-diMeDBT (C_2DBT), 3,7-diMeDBT (C_2DBT), and 2,4,8-triMeDBT (C_3DBT). All these DBT compounds were then converted to the corresponding sulfones. In addition, several precursors for alkylated DBTs and a mixture of monoethyl DBTs have been prepared. Precursors include a mixture of monoacylated 4-MeDBT (C_3DBT), mixture of bisacylated 4-MeDBT (C_5DBT), 2-acyl-3,7-diMeDBT (C_4DBT), mixture of bisacylated 3,7-diMeDBT (C_6DBT), a mixture of monoacylated 4,6-diMeDBT (C_4DBT), and mixture of bisacylated 4,6-diMeDBT (C_6DBT).

In addition, a synthetic reaction for the formation of a sultine derivative of 4, 6-dimethyl $DBTO_2$ was devised and carried out **(Figure 4).** This compound is to be used as a molecular product standard for the quantification of DszA activity on dimethyl $DBTO_2$. The two-step synthesis resulted in the generation of a mixture of two isomers of the sultine. The mixture was analyzed by LC/MS/MS and the fragmentation ions of both isomers were confirmed to be identical to those of the DszA-generated product. As each component can be separated from the other by LC, purification was carried out in order to use the correct single isomer as a quantitative standard.

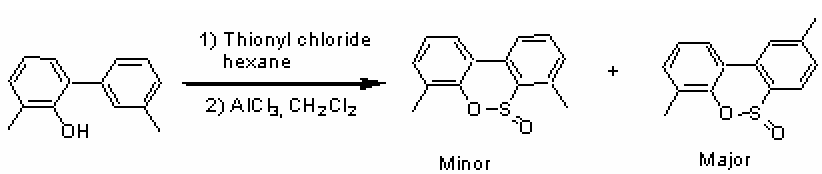


Figure 4. *Scheme for the synthesis of the 4, 6-dimethylbenzothiophene sultine derivative.*

We had also acquired seven commercially available symmetric dialkyl sulfides (butyl through decyl) and prepared a series of corresponding sulfones. Analysis of GC-MS chromatograms of the sulfones confirmed our initial observation that these compounds are not present in CED of Petro Star diesel. Currently, we use the dialkyl sulfones as internal standards for quantitative analysis of CED fractions.

4.3 Cloning, expression and characterization of DszA, -B, -C and -D

4.3.1 Cloning and expression

In order to most effectively characterize the enzymatic properties of various Dsz enzymes for their substrate specificities and to generate DNA constructions amenable to directed evolution, *dsz* genes from a variety of sources were subcloned for expression in *E. coli*. In those cases where DNA sequence was not already available, available genomic clones from the Energy Biosystems strain collection were prepared for DNA sequence analysis. We also cloned and expressed three ToeA proteins, which are close homologues to DszA and have been proposed to have significant activity on benzothiophenes compounds.

From these subclones, we generated expression clones that enabled us to overexpress and purify active proteins for enzymatic characterization. In all cases, with the exception of the DszB proteins, native and His-tagged (both at the N- and C-termini) derivatives were generated. In addition, we generated subclones of three different flavin reductase accessory proteins, DszD (from *Rhodococcus* IGTS8), Fre (from *E. coli* K12) and HpaC (from *E. coli* W), which can each be used for the generation of $FMNH_2$ reducing equivalents for the DszA and C monooxygenases (summary of constructs in **Table 1**).

Enzyme	Organism	Native	N-His	C-His
DBT/BTO$_2$ monooxygenase				
DszA	*Rhodococcus* IGTS8	+	+	+
DszA	*Nocardia* A3HI	+	+	+
DszA	*Sphingomonas* AD109	+	+	+
ToeA	*Tsukamarella* 670-1	+	+	+
ToeA	*Tsukamarella* EMT4	+	+	+
ToeA	*Nocardia* KGB1	+	+	+
Desulfinase				
DszB	*Rhodococcus* IGTS8	+	n.t	n.t
DszB	*Nocardia* A3HI	+	n.t	n.t
DszB	*Sphingomonas* AD109	+	n.t	n.t
DBT/BT monooxygenase				
DszC	*Rhodococcus* IGTS8	+	+	+
DszC	*Nocardia* A3HI	+	+	+
DszC	*Sphingomonas* AD109	+	+	+

Table 1. *Cloning and expression of Dsz genes from various strains.*

4.3.2 Characterization of flavin reductase activities

In order to evaluate the flavin-dependent monooxygenase in vitro, it requires the addition of a flavin reductase to regenerate the reduced $FMNH_2$ from NADH. Purified DszD, Fre and HpaC proteins were each evaluated for flavin reductase activity using standard assay conditions. From these results it was seen that purified DszD appeared to have more activity than the others **(Table 2)**.

Reductase		Subcloning	Purification	Specific activity: (μM/min/mg)
IGTS8 DszD	Native	+	-	ND*
	N-His	BD10606	+	42.9
	C-His	BD10607	+	25.0
E. coli Fre	Native	+	-	ND
	N-His	+	+	19.6
	C-His	+	+	9.8
E. coli HpaC	Native	+	-	ND
	N-His	BD10465	+	23.3
	C-His	BD10466	+	13.7

Table 2. *Subcloning and activity of flavin reductases.*

To evaluate an optimum combination and concentration together with DszA, each were tested using DBT sulfone as substrate together with IGTS8 DszA. As shown in **Table 3**, most demonstrated nearly equivalent activity. As the Fre-NHis fusion protein proved easiest to express and purify in large quantities and was the most stable to long term storage (data not shown), it was selected for all further evaluations of in vitro monooxygenase activity.

Flavin Reductase	uM $DBTO_2$ conversion/min/200pmole	uM $DBTO_2$ conversion/min/1nmole
HpaC-N	6.5 +/- 1.3	29.3 +/- 1.9
HpaC-C	7.6 +/- 1.1	38.0 +/- 5.7
Fre-N	6.1 +/- 1.4	30.7 +/- 7.3
Fre-C	3.6 +/- 0.9	17.9 +/- 4.4
DszD-N	5.3 +/- 1.8	26.4 +/- 8.8

Table 3. *Assay of Rhodococcus IGTS8 DszA using different flavin reductases.*

4.3.3 Characterization of DszA activities

Once cloned and expressed we then set out to determine the specific activity of the different DszA proteins with substrates likely to be relevant to biodesulfurization. We focused on the following substrates: $DBTO_2$; 4-methyl$DBTO_2$, 4, 6-dimethyl$DBTO_2$, 2, 4, 8-trimethyl$DBTO_2$, BTO_2, 3-methylBTO_2; 5-methylBTO_2 and 7-methylBTO_2. In initial experiments, we used crude lysates of *E. coli* expressing the genes of interest, with the addition of purified Fre protein. These initial experiments allow us chose the right conditions for the experiments to be performed with purified proteins. Since the majority of substrates are poorly soluble in water the specific activity was determined at close to their saturation concentration.

A summary of rates observed is shown in **Table 4**. From these data, certain characteristics of the enzymes could be seen. For instance, whereas the *Rhodococcus* and *Nocardia* DszA proteins demonstrated higher activity towards $DBTO_2$ and derivatives, the *Tsukamarella* ToeA proteins displayed a preference for BTO_2 compounds (unfortunately we were not able to observe activity from the *Gordonia* KGB ToeA). *Sphingomonas* DszA, unlike IGTS8 DszA, was most active at pH 8.2 and also required more Fre reductase for optimal activity. The highest specific activity for $DBTO_2$ was obtained with 1:10 DszA:Fre ratio comparing to 1:2 that was optimal for IGTS8 DszA. Under these conditions, specific activity of *Sphingomonas* DszA with $DBTO_2$ was determined to be ~22 nmols/min/nmol of enzyme. In addition, the *Sphingomonas* DszA appears to have a higher level of activity on unsubstituted benzothiophene sulfone than the IGTS8 enzyme and was less affected by methyl substitution on the dibenzothiophene sulfones.

	DBTO2	*4-MeDBTO₂*	*4,6-diMeDBTO₂*	*2,4,8-trMeDBTO₂*	*BTO₂*	*3Me-BTO₂*	*5Me-BTO₂*	*7Me-BTO₂*
Rhodococcus IGTS8 DszA	1 (23.9+/-6.0)	0.4 (9.0+/-1.7)	0.2 (4.1+/-1.3)	0.5 (11.2+/-5.5)	0.11 (2.64)	0.21 (5.24)	0.18 (4.32)	0.26 (6.16)
Sphingomona s AD109 DszA	1	1.6	0.7	0.9	1.8	0.26	0.21	0.14
Nocardia A3H1DszA	1	0.1	0.7	2.6	0.01	0.03	0.03	0.9
Tsukamarella EMT4 ToeA	1	0.11	0.07	0.1	2.1	2.0	1.9	1.9
Tsukamarella 670-1	1	0.5	0.01	0.16	0.9	1.25	0.28	1.1
Gordonia KGB ToeA	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Table 4. *Activity of DszA and ToeA proteins with different benzothiophene sulfones.* The activity is expressed as the fraction of activity with $DBTO_2$ (expressed as 1). In those cases where the specific activity was determined using purified proteins, the values are given in brackets (nmols of substrate/min/nmol of enzyme). n.d., not detected.

4.3.4 Characterization of DszC activities

In contrast to DszA, we were only able to clone and stably express the DszC from *Rhodococcus* IGTS8. While we could detect activity from recombinant *E. coli* clones expressing the *Sphingomonas* AD109 DszC, it proved unstable and we were unable to obtain specific activity data. As in the case of the DszA, DszC of IGTS8 demonstrated higher activities towards the dibenzothiophenes and derivatives as compared to the benzothiophenes **(Table 5).** Activity of DszC also appeared less affected by substitutions on DBT compared to the influence of $DBTO_2$ modifications on DszA activity.

	DBT	4Me DBT	4,6diMe DBT	2,4,8triMe DBT	BT	3Me BT	5Me BT	7Me BT
Rhodococcus IGTS8	1 (2.6±0.5)	1 (2.6±0.8)	0.6 (1.6±0.4)	0.5 (1.4±0.67)	0.006 (0.016±0.0007)	0.05 (0.12±0.04)	0.005 (0.013±0.009)	0.02 (0.06±0.01)
Sphingomonas AD109	+	n.t.	n.t	n.t	n.t	n.t	n.t	n.t

Table 5. *Activity of DszC from Rhodococcus IGTS8.* The activity is expressed as the fraction of activity with DBT (expressed as 1). Specific activity was determined with purified protein; the values are given in brackets (nmols of substrate/min/nmol of enzyme).

4.4 Construction of DszA-reductase fusions

One of the challenges for improved biocatalyst is the coordinated expression and activity of flavin reductase component with the DszA and DszC monooxygenases. A possible strategy for addressing this challenge is the construction a translational fusion of each the monooxygenases with a flavin reductase component. Examples of naturally occurring fusion proteins are the sterol α-demethylase/ferredoxin fusion protein from *Methylococcus capsulatus* (6) and the $P450_{BM-3}$ a *Bacillus megaterium* flavocytochrome, in which the fatty acid hydroxylase component is fused to a diflavin NADPH reductase and has the highest catalytic activity of any known cytochrome P450 (7).

To investigate this possibility, we constructed translational fusions between the IGTS8 DszA and either one of two flavin reductases, DszD and Fre. The fusions were constructed to join each of the proteins by a flexible alanine-rich linker region and in both possible orientations DszA-linker DszD (11902), DszA-linker-Fre (11903), DszD-linker-DszA (11904), and Fre-linker-DszA (11901).

All proteins were expressed and purified to determine both their respective reductase and oxygenase activities. As can be seen in **Figure 5**, all constructs except one (DszA-linker-Fre) had comparable activities to the Fre reductase itself. Unfortunately, under assay conditions tested, no oxygenase activities could be seen for any of the fusion proteins.

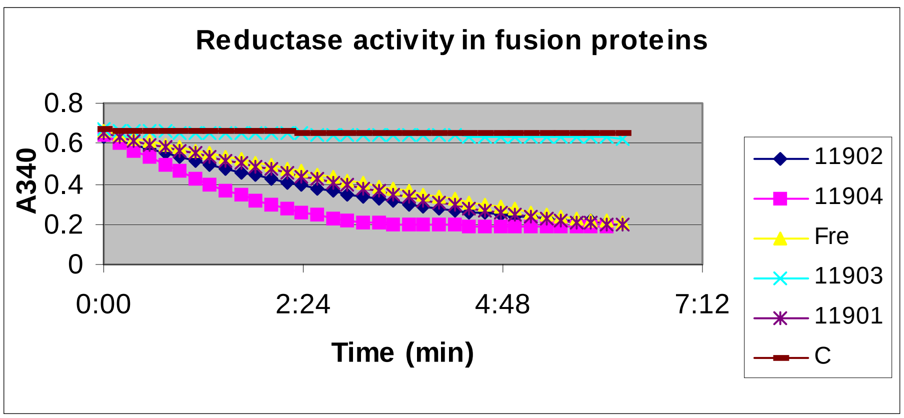


Figure 5. *Reductase activity of fusion proteins and comparison to native Fre.* " C" = no enzyme control.

Although we investigated a number of possible reasons for the lack of monooxygenase activity, including subunit structure and aggregation state, no suitable explanations were found. Work in this area was discontinued.

4.5 Discovery of new *dsz* genes

As one of the challenges of biodesulfurization is the highly complex composition of the organosulfur compounds in petroleum feedstocks, the ability to access Dsz monooxygenases with a wide range of substrate specificities was felt to be important. Although we had already cloned, expressed and characterized a number of DszA and Toe A proteins, we investigated a number of methods to identify additional *dsz* homologues from the genetic diversity that was available to Diversa in the form of metagenomic environmental libraries and microbial strains. Both sequence-based and functional screening strategies were employed as described.

4.5.1 Sequence-based discovery

Sequenced-based discovery relies on the bioinformatic analysis of previously discovered genes of a particular class to discern regions of sequence homology that can be used to design oligonucleotide primers for PCR amplification or hybridization of novel genes. As the nucleotide sequences of a number of *dszA* genes were either available to us from prior sequencing efforts or had been described in the literature, we decided to focus our discovery efforts on this gene. Because of the observation that all previously described *dsz* genes were found in an operon along with *dszB* and *–C*, this strategy would also potentially allow us to obtain these genes from individual strains or Diversa environmental libraries.

Dsz sequences that were already on hand, as well as ToeA sequences were used to search the GenBank database and alignments were constructed. As shown in **Figure 6**, these sequences could be placed in a phylogenic tree and families of relatedness determined. This analysis resulted in the identification of three main groups of sequences, the bona fide DszA-like monoxygenases, a larger family of nitriloacetate monooxygenase-like proteins and a family of hypothetical flavin-dependent monooxygenases (no activities described in literature).

Using this information, we designed degenerate oligonucleotides to specifically amplify sequences belonging to the bona fide DszA-like family. Correct PCR products **(Figure 7)** that result should be ~350 base pairs in length or about 25% of the hypothesized full length genes. To first validate these primers, test PCR reactions were carried out on genomic DNA prepared from in-house BDS strains known to encode DszA homologues. PCR products of the predicted size were obtained in these test reactions and were then cloned for subsequent DNA sequencing to confirm their identities.

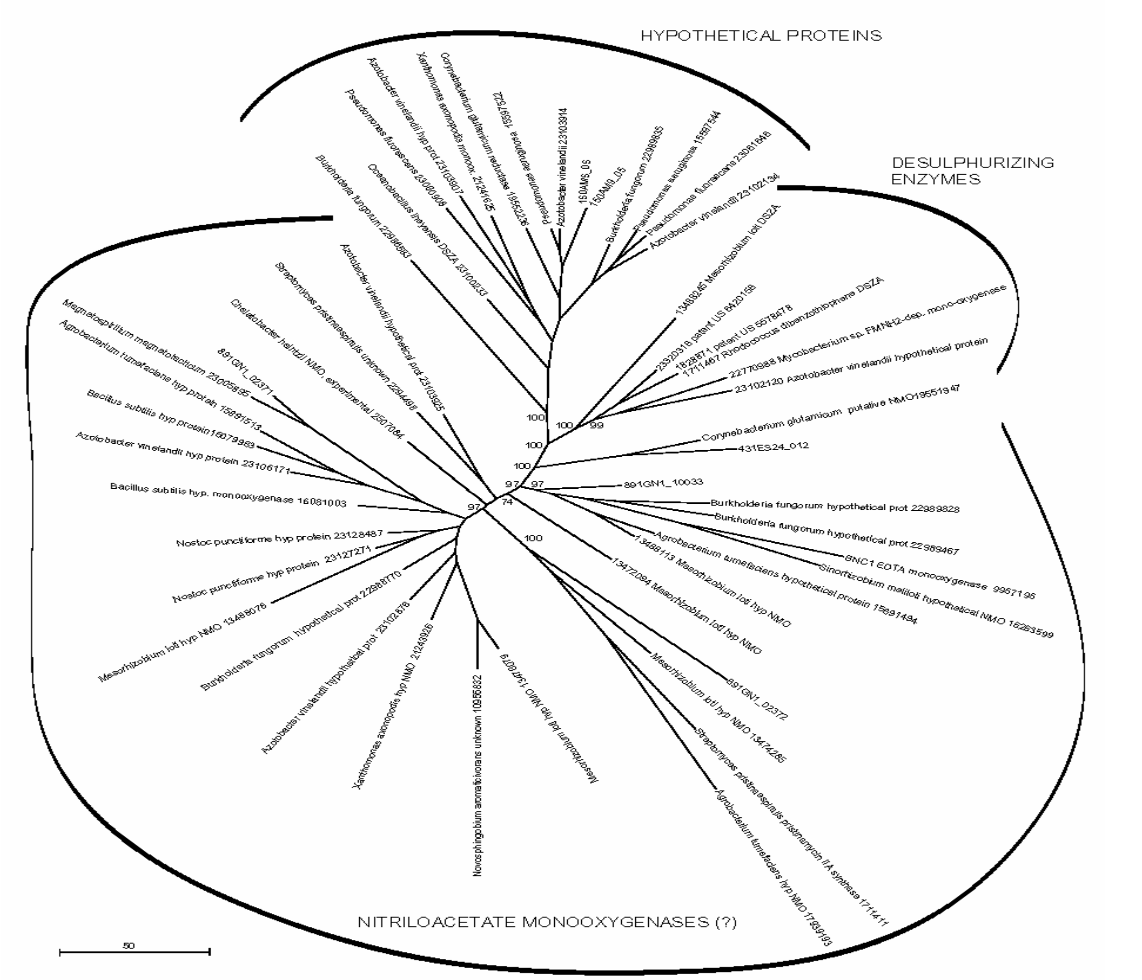


Figure 6. *Phylogenetic tree of known sulfone/sulfan monoxygenases, nitriloacetate monooxygenases and hypothetical flavin-dependent monooxygenases.*

```
                                       (1) 1       10        20        30        40        50        60        70               89
DszA (IGTS8)                           (1) MTQQRQMHLAGFFSAGNVTHAHGAWRHTDASND-FLSGKYYQHIARTLERGKFDLLFLPDGLAVEDSYGDNLDTGVGLGGQGAVALEPA
DszA (Sphingomonas)                    (1) MTDPRQLHLAGFFCAGNVTHAHGAWRHADDSNG-FLTKEYYQQIARTLERGKFDLLFLPDALAVWDSYGDNLETGLRYGGQGAVMLEPG
DszA (Paenibacillus)                   (1) ---MRQMHLAGFFAAGNVTHHHGAWRHPKTDNG-FLSISWYQHIARTLERGRFDLLFLPDGLAIWDSYGNNLDAGLRFGGQGAAFLDPV
DszA (EMT)                             (1) --MSRELHLAGFLIASHVTHSHAAWRHPASETD-YLGPDYYRRVAQTLERGKFDFLFFADLLATPVRYGNDIRVPLSSGTQASATIDPS
DszA (6701)                            (1) --MSRELHLAGFLIASHVTHSHAAWRHPASETD-YLGPDYYRRVAQTLERGKFDXLFFADLLATPVRYGNDIRVPLSSGTQASATIDPS
DszA (KGB1)                            (1) --VTRQLHLGGFLIASPVTHSHAAWRHPGSETD-YFGPDHYHRVGRILERGKFDFAFFADLLAAPVRFGGNQSEPFRRGTQAAATIDPS
Endosulfan monooxygenase               (1) --MTRQLHLGGFQIASQVTHSHAAWRHPGSDTD-FTTPEYYHRIGRILERGKFDFVFFADLLAAPVRFGSDITEPLRRGTPATATLDPS
DszA A3HI                              (1) MAQRRQLHLAGFFSAGNVTHAHGAWRHTDASNG-FLTGKW-QHIARTLERGKFDLLFLPDGLAVEDSYGDDLRTGVGLGGQGAVALEPA
59968 Internal DszA homolog            (1) ----------------------GAWRHPESQAARYKDLEYWTDLAALLERGLFDGLFIADVLGVYDVYGGGPDAALRAGTQVPVN-DPL
59971 Internal DszA homolog            (1) --------------------SHGAWRHPADQTYRYNTIDHWVQLAKILDDGGFDALFIADALGLLDTYGGGPEAALRTGTQSPVS-DPL
Translation of dszA gene (670-1) comp  (1) ---SRELHLAGFLIASHVTHSHAAWRHPASETD-YLGPDYYRRVAQTLERGKFDSPVLRRSPRHARSI-----RPLSSGTQASATIDPS
Translation of Azotobacter DszA homolog (1) --MSRQIHLAGFLLAGPVVHSHAAWRHPETQGN-FLEPEYYARSAKVLEEGLFDLLFFADRFAIGDQLGGSRELALRHGAQDATRLDPL
Consensus                              (1)    SRQLHLAGF IA  VTHSHAAWRHPASETD FLTPDYY RIARTLERGKFD LFLAD LAV DSYG  LD GLR GTQAAATLDPS
```

5' SCCAYGSSGCSTGGCGGCA 3'

3' TGGAACRTCGTCCTCSM

M=A or C
S=G or C
R=G or A
Y=T or C

Figure 7. *Sequence alignment of DszA and ToeA proteins.* PCR primers used to amplify products from Diversa environmental libraries and strains are indicated below.

Surprisingly, for many of the BDS strain isolates, at least two different products were obtained. In addition to the predicted *dszA or toeA* product, additional sequences encoding products closely related to DszA were found. Phylogenetic comparisons of these sequences, however, suggested that they cluster closest to the hypothetical flavin-dependent monooxygenases.

Comparisons of the sequences amplified from the microbial isolates suggested that the designed PCR primers were specifically amplifying *dszA* or *dszA*-related sequences. Amplification of products from three environmental DNA libraries was been carried out and products were cloned and sequenced. Sequence analyses and alignment showed that *dszA*-related sequences were also very prevalent in these environmental libraries. Although we have obtained a few products highly related to the *dszA* gene of IGTS8, the vast majority of products, however, clustered within the hypothetical flavin-dependent monooxygenases described above.

Because of the observation that the hypothetical flavin-dependent monooxygenase were abundant, not only in the environmental libraries but within individual organisms, we felt it would have required considerable work with no guarantee that the encoded proteins would have activity on relevant sulfur-containing compounds. For this reason, work in this area was discontinued.

4.5.2 Functional-based screening for new *dsz* genes.

Another, more direct approach for discovering novel BDS enzymes from environmental libraries is the use of functional-based expression screening. By developing an appropriate *E. coli* host it is possible to select directly or screen for genes that express functional enzymes, in this case that catalyze the oxidation of sulfur compounds. To this end, we constructed two host systems for the selection/screening of environmental clones that express the DszB-dependent conversion of hydroxybiphenylsulfinate to hydroxybiphenyl and sulfite. As described above, because of the operon organization of known *dsz* genes, it is likely that clones containing *dszB* would also contain *dszA* and *–C* sequences.

The first system was designed to specifically select for metagenomic clones expressing DszB activity by linking production of hydroxybiphenyl and its detection by the regulatory protein HbpR to the expression of a reporter gene (diagrammed in **Figure 8**). HbpR is a positive regulator of *Pseudomonas azelaica* HBP1 that, in the presence of hydroxybiphenyl, activates the transcription of the *hbpCA* operon, which encodes enzymes for the oxidation of hydroxybiphenyl in its native host (8). By cloning the gene for HbpR and the regulatory sequences upstream of the *hbpCA* operon into a transcriptional reporter plasmid, the presence or production of HBP could be detected by expression of reporter genes.

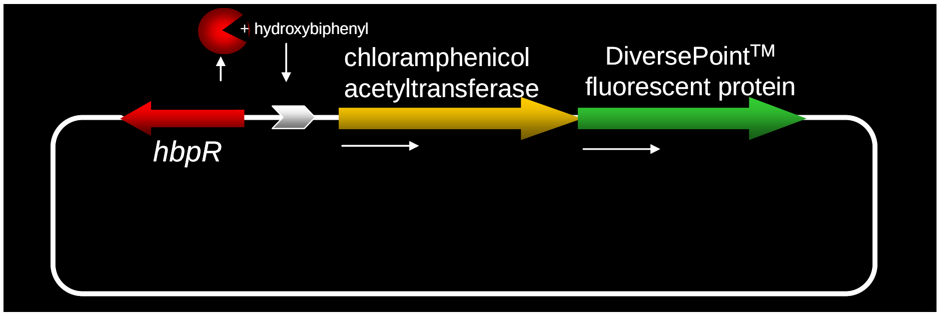


Figure 8. *Diagram of hydroxybiphenyl detection reporter plasmid.*

The reporters selected for this experiment were the chloramphenicol acetyltransferase, which allows for the direct selection of expressing clones by conferring chloramphenicol resistance and the DiversaPoint™ green fluorescent protein, which allows for the detection of expression by FACS or direct screening of fluorescent clones.

The reporter construct was tested initially for its response to exogenously added HBP and the ability to confer chloramphenicol resistance. As predicted, the addition of exogenous HBP at nanomolar levels resulted in increased levels of chloramphenicol resistance and the ability to grow on normally inhibitory levels of the antibiotic.

Unfortunately, the control experiment where HBP was not added resulted in spontaneous chloramphenicol-resistant clones that arose at a frequency of $10e^{-5}$-$10e^{-6}$. Upon further investigation it was shown that the reporter plasmid alone, without the *hbpRC* sequences that respond to HBP, gives a similar level of spontaneous resistant colonies. Cells without any added plasmid, however, did not demonstrate detectable levels of resistant colonies.

To determine the cause of the resistant clones, a number of chloramphenicol-resistant clones from the reporter plasmid alone (without the *hbpRC* sequences) were selected and the nucleotide sequence of the reporter plasmid was determined. As can be seen in **Figure 9,** IS sequences (insertion elements) of both the IS3 and IS10 family have appeared to transpose upstream of the chloramphenicol acetyltransferase gene, within or immediately downstream of the resident terminator sequences. Insertion elements are found scattered throughout the sequence of most bacterial strains and can transpose into multiple DNA sites, including foreign plasmids. Many IS sequences contain active promoters and can induce expression of genes that normally would not be expressed. This observation suggests that the low level of false positives seen with the bioreporter is unavoidable in normal strains of *E. coli*. Although this work was discontinued for this reason, Kolisnychnko *et al* (9) have reported the construction of *E. coli* strains that are devoid of IS sequences and may be useful as host if these studies were to continue.

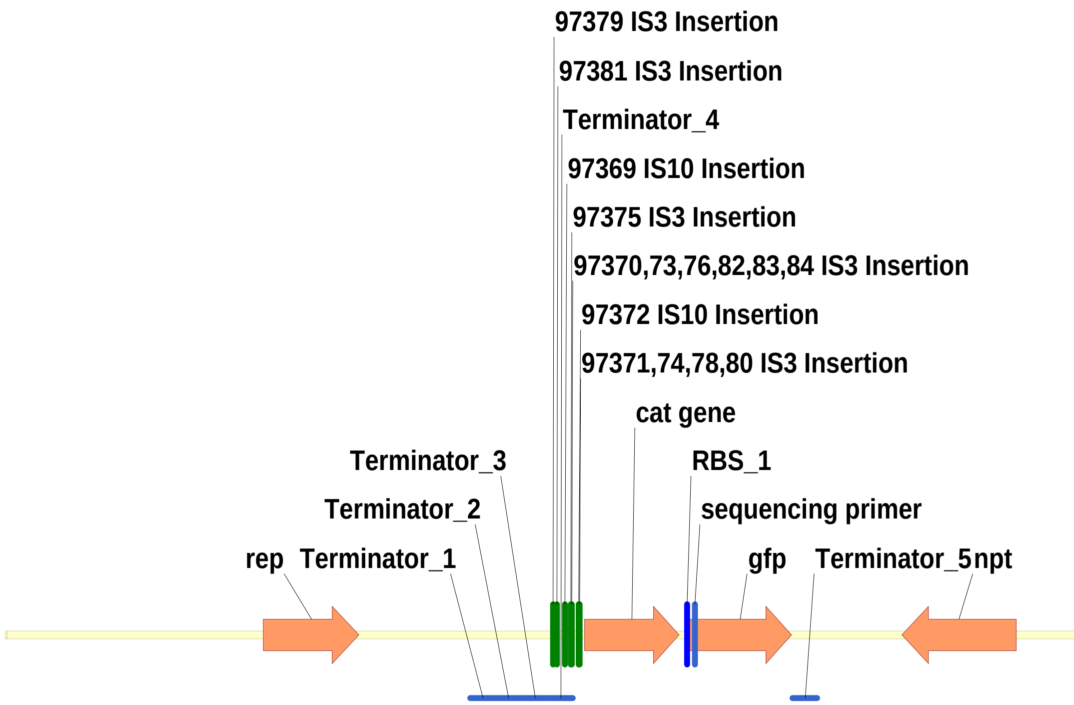


Figure 9. *Map of bioreporter plasmid showing sites of IS insertions.* The IS insertions leading to false-positive expression of cat gene (encoding chloramphenicol resistance). gfp = Diversa green fluorescent protein

The second system was designed as a direct selection for *E. coli* clones from environmental libraries having DszB activity will be based on the generation of intracellular sulfite to provide sulfur for microbial growth from the conversion of hydroxybiphenyl sulfinate. As mentioned above, all known *dszB* genes are directly linked to *dszA* and *dszC*, suggesting such a strategy should yield these genes if the DNA insert is of adequate size as isolated from the environmental library. This system could also be used for the selection of evolved variants of DszB that have higher rates of activity or expanded substrate specificity provided they result in increased levels of sulfite production.

A difficulty in using this type of selection arises from the observation that very small amounts of sulfur are need for cellular metabolic requirements. Traces of sulfate ions in even highly purified microbiological media can provide sufficient sulfur for interfering levels of bacterial growth. In addition, cross-feeding of cells in a population precludes the use of this method in liquid cultures or at high cell densities. With this in mind, we attempted to construct an *E. coli* strain that is unable to transport extracellular sulfate, thiosulfate or taurine derivatives and required cysteine for growth in minimal medium. By introducing environmental libraries into this strain and selecting for growth in the absence of added cysteine, clones expressing DszA-like activities and able to oxidize sulfones to sulfinate derivatives (which are hydrolyzed by co-expressed DszB to sulfite) could be isolated. This system may also be used for the selection of evolved variants of DszA with high rates of activity or expanded substrate specificity.

To construct the *cysP* operon (encoding sulfate/thiosulfate permease) deletion in *E. coli*, a composite PCR fragment containing ~1kb on either side of the *cysP* operon was generated by overlap PCR and introduced into the *Eco*RI site of pST98-AS, a vector for the markerless replacement of genes in the *E. coli* chromosome. This construct was then used to generate the chromosomal deletion of the *cysP* operon and the mutation was confirmed by chromosomal PCR.

The *cysP* operon deletion mutant was then tested and found to be unable to utilize sulfate in both liquid and on solid media. In addition, its ability to utilize the residual sulfur present in solid agar or agarose media was almost completely eliminated as compared to the wild-type strain. It was still able to grow as well as wild-type on rich media or minimal media containing sulfite or thiosulfate as sole source of sulfur. This latter observation is surprising, as it has been reported that the *cysP* operon encodes a thiosulfate transporter and its elimination should abolish the ability to utilize thiosulfate (10). This result remains to be resolved but did not directly affect the use of this strain for sulfur selection in a BDS screen.

The *dszB* genes from *Sphingomonas* AD109 and A3HI were then cloned and introduced into both the *cysP* mutant and the wild-type strain parent. HBPS was then tested for its ability to support the growth of the strains in the absence of any other sulfur source and was found to support growth when only when DszB was expressed (vector only control was unable to significantly grow although a noticeable was seen with the wild-type strain). There was, however, a significant delay in the growth of the *cysP* mutant as compared to the wild-type strain that is not readily explained. This is also apparent when comparing the utilization of HBPS on solid medium, with growth of the mutant being much slower and less vigorous than wild-type. This suggested that the deletion of the *cysP* operon has some additional unexplained effect on HBPS or sulfite utilization that remains to be resolved. No further work was carried out to investigate these possibilities.

4.6 Directed evolution of DszA

Because of the critical need for the DszA protein in any commercial biodesulfurization process, whether it is BDS-standalone or in combination with CED or HDS, efforts to directly evolve and expand the substrate specificity of the BDS system began with this protein. From our previous work and subsequent experience with purification and stability, we chose the *Rhodococcus* IGTS8 DszA protein as a starting point for directed evolution using Diversa Gene Site Saturation Mutagenesis™ and GeneReassembly™ technology.

As the goals of the project changed from the development of a BDS standalone, or BDS biocatalyst to be combined with CED, to a BDS biocatalyst to be used in combination with HDS, it was decided to direct the evolution of DszA substrate specificity to improve activity on the HDS-recalcitrant substrate 4, 6-dimethyl DBT, relative to DBT.

4.6.1 GSSM mutagenesis

For construction of the *dszA* GSSM library, the *dszA* gene, cloned into pASK5, was mutagenized at every position in the protein using degenerate oligonucleotides where the residue codon to be modified was represented by the sequence NNK (N= G, A, T or C; K=G or C) and was carried out by Diversa proprietary GSSM technology. Quality control of the GSSM library was carried out by the random selection of codon mutants and nucleotide sequencing to determine the extent of the substitutions obtained. This strategy, using 32-fold codon degeneracy (NNK) and 3X oversampling, results in a library of ~50,000 variants to be screened. This requires the need for a high throughput screen for DszA activity on substrates of interest.

4.6.2 Assay development

Optimal reaction and assay conditions for carrying out an *in vitro* high throughput characterization of mutant libraries were developed, investigating a variety of reaction conditions and compositions that could be adapted to robotic analysis.

Growth and induction of DszA activity.

An important first step in the robotic automation of the DszA GSSM assay was to determine growth characteristics of cells that were inoculated into 96-well microtiter plates using a high throughput colony picker. Test samples of the GSSM library as well as vector only controls were picked into microtiter plates and grown under a variety of conditions to obtain maximum reproducible growth in this format.

Further investigations were carried out to determine the optimal timing and concentration of anhydrotetracycline (AHT) added to induce DszA gene expression (pASK5 contains a *tet* element responsive promoter for gene expression). The time of induction was determined to be optimal when the cells had reached an absorbance of 1 at 600nm with 50ng/ml AHT added.

Determination of optimal assay conditions.

To investigate optimal conditions for assaying DszA activity, time of harvesting cells post-induction was determined and found to vary little between 7 hours and 18 hours, suggesting that DszA activity was stable in the induced cells. To obtain maximum and reproducible activity it was also determined that cells needed to be concentrated to 1/5 the original culture volume by centrifugation before lysis and activity determination.

In early investigations of *in vitro* DszA activity, oxidation of the substrate was found to reach a maximum level of conversion within 15 minutes but before complete utilization of substrate. These results suggested that the uncoupled oxidation of NADH by the Fre reductase used in the assay was problematic. To address this problem, a number of Fre concentrations were tested and it was found that linear DszA activity could be increased to a period of thirty minutes, which was deemed adequate for the robotic screen, by using a concentration of 0.5 μg/ml in the assay mixture.

As a minimum number of additions are important for robotic automation of the assay a number of conditions were investigated to determine the optimal order and minimum number of additions that could be easily implemented. The result of these experiments and the protocol that was established for transfer to the robotic platform is described in **Figure 10.**

Growth and induction of cells

1) Colonies from plated GSSM library picked into 1.2 ml LB (w/carbenicillin at 100 μg/ml) in deep well plates and incubated at 30°C, 220 rpm.
2) When cell reached an $O.D._{600}$ of 1 cells were induced with 50 ng/ml AHT (a daughter plate is prepared by pin-tool prior to addition of AHT for long-term storage)
3) Cells are harvest by centrifugation after 7 hours of induction. Plates are stored at -20°C overnight before assay.

Assay of DszA activity

4) 200ul of reaction mixture (see below) is added to each well and incubated for 15 minutes, with mixing to lyse cells
5) 150ul of lysed cells are transferred to shallow well 96-well microtiter plate
6) Reaction is started by addition of NADH (to 5mM)* and shaken.
7) Reaction is stopped after 15 minutes by addition of 150ul of acetonitrile.
8) Mixture is centrifuged for ten minutes and *diluted with 3 volumes of* dH_2O before analysis by LC/MS/MS.

Reaction mixture (final concentration):
10% (v/v) B-PER (lysis reagent, Pierce Biotechnology, Rockford, IL)
0.1% Triton X-100
Potassium phosphate buffer (pH 7.5, 25mM)
NaCl (100mM)
FMN (10μM)
$DBTO_2$ (50uM)
4,6-methyl$DBTO_2$ (50 μM)
Reductase (Fre) (0.5 μg/ml)

*NADH is prepared as 50mM solution *in alkaline buffer (pH10).*

Figure 10. *Protocol for analysis of DszA GSSM library. Steps in* italics describe protocol modified after transfer to and testing on robotic platform.

Optimization of robotic DszA GSSM screening.

Although the protocols described above were developed for transfer to the robotic platform (**Figure 11**), it was essential to further refine the robotic high throughput assay by additional experiments to insure robustness and reproducibility. Wild-type DszA clones were inoculated with colony picker and assayed on robot using the described conditions containing $DBTO_2$ and 4,6diMe$DBTO_2$.

As can be seen in **Figure 12**, a consistent level of activity on all substrates was obtained with a minimal number of culture wells exhibiting anomalous levels of activity. Average levels of activity of wild-type reaction wells across plate compared to 'vector-only' negative control wells (column 12) demonstrate a high signal-to-noise ratio.

Figure 11. *Photograph of robotic platform used for DszA GSSM assay.*

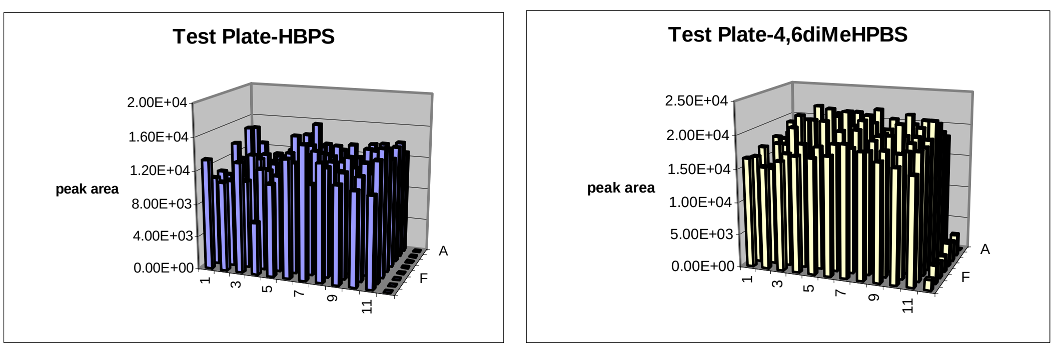


Figure 12 *Example of DszA test plate data.* Graph shows conversion of $DBTO_2$ and 4, 6-dimethyl $DBTO_2$ to products HBPS and 4,6-dimethyl HBPS, respectively. Peak areas do not reflect actual product concentration.

To determine the reproducibility and robustness of the robotic assay using a "real world" example, a plate of DszA variants at residue 112 (randomly selected, leucine in wt DszA) were tested**. Figure 13A** and **B** shows results for the activity of the variants on $DBTO_2$ and 4, 6-dimethyl $DBTO_2$ for a single run. Wells were assayed to determine if consistent levels of activity were seen between the two substrates. It can be seen that levels of activity on the substrates vary substantially with a number of active and inactive variants to be seen. Comparison of the two substrates shows similar patterns and demonstrates the feasibility of assaying multiple substrates in the same reaction.

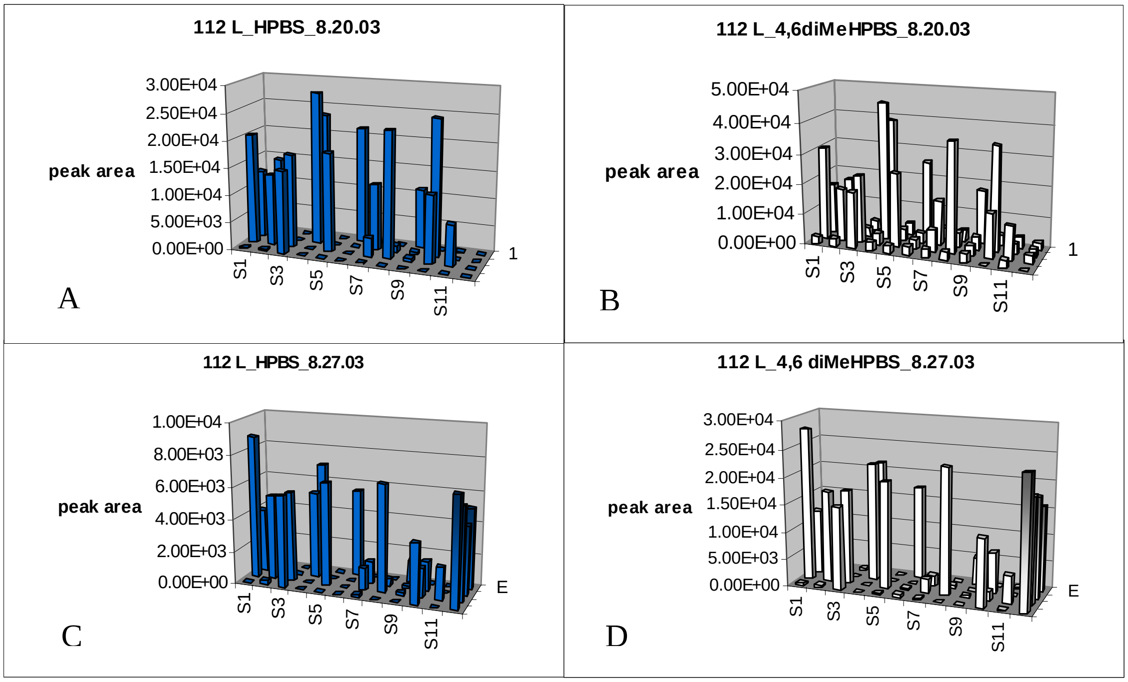


Figure 13. *Example of DszA GSSM data of mutations at residue 112 (leucine).* A and B show data from first run, C and D show data from second run, one week later.

To determine if the pattern of activity was reproducible between runs, an experiment where the same plate of mutants, prepared by two separate inoculations and robotic manipulations, was carried out. As can be seen in **Figure13B** and **C**, the additional run exhibits a similar pattern as seen with the run one week previous and provides confidence in robustness of the GSSM screen.

To further provide confidence in the results, each of the 112L variants was sequenced to determine the nature of the substitution at residue 112. In cases where there were identical residues generated by synonymous codon substitutions, the activity data was nearly identical (data not shown). In addition, substitutions that restored the wild-type leucine residue generated activities indistinguishable from the wild-type controls.

GSSM data analysis

To carry out the GSSM screening of the IGTS8 DszA variants, the following data analysis protocol was used. To determine activity of DszA on $DBTO_2$ and 4, 6-dimethyl $DBTO_2$, products were determined by LC/MS/MS. To identify interesting mutants, the data was analyzed by evaluating the absolute converstion of substrates (to identify overall up mutants) as well as activity on 4,6-dimethyl $DBTO_2$ relative to activity on $DBTO_2$ (reflecting change in substrate specificity).

4.6.3 Primary screening of *dszA* GSSM library

Primary screening consisted of transformation of the GSSM library into *E. coli* (one transformation per residue-reaction), robotic colony picking into 96 well format (96 clones for each mutated residue), growth of the cultures, inducing the expression of the variant DszA protein, cell lysis, *in vitro* end point DszA assay with $DBTO_2$ and 4, 6-diMe$DBTO_2$, in the presence of added *E. coli* Fre reductase and analysis of the reaction products and substrates. Additionally each plate of mutants was sequenced to determine the nature of the mutations. Sequencing was done in 96-well format and only one sequencing reaction across mutated residues was performed in order to determine the responsible base substitution. This approach reduced material cost three times comparing to the standard protocol, with three independent sequencing reactions, and provided sufficient quality data. From these combined data, apparent enzyme activity and nucleotide sequencing, putative hits were identified.

Although perhaps not readily apparent, there are definite advantages in sequencing of plates of mutants as a component of primary screening. The most important advantage is that it allows for a higher confidence level in confirming hits. Because of the relative complexity of the high throughput assay, a significant challenge in the DszA GSSM screen is to distinguish signal from noise. This noise can have many sources as the substrates of the reaction are only poorly soluble, the MS analysis is not very sensitive and has an error range of 10-15%, and the many steps of robotic additions also contribute to experimental error. By determination of the nucleotide sequence, confidence in the apparent levels of product formation in different wells increases if clones have the same or similar substitutions. For instance, **Figures 14** and **15** show examples of how determination of sequence was crucial in identifying potential hits.

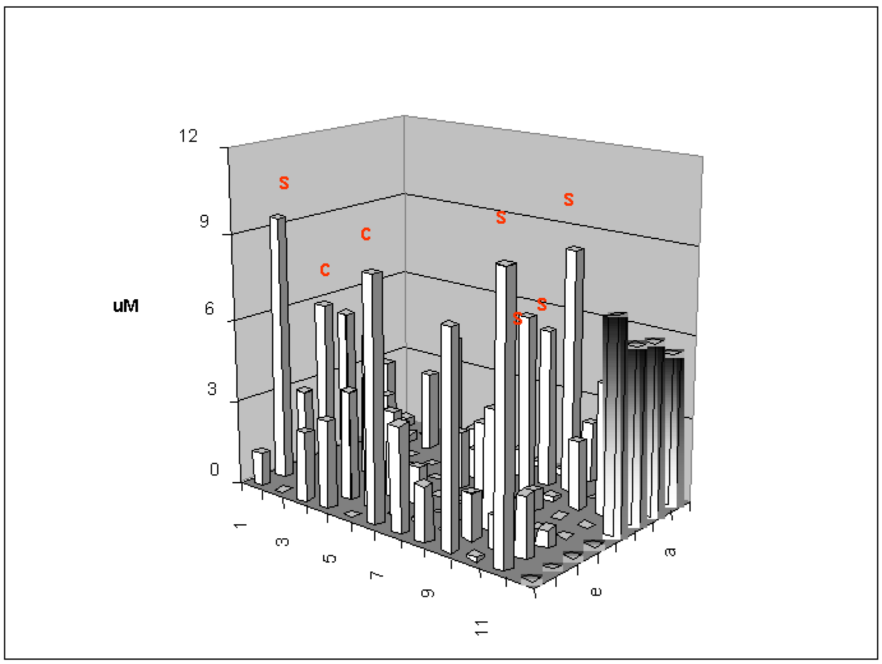


Figure 14. *Results from sequencing and enzymatic assay for an alanine residue.* Graph shows the amount of 4, 6-diMeHPBS in 96-well plate. Red labels over the higher bars indicate amino acid substitution determined after sequencing. Shadowed bars in column 12, rows A-D are wild type (wt) controls. Negative controls (vector only) are in column 12, rows E-H.

Figure 14 shows the primary results of screening an alanine residue, where a large number of residues showed activities equal to or greater than wild-type but the apparent variability of the overall plate was very high. After determination of the nucleotide sequence of the entire plate of mutants it became apparent that all substitutions of serine for alanine resulted in a slightly improved rate of activity on 4, 6-methyldibenzothiophene. In addition, substitutions with cysteine, a residue with many similar properties to serine gave similar levels of activity.

Similarly, **Figure 15** shows the results of mutagenesis of an aspartate residue, where fairly high levels of activity were seen with a number of clones and an occasional well with higher than wild type levels. By determining the nucleotide sequence of this plate it became apparent that mutations with asparagines substitutions were solely responsible for the higher level of activities seen. With these data, confidence in the validity of these putative hits was increased. In addition, it was therefore necessary to advance only a small subset of mutants to secondary characterization as they all contained the same or similar substitutions. Although not shown, the sequence data from both of these examples contained the expected distribution of overall amino acid substitutions without apparent bias for ultimately selected residues.

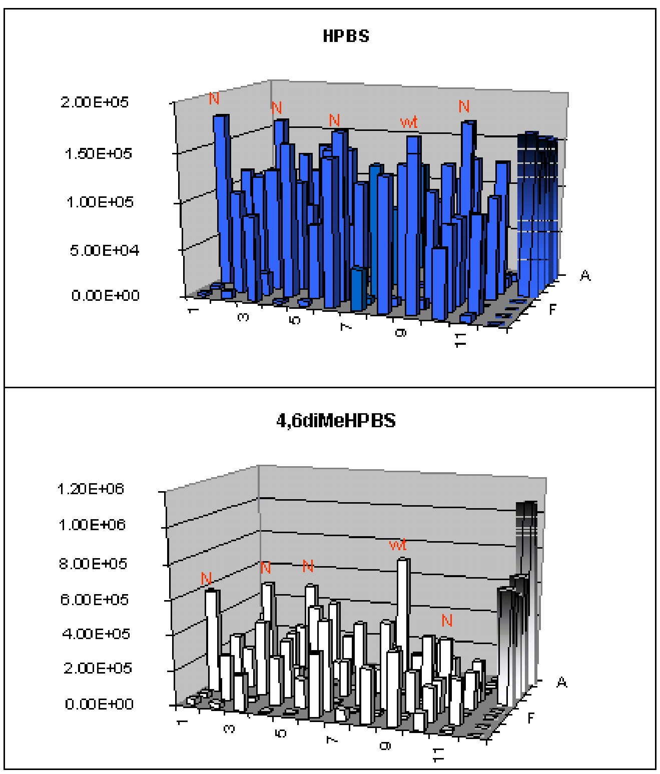


Figure 15. *Results from sequencing and enzymatic assay for an aspartate residue.* Top graph shows the amount of HPBS in a 96-well plate, bottom graph shows the amount of 4, 6-diMeHPBS from the same plate. Red labels over bars indicate amino acid substitution determined after sequencing. Shadowed bars in column 12, rows A-D are wild type (wt) controls. Negative controls (vector only) are in column 12, rows E-H.

Another advantage of sequencing is that it provides insight about the residues that are crucial for DszA activity and allows us to classify amino acids into three groups:

1) Non-permissive amino acids that are crucial for the protein function and can be seen by most substitutions resulting in null phenotypes. An example of such a residue is shown in **Figure 16**.
2) Permissive amino acids that can be seen as residues where most substitutions result in no change in DszA activity. An example of such a residue is shown in see **Figure 17**.
3) Amino acids of intermediate importance where different substitutions have differing effects on enzyme activity.

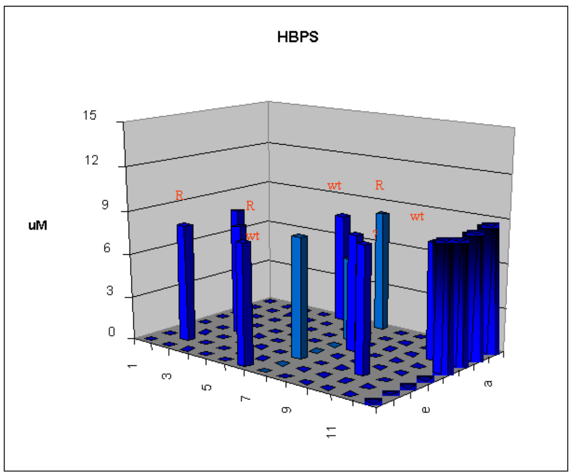


Figure 16. *Results from sequencing and enzymatic assay of a non-permissive residue (Arg).* Graph shows the amount of HBPS in 96-well plate. Red labels over the higher bars indicate amino acid substitution determined after sequencing. Shadowed bars in column 12, rows A-D are wild type (wt) controls. Negative controls (vector only) are in column 12, rows E-H.

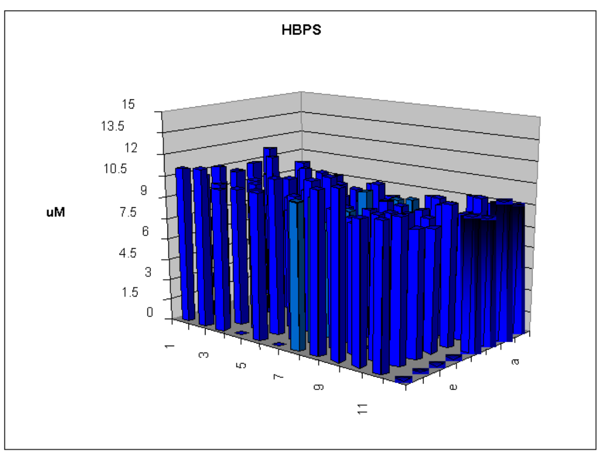


Figure 17. *Results from sequencing and enzymatic assay of a permissive residue (Glu).* Graph shows the amount of HBPS in 96-well plate. Shadowed bars in column 12, rows A-D are wild type (wt) controls. Negative controls (vector only) are in column 12, rows E-H.

4.6.4 Secondary screening of *dszA* GSSM library

Approximately 150 clones from the primary screening were shown to have either higher activity towards both of the substrates or increased ratio of 4, 6-diMeDBTO$_2$ to DBTO$_2$ oxidation and were validated by nucleotide sequencing (having the same or similar substitutions with altered activity) and were selected for secondary confirmation.

These assays were performed in a similar format to the primary screens and putative hits were inoculated randomly into 96-well plate, in replicates of ten, together with wild type controls. End point assays were performed and the average product formation and standard deviation were calculated and compared to results with wild type controls. An example of secondary analysis is shown in **Figure 18,** where a hit from a primary screen is confirmed in secondary assay.

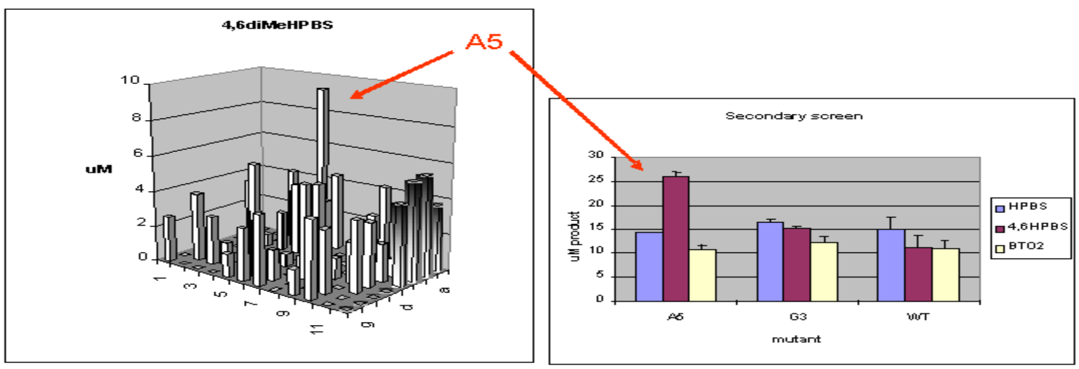


Figure 18. *Results from primary and secondary screen for a selected mutant.* Graph on the left shows the amount of 4, 6-diMeHBPS product in 96-well plate primary screen. Shadowed bars in column 12, rows A-D are wild type (wt) controls. Negative controls (vector only) are in column 12, rows E-H. Well A5 was selected as a putative hit with increased activity towards 4, 6diMeDBTO$_2$. Graph on the right shows results of the secondary analysis, where the A5 clone was assayed in triplicate and compared to wild type.

From the secondary screenings 28 variants were identified**.** The mutants fell into three distinct classes:

1) mutants with higher level of activity on 4, 6-diMeDBTO$_2$ but wild-type activity on DBTO$_2$;
2) mutants with higher level of activity on 4, 6-diMeDBTO$_2$ but lower than wild-type activity on DBTO$_2$; and
3) higher activity on DBTO$_2$ relative to 4, 6-diMeDBTO$_2$.

4.6.5 Tertiary screening of *dszA* GSSM library

After identification of putative hits by primary and secondary screening, a total of 28 variants were carried through to a more rigorous by a tertiary analysis. Here, DszA proteins expressed from putative were purified and the specific activity of the variants, with $DBTO_2$ and 4, 6-dimethyl $DBTO_2$, both separately added to the assay or in combination. The inclusion of both substrates in the characterization mirrors both original primary screening conditions as well as conditions that are likely to be similar to those in diesel fuel, where multiple DBT species are found and competitive inhibition may be seen.

Figures 19-27 show results for three DszA residues (with two variants each) and follows their progression through the primary, secondary and tertiary screening.

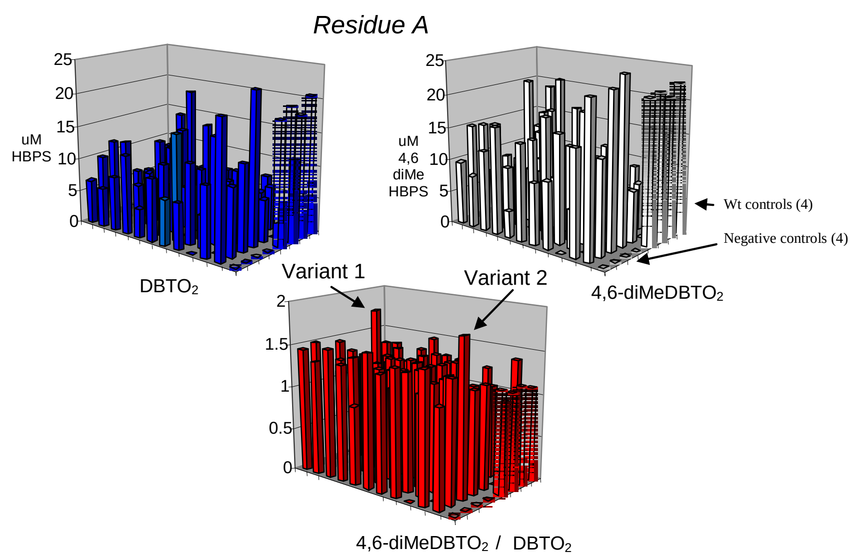


Figure 19. *Primary screening data from GSSM optimization of DszA residue A*. Results from $DBTO_2$, 4, 6-diMe$DBTO_2$ assays and ratio of 4, 6-diMe$DBTO_2$ to $DBTO_2$ activity. Two variants are indicated.

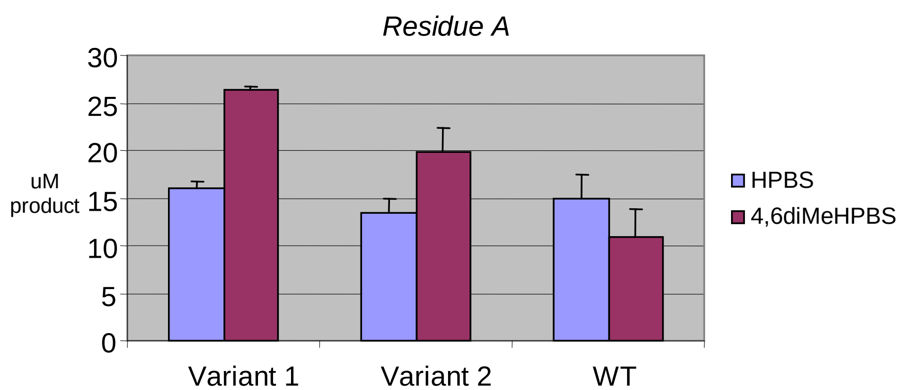


Figure 20. *Secondary screening data for two DszA residue A variants.* Conditions were same as used for primary screening but in replicates of ten.

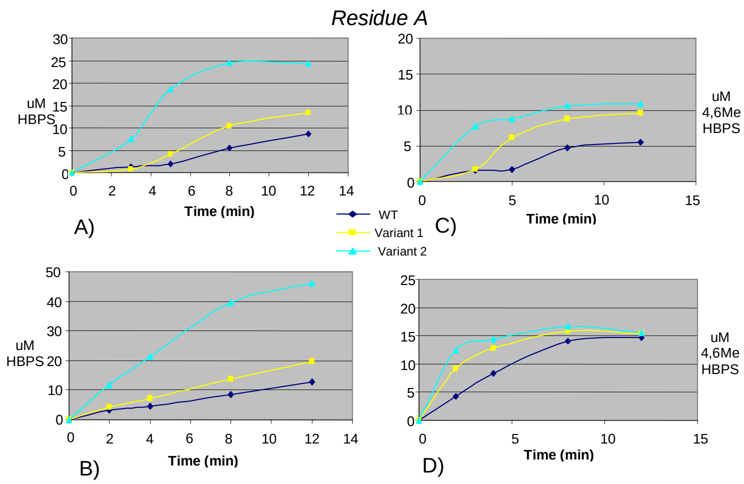


Figure 21. *Tertiary screening data from two DszA residue A variants*. The following conditions were used- A) $DBTO_2$ alone (100uM) and assaying HBPS product; B) $DBTO_2$ (100uM) plus 4,6-diMeDBTO$_2$ (100uM) and assaying HBPS product; C) 4,6-diMeDBTO$_2$ alone (100uM) and assaying 4,6-diMeHBPS product; D) 4,6-diMeDBTO$_2$ (100uM) plus $DBTO_2$ (100uM) and assaying 4,6-diMeHBPS product.

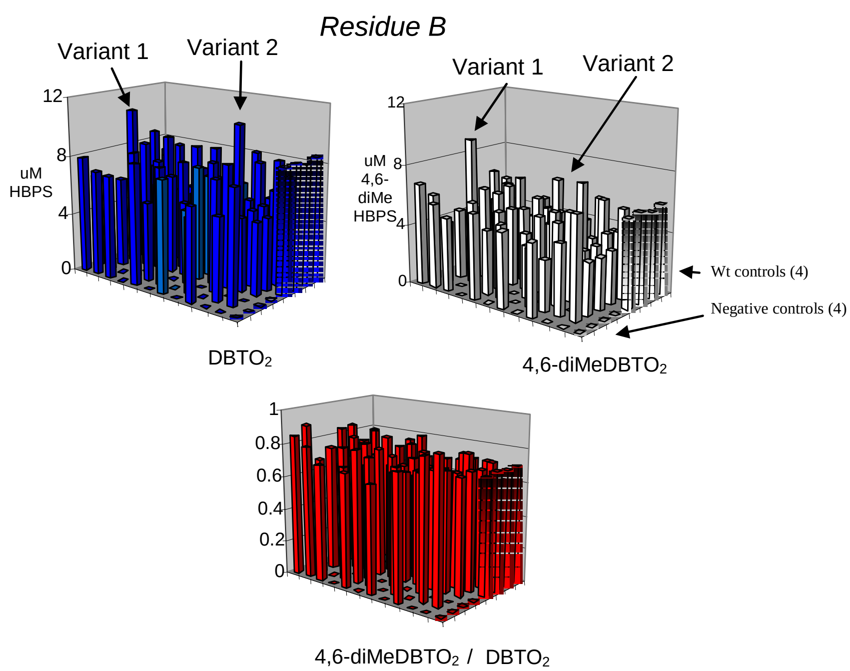


Figure 22. *Primary screening data from GSSM optimization of DszA residue B*. Results from $DBTO_2$, 4, 6-diMeDBTO$_2$ assays and ratio of 4, 6-diMeDBTO$_2$ to $DBTO_2$ activity. Two variants are indicated.

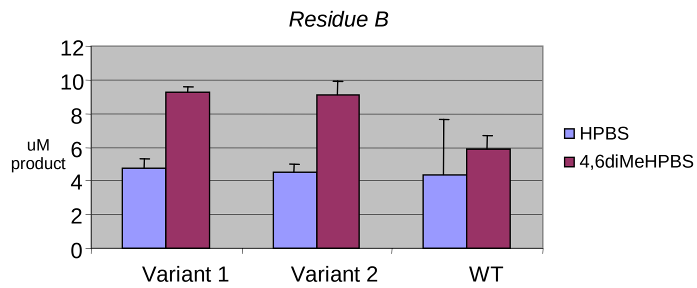


Figure 23. *Secondary screening data for two DszA residue B variants.* Conditions were same as used for primary screening but in replicates of ten.

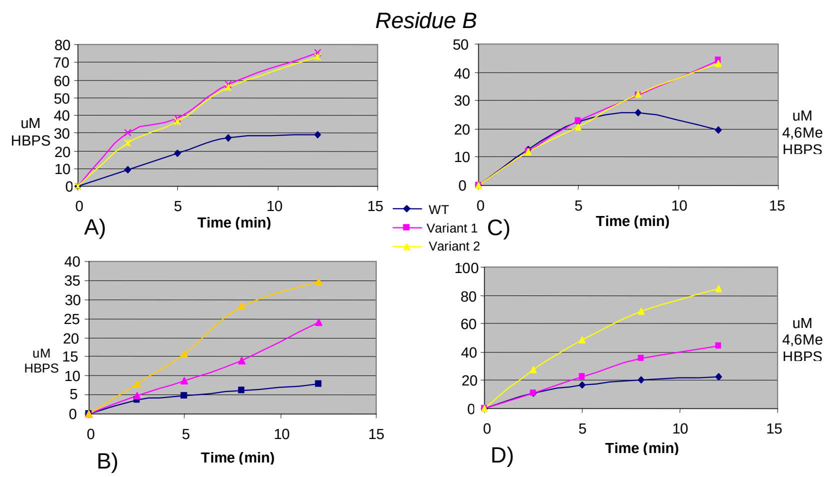


Figure 24. *Tertiary screening data from two DszA residue B variants*. The following conditions were used- A) $DBTO_2$ alone (100uM) and assaying HBPS product; B) $DBTO_2$ (100uM) plus 4,6-diMe$DBTO_2$ (100uM) and assaying HBPS product; C) 4,6-diMe$DBTO_2$ alone (100uM) and assaying 4,6-diMeHBPS product; D) 4,6-diMe$DBTO_2$ (100uM) plus $DBTO_2$ (100uM) and assaying 4,6-diMeHBPS product.

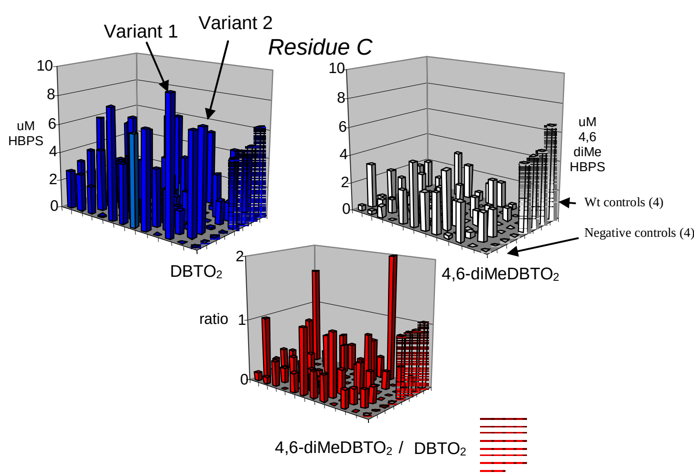


Figure 25. *Primary screening data from GSSM optimization of DszA residue C*. Results from $DBTO_2$, 4, 6-diMe$DBTO_2$ assays and ratio of 4, 6-diMe$DBTO_2$ to $DBTO_2$ activity. Two variants are indicated.

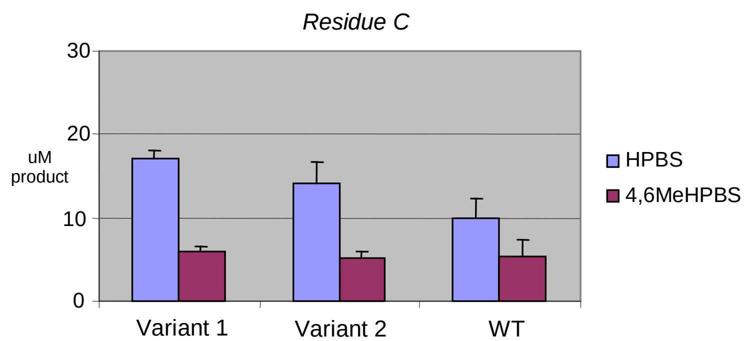


Figure 26. *Secondary screening data for two DszA residue C variants.* Conditions were same as used for primary screening but in replicates of ten.

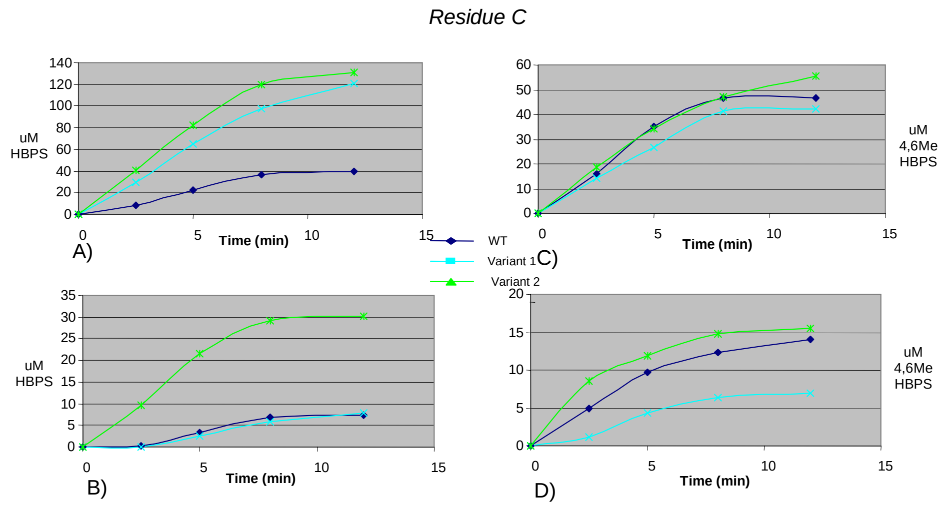


Figure 27. *Tertiary screening data from two DszA residue C variants*. The following conditions were used- A) $DBTO_2$ alone (100uM) and assaying HBPS product; B) $DBTO_2$ (100uM) plus 4,6-diMe$DBTO_2$ (100uM) and assaying HBPS product; C) 4,6-diMe$DBTO_2$ alone (100uM) and assaying 4,6-diMeHBPS product; D) 4,6-diMe$DBTO_2$ (100uM) plus $DBTO_2$ (100uM) and assaying 4,6-diMeHBPS product.

Three mutants with pronounced improvement of activity on 4, 6-diMet$DBTO_2$ vs. $DBTO_2$ were purified at larger scale. As the DszA reaction requires the transfer of reducing equivalents from NADH to $FMNH_2$ via a flavin reductase, activity was determined as a function of the concentration of either the flavin reductase Fre (used in GSSM screen) or DszD (the IGTS8 flavin reductase).

Figure 28 shows the results of these experiments and it can be seen that while the ratio of diMet$DBTO_2$ to $DBTO_2$ activity catalyzed by the wild-type enzyme is unaffected by the amount of flavin reductase added, the three mutants all showed a pronounced effect of flavin reductase levels. At the lowest concentrations of reductase tested, the ratio of diMet$DBTO_2$ to $DBTO_2$ activity is highest, while increasing the amount of flavin reductase results in a less pronounced ratio of diMet$DBTO_2$ to $DBTO_2$ activity, approaching that of the wild-type enzyme at the highest levels of reductase. Although there are differences in the activity supported by Fre vs. DszD (may be a reflection of the specific activity of each preparation), the trend is the same for both.

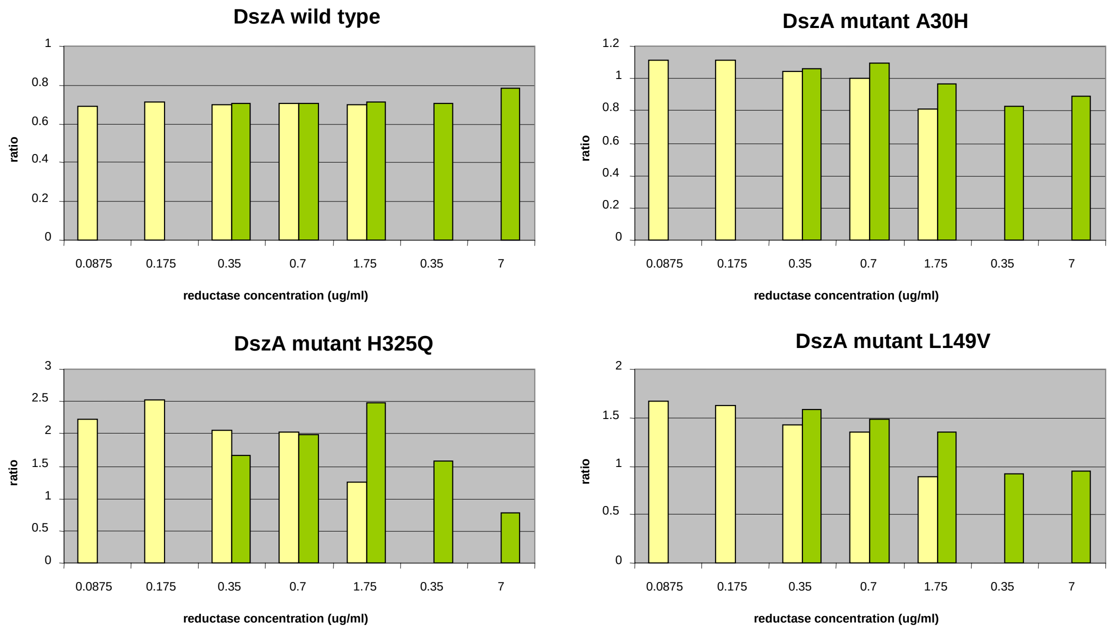


Figure 28. *Effect of varying the amount of flavin reductase on ratio of diMetDBTO$_2$ to DBTO$_2$ activity of DszA mutants.* Yellow bars are data using Fre; green bars are data using DszD.

One possible explanation of this result is that the DszA variants have resulted from a decreased Km (higher affinity) for diMetDBTO$_2$ relative to DBTO$_2$. The higher ratio activity that results from lower reductase levels may reflect the lower availability of reduced FMNH$_2$. As DszA must simultaneous bind three substrates, O_2, FMNH$_2$ and DBT sulfones, an increase in affinity for sulfones will result in a greater likelihood of full substrate-enzyme occupancy.

4.6.6 Bioinformatic analysis of DszA GSSM mutants

To obtain the most information possible from the GSSM mutations to address the structure-function relationship of DszA, we developed a hypothetical model of the DszA structure derived from previously determined structures of related proteins. To construct this model, a template structure was selected. A BLAST search was performed, querying the DszA sequence against the sequences of experimentally determined structures in the Protein Data Bank. DszA's nearest structural neighbor is the *E. coli* alkanesulfonate monooxygenase SsuD (BLAST score of $5e^{-7}$, PDB ID 1m41).

DszA is predicted to have a classic $\beta 8 \alpha 8$ fold also known as a TIM barrel (see **Figure 29**). Typically, substrate binds to the loops that are C-terminal to each canonical strand. The DszA model was generated using the homologous structure of SsuD from *E. coli* (PDB code 1m41, SwissProt entry SSUD_ECOLI). The homology model was created by aligning the homologous sequences and replacing residues of the template structure (1m41) with those of the target sequence (DszA). Labeling corresponds to canonical secondary structural elements.

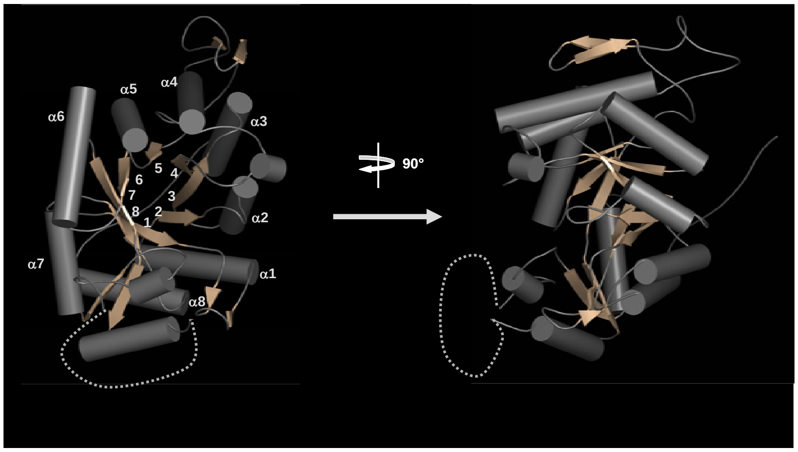
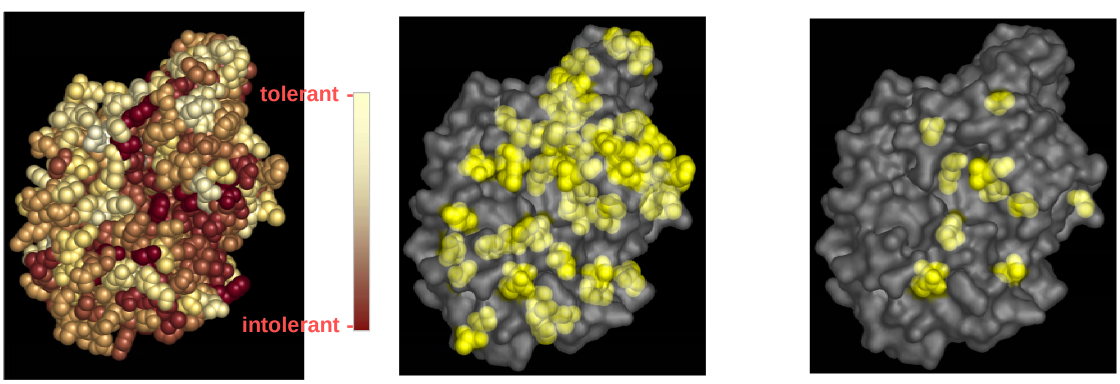


Figure 29. *Ribbon model of DszA derived from threading of E. coli SsuD protein.*

Using this model, we then superimposed the data from the GSSM experiments by mapping tolerant and non-permissive positions onto a space filling model derived from above. In addition, mutants confirmed to have either increased activity on both $DBTO_2$ and 4, 6-dimethyl $DBTO_2$, or increased activity on 4, 6-dimethyl $DBTO_2$ relative to $DBTO_2$ were also mapped. Finally, those mutants that were selected for GeneReassembly were also mapped to this model **(Figure 30).**



GSSM substitution tolerance | Confirmed variants (tertiary screening) | Variants selected for GeneReassembly

Figure 30. *GSSM data superimposed onto DszA space-filled model.*

We have also attempted to use this information, together with sequence alignments from other known DszA enzymes as well as an endosulfan monooxygenase recently described (11) and the SsuD protein to determine candidate active site residues. Of all positions conserved across these proteins, 31 residues were investigated that could act in a catalytic fashion (CDEHST). Of these only 3 did not tolerate substitution as assessed by GSSM (134D, 153E, 174E). Of these, only one (153E) is near the putative

```
DszA_66E5                      DHLSRGRAGWNVVTSLNQAEAQNFGIENHL..
DszA_6701                      DHLSRGRAGWNVVTSLNQAEAQNFGIENHL..
DszA_A3HI                      DQLSGGRVSWN-WTSLNDAEARNFGIDQHL..
DszA_EMT                       DHLSRGRAGWNVVTSLNQAEAQNFGIENHL..
DszA_IGTS8                     DQLSGGRVSWNVVTSLNDAEARNFGINQHL..
DszA_KGB                       DHLSRGRIAWNIVTSLSQAEAQNFGFDDHV..
DszA_Paenibacillus             DHLSKGRAAWNVVTSLNNAEARNFGYEEHL..
DszA_Sphingomonas              DQLSSGRVSWNVVTSLSNAEARNFGFDEHL..
Endosulfan_monooxygenase       DHLSRGRVAWNIVTSLTQSEAQNFGHDDHL..
SsuD E.coli (monooxygenase)    DRLSNGRALFNLVTGSDPQELA--GDGVFL..
                                                  *
```

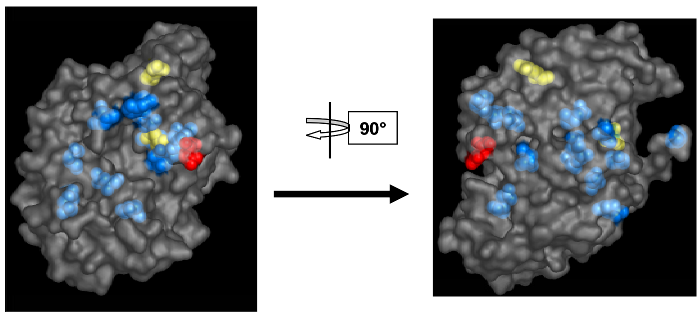


Figure 31. *Hypothetical active site glutamate active residue, indicated by asterisk, as determined by homology and GSSM data.*

active site in the DszA model (**Figure 31)** (the 31 positions investigated were: 57E, 62D, 68D, 95E, 132T, 134D, 137S, 147T, 153E, 174E, 165H, 187D, 189D, 194D, 202D, 210D, 211H, 240S, 252E, 283D, 297E, 323S, 336D, 365E, 371E, 422E, 425D, 440E, 445T and 449H).

4.6.7 GeneReassembly mutagenesis of DszA GSSM mutants.

Thirteen DszA GSSM variants shown to have either a higher ratio of activity with 4, 6-diMetDBTO$_2$ versus DBTO$_2$ or higher activity on both substrates were selected as parents for GeneReassembly **(Figure 32).** GeneReassembly is a proprietary Diversa technology for the complete synthetic blending of parental genes in order to create a random combinatorial library of variants to be screened by high throughput methods for further improved properties relative to the input parents.

Using proprietary software and design parameters, the combinatorial introduction of these variants and their subsequent screening for activity on 4, 6-dimethyl DBTO$_2$ and DBTO$_2$ was carried out. With thirteen parents, the predicted complexity of the library was 2^{13} or 8,192 unique combinations. A total of 15,000 individual transformants was generated, which represented an approximately 2X coverage of the total possible combinations**.**

RESIDUE	Original AA	Mutated AA	$DBTO_2$	4,6diMeDBTO$_2$	4,6diMeDBTO$_2$ /$DBTO_2$
30	A	H	1.47	2.11	1.43
69	G	N	1.59	1.86	1.17
75	S	T	1.53	1.89	1.24
83	G	V	1.33	1.97	1.48
149	L	V	1.08	1.84	1.70
167	A	T	1.60	2.13	1.33
247	A	M	1.08	1.91	1.77
358	F	L	1.23	1.78	1.45
374	R	C	1.97	1.97	1.00
114	A	F	0.76	1.20	1.57
325	H	Q	0.36	1.14	3.16
382	F	V	0.74	1.11	1.52

ratio to wild-type

Figure 32. *GSSM variants selected for GeneReassembly and activity on substrates relative to wild-type parent.*

To assess the quality of the GeneReassembly library, 142 random clones were selected and sequenced. Using proprietary ParentFinder™ software, the parental contribution of each clone was determined. **Figures 33-35** demonstrate the relatively random positional and numeric distribution of the library generated.

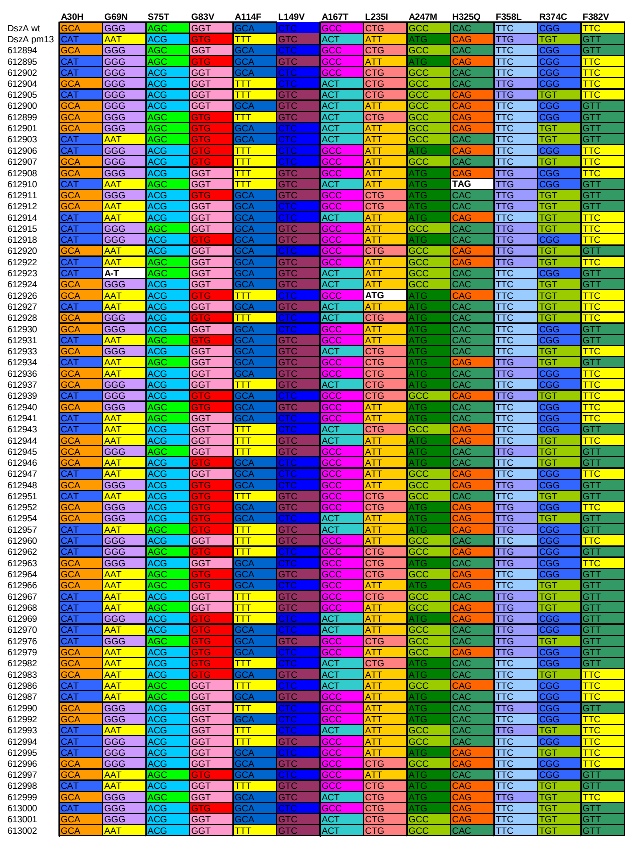


Figure 33. *Parental contribution to each of the 142 randomly selected and sequenced GeneReassembly mutants.*

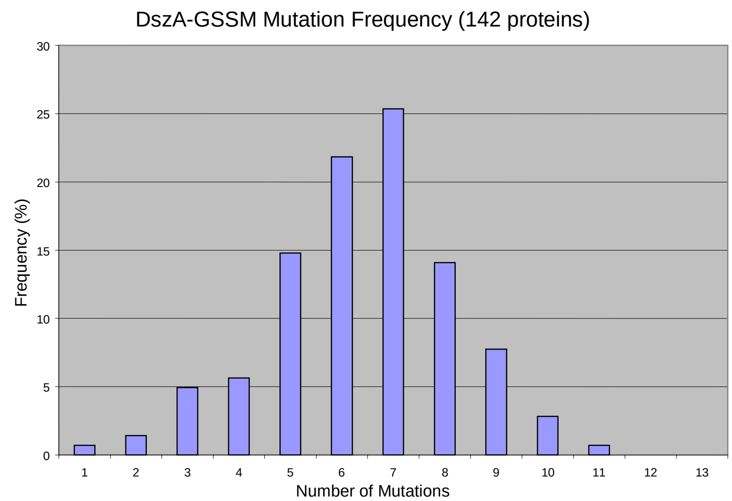


Figure 34. *Distribution of the number of parental contributions to each of the 142 sequenced GeneReassembly mutants*.

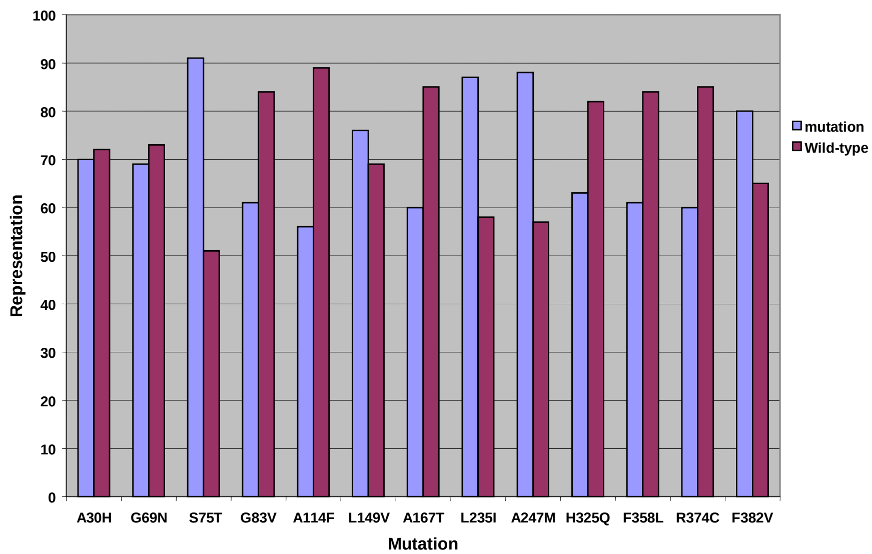


Figure 35. *Relative contribution of each of the parents to the final library as seen in the 142 sequenced GeneReassembly mutants.*

4.6.8 Characterizations of DszA GSSM variants and reassembled derivatives.

As stated above, a total of 15,000 clones were generated. ~4,000 of these reassembled clones were assayed for activity using a similar high throughput assay as described for the primary screening of the DszA GSSM library.

Although a large percentage of clones appeared to have lower levels of activity than the original parent clones (likely as a result of negative combinatorial effects of active site mutants as discussed previously) approximately 70 mutants were selected that had activity equal to or higher than one of the original parent clones selected as benchmark. Six mutants were selected for further study.

As can be seen in **Table 6,** each of the mutants shows increased activity on 4, 6-dimethylDBTO$_2$ (bold numbers) from the wild-type and the benchmark mutant. Although the average number of mutants for the library was ~7 substitutions per clone (plotted from the distribution of the 142 randomly sequenced clones), it is apparent that the clones with improved activity have an average of 3 mutations. Although there is some degree of variation between results from the two separate trials, overall it is apparent that the reassembled mutants have a 1.5-2X improvement of activity for 4, 6-dimethyl DBTO$_2$ as compared to the benchmark single mutant and a 3-4X improvement over the wild-type enzyme. In addition, the results suggest that there is also an apparent increase in activity on DBTO$_2$, although not as dramatic as on the larger substrate. It must be remembered, however, that these enzyme variants have not been purified, so the numbers are not true measurements of specific activity.

	Trial 1	*Trial 2*	*# and location of mutations*
Wild-type	13.6 **4.72**	15.1 **6.12**	*0*
Benchmark	11.1 **8.99**	17.6 **13.2**	*1 L149V*
Mutant 1	21.16 **15.32**	22.56 **15.32**	*3 A30H, S75T, R374C*
Mutant 2	17.92 **15.48**	16.20 **15.68**	*4 S75T, L149V, A167T, R374C*
Mutant 3	21.84 **15.12**	24.76 **16.36**	*2 G69N, S75T*
Mutant 4	23.04 **14.08**	23.04 **13.76**	*3 G69N, S75T, A167T*
Mutant 5	21.12 **16.28**	19.28 **17.40**	*3 S75T, L149V, R374C*
Mutant 6	24.96 **18.16**	23.00 **18.28**	*3 G69N, G83V, R374C*

Normal **-** DBTO$_2$ **Bold – 4,6-diMeDBTO$_2$**

Table 6. *In vitro activities of reassembled DszA GSSM variants on DBTO$_2$ and 4,6-dimethylDBTO$_2$ (in bold) (uM product/endpoint).*

4.6.9 Expression of selected variants in *Rhodococcus*

To determine the behavior of the DszA variants when expressed in *Rhodococcus* IGTS8 two of the mutants were cloned into the expression vector pEBC1104 **(Figure 36),** introduced into *Rhodococcus* CPE648 (a derivative of IGTS8 cured of the pSOX plasmid) and purified using the following protocol:

1) Cells grown and expression induced in BSM medium with DMSO as sole source sulfur.
2) Cells resuspended in phosphate buffer and cells disintegrated using microfluidizer.
3) Cell debris removed by centrifugation and supernatant proteins precipitated with ammonium sulfate.
4) Reverse phase chromatography (RPC) using a gradient of reducing ammonium sulfate.
5) Buffer dilution followed by ion exchange chromatography (MonoQ).

Progress of DszA purification was monitored by immunoblot analysis and *in vitro activity* determination. Results are shown in **Figure 37**.

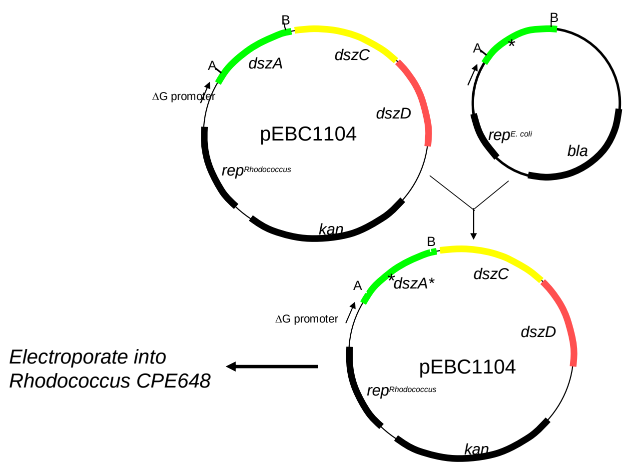


Figure 36. *Plasmid pEB1104 and strategy for cloning DszA variants for expression in Rhodococcus CPE648.*

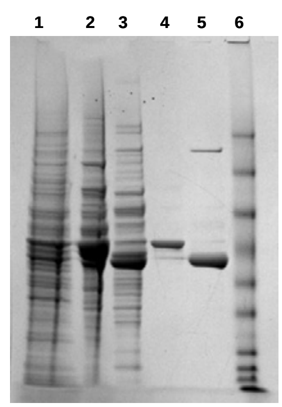


Figure 37. *Purification of DszA and DszC proteins expressed in Rhodococcus IGS8 (pEBC1104). Coomassie Blue-stained SDS-PAGE gel. Lanes: 1) crude extract; 2) DszA-containing fraction from RP; 3) DszC-containing fraction from RPC; 4) DszA-containing fraction from MonoQ; 5) DszC-containing fraction from MonoQ; 6) MW markers.*

From these efforts we saw a high degree of variation in the specific activity of the variant enzymes from batch to batch. Nonetheless, we have seen that the relative activity of the

DszA variants on the two substrates $DBTO_2$ and 4, 6-dimethyl $DBTO_2$ is reproducibly higher with the variants than the wild-type parent. **Figure 38** shows an example of a kinetic experiment using two variants in comparison with wild-type, where the overall wild-type specific activity is lower than normal. **Table 7** shows the specific activity values of this experiment and an additional purification where wild-type activity is higher but the ratio of activity on the two substrates is similar as the first experiment. Again, the variants show a substantially higher activity on the 4, 6-dimethyl $DBTO_2$ substrate vs. $DBTO_2$ than the wild type parent.

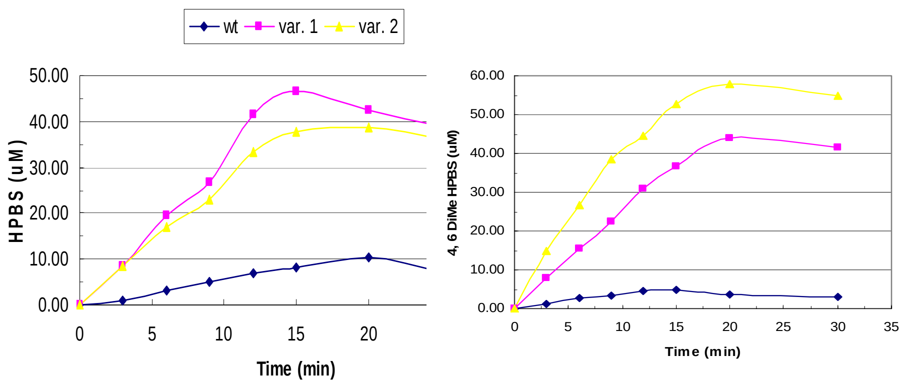


Figure 38. *Kinetic analysis of wild-type DszA and variant activities on $DBTO_2$ and 4, 6-dimethyl $DBTO_2$.*

Variant	Specific activity (uM/min/mg protein) w/ $DBTO_2$	Specific activity (uM/min/mg protein) w/ 4, 6-dimethyl $DBTO_2$	Ratio of Sp. activity	Normalized to wild-type
Wild-type	164	103	0.63	1
1	662	763	1.15	1.83
2	603	1096	1.82	2.88
Wild-type	2468	951	0.39	1
1	1073	917	0.86	2.22
2	868	937	1.08	2.76

Table 7. *Specific activities of wild-type DszA and variants on $DBTO_2$ and 4, 6-dimethylDBTO$_2$.* Two separate kinetic experiments were carried out using material purified on two separate occasions.

4.7 Directed evolution of DszC

Although DszC is the first enzyme in the BDS 4S pathway, it was the second enzyme for which we carried out a directed evolution effort. As in the case of DszA our target was the development of an enzyme with improved ability to oxidize the 4, 6-dimethyl DBT that is recalcitrant to HDS. From the many lessons learned in the optimization of the high throughput assay for directed evolution of DszA, we designed a modified strategy to carry out the DszC effort.

4.7.1 Revision of strategy

As described previously, the determination of the variant substitutions by nucleotide sequencing provided a high degree of confidence in selection and rejection of potential hits. To more completely take advantage of this information, we elected to determine the nucleotide sequence of all DszC variants at each position before carrying out the high throughput activity assays. This allowed us to “cherrypick” and array microtiter plates with known substitutions and served to:

1) reduce throughput, since it was necessary to screen only preselected residues which were arrayed in duplicate, avoiding the need to oversample to insure adequate representation,
2) give a higher degree of confidence in the data since activity can be directly compared between identical or comparable residues,
3) provide information on residues whose modification gives a desirable outcome as well as information on residues critical for activity whose modification leads to a loss of activity.

There are, however, issues that this strategy creates as it is essential to have robust data-tracking procedures in place in order to carry data through from sequencing, arraying and assaying to analysis. With this in mind we developed procedures that included automated clone arraying, plate tracking, data analysis and report generation.

4.7.2 Optimization of high throughput assay

A variety of conditions and experiment protocols were tested in order to develop the most reliable and robust assay for evaluating DszC GSSM variants. Variables that were tested included alternate *E. coli* host strains, incubation and induction conditions, various lytic preparations for releasing enzyme from induced cells and substrate concentrations.

The induction of enzyme expression, lysis of cells and order of addition of reagents is very similar to that previously described for the DszA GSSM assays. In the assay protocol, 50uM DBT and 50uM 4, 6-dimethylDBT were added as substrates and the reaction proceeded at room temperature for 30 minutes. Reactions were quenched by the addition of an equal volume of acetonitrile and products were assayed by LC/MS/MS as described previously.

4.7.3 Results

As in the case of the DszA GSSM effort, we were able to identify sites that were both permissive and restrictive positions to substitutions. **Figure 39** shows a typical permissive residue where the wild-type can be replaced by any other substitution tested. **Figure 40,** in contrast, shows a residue where not other residue other than wild-type can substitute. Throughout the protein were seen residues that were of varying degrees of permissiveness or restriction.

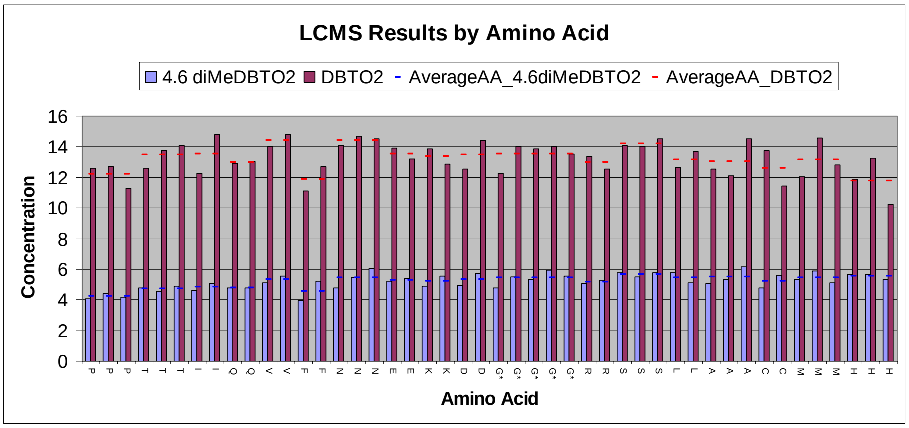


Figure 39. *Result of DszC GSSM variant activity screening for a "permissive" residue on DBT and 4, 6-dimethylDBT.*

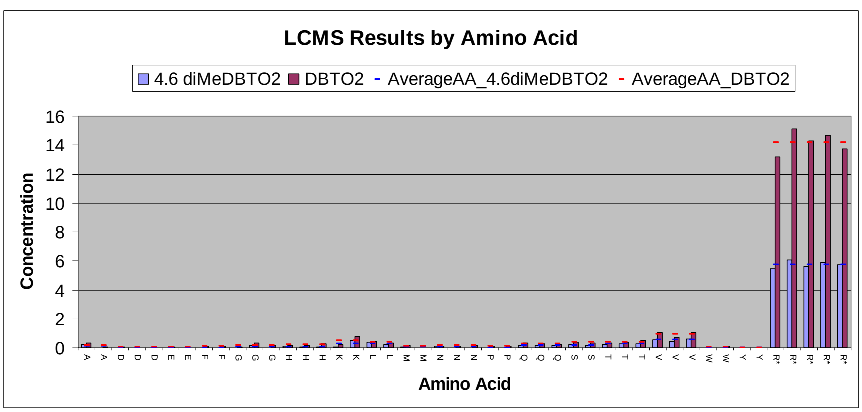


Figure 40. *Result of DszC GSSM variant activity screening for a "restrictive" residue on DBT and 4, 6-dimethylDBT.*

In the initial primary screening of the DszC GSSM library, a total of 91 putative "upmutants", with either an improved ratio of activity on 4, 6-diMeDBT vs. DBT or an increase in apparent total activity, were identified. These were then characterized by a rigorous secondary screening effort, with a high degree of replication for each during assaying. Of the original 91 mutants, only three were found to be significantly improved relative to the wild-type benchmark.

To further confirm the properties of these three mutants, plasmid DNA from each were purified and used to retransform a “naive” *E. coli* host. The resultant transformants were then reassayed for activity on 4, 6-diMeDBT vs. DBT.

Unfortunately, none of the three mutant variants demonstrated significantly different activity than the wild-type control, although the original parental clone still showed the improved activity. This suggested that it was a change in the *E. coli* host background that affected the change in activity. Upon reevaluation of the DNA sequence data from the plates of mutations that the three variants were derived, it was apparent that each was the sole representative of that particular substitution, providing further evidence that the effect was due to an infrequent change in the host itself. Although an interesting observation, we did not follow up further because of the irrelevance of the observation to the development of a final biocatalyst host.

Interestingly, we were able to identify residues whose modification resulted in a significant loss in activity on the 4, 6-dimethyl DBT substrate relative to DBT. **Figure 41** shows an example of one such residue and it can be seen that the substitution of some residues, such as tryptophan (W), have a profound effect on the ability of the enzyme to convert the 4, 6-dimethyl DBT substrate. These results would suggest that this residue either directly or indirectly contributes to the shape of the substrate binding pocket and certain substitutions prevent interaction with the more bulky dimethylated substrate.

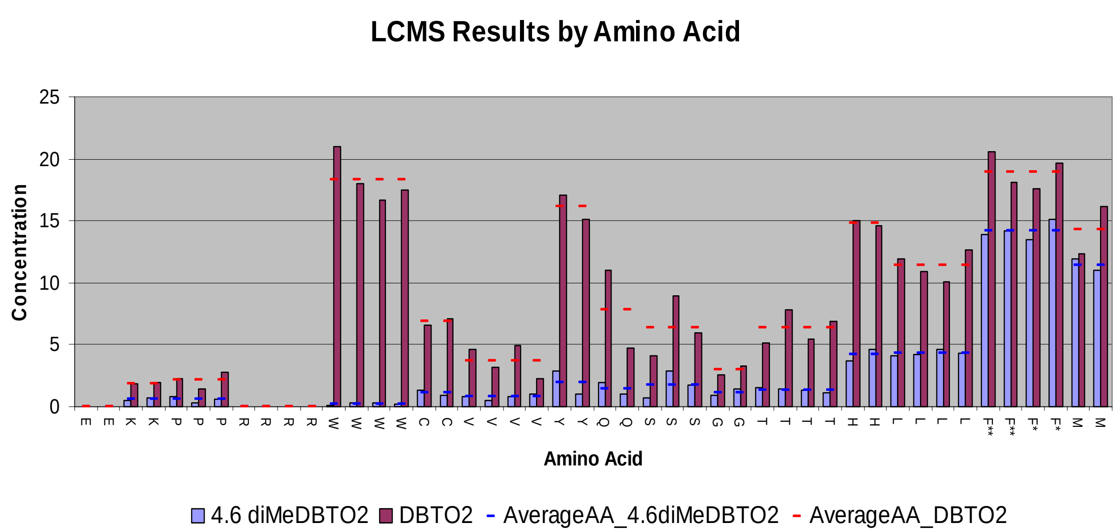


Figure 41. *Example of a DszC residue showing substitutions leading to a selective reduction in activity on 4, 6-dimethyl DBT.* Wild-type residue is indicated by asterisk; results reflect amount of product in a predefined time.

4.7.4 Bioinformatic analyses of DszC GSSM mutations

As described for DszA, it was necessary to identify a protein homolog with a know structure in the PDB database. This model was built by threading onto the known crystal structures of an acyl-CoA dehydrogenase, to which DszC shows significant homology when comparing secondary structure and known protein folds

Figure 2 shows the results of this DszC structural prediction. From this model, a few observations can me made. First, substrate binding site appears to be at the nexus of the three major structural domains, with key residues indicated in yellow. It is this region, at the vertex of helical domains that appears to impact substrate specificity since it is this region where mutations that selectively reduce activity on 4, 6-diMeDBT, relative to DBT, are found.

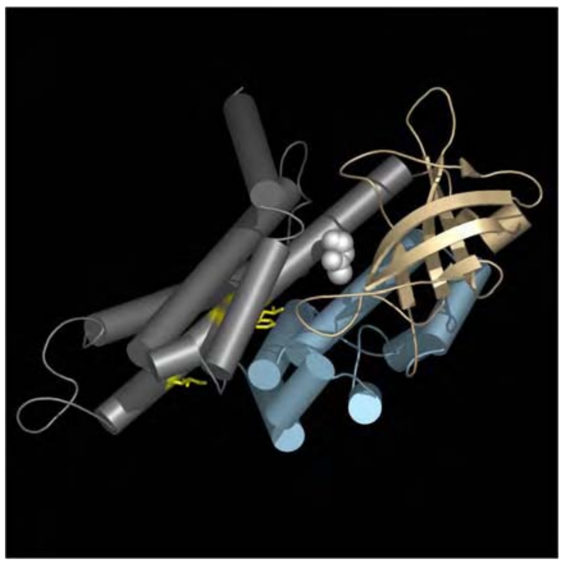


Figure 42. *Structural model of DszC derived from threading to the known structure of an acyl CoA dehydrogenase.*

Figure 43 summarizes the results of the DszC GSSM by mapping restrictive-permissive residue substitutions onto a space-filling model of the DszC protein. As can be seen, restrictive residues tend to cluster and may define substrate binding sites as compared to the known binding sites of the acyl-CoA dehydrogenase. In addition, as it is known that the acyl-CoA dehydrogenase is found as a homotetramer, composed of two symmetrical dimmer structures, it appears that a number of non-permissive residues may map to a hypothesized dimmer contact zone.

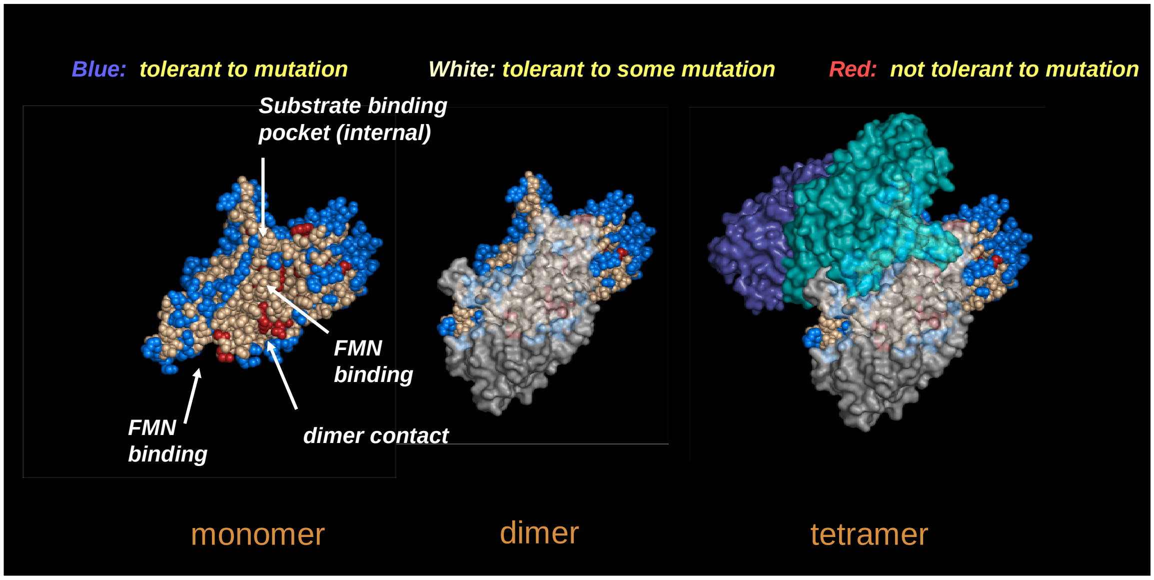


Figure 43. *Mapping of DszC GSSM residue substitutions to a predicted structure of DszC.* Based on homology to the acyl CoA dehydrogenase monomer, homodimer and tetramer.

4.8 Identification of alternate hosts

Although *Rhodococcus* IGTS8 has been the prototype strain for biodesulfurization, it is possible that other organisms may represent potentially better organisms for biocatalysis. Properties such as faster growth rates and general robustness may also be important properties in the development of an economically viable biocatalyst. With this in mind, we set out to characterize >130 *Rhodococcus* and related strains to identify potential hosts for the introduction of the biodesulfurization genes and comparison of properties to *Rhodococcus* IGTS8. *Rhodococcus erythropolis*, *R. globerulus*, *R. opacus*, *R. ruber* and *R. rhodochrous*, as well as *Gordonia ruberperfincta* strains were obtained from both the ATCC and DSM culture collections. Phenotypic characterizations included the ability to utilize rich and minimal media under a variety of aeration conditions, and ease of plating to identify strains that could most easily be genetically manipulated.

4.8.1 Growth characteristics

From initial experiments it is clear that a subset of strains have significantly more robust growth properties as compared to *Rhodococcus* IGTS8. In particular, a number of isolates, primarily *Rhodococcus opacus* strains, were able to grow to higher density with significantly less aeration and may represent strains that are capable of utilizing available oxygen more effectively. These strains all demonstrated extremely robust growth characteristics in liquid and solid, as well as rich and minimal, media. Each was capable of reproducible formation of large uniform colonies on minimal agar medium and growth to maximum density on minimal liquid media within 18-24 hours at 30°C.

From descriptions in the literature, *R. opacus* strains are capable of growth on a wide variety of carbon sources including acetate and ethanol and are also able to store large amounts of triacylglycerols when grown under appropriate conditions (**Figure 44)** (12)**.** Stored triacylglycerols represent a ready source of cellular reductant upon mobilization and could be envisioned to minimize the need to provide exogenous carbons sources to provide reductant for biodesulfurization reaction.

Figure 44. *Electron micrograph of Rhodococcus opacus DSM 43943 and accumulated droplets of triacylglycerols.*

4.8.2 Genetic amenability

As mentioned above, another important criterion for the potential development of new strains as biodesulfurization biocatalyst is the ability to be genetically manipulated. To assess this property of the twenty *R. opacus* strains, each was prepared for electroporation using a method developed for IGTS8. Plasmid pEBC1100 was then used to test the ability of each to receive DNA. This plasmid expresses the entire *dszABC* operon as well as DszD, encodes kanamycin resistance and can confer the complete 4S pathway phenotype onto a recipient.

Kanamycin-resistant clones were selected after electroporation of the strains. From these experiments, it was determined that seven of the twenty strains were not able to be efficiently electroporated and were dropped from further consideration as biocatalyst hosts due to the need for their genetic manipulation at later stages in the project. Results for ten of the strains, in terms of qualitative efficiency of electroporation are shown in **Figure 45.**

Strain	*Efficiency*	*Strain*	*Efficiency*
43250	+	44236	+++
43251	+	44305	++
43252	++	44311	+++
43943	++++	44312	++++
44193	++++	46027	++

Figure 45. *Electroporation efficiency of representative Rhodococcus opacus strains*. Measured with pEBC1100 as electroporation substrate. All strains are from the Deutsche Sammlung von Mikroorganismen und Zellkulturen (DSMZ).

4.8.3 In *vivo* biodesulfurization activity

The remaining thirteen strains, each containing pEBC1100, were then tested for their ability to use DBT, $DBTO_2$ or HBPS as sole source of sulfur when grown on minimal medium, **Figure 46** shows the results of these experiments, with growth being expressed qualitatively.

Strain	*DBT*	*$DBTO_2$*	*HPBS*
44236	++	++	+/-
43252	+/-	++	++
44311	+++	+++	+++
43943	+++	+++	+++
46027	-	+++	-
44186	+	++	+
44315	-	+++	++
44307	+/-	+++	+
44193	+++	+++	+++
44251	-	++	+/-
44312	+++	++	+++
44305	-	++	-
43250	+/-	++	+/-

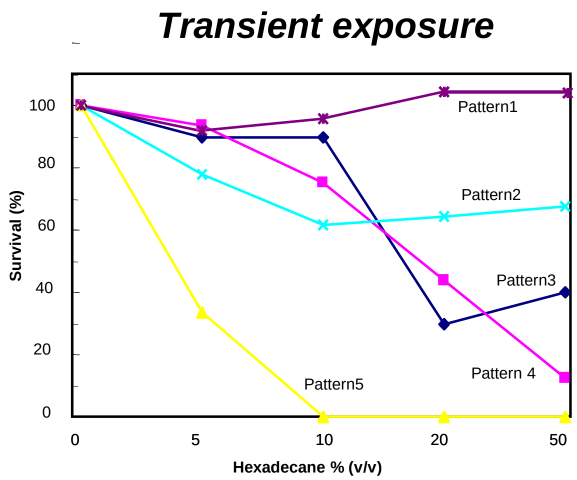
Figure 46. *Utilization of organosulfur compounds by R. opacus strains as sole source of sulfur in strains containing pEBC1100.* All strains are from the DSMZ.

4.8.4 Survival on exposure to hexadecane and diesel

Another important property of a potential biocatalyst strain is the ability to survive exposure to organic solvents and diesel fuel. Both the ability to survive a transient exposure as well as continuous exposure was tested for the subset of *R. opacus* strains that demonstrated activity on DBT, $DBTO_2$ or HBPS.

To determine survival after transient exposure to hexadecane, various amounts of hexadecane were added to a diluted suspension of the organism (10^5 CFU/ml) to be tested and samples were taken after 15 minutes of exposure. A high degree of variability was seen between experiments, most likely due to difficulty in completely separating cells from the hexadecane/water interface. Overall, patterns of survivability could be seen with each strain in comparison to IGTS8 and derivatives JB55 (*dszABC* deletion mutant - retains the remainder of the pSOX plasmid) and CPE648 (cured of pSOX plasmid). From these patterns an overall score was generated for each strain that qualitatively describes survivability under these conditions (**Figure 47**).

Using this scoring scheme, strains exhibiting pattern 1 are most tolerant, and pattern 5 are least tolerant. By combining results from multiple experiments, it can be seen that overall, IGTS8 and its derivatives are more tolerant to hexadecane than most *R. opacus* strains. Some, however, such as DSM43250, DSM43236 and DSM44312, appear to be nearly as tolerant. It is interesting to note that IGTS8 is noticeably more tolerant than its derivatives CPE648 and JB55, which appears to correlate with its more pronounced mucoidy and presumed production of biosurfactant (see below).



	A	B	C	D	E	AVG
IGTS 8	1	1	1	1	1	1
CPE 648	2	3	2	2	2	2.2
JB-55	3	2	2	3	2	2.4
43250	2	2	1	2	2	1.8
43251	4	4	4		4	4
43252	2	4	2	2	4	2.8
43943	5	4	5	5	4	4.6
44186	4	5	4	4	5	4.4
44193	5	5	4	5	4	4.6
44236	3	2	2	2	2	2.2
44305	1	4	1	1	4	2.2
44311	4	5	4	4	5	4.4
44312	3	2	3	2	3	2.6

Figure 47. *Transient survivability of strains with hexadecane.* A) Patterns of survivability seen in multiple experiments; B) Scoring of strains, 1-5, using pattern in A) with 1 being best, 5 being worst. All strains are from the DSMZ.

To determine the ability of each of the strains to survive *continuous exposure to either hexadecane or diesel* strains were diluted to 10^4 CFU and plated onto medium that had previously been covered with a layer of either hexadecane or Petro Star diesel. After 2 weeks of incubation, the number of CFU as compared to a control plate with no treatment was determined and survival rate indicated **(Figure 48).**

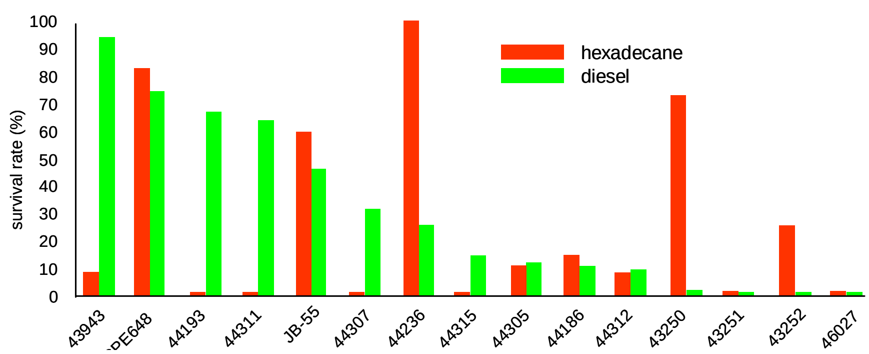


Figure 48. *Continuous survivability of strains with hexadecane.* All strains are from the DSMZ.

From these experiments, it was apparent that many of the strains that were most tolerant in the transient exposure, such as DSM44236, DSM43252, DSM43250, were also found to be tolerant in this experiment. Surprisingly strains such as DSM44186 and DSM43943 did not stand out in the transient exposure experiment but did survive continuous exposure. This may be a result of inadequate partitioning in the transient exposure experiment, with cells remaining associated with the hexadecane phase and not being plated for CFU determination.

It is clear from these experiments that IGTS8 and its derivatives are comparatively resistant to hexadecane and diesel and suggests that they express specialized properties for this resistance. It has been suggested that IGTS8 produces a biosurfactant that contributes to both its survival to hydrophobic compounds and its biodesulfurization ability. Extensive characterization of surfactants from *Rhodococcus*, *Nocardia* and *Mycobacterium* species suggests that they are sugar ester derivatives (primarily trehalose as sugar) of the cell wall mycolic acids that are found in these organisms. Surprisingly, little is known about the genetic basis of *Rhodococcus* biosurfactant production. Any use of alternate *Rhodococcus* strains for biodesulfurization is likely to benefit from the expression of these biosurfactant compounds

4.8.5 Whole cell two-phase BDS activity

From the above experiments we selected four *R. opacus* strains for further evaluation by carrying out two-phase whole cell oxidation experiments, using DBT substrate in a hexadecane matrix. Into each of the strains, we introduced plasmid pEBC1104, which encodes *dszA*, *dszC* and *dszD*, but is missing the *dszB* gene. Since DszB is not expressed, the final product of oxidation from DBT is HBPS, whose accumulation was monitored to evaluate BDS activity. As can be seen in **Figure 49,** the *R. opacus* strain DSM 43943 was noticeably more active only a longer period of time, in comparison to DSM44311, which although it had a faster initial rate, appeared to reach a maximum, extent at ~40 hours.

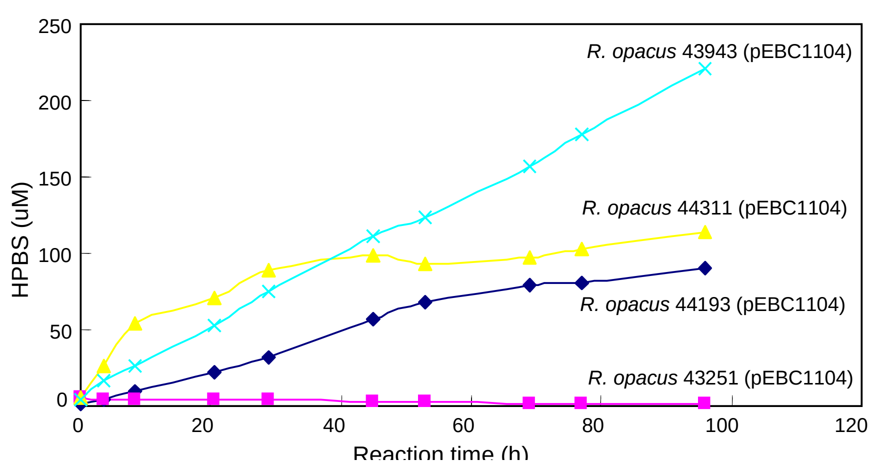


Figure 49. *Whole cell BDS activity of R. opacus strains containing pEBC1104.*

To further evaluate this difference between DSM43943 and DSM44311, we carried out additional whole cell reactions and evaluated both HBPS appearance and DBT depletion in order to insure mass balance of the constituents and that HBPS was not being converted to another product. As can be seen in **Figure 50,** the disappearance of DBT and appearance of HBPS was reciprocal, demonstrating again that DSM 43943 was clearly able to sustain DBT oxidation to completion in this assay.

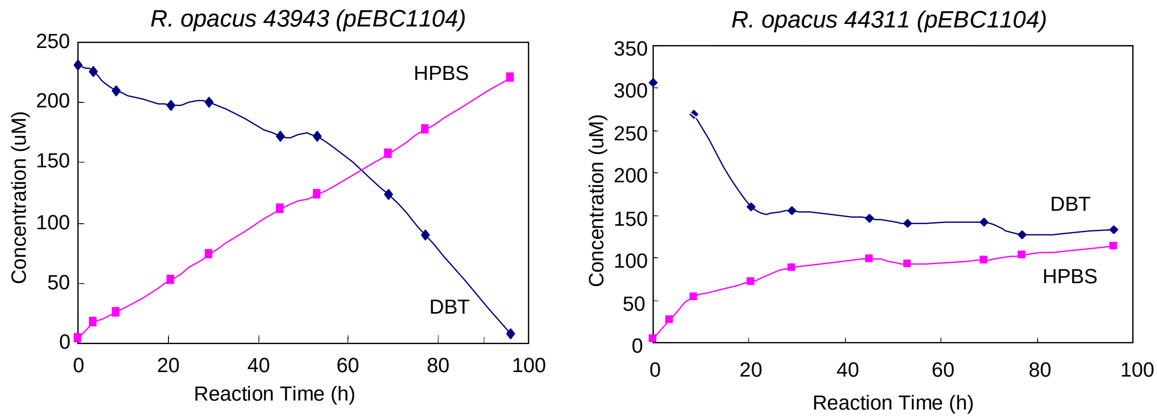


Figure 50. *Whole cell BDS activity of R. opacus strains DSM 43943 and DSM 44311containing pEBC1104.*

4.8.6 Contribution of pSOX genes to BDS activity

To determine if additional genes are present on the IGTS8 pSOX plasmid that contribute to biodesulfurization activity, plasmid pEBC1104 was introduced into CPE648 (a derivative of IGTS8 cured of the pSOX plasmid), JB55 (a derivative of IGTS8 with the *dsz* genes deleted from pSOX) and *R. opacus* strain 43943. In addition, *Rhodococcus* IGTS8 derivative BKO53A was included.

BKO53A is a strain previously constructed by Energy Biosystems that demonstrated the highest level BDS activity of any strain previously reported and served as their benchmark for any further development. This strain contains the pSOX plasmid modified to include cointegrated, additional copies of the *dszA*, *-C* and *D* genes, under the control of the ΔG promoter, a variant of the normal *dsz* promoter that is less sensitive to inorganic sulfur repression. In addition, the *dszB* gene has been deleted and replaced with a chloramphenicol acetyltransferase gene, conferring chloramphenicol resistance to the strain.

As can be seen in **Figure 51,** JB55 (pEBC1104) shows more long-lived rate of BDS activity compared to CPE648, suggesting that pSOX may express additional gene products that contribute to continuing activity of the biocatalyst over time. It can also be seen that the *R. opacus* host shows higher levels of sustained activity than either of the IGTS8 backgrounds, suggesting that longevity of the biocatalyst is more robust in this host in the hexadecane model system. BKO53A, however, still demonstrates the highest level of activity and completely removes all substrate after twenty hours.

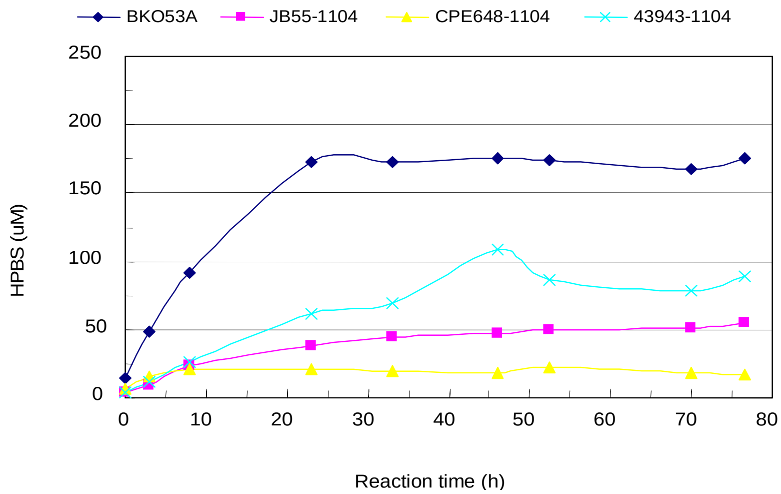


Figure 51. *Activity of pEBC1104-containing strains in DBT-hexadecane shake flask assay.* Reactions contained 0.6% DBT in hexadecane at a 3:1 WOR. Equivalent dry cell weights were added for each.

4.8.7 Introduction of pBKO53A into *Rhodococcus opacus*

Since we had observed that *R. opacus* DSM 43943 exhibited higher levels activity than either IGTS8 derivatives CPE648 or JB55 containing pEBC1104, we wanted to determine if the introduction of the pBKO53 plasmid (modified pSOX plasmid) from the IGTS8 derivative BKO53A would confer comparable or better BDS activity. It had been previously reported (3) that the pSOX plasmid might be conjugatable and we had also evidence that transfer genes were found in the pSOX plasmid (see below).

With this in mind we attempted to transfer the pBKO53A plasmid to DSM 43943 by conjugation. A spontaneous rifamycin-resistant derivative of DSM 43943 was generated and used as a recipient in a biparental mating with IGTS8 BKO53A as donor. Since pBK053A was generated by cointegration of a chloramphenicol-resistant *E. coli* cloning vector into the native pSOX plasmid, rifampicin- and chloramphenicol resistant exconjugants were isolated. Two independent colonies were purified and confirmed to be *R. opacus* DSM 43943 by sequence comparison of the 16S DNA to the parent strains.

The two *R. opacus* 43943 (pBKO53A) clones were tested for BDS activity in a two phase hexadecane-DBT assay and compared to the IGTS8 BKO53A strain as well as a DSM 43943 control strain (**Figure 52**). Both strains exhibited comparable activity and equal or better activity to the IGTS8 BKO53A benchmark strain.

4.8.8 Characterization of biocatalyst activities on partially hydrotreated diesel.

As previously discussed, we are considering the combination of the hydrotreatment and biodesulfurization processes as having the most likelihood of success. With this in mind, we set out to characterize the activities of candidate biocatalysts on the partially hydrotreated material.

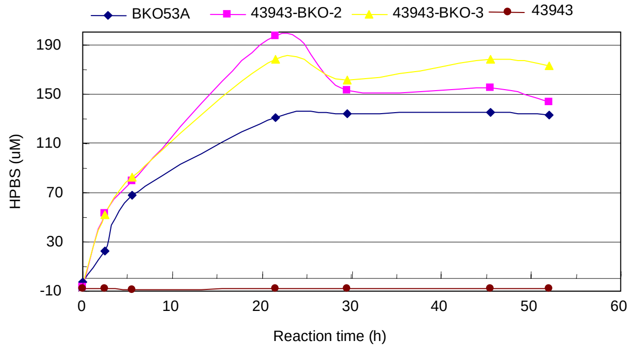


Figure 52. *Whole cell BDS activity of IGTS8-derivative BKO53A compared to two independent isolates of R. opacus DSM43943 containing pBKO53A plasmid.* Reactions contained 0.6% DBT in hexadecane at a 3:1 WOR. Equivalent dry cell weights were added for each.

Both the *Rhodococcus* IGTS8 (pBKO53A) and the *Rhodococcus opacus* (pBKO53A) strains were tested for their ability to remove sulfur from partially hydrotreated diesel the 418ppm **(Figure 53).**

Rhodococcus IGTS8 (pBKO53A) *Rhodococcus opacus* (pBKO53A)

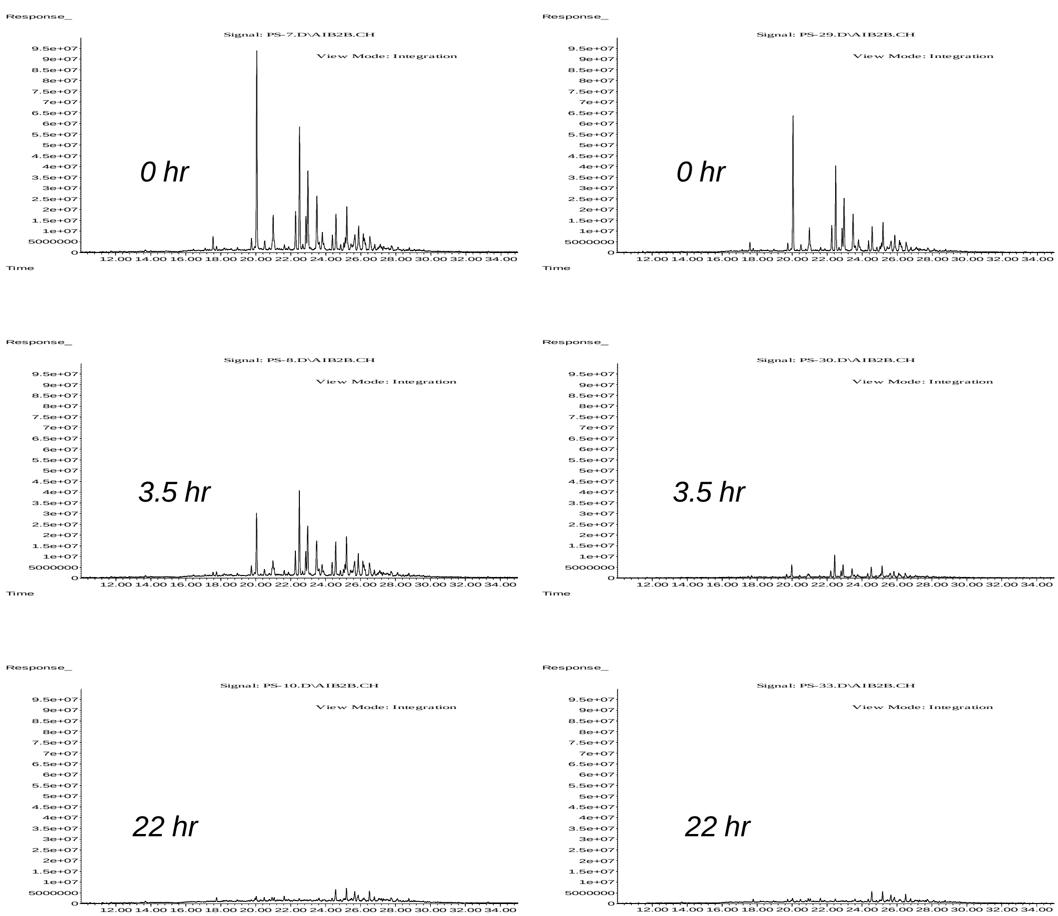


Figure 53. *Time course of biocatalyst activity on partially hydrotreated diesel fuel (418ppm) showing reduction of Cx-DBT compounds.*

When the quantification of each of the Cx-DBTs was determined, little difference was seen between the performances of the two different biocatalysts. As can be seen in **Figure 54** (showing the results of the IGTS8-BKO53A biocatalyst) the reduction of Cx-DBT compounds is nearly complete at fifty hours while the remaining total sulfur content remains levels off earlier and does not appear to be acted upon by the biocatalyst. This residual sulfur is likely to be represented by the “hump” that is seen to remain at the 22 hour time point (**Figure 55**).

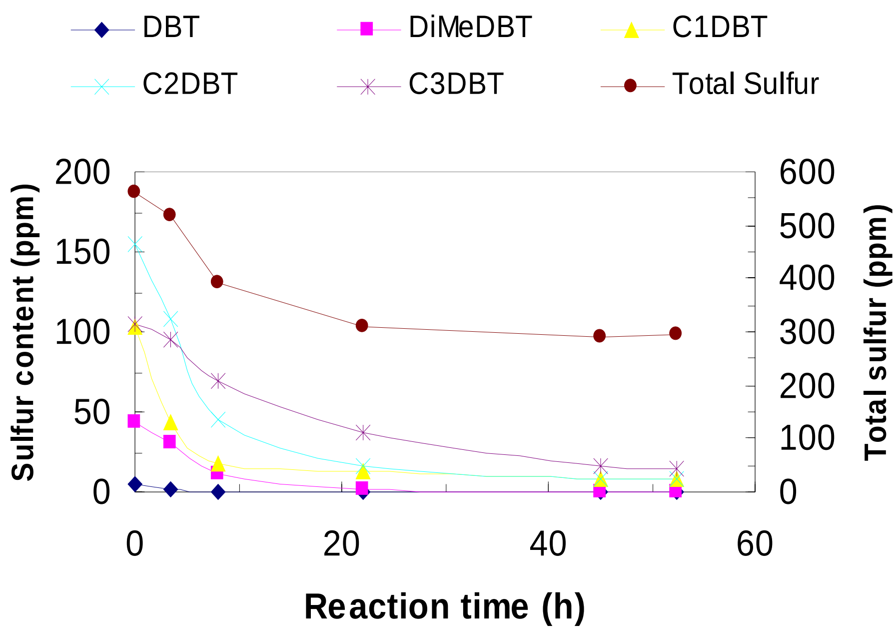


Figure 54. *Time course of IGTS8-BKO53A biocatalyst activity on partially hydrotreated diesel fuel (418ppm).*

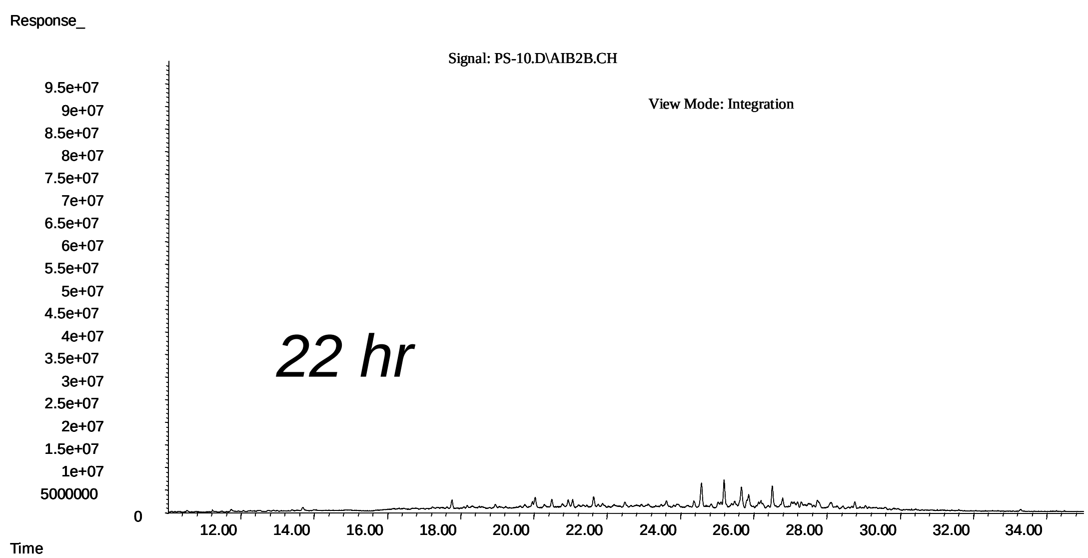


Figure 55. *Expanded chromatogram of 22hour time point.* From Figure 53 (IGTS8-BKO53A) showing residual “hump” of sulfur compounds not acted upon by biocatalyst.

This suggests that there are compounds that are resistant to the effects of the biocatalyst even in this partially hydrotreated diesel. It is unlikely to be C_x-DBT compounds of C4 or higher because of their negligible contribution to total sulfur. Instead, this would appear to be the presence of a highly heterogeneous group of compounds that are not substrates for the biocatalyst. To further illustrate this point, we carried out the BDS treatment of diesel that has been hydrotreated further to 43ppm total sulfur. **Figure 56** shows the results of this treatment and again demonstrates that, while the C_x-DBT content is nearly completely removed, a significant amount of sulfur remains that does not appear to be a substrate for the biocatalyst. As can be seen in previous GC/SCD traces, a small but detectable "hump" of sulfur-containing compounds is found even in the deepest hydrotreated fuels (**Appendix 2**). No obvious peaks however can be seen, suggesting again that this material is a highly heterogeneous population of species with apparent masses of less than C_5-DBTs. This indicates that the failure of the biocatalyst to remove this material is not as a result of mass transfer or solubility problems with high molecular weight C_x-DBT compounds but due to the inability of the biocatalyst to act on these unknown species.

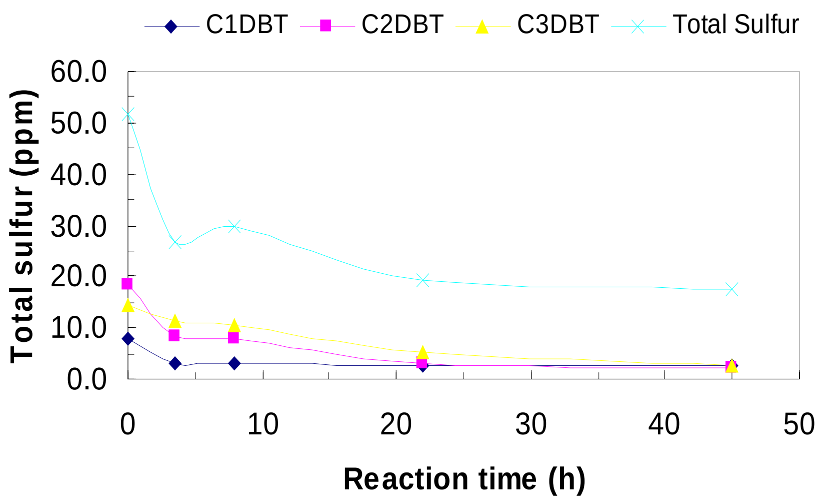


Figure 56. *Time course of IGTS8-BKO53A biocatalyst activity on partially hydrotreated diesel fuel (43ppm).*

To determine if there may be differences in the ability of these two hosts to use endogenous reductants as sources of redox equivalents in the oxidation of DBT, both strains were tested with and without the addition of glucose for their ability to oxidize partially hydrotreated diesel fuel. As can be seen in **Figure 57** both strains required the addition of glucose for full activity, but it appears that *Rhodococcus opacus* 43943 is able to sustain a low level of oxidation over the course of the assay. In contrast, activity of IGTS8 appears to level off after 25 hours. To further define this observation, oxidation of individual DBT species was determined. Again, it can be seen that the *R. opacus* strain appears to sustain a low level of oxidation of each of the Cx-DBTs monitored over time where the IGTS8 levels off **(Figure 58).**

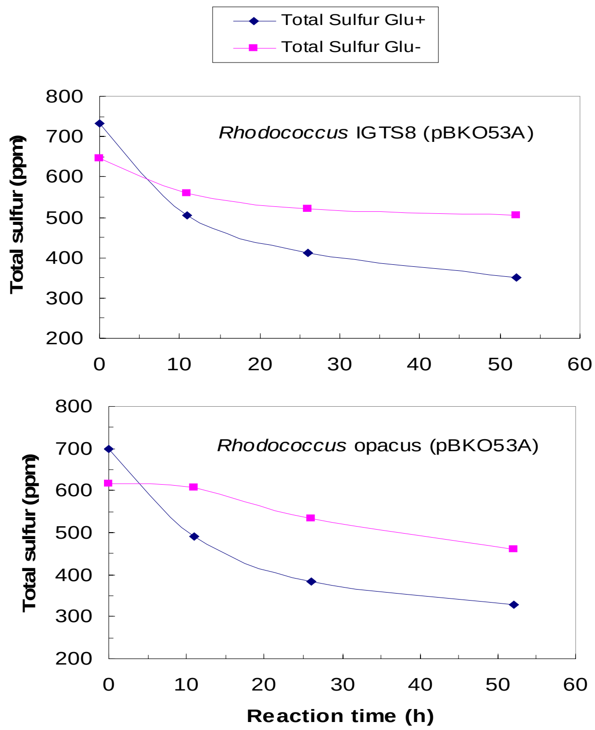


Figure 57. *Activity of biocatalysts on partially hydrotreated diesel fuels with and without the addition of glucose as reductant and the effect on total sulfur.*

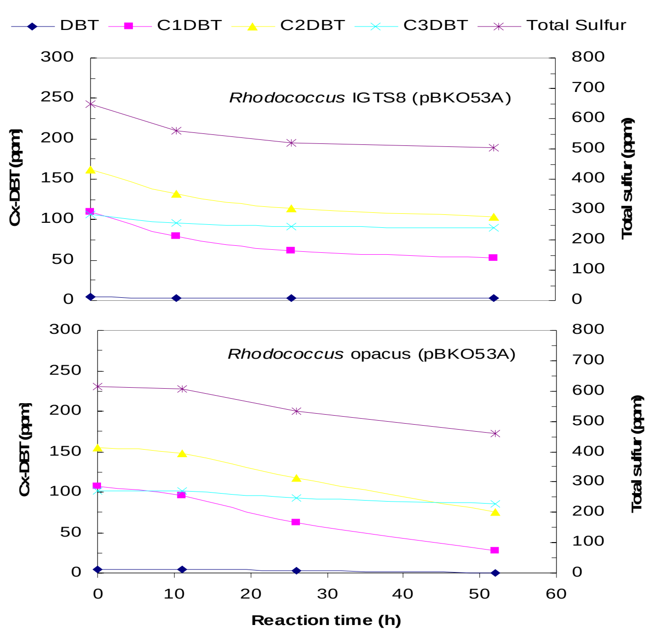


Figure 58. *Activity of biocatalysts on partially hydrotreated diesel fuels with and without the addition of glucose as reductant and the effect on C_x-DBT compounds.*

4.8.9 Stability of pBKO53A in host strains

As we had previously noted, there are some differences in the tolerance of the two strains to diesel fuel. In addition, we have noticed there is also a general instability in the maintenance of the pBKO53A plasmid as detected by loss of chloramphenicol resistance upon passage. To test this we carried out another plating efficiency experiment with each of the strains containing pBKO53A by plating dilutions cells onto BSM-glucose, BSM-glucose with chloramphenicol and BSM-glucose with chloramphenicol overlaid with diesel. **Figure 59** shows the results of this experiment where the total colony forming units of the latter two conditions were compared to the cells plated onto BSM-glucose.

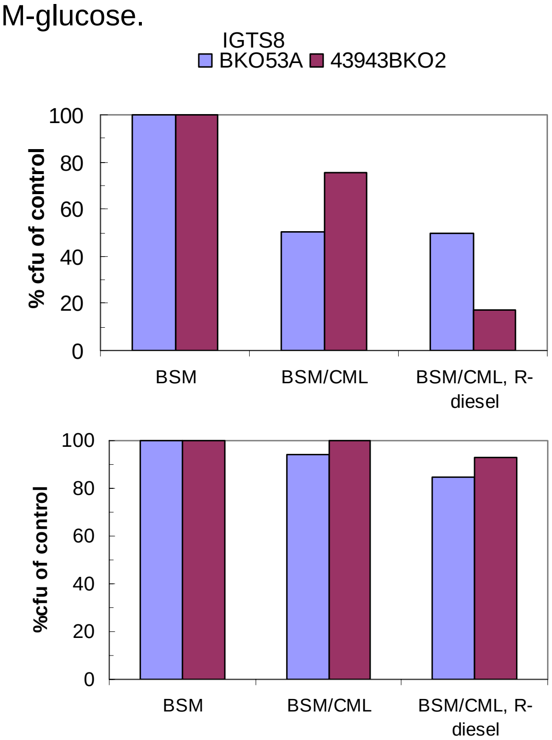


Figure 59. *Relative plating efficiencies of strains.* CFUs compared upon addition of chloramphenicol and diesel overlay to number of cells plated on BSM-glucose alone.

From these results it is apparent that there is instability of maintaining pBKO53A in both hosts although it appears to be less pronounced in the *R. opacus* strain. We have, however, seen that the growth of *R. opacus* 43943 carrying the pBKO53A plasmid is less vigorous than the parent strain and is of concern if robustness of growth is a distinguishing characteristic of this strain. When cells are plated on BSM-glucose with diesel overlaid, it is apparent that *R. opacus* 43943 is less resistant to the diesel fuel.

During these experiments, it was noticed that *R. opacus* 43943 colonies that survived the overlay with diesel had a different morphology than the originally plated cells. These colonies appeared “dry” and spread across the plate (**Figure 60**). To test whether this phenotype was associated with resistance to diesel, colonies were resuspended in BSM liquid media and replated onto BSM-glucose with chloramphenicol and a diesel overlay.

As can be seen in **Figure 60,** these cells retained there resistance to diesel fuel as well as maintaining the pBK053A plasmid.

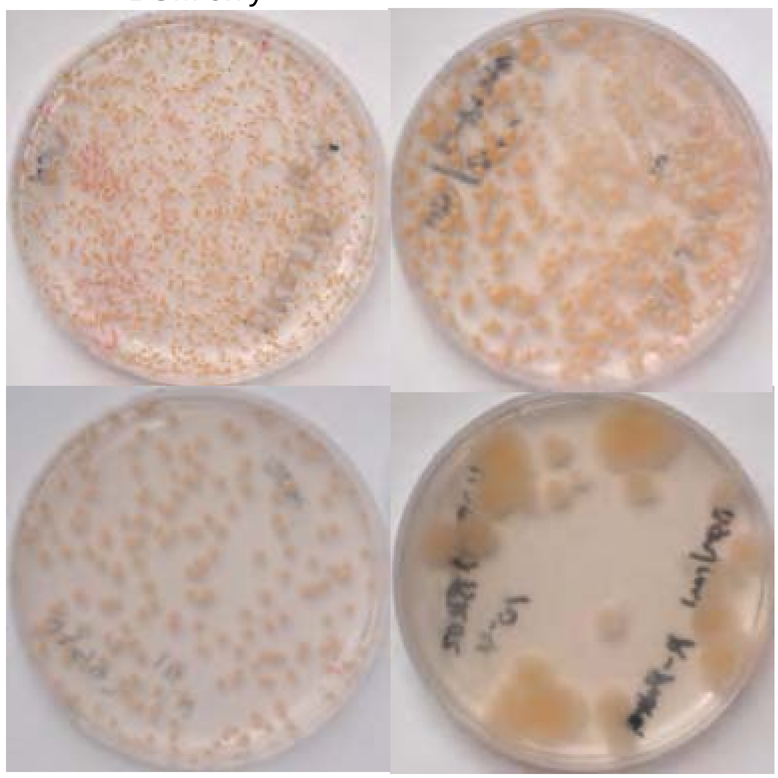


Figure 60. *Phenotypes of Rhodococcus hosts on BSM-glucose and BSM-glucose overlaid with diesel.*

4.9 Generation of an antibiotic-free stable *dsz* expression system

4.9.1 Background and strategy

The development of a commercially viable BDS host requires that the catalytic activity be stable throughout the entire process. Since the results described above indicate that the modified pSOX plasmid is unstable in the absence of antibiotic selection pressure, it was necessary to generate a system for stabilizing expression without the need for addition of antibiotics. In a commercial large-scale fermentation unit of the sort required for BDS it would be very difficult to insure that antibiotic resistance genes from the host organism are not released into the environment, as mandated by the EPA, without an expensive addition to the process to sterilize the waste stream and remove all DNA.

An alternative strategy to antibiotic selection would be to use a chromosomal auxotrophic mutant (requirement for a growth factor that the wild-type prototrophic strain does not require) as host and a complementing gene as selection marker on the vector for expression of recombinant genes.

With this in mind, we selected thymidylate synthase (ThyA), an essential gene for purine and nucleic acid metabolism, as the selectable marker. This enzyme is absolutely required by all living organisms for prototrophic growth (**Figure 61**). Mutations in this gene result in strains that are absolutely dependent on the presence of exogenous thymine or thymidine in the medium. By deleting the gene from the biocatalyst chromosome and then providing the complementing gene by cloning into a *dsz* expression vector, we could then insure maintenance and stability of *dsz* genes introduced into a biocatalyst host.

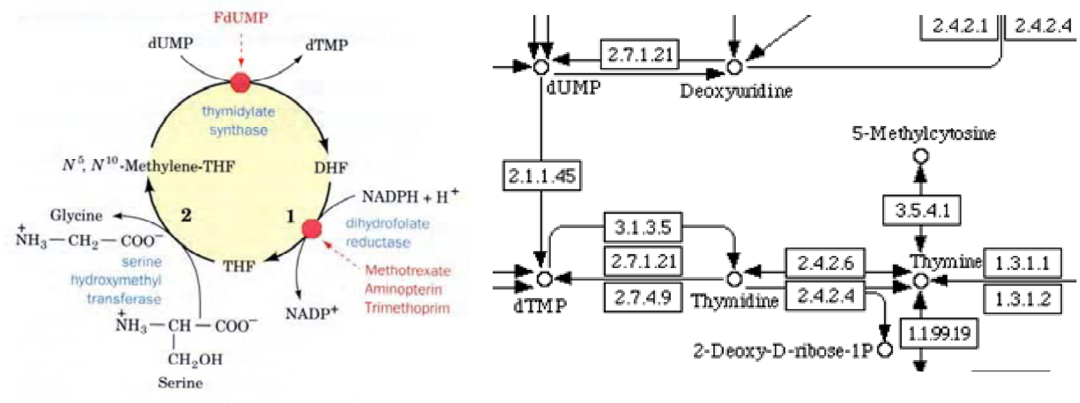


Figure 61. *Role of thymidylate synthase (ThyA) in cellular metabolism and thymidine salvage pathway.*

4.9.2 Generation of *thyA* deletion strain

The overall strategy for generating a host for the stable expression of evolved *dsz* genes is diagrammed in **Figure 62**. To construct a *thyA* deletion mutant, the *Rhodococcus* IGTS8 derivative JB55 was selected as host. This strain contains the entire pSOX plasmid, with the exception of the *dsz* genes, which have been replaced with a tetracycline resistance gene. This enabled us to construct gene replacement "cassettes" consisting of 1) pSOX sequences flanking the *dsz* genes to provide homology for recombination, 2) a *thyA* gene to complement the chromosomal deletion and enable prototrophic growth once integrated, 3) a strong promoter for expression of the *dsz* genes, 4) the optimized *dsz* genes including *dszD*, in various gene orders to test optimal organization of expression and 5) a terminator to prevent read-through transcription. This cassette could then be integrated into the JB55 *thyA* strain, as a linear fragment, by homologous recombination, selecting for prototrophic growth and screened for the loss of tetracycline resistance.

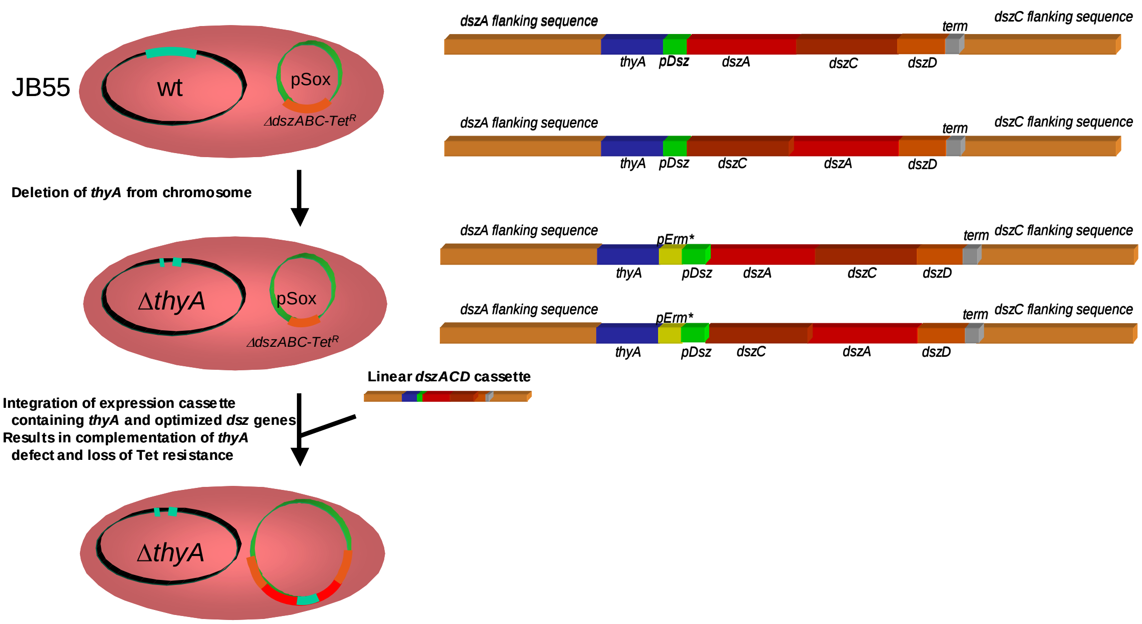


Figure 62. *Diagram of the strategy for generating an antibiotic markerless selection system for the introduction and maintenance of modified dsz genes.*

We had previously identified the thymidylate synthase (*thyA*) gene from the genome sequence of *Rhodococcus* strain RHA1 (http://www.rhodococcus.ca) and used it to isolate the corresponding gene and flanking sequences from *Rhodococcus* IGTS8. We then constructed a vector containing the *thyA* flanking regions, a kanamycin-resistance gene and a sucrose synthase gene (*sacB*) (**Figure 67**). By electroporating this vector into JB55 and selecting for kanamycin resistance, we generated a primary cointegrate.

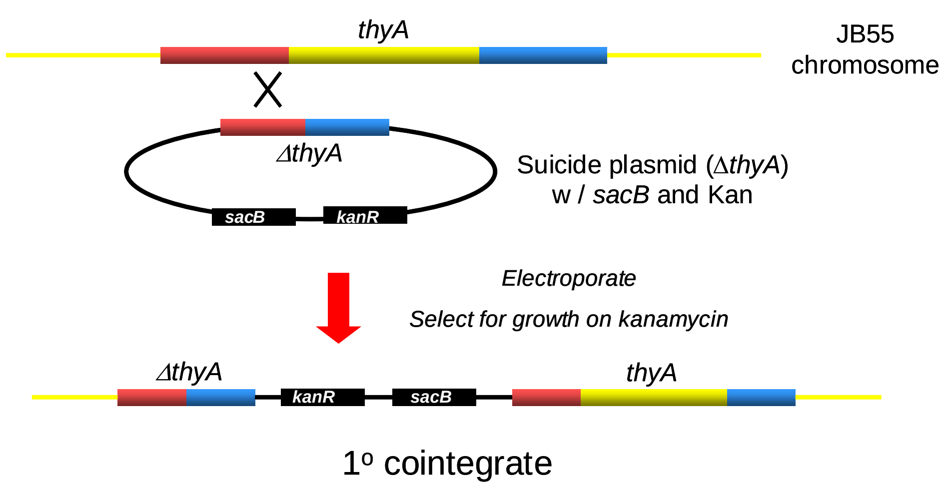


Figure 63. *Generation of primary cointegrate for construction of JB55 thyA deletion mutant.*

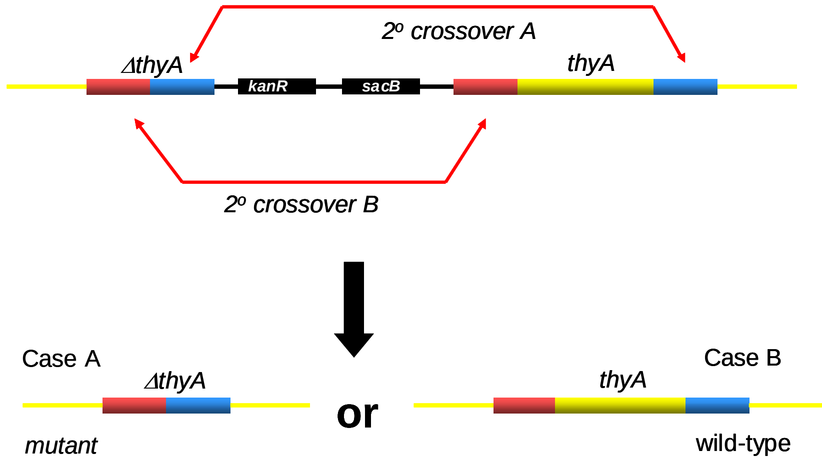


Figure 64. *Generation of second crossover and creation of JB55 thyA deletion mutant.*

The correct integration of the vector by homologous recombination was confirmed by Southern hybridization. To generate the *thyA* deletion, we then selected for the ability to grow in the presence of 5% sucrose. In this manner we could then force a second recombination between homologous duplicated sequences to remove the *sacB* gene, which is toxic if expressed in the presence of sucrose. As can be seen in **Figure 64**, two different recombination events can lead to loss of *sacB*, 1) recombination through the right-hand duplicate sequences (relative to the *thyA* gene, *2^{o} crossover A*) resulting in a *thyA* deletion mutant or 2) recombination through the left-hand duplicate sequences (*2^{o} crossover B*) resulting in restoration of the wild-type.

When sucrose-resistant clones were selected in approximately 50% were found to be unable to grow in the absence of added thymidine. **Figure 65** shows the growth of one such mutant in liquid medium (nutrient broth) in the presence and absence of added.

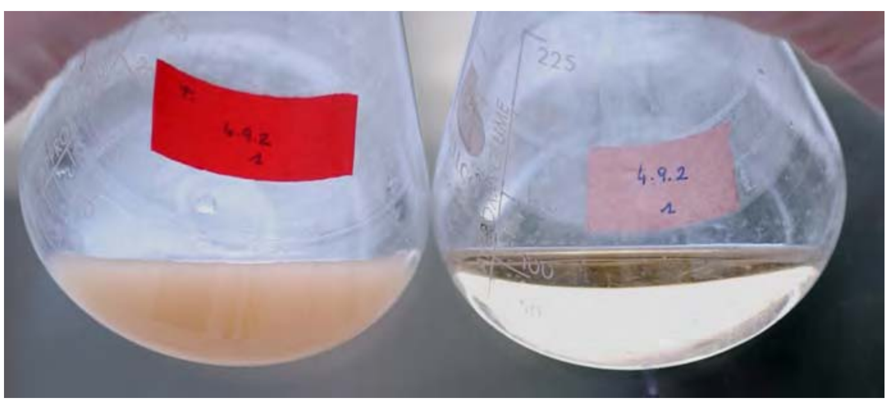


Figure 65. *Growth phenotype of thyA mutant in the presence and absence of added thymidine.* Thymidine added to 10ug/ml in left hand flask.

4.9.3 Complementation and construction of *dsz* expression cassette

With the successful generation of the JB55 *thyA* mutant it was necessary to test for the ability to complement the mutation by the introduction of a wild-type *thyA* gene. Our strategy for stable *dsz* gene expression required the ability to introduce and incorporate a linear DNA fragment by recombination (**Figure 62**). To determine if this was feasible, we amplified a copy of the *thyA* gene from the IGTS8 chromosome, along with 1kb of flanking sequence on either side, to produce a linear fragment of DNA. This fragment was then electroporated into the JB55 *thyA* mutant and cells were plated onto agar medium without added thymidine to select for prototrophs. Prototrophic colonies were obtained at high frequency (~10^{-5}) after electroporation while no colonies were obtained without the added *thyA*-containing fragment.

To construct the *dsz* expression cassette, we combined a number of different elements using an *in vitro* recombinant technique. These elements are shown in **Figure 66** and consisted of; 1) pSOX sequences flanking the *dsz* genes to provide homology for recombination, 2) a *thyA* gene to complement the chromosomal deletion and enable prototrophic growth once integrated, 3) a strong promoter for expression of the *dsz* genes, 4) the optimized *dsz* genes including *dszD* and 5) a terminator to prevent read-through transcription. In addition, the construction of this cassette allowed for varying the *dszACD* gene order to enable testing the optimal combination for effective biodesulfurization activity.

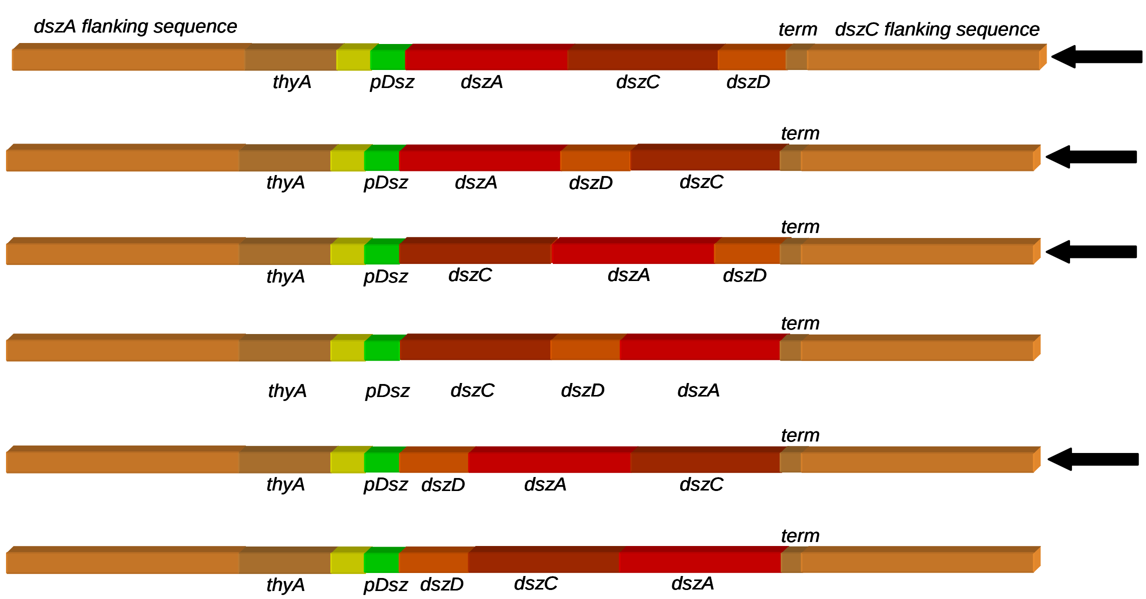


Figure 66. *Diagram of dsz gene cassettes for integration into JB55 thyA deletion mutant.* Only those marked with an arrow were successfully generated.

As of the end of the project, four of the six gene cassettes were successfully constructed. Although multiple attempts were carried out to generate the remaining two constructs, instability of the clones seem to preclude their construction.

Two of the constructs, with *dsz* gene order ADC and ACD, were prepared as linear fragments by restriction digestion at flanking sites and used to electroporate JB55 Δ*thyA*. Correct integrants were verified by the restoration of prototrophy, loss of tetracycline resistance and by Southern hybridization.

Two independent clones from each of the two constructs were purified and tested for whole cell BDS activity and compared to the benchmark BKO53A strain. As seen in **Figure 67**, each of the constructs showed substantial BDS activity but neither approached the levels and initial rates seen with BKO53A.

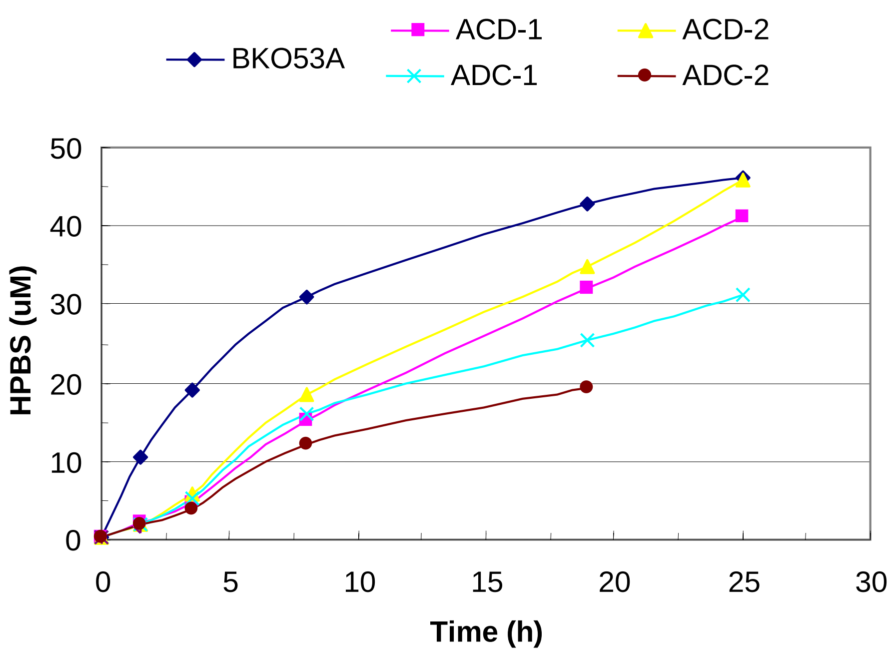


Figure 67. *Whole cell BDS activity of BKO53A vs. JB55 ΔthyA – dsz integrants.*

4.10 Sequencing of IGTS8 plasmids

As our previous data suggested, it is likely that pSOX-encoded genes in addition to *dszABC* play a role in the ability of IGTS8 to carry out biodesulfurization. To attempt to identify additional genes, we carried out an effort to sequence the plasmids of this organism.

Studies in the literature have suggested that there are at least two plasmids, one of ~150kb and one of ~90kb in this strain (13) but prior sequencing efforts have been limited to the *dsz* and *rep* regions of the ~150kb pSOX plasmid.

To prepare IGTS8 plasmid complement, total plasmids were prepared from IGTS8 using a modified alkaline lysis procedure and two libraries were generated, a small insert library of 1-3kb inserts derived from randomly shearing IGTS8 plasmid DNA and a large insert cosmid library using randomly sheared DNA with inserts of 35-40b fragments in pCC1Fos.

To analyze the library for plasmid composition, fragments containing either the known *dsz* genes or the pSOX *rep* region were used as hybridization probes against 600 randomly selected cosmids. Only 15 were obtained that were derived from the pSOX plasmid, suggesting that the copy number of the 90kb plasmid is much higher than the 150kb pSOX plasmid. In addition, many of these 15 clones prove to be unstable upon further purification, suggesting that the pSOX plasmid contains many repeated or unstable sequences prone to recombination in the *E. coli* host.

To carry out the sequencing, >5000 randomly selected small insert clones were sequenced and assembled to generate a complete sequence for the 90kb plasmid (**Figure 68, Appendix 3**). Although we could not generate enough sequence to assemble the entire 150kb pSOX plasmid, we were able to assembly five contigs that in total = ~120kb of sequence (**Figure 69-70, Appendix 3**). In a number of regions there were highly repeated sequences which created ambiguous assembly into a complete sequence.

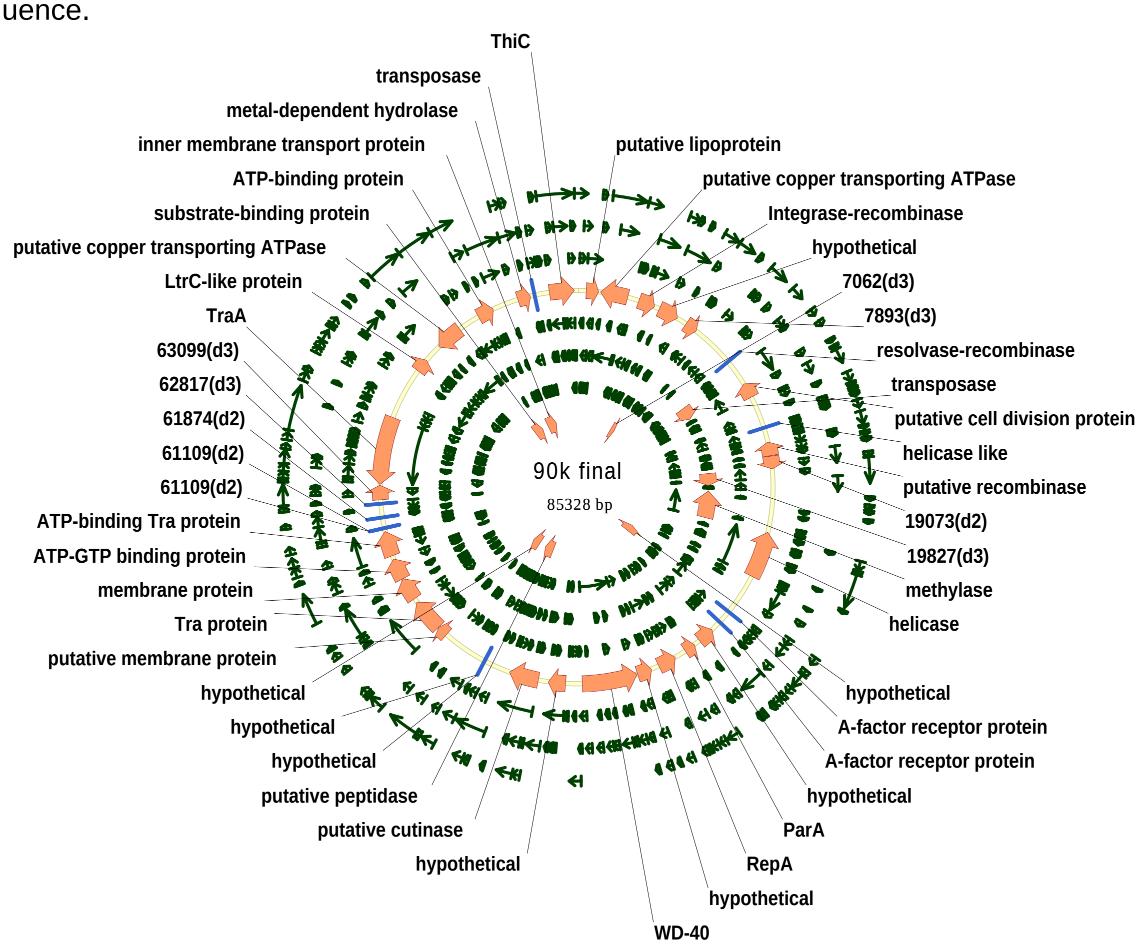


Figure 68. *Map of the 90kb (85,328bp) IGTS8 plasmid.*

Annotations of the both the "90kb" and incomplete pSOX sequences suggest that they encode a variety of transporters for heavy metals and other cations as well as a number of transposons and insertion sequences that suggest horizontal transmission from other organisms. This implies that IGTS8 normally finds itself in an environment containing a variety of toxic compounds and employs numerous efflux mechanisms to protects itself.

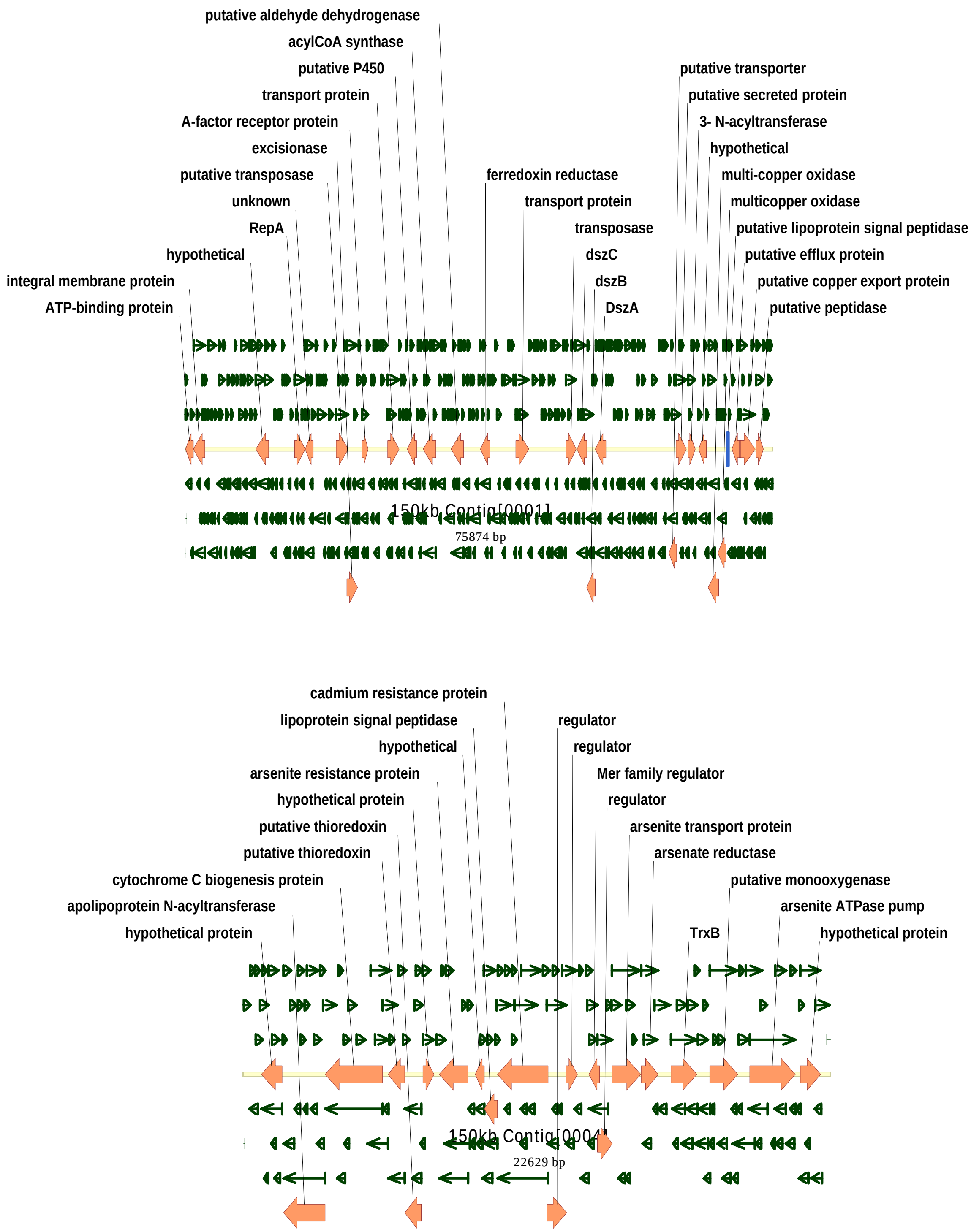


Figure 69. *Maps of the two largest IGTS8 pSOX contigs.*

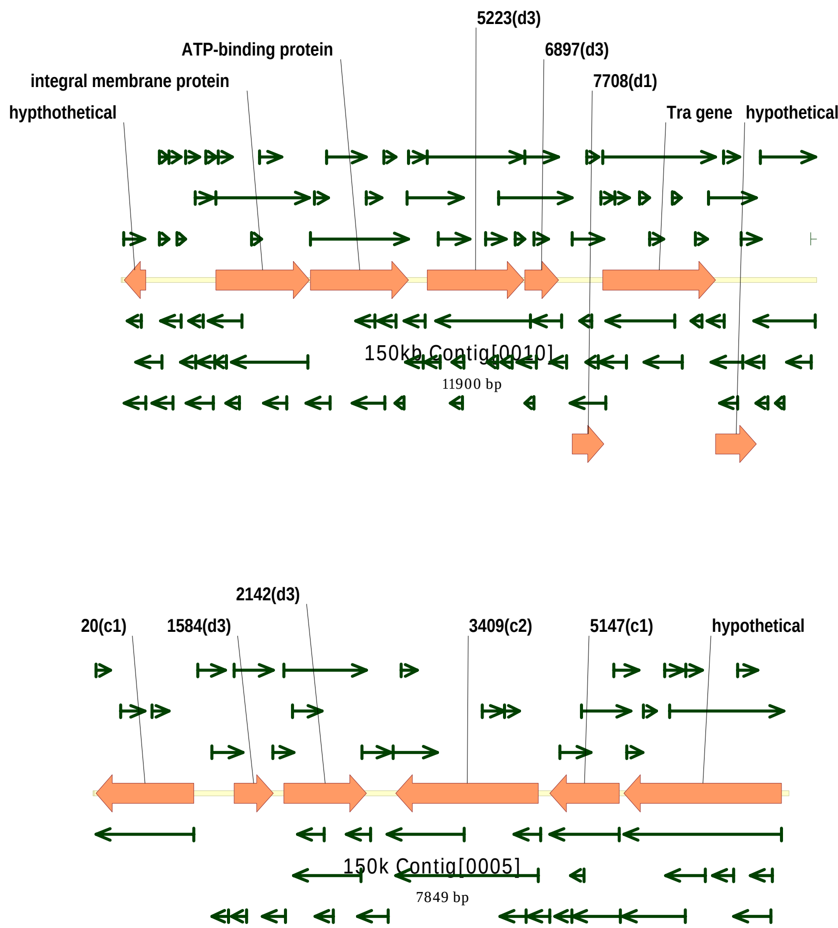


Figure 70. *Maps of the two smallest IGTS8 pSOX contigs.*

4.11 Economic study of BDS standalone and combined processes

To address the economic costs associated with biodesulfurization as both a stand-alone process as well as in combination with HDS, a study was carried out by Pelorus, Petro Star and Anvil and is reported in detail in Appendix 4.

The design throughput for the study is 6,000 bpd of straight run diesel containing 0.5 weight percent sulfur from PetroStar's Valdez Refinery. The specification for the ULSD product sulfur content is 10 ppm.

To simplify the economic study and avoid biasing the study results, the study excluded all outside battery limits (OBL) facilities. The approach is consistent with the 1999 BDS study which excluded all utility systems improvements, offsite tankage, and waste stream disposal.

4.11.1 Study approach

The HDS/BDS Study looked at five cases to determine if a BDS process is a viable means to produce USLD when compared to traditional hydro-processing methods:

- A standalone HDS process, used as a benchmark to assess the viability of a BDS process
- A standalone BDS process
- A BDS process followed in series by an HDS process (BDS/HDS Case)
- A HDS process followed in series by a BDS process (HDS/BDS Case)
- A Diesel Splitter followed by an HDS Unit operated in parallel with a BDS Unit (Pre Fractionation Case)

4.11.2 Study details

This Task 4 Final Report includes this Summary as well as details for each of the studied Cases that were developed as three standalone reports:

- HDS Baseline Case Report and Cost Estimate
- BDS Baseline Report and Cost Estimate
- BDS/HDS Combination Cases Report and Cost Estimates.

The HDS and BDS Baseline Reports cover their respective process operated as a standalone unit.

The Combination Cases Report covers three possible sequencing options when a BDS process is operated in conjunction with an HDS process. All three reports are included as sections of this Task 4 Final Report.

4.11.3 Study results

The results of the study are contained in the summary table below. From this table, the following conclusions can be made regarding the viability of a BDS process to produce ULSD at PetroStar's Valdez Refinery:

- An HDS Unit has a lower installed cost than a comparable BDS Unit
- An HDS Unit has substantially lower operating costs than a comparable BDS Unit
- The combination of a BDS Unit and an HDS Unit is not economically viable when compared to either of the standalone units.

5.0 CONCLUSIONS

In this final technical report we have described our efforts to develop a biodesulfurization host optimized for its ability to meet the many challenges of implementing a commercially viable BDS technology. Many of these challenges were apparent from the outset, while a number of new challenges and levels of understanding of the existing problems became more obvious during the course of this work.

These challenges are not only technical in nature but include the economics of introducing and implementing this new technology and the competitive threats posed by competing, established technologies. In addition, new regulatory challenges have been imposed, to attain levels of sulfur in ULSD, which may prove extremely difficult in achieving using BDS.

Here we highlight some of the most important technical challenges to the success of a BDS technology, whether as standalone or in combination with HDS.

Organosulfur composition

From the two analytical efforts we have carried out to determine the organosulfur composition of both straight-run diesel and partially hydrotreated diesel, it is apparent that the overall composition of the organosulfur compounds is highly heterogeneous. While major species, alkylated benzothiophenes and dibenzothiophene, can certainly be identified that make up the bulk of the organosulfur compounds, the remaining minor species contribute to the total sulfur and must be effectively removed to attain the ULSD specifications mandated. As our data on the action of a biocatalyst on deeply hydrotreated diesel demonstrates that even the nearly complete reduction of the most HDS-recalcitrant species, 4-alkyl and 4-dialkylbenzothiophenes, to low ppm levels is not enough to reduce the “hump” of heterogeneous, undefined sulfur compounds to acceptable levels.

It is probably this challenge, more than any other, which presents the greatest obstacle to successful implementation of this technology. The enzymes at the core of the process must be able to act upon a large variety of substrates at sub-Km levels in a reasonable amount of time to be commercially viable. Optimizing the enzymes to be simultaneously high affinity and broad specificity presents a formidable challenge and is perhaps counter to our current understanding. Alternatively, one could propose to introduce a number of enzyme systems in a single biocatalyst, or use multiple biocatalysts with unique enzyme systems, but is likely to be as technically challenging and cost-prohibitive.

Biocatalyst host properties

Although these challenges are significant, we chose to focus on the optimization of *Rhodococcus* IGTS8 DszC and A to improve activity on the HDS-recalcitrant 4-dialkylbenzothiophenes. If BDS were used as a front-end to a combined process, it could be envisioned that a reduction in this species would afford a reduction in the operating and capital costs required for hydrotreatment.

While we were successful at identifying mutants of DszA that were ~2X more active on 4, 6-dimethyl $DBTO_2$ we were unable to identify variants in DszC with significant improvement on 4, 6-dimethyl DBT. Interestingly, in both cases, evidence of the effect of other factors contributing to apparent specificity was apparent.

In the case of the DszA variants, we observed that the relative ratio of DszA, flavin reductase and substrate had a pronounced effect on the activity on 4, 6-dimethyl $DBTO_2$ vs. $DBTO_2$. This suggests that the intracellular redox state and availability of reduced flavin will have important consequences on the ultimate activity profile of the Dsz system. As mentioned in the introduction, other observations from the literature have also shown that in spite of the identity of the expressed dsz genes, the host contributes significantly to the apparent range of substrates acted upon (2).

During our screening for DszC variants, we were able to identify three clones that reproducibly showed increased activity on 4, 6-dimethylDBT vs. DBT. Unfortunately, retransformation of the three responsible mutated plasmids, expressing the DszC variants, into a “naïve” *E. coli* host results in the loss of this phenotype. This likely resulted from a mutation in the chromosome of the original *E. coli* host that somehow altered the cell physiology and again demonstrates the apparent contribution of the host to the activity profile of the enzyme.

These observations highlight the need to develop not only the enzymes required for BDS but to carefully consider the properties of the host organism, not only in terms of contributing the enzymatic activities, but for other important properties relevant to a commercial process including robustness, efficient generation of cellular reductant and tolerance to organic matrices.

With this mind, we set out to identify alternative hosts to *Rhodococcus* IGTS8. We had noticed during our initial characterizations of this strain that its properties were less than ideal as it had a slower growth rate and achieved lower total biomass concentrations than desirable.

After screening >100 different *Rhodococcus*, *Nocardia*, *Mycobacterium* and *Gordonia* strains for their growth characteristics, we focused on a number of *Rhodococcus opacus* strains for further work. These strains grew at a comparably fast rate to high densities, were non-pigmented (in contrast to IGTS8, which produces a red pigment that partitions to the oil phase) and had a reported property of being able to accumulate triacylglycerols when grown under nitrogen-limited conditions.

As one of the important requirements for a BDS host is an ability to efficiently produce the necessary cellular reductant from an oxidizable substrate. Previous efforts in this area have focused on the addition of glucose, acetate, ethanol or alkanes during the catalytic stage of a BDS process. The use of an organism that can accumulate triacylglycerols during the biomass production stage, when the cells are at their most robust and healthy would allow for the mobilization and utilization of these storage compounds to provide cellular reductant during the following catalytic stage. Unlike glucose, acetate, ethanol or alkanes, which require an activation cost (transport, phosphorylation, alkane oxidation) and input energy for their utilization if provided exogenously, intracellular accumulated triacylglycerols can be directly used, without activation, by β-oxidation and are very efficiently converted to cellular reductant.

We have demonstrated that a number of *R. opacus strains* are also able to tolerate hexadecane and diesel fuel nearly as well as IGTS8, although it appears that IGTS8 and its derivatives do possess an inherent resistance that may be due to the production of a biosurfactant. It will be an interesting to determine the mechanism of IGTS8 biosurfactant production and whether the responsible genes can be transferred to other hosts. Most descriptions of biosurfactants in the Actinomycetes, particularly Mycobacterium, describe sugar-mycolic acid conjugates as the most prevalent, suggesting that the genes necessary to glycosylate the already present cell wall mycolic acids of *Rhodococcus* would be minimal.

Expression of dsz genes

From these studies, it is apparent that the stability of expression of the *dsz* genes in IGTS8 is questionable and development of a biocatalyst strain will require a mechanism to insure robust and stable expression of the pathway. In addition, the proper stoichiometric balance of expression of each of the Dsz enzymes will be important to most efficiently oxidize the organosulfur compounds and avoid bottlenecks. It is not readily apparent from either this work or from the literature what is the proper balance of the two or three Dsz proteins (depending on whether DszB is included). This is likely to depend on the specific organosulfur compound and the relative affinity of each of the enzymes, as well as the indirect contribution of host factors, as described above.

For this reason, in the last stages of our work we set out to generate a system for the stable expression of the Dsz proteins without the need for including antibiotics in a fermentation that would create environmental issues with the potential release of resistance genes. We also designed the system to allow for the introduction of modified genes and construction of cassettes with various combinations of *dsz* gene orders to study the effect of altering relative expression levels of each of the components. This would hopefully enable the empirical optimization of both genes and stoichiometry of expression in a BDS host.

Economics

Finally, we have presented an in-depth analysis of the operating and capital costs of BDS as both a standalone process and in combination with HDS. Current cost estimates of a HDS-treatment facility of comparable scale served as the benchmark case. Since performance specifications of the biocatalyst strain have a major effect on the economics, assumptions of significant improvement (50-100x) over current biocatalyst performance were made to derive these values.

In short, the study concludes that implementation of a BDS facility by itself or in combination with HDS would not afford a significant cost reduction and in some cases would be significantly higher. Factors that contribute most significantly to the relative costs of the processes are the reductions in operating costs and catalyst performance in hydrotreating plants that were not the case ten years ago when intense work began on the development of the biocatalyst host and BDS process by Energy Biosystems and others.

6.0 REFERENCES

1. Kilbane, J. J. and B. A. Bielage (1990) *Proceedings: 1990 First International Symposium of the Biological Processing of Coal*, Electric Power Research Institute, Palo Alto, CA

2. Noda K, K. Watanabe and K. Maruhashi K(2003) J*. Biosci. Bioeng*., **95**:354-360.

3. Kayser K.J., H.S. Park, J. H. Kwak, A. Kolhatkar and J. J. Kilbane II (2002) *Appl. Microbiol. Biotechnol.*, **59**:737-746.

4. Sambrook, J., E. F. Fritsch, and T. Maniatis. (1989) *Molecular cloning: A laboratory manual, 2nd Ed.* Cold Spring Harbor Laboratory Press.

5. Gray K.A., O.S. Pogrebinsky, G.T. Mrachko, L. Xi , D.J. Monticello and C.H. Squires. (1996) *Nat Biotechnol*. **14**:1705-1709.

6. Jackson C.J., D.C. Lamb, T.H. Marczylo, A.G. Warrilow, N.J. Manning, D.J. Lowe, D.E. Kelly and S.L Kelly (2002) *J. Biol. Chem*. **277**:46959-46965.

7. Munro A.W., D.G. Leys, K.J. McLean, K.R. Marshall, T.W. Ost, S. Daff, C.S. Miles, S.K. Chapman, D.A. Lysek, C.C. Moser, C.C. Page and P.L. Dutton. *Trends Biochem. Sci.* **27**:250-257.

8. Jaspers M.C., W.A. Suske, A. Schmid, D.A. Goslings, H.P. Kohler and J.R. van der Meer. (2000) *J. Bacteriol*. **182**:405-417

9. Kolisnychenko, V, G. Plunkett, C.D. Herring, T. Feher, J. Posfai and F. R. Blattner (2002) *Genome Research.* **12**:640-7.

10 Sirko, A., M. Zatyka, E. Sadowy and D. Hulanicka (1995) *J. Bacteriol*. **177**:4134-4146.

11. Sutherland TD, I. Horne, R.J. Russell, and J.G. Oakeshott (2002). *Appl Environ Microbiol. 68*:6237-45.

12. Waltermann M, H. Luftmann, D. Baumeister, R. Kalscheuer, and A. Steinbuchel. (2000) *Microbiology.* **146**:1143-9.

13. Denis-Larose, C., D. Labbe, H. Bergeron, A.M. Jones, C.W. Greer, J. al-Hawari, M.J. Grossman, B.M. Sankey and P.C. Lau (1997) *Appl. Environ. Microbiol*. **63**:2915-9.

7.0 LIST OF ACRONYMS AND ABBREVIATIONS

BP	Boiling point
bp	Base pair
BDS	Biodesulfurization
BSM	Basal salts medium
CAT	Chloramphenicol acetyltransferase
CED	Conversion-extraction desulfurization
DBT	Dibenzothiophene
DBTO2	Dibenzothiophene sulfone
DCW	Dry cell weight
DiMe(t)	Dimethyl-
DMSO	Dimethylsulfoxide
DNA	Deoxyribonucleic acid
Dsz	Desulfurization
EPA	Environmental Protection Agency
FMN(H_2)	Flavin mononucleotide (reduced)
GC	Gas chromatography
GFP	Green fluorescent protein
GSSM	Gene Site Saturation Mutagenesis™
HDS	Hydrodesulfurization
HBP	Hydroxybiphenyl
HBPS	Hydroxybiphenylsulfinate
His	Hexahistidine affinity tag
HPLC	High performance (pressure) liquid chromatography
kb	Kilobase
LC	Liquid chromatography
MS	Mass spectrometry
MW	Molecular weight
NAD(H)	Nicotinamide adenine dinucleotide (reduced)
OD	Optical density
PCR	Polymerase chain reaction
RPC	Reverse-phase chromatography
RPM	Revolutions per minute
ULSD	Ultra-low sulfur diesel

Analysis of Sulfur Compounds in Petrostar Chemical Extraction Desulfurization Materials

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DIVERSA

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Introduction

This report describes the analytical approach used to determine the composition of sulfur-containing compounds in Petrostar chemical extraction desulfurization (CED) material. The origin and nature of the samples, their handling, methodology of analysis and detailed procedures are explained. Qualitative and quantitative results of analysis are discussed.

Background

Petrostar marine diesel is obtained by straight run distillation from North Slope Alaskan crude oil. It is not subjected to cracking, reforming, hydrotreatment, or any other condition, which might change the chemical composition of substances present in the crude. Only the boiling point range of the diesel fraction and the crude composition limit the diversity of structures. Thus, the number of sulfur-containing compounds present in detectable concentrations is very high. Attempts to analyze the composition of these compounds by individual methods of separation yield only very broad unresolved humps with few structural features. The retention properties of sulfur-containing organic compounds are very similar to each other, and to those of hydrocarbons, which are present in a much higher concentration in diesel. This makes speciation even more problematic.

Sulfur-containing compounds found in diesel fractions may be divided into two large groups: aromatic thiophenes and aliphatic sulfides. In aromatic thiophenes, sulfur is part of an aromatic ring structure, while in aliphatic sulfides sulfur atoms do not participate in aromatic conjugation. Aromatic thiophenes may be divided further into thiophenes (Thios), benzothiophenes (BTs), and dibenzothiophenes (DBTs). In aliphatic sulfides the sulfur atom may be attached to saturated hydrocarbon substituents, cyclic or aromatic substituents, or be part of a cyclic structure itself. The presence of thiols and disulfides in diesel fraction distillates has been reported as well.

Petrostar marine diesel contains around 3500 ppm total sulfur. The distillation range of the diesel fraction defines the range of molecular weights for each class of compounds. For all classes but DBTs, this range corresponds to heavily alkylated core structures. The number of possible isomers grows exponentially with the degree of alkylation, and so does the complexity of mixtures.

One of the commonly used techniques to simplify the separation of sulfides and thiophene derivatives is initial oxidation to the corresponding sulfones and analysis of the resulting mixtures. With the notable exception of Thios, oxidation of sulfides to sulfones can be done selectively and quantitatively. Oxidation usually produces one well-defined product, which can be easily traced back to the original sulfide. Sulfones can be easily separated from the matrix of hydrocarbons since they are more polar than sulfides. This separation may be achieved by selective extraction or by chromatography. Sulfones also differ in retention properties among themselves much more than the original sulfides.

Oxidation of thiophenes occurs at a lower rate than oxidation of benzothiophenes, dibenzothiophenes, and aliphatic sulfides. The reaction results in a complex mixture of products of side reactions, the most prominent of which is Diels-Alder addition. Thiophene sulfoxides and thiophene sulfones are strong dieneophiles, and can react with themselves, or with starting thiophenes and benzothiophenes. Extensive alkylation of the thiophene framework reduces the Diels-Alder reactivity of the corresponding sulfoxides and sulfones, rendering them somewhat more stable.

Experimental

CED material

The CED material was obtained by chemical oxidation of Petrostar stock diesel with peracetic acid and extraction of polar products with acetic acid. A sample of CED material was provided by Petrostar and analyzed according to a procedure outlined in a flowchart in **Figure 1**.

Sample manipulations

A sample of CED material was separated into fractions by preparative HPLC on a C_{18} reverse phase column. Fifty fractions of equal volume were collected. Solvents were evaporated from each of the fractions. An *i*-propanol solution of two internal standards, butyl sulfone and pentyl sulfone, was used to redissolve residues from fractions. The reconstituted fractions were analyzed by gas chromatography-

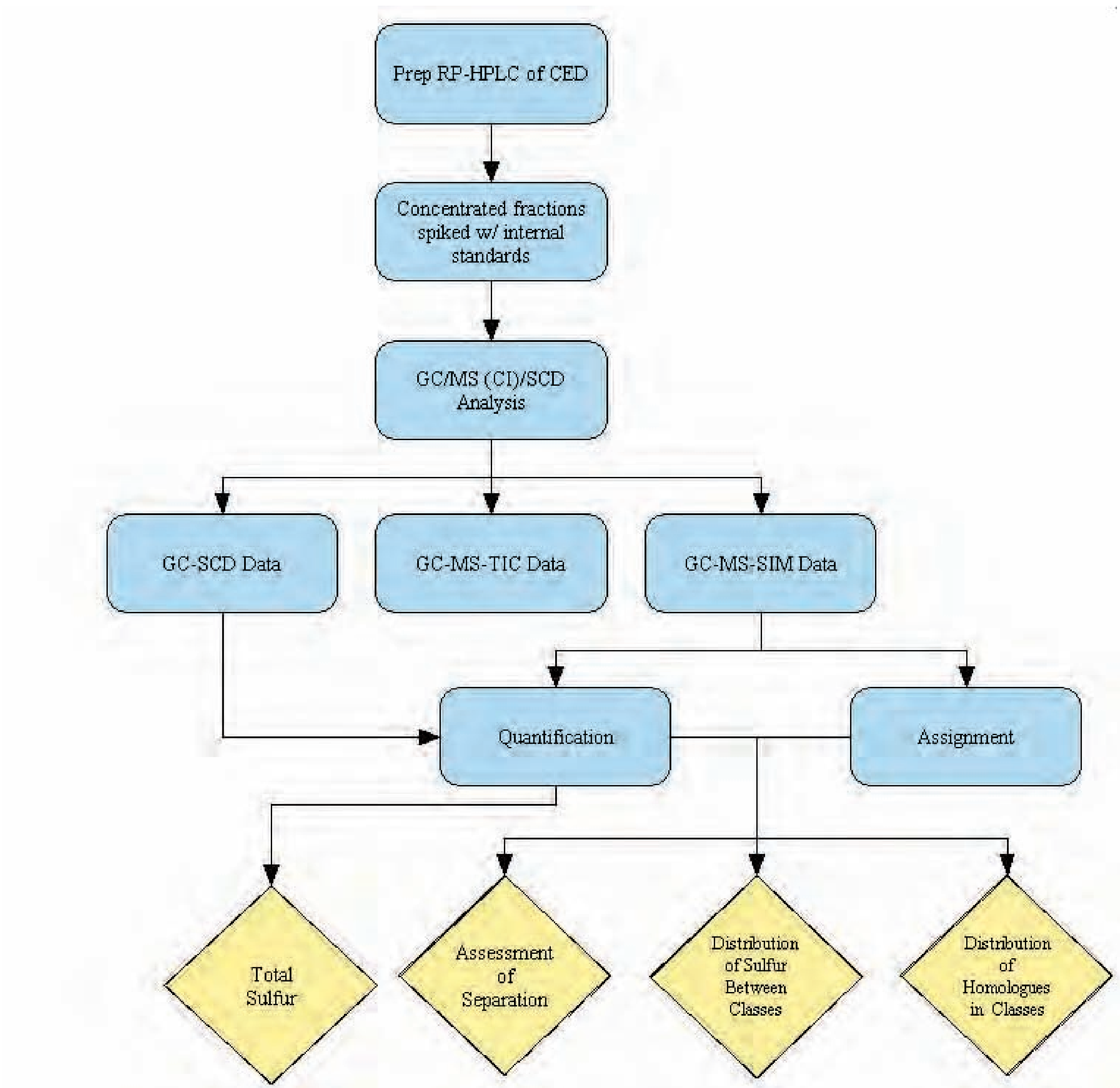


Figure 1. Flow-chart describing the analytical techniques used to analyze and characterize the Petrostar CED material.

mass spectrometry (chemical ionization)-sulfur chemiluminescence detection (GC/MS(CI)/SCD). GC inlet split ratios were optimized for each fraction such that the maximum signal before saturation was obtained in the SCD detector. Two injections were done for each sample. The first injection was used to obtain an estimate for the optimal split ratio and to acquire a mass spectrometer total scan total ion chromatogram (TIC). Ions observed in the TIC mode were used to perform selected ion monitoring (SIM) during the second run with the optimal split ratio. Only the data of the second set of chromatograms were used in analysis.

Data analysis

The sulfur-containing species from the CED material eluted between 13 and 21 minutes under the GC conditions. The SCD trace was integrated between these times, and the integral was converted into molar concentration of sulfur by comparison with the integrals of two internal standards. The integrated intensities of individual ions from SIM data were used to estimate concentrations of isomeric species in each fraction. These calculations were done under assumptions of (i) equal ionization efficiency for different species and (ii) no significant ion suppression in cases when compounds were not separated before they entered an ionization chamber of the mass spectrometer.

Five classes of compounds were identified in the CED material fractions based on the mass spectrometric data: benzothiophene sulfones (BTO_2s), dibenzothiophene sulfones ($DBTO_2$s), thiophene sulfones ($ThioO_2$s), bicyclic aliphatic sulfones ($BicycO_2$s), and monocyclic aliphatic sulfones ($MonoO_2$s). Compounds within these classes were identified as members of a homologous series differing from one another by an integral number of CH_2 fragments. Masses of observed [M+H] ions for different homologues are listed in **Table 1**. Concentrations of various homologues belonging to the same class of compounds were summed up across fractions and provided the total concentration of compounds belonging to this class. SCD data from different fractions were normalized for different split ratios.

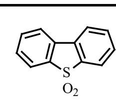
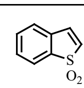
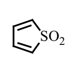
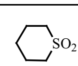
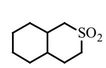
Classes	Base structure	[M+H] for Cx homologues
$DBTO_2$		217 + 14x
BTO_2		167 + 14x
$ThioO_2$		117 + 14x
$MonoO_2$		121 + 14x
$BicycO_2$		189 + 14x

Table 1. Masses of observed [M+H] ions for different homologues.

Results and Discussion

Separation

HPLC-UV traces of preparative separations (not shown) are not informative due to overloading of the detector and a lack of resolution on this step. GC/SCD/MS traces of individual fractions show various degrees of separation. The first four fractions (eluting at 11 – 12.5 min. on HPLC) show good separation of peaks down to baseline. In the next seven fractions (13 – 16 min.) many peaks overlap to some degree. Starting with the fraction eluting at 16.5 min. on HPLC, the GC chromatograms develop an unresolved hump between 14 and 20 minutes with peaks on top of it. The contribution of the hump steadily increases from fraction to fraction relative to the contribution of resolved peaks. The retention time of the signals increases as well. The last nine chromatograms (fractions 32 – 35.5) display mostly unresolved signal between 17 and 21 minutes. Every gas chromatogram contains peaks for two internal standards: butyl sulfone (retention time 8.3 min) and pentyl sulfone (retention time 11.5 min).

Integration of GC/SCD traces normalized to internal standards revealed the total sulfur distribution between fractions (**Figure 2**). The graph shows four peaks and three valleys between them. The first peak (fraction 12.5) is attributed to elution of C1 $DBTO_2$s. C2 $DBTO_2$s and C5 BTO_2s form the second peak (fractions 14.5 and 15). The peak at fraction 17 is due to elution of C6 BTO_2s, the most abundant homologue among alkylated BTO_2s. The last broad peak around fraction 19.5 is composed of a variety of compound classes with some dominance of C7 BTO_2s. Total sulfur content in the initial CED material is 15.4 g/l.

A contour plot of SIM data (**Figure 3**) allows the assessment of the separation achieved by 2D chromatography. Separation must be assessed along several lines: (i) separation among classes of compounds, (ii) separation among series of homologues within classes, and (iii) separation among individual compounds within series of homologues.

(i) The contour plot of SIM data reveals that $DBTO_2$s were nicely separated from all other classes of compounds present in CED. $ThioO_2$s, on the other hand, overlap extensively with BTO_2s and $BicycO_2$s.

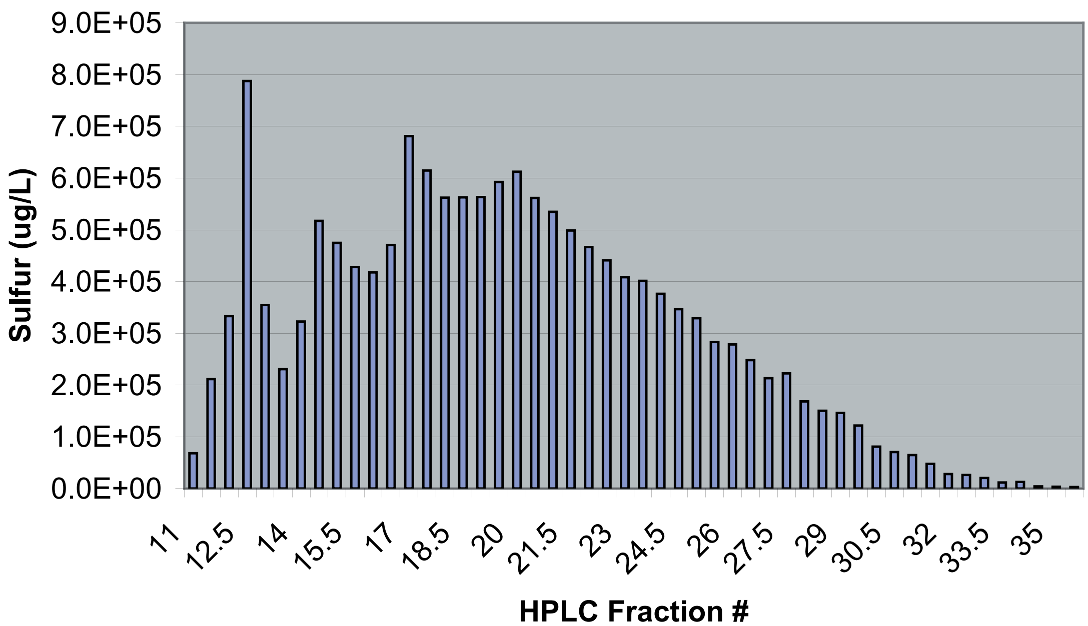


Figure 2. Total sulfur distribution between fractions.

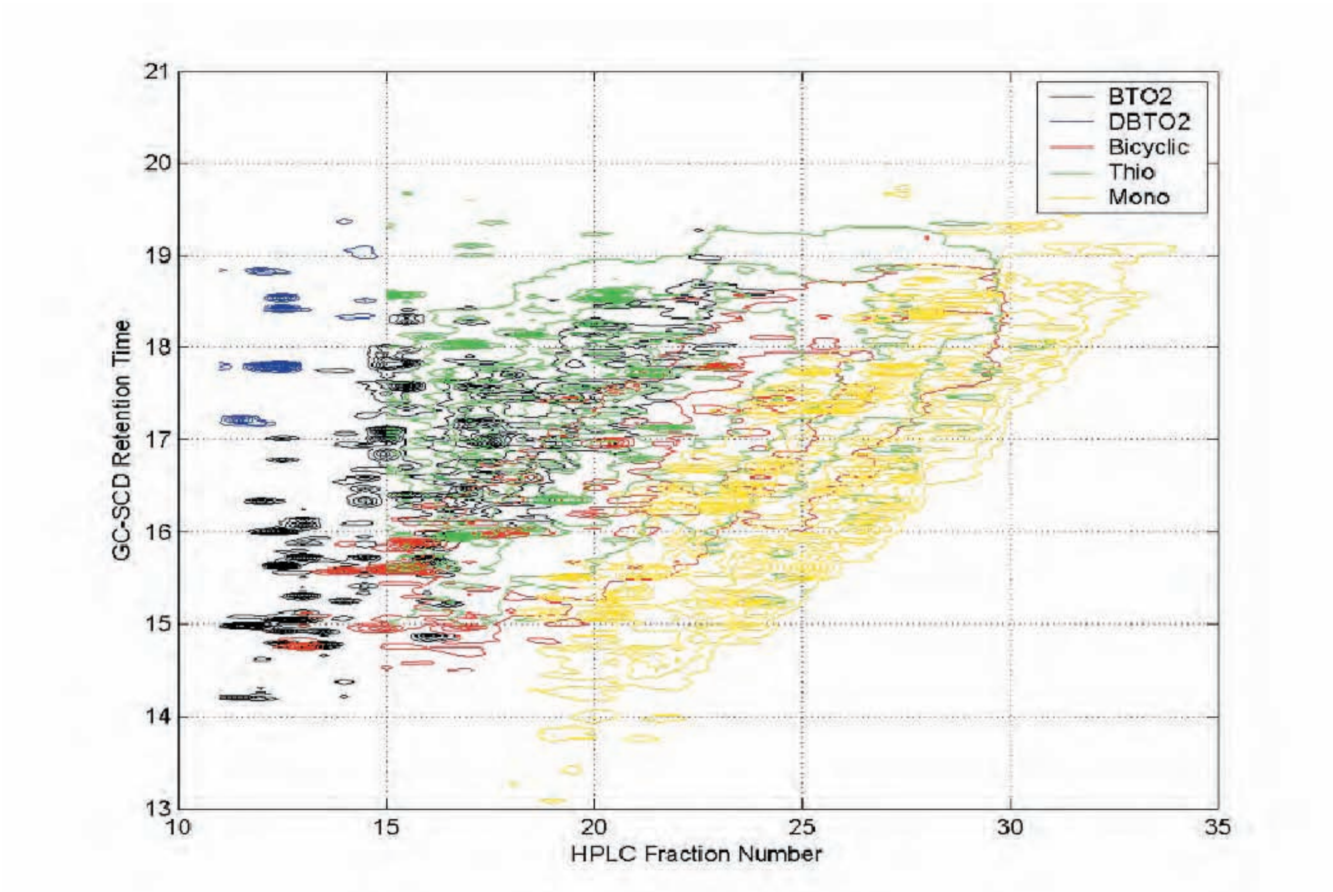


Figure 3. A contour plot of SIM data.

BTO_2s and $BicycO_2$s have some overlaps, especially in the area between HPLC fractions 12.5 and 16.5 and GC retention times between 14.7 and 16 minutes. Quite good separation was achieved for $MonoO_2$s. Contours of $ThioO_2$s and $BicycO_2$s overlapping with the $MonoO_2$ area represent only a low concentration of the contaminating species.

The intensities of the peaks corresponding to different classes of compounds are shown on surface plots of SCD data (**Figure 4**). The landscape is clearly dominated by a single peak of 4-methyldibenzothiophene sulfone (**Figure 4a)**. All $DBTO_2$s combined contribute a minor fraction to the overall sulfur content of the CED material, but the relatively small number of isomers of $DBTO_2$ in the mixture provide for high intensity of peaks corresponding to individual compounds. In order to observe peaks corresponding to other compounds the SCD count vertical scale has to be expanded. Peaks of BTO_2s (**Figure 4b**) cover an underlying plateau of $ThioO_2$s. The intensity of individual peaks steadily decreases along with the HPLC fraction numbers and the number of possible isomers corresponding to the homologues. Some smaller peaks on the front edge of the BTO_2 ridge can be assigned to $BicycO_2$s. These peaks are more visible in **Figure 4c**, along with the $MonoO_2$ ridge in front and to the right of them.

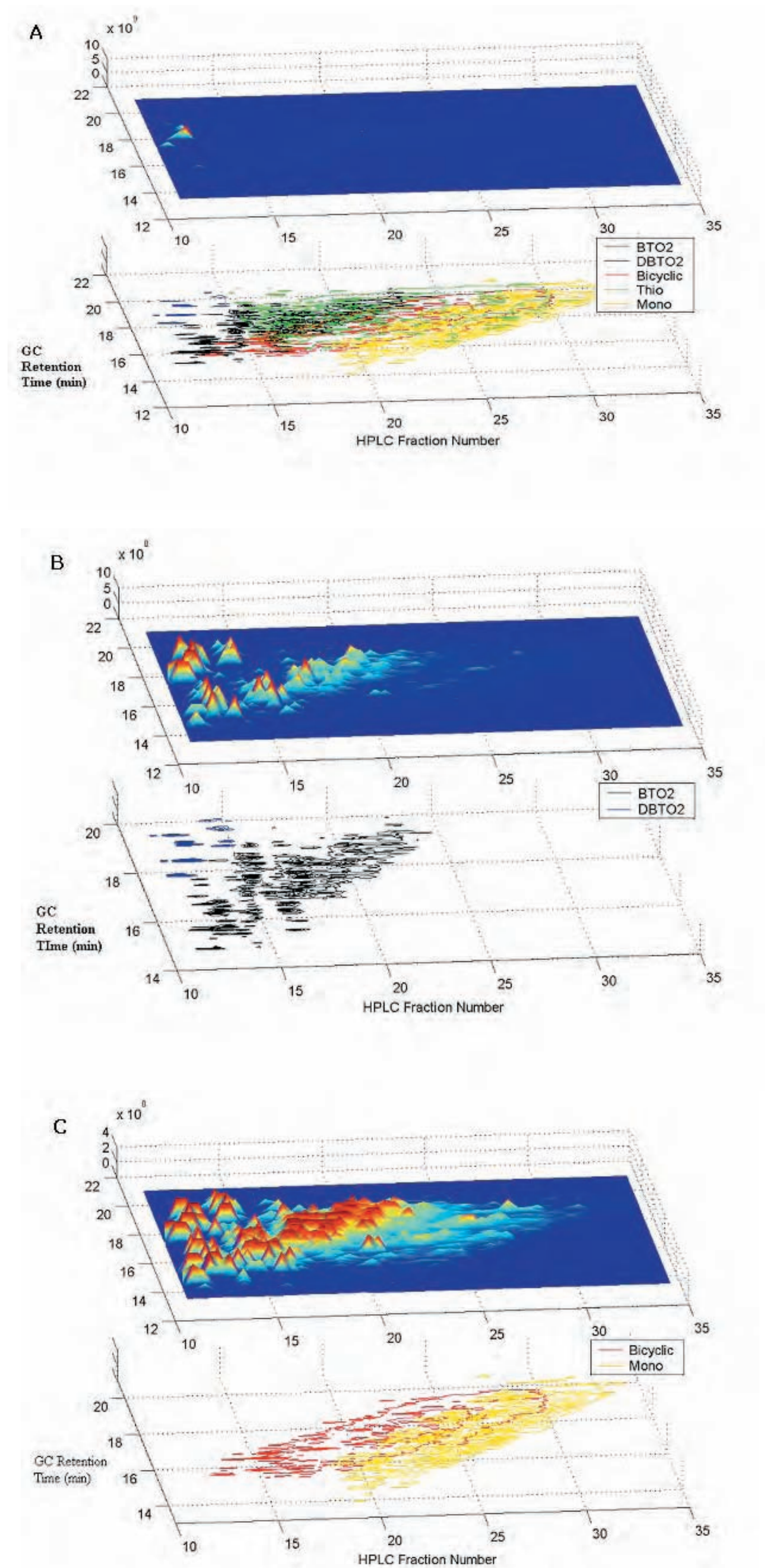
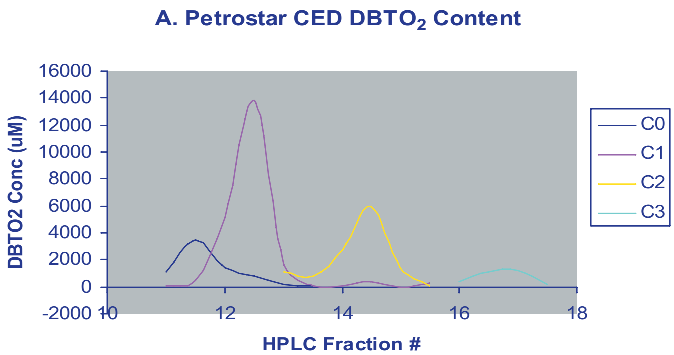


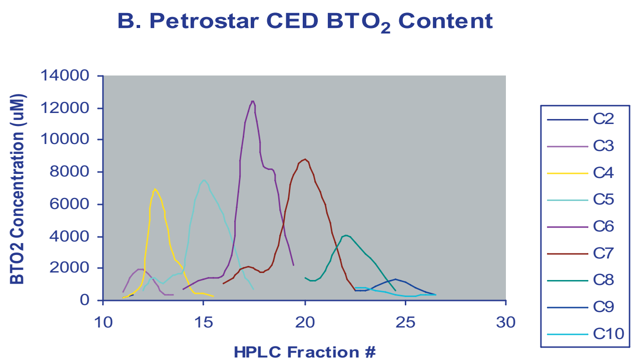
Figure 4. Surface plot of SCD intensities and contour plot of SIM intensities for 2-D chromatography of CED material

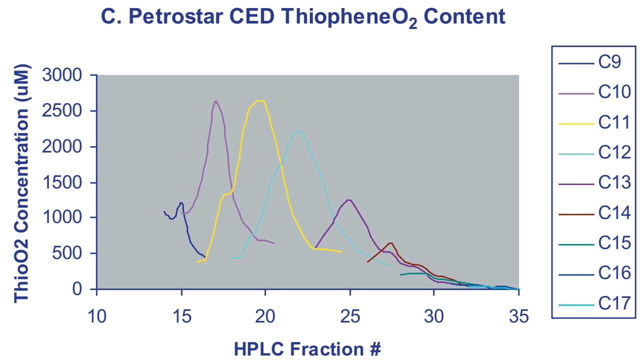
a) Full vertical scale for SCD and contours for all five classes of compounds

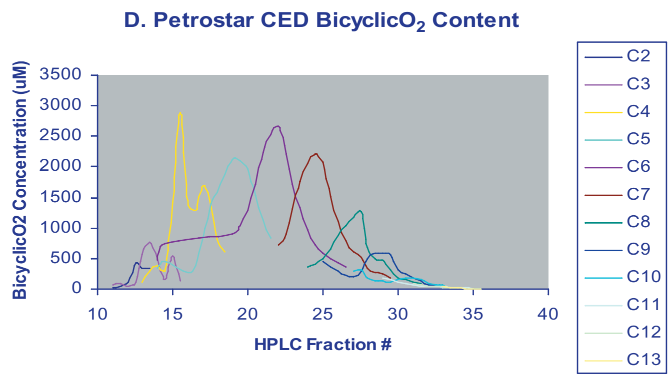
b) Expanded 10x vertical scale for SCD and contours for $DBTO_2$s and BTO_2s

c) Expanded 25x vertical scale for SCD and contours for $BicycO_2$s and $MonoO_2$s









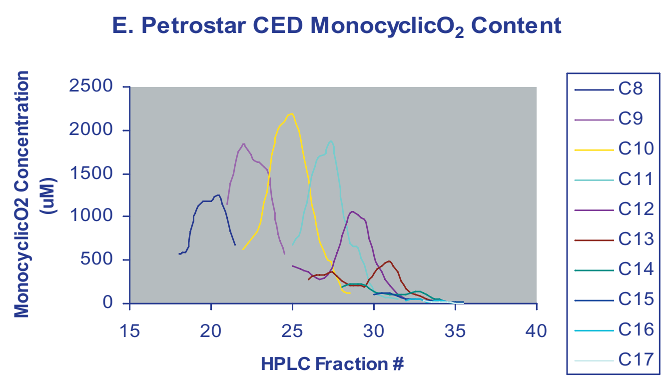


Figure 5. Elution of homologues series of sulfur-containing organic compounds belonging to the same class a) $DBTO_2$s, b) BTO_2s, c) $ThioO_2$s, d) $BicycO_2$s, e) $MonoO_2$s.

(ii) Separation within series of homologues within classes is achieved primarily by HPLC (**Figure 5**). GC improves separation only when the number of isomers for homologues is small and individual compounds can be separated (fractions 11 – 12.5). In the latter fractions, signals corresponding to different homologues overlap significantly. Distributions of sulfur among homologues within classes of compounds have broad maxima characteristic for each class (C1 for $DBTO_2$s (**Figure 5a**), C6 for BTO_2s and $BicycO_2$s (**Figure 5b**), C11 for $ThioO_2$s (**Figure 5c**), and C10 for $MonoO_2$s (**Figure 5d**). The boiling range of the diesel fraction probably defines these maxima. All distributions but the one for $DBTO_2$ have bimodal character. This effect is most prominent for C4 $BicycO_2$s (**Figure 5d**). This bimodality may be explained by the presence of two prevailing trends in substitution patterns of the core structures with different elution properties, each of which has its own distribution pattern. More experiments will be needed in order to study this phenomenon in details.

(iii) GC separation of individual compounds is achieved only in the first four HPLC fractions, containing a limited number of $DBTO_2$s and BTO_2s. In the rest of the fractions, the presence of an overwhelming number of individual compounds precludes their separation.

Assessment of accuracy of various aspects of analysis

The experiments described here were designed to obtain the most accurate analysis possible. However, we worked under several assumptions, and we feel obliged to discuss the possible effects that these assumptions may have on the accuracy of our analysis. CED material was obtained by oxidation of a sample of Petrostar marine diesel and the subsequent extraction of polar compounds with acetic acid. We assumed that (i) oxidation quantitatively converts all sulfides and thiophenes into the corresponding sulfones and that (ii) acetic acid completely and selectively extracts all sulfones out of the matrix of diesel hydrocarbons. Assumption (i) is not true for substituted thiophenes. Thus, the concentration of their oxidation products can be significantly lower in the CED material compared to the concentration of thiophenes in diesel. In addition, acetic acid may be less efficient in extraction of saturated aliphatic sulfones due to their lower polarity. Thus, the fact that we did not find dialkyl sulfones in the CED material may be attributed to an incomplete extraction.

The SCD data is quantitative and does not require any assumptions to yield the values for total sulfur content of individual fractions and of the whole CED material. However, TIC and SIM data were processed under two major assumptions: (i) ionization efficiency of individual compounds is the same, and (ii) compounds do not compete for ionization when they enter the mass spectrometer as a mixture. In order to remove the dependence of our analysis on the first assumption we would have to synthesize all individual compounds and measure standard curves for them under the ionization conditions used. This is a formidable task. The second assumption was validated by an extensive separation achieved by the 2D chromatography and by the fact that the amount of overlapping samples entering the ionization chamber of the mass spectrometer did not exceed its overall ionization capacity. Still, $ThioO_2$s were not separated from BTO_2s and $BicycO_2$s, and our estimate of their contributions may not be completely accurate.

Conclusions

Sulfur-containing organic compounds of the CED material of Petrostar marine diesel was separated by 2D chromatography. The CED material contains 15.3 g/l total sulfur, distributed between five classes of sulfur-containing organic compounds. BTO_2s have most of the sulfur (43%) with $BicycO_2$s, $ThioO_2$s, and $MonoO_2$s contributing 19, 17, and 12%, respectively. Despite the prominent contribution of individual $DBTO_2$s, the whole class brings only 9% of the total sulfur. Each class is represented by a large number of individual compounds such that baseline separation of all the compounds present in the mixture is not possible with the current technology. However, we achieved sufficient separation to allow us to assess contributions of classes of compounds, homologous isomers within these classes, and several individual dibenzothiophene sulfones.

APPENDIX 8.2

GS/MS characterization of hydrotreated diesel.

As we had previously reported that we are exploring the combination of biodesulfurization with hydrotreatment of diesel fuel, partially hydrotreated Petro Star diesel was obtained. In order to determine the effect of the biocatalyst it was necessary to determine the composition of the sulfur-containing species in this material.

To quantify the sulfur containing species, GC/MS and GC/SCD methods were developed and used. For the initial determinations, a table of predicted masses was prepared for all potential sulfur-containing compounds and their alkylation-series derivatives expected to be found in diesel fuel (**Table 1**).

	Cx-DBT	Cx-bicyclic sulfides	Cx-BT	Cx-thiophenes	Cx-monocyclic sulfides	Cx-alkyl aryl sulfides	Cx-dialkyl sulfides	Cx-ThioIndans
C0	185	157	135	85	103	125	63	137
C1	199	171	149	99	117	139	77	151
C2	213	185	163	113	131	153	91	165
C3	227	199	177	127	145	167	105	179
C4	241	213	191	141	159	181	119	193
C5	255	227	205	155	173	195	133	207
C6	269	241	219	169	187	209	147	221
C7	283	255	233	183	201	223	161	235
C8	297	269	247	197	215	237	175	249
C9	311	283	261	211	229	251	189	263
C10	325	297	275	225	243	265	203	277
C11	339	311	289	239	257	279	217	291
C12	353	325	303	253	271	293	231	305
C13	367	339	317	267	285	307	245	319
C14	381	353	331	281	299	321	259	333
C15	395	367	345	295	313	335	273	347
C16	409	381	359	309	327	349	287	361
C17	423	395	373	323	341	363	301	375
C18	437	409	387	337	355	377	315	389
C19	451	423	401	351	369	391	329	403

Table 1. *Structure-molecular mass (M+1) correlation table for sulfur compounds.*

To begin the characterization efforts, a partially hydrotreated sample (1746ppm S as per producers specification) was analyzed. From this dataset, all possible Cx-DBT compounds were identified by GC-MS and their retention times compared to known standards (**Figure 1A**). The same sample was also analyzed using GC/SCD (sulfur compound detector) (**Figure 1B**). and the two chromatograms were compared. As can be seen, the major peaks in both the GC/MS (integrating only Cx-DBT compounds) and the GC-SCD (detecting all sulfur-containing compounds) correlate strongly suggesting that Cx-DBT compounds make up a majority of the sulfur-containing compounds present in this partially hydrotreated diesel.

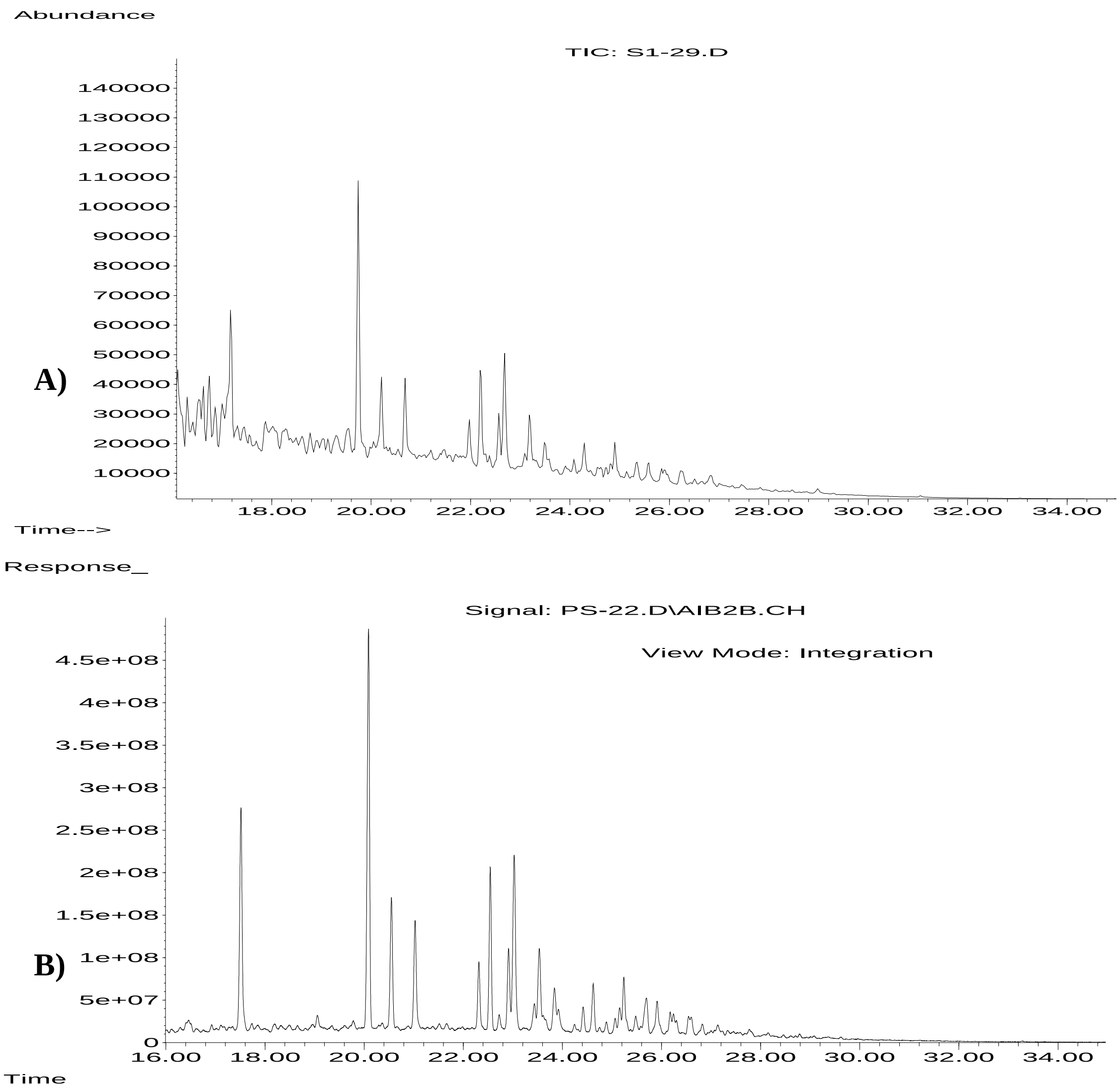


Figure 1. *GC chromatograms of partially hydrotreated diesel fuel (1746ppm S).*
A) GC/MS trace detecting masses corresponding to Cx-DBTs (M+1); B) GC/SCD trace of total sulfur compounds.

To roughly define the composition of the partially treated diesel for its Cx-DBT composition, a similar comparative analysis was carried out, focusing on the individual members of the DBT alkylation series (Figure 2). In the case of DBT (with only one isomer), the retention time could be determined by using of a known standard. In the case of the other compounds, because of the complexity of the isomeric composition, GC/MS and GC/SCD traces were compared to identify each compound. From these data it can be seen that C1-, C2-, and C3-DBT derivatives compose the majority of the sulfur –compounds with minor amounts of C4- and C5-DBT compounds present.

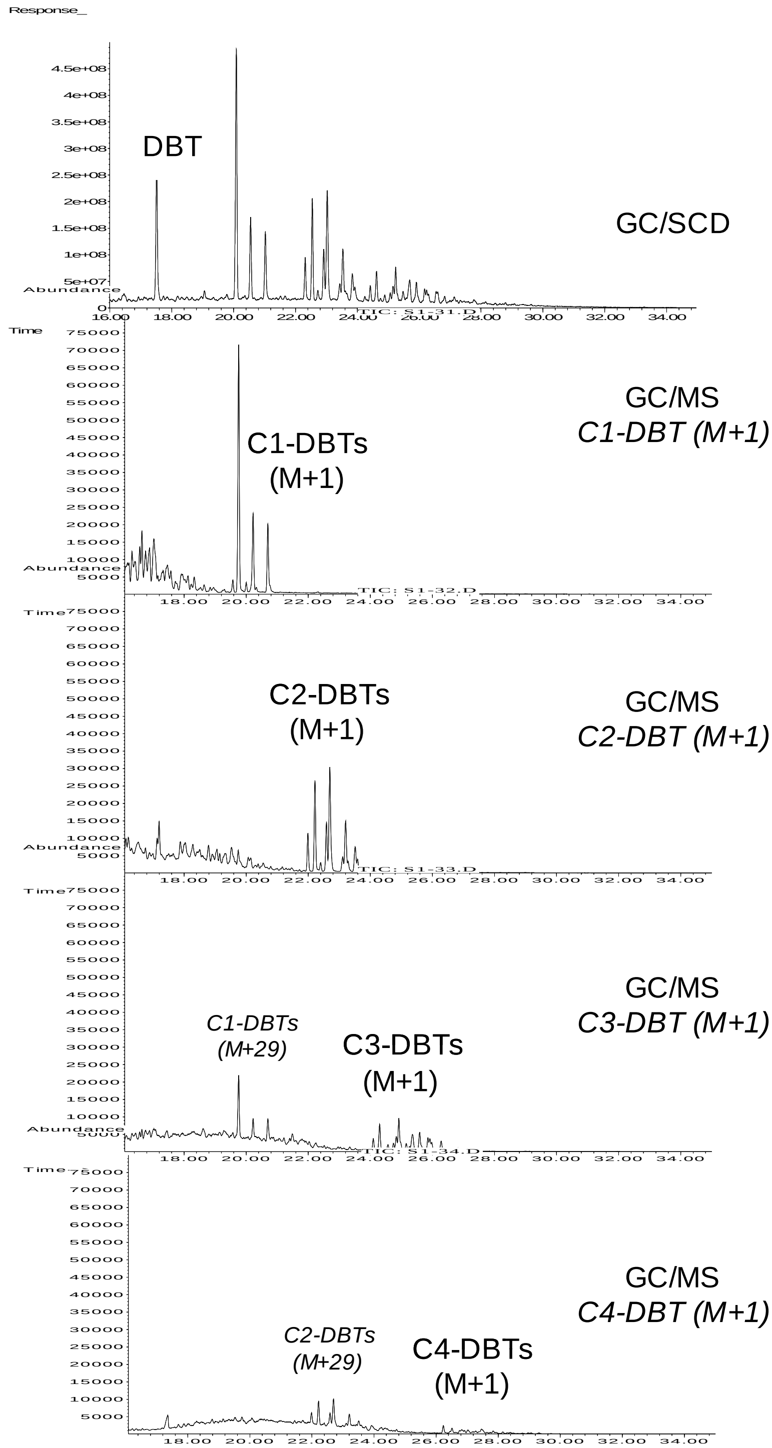


Figure 2. *GC/MS traces of partially hydrotreated diesel fuel (1746ppm S).* Each trace is detecting masses corresponding to the indicated Cx-DBT (M+1). M+29 peaks can also be seen of the C1-DBT and C2-DBT compounds in the C3- and C4-DBT traces, respectively.

To quantify the DBT species in the partially hydrotreated diesel fuel, an internal standard, benzothiophene, of known quantity was added to each of the samples before separation. The response factor of this standard and known DBT standards was compared and seen to be similar (**Table 2**).

Compound	*BT*	*DBT*	*4,6-dimethyl DBT*	*4,6-diethyl DBT*
Response Factor	1.000	1.003	1.003	0.970

Table 2. *Detector response values for benzothiophene and DBT standards*.

Since the response factors of each of the compounds was similar, 0.4mM DBT was added as internal standard, peak areas were determined and the quantity of the DBT compounds was determined (**Figure 3, Table 3**). This analysis shows that upon deeper hydrotreatment, DBT and certain isomers of Cx-DBTs are removed selectively. These results suggest that Cx-DBT compounds substituted at certain positions (presumably the 4- and 6-) are most resistant to hydrotreating. It can also be seen that the contribution of Cx-DBT to the total sulfur increases upon hydrotreatment but does so less between the 418 and 43ppm material.

Diesel samples	*DBT (ppm)*	*C1-DBT (ppm)*	*C2-DBT (ppm)*	*C3-DBT (ppm)*	*C4-DBT (ppm)*	*Total sulfur* (ppm)*	*% of sulfur in Cx-DBT*
43 ppm	0.0	5.0	12.1	10.1	0.86	58	48.4
418 ppm	2.87	61.3	92.7	59.3	4.63	487	45.3
1746 ppm	58.9	178.6	226.0	119.1	10.4	1780	33.3
Straight	110.2	237.6	274.9	161.8	13.3	4130	19.3

** determined with Antek SIO analyzer*

Table 3. *Determined values of Cx-DBT compounds contributing to sulfur in Petro Star diesel and hydrotreated samples.*

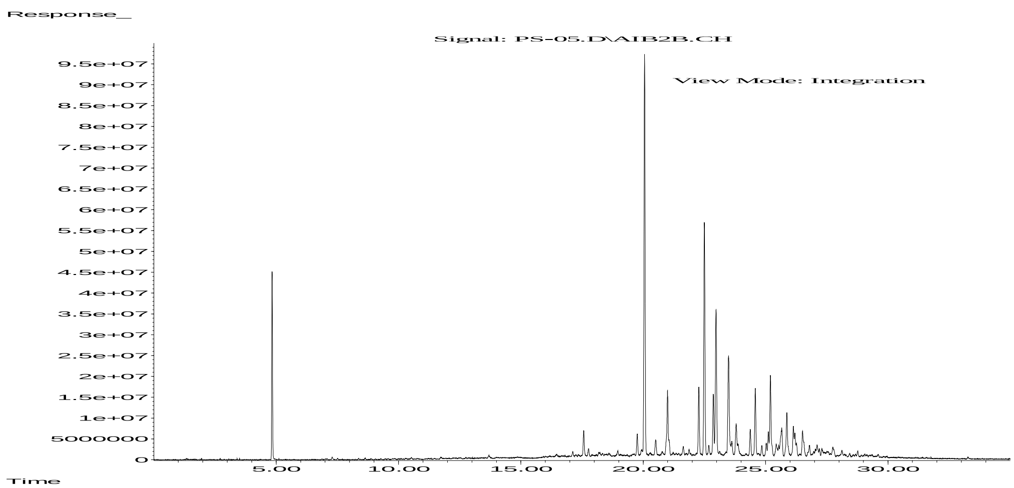
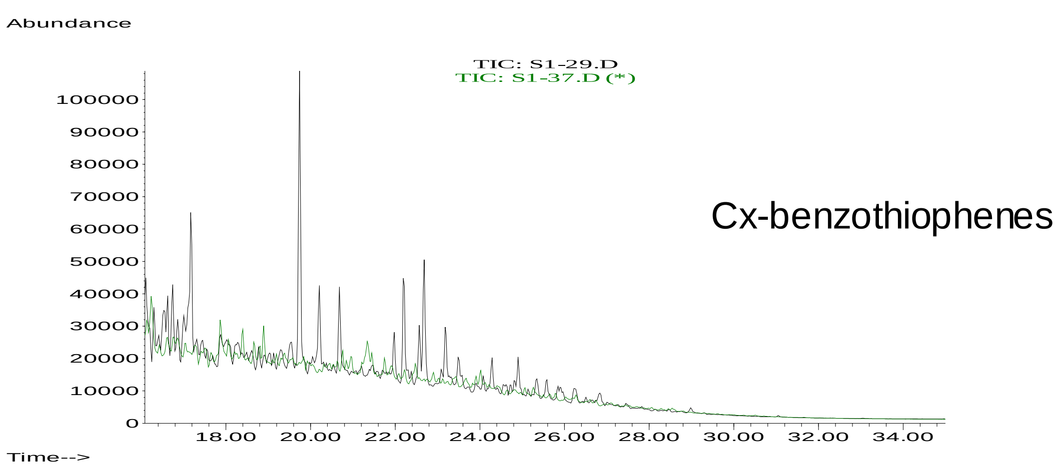


Figure 3. *Example of a GC/SCD trace with BT spiked to aid quantification of Cx-DBT compounds.*

Since these results suggested that additional non Cx-DBT sulfur species are present in the partially hydrotreated diesel, the 1746ppm material was analyzed by GC/MS and compounds of other classes were specifically analyzed and compared to the chromatogram of Cx-DBT compounds (since the peaks appear essentially the same as the GC/SCD trace the GC/MS trace was used for direct comparison of retention times) (**Figure 4A-F**).

A)



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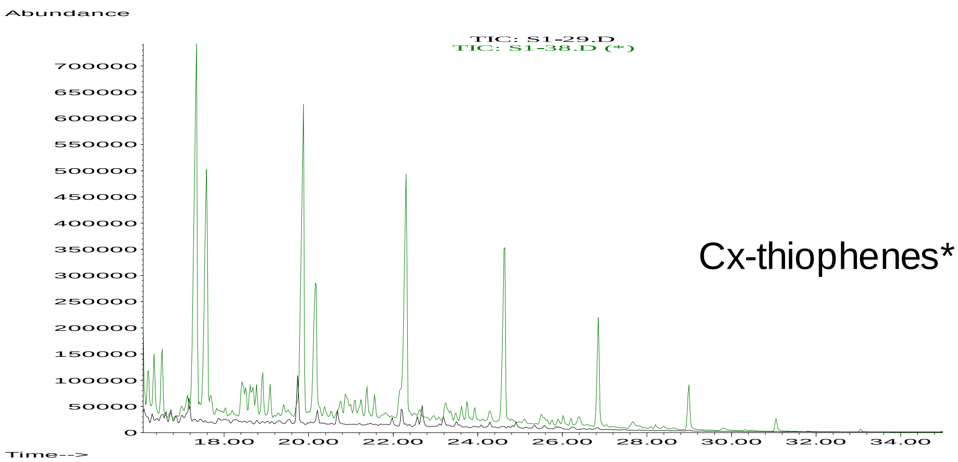
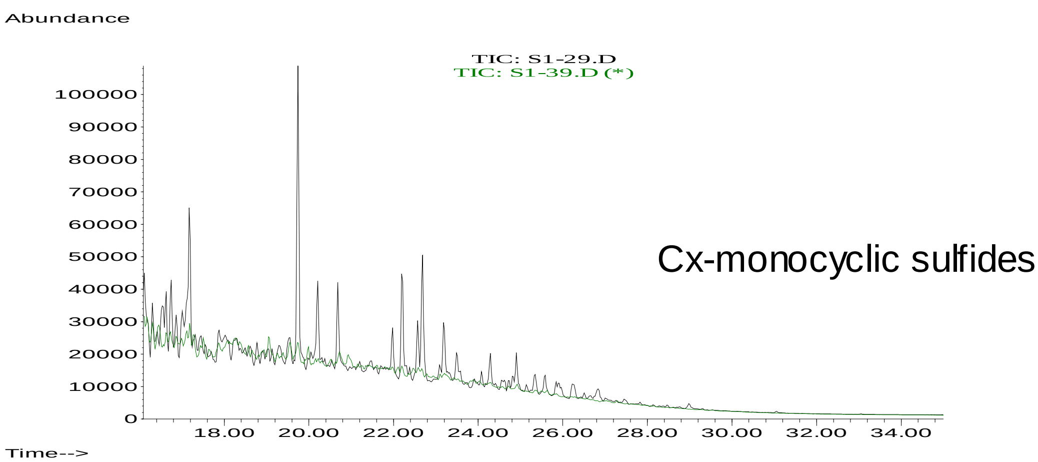


** the ionization of Cx-thiophenes is M+1, the ionization of alkanes is M-1, giving the same relative mass of these series of compounds.*

C)



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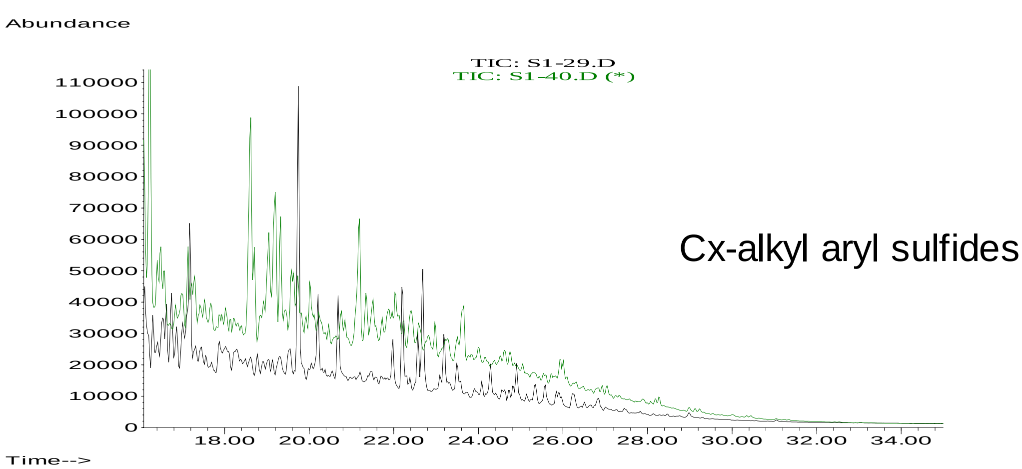

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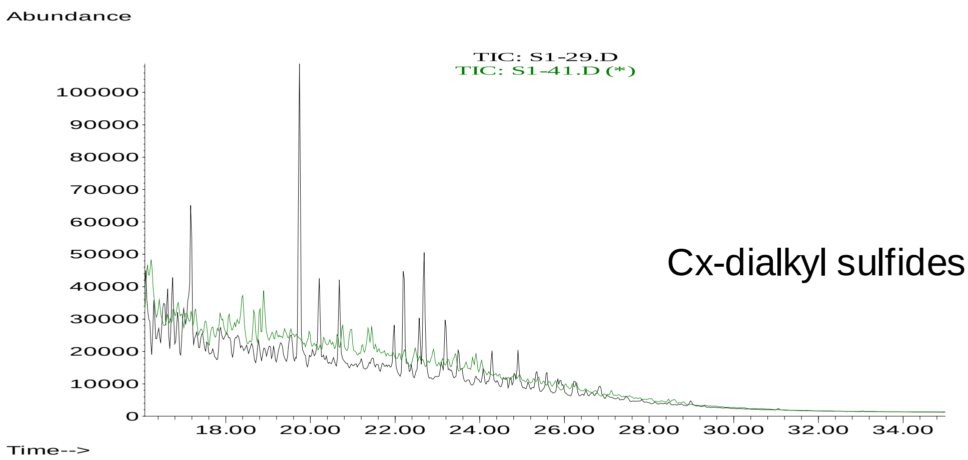

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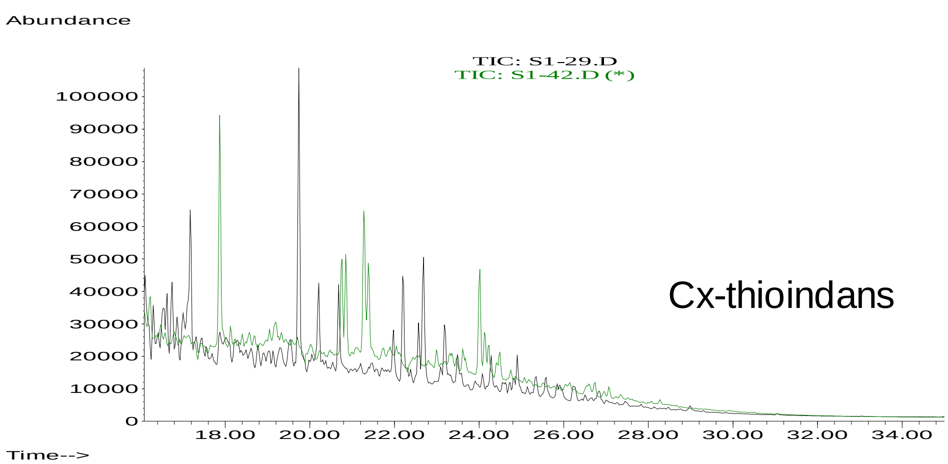

Figure 4. *GC/MS traces to identify alkylation series of each of the possible classes of compounds that may contribute to total sulfur. Traces in green are experimental; trace in black is GC/MS of Cx-DBT compounds.*

As the retention times of none these compounds matches significant peaks in the GC/SCD traces (again as correlated to the GC/MS trace of Cx-DBT) it argues against their major contribution to sulfur as individual species in the partially hydrotreated diesel. It is, however, likely that trace amounts of many of these compounds composes the residual “hump” of sulfur that is seen on the traces and the remaining ~50% of the non-Cx-DBT sulfur that is seen in these samples.

APPENDIX 8.3

Nucleotide sequence of the IGTS8 plasmids

>IGTS8 “90kb” plasmid – complete sequence

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>IGTS8 pSOX plasmid – contig001
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TASK 4 FINAL REPORT
HDS/BDS STUDY

ALASKA ANVIL NO. AE1416

REVISION 0
AUGUST 2005

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SUMMARY

HDS BASELINE REPORT AND COST ESTIMATE

BDS BASELINE REPORT AND COST ESTIMATE

BDS/HDS COMBINATION CASES REPORT AND COST ESTIMATES

SUMMARY

Background

To meet the EPA's 2006 sulfur content requirements, Petro Star is leading a Department of Energy study to determine the viability of ULSD (i.e. <10 ppmw sulfur) production from a biodesulfurization (BDS) process. This study is a continuation of a 1999 study that investigated the feasibility of ULSD production using a BDS Unit.

Study Basis

The design throughput for the study is 6,000 bpd of straight run diesel containing 0.5 weight percent sulfur from PetroStar's Valdez Refinery. The specification for the ULSD product sulfur content is 10 ppmw.

To simplify the economic study and avoid biasing the study results, the study excluded all outside battery limits (OBL) facilities. The approach is consistent with the 1999 BDS study which excluded all utility systems improvements, offsite tankage, and waste stream disposal.

Study Approach

The HDS/BDS Study looked at five cases to determine if a BDS process is a viable means to produce USLD when compared to traditional hydro-processing methods:

- A standalone HDS process, used as a benchmark to assess the viability of a BDS process
- A standalone BDS process
- A BDS process followed in series by an HDS process (BDS/HDS Case)
- A HDS process followed in series by a BDS process (HDS/BDS Case)
- A Diesel Splitter followed by an HDS Unit operated in parallel with a BDS Unit (Pre Frac Case).

Axens North America, Inc. provided the HDS Unit reactor design and unit yields for this study under a proprietary agreement. Pelorus provided the BDS Unit design as well as the operating cost estimates and equipment costs for the specialized equipment.

Study Details

This Task 4 Final Report includes this Summary as well as details for each of the studied cases that were developed as three standalone reports:

- HDS Baseline Case Report and Cost Estimate
- BDS Baseline Report and Cost Estimate
- BDS/HDS Combination Cases Report and Cost Estimates.

The HDS and BDS Baseline Reports cover their respective process operated as a standalone unit. The Combination Cases Report covers three possible sequencing options when a BDS process is operated in conjunction with an HDS process. All three reports are included as sections of this Task 4 Final Report.

Study Results

The results of the study are contained in the summary table below. From this table, the following conclusions can be made regarding the viability of a BDS process to produce ULSD at PetroStar's Valdez Refinery:

- An HDS Unit has a lower installed cost than a comparable BDS Unit
- An HDS Unit has substantially lower operating costs than a comparable BDS Unit
- The combination of a BDS Unit and an HDS Unit is not economically viable when compared to either of the standalone units.

	HDS Baseline	BDS Baseline	BDS/HDS	HDS/BDS	Pre Frac
Diesel Yield -- vol %	**96.6**	**98.6**	**95.9**	**96.9**	**96.5**
HDS Unit	_96.6_	--	_96.3_	_97.2_	_95.6_
BDS Unit	--	_98.6_	_99.6_	_99.7_	_98.3_
Capital Cost -- $MM (Note 1)	**27.8**	**33.9**	**44.5**	**43.3**	**46.5**
HDS Unit	_17.5_	--	_14.3_	_14.8_	_11.6_
H2 Unit	_6.7_	--	_5.8_	_5.5_	_4.1_
Sulfur Unit	_3.6_	--	_2.6_	_3.4_	_2.3_
BDS Unit	--	_33.9_	_21.8_	_19.6_	_22.0_
Diesel Splitter	--	--	--	--	_6.5_
Operating Cost -- $MM/year (Note 2)	**5.8**	**9.2**	**9.4**	**8.0**	**10.2**
HDS, H2, and Sulfur Units	_5.8_	--	_5.4_	_5.2_	_4.2_
BDS Unit	--	_9.2_	_4.0_	_2.8_	_4.7_
Diesel Splitter	--	--	--	--	_1.3_
Total Cost - cpg of ULSD (Note 3)	**13.4**	**18.6**	**21.4**	**19.4**	**23.1**
HDS, H2, and Sulfur Units - Capital	_6.6_	--	_5.4_	_5.6_	_6.7_
BDS Unit - Capital	--	_7.9_	_5.0_	_4.5_	_14.4_
Diesel Splitter - Capital	--	--	--	--	_1.5_
HDS, H2, and Sulfur Units - Operating	_6.8_	--	_6.5_	_6.2_	_7.8_
BDS Unit - Operating	--	_10.7_	_4.6_	_3.2_	_15.2_
Diesel Splitter - Operating	--	--	--	--	_1.5_

Notes
1. The capital cost is the expected IBL installed cost based on 2005 US Gulf Coast (USGC) pricing. OBL costs, owner costs, licensing/royalty fees, and BDS R&D costs are excluded from the estimate. The estimate accuracy for each case is +50% to -15%.
2. Includes variable and fixed costs, excludes raw material costs.
3. The total cost of ULSD production includes both capital recovery and recurring operating costs. The capital recovery component was calculated using the expected TIC and a 5 year recovery period. Interest expense was not included in this analysis.

PETRO STAR INC.

HDS/BDS STUDY

BDS BASELINE REPORT AND COST ESTIMATE

AUGUST 2005

Pelorus Environmental & Biotechnology Corp.

ALASKA ANVIL INCORPORATED

EXECUTIVE SUMMARY

To meet the EPA's 2006 sulfur content requirements, Petro Star is leading a Department of Energy study to determine the viability of ULSD production from a biodesulfurization process. This BDS Baseline Report, a part of the larger investigation, presents the BDS process and the total installed costs that will serve as the baseline economics that the BDS process must surpass.

The effort is based on an installation at Valdez, Alaska that produces 6,000 bpd of ultra low sulfur diesel meeting a 10-ppmw sulfur requirement.

The design includes the following proposed IBL facilities:

- A new BDS Unit
- A new Fermentor to produce biocatalyst on site
- New facilities to treat biocatalyst waste

The cost estimate for the BDS Unit includes only the inside battery limits (IBL) portion of the BDS Unit. Based on equipment-based costs for the BDS Unit, the total expected installed cost for the BDS complex is $33.9 million in 2005 dollars based on USGC equipment pricing. The expected accuracy of the estimate is +50/-15%.

The annual BDS Unit operating cost is $9,232,900 which translates to 10.7 cents per gallon of ULSD. The total incremental selling price for ULSD would be 18.6 cents per gallon to recover the capital in 5 years (excluding interest expense) and pay the yearly operating cost.

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INTRODUCTION

Background

All U.S. refineries will be required to meet the EPA's third quarter 2006 sulfur content requirements for highway diesel. The EPA requirement for maximum sulfur content of ultra low sulfur diesel (ULSD) is 15 ppmw. The refinery product should have about 10 ppmw sulfur or less to ensure that the product specification can be met on a reliable basis after product shipping and distribution logistics.

To compare different strategies to accomplish this requirement, Petro Star is leading a Department of Energy HDS/BDS study that evaluates the following processing routes:

- A standalone hydrodesulfurization (HDS) process
- A standalone biodesulfurization (BDS) process
- A combination of the two.

To be economically viable, a BDS process must be competitive with other commercially proven desulfurization routes. The route most chosen and best known to refiners for diesel is HDS. A new BDS facility must be less costly than a comparable new HDS facility. Or, in the various combination scenarios, using the BDS facility as a pre- or post-treatment facility combined with an existing HDS unit must be less costly than modifications to an existing HDS Unit that would be required to achieve the lower sulfur requirement.

As part of the study of potential BDS economics, this baseline report provides the process description and total installed cost of a new standalone BDS Unit producing 6,000 bpd of highway ULSD at 10 ppmw sulfur.

Exclusions

To simplify the economic baseline study and avoid biasing the study results, we have excluded all outside battery limits (OBL) facilities. A prior 1999 Kellogg report exploring a BDS baseline also excluded all utility systems improvements, offsite tankage, and waste stream disposal.

Process Design Basis

Unit Throughput

The design throughput for the BDS Unit is 6,000 bpd of straight run diesel containing 0.5 weight percent sulfur.

Unit Feed Characteristics

The design basis composition and characteristics of the diesel feed, including a sulfur speciation, are included in Appendix A.

Product Specification

The specification for diesel product sulfur content is 10 ppmw.

Utility and Infrastructure Availability

The study assumes the refinery has the following utility systems and infrastructure available to support the BDS Unit:

- Refinery fuel gas
- Water (available as feed to a new demineralization unit)
- Instrument air
- Electricity for drivers
- Nitrogen
- Process vent system
- Product tanks
- Cooling fluid system
- Steam/boiler feed water
- Naphtha fuel
- Flare.

Refinery Ambient Conditions

The new BDS facility design is based on a Valdez, Alaska location.

Ambient Temperature Condition	Degrees F
Highest monthly average	62
Lowest monthly average	17
Record high	86
Record low	-23

PROCESS DESCRIPTION

The design includes the following proposed IBL facilities:

- A new BDS Unit
- A new Fermentor to produce biocatalyst on site
- New facilities to treat biocatalyst waste.

BDS Unit (Inside Battery Limits)

Overview

The BDS process employs a selected strain of microorganisms (biocatalyst) which, through the action of produced enzymes, convert a portion of the sulfur contained in a liquid petroleum fuel into an oil-soluble compound, hydroxy biphenyl (HBP), which partitions to the diesel fuel, resulting in higher diesel yields. For the Petro Star BDS application, the petroleum fuel is diesel with a total sulfur content of 5,000 ppmw. Through processing in the BDS Unit, the sulfur content of the fuel is reduced to 10 ppmw.

The BDS Unit is operated as a continuous flow system at low pressures and moderate temperatures in an aerobic environment. Water is used both as a medium in which to sustain the microorganisms as well as the carrier for the microorganisms within the unit.

The BDS Reactors are operated at a 50:50 oil-to-water volumetric ratio, a biocatalyst cell density of 20 g/L (combined phase basis) and a biocatalyst residence time of 200 hours. The majority of the water and biocatalyst supplied to the reaction section is provided by internal recycle. A portion of the biocatalyst inventory is, however, continuously purged from the system, with an equivalent amount of fresh biocatalyst added, to maintain biocatalyst activity. The biocatalyst makeup is continuously grown in an on-site Fermentor. See Appendix B for process flow diagrams and the material balance. See Appendix C for the equipment list and budgetary equipment data sheets.

The main processing sections of the BDS Unit include a feed section, reaction section, and a separation section. The feeds to the reactors include the raw diesel feed, biocatalyst-containing water recycle and biocatalyst makeup streams, oxygen (supplied air), and the various substrates and nutrients necessary to sustain the organisms. The reaction section consists of three identical, series-flow, airlift reactors in which the biodesulfurization reactions occur. The emulsified water-oil-biocatalyst effluent from the last reactor is forwarded to the separation section. The separation section consists of two stages of gravity separation; the first to recover the desulfurized diesel product and the second to recover a biocatalyst-free aqueous stream that provides a water effluent. The remainder of the reactor effluent, consisting of the bulk of the biocatalyst and water plus some entrained oil, is recycled back to the reactors.

The biocatalyst-containing sections of the process are operated under aseptic conditions. Aseptic operation requires that all inputs to the system are treated to remove or destroy any foreign organisms. Foreign organisms, if introduced into the system, could inhibit the performance of the biodesulfurization organisms, even to the point of complete failure. Sterilization of the inputs to the system is accomplished either through removal of the foreign organisms in cartridge filters or by deactivating (killing) the organisms with heat in continuous heat sterilizers. Where sterilization is by means of filtration, a pre-filter is provided to remove relatively large suspended matter that could plug, and thus shorten the life of, the more expensive bio-filters. Where heat sterilization is employed, the sterilizers would be provided as packaged systems complete with heater, holding loop and cooler; heating being provided by a separate circulating loop of steam heated hot water.

Ancillary facilities are included for feed and chemical handling, treatment of the reactor off-gases, drying of the treated diesel product, and disposal of the waste biocatalyst purge stream. A support utility system includes a chilled water system. The chilled water system removes the external heat of reactions in the BDS Reactors and regulates the biodesulfurization reaction operating temperature. The design biodesulfurization temperature is 86°F. Temperatures much higher than 86°F result in microorganism deactivation, while temperatures below the optimum result in a decrease in the desulfurization reaction rates (and a corresponding decrease in the overall level of desulfurization).

Feed

Feeds to the BDS Unit include the raw diesel feed, compressed air, process water, and various additives and chemicals.

The diesel charge to the BDS Unit will normally come directly from the Crude Unit. For proper operation of the downstream BDS Reactors, the diesel charge must have a relatively uniform rate, have its temperature regulated to the operating temperature of the downstream BDS Reactors, and be sterilized.

Diesel feed to the unit is received into the Diesel Feed Drum (D-101). D-101 serves as a surge vessel to dampen fluctuations in the diesel feed flows, thus ensuring a more uniform rate to the downstream reactors. The drum provides approximately 30 minutes of residence time at the design diesel feed rate when operating at a maximum level of 80%.

From the Diesel Feed Drum, the diesel feed is transferred to the No. 1 BDS Reactor by the Diesel Charge Pumps (J-101A/B). Prior to entering the reactor, the temperature of the diesel feed is regulated to that of the downstream reactors in the Diesel Feed Cooler (C-101), and the diesel feed is sterilized by the Diesel Prefilters (L-101A/B) and Diesel Bio-Filters (L-102A/B). Chilled water from the chilled water system provides cooling within the Diesel Feed Cooler.

Operation of the Fermentor, BDS Reactors, and Seed Tanks requires oxygen for the desulfurization oxidation reactions and to maintain the aerobic environment necessary to sustain the biocatalyst. Oxygen is supplied to the various vessels in the form of air by the Air Compressors (J-109A/B). The air supply is cooled to the BDS operating temperature in the Process Air Cooler (C-103), and then routed through the Air Pre-Filters (L-103A/B) before distribution to the various users. Chilled water from the chilled water system provides cooling within C-103. Air feed sterilization is accomplished downstream of the pre-filters in individual bio-filters located at the various points of use.

The majority of the water feed to the BDS Reactors consists of recycled water. However, process water is required to supply the Seed Tanks and Fermentor. Process water makeup may also be required to maintain the water balance in the reaction section should water losses become excessive. For aseptic reasons, the process water is routed through the Makeup Water Pre-Filter (L-113A/B) and the sterilizing Makeup Water Bio-Filters (L-114A/B) before distribution to the end-users.

Substrates and nutrients are required to sustain the microorganisms, and chemicals are required for pH control. Glucose serves as the substrate source for the Seed Tanks and Fermentor, while ethanol is used in the BDS Reactors. A common nutrient cocktail is fed to both the Fermentor and the BDS Reactors. For pH control, potassium hydroxide is used in the BDS Reactors while ammonia is used in the Fermentor. Ammonia is a preferred alkali in the Fermentor since it also serves as an additional source of nitrogen, a necessary nutrient.

Glucose is stored in Glucose Storage Tank (F-101), and fed to the Fermentor by the Glucose Pumps (J-104A/B). F-101 provides 14 days storage of the 50% glucose solution at the design usage rate. The glucose feed to the Fermentor is sterilized in the Glucose Sterilizer (L-109) before entering the Fermentor.

The premixed nutrient cocktail is stored in the Nutrient Storage Tanks (F-102A/B), and fed to the Fermentor and BDS Reactors by the Nutrient Pumps (J-105A/B). Two storage tanks allow for the batch preparation of the nutrient cocktail. Each tank provides 2 days storage of the nutrient solution at the design usage rate. The nutrient feed stream is sterilized prior to entering the Fermentor and BDS Reactors in the Nutrient Sterilizer (L-110).

Ethanol is stored in the Ethanol Storage Tank (F-103) and fed to the BDS Reactors by the Ethanol Pumps (J-106A/B). F-103 provides 7 days storage of the 70% ethanol solution at the design usage rate. The ethanol feed is sterilized in the Ethanol Bio-Filter (L-111) before entering the reactors.

Potassium hydroxide (KOH) is stored in the KOH Storage Tank (F-104), and fed to the BDS Reactors by the KOH Pumps (J-107A/B/C/D). F-104 provides 7 days storage of the 4N KOH solution at the design usage rate. The KOH feed is sterilized in the KOH Bio-Filter (L-112) before entering the reactors.

Anhydrous ammonia is stored in the Anhydrous Ammonia Storage Drum (D-102). D-102 provides 7 days storage of the 100% ammonia solution at the design usage rate. From the storage drum, ammonia is fed to the Fermentor as a vapor stream. Vaporization of the liquid ammonia stored in the tank is accomplished by means of external heating coils. The ammonia is injected into the air stream which feeds the Fermentor, and is routed, along with the air, through the Fermentor Air Bio-Filter (L-104) for sterilization.

Reaction

The reaction section consists of the Fermentor, main BDS Reactors, and Seed Tanks.

Biocatalyst makeup to the BDS Reactors is grown in, and provided from, the Fermentor (D-201). The Fermentor operates in a continuous mode, with the rate of cell growth adjusted to meet the makeup requirements of the BDS system. The Fermentor is initially inoculated with biocatalyst from Seed Tank B.

Water, air, glucose, and nutrients are added to the Fermentor at controlled rates to provide the necessary environment for cell growth, and anhydrous ammonia is injected to control the pH and to provide additional nitrogen nutrient. The water can be supplied from fresh makeup or recycled from the effluent of the separation section. The remaining additives, chemicals and air are supplied from the feed section. All inputs to the Fermentor are sterilized.

The Fermentor is operated as an airlift reactor vessel. Chilled water is circulated through the vessel jacket to remove the heat generated from the glucose (substrate) oxidation and to control the Fermentor temperature at approximately 86°F. Biocatalyst makeup to the BDS Reactors, in the form of an aqueous slurry of 20 g/L, is transferred at a controlled rate by the Fermentor Transfer Pump (J-201A/B).

Diesel desulfurization occurs in three identical BDS Reactors (D-202, D-203, and D-204), each of which provides a hydraulic residence time of approximately 1.0 hour at the design flows. The reactors are operated in series flow, with the raw diesel and recycle plus makeup biocatalyst fed to BDS Reactor No. 1. The biocatalyst recycle is predominately a water stream with as much as 25 wt% entrained oil. Fresh makeup water can also be supplied if necessary to maintain the desired volumetric water-to-oil ratio of 50:50. The fresh biocatalyst makeup is set to maintain an operating cell density of 20 g/L, total fluid basis, in the reactors. The oil-water-biocatalyst emulsion is transferred from the first reactor to the second reactor by the BDS Reactor No. 1 Transfer Pumps (J-202A/B), and from the second reactor to the third by the BDS Reactor No. 2 Transfer Pumps (J-203A/B). The BDS Reactor No. 3 Transfer Pumps (J-204A/B) transfer the effluent from the third reactor to the downstream separation section.

Ethanol, nutrients, and air are supplied to each of the reactors to sustain the microorganisms and potassium hydroxide is added for pH control (the desired operating pH being 7). The air supply to each reactor is sterilized in individual Bio-Filters (L-105, L-106, and L-107, respectively) before entering the reactors. The air rate to each reactor is regulated to limit the carbon dioxide content of the off-gas to a maximum concentration of approximately 7 vol%. Carbon dioxide is formed from the oxidation of the ethanol substrate fed to the reactors.

Chilled water from the Chilled Water System is circulated through the vessel jackets as well as internal coils to remove the reaction heat and to control the reactor temperatures at the desired operating temperature of 86°F.

When the plant is first started up or when it is restarted after a shutdown, the required biocatalyst inventory must be re-established. The required microorganisms are grown in the two seed tanks, Seed Tank A (D-205) and Seed Tank B (D-206). D-205 is a packaged 40 L seed system and D-206 a packaged 2000 L system. The seed tanks are operated in a batch mode, with the tanks and associated piping sterilized between batch runs.

Separation

The separation section serves two functions; to recover the desulfurized diesel product and to separate a biocatalyst and oil-free water stream. The separation section consists of the 1st Stage Separator, the Coalescer Separators, and the Electrostatic Dehydrator.

The pumped effluent from BDS Reactor No. 3 is discharged into the 1st Stage Separator. A surfactant is injected into the reactor effluent stream upstream of the Separator to enhance phase separation. Phase separation within the 1st Stage Separator occurs exclusively by gravity. The Separator is constructed with an internal overflow weir and effluent section for recovery of the separated light liquid (diesel) phase. The Separator is sized to provide 30 minutes of residence time at an operating level of 80%.

The recovered diesel product from the Separator will contain a small residual amount of water and biocatalyst that must be removed prior to transfer to storage. The 1st Stage Separator Overflow Pumps (J-301 A/B) transfer the diesel from the effluent compartment of the 1st Stage Separator to the downstream Electrostatic Dehydrator.

The underflow from the Separator, consisting of the majority of the water and biocatalyst plus approximately 25 wt.% retained oil, is split into two streams downstream of the 1st Stage Separator Underflow Pumps (J-302 A/B). Approximately 25% of the stream is directly recycled back to the reaction section, while the remaining 75% is forwarded to the Coalescer Separators. The amount of direct recycle is limited by a maximum sulfate concentration 5% in the effluent from BDS Reactor No. 3. Sulfate concentrations in excess of 5% can inhibit the activity of the biocatalyst.

A small quantity of air is continuously injected into the 1st Stage Separator. The air serves as a purge to control buildup of any gases that may be released from the BDS Reactor effluent stream. The vent stream from the separator is sent to the plant off-gas handling system.

The majority of the water and biocatalyst retained with the separated diesel product is removed in the Electrostatic Dehydrator (L-302). Recovery is accomplished by imposing an electrical voltage to the fluid that serves to coalesce the entrained water droplets. A wash water stream is injected into the dehydrator feed stream to enhance water removal. The effluent from the precipitator is forwarded to the Salt Dryers for removal of the last traces of moisture. The recovered biocatalyst-containing water stream from the dehydrator is recycled to BDS Reactor No. 1.

The Coalescer Separators (L-301 A/B) receive a portion (approximately 75%) of the underflow from the upstream 1st Stage Separator. The purpose of these separators is to recover an essentially oil and biocatalyst-free water stream. Each of the separators is equipped with an internal coalescer element to promote phase separation. Two separators, one in-service and a spare, allow for cleaning the coalescer elements during a run.

The light phase from the Coalescer Separators consists of a water-oil-biocatalyst mixture of approximately 65 wt% water and 35 wt% oil plus biocatalyst. This light phase is recycled back to the reaction section by means of the Coalescer Separator Overflow Pumps (J-303 A/B). A strip stream, representing the biocatalyst purge, is taken from the light phase recycle and forwarded to the Oxidizer. The absolute biocatalyst purge quantity is equivalent to the fresh makeup supplied to maintain catalyst activity.

The last traces of residual water are removed from the diesel product in the Salt Dryers (D-401 A/B) before transfer to storage. A final removal step is required since even trace amounts of water will cause the diesel product to have a hazy appearance. Flows through the parallel-operated dryers are upwards through the salt beds. While salt replacement in the dryers would normally occur during a scheduled plant shutdown, two dryers are provided to allow for salt replacement during a run if required.

Biocatalyst Waste Oxidation

Waste biocatalyst purge stream disposal is through thermal oxidation. The biocatalyst purge stream from the separation section is forwarded to the Thermal Oxidizer (L-801), which is a horizontally-fired, liquid injection-type incinerator.

Refrigeration System

Cooling is required to regulate the temperatures of the feed streams to the BDS Unit and to remove the heat generated in the Fermentor and BDS Reactors. A closed loop circulating chilled water (water/glycol mixture) system is used for this purpose, with water chilling provided by the Chilled Water Refrigeration Package (L-601).

The chilled water is pumped from the Chilled Water Expansion Drum (F-601) to the Chilled Water Cooler (C-601) by the Chilled Water Circulation Pumps (J-601 A/B). In C-601, the water-glycol solution temperature is reduced to the desired operating temperature by exchange with refrigerant. The supply temperature of the solution will be low enough to achieve the necessary thermal driving force so that process heat transfer areas are reasonable. From the chiller, the water is distributed to the various users and then returned to the expansion drum.

The largest heat loads on the system are the exothermic heat removal requirements of the Fermentor and BDS Reactors. Additional heat loads are associated with cooling the diesel feed, the process air from the air compressors, and the reactor system vent gases, with smaller loads associated with the package sterilization systems. With the exception of the Vent Gas Chiller, the cooling medium for all applications is circulating chilled water. Refrigerant will be directly used as the cooling medium for the Vent Gas Chiller due to the lower required operating temperature.

COST ESTIMATE

Total Installed Cost

The conceptual cost estimate is based on installing an BDS Unit processing 6,000 bpd raw diesel feed and producing ULSD meeting the 10-ppmw sulfur requirement. The cost estimate is for the IBL portion of the BDS complex only.

Based on equipment-based costs for the BDS Unit, the total installed cost estimate for the IBL portion of the BDS complex is $33.9 million in 2005 dollars based on USGC pricing. The accuracy of the estimate is +50/-15%.

The cost estimate excludes other owner costs such as startup and commissioning costs, initial operator training, startup procedures, and pre-startup operator staffing. A contingency of 25% is in the total installed cost.

See Appendix D for the Cost Estimate Basis and Cost Estimate.

Operating Cost and Capital Recovery

The total annual operating cost of the BDS Unit is $9,232,900. This cost is based on a 95% on-stream availability for the plant. The operating cost can also be expressed in terms of cents per gallon of ULSD, based on a 98.6% yield on the ULSD. The total operating cost of the BDS Unit is 10.7 cents per gallon of ULSD. The basis for developing the operating cost including utilities can be seen in Appendix E.

Based on the expected TIC of the BDS Unit, the incremental selling price for ULSD would be 7.9 cents per gallon to recover the capital in 5 years (excluding interest expense), and the incremental selling price to recover operating costs would be 10.7 cents per gallon. The total incremental selling price for ULSD would be 18.6 cents per gallon to recover the capital in 5 years and pay the yearly operating cost.

The operating cost includes lost diesel sales due to loss of diesel with the biocatalyst purge stream.

APPENDICES

A. Diesel Feed Properties and Sulfur Speciation

B. BDS Unit Process Flow Diagrams and Material Balance

Process Flow Diagrams
Material Balance

C. BDS Unit Equipment and Budgetary Equipment Data Sheets

Equipment List
Budgetary Equipment Data Sheets

D. Cost Estimate Basis and Cost Estimate

E. BDS Baseline Case Operating Costs for 6,000 BPD Diesel Feed including Utilities

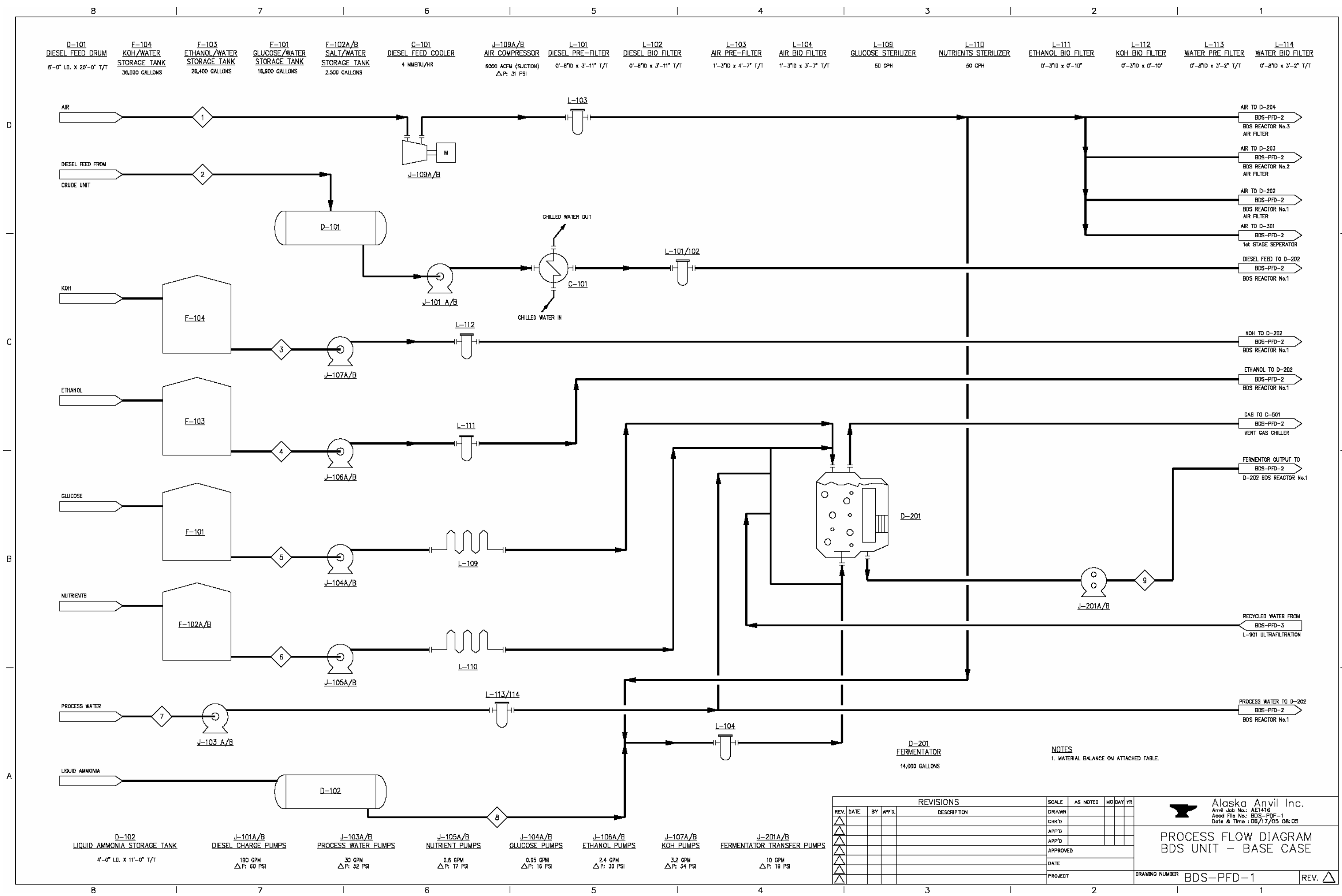
Appendix A – Diesel Feed Properties and Sulfur Speciation

Diesel Feed Properties			
Test	**Units**	**Results**	**Specification**
Gravity @ 60°F, Min/Max	API	33.3	32-36
Flash Pt, Min.	Celsius	63.5 (146°F)	60 (140°F)
Cloud Pt, Max.	Celsius	-12.3 (10°F)	-9.5 (15°F)
Pour Pt, Max.	Celsius	-15 (5°F)	-12 (10°F)
Distillation			
IBP	Celsius	171 (340 °F)	Report
10% Recovery	Celsius	249 (480 °F)	Report
20% Recovery	Celsius	265 (509 °F)	Report
50% Recovery	Celsius	287 (549 °F)	Report
90% Recovery	Celsius	317 (603 °F)	282-338
Final Boiling Pt.	Celsius	336 (637 °F)	Report
Recovery	Vol %	99.9	Report
Residual	Vol %	0.1	Report
Loss	Vol %	0	Report
Viscosity @ 40 C, Min/Max	CSt	3.57	2.0-4.3
Ash, Max	Wt%	<0.001	0.01%
Carbon Residue on 10% Bottoms, Max	Wt%	0.08	0.35%
Btu Gross, Min	Btu/Gallon	139,190	136,000
Calculated Cetane, Min	Index	48	45
Copper Strip Corrosion, Max	Code	1a	3
Total Sulfur	Wt.%	0.500	0.500

Sulfur Speciation (Ratioed to 5,000 ppm*)			
Component	**ppm wt sulfur**	**Component**	**ppm wt sulfur**
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	2
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	29
Thiophene	<1	Trimethyl benzothiophene	119
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	354
Isobutyl mercaptan	<1	Dibenzothiophene	229
Ethyl sulfide	<1	4-Methyl benzothiophene	213
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	147
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	94
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	97
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	354
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	75
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	4
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

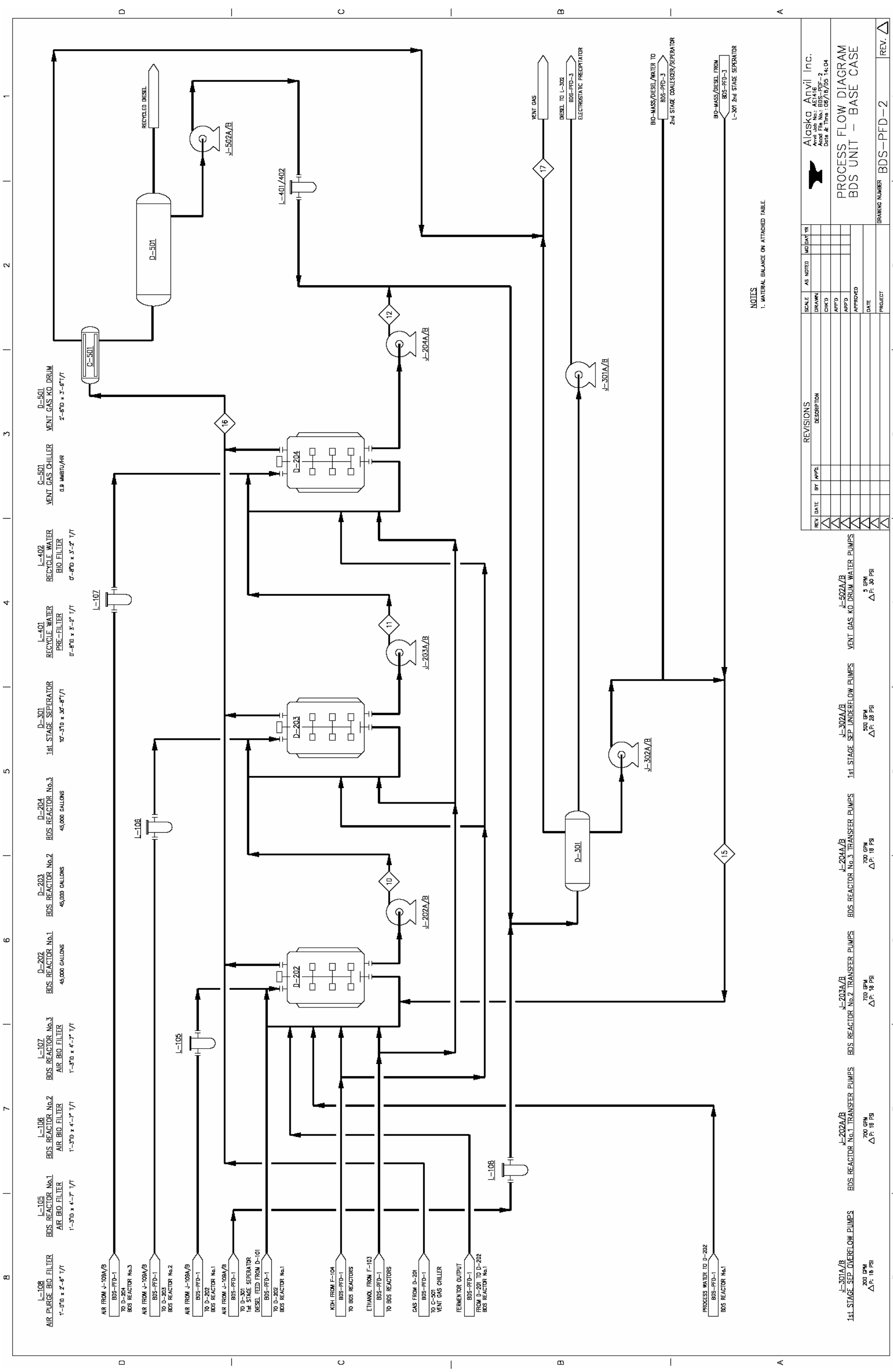
* Raw data from the speciation analysis ratioed to 5,000 ppm to reflect the design basis sulfur content.

Appendix B – BDS Unit Process Flow Diagrams and Material Balance



BDS BASELINE REPORT

PETRO STAR INC.
HDS/BDS STUDY



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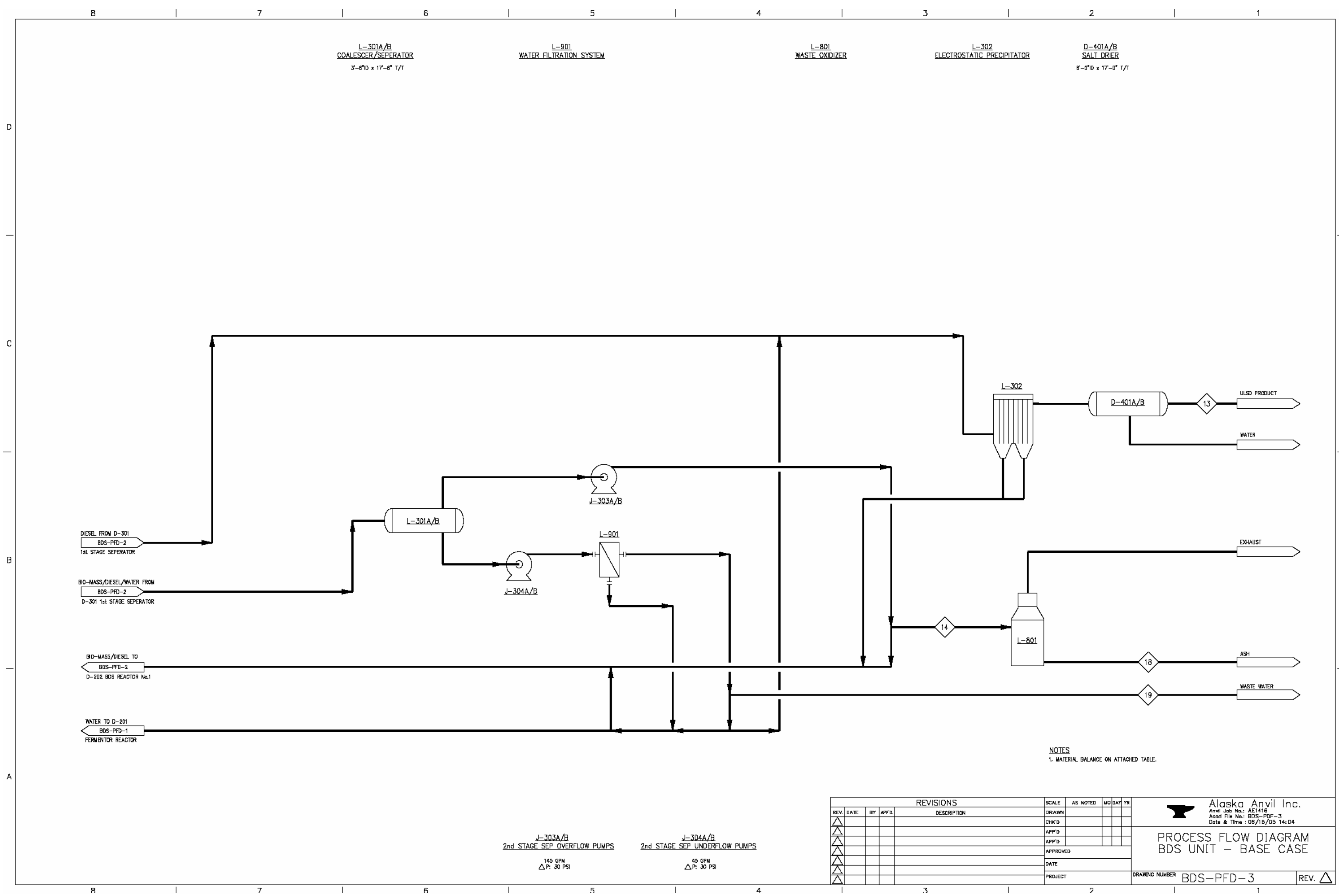
L-301A/B
COALESCER/SEPERATOR
3'-8"ID x 17'-6" T/T
L-901
WATER FILTRATION SYSTEM
L-801
WASTE OXIDIZER
L-302
ELECTROSTATIC PRECIPITATOR
D-401A/B
SALT DRIER
8'-0"ID x 17'-0" T/T
DIESEL FROM D-301
BDS-PFD-2
1st STAGE SEPERATOR
BIO-MASS/DIESEL/WATER FROM
BDS-PFD-2
D-301 1st STAGE SEPERATOR
BIO-MASS/DIESEL TO
BDS-PFD-2
D-202 BDS REACTOR No.1
WATER TO D-201
BDS-PFD-1
FERMENTOR REACTOR
J-303A/B
J-304A/B
ULSD PRODUCT
WATER
EXHAUST
ASH
WASTE WATER
13
14
18
19
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
J-303A/B
2nd STAGE SEP OVERFLOW PUMPS
145 GPM
ΔP: 30 PSI
J-304A/B
2nd STAGE SEP UNDERFLOW PUMPS
45 GPM
ΔP: 30 PSI
REVISIONS
REV. DATE BY APP'D. DESCRIPTION
SCALE AS NOTED
DRAWN
CHK'D
APP'D
APPROVED
DATE
PROJECT
Alaska Anvil Inc.
PROCESS FLOW DIAGRAM
BDS UNIT - BASE CASE
DRAWING NUMBER BDS-PFD-3
REV.

Material Balance

BDS Unit Material Balance -- BDS Baseline Case

PFD Stream Number		1	2	3	4	5	6	7
Simulation Stream Number		Air	Diesel	NaOH	Ethanol	Glucose	Nutrients	Process Water
Stream Description		Air Feed	Diesel Feed	NaOH Feed	Ethanol Feed	Glucose Feed	Nutrient Feed	Process Water Feed
Phase		VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flow	LB/HR		74483					
Aqueous Mass Flow	LB/HR			1900	926	456	370	13270
Biomass Mass Flow	LB/HR							
Sulfur in HC	PPM		5000					
Total Mass Flow Rate	LB/HR	26663	74483	1900	926	456	370	13270
Temperature	F	68	176	68	68	68	68	68
Pressure	PSIG	0	0	0	0	0	0	0
Standard Liq Flow	BPD		6000	85	69	26	25	912
Vapor Flow	MSCFH	359						
Wt % Vapor		100	0	0	0	0	0	0
MW								

PFD Stream Number		8	9	10	11	12	13	14
Simulation Stream Number		Liquid Ammonia	S-16	S-17	S-18	S-19	S-27	S-31
Stream Description		Liquid Ammonia Feed	Fermentor Output	R#1 Output	R#2 Output	R#3 Output	Diesel Product	Biomass Purge
Phase		LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flow	LB/HR			124764	124517	124322	73413	907
Aqueous Mass Flow	LB/HR	33	3367	146244	147805	148092	0	1660
Biomass Mass Flow	LB/HR		456	32181	32181	32181	0	456
Sulfur in HC	PPM			1269	177	10	10	10
Mass Flow Rate	LB/HR	33	3823	303188	304530	304594	73413	3024
Temperature	F	-40	86	86	86	86	86	86
Pressure	PSIG	210	33.1	36.4	36.4	26.8	5	5
Standard Liq Flow	BPD	3.2	262	21751	21813	21813	5914	212
Vapor Flow	MSCFH							
Wt % Vapor		0	0	0	0	0	0	0
MW								

PFD Stream Number		15	16	17	18	19		
Stream Number		S-32	S-38	S-39	Ash	Waste Water		
Stream Description		Reactor Recycle	Reactor Air Effluent	Gas Purge	Incinerator Waste	Waste Water		
Phase		LIQUID	GAS	GAS	SOLID	LIQUID		
Hydrocarbon Mass Flow	LB/HR	50562	561					
Aqueous Mass Flow	LB/HR	128530	405			16398		
Biomass Mass Flow	LB/HR	31725						
Sulfur in HC	PPM	10	487					
Total Mass Flow Rate	LB/HR	210816	25936	25100	61	16398		
Temperature	F	86	86	60	68	86		
Pressure	PSIG	37.4	10	1	0	10		
Standard Liq Flow	BPD	14561				1074		
Vapor Flow	MSCFH		342	331				
Wt % Vapor		0	100	100	0	0		
MW								

Appendix C – BDS Unit Equipment List and Budgetary Equipment Data Sheets

BDS Unit Equipment List

Pumps & Compressors

ITEM	SERVICE	Rated Flow gpm [acfm]	Sp.Gr @ Temp	Suction Temp (Deg F)	Suction Press (psig)	Disch Press (psig)	Differential Press (psig)	Differential Head (ft)	Type	Driver Type	Rating Driver (Hp)	Metallurgy Casing/Impeller	Comments
PUMPS													
J-101A	Diesel Charge Pump	190.0	0.85	60 / 140	1.2	61.3	60.1	163.1	Cent	Motor	15.0	CS/CS	
J-101B	Diesel Charge Pump (Spare)	190.0	0.85	60 / 140	1.2	61.3	60.1	163.1	Cent	Motor	15.0	CS/CS	
J-103A	Process Water Pump	30	1.00	Amb	5.0	57.4	52.4	121.0	Cent	Motor	5.0	CS/CS	Periodic Operation
J-103B	Process Water Pump (Spare)	30	1.00	Amb	5.0	57.4	52.4	121.0	Cent	Motor	5.0	CS/CS	Periodic Operation
J-104A	Glucose Pump	1	1.22	Amb	1.6	18.0	16.4	31.0	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-104B	Glucose Pump (Spare)	1	1.22	Amb	1.6	18.0	16.4	31.0	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-105A	Nutrients Pump	0.8	1.00	Amb	1.2	18.0	16.8	38.7	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-105B	Nutrients Pump (Spare)	0.8	1.00	Amb	1.2	18.0	16.8	38.7	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-106A	Ethanol Pump	2.4	0.87	Amb	1.0	31.4	30.4	80.7	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-106B	Ethanol Pump (Spare)	2.4	0.87	Amb	1.0	31.4	30.4	80.7	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Manual adjustable
J-107A	Potassium Hydroxide Pump	3.2	1.21	Amb	1.6	35.9	34.3	65.4	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Automatic adjustable

BDS BASELINE REPORT

ITEM	SERVICE	Rated Flow gpm [acfm]	Sp.Gr @ Temp	Suction Temp (Deg F)	Suction Press (psig)	Disch Press (psig)	Differential Press (psig)	Differential Head (ft)	Type	Driver Type	Rating Driver (Hp)	Metallurgy Casing/Impeller	Comments
PUMPS													
J-107B	Potassium Hydroxide Pump (Spare)	3.2	1.21	Amb	1.6	35.9	34.3	65.4	Diaphram	Hydraulic (Air)	---	SS Wetted Parts	Automatic adjustable
J-201A	Fermentor Transfer Pump	10	1.01	Amb	14.1	33.1	19.0	43.4	Rotary Lobe	Motor	0.5	SS Wetted parts	Double Mech. Seals
J-201B	Fermentor Transfer Pump (Spare)	10	1.01	Amb	14.1	33.1	19.0	43.4	Rotary Lobe	Motor	0.5	SS Wetted parts	Double Mech. Seals
J-202A	BDS Reactor No. 1 Transfer Pump	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-202B	BDS Reactor No. 1 Transfer Pump (Spare)	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-203A	BDS Reactor No. 2 Transfer Pump	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-203B	BDS Reactor No. 2 Transfer Pump (Spare)	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-204A	BDS Reactor No. 3 Transfer Pump	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-204B	BDS Reactor No. 3 Transfer Pump (Spare)	700	0.93	86	18.4	36.4	18.0	44.7	Cent	Motor	15.0	SS/SS	Double Mech. Seals
J-301A	1st Stage Separator Overflow Pump	200	0.85	86	6.95	25.0	18.0	48.9	Cent	Motor	5.0	SS/SS	Double Mech. Seals
J-301B	1st Stage Separator Overflow Pump (Spare)	200	0.85	86	6.95	25.0	18.0	48.9	Cent	Motor	5.0	SS/SS	Double Mech. Seals
J-302A	1st Stage Separator Underflow Pump	500	0.96	86	9.0	37.4	28.4	68.4	Cent	Motor	10.0	SS/SS	Double Mech. Seals
J-302B	1st Stage Separator Underflow Pump (Spare)	500	0.96	86	9.0	37.4	28.4	68.4	Cent	Motor	10.0	SS/SS	Double Mech. Seals
J-303A	2nd Stage Separator Overflow Pump	145	0.95	86	7.7	37.4	29.7	72.2	Cent	Motor	5.0	SS/SS	Double Mech. Seals
J-303B	2nd Stage Separator Overflow Pump (Spare)	145	0.95	86	7.7	37.4	29.7	72.2	Cent	Motor	5.0	SS/SS	Double Mech. Seals
J-304A	2nd Stage Separator Underflow Pump	45	1.00	86	7.7	37.4	29.7	68.5	Cent	Motor	3.0	SS/SS	Double Mech. Seals

ITEM	SERVICE	Rated Flow gpm [acfm]	Sp.Gr @ Temp	Suction Temp (Deg F)	Suction Press (psig)	Disch Press (psig)	Differential Press (psig)	Differential Head (ft)	Type	Driver Type	Rating Driver (Hp)	Metallurgy Casing/Impeller	Comments
PUMPS													
J-304B	2nd Stage Separator Underflow Pump (Spare)	45	1.00	86	7.7	37.4	29.7	68.5	Cent	Motor	3.0	SS/SS	Double Mech. Seals
J-502A	Vent Gas KO Drum Water Pump	5	1.00	86	3.6	33.8	30.2	69.8	Cent	Motor	0.5	CS/CS	On/Off Operation
J-502B	Vent Gas KO Drum Water Pump (Spare)	5	1.00	86	3.6	33.8	30.2	69.8	Cent	Motor	0.5	CS/CS	On/Off Operation
J-601A	Chilled Water Circulation Pump	2000	1.00	65	2.5	38.5	36.0	83.1	Cent	Motor	60	CS/CS	
J-601B	Chilled Water Circulation Pump (Spare)	2000	1.00	65	2.5	38.5	36.0	83.1	Cent	Motor	60	CS/CS	
Compressors													
J-109A	Air Compressor	[6000]			0	31			Screw	Motor	550		
J-109B	Air Compressor (Spare)	[6000]			0	31			Screw	Motor	550		

Exchangers

ITEM	DESCRIPTION	Duty (MMBtu/Hr)	Shells (Bays)	Surface Per Shell (Bay) (ft2)	Design Shellside (psig)	Design Shellside (F)	Design Tubeside (psig)	Design Tubeside (F)	TEMA Type & Shell Size or	Metallurgy Shellside	Metallurgy Tubeside
C-101	Diesel Feed Cooler	4	1	1750	100	300	100	300	AES	CS	CS
C-501	Vent Gas Chiller	0.9	1	1200	50	300	100	300	AES	CS	CS
C-601	Chilled Water Cooler	19	1	8375	100	300	100	300	AES	CS	CS

Vessels

			Dia (ft)	T/T (ft)	Press (psig)	Temp (Deg F)	Press (psig)	Temp (Deg F)	Shell/Heads	
D-101	Diesel Feed Drum	Pressure Vessel	8.0	20.0	5	60 / 140	30	190	CS/CS	HORIZ
D-102	Anhydrous Ammonia Storage Drum	Pressure Vessel	4.0	11.0	225	Amb	275	150	CS/CS	HORIZ
D-201	Fermentor	Jacketed Pressure Vessel	10.0 (shell)	30.0 (shell)	5	86	50 (2)	315 (2)	SS/SS	VERT
D-202	BDS Reactor No. 1	Jacketed Pressure Vessel	15.0 (shell)	40.0 (shell)	5	86	50 (2)	315 (2)	SS/SS	VERT
D-203	BDS Reactor No. 2	Jacketed Pressure Vessel	15.0 (shell)	40.0 (shell)	5	86	50 (2)	315 (2)	SS/SS	VERT
D-204	BDS Reactor No. 3	Jacketed Pressure Vessel	15.0 (shell)	40.0 (shell)	5	86	50 (2)	315 (2)	SS/SS	VERT
D-205	Seed Tank A	Pressure Vessel (40 L)			5	86	50 (2)	315 (2)	SS/SS	VERT
D-206	Seed Tank B	Jacketed Pressure Vessel	5.0 (shell)	5.0 (shell)	5	86	50 (2)	315 (2)	SS/SS	VERT
D-301	1st Stage Separator	Pressure Vessel	10.3	30.7	5	86	50 (2)	150	SS/SS	HORIZ
D-401A	Salt Drier	Pressure Vessel	6.0	17.0	25 (3)	86	50	150	CS/CS	VERT
D-401B	Salt Drier	Pressure Vessel	6.0	17.0	25 (3)	86	50	150	CS/CS	VERT
D-501	Vent Gas KO Drum	Pressure Vessel	2.5	3.8	5	40	30	150	CS/CS	VERT

Tanks

ITEM	SERVICE	Type	Dimensions		Design Conditions		Metallurgy
			Dia (ft)	T/T (ft)	Press (psig)	Temp (Deg F)	
F-101	Glucose Storage Tank (50%)	Atm. Tank	12.0	20.0	Atm.	150	CS Internally Coated
F-102A	Nutrients Storage Tank	Atm. Tank	6.0	12.0	Atm.	150	CS Internally Coated
F-102B	Nutrients Storage Tank	Atm. Tank	6.0	12.0	Atm.	150	CS Internally Coated
F-103	Ethanol Storage Tank (70%)	Atm. Tank	15.0	20.0	Atm.	150	Epoxy Resin
F-104	KOH Storage Tank	Atm. Tank	16.0	24.0	Atm.	150	CS Internally Coated

Special Equipment

ITEM	SERVICE	DESCRIPTION	Materials
L-101	Diesel Pre Filter	Five 1.5um 30" long cartridge filters in 8" diameter by 47" housing.	316L SS housing / polypropylene elements.
L-102	Diesel Bio Filter	Five 0.2um 30" long cartridge filters in 8" diameter by 47" housing.	316L SS housing / polyethersulphone elements.
L-103	Air Pre Filter	Five 1.0um 30" long cartridge filters in 15" diameter by 55" housing.	316L SS housing / GF elements.
L-104	Fermentor Air Bio Filter	Five 0.01um 10" long cartridge filters in 15" by 43" housing.	316L SS housing / PTFE elements.
L-105	BDS Reactor No. 1 Air Bio Filter	Five 0.01um 30" long cartridge filters in 15" by 55"" housing.	316L SS housing / PTFE elements.

ITEM	SERVICE	DESCRIPTION	Materials
L-106	BDS Reactor No. 2 Air Bio Filter	Five 0.01um 30" long cartridge filters in 15" by 55"" housing.	316L SS housing / PTFE elements.
L-107	BDS Reactor No. 3 Air Bio Filter	Five 0.01um 30" long cartridge filters in 15" by 55"" housing.	316L SS housing / PTFE elements.
L-108	Air Purge Bio Filter	Three 0.01um 10" long cartridge filters in 12" by 30" housing.	316L SS housing / PTFE elements.
L-109	Glucose Sterilizer	Packaged 50 gph continuous steam sterilizer system complete with preheater, heater, cooler and holding coil.	316L SS
L-110	Nutrients Sterilizer	Packaged 50 gph continuous steam sterilizer system complete with preheater, heater, cooler and holding coil.	316L SS
L-111	Ethanol Bio Filter	One 0.2um 5" long cartridge filter in 2.5" by 10" housing.	316L SS housing / polyethersulphone filters.
L-112	KOH Bio Filter	One 0.2um 5" long cartridge filter in 2.5" by 10" housing.	316L SS housing / polyethersulphone filters.
L-113	Makeup Water Pre Filter	Three 1.5um 20" long cartridge filters in 8" by 38" housing.	316L SS housing / polypropylene filters
L-114	Makeup Water Bio Filter	Three 0.2um 20' long cartridge filters in 8" by 38" housing.	316L SS housing / polyethersulphone filters.
L-301A	Coalescer/Separator	3.5' by 17.5' horizontal pressure vessel with 1.0' by 2.0' boot equipped with 24" OD by 18" ID by 120" L internal fiberbed coalescer element	304L SS vessel with glass/304 SS coalescer element.
L-301B	Coalescer/Separator Spare	3.5' by 17.5' horizontal pressure vessel with 1.0' by 2.0' boot equipped with 24" OD by 18" ID by 120" L internal fiberbed coalescer element	304L SS vessel with glass/304 SS coalescer element.
L-302	Electrostatic Dehydrator	Horizontal pressure vessel with internal distributors and electrodes, power supply, mixing valve and liquid level controller.	316l stainless steel vessel and internals.
L-401	Recycle Water Pre Filter	Five 1.5um 20" long cartridge filters in 8" by 38" housing.	316L SS housing / polypropylene filters
L-402	Recycle Water Bio Filter	Five 0.2um 20' long cartridge filters in 8" by 38" housing.	316L SS housing / polyethersulphone filters.
L-601	Cooling Water Refrigeration Unit	Package propane refrigeration unit complete with compressor, 1500 HP driver, lube oil system, KO drum and all necessary	

ITEM	SERVICE	DESCRIPTION	Materials
		instrumentation and controls. System would be provided on two skids: one for the compressor system and one for the air cooler.	
L-801	Waste Oxidizer	Packaged horizontal thermal oxidizer with high intensity burner, refractory lined chamber and stack.	

ANVIL

BUDGETARY DATA SHEET
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	D-101		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8'		
TANGENT TO TANGENT LENGTH, FT.	X	20'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	190		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
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BUDGETARY DATA SHEET
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	D-102		
SERVICE	X	Storage Tank		
FLUID	X	Liquid Ammonia		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	4'		
TANGENT TO TANGENT LENGTH, FT.	X	11'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	275		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	N/A		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	10'-3"		
TANGENT TO TANGENT LENGTH, FT.	X	30'-8"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	D-501		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	3'-9"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	F-101		
SERVICE	X	Storage Tank		
FLUID	X	Glucose/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	12'		
TANGENT TO TANGENT LENGTH, FT.	X	20'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

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BUDGETARY DATA SHEET
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	F-102 A/B		
SERVICE	X	Storage Tank		
FLUID	X	Salt/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	6'		
TANGENT TO TANGENT LENGTH, FT.	X	12'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	F-103		
SERVICE	X	Storage Tank		
FLUID	X	Ethanol/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	15'		
TANGENT TO TANGENT LENGTH, FT.	X	20'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	Epoxy Resin		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

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BUDGETARY DATA SHEET
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	F-104		
SERVICE	X	Storage Tank		
FLUID	X	NaOH/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	16'		
TANGENT TO TANGENT LENGTH, FT.	X	24'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-101 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	140		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	190		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	61.3		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		60.1		
DIFFERENTIAL HEAD, FT		163.1		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**	

ITEM NUMBER	X	J-103 A/B (1)		
SERVICE (FLUID)	X	Process Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.997		
RATED FLOW (GPM)	X	30		
SUCTION PRESSURE, PSIG	X	5		
DISCHARGE PRESSURE PSIG	X	57.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		52.4		
DIFFERENTIAL HEAD, FT		121		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
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O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER HDS/BDS Study **PROJECT ENGINEER PMD**
LOCATION Alaska **PROJECT NO. AE1416**
PROCESS UNIT BDS ULSD Baseline **DATE 3/17/05**

ITEM NUMBER	X	J-104 A/B (1)		
SERVICE (FLUID)	X	Glucose/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.2		
RATED FLOW (GPM)	X	0.95		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.4		
DIFFERENTIAL HEAD, FT		31		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-105 A/B (1)		
SERVICE (FLUID)	X	Salts/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	0.8		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.8		
DIFFERENTIAL HEAD, FT		38.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**	

ITEM NUMBER	X	J-106 A/B (1)		
SERVICE (FLUID)	X	Ethanol/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.914		
RATED FLOW (GPM)	X	2.4		
SUCTION PRESSURE, PSIG	X	1		
DISCHARGE PRESSURE PSIG	X	31.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.4		
DIFFERENTIAL HEAD, FT		80.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-107 A/B (1)		
SERVICE (FLUID)	X	NaOH/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.53		
RATED FLOW (GPM)	X	3.2		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	35.9		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		34.3		
DIFFERENTIAL HEAD, FT		65.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-109 A/B		
FLUID	X	Air		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Screw		
TOTAL NUMBER OF MACHINES	X	2		
RATED CAPACITY (ACFM @ SUCTION)	X	6,000		
SUCTION TEMPERATURE ^{O}F	X	68		
SUCTION PRESSURE, PSIA	X	14.7		
DISCHARGE PRESSURE, PSIA	X	31		
GAS MOLECULAR WEIGHT	X	28.9		
'K' VALUE OF GAS	X			
MOL % HYDROGEN IN GAS	X	0		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	Water		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	550		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	516		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS
1) Will be subject to -20¡F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-201 A/B (1)		
SERVICE (FLUID)	X	Biomass/Salts/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	10		
SUCTION PRESSURE, PSIG	X	14.1		
DISCHARGE PRESSURE PSIG	X	33.1		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Rotary Lobe		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		19		
DIFFERENTIAL HEAD, FT		43.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-202 A/B (1)		
SERVICE (FLUID)	X	Biomass/Diesel/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.93		
RATED FLOW (GPM)	X	700		
SUCTION PRESSURE, PSIG	X	18.4		
DISCHARGE PRESSURE PSIG	X	36.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		44.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
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M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**	

ITEM NUMBER	X	J-301 A/B (1)		
SERVICE (FLUID)	X	Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	200		
SUCTION PRESSURE, PSIG	X	7		
DISCHARGE PRESSURE PSIG	X	25		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		48.9		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
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M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**	

ITEM NUMBER	X	J-302 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.96		
RATED FLOW (GPM)	X	500		
SUCTION PRESSURE, PSIG	X	9		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	10		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		28.4		
DIFFERENTIAL HEAD, FT		68.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-303 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	145		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
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M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-304 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	45		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	3		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-502 A/B (1)		
SERVICE (FLUID)	X	Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	5		
SUCTION PRESSURE, PSIG	X	3.6		
DISCHARGE PRESSURE PSIG	X	33.8		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.2		
DIFFERENTIAL HEAD, FT		69.8		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 6/11/05**

ITEM NUMBER	X	J-601 A/B (1)		
SERVICE (FLUID)	X	Water Chiller Pump		
TEMPERATURE OF FLUID	X	65		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.95		
RATED FLOW (GPM)	X	2000		
SUCTION PRESSURE, PSIG	X	2.5		
DISCHARGE PRESSURE PSIG	X	38.5		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	60		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		36		
DIFFERENTIAL HEAD, FT		81.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20¡F.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	x	C-101		
SERVICE	x	Diesel Feed Cooler		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	1750		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	4		

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BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	x	C-501		
SERVICE	x	Vent Gas Chiller		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	1200		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Air		
DESIGN PRESSURE, PSIG	x	50		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	0.9		

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BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER PMD**	
LOCATION	Alaska		**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline		**DATE 6/11/05**	

ITEM NUMBER	x	C-601		
SERVICE	x	Chiller Exchanger		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	8375		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	19		

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-101		
SERVICE	X	Diesel Pre-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

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BUDGETARY DATA SHEET

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-102		
SERVICE	X	Diesel Pre-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	PMD
LOCATION	Alaska		**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline		**DATE**	2/22/05

ITEM NUMBER	X	L-103		
SERVICE	X	Air Pre-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		GF		
PORE SIZE, MICRON	X	1.0 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-104		
SERVICE	X	Air Bio-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	43"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSIN(	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-105		
SERVICE	X	Reactor Bio Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	PMD
LOCATION	Alaska		**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline		**DATE**	2/22/05

ITEM NUMBER	X	L-108		
SERVICE	X	Air Purge Biofilter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	30"		
HOUSING DIAMETER, IN	X	12"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-111		
SERVICE	X	Ethanol Bio Filter		
FLUID	X	Ethanol/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-112		
SERVICE	X	NaOH Bio Filter		
FLUID	X	NaOH/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	L-113		
SERVICE	X	Water Pre Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/17/05

ITEM NUMBER	X	L-113		
SERVICE	X	Water Bio Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (¡F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUSING	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMENTS		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

ANVIL

BUDGETARY DATA SHEET
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	2/22/05

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	17'-6"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (¡F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	24"ODx18"IDx120"L		
PACKING MATERIAL	X	Fiberbed Coalescer		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes 1'x2'		

PETRO STAR INC.

ULTRA LOW SULFUR DIESEL (BDS BASELINE - IBL)

PHASE 1 ESTIMATE BASIS REVISION 0

ALASKA ANVIL NO. AE1416

JUNE 2005

ALASKA ANVIL INCORPORATED

ESTIMATE BASIS GOAL

This Estimate Basis identifies information, qualifications, exceptions, and assumptions used in developing the cost estimate.

ESTIMATE BASIS PURPOSE

During the estimate review process, the project team uses the Estimate Basis for the following purposes:

- As a checklist of items to consider during estimate preparation.
- To document what is included and not included in the cost estimate.
- To assess cost risks of estimate components.
- As part of the decision support package for assessing the BDS process feasibility.

GENERAL INFORMATION

- The purpose of the project estimate is to determine if the ULSD BDS process is economically viable as a standalone process or in combination with an HDS Unit. This estimate addresses the BDS standalone process.
- Estimate type:
  - The estimate was developed using equipment based factored estimates for Inside Battery Limits (IBL) costs.
  - Most of the equipment pricing in the Diesel Biodesulfurization Unit was derived from the ICARUS estimating program.
  - Pricing for equipment marked with an asterisk* in the estimate was provided by Pelorus.
  - Outside Battery Limits (OBL) costs have been excluded from this estimate.
- The project will be installed in a brownfield location within a Valdez Alaska Refinery.

PROCESS BASIS

Facility Data

- Facility type – Ultra Low Sulfur Diesel Treating Complex, which includes:
  - Diesel Biodesulfurization Unit

Design Basis

Product specification – Feed 6,000 bpd of untreated diesel to produce 10-ppmw sulfur maximum ultra low sulfur diesel.

COST BASIS

Labor, Indirects, Equipment, and Bulk Materials

- Included in the equipment factor.

Project Services

- BDS – estimated based on 15 percent of TIC.

Owner Services

Not included in the TIC cost. Historically, owner services will cost from 5 to 7 percent of TIC, not including licensing, royalties, or catalyst.

Escalation

Project is based on 2005 costs. No escalation is included.

Location Factor

All costs for this estimate have been developed from a U.S. Gulf Coast (USGC) basis. No location factor is included.

Other Costs

- Catalyst and chemical initial charge has been added as an additional line item.

ASSUMPTIONS

- Process licensing and royalty costs are not included.
- Assumes fully installed pump spares, but no warehouse spares.

PROJECT COST & SCHEDULE ESTIMATE SUMMARY

CLIENT: Petrostar	**CLIENT PROJECT NO.:**	**CLIENT PE:**
PROJECT: BDS Baseline	**ANVIL PROJECT NO.: AE1416**	**ANVIL PE: B. Johnson**
STAGE: Phase 1	**REV NO.: 1**	**Date: 6/17/05**

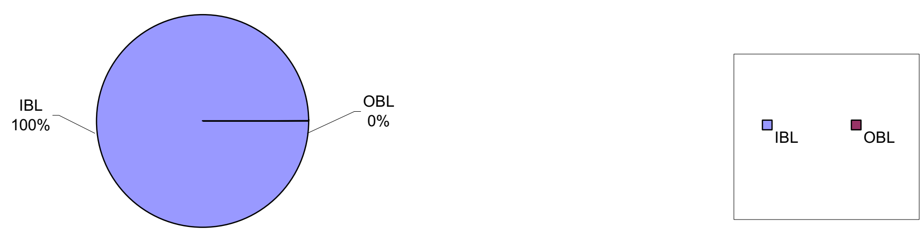
PROJECT DESCRIPTION:	**PROJECT RISKS:**

PROJECT COST ESTIMATE SUMMARY

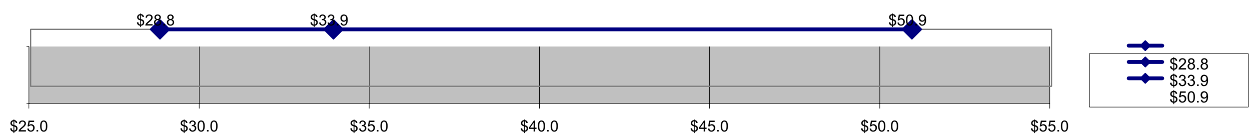
COST ESTIMATE STRUCTURE	**TOTAL PROJECT COST - USGC**	
COST ESTIMATE PARAMETERS		
Estimate Classification	Phase 1	
Estimating Method	Factored	
COST ESTIMATE SUMMARY		
Expected Cost ($MM)	**$**	**33.9**
High Range ($MM)	**$**	**50.9**
Low Range ($MM)	**$**	**28.8**

PROJECT COST ESTIMATE ANALYSIS

Total Project Expected Cost Component Analysis

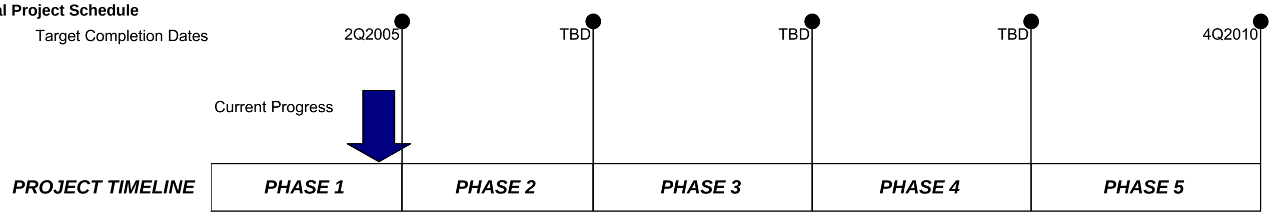


Total Project Cost Profile ($MM)



PROJECT SCHEDULE ESTIMATE ANALYSIS

Total Project Schedule



PROJECT: BDS Baseline
ANVIL NO: AE1416

CLIENT: Petrostar
Date: 6/17/05
REV: 0

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
SHELL & TUBE HEAT EXCHANGERS						
C-101	1	Diesel Feed Cooler	$31,500	4.0	$126,000	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1750SF, CS
C-501	1	Vent Gas Chiller	$25,600	4.0	$102,400	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1200SF, CS
C-601	1	Water Chiller	$83,000	4.0	$332,000	19 MM BTU/Hr, 8375 SF w/ 1 shell, TEMA type AES, Tubes: CS , Shell: CS
		SUB-TOTAL	**$140,000**		**$560,000**	
PRESSURE VESSELS						
D-101	1	Diesel Feed Drum	$39,500	4.2	$165,900	1(ea) - Horizontal Vessel, 8'0" DIA x 20'-0" T-T, CS
D-102	1	Liquid Ammonia Storage Tank	$16,400	4.2	$68,880	1(ea) - Horizontal Vessel, 4'0" DIA x 11'-0" T-T, CS, Insulated(safety)
D-201*	1	Fermentor Reactor	$185,000	4.2	$777,000	1(ea) - 14,000 gal airlift fermenter
D-202*	1	BDS Reactor #1	$595,000	4.2	$2,499,000	1(ea) - 45,000 gal airlift reactor, S/C Field Erected.
D-203*	1	BDS Reactor #2	$595,000	4.2	$2,499,000	1(ea) - 45,000 gal airlift reactor, S/C Field Erected.
D-204*	1	BDS Reactor #3	$595,000	4.2	$2,499,000	1(ea) - 45,000 gal airlift reactor, S/C Field Erected.
D-301	1	Diesel / Water / Biomass Separator	$112,300	4.2	$471,660	1(ea) - Horizontal Vessel, 10'3" DIA x 30'-8" T-T, 304SS, w/ overflow baffle
D-401A/B	2	Salt Drier	$62,600	4.2	$262,920	2(ea) - Horizontal Vessel, 6' DIA x 17' T-T, CS
D-501	1	Diesel / Water Separator	$9,600	4.2	$40,320	1(ea) - Horizontal Vessel, 2'6" DIA x 3'-9" T-T, CS, w/ overflow baffle
L-301	2	Diesel / Water / Biomass Separator	$61,600	4.2	$258,720	2(ea) - Horizontal Vessel, 316L SS, 3' 6" Dia. x 17' 6" T-T, 24"ODx18"IDx120"L Fiberbed Coalescer, Overflow Baffle and 1'x2' Boot
		SUB-TOTAL	**$2,272,000**		**$9,542,000**	

PROJECT: BDS Baseline
ANVIL NO: AE1416

CLIENT: Petrostar
Date: 6/17/05
REV: 0

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PACKAGED SKIDS/SYSTEMS						
D-205*	1	Seed Tank A	$94,000	2.5	$235,000	Packaged Seed Fermenter System
D-206*	1	Seed Tank B	$328,000	2.5	$820,000	Packaged Seed Fermenter System
J-109A/B	2	Air Compressor	$714,600	2.5	$1,786,500	2(ea) - Air Compressor, Reciprocating, 6000ACFM, CS body/internals, 600HP Motor Driven
L-109*	1	Glucose Sterilizer	$98,000	2.5	$245,000	1(ea) - Packaged 50 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-110*	1	Nutrients Sterilizer	$98,000	2.5	$245,000	1(ea) - Packaged 50 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-302*	1	Electrostatic Precipitator	$457,000	2.5	$1,142,500	Packaged ESP Unit
L-601*	1	Water Chiller	$860,000	2.5	$2,150,000	1(ea) - Packaged propane refirigeration unit complete w/ compressor, driver, lube oil system, KO drum & all necessary instr. & controls.
L-801*	1	Waste Oxidizer	$723,000	2.5	$1,807,500	1(ea) - Packaged horizontal thermal oxidizer w/ high intensity burner, refractory lined chamber & stack.
L-901*	1	Water Filtration System	$240,000	2.5	$600,000	1(ea) - Cross flow filtration system for water purification
		SUB-TOTAL	**$3,613,000**		**$9,032,000**	
ATMOSPHERE STORAGE TANKS						
F-101	1	Glucose / Water Storage Tank	$34,500	2.9	$100,050	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 12' DIA x 20' T-T, Epoxy Resin coated CS
F-102	1	Salt / Water Storage Tank	$14,900	2.9	$43,210	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 6' DIA x 12' T-T, Epoxy Resin coated CS
F-103	1	Ethanol / Water Storage Tank	$53,100	2.9	$153,990	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 15' DIA x 20' T-T, Epoxy Resin coated CS
F-104	1	NaOH / Water Storage Tank	$60,500	2.9	$175,450	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 16' DIA x 24' T-T, Epoxy Resin coated CS
		SUB-TOTAL	**$163,000**		**$473,000**	

A N V I L   C O R P O R A T I O N

PROJECT: BDS Baseline
ANVIL NO: AE1416

CLIENT: Petrostar
Date: 6/17/05
REV: 0

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PUMPS						
J-101A/B	2	Diesel Charge Pump	$55,000	4.5	$247,500	2(ea) - API Centrifugal Pump, 190 gpm, 163 ft. Head, 15HP Motor driven, CS, 1 operating, 1 installed spare
J-103A/B	2	Process Water Pump	$7,600	4.5	$34,200	2(ea) - Centrifugal Pump, 30 gpm, 121 ft. Head, 5HP Motor driven, CS, 1 operating, 1 installed spare
J-104A/B	2	Glucose Pump	$14,200	4.5	$63,900	2(ea) - Diaphragm Pump, 0.95 gpm, 31 ft. Head, 0.125HP Motor driven, 304SS, 1 operating, 1 installed spare
J-105A/B	2	Nutrients Pump	$13,800	4.5	$62,100	2(ea) - Diaphragm Pump, 0.8 gpm, 39 ft. Head, 0.125HP Motor driven, 304SS, 1 operating, 1 installed spare
J-106A/B	2	Ethanol Pump	$15,800	4.5	$71,100	2(ea) - Diaphragm Pump, 2.4 gpm, 81 ft. Head, 0.125HP Motor driven, 304SS, 1 operating, 1 installed spare
J-107A/B	2	Potassium Hydroxide Pump	$16,400	4.5	$73,800	2(ea) - Diaphragm Pump, 3.2 gpm, 65 ft. Head, 0.125HP Motor driven, 304SS, 1 operating, 1 installed spare
J-201A/B	2	Fermentor Transfer Pump	$12,800	4.5	$57,600	2(ea) - Rotary Lobe Pump, 10 gpm, 43 ft Head, 0.5HP Motor, 304SS, 1 operating, 1 installed spare
J-202A/B	2	BDS Reactor No1 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-203A/B	2	BDS Reactor No2 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-204A/B	2	BDS Reactor No3 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-301A/B	2	1st Stg Sep Overflow Pump	$47,600	4.5	$214,200	2(ea) - API Centrifugal Pump, 200 gpm, 49 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-302A/B	2	1st Stg Sep Underflow Pump	$18,400	4.5	$82,800	2(ea) - Centrifugal Pump, 500 gpm, 68 ft. Head, 10HP Motor driven, 304SS, 1 operating, 1 installed spare
J-303A/B	2	2nd Stg Sep Overflow Pump	$11,800	4.5	$53,100	2(ea) - Centrifugal Pump, 145 gpm, 72 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-304A/B	2	2nd Stg Sep Underflow Pump	$10,200	4.5	$45,900	2(ea) - Centrifugal Pump, 45 gpm, 72 ft. Head, 3HP Motor driven, 304SS, 1 operating, 1 installed spare
J-502A/B	2	Vent Gas KO Drum Wtr Pump	$6,200	4.5	$27,900	2(ea) - Centrifugal Pump, 5 gpm, 70 ft. Head, 0.5HP Motor driven, CS, 1 operating, 1 installed spare
J-601	2	Water Chiller Pump	$25,000	4.5	$112,500	API Centrifugal Pump, 2000 GPM, 0.95 SG, 81.7 Ft. Head, CS Case, 12%CR Impeller, 60HP Motor
		SUB-TOTAL	**$319,000**		**$1,436,000**	

PROJECT: BDS Baseline
ANVIL NO: AE1416

CLIENT: Petrostar
Date: 6/17/05
REV: 0

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
FILTERS						
L-101	1	Diesel Pre-Filter Vessel	$5,210	4.2	$21,882	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 1.5um pore size
L-102	1	Diesel Pre-Filter Vessel	$5,280	4.2	$22,176	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 0.2um pore size
L-103	1	Air Pre-Filter Vessel	$11,400	4.2	$47,880	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - GF element, 30" long, 1.0um pore size
L-104	1	Air Bio-Filter Vessel	$11,125	4.2	$46,725	1(ea) - Filter housing, 316L SS, 43" T-T x 15" Dia. w/ 5 (ea) - PTFE element, 10" long, 0.01um pore size
L-105	1	BDS Reactor #1 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-106	1	BDS Reactor #2 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-107	1	BDS Reactor #3 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-108	1	Air Purge Bio-Filter Vessel	$7,011	4.2	$29,446	1(ea) - Filter housing, 316L SS, 30" T-T x 12" Dia. w/ 3(ea) - PTFE element, 10" long, 0.01um pore size
L-111	1	Ethanol Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-112	1	NAaOH Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-113	1	Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-114	1	Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
L-401	1	Recycle Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-402	1	Recycle Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
		SUB-TOTAL	**$91,000**		**$384,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$462,000		$462,000	
		SUB-TOTAL	**$462,000**		**$462,000**	
		TOTAL	**$7,060,043**		**$21,900,000**	

A N V I L   C O R P O R A T I O N

PROJECT: BDS Baseline
ANVIL NO: AE1416

CLIENT: Petrostar
Date: 6/17/05
REV: 0

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
		DESIGN SERVICES			$ 5,000,000	
		OWNER'S SERVICES & COSTS (provided by owner)			$ -	
		INITIAL CHEMICAL CHARGE			$ 229,000	
		ESCALATION (provided by owner)			$ -	
		UNADJUSTED COST ESTIMATE (UCE)			$ 27,129,000	
		CONTINGENCY			$ 6,771,000	
		EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*			$ 33,900,000	

S:\PETRSTAR\AE1416\WORD_Finals\3 BDS Pelorus\[AE1416 BDS Baseline Est Rev1.xls]EB Summ

***Note: Equipment pricing by Pelorus.**

Appendix E. BDS Baseline Case Operating Costs for 6,000 BPD Diesel Feed

Item	2005$/year (365 day/yr)	cent/gal (ULSD)	Basis	
Utility - electricity	$ 1,715,041	2.0	2061 kw	0.1 $/kwH
Utility - steam	$ 2,915	0.0	47 lb/hr	7.5 $/1000 lb
Chemicals	$ 4,000,612	4.6		
Cost of Loss Diesel Production	$ 1,343,482	1.6	98.6% yield on diesel at $1.07/gallon	
Total volume related costs	**$ 7,062,050**	**8.2**		

Basis:

diesel feed:	252000	gal/day
On-stream availability:	95	%
ULSD yield (% of feed)	98.6	%

Fixed Costs (not volume dependent)

Item	2005$/year (365 day/yr)	cent/gal (ULSD)	Basis
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint
Contract Services	$ 169,500	0.2	0.5% of TIC
Operating Supplies	$ 184,000	0.2	Filters and Membranes
Maintenance and T/A Costs	$ 508,500	0.6	1.5% of TIC, 2 - 3 Year T/A Cycle
Insurance & Taxes	$ 847,500	1.0	2.5% of TIC
Total fixed costs	**$ 2,170,850**	**2.5**	

Basis:
BDS Total Installed Cost: 33.9 $MM

Total Operating Cost:	**2005$/year**	**cent/gal (ULSD)**
	$ 9,232,900	**10.7**

PETRO STAR INC.

HDS/BDS STUDY

HDS BASELINE CASE
REPORT AND COST ESTIMATE

ALASKA ANVIL NO. AE1416

REVISION 1
AUGUST 2005

ALASKA ANVIL
INCORPORATED

EXECUTIVE SUMMARY

To meet the EPA's 2006 sulfur content requirements, Petro Star is leading a Department of Energy study to determine the viability of ULSD production from a biodesulfurization process. This HDS Baseline Report, a part of the larger investigation, presents the HDS process and the total installed costs that will serve as the baseline economics that the BDS process must surpass.

The effort is based on an installation at Valdez, Alaska producing ultra low sulfur diesel meeting a 10-ppmw sulfur requirement.

The design includes the following proposed IBL facilities:

- A new 6,000 bpd HDS Unit
- A new 2 MMSCFD Hydrogen Unit
- A new 3.7 LTD Sulfur Unit to treat the off-gas from the HDS Unit.

The cost estimate for the HDS Unit includes only the inside battery limits (IBL) portion of the HDS Unit. Based on equipment-based costs for the HDS Unit and licensor quotes for new Hydrogen and Sulfur Units, the total expected installed cost for the HDS complex is $27.8 million in 2005 dollars based on USGC equipment pricing. The expected accuracy of the estimate is +50/-15%.

The annual HDS Unit operating cost is $5,800,000, which translates to 6.8 cents per gallon of ULSD. The total incremental selling price for ULSD would be 13.4 cents per gallon to recover the capital in 5 years (excluding interest expense) and pay the yearly operating cost.

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INTRODUCTION

Background

All U.S. refineries will be required to meet the EPA's third quarter 2006 sulfur content requirements for highway diesel. The EPA requirement for maximum sulfur content of ultra low sulfur diesel (ULSD) is 15 ppmw. The refinery product should have about 10 ppmw sulfur or less to ensure that the product specification can be met on a reliable basis after product shipping and distribution logistics.

To compare different strategies to accomplish this requirement, Petro Star is leading a Department of Energy HDS/BDS study that evaluates the following processing routes:

- A standalone hydrodesulfurization (HDS) process
- A standalone biodesulfurization (BDS) process
- A combination of the two.

To be economically viable, a BDS process must be competitive with other commercially proven desulfurization routes. The route most chosen and best known to refiners for diesel is HDS. A new BDS facility must be less costly than a comparable new HDS facility. Or, in the various combination scenarios, using the BDS facility as a pre- or post-treatment facility combined with an existing HDS unit must be less costly than modifications to an existing HDS Unit that would be required to achieve the lower sulfur requirement.

As part of the study of potential BDS economics, this baseline report provides the process description and total installed cost of a new standalone 6,000 bpd HDS Unit producing highway ULSD at 10 ppmw sulfur.

Exclusions

To simplify the economic baseline study and avoid biasing the study results, we have excluded all outside battery limits (OBL) facilities. A prior 1999 Kellogg report exploring a BDS baseline also excluded all utility systems improvements, offsite tankage, and waste stream disposal.

Information Sources

Axens North America, Inc. provided the HDS Unit reactor design and unit yields for this study under a proprietary agreement. A cursory inspection of other licensor data revealed little difference in yields, process conditions, and reactor size. Therefore, only the data received from Axens was used for this study.

Process Design Basis

Unit Throughput

The design throughput for the HDS Unit is 6,000 bpd of straight run diesel containing 0.5 weight percent sulfur.

Unit Feed Characteristics

The design basis composition and characteristics of the diesel feed, including a sulfur speciation, are included in Appendix A. The hydrogen from the Hydrogen Unit is 99.7% pure.

Product Specification

The specification for diesel product sulfur content is 10 ppmw.

Utility and Infrastructure Availability

The study assumes the refinery has the following utility systems and infrastructure available to support the HDS Unit:

- Refinery fuel gas (for fired heaters and Hydrogen Unit feed)
- Water (available as feed to a new demineralization unit)
- Instrument air
- Electricity for drivers
- Nitrogen
- Process vent system
- Product tanks
- Cooling fluid system
- Steam/boiler feed water
- Refinery fuel gas
- Naphtha fuel
- Wastewater treatment
- Flare.

Refinery Ambient Conditions

The new HDS, hydrogen, and sulfur recovery facilities design is based on a Valdez, Alaska location.

Ambient Temperature Condition	Degrees F
Highest monthly average	62
Lowest monthly average	17
Record high	86
Record low	-23

PROCESS DESCRIPTION

The design includes the following proposed IBL facilities:

- A new 6,000 bpd HDS Unit
- A new 2 MMSCFD Hydrogen Unit
- A new 3.7 LDT Sulfur Unit to treat the off-gas from the HDS Unit.

HDS Unit (Inside Battery Limits)

Feed Section

In an integrated refinery, the diesel feed to the HDS Unit comes directly from a refinery feed/product exchanger without being cooled or routed through an intermediate storage tank. The diesel feed enters the Diesel Feed Drum, V-500, at 216°F. The feed drum provides 15 minutes of surge capacity and a stable level for the Diesel Feed Pump, P-500 A/B. See Appendix B for the IBL HDS Unit's process flow diagrams and material balance. See Appendix C for the HDS Unit equipment list and budgetary equipment data sheets.

The feed is pumped through two Reactor Feed/Bottoms Exchangers, Nos. 1 and 2, E-500 and E-501, where it is preheated to 650°F. Makeup hydrogen from the Hydrogen Unit, described below, is compressed by the Makeup Hydrogen Compressor, C-500, and enters the diesel feed stream upstream of the first Reactor Feed/Bottoms Exchanger. Hydrogen-rich recycle gas enters the diesel feed stream upstream of the second Reactor Feed/Bottoms Exchanger.

The combined diesel and hydrogen feed stream to the HDS reactor is heated to reaction temperature in the Diesel Charge Heater, H-500. The Diesel Charge Heater has an absorbed duty of 3.5 MM Btu/hr and uses refinery fuel gas or naphtha as its fuel source.

Reaction Section

The diesel and hydrogen feed stream enters the HDS Reactor, R-500, at 678°F and 660 psig at end-of-run (EOR) conditions. The catalyst in the reactor reduces the sulfur content of the diesel to 10 ppmw, and will effectively hydrogenate the most resistant sulfur species, 4,6 dibenzothiophenes. The hydrogenation reaction converts sulfur compounds to H_2S and also converts a small portion of the diesel to naphtha.

Post-Reaction Cooling

The hydrotreated diesel leaves the reactor at 721°F and 600 psig, and is cooled in the reactor feed/bottoms exchangers to 330°F. The diesel is further cooled in the Separator Feed/Bottoms Exchanger, E-502, to 326°F by preheating the bottoms stream from the Low Temperature Separator, V-502.

The diesel stream then enters the High Temperature Separator, V-501, to separate the diesel and naphtha from lighter hydrocarbons, hydrogen, and H_2S.

The bottoms stream from the High Temperature Separator is routed to the Naphtha Stripper, V-503, to separate the diesel from naphtha and sour hydrocarbon gas.

The overhead vapor from the separator is mixed with wash water to mitigate potential plugging and corrosion from ammonium sulfide salts which could otherwise precipitate in the air cooler. The overhead stream is then cooled to 120°F in the High Temperature Separator Overhead Cooler, E-503, and is then routed to the Low Temperature Separator, V-502. Like E-503, all coolers in the HDS Unit are air coolers to minimize the size of the cooling fluid system.

Low Temperature Separator

The Low Temperature Separator (V-502) separates the naphtha from lighter hydrocarbons, H_2S, and hydrogen. A water draw is included to remove sour wash water.

The hydrogen-rich overhead stream is recycled to the reactor feed stream via the Recycle Gas Compressor (C-501). An amine absorber is not required to treat the recycle gas because of the diesel feed's low sulfur content, the high purity of the makeup hydrogen gas, and consequently low H_2S content of the recycle gas.

Excess gas from the separator overhead is bled via pressure control to the Sulfur Unit's H_2S scrubbing section and is ultimately used as refinery fuel. The Low Temperature Separator pressure setting dictates the pressure level in the reactor system.

The bottoms stream is routed through the Separator Feed/Bottoms Exchanger (E-502) for preheating before entering the Naphtha Stripper (V-503) at the upper feed point. Because of the low flow rate of Low Temperature Separator bottoms, the duty of the E-502 service is small; in the design phase, the size or need for an exchanger in this service could be optimized.

Naphtha Stripper

The Naphtha Stripper (V-503) separates naphtha and sour hydrocarbon gas from the diesel product. The bottoms stream from the Low Temperature Separator enters the stripper at 325°F via the Separator Feed/Bottoms Exchanger. The bottoms stream from the High Temperature Separator enters the stripper at 580°F via the Stripper Feed/Bottoms Exchanger (E-505).

The Naphtha Stripper employs 22 distillation trays to the separate naphtha and sour hydrocarbon gas from the diesel product. The diesel yield from the stripper is approximately 97.0 volume percent of the diesel fed to the HDS Unit.

The overhead from the stripper is condensed in the Stripper Overhead Condenser (E-504) and is collected in the Stripper Overhead Accumulator (V-504). The non-condensed sour gas from the accumulator is routed to the sulfur recovery unit and the sweetened gas is ultimately used as refinery fuel. The Stripper Overhead Pump (P-502A/B) delivers the naphtha from the accumulator to the plant liquid fuel system. A part of the condensed naphtha is returned to the top tray of the stripper as a reflux stream.

The bottoms stream from the stripper is routed through the Stripper Feed/Bottoms Exchanger (E-505) where it is cooled to 417°F. The product diesel is further cooled to 120°F in the Diesel Product Cooler (E-506) before being routed to a product storage tank. The Stripper Bottoms Pump (P-501A/B) sends a portion of the stripper bottoms stream through the Stripper Reboiler (H-501). The Stripper Reboiler has an absorbed duty of 5.6 MM Btu/hr and uses refinery fuel gas or naphtha for firing.

Hydrogen Unit

A new steam reforming-type Hydrogen Unit will supply hydrogen for the HDS Unit. This process is generally used in refineries to generate hydrogen needed for hydroprocessing. The unit size for this project is 2 MMSCF/D of hydrogen. The hydrogen produced in the unit has a purity of 99.7+%. See Appendix D for a typical steam reformer's general flow scheme.

Feed to the Hydrogen Unit is off-gas from the Crude Unit. At the Crude Unit, this gas is treated for H_2S removal. This feed gas is first compressed up to a pressure of about 350 psig. The feed is then heated and passed through a guard bed to remove any remaining H_2S. The guard bed vessels are arranged so that the adsorbent can be changed while the plant operates. The feed gas is then mixed with steam and superheated in a feed preheat coil of the Reformer furnace. The feed mixture goes through catalyst filled tubes in the Reformer where the feed reacts with steam to produce hydrogen and carbon oxides. The reforming reactions are endothermic and heat is supplied by controlling the firing of the Reformer furnace.

The steam used by the process is produced by steam generation in the Reformer. This Reformer Unit would be designed to be self-contained from the viewpoint that no net steam would be produced in the process.

The reformed gas is cooled by the process steam generator and then sent to the shift converter in which CO and water vapor are converted to additional H_2 and CO_2. The gas leaving the shift converter is cooled with feed preheat and a trim cooler and then condensate is removed and the gas then goes to a pressure swing adsorption (PSA) hydrogen purification system.

The PSA is an automated system and runs on repeated cycles, first in adsorption mode and then in regeneration mode. An off-gas stream from the PSA is routed to the Reformer furnace and provides a large portion of the fuel required. The hydrogen stream from the PSA unit is very high purity and available at a pressure of about 300 psig to the HDS makeup hydrogen compressor.

Sulfur Unit

The purge gas from the HDS Low Temperature Separator (V-502) and the off-gas stream from the HDS Stripper Overhead Accumulator (V-504) are combined and sent to the Sulfur Recovery Unit in which the H_2S is removed from the hydrocarbon gas before use as fuel gas. The Sulfur Unit converts the H_2S into elemental sulfur.

The process that converts the H_2S is the Thiopaq Biological H_2S Removal Process. This process provides an economic means to recover small tonnages of sulfur from commercial plants. The process has been successfully applied in over 40 locations. See Appendix E for a Thiopaq process simplified block diagram.

The Thiopaq process operates at very mild conditions and requires little attention from an operational point of view, making it an attractive process compared to conventional amine/ Claus/ TGU schemes. The Thiopaq process is fairly simple and uses microbial oxidation. The process uses a soda solution and air for regeneration and operates at atmospheric pressure and a temperature of about 110°F.

In the Thiopaq process, the sour gas is fed to a scrubber and contacted with Thiopaq solution that removes the H_2S from the off-gas. The sweetened gas goes overhead in the scrubber and on to the plant fuel gas system. The rich Thiopaq solution goes to a low-pressure flash vessel in which a flash gas is taken overhead which can be used as fuel gas in a low-pressure burner. The solution then goes to the bioreactor where the H_2S is oxidized under controlled conditions to elemental sulfur in the presence of microorganisms. The elemental sulfur produced is hydrophilic and is separated from the aqueous effluent in a separator. This sulfur is in cake form that can be filtered to reach 90+% solids and used for agricultural purposes or land filled.

The project does not include a storage area for the sulfur product to hold the sulfur between outhaul shipments. The sulfur product would be about 3.7 tons per day. This translates to about a truckload of sulfur per week.

A water bleed stream is taken from the bioreactor, which along with caustic injection, is used to control the pH inside the reactor.

Utilities

Anvil has identified the preliminary utility requirements for the proposed facilities to serve an HDS Unit. See Appendix F for an itemized list.

COST ESTIMATE

Total Installed Cost

The conceptual cost estimate is based on installing an HDS Unit processing 6,000 bpd raw diesel feed and producing ULSD meeting the 10-ppmw sulfur requirement. The cost estimate is for the IBL portion of the HDS complex only.

Based on equipment-based costs for the HDS Unit and vendor quotes for the Hydrogen Unit and Sulfur Unit, the total installed cost estimate for the IBL portion of the HDS complex is $27.8 million in 2005 dollars based on USGC pricing. The accuracy of the estimate is +50/-15%.

The cost estimate excludes other owner costs such as startup and commissioning costs, initial operator training, startup procedures, and pre-startup operator staffing. It also excludes licensing and royalty fees. A contingency of 25% is in the total installed cost. See Appendix G for the Cost Estimate Basis and Cost Estimate.

Operating Cost and Capital Recovery

The total annual operating cost of the HDS Unit is $5,800,000. This cost is based on a 95% on-stream availability for the plant. The operating cost includes fuel, power, chemicals, utilities, sulfur disposal, other consumables, operating and maintenance labor, maintenance expense, and taxes and insurance. The operating cost also includes lost diesel sales due to conversion of diesel to naphtha and fuel gas in the HDS Unit. However, a credit is taken for the value of naphtha and fuel gas as refinery fuel. The basis and methodology for developing the operating cost estimates is presented in Appendix H.

The operating cost can be expressed in terms of cents per gallon of ULSD, based on a 97% yield on the ULSD. The total operating cost of the HDS Unit is 6.8 cents per gallon of ULSD.

Based on the expected TIC of the HDS Unit, the incremental selling price for ULSD would be 6.6 cents per gallon to recover the capital in 5 years (excluding interest expense). Therefore, the total incremental selling price for ULSD would be 13.4 cents per gallon to recover the capital in 5 years and pay the yearly operating cost.

APPENDICES

A. Diesel Feed Properties and Sulfur Speciation

B. HDS Unit Process Flow Diagrams and Material Balance

Process Flow Diagrams
HDS Unit Reactor Section
HDS Unit Naphtha Stripper Section

Material Balance

C. HDS Unit Equipment List and Budgetary Equipment Data Sheets

Equipment List

Budgetary Equipment Data Sheets

D. Hydrogen Unit Flow Diagram

E. Sulfur Unit Block Flow Diagram

F. Utility Requirements

G. Cost Estimate Basis and Cost Estimate

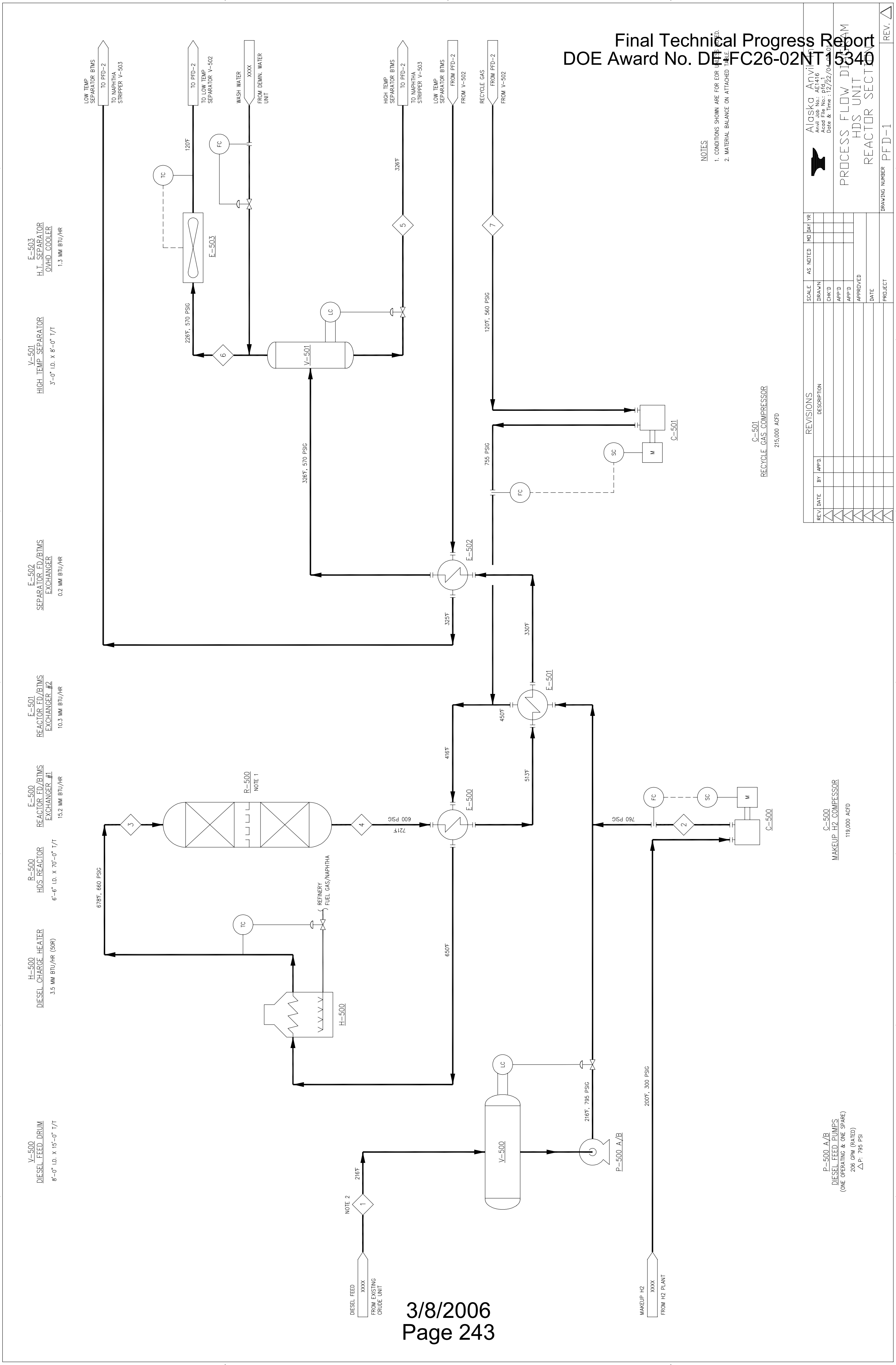
H. HDS Baseline Case Operating Costs for 6,000 BPD Diesel Feed

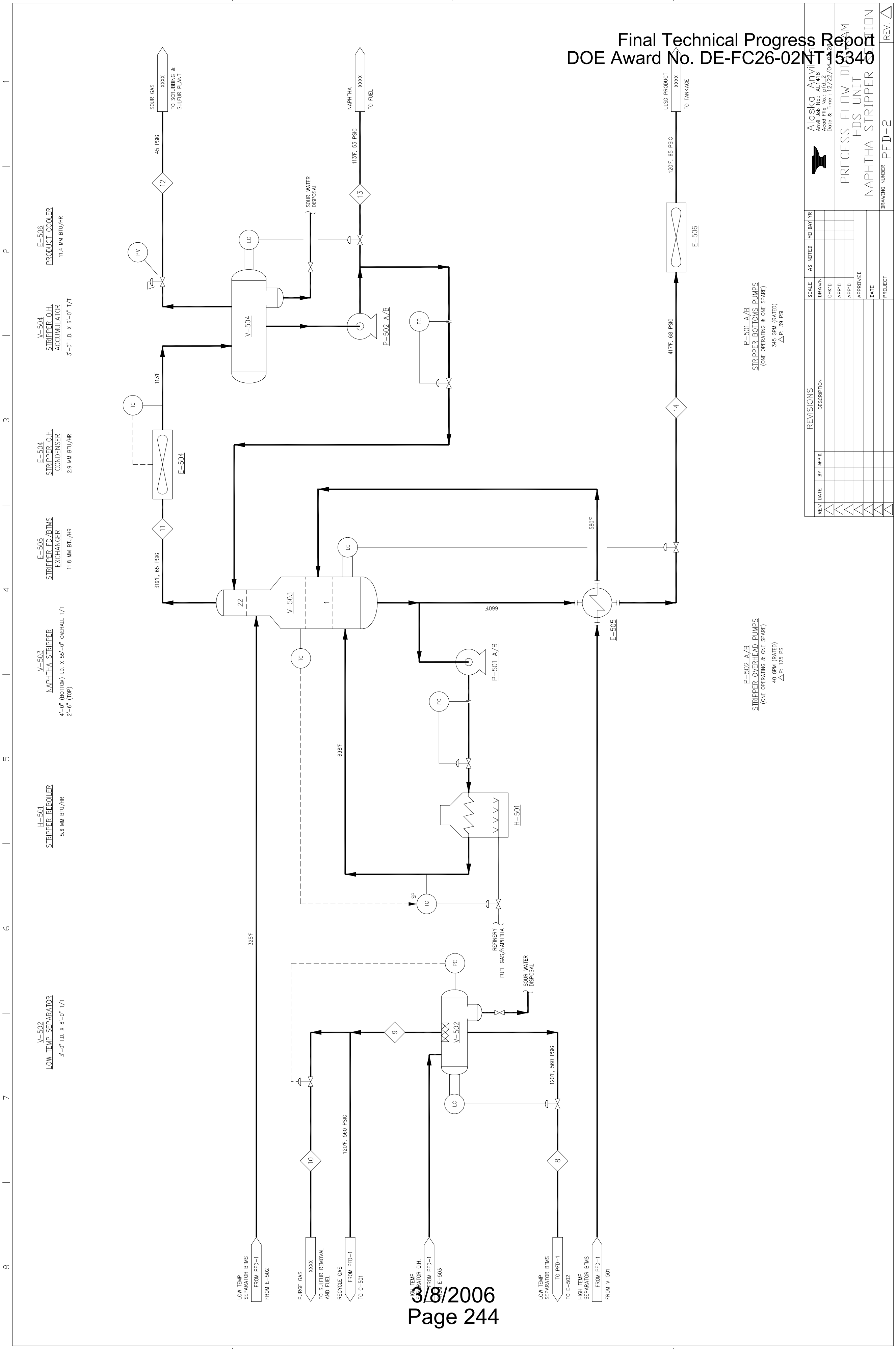
Appendix A – Diesel Feed Properties and Sulfur Speciation

Diesel Feed Properties			
Test	**Units**	**Results**	**Specification**
Gravity @ 60°F, Min/Max	API	33.3	32-36
Flash Pt, Min.	Celsius	63.5 (146°F)	60 (140°F)
Cloud Pt, Max.	Celsius	-12.3 (10°F)	-9.5 (15°F)
Pour Pt, Max.	Celsius	-15 (5°F)	-12 (10°F)
Distillation			
IBP	Celsius	171 (340 °F)	Report
10% Recovery	Celsius	249 (480 °F)	Report
20% Recovery	Celsius	265 (509 °F)	Report
50% Recovery	Celsius	287 (549 °F)	Report
90% Recovery	Celsius	317 (603 °F)	282-338
Final Boiling Pt.	Celsius	336 (637 °F)	Report
Recovery	Vol %	99.9	Report
Residual	Vol %	0.1	Report
Loss	Vol %	0	Report
Viscosity @ 40 C, Min/Max	CSt	3.57	2.0-4.3
Ash, Max	Wt%	<0.001	0.01%
Carbon Residue on 10% Bottoms, Max	Wt%	0.08	0.35%
Btu Gross, Min	Btu/Gallon	139,190	136,000
Calculated Cetane, Min	Index	48	45
Copper Strip Corrosion, Max	Code	1a	3
Total Sulfur	Wt.%	0.500	0.500

Sulfur Speciation (Ratioed to 5,000 ppm*)			
Component	**ppm wt sulfur**	**Component**	**ppm wt sulfur**
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	2
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	29
Thiophene	<1	Trimethyl benzothiophene	119
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	354
Isobutyl mercaptan	<1	Dibenzothiophene	229
Ethyl sulfide	<1	4-Methyl benzothiophene	213
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	147
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	94
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	97
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	354
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	75
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	4
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

* Raw data from the speciation analysis ratioed to 5,000 ppm to reflect the design basis sulfur content.


V-500
DIESEL FEED DRUM
8'-0" I.D. X 15'-0" T/T
H-500
DIESEL CHARGE HEATER
3.5 MM BTU/HR (50R)
R-500
HDS REACTOR
6'-6" I.D. X 70'-0" T/T
E-500
REACTOR FD/BTMS
EXCHANGER #1
15.2 MM BTU/HR
E-501
REACTOR FD/BTMS
EXCHANGER #2
10.3 MM BTU/HR
E-502
SEPARATOR FD/BTMS
EXCHANGER
0.2 MM BTU/HR
V-501
HIGH TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
E-503
H.T. SEPARATOR
OVHD COOLER
1.3 MM BTU/HR
C-501
RECYCLE GAS COMPRESSOR
215,000 ACFD
C-500
MAKEUP H2 COMPRESSOR
119,000 ACFD
P-500 A/B
DIESEL FEED PUMPS
(ONE OPERATING & ONE SPARE)
206 GPM (RATED)
ΔP: 795 PSI
NOTES
1. CONDITIONS SHOWN ARE FOR EOR UNLESS NOTED.
2. MATERIAL BALANCE ON ATTACHED TABLE.
DIESEL FEED
XXXX
FROM EXISTING
CRUDE UNIT
MAKEUP H2
XXXX
FROM H2 PLANT
LOW TEMP
SEPARATOR BTMS
TO PFD-2
TO NAPHTHA
STRIPPER V-503
TO PFD-2
TO LOW TEMP
SEPARATOR V-502
WASH WATER
XXXX
FROM DEMIN. WATER
UNIT
HIGH TEMP
SEPARATOR BTMS
TO PFD-2
TO NAPHTHA
STRIPPER V-503
LOW TEMP
SEPARATOR BTMS
FROM PFD-2
FROM V-502
RECYCLE GAS
FROM PFD-2
FROM V-502
REFINERY
FUEL GAS/NAPHTHA
NOTE 1
NOTE 2
216°F
216°F, 795 PSIG
200°F, 300 PSIG
760 PSIG
650°F
678°F, 660 PSIG
721°F
600 PSIG
416°F
450°F
513°F
330°F
325°F
326°F, 570 PSIG
755 PSIG
120°F, 560 PSIG
226°F, 570 PSIG
120°F
326°F
REVISIONS
REV. DATE BY APP'D DESCRIPTION
SCALE AS NOTED
DRAWN
CHK'D
APP'D
APPROVED
DATE
PROJECT
MO DAY YR
Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT
REACTOR SECTION
DRAWING NUMBER PFD-1
REV.


E-506
PRODUCT COOLER
11.4 MM BTU/HR
V-504
STRIPPER O.H. ACCUMULATOR
3'-0" I.D. X 6'-0" T/T
E-504
STRIPPER O.H. CONDENSER
2.9 MM BTU/HR
E-505
STRIPPER FD/BTMS EXCHANGER
11.8 MM BTU/HR
V-503
NAPHTHA STRIPPER
4'-0" (BOTTOM) I.D. X 55'-0" OVERALL T/T
2'-6" (TOP)
H-501
STRIPPER REBOILER
5.6 MM BTU/HR
V-502
LOW TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
P-501 A/B
STRIPPER BOTTOMS PUMPS
(ONE OPERATING & ONE SPARE)
345 GPM (RATED)
ΔP: 39 PSI
P-502 A/B
STRIPPER OVERHEAD PUMPS
(ONE OPERATING & ONE SPARE)
40 GPM (RATED)
ΔP: 125 PSI
SOUR GAS
TO SCRUBBING & SULFUR PLANT
NAPHTHA
TO FUEL
ULSD PRODUCT
TO TANKAGE
SOUR WATER DISPOSAL
REFINERY FUEL GAS/NAPHTHA
LOW TEMP SEPARATOR BTMS FROM E-502
PURGE GAS TO SULFUR REMOVAL AND FUEL
RECYCLE GAS TO C-501
HIGH TEMP SEPARATOR O.H. FROM E-503
LOW TEMP SEPARATOR BTMS TO E-502
HIGH TEMP SEPARATOR BTMS FROM V-501
Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT
NAPHTHA STRIPPER SECTION
PFD-2
REVISIONS

Material Balance – EOR Conditions

Stream Number		1	2	3	4	5	6	7
Stream Description		ANS FEED	Compressed Make-up Gas	Reactor Feed	Reactor Outlet	V-501 Liquid	V-501 Vapor + Wash Water	Recycle Gas
Phase		Liquid	Vapor	Mixed	Mixed	Liquid	Mixed	Vapor
Mass Flow Rate	LB/HR	75,128	463	79,713	79,714	74,910	5,504	4,123
Temperature	F	216	227	678	721	300	226	120
Pressure	PSIG	20.0	730.0	660.0	600.0	570.0	570.0	560.0
Standard Liq Flow	BPD	6,000				6,055		
Volumetric Flow	MSCFH		85.3					306.9
Wt % Vapor		0.0	100.0	43.0	66.6	0.0	93.1	100.0
MW		218.8	2.1	57.8	64.9	194.5	6.2	5.1

Stream Number		8	9	10	11	12	13	14
Stream Description		V-502 HC Liquid	V-502 Vapor	Purge Gas	Column Vapor to Condenser	Sour Gas	Naphtha	Diesel from E-505
Phase		Liquid	Vapor	Vapor	Vapor	Vapor	Liquid	Liquid
Mass Flow Rate	LB/HR	547	4,267	144	12,614	574	2,292	72,591
Temperature	F	120	120	120	319	113	113	352
Pressure	PSIG	560.0	560.0	560.0	65.0	63.0	63.0	68.0
Standard Liq Flow	BPD	48					208	5,817
Volumetric Flow	MSCFH		317.6	10.7	61.8	10.0		
Wt % Vapor		0.0	100.0	100.0	100.0	100.0	0.0	0.0
MW		110.0	5.1	5.1	77.4	21.7	88.2	214.9

Appendix C – HDS Unit Equipment List and Budgetary Equipment Data Sheets

HDS Unit Equipment List

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
R-500	HDS Reactor	6'-6" ID X 70'-0" T/T w/ 2 sections of HR-526 Co Mo catalyst.	710 PSIG/FV	750°F	SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-500	Diesel Feed Drum	8'-0" ID X 15'-0" T/T (Horizontal)	50 PSIG/FV	275/-20°F	Killed Carbon Steel
V-501	High Temperature Separator	3'-0" ID X 8'-0" T/T (Vertical)	620 PSIG/FV	380/-20°F	Killed Carbon Steel w/0.15" CA
V-502	Low Temperature Separator	3'-0" ID X 8'-0" T/T` (Horizontal w/ Boot)	610 PSIG/FV	350/-20°F	Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-503	Naphtha Stripper	2'-6" ID (Top), 4'-0" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays	125 PSIG/FV	750/-20°F	Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-504	Stripper O. H. Accumulator	3'-0" ID X 6'-0" T/T (Horizontal w/Boot)	125 PSIG/FV	250/-20°F	Killed Carbon Steel w/0.125" CA (PWHT)
E-500	Reactor Fd/Btms Exchanger #1	15.2 MM BTU/Hr, 4770 FT2 w/ 2 shells, TEMA type CEU	Tubes: 650 PSIG Shell: 800 PSIG	775°F 700°F	Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	Reactor Fd/Btms Exchanger #2	10.3 MM BTU/Hr, 2904 FT2 w/2 shells, TEMA type CEU	Tubes: 650 PSIG Shell: 810 PSIG	540°F 475°F	Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover Shell: Killed C. S. w/0.125" CA
E-502	Separator Fd/Btms Exchanger	0.2 MM BTU/Hr, 70 FT2, double pipe.	Tubes: 625 PSIG Shell: 610 PSIG	355°F 350°F	Tubes: 516-70 Carbon Steel Shell: Killed Carbon Steel
E-503	H. T. Separator Overhead Cooler	1.3 MM BTU/Hr 838 FT2 (Bare Tube) 17,800 FT2 Extended Surface, 10 HP Fan	Tubes: 620 PSIG	350°F	Seamless Carbon Steel tubes with aluminum fins
E-504	Stripper O. H. Condenser	2.9 MM BTU/Hr 838 FT2 (Bare Tube) 17,800 FT2 Extended Surface, 10 HP Fan	Tubes: 125 PSIG	370°F	Seamless Carbon Steel tubes with aluminum fins
E-505	Stripper Fd/Btms Exchanger	11.8 MM BTU/Hr 3,371 FT2 w/3 shells, TEMA type CEU	Tubes: 620 PSIG Shell: 100 PSIG	630°F 710°F	Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS Shell: CS w/0.25" CA, CS baffles
E-506	Product Cooler	11.4 MM BTU/Hr 2,203 FT2 (Bare Tube) 46,700 FT2 (Extended Surface, 17 HP Fan	Tubes: 100 PSIG	450°F	Seamless Carbon Steel tubes with aluminum fins
H-500	Diesel Charge Heater	3.5 MM BTU/Hr Fired Heater, Convection Section shared w/ H-501	Tubes: 800 PSIG	750°F	Tubes: 9 Cr – 1 Mo w/ 0.1" CA
H-501	Stripper Reboiler	5.6 MM BTU/Hr Fired Heater, Convection Section shared w/ H-500	Tubes: 230 PSIG	770°F	Tubes: 5 Cr – ½ Mo w/ 0.1" CA

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
C-500	Makeup Hydrogen Compressor	Capacity: 119,000 ACFD Motor Driven Shaft HP: 136 BHP	Suction: 300 PSIG Disch: 760 PSIG	Suction: 200°F	Casing: killed C. S. Internals: CS
C-501	Recycle Gas Compressor	Capacity: 215,000 ACFD Motor Driven Shaft HP: 126 BHP	Suction: 560 PSIG Disch: 755 PSIG	Suction: 120°F	Casing: killed C. S. Internals: Stainless Steel
P-500 A/B	Diesel Feed Pump (One Operating + One Spare	Rated Capacity: 206 GPM Diff. Press: 794 PSI Head: 2282 feet Motor: 150 HP	955 PSIG	250°F	Casing: killed C. S. Impeller: 12% chrome
P-501 A/B	Stripper Bottoms Pump (One Operating + One Spare	Rated Capacity: 345 GPM Diff. Press: 125 PSI Head: 489 feet Motor: 50 HP	225 PSIG	710°F	Casing: killed C. S. w/ 0.2" CA Impeller: 12% chrome
P-502 A/B	Stripper Overhead Pump (One Operating + One Spare	Rated Capacity: 40 GPM Diff. Press: 39 PSI Head: 124 feet Motor: 5 HP	115 PSIG	125°F	Casing: killed C. S. w/ 0.125" CA Impeller: 12% chrome

ANVIL

BUDGETARY DATA SHEET

COMPRESSORS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER BGJ**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		HDS ULSD Baseline	**DATE 11/16/04**	
ITEM NUMBER	X	C-500		
FLUID	X	Makeup H2		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	119,000		
SUCTION TEMPERATURE ^{O}F	X	200		
SUCTION PRESSURE, PSIA	X	315		
DISCHARGE PRESSURE, PSIA	X	775		
GAS MOLECULAR WEIGHT	X	2.1		
'K' VALUE OF GAS	X	1.4		
MOL % HYDROGEN IN GAS	X	99.7		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	None		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	150		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	136		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20°F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS ULSD Baseline	**DATE 11/16/04**

ITEM NUMBER	X	C-501		
FLUID	X	Recycle Gas		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	215,000		
SUCTION TEMPERATURE ^{O}F	X	120		
SUCTION PRESSURE, PSIA	X	575		
DISCHARGE PRESSURE, PSIA	X	770		
GAS MOLECULAR WEIGHT	X	5.1		
'K' VALUE OF GAS	X	1.36		
MOL % HYDROGEN IN GAS	X	91.7		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	H2S, H2O		
CASING MATERIAL	M	CS		
PISTON, SLEEVE, VALVES MATERIAL	M	Stainless Steel		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER, Motor HP	X	150		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER, BHP	X	126		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20 °F ambient conditions.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	x	E-500		
SERVICE	x	Reactor Fd/Btms Exch #1		
TEMA TYPE	x	CEU		
SURFACE AREA (TOTAL) FT^2	x	4770		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	650		
DESIGN TEMPERATURE, ^{O}F	x	775		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	800		
DESIGN TEMPERATURE, ^{O}F	x	700 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo (3)		
DUTY, MMBTU/HR	O	15.2		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Type 1 1/4 Cr - 1/2 Mo for tubes and tube sheet and weld overlay 316 SS for tube sheet, channnel, cover & nozzles.
U tubes to be PWHT.
3) Clad w/ Type 321 SS , Baffles to be Type 304 SS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	BGJ
LOCATION	Alaska		**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline		**DATE**	11/16/2004

ITEM NUMBER	x	E-501		
SERVICE	x	Reactor Fd/Btms Exch #2		
TEMA TYPE	x	CEU		
SURFACE AREA (TOTAL) FT^2	x	2904		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	650		
DESIGN TEMPERATURE, ^{O}F	x	540		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	810		
DESIGN TEMPERATURE, ^{O}F	x	475 / -20		
MATERIAL OF CONSTRUCTION	x	Killed C. S. (3)		
DUTY, MMBTU/HR	O	10.3		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

(2) Use SA182 F11 (1 1/4 Cr - 1/2 Mo) for tubesheet + channel cover + nozzles and SA 387 Gr 11 for channel
Weld overlay tube sheet, channel cover, and channel with 321 SS.

(3) Use 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	x	E-502		
SERVICE	x	Separator Fd/Btms Exch		
TEMA TYPE	x	CEU (2)		
SURFACE AREA (TOTAL) FT^2	x	70		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel w/Hydrogen		
DESIGN PRESSURE, PSIG	x	625		
DESIGN TEMPERATURE, ^{O}F	x	355		
MATERIAL OF CONSTRUCTION	x	516-70 (CS)		
SHELL SIDE				
FLUID	x	Hydrocarbon		
DESIGN PRESSURE, PSIG	x	610		
DESIGN TEMPERATURE, ^{O}F	x	350 / -20		
MATERIAL OF CONSTRUCTION	x	516-70 (Killed CS)		
DUTY, MMBTU/HR	O	0.2		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) AS AN ALTERNATIVE TO TYPE CEU, CONSIDER USE OF DOUBLE TUBE EXCHANGER.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	E-503		
SERVICE	X	H. T. Seprtr Ovrhd Clr		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Hydrocarbon Vapor		
INLET TEMPERATURE	X	226		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	350		
DESIGN PRESSURE, PSIG	X	620		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	838		
EXTENDED SURFACE	X	17,800		
TYPE OF FINS	O			
FAN HORSEPOWER (EACH)	X	10		
NUMBER OF FANS	X	One		
MATERIAL OF CONSTRUCTION	X	SA179 (CS) (1)		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	1.3		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Killed carbon steel for the header.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	BGJ
LOCATION	Alaska		**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline		**DATE**	11/16/2004

ITEM NUMBER	X	E-504		
SERVICE	X	Strpr Ovrhd Condenser		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Naphtha		
INLET TEMPERATURE	X	319		
OUTLET TEMPERATURE	X	113		
DESIGN TEMPERATURE, ^{O}F	X	370		
DESIGN PRESSURE, PSIG	X	125		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	838		
EXTENDED SURFACE	X	17,800		
TYPE OF FINS	O			
FAN HORSEPOWER (EACH)	X	10		
NUMBER OF FANS	X	1		
MATERIAL OF CONSTRUCTION	X	Note (1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	2.9		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	**NO**		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	x	E-505		
SERVICE	x	Stripper Fd/Btms Exch		
TEMA TYPE	x	CEU		
SURFACE AREA (TOTAL) FT^2	x	3,371		
NUMBER OF SHELLS	x	3		
TUBE SIDE				
FLUID	x	Diesel/Naphtha		
DESIGN PRESSURE, PSIG	x	620		
DESIGN TEMPERATURE, ^{O}F	x	630		
MATERIAL OF CONSTRUCTION	x	Note 2		
SHELL SIDE				
FLUID	x	Diesel Product		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	710		
MATERIAL OF CONSTRUCTION	x	Note 3		
DUTY, MMBTU/HR	O	11.8		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Channel is CS + 0.25" CA, Tube sheets are Type 410 SS, Tubes are 18 Cr - 8 Ni

3) Shell is CS + 0.25" CA, Baffles are CS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	E-506		
SERVICE	X	Product Cooler		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Diesel		
INLET TEMPERATURE	X	417		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	450		
DESIGN PRESSURE, PSIG	X	100		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	2203		
EXTENDED SURFACE	X	46700		
TYPE OF FINS	O			
FAN HORSEPOWER (EACH)	X	17		
NUMBER OF FANS	X	One		
MATERIAL OF CONSTRUCTION	X	Note 1		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	11.4		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) CS tubes with aluminum fins and killed CS header with 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PROCESS HEATERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	H-500		
SERVICE	X	Diesel Charge Heater		
HEATER TYPE	X	Fired Heater (1)		
FLUID	X	Diesel w/Hydrogen		
TOTAL FLOW RATE, LB/HR	X	79,714		
LIQUID - GPM	X	158		
DENSITY, LB/FT^3	X	35.8		
VISCOSITY, CP	X	0.1		
SPECIFIC HEAT, BTU/LB-°F	X	0.7		
VAPOR - MMSCFD	X	10.5		
DENSITY, LB/FT^3	X	1.6		
VISCOSITY, CP	X	-		
SPECIFIC HEAT, BTU/LB-°F	X	0.8		
THERMAL COND., BTU/HR-FT^2-°F	X	0.1		
INLET TEMPERATURE	X	650		
OUTLET TEMPERATURE	X	678		
DESIGN TEMPERATURE (°F)	X	750		
DESIGN PRESSURE (PSIG)	X	800		
MATERIAL OF CONSTRUCTION	X	9 Cr - 1 Mo + 0.1" CA		
ABS DUTY, MMBTU/HR	X	3.5 (2)		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Based on SOR requirements. The duty consistent with the data shown above is 2.3 MMBTU/Hr.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PROCESS HEATERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	H-501		
SERVICE	X	Stripper Reboiler		
HEATER TYPE	X			
FLUID	X	Hydrotreated Diesel		
TOTAL FLOW RATE, LB/HR	X	87,975		
HEATER OUTLET CONDITIONS:				
LIQUID - GPM	X	159		
DENSITY, LB/FT^3	X	36.3		
VISCOSITY, CP	X	0.12		
SPECIFIC HEAT, BTU/LB-°F	X	0.759		
THERMAL COND., BTU/HR-FT^2-°F	X	0.033		
VAPOR - MMSCFD	X	1.86		
DENSITY, LB/FT^3	X	1.65		
VISCOSITY, CP	X	0.011		
SPECIFIC HEAT, BTU/LB-°F	X	0.656		
THERMAL COND., BTU/HR-FT^2-°F	X	0.024		
INLET TEMPERATURE	X	660		
OUTLET TEMPERATURE	X	698		
DESIGN TEMPERATURE (°F)	X	770		
DESIGN PRESSURE (PSIG)	X	230		
MATERIAL OF CONSTRUCTION	X	5 CR - 1/2 Mo (2)		
ABS DUTY, MMBTU/HR	X	5.60		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Add 0.1" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	HDS ULSD Baseline	**DATE 11/16/04**	

ITEM NUMBER	X	P-500 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	216		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.803		
RATED FLOW (GPM)	X	206		
SUCTION PRESSURE, PSIG	X	3		
DISCHARGE PRESSURE PSIG	X	797		
NPSH AVAILABLE (FT)	X	10		
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	killed C. S. (2)		
IMPELLER MATERIAL	M	12% chrome		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (MHP)	X	150		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		794		
DIFFERENTIAL HEAD, FT		2282		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS ULSD Baseline	**DATE 12/1/04**

ITEM NUMBER	X	P-501A/B (1)		
SERVICE (FLUID)	X	Stripper Btms Pump		
TEMPERATURE OF FLUID	X	660		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.59		
RATED FLOW (GPM)	X	345		
SUCTION PRESSURE, PSIG	X	73		
DISCHARGE PRESSURE PSIG	X	198		
NPSH AVAILABLE (FT)	X	11		
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS + 0.2" CA		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	50		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
Differential Pressure, PSIG	X	125		
Differential Head, Feet	X	489		
		API Standard		

REMARKS

1) One operating pump + one spare

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**		
LOCATION	Alaska	**PROJECT NO. AE1416**		
PROCESS UNIT	HDS ULSD Baseline	**DATE 11/16/04**		

ITEM NUMBER	X	P-502 A/B (1)		
SERVICE (FLUID)	X	Stripper Ovrhd Pump		
TEMPERATURE OF FLUID	X	113		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.73		
RATED FLOW (GPM)	X	40		
SUCTION PRESSURE, PSIG	X	65		
DISCHARGE PRESSURE PSIG	X	104		
NPSH AVAILABLE (FT)	X	10		
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
Differential Pressure, PSIG	X	39		
Differential Head, Feet	X	124		
		API Standard		

REMARKS

1) One operating pump + one spare

2) With 0.125" CA

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	R-500		
SERVICE	X	HDS Reactor		
FLUID	X	Diesel / Hydrogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	6' - 6"		
TANGENT TO TANGENT LENGTH, FT.	X	70' - 0"		
SKIRT HEIGHT (FT-IN)	X	Min		
DESIGN TEMPERATURE (°F)	X	750 (4)		
DESIGN PRESSURE (PSIG)	X	710 (1)		
MATERIAL OF CONSTRUCTION	X	SA387 Gr. 11 (5)		
INSULATION (YES/NO)		Yes (Heat Conservation)		
TRAY OR PACKING TYPE	X	HR-526 Co-MO Catalyst		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
Catalyst VOLUME, FT^3	X	2,100 Note 2		
PACKING MATERIAL	X	Note 3		
INTERNALS	X	2 Distributor trays		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) The packing is in two sections with an internal distributor above each section
3) The total weight of catalyst is 106,620 lbs. The price is supplied by the catalyst vendor for the estimate.
4) Reactor is design temperature at 25°F above end of run. Reactors are generally designed for EOR operating temperature, but margin is added to be conser
5) Include 321 SS or 347 SS weld overlay. Internal trays (two) may be 410 SS or 321 SS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

S:\PetroStar\AE1416.AUX\subjob 41\HDS_BASECASE_FINAL REPORT\Appendix C--Datasheets\[R-500.xls]Sheet1

ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	V-500		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	15' - 0"		
SKIRT HEIGHT (FT-IN)	X	Note 2		
DESIGN TEMPERATURE (°F)	X	275 / -20		
DESIGN PRESSURE (PSIG)	X	50 (1)		
MATERIAL OF CONSTRUCTION	X	SA-516-70		
INSULATION (YES/NO)		Yes for Ht Consvtn		
TRAY OR PACKING TYPE	X	None		
NUMBER OF TRAYS	X	None		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) The horizontal vessel will be supported on saddles 10 feet above grade.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

S:\PetroStar\AE1416.AUX\subjob 41\HDS_BASECASE_FINAL REPORT\Appendix C--Datasheets\[V-500.xls]V-500 Rev B

ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	V-501		
SERVICE	X	H. T. Separator		
FLUID	X	Hydrcrbn w/Hydogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' 0"		
SKIRT HEIGHT (FT-IN)	X	2' - 0"		
DESIGN TEMPERATURE (°F)	X	380 / -20		
DESIGN PRESSURE (PSIG)	X	620		
MATERIAL OF CONSTRUCTION	X	Killed CS w/ 0.15" CA		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breakers		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	V-502		
SERVICE	X	Low Temp Separator		
FLUID	X	Hydrocarbon w/ H2/H2S		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	MIN		
DESIGN TEMPERATURE (°F)	X	**350**		
DESIGN PRESSURE (PSIG)	X	610		
MATERIAL OF CONSTRUCTION	X	Killed C. S. (2)		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	No		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Demister (2)		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (3)		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) w/ 0.1" CA and PWHT. Demister to be Monel

3) Sour water removal

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	V-503		
SERVICE	X	Naphtha Stripper		
FLUID	X	Hydrotreated Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	TOP = 2'-6", BTM = 4'-0"		
TANGENT TO TANGENT LENGTH, FT.	X	55'-0" (Note 3)		
SKIRT HEIGHT (FT-IN)	X	15'-0"		
DESIGN TEMPERATURE (°F)	X	750 (BTM)		
DESIGN PRESSURE (PSIG)	X	125		
MATERIAL OF CONSTRUCTION	X	Note 4		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X	Valve Trays		
NUMBER OF TRAYS	X	22		
TRAY MATERIAL	X	410 S.S.		
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Vortex Breakers		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) VESSEL SHALL BE SWAGED ABOVE FEED
3) Length of top section = 25'-0", length of bottom section = 30'-0"
4) Vessel to be killed CS + 0.2" CA. Trays, tray supports, and downcomers are Type 410 SS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS ULSD Baseline	**DATE**	11/16/2004

ITEM NUMBER	X	V-504		
SERVICE	X	Strpr O. H. Accumulator		
FLUID	X	Naphtha		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	6' - 0"		
SKIRT HEIGHT (FT-IN)	X	Provide Saddles		
DESIGN TEMPERATURE (°F)	X	250		
DESIGN PRESSURE (PSIG)	X	125		
MATERIAL OF CONSTRUCTION	X	Killed CS Note (2)		
INSULATION (YES/NO)		No		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	None		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (sour water)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) Add 0.125" CA and PWHT.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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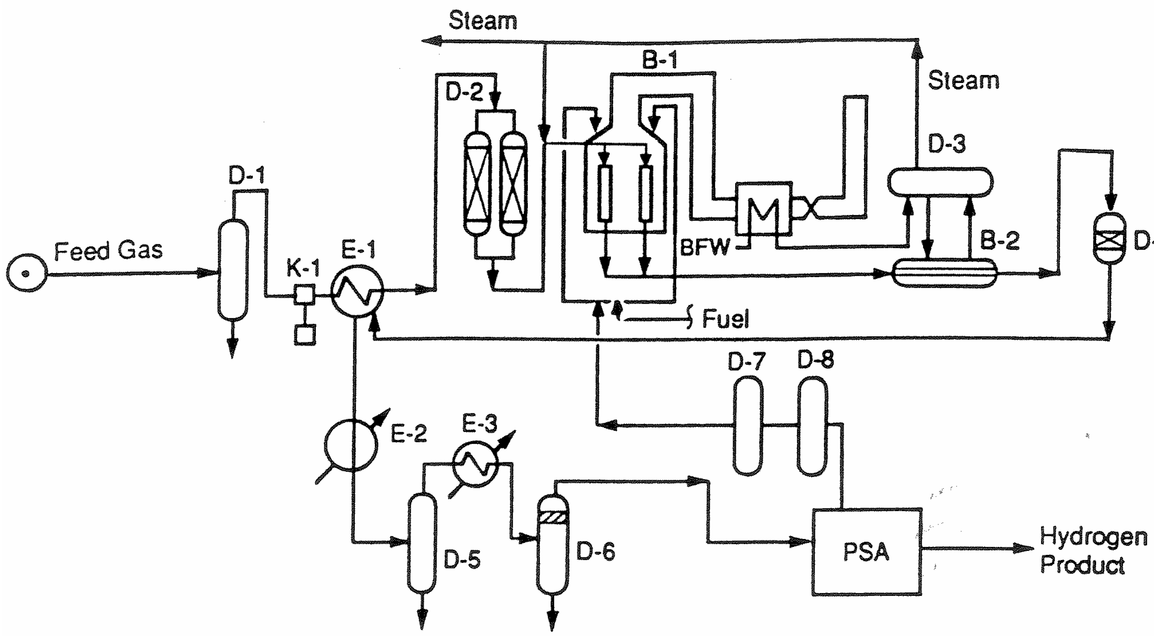
Appendix D – Hydrogen Unit Flow Diagram

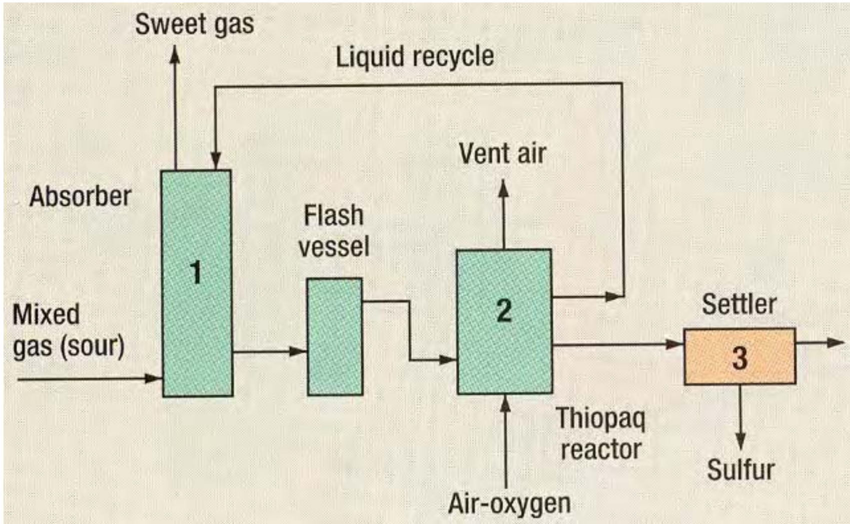
Typical Flow Plan



Equipment List

Item	Description
K-1	Feed Compressor
D-1	Knockout drum
D-2	Desulfurizer Drums
D-3	High Pressure Steam Drum
D-4	High Temperature Shift Reactor
D-5	Knockout Drum
D-6	Knockout Drum
D-7	PSA Surge Drum
D-8	PSA Mixing Drum
E-1	Feed Preheater
E-2	Cooler
E-3	Cooler
B-1	Reformer Furnace/Flue Gas/Heat Recovery
B-2	Waste Heat Boiler
PSA	Pressure Swing Adsorbers

Appendix E – Sulfur Unit Block Flow Diagram



Appendix F - Utility Requirements

HDS Project Utility Requirements
6,000 BPD Feed Rate, 10 ppmw Sulfur ULSD Product

	Power kW	Fuel Gas MMBTU/Hr	Process Water lb/hr	BFW lb/hr
IBL				
Feed gas compressor	75			
H2 Makeup Compressor	105			
Recycle gas compressor	100			
Charge pump	120			
Stripper reflux pump	1			
Stripper Btms Circ	40			
Effluent air cooler	10			
Prod stripper condensor	5			
Prod rundown cooler	12			
Wash water injection pump	2			
Charge Heater		4.4		
Product Stripper Reboiler		6.8		
Wash water			700	
OBL				
H2 Plant	62	32.9		5554
Sulfur recovery	105			
Other OBL Allowance	118			
Total	755	44.1	700	5554

PETRO STAR INC.

ULTRA LOW SULFUR DIESEL
(6000 BPD HDS BASELINE - IBL ONLY)

PHASE 1 ESTIMATE BASIS
REVISION 1

ALASKA ANVIL NO. AE1416

JUNE 2005

ALASKA ANVIL
INCORPORATED

ESTIMATE BASIS GOAL

This Estimate Basis identifies information, qualifications, exceptions, and assumptions used in developing the cost estimate.

ESTIMATE BASIS PURPOSE

During the estimate review process, the project team uses the Estimate Basis for the following purposes:

- As a checklist of items to consider during estimate preparation.
- To document what is included and not included in the cost estimate.
- To assess cost risks of estimate components.
- As part of the decision support package for assessing the BDS process feasibility.

GENERAL INFORMATION

- The purpose of the project estimate is to determine if the ULSD BDS process is economically viable as a standalone process or in combination with an HDS Unit.
- Estimate type:
  - The estimate was developed using a combination of vendor quotes & equipment based factored estimates for Inside Battery Limits (IBL) costs. Licensor quotes were obtained for the Sulfur and Hydrogen Unit costs. Equipment costs were derived from the ICARUS estimating program for equipment in the Diesel Hydrotreating Unit.
  - Outside Battery Limits (OBL) costs have been excluded from this estimate.
- The project will be installed in a brownfield location within a Valdez Alaska Refinery.

PROCESS BASIS

Facility Data

- Facility type – Ultra Low Sulfur Diesel Treating Complex, which includes:
  - Diesel Hydrotreating Unit
  - Hydrogen Production Unit
  - Sulfur Recovery Unit

Design Basis

Product specification – Feed 6,000 bpd of untreated diesel to produce 10 ppmw sulfur maximum ultra low sulfur diesel.

COST BASIS

Labor, Indirects, Equipment, and Bulk Materials

- Included in the equipment factor.

Project Services

- HDS – estimated based on a typical percentage for brownfield type projects.
- Sulfur and Hydrogen Units – included in the package price.

Owner Services

Not included in the TIC cost. Historically, owner services will cost from 5 to 7 percent of TIC, not including licensing, royalties, or catalyst.

Escalation

Project is based on 2005 costs. No escalation is included.

Location Factor

All costs for this estimate have been developed from a U.S. Gulf Coast (USGC) basis. No location factor is included.

Other Costs

- CEMS, air preheating, and burner management allowances have been added to the fired heater costs.
- Catalyst and chemical initial charge has been added as an additional line item.

ASSUMPTIONS

- Process licensing and royalty costs are not included.
- Assumes fully installed pump spares, but no warehouse spares.

PROJECT COST & SCHEDULE ESTIMATE SUMMARY

CLIENT: PetroStar
PROJECT: PetroStar Valdez ULSD - 6000 BPD HDS Baseline
STAGE: Phase 1

CLIENT PROJECT NO.:
ANVIL PROJECT NO.: AE1416
REV NO.: 1

CLIENT PE: J. Boltz
ANVIL PE: L. Nace
Date: 6/15/05

PROJECT DESCRIPTION:
Install Ultra Low Sulfur Diesel Complex.

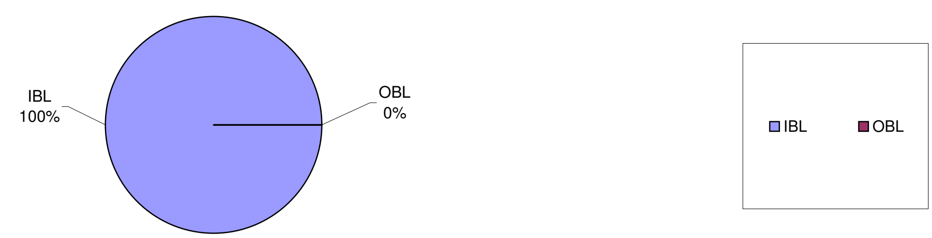
PROJECT RISKS:

PROJECT COST ESTIMATE SUMMARY

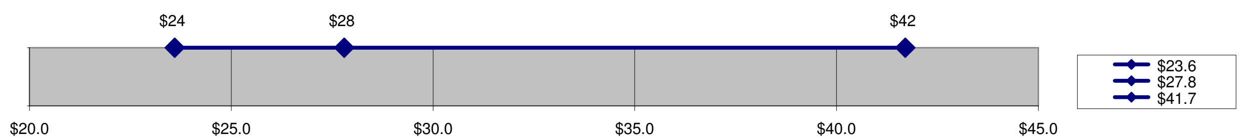
	TOTAL PROJECT COST - Valdez
COST ESTIMATE STRUCTURE	
COST ESTIMATE PARAMETERS	
Estimate Classification	Phase 1
Estimating Method	Factored/ROM
COST ESTIMATE SUMMARY	
Expected Cost ($MM)	**$ 27.8**
High Range ($MM)	**$ 41.7**
Low Range ($MM)	**$ 23.6**

PROJECT COST ESTIMATE ANALYSIS

Total Project Expected Cost Component Analysis



Total Project Cost Profile ($MM)



PROJECT SCHEDULE ESTIMATE ANALYSIS

Total Project Schedule

Target Completion Dates	2Q2005	TBD	TBD	TBD	4Q2010
Current Progress	↓				
PROJECT TIMELINE	***PHASE 1***	***PHASE 2***	***PHASE 3***	***PHASE 4***	***PHASE 5***

Petro Star Ultra Low Sulfur Diesel (6000 BPD) Project - Valdez Refinery

IBL Impact Matrix - 2005$ - Total Installed Costs USGC

Scenario: HDS Baseline

IBL Component	HDS Unit	Hydrogen Unit	Sulfur Unit	Total Cost $MM
Option 1 - LSG	Diesel hydrotreater, feed rate of 6000 B/D, producing ULSD (10 ppmw sulfur)	2 MMSCF/D H2 Production Plant.	Thiopaq process to be used for 3.7 T/D. Will also need sulfur storage / handling	
Cost Basis	Factored equipment based estimate	Verbal vendor quote from Howe Baker for module = $6.5 MM plus 3% for engineering	Vendor quote for 3.5 $ MM plus 3% for engineering	
High Range Cost, $ MM	$26.3	$10.0	$5.4	$41.7
Expected Cost, $ MM	$17.5	$6.7	$3.6	$27.8
Low Range Cost, $ MM	$14.9	$5.7	$3.1	$23.6

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - 6000 BPD HDS Baseline | **CLIENT: PetroStar**
ANVIL NO: AE1416 | **DATE: 6/15/05**
REV: 1

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COMPRESSORS						
C-500	1	Makeup Hydrogen Compressor	$190,300	2.8	$532,840	Reciprocating, 83 CFM, 150HP Motor, CS
C-501	1	Recycle Gas Compressor	$203,500	2.8	$569,800	Reciprocating, 150 CFM, 150HP Motor, CS Casing, SS Piston
		SUB-TOTAL	**$394,000**		**$1,103,000**	
EXCHANGERS						
E-500	1	Reactor Fd/Btms Exchanger #1	$207,000	4.0	$828,000	Shell & Tube Heat Exchanger, TEMA Type CEU, 4770 SF, 2 Shells, Shell Mat'l 1.25CR-1/2MO w/ 321SS Cladding, Tube Mat'l 1.25CR-1/2MO w/ 316SS Weld
E-501	1	Reactor Fd/Btms Exchanger #2	$88,500	4.0	$354,000	Shell & Tube Heat Exchanger, TEMA Type CEU, 2904 SF, 2 Shells, Shell Mat'l CS, Tube Mat'l 1.25CR-1/2MO w/ 321SS Weld Overlay
E-502	1	Separator Fd/Btms Exchanger	$8,200	4.0	$32,800	Double Pipe Heat Exchanger, 70 SF, 1 Shell, CS
E-505	1	Stripper Fd/Btms Exchanger	$148,900	4.0	$595,600	Shell & Tube Heat Exchanger, TEMA Type CEU, 3371 SF, 3 Shells, Shell Mat'l CS, Tube Mat'l 304SS
		SUB-TOTAL	**$453,000**		**$1,810,000**	
AIR COOLERS						
E-503	1	H. T. Separator Overhead Cooler	$51,100	4.0	$204,400	Air Cooler, Forced, 838SF Bare tube, Single Fan 10HP, CS
E-504	1	Stripper O. H. Condenser	$49,300	4.0	$197,200	Air Cooler, Forced, 838SF Bare tube, Single Fan 10HP, CS
E-506	1	Product Cooler	$78,500	4.0	$314,000	Air Cooler, Forced, 2203SF Bare tube, Single Fan 15.5HP, CS
		SUB-TOTAL	**$179,000**		**$716,000**	
FURNACES						
H-500	1	Diesel Charge Heater	$240,200	2.5	$588,490	Vertical Fired Heater, 3.5 MMBTU/HR, 9CR-1MO
H-500	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-500	1	Preheating	$40,000	1.0	$40,000	
H-500	1	Burner Management	$30,000	1.0	$30,000	
H-501	1	Stripper Reboiler	$285,700	2.5	$699,965	Vertical Fired Heater, 5.6 MMBTU/HR, 5CR-1/2MO
H-501	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-501	1	Preheating	$40,000	1.0	$40,000	
H-501	1	Burner Management	$30,000	1.0	$30,000	
		SUB-TOTAL	**$866,000**		**$1,728,000**	
PUMPS						
P-500 A/B	2	Diesel Feed Pump	$235,600	5.0	$1,178,000	API Centrifugal Pump, 206GPM, 0.80 SG, 2284 Ft. Head, CS Case, 12%CR Impeller, 150HP Motor
P-501 A/B	2	Stripper Bottoms Pump	$54,400	5.0	$272,000	API Centrifugal Pump, 345GPM, 0.59 S, 489 Ft. Head, CS Case, 12%CR Impeller, 50HP Motor
P-502 A/B	2	Stripper Overhead Pump	$44,400	5.0	$222,000	API Centrifugal Pump, 40GPM, 0.73 SG, 124 Ft. Head, CS Case, 12%CR Impeller, 5HP Motor
		SUB-TOTAL	**$334,000**		**$1,672,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - 6000 BPD HDS Baseline | **CLIENT: PetroStar**
ANVIL NO: AE1416 | **DATE: 6/15/05**
REV: 1

PHASE 1 ESTIMATE - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COLUMNS						
R-500	1	HDS Reactor	$520,000	4.4	$2,288,000	Vertical Reactor Column, 6'-6" Dia x 70' T-T, SA387 Gr 11 w/ 321SS Cladding, 2 Dist. Trays for Catalyst, Catalyst price included below
V-503	1	Naphtha Stripper	$50,900	4.4	$223,960	Vertical DBL Dia Trayed Column, Top (2'6" Dia x 25'-0"T-T) & Btm (4'-0" Dia x 30'-0" T-T), CS
V-503	1	Naphtha Stripper Trays	$48,700	2.7	$131,490	22 Valve Trays, 410SS
		SUB-TOTAL	**$620,000**		**$2,643,000**	
VESSELS						
V-500	1	Diesel Feed Drum	$34,600	4.2	$145,320	Horizontal, 8'-0" Dia x 15'-0" T-T, CS, 10% internals
V-501	1	High Temperature Separator	$15,500	4.2	$65,100	Vertical, 3'-0" Dia x 8'-0" T-T, CS, 10% internals
V-502	1	Low Temperature Separator	$16,100	4.2	$67,620	Horizontal, 3'-0" Dia x 8'-0" T-T, CS, PWHT, Boot, 10% internals
V-504	1	Stripper O. H. Accumulator	$12,800	4.2	$53,760	Horizontal, 3'-0" Dia x 6'-0" T-T, CS, PWHT, Boot, 10% internals
		SUB-TOTAL	**$79,000**		**$332,000**	
SKID PACKAGES / ALLOWANCES						
	1	Sulfur Analyzer	$250,000	1.0	$250,000	
		SUB-TOTAL	**$250,000**		**$250,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$222,000		$222,000	
		SUB-TOTAL	**$222,000**		**$222,000**	
		TOTAL	**$3,397,000**		**$10,476,000**	

DESIGN SERVICES (% of TIC)	**15%**	**$ 2,619,000**
OWNER'S SERVICES & COSTS (not included)		
HDS REACTOR CATALYST		**$ 692,000**
MISC. CATALYST, CHEMICALS INITIAL CHARGE		**$ 200,000**
ESCALATION (not included)		
UNADJUSTED COST ESTIMATE (UCE)		**$ 13,987,000**
UNALLOCATED PROVISION (UAP) *contingency*		**$ 3,513,000**
EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*		**$ 17,500,000**
HIGH RANGE *TOTAL INSTALLED COST (TIC)*		**$ 26,300,000**
LOW RANGE *TOTAL INSTALLED COST (TIC)*		**$ 14,900,000**

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***Note: Field Cost Multiplier includes the following bulk material and installation labor: Civil, Concrete, Structural, Piping, Electrical, Instrumentation, Insulation, Fireproofing, Painting, and Testing.**

Appendix H – HDS Baseline Case Operating Costs for 6000 BPD Diesel Feed

HDS Base Case -- Operating Costs for 6,000 BPSD Diesel Feed (Rev. 1, 6/22/05)

Volume Related Costs

Item	2005$/year (365 day/yr)	cent/gal (ULSD)	Basis		Comments
Utility - electricity	$ 628,311	0.7	755 kw	0.1 $/kwH	
Utility - fuel	$ 998,640	1.2	24.00 MMBTU/H	5 $MMBTU	
Utility - H2 plant feed	$ 842,603	1.0	20.25 MMBTU/H	5 $MMBTU	
Sulfur Disposal	$ 358,886	0.4	3.45 tons/day	0.15 $/Lb	Assuming the sulfur can be disposed of locally.
Chem - fuel additives	$ 106,875	0.1	Lubricity Improver		
Chem - sulfur plant	$ 142,500	0.2	Caustic & Nutrients for sulfur		
Cost of lost diesel production	$ 622,527	0.7	97% yield on diesel at $1.07/gallon		Yield losses on diesel minus credit for the resulting naphtha & LPG Fuel.
Total volume related costs	**$ 3,700,342**	**4.4**			

Basis:		
diesel feed:	252000	gal/day
On-stream availability:	95	%
ULSD yield (% if feed)	97	%

Fixed Costs (not volume dependent)

Item	2005$/year (365 day/yr)	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint	
Contract Services	$ 150,000	0.2	All disciplines including laboratory	
Operating Supplies	$ 200,000	0.2	Laboratory and other ovhd	May be somewhat volume dependendent
Maintenance	$ 200,000	0.2	Excluding TA costs	
Turnaround costs	$ 150,000	0.2	Amortized per year cost	Two to Three year turnaround assumed
Insurance & Taxes	$ 695,000	0.8	2.5% of TIC	Based on expected TIC of IBL plant
Catalyst	$ 200,000	0.2	Amortized per year cost	
Total fixed costs	$ 2,056,350	2.4		

Basis:	
IBL Total Installed Cost:	27.8 $MM

Total Operating Cost:	2005$/year (365 day/yr)	cent/gal (ULSD)
	$ 5,756,692	**6.8**

PETRO STAR INC.

HDS/BDS STUDY

BDS/HDS COMBINATION CASES REPORT AND COST ESTIMATES

ALASKA ANVIL NO. AE1416

REVISION 0
AUGUST 2005

Pelorus Environmental & Biotechnology Corp.

ALASKA ANVIL INCORPORATED

EXECUTIVE SUMMARY

To meet the EPA's 2006 sulfur content requirements, Petro Star is leading a Department of Energy study to determine the viability of ULSD production from a biodesulfurization process. This *BDS/HDS Combination Cases Report*, a part of the larger investigation, presents several BDS/HDS combinations to determine if a combined process has improved economics (i.e. capital and/or operating cost) over a standalone BDS or HDS process.

The effort is based on an installation at Valdez, Alaska producing ultra low sulfur diesel meeting a 10-ppmw sulfur requirement. The design feed rate to the desulfurization complex is 6,000 bpd of straight run diesel.

The design includes the following proposed IBL facilities:

- A new HDS Unit
- A new BDS Unit
- A new Diesel Splitter (Pre Frac Case only)
- A new Hydrogen Unit
- A new Sulfur Unit to treat the off-gas from the HDS Unit.

The cost estimate for the each case includes only the inside battery limits (IBL) portion of the desulfurization complex. The estimates are based on 2005 USGC pricing and have an accuracy range of +50% to –15%. The annual operating cost for each case was calculated as was the total incremental selling price for ULSD. This figure is based on a 5-year capital recovery period (excluding interest expense) plus the yearly operating cost. The cost summary for each case is presented in the table below.

Case	Expected TIC ($MM)	Annual Operating Cost ($MM)	Total Annual Cost (cents per gallon of ULSD)
BDS/HDS	44.5	9.4	21.4
HDS/BDS	43.3	8.0	19.4
Pre Frac	46.5	10.2	23.1

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INTRODUCTION

Background

All U.S. refineries will be required to meet the EPA's third quarter 2006 sulfur content requirements for highway diesel. The EPA requirement for maximum sulfur content of ultra low sulfur diesel (ULSD) is 15 ppmw. The refinery product should have about 10 ppmw sulfur or less to ensure that the product specification can be met on a reliable basis after product shipping and distribution logistics.

To compare different strategies to accomplish this requirement, Petro Star is leading a Department of Energy HDS/BDS study that evaluates the following processing routes:

- A standalone hydrodesulfurization (HDS) process
- A standalone biodesulfurization (BDS) process
- A combination of the two.

To be economically viable, a BDS process must be competitive with other commercially proven desulfurization routes. The route most chosen and best known to refiners for diesel is HDS. A new BDS facility must be less costly than a comparable new HDS facility. Or, in the various combination scenarios, using a BDS facility for pre- or post-treatment combined with an existing HDS unit must be less costly than the modifications to an existing HDS Unit that would achieve the lower sulfur requirement.

As part of the study of potential BDS economics, this report provides the process description and total installed cost for three BDS/HDS unit combinations:

- BDS/HDS Case
  A new 6,000 bpd BDS Unit producing low sulfur diesel (LSD) followed in series by a new 6,000 bpd HDS Unit producing ULSD
- HDS/BDS Case
  A new 6,000 bpd HDS Unit producing LSD followed in series by a new 6,000 bpd Unit producing ULSD
- Pre Frac Case
  A new 6,000 bpd Diesel Splitter followed in parallel by a new 3,860 bpd HDS Unit producing ULSD and a new 2,140 bpd BDS Unit producing USLD.

Exclusions

To simplify the economic baseline study and avoid biasing the study results, we have excluded all outside battery limits (OBL) facilities. A prior 1999 Kellogg report exploring a BDS baseline also excluded all utility systems improvements, offsite tankage, and waste stream disposal.

Information Sources

Axens North America, Inc. provided the HDS Unit reactor design and unit yields for this study under a proprietary agreement. A cursory inspection of other licensor data revealed little difference in yields, process conditions, and reactor size. Therefore, only the HDS data received from Axens was used for this study.

Pelorus provided the BDS Unit design as well as the operating costs estimate and equipment costs for the specialized equipment.

Process Design Basis

Throughput

The design throughput for the BDS/HDS combination cases is 6,000 bpd of straight run diesel containing 0.5 weight percent sulfur.

Feed Characteristics

The design basis composition and characteristics of the diesel feed, including a sulfur speciation, are included in Appendix A. The hydrogen from the Hydrogen Unit is 99.7% pure.

Product Specification

The specification for diesel product sulfur content is 10 ppmw.

Utility and Infrastructure Availability

The study assumes the refinery has the following utility systems and infrastructure available to support the BDS/HDS Combination Cases:

- Refinery fuel gas (for fired heaters and Hydrogen Unit feed)
- Water (available as feed to a new demineralization unit)
- Instrument air
- Electricity for drivers
- Nitrogen
- Process vent system
- Product tanks
- Cooling fluid system
- Steam/boiler feed water
- Refinery fuel gas
- Naphtha fuel
- Wastewater Treatment
- Flare.

Refinery Ambient Conditions

The new desulfurization facilities design is based on a Valdez, Alaska location.

Ambient Temperature Condition	Degrees F
Highest monthly average	62
Lowest monthly average	17
Record high	86
Record low	-23

BDS/HDS CASE

The BDS/HDS case includes the following proposed IBL facilities:

- A new 6,000 bpd BDS Unit
- A new 6,000 bpd HDS Unit
- A new Hydrogen Unit
- A new Sulfur Unit to treat the off-gas from the HDS Unit.

BDS Unit (Inside Battery Limits)

The BDS/HDS combination case is designed to take advantage of the substrate specificity of the existing prototype biocatalyst. For this cost estimate, it is assumed that the BDS section of the process will remove approximately 1,500 ppm of sulfur in the feed. This assumption is based upon the removal of all dibenzothiophenes and the majority of the benzothiophenes species from the feed.

The BDS process employs a selected strain of microorganisms (biocatalyst) which, through the action of produced enzymes, convert a portion of the sulfur contained in a liquid petroleum fuel into an oil-soluble compound, hydroxy biphenyl (HBP), which partitions to the diesel fuel, resulting in higher diesel yields. For the Petro Star BDS application, the petroleum fuel is diesel with a total sulfur content of 5,000 ppmw. Through processing in the BDS Unit, the fuel's sulfur content is reduced to 3,500 ppmw.

For a complete description of the BDS Unit process, please refer to the *BDS Baseline Report and Cost Estimate*. The BDS/HDS combination case differs from the BDS Baseline description in the following ways:

- The petroleum fuel is diesel with a total sulfur content of 5,000 ppmw. Through processing in the BDS Unit, the fuel's sulfur content is reduced to 3,500 ppmw. (Overview section)
- The BDS Reactors provide a hydraulic residence time of approximately 15 minutes at the design flows. (Reaction section.)

HDS Unit (Inside Battery Limits)

Feed Section

The feed to the HDS Unit is taken directly from the BDS Unit without routed through an intermediate storage tank. The diesel from the BDS Unit contains approximately 3,500 ppmw total sulfur and has low concentrations of benzothiophenes and dibenzothiophenes which are the most difficult sulfur species to hydrogenate in the HDS process. See Appendix B.3 for the sulfur speciation in the HDS feed. The diesel feed enters the Feed Preheater, E-507, where it is heated against the desulfurized diesel product to 335°F. The feed then enters the Diesel Feed Drum, V-500, which provides 15 minutes of surge capacity and a stable level for the Diesel Feed Pump, P-500 A/B. See Appendix B.4 for the IBL HDS Unit's process flow diagrams and material balance. See Appendix B.5 for the HDS Unit equipment list and budgetary equipment data sheets.

The feed is pumped through two Reactor Feed/Bottoms Exchangers, Nos. 1 and 2, (E-500 and E-501) where it is preheated to 650°F. Makeup hydrogen from the Hydrogen Unit, described below, is compressed by the Makeup Hydrogen Compressor (C-500) and enters the diesel feed stream upstream of the first Reactor Feed/Bottoms Exchanger. Hydrogen-rich recycle gas enters the diesel feed stream upstream of the second Reactor Feed/Bottoms Exchanger.

The combined diesel and hydrogen feed stream to the HDS reactor is heated to reaction temperature in the Diesel Charge Heater (H-500). The Diesel Charge Heater has an absorbed duty of 3.8 MM Btu/hr and uses refinery fuel gas or naphtha as its fuel source.

Reaction Section

The diesel and hydrogen feed stream enters the HDS Reactor (R-500) at 681°F and 630 psig at end-of-run (EOR) conditions. The catalyst in the reactor reduces the sulfur content of the diesel to 10 ppmw, and will effectively hydrogenate the most resistant sulfur species, 4,6 dibenzothiophenes. The hydrogenation reaction converts sulfur compounds to H_2S and also converts a small portion of the diesel to naphtha.

Post-Reaction Cooling

The hydrotreated diesel leaves the reactor at 719°F and 600 psig, and is cooled in the reactor feed/bottoms exchangers to 426°F. The diesel is further cooled in the Separator Feed/Bottoms Exchanger (E-502) to 419°F by preheating the bottoms stream from the Low Temperature Separator (V-502).

The diesel stream then enters the High Temperature Separator (V-501) to separate the diesel and naphtha from lighter hydrocarbons, hydrogen, and H_2S.

The bottoms stream from the High Temperature Separator is routed to the Naphtha Stripper (V-503) to separate the diesel from naphtha and sour hydrocarbon gas.

The overhead vapor from the separator is mixed with wash water to mitigate potential plugging and corrosion from ammonium sulfide salts which could otherwise precipitate in the air cooler. The overhead stream is then cooled to 120°F in the High Temperature Separator Overhead Cooler (E-503) and is then routed to the Low Temperature Separator (V-502). Like E-503, all coolers in the HDS Unit are air coolers to minimize the size of the cooling fluid system.

Low Temperature Separator

The Low Temperature Separator (V-502) separates the naphtha from lighter hydrocarbons, H_2S, and hydrogen. A water draw is included to remove sour wash water.

The hydrogen-rich overhead stream is recycled to the reactor feed stream via the Recycle Gas Compressor (C-501). An amine absorber is not required to treat the recycle gas because of the diesel feed's low sulfur content, the high purity of the makeup hydrogen gas, and consequently low H_2S content of the recycle gas.

Excess gas from the separator overhead is bled via pressure control to the Sulfur Unit's H_2S scrubbing section and is ultimately used as refinery fuel. The Low Temperature Separator pressure setting dictates the pressure level in the reactor system.

The bottoms stream is routed through the Separator Feed/Bottoms Exchanger (E-502) for preheating before entering the Naphtha Stripper (V-503) at the upper feed point. Because of the low flow rate of Low Temperature Separator bottoms, the duty of the E-502 service is small; in the design phase, the size or need for an exchanger in this service could be optimized.

Naphtha Stripper

The Naphtha Stripper (V-503) separates naphtha and sour hydrocarbon gas from the diesel product. The bottoms stream from the Low Temperature Separator enters the stripper at 415°F via the Separator Feed/Bottoms Exchanger. The bottoms stream from the High Temperature Separator enters the stripper at 590°F via the Stripper Feed/Bottoms Exchanger (E-505).

The Naphtha Stripper employs 22 distillation trays to the separate naphtha and sour hydrocarbon gas from the diesel product. The diesel yield from the stripper is approximately 96.3 volume percent of the diesel feed to the HDS unit.

The overhead from the stripper is condensed in the Stripper Overhead Condenser (E-504) and is collected in the Stripper Overhead Accumulator (V-504). The non-condensed sour gas from the accumulator is routed to the sulfur recovery unit and the sweetened gas is ultimately used as refinery fuel. The Stripper Overhead Pump (P-502A/B) delivers the naphtha from the accumulator to the plant liquid fuel system. A part of the condensed naphtha is returned to the top tray of the stripper as a reflux stream.

The bottoms stream from the stripper is routed through the Stripper Feed/Bottoms Exchanger (E-505) where it is cooled to 505°F. The diesel product than passes through the Feed Preheater, (E-507) where it is cooled against the diesel feed to 298°F. The product diesel is further cooled to 120°F in the Diesel Product Cooler (E-506) before being routed to a product storage tank. The Stripper Bottoms Pump (P-501A/B) sends a portion of the stripper bottoms stream through the Stripper Reboiler (H-501). The Stripper Reboiler has an absorbed duty of 5.7 MM Btu/hr and uses refinery fuel gas or naphtha for firing.

Hydrogen Unit

A new steam reforming-type Hydrogen Unit will supply hydrogen for the HDS Unit. The unit size for this case is 1.7 MMSCF/D hydrogen. The hydrogen produced in the unit has a purity of 99.7+%. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit.

Sulfur Unit

The purge gas from the HDS Low Temperature Separator (V-502) and the off-gas stream from the HDS Stripper Overhead Accumulator (V-504) are combined and sent to the Thiopaq Sulfur Recovery Unit in which the H_2S is removed from the hydrocarbon gas before use as fuel gas. The Sulfur Unit converts the H_2S into elemental sulfur. The unit size for this case is 2.4 LTD. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit.

Utilities

Preliminary utility loads for the BDS Unit, HDS Unit, Hydrogen Unit, and the Sulfur Unit are contained in Appendix B.6.

Cost Estimate

Total Installed Cost

The conceptual cost estimate is based on installing a 6,000 bpd BDS Unit and a 6,000 bpd HDS Unit producing ULSD meeting the 10-ppmw sulfur requirement. The cost estimate is for the IBL portion of the desulfurization complex only.

Based on equipment costs for the BDS and HDS Units and vendor quotes for the Hydrogen Unit and Sulfur Unit, the total installed cost estimate for the IBL portion of the desulfurization complex for the BDS/HDS Case is $44.5 million based on 2005 USGC pricing. The accuracy of the estimate is +50/-15%.

The cost estimate excludes owner costs such as startup and commissioning costs, initial operator training, startup procedures, and pre-startup operator staffing. It also excludes licensing and royalty fees and BDS R&D costs. A contingency of 25% is in the total installed cost. See Appendix B.7 for the Cost Estimate Basis and Cost Estimate.

Operating Cost and Capital Recovery

The total annual operating cost of the desulfurization complex for the BDS/HDS Case is $9,400,000. This cost is based on a 95% on-stream availability for both plants. The operating cost includes fuel, power, chemicals, utilities, sulfur disposal, other consumables, operating and maintenance labor, maintenance expense, and taxes and insurance. The operating cost includes lost diesel sales due to the loss of diesel to naphtha/fuel gas (HDS Unit) and to biomass (BDS Unit). However, a credit is taken for the value of naphtha and fuel gas as refinery fuel in the HDS Unit.

The operating cost can be expressed in terms of cents per gallon of ULSD, based on a 95.9% overall yield on the ULSD. The total operating cost of the desulfurization complex for the BDS/HDS Case is 11.1 cents per gallon of ULSD. The basis for developing the operating cost can be seen in Appendix B.8.

Based on the expected TIC of the desulfurization complex, the incremental selling price for ULSD would need to be 10.4 cents per gallon higher to recover the capital in 5 years (excluding interest expense) and 11.1 cents per gallon higher to recover operating costs. Therefore, the total incremental selling price for ULSD would need to be 21.4 cents per gallon above normal diesel sale prices in order to pass the cost of the investment on to the consumer.

HDS/BDS CASE

The HDS/BDS case includes the following proposed IBL facilities:

- A new 6,000 bpd HDS Unit
- A new 6,000 bpd BDS Unit
- A new Hydrogen Unit
- A new Sulfur Unit to treat the off-gas from the HDS Unit.

HDS Unit (Inside Battery Limits)

Feed Section

The feed to the HDS Unit is taken directly from the Crude Unit without cooling or routing through an intermediate storage tank. The diesel feed enters the Diesel Feed Drum (V-500) at 216°F. The feed drum provides 15 minutes of surge capacity and a stable level for the Diesel Feed Pump (P-500 A/B). See Appendix C.1 for the inside battery limits HDS Unit's process flow diagrams and material balance. See Appendix C.2 for the HDS Unit equipment list and budgetary equipment data sheets.

The feed is pumped through two Reactor Feed/Bottoms Exchangers, Nos. 1 and 2 (E-500 and E-501), where it is preheated to 645°F. Makeup hydrogen, from the Hydrogen Unit, described below, is compressed by the Makeup Hydrogen Compressor (C-500) and enters the diesel feed stream upstream of the first Reactor Feed/Bottoms Exchanger. Hydrogen-rich recycle gas enters the diesel feed stream upstream of the second Reactor Feed/Bottoms Exchanger.

The combined diesel and hydrogen feed stream to the HDS reactor is heated to reaction temperature in the Diesel Charge Heater (H-500). The Diesel Charge Heater has an absorbed duty of 4.7 MM Btu/hr and uses refinery fuel gas or naphtha as its fuel source.

Reaction Section

The diesel and hydrogen feed stream enters the HDS Reactor (R-500) at 684°F and 620 psig at end-of-run (EOR) conditions. The catalyst in the reactor reduces the sulfur content of the diesel to 500 ppmw. The hydrogenation reaction converts sulfur compounds to H_2S and also converts a small portion of the diesel to naphtha.

Post-Reaction Cooling

The hydrotreated diesel leaves the reactor at 717°F and 600 psig, and is cooled in the reactor feed/bottoms exchangers to 335°F. The diesel is further cooled in the Separator Feed/Bottoms Exchanger (E-502) to 333°F by preheating the bottoms stream from the Low Temperature Separator (V-502).

The diesel stream then enters the High Temperature Separator (V-501) to separate the diesel and naphtha from lighter hydrocarbons, hydrogen, and H_2S.

The bottoms stream from the High Temperature Separator is routed to the Naphtha Stripper (V-503) to separate the diesel from naphtha and sour hydrocarbon gas.

The overhead vapor from the Separator is mixed with wash water to mitigate potential plugging and corrosion from ammonium sulfide salts which could otherwise precipitate in the air cooler. The overhead stream is then cooled to 120°F in the High Temperature Separator Overhead Cooler (E-503) and is then routed to the Low Temperature Separator (V-502). Like E-503, all coolers in the HDS Unit are air coolers to minimize the size of the cooling fluid system.

Low Temperature Separator

The Low Temperature Separator (V-502) separates the naphtha from lighter hydrocarbons, H_2S, and hydrogen. A water draw is included to remove sour wash water.

The hydrogen-rich overhead stream is recycled to the reactor feed stream via the Recycle Gas Compressor (C-501). An amine absorber is not required to treat the recycle gas because of the diesel feed's low sulfur content, the high purity of the makeup hydrogen gas, and consequently low H_2S content of the recycle gas.

Excess gas from the Separator overhead is bled via pressure control to the Sulfur Unit's H_2S scrubbing section and is ultimately used as refinery fuel. The Low Temperature Separator pressure setting dictates the pressure level in the reactor system.

The bottoms stream is routed through the Separator Feed/Bottoms Exchanger (E-502) for preheating before entering the Naphtha Stripper (V-503) at the upper feed point. Because of the low flow rate of Low Temperature Separator bottoms, the duty of the E-502 service is small; in the design phase, the size or need for an exchanger in this service could be optimized.

Naphtha Stripper

The Naphtha Stripper (V-503) separates naphtha and sour hydrocarbon gas from the diesel product. The bottoms stream from the Low Temperature Separator enters the stripper at 325°F via the Separator Feed/Bottoms Exchanger. The bottoms stream from the High Temperature Separator enters the stripper at 580°F via the Stripper Feed/Bottoms Exchanger (E-505).

The Naphtha Stripper employs 22 distillation trays to the separate naphtha and sour hydrocarbon gas from the diesel product. The diesel yield from the stripper is approximately 97.2 volume percent of the diesel entering the HDS Unit.

The overhead from the stripper is condensed in the Stripper Overhead Condenser (E-504) and is collected in the Stripper Overhead Accumulator (V-504). The non-condensed sour gas from the accumulator is routed to the Sulfur Recovery Unit and the sweetened gas is ultimately used as refinery fuel. The Stripper Overhead Pump (P-502A/B) delivers the naphtha from the accumulator to the plant liquid fuel system. A part of the condensed naphtha is returned to the top tray of the stripper as a reflux stream.

The bottoms stream from the stripper is routed through the Stripper Feed/Bottoms Exchanger (E-505) where it is cooled to 426°F. The product diesel is further cooled to 120°F in the Diesel Product Cooler (E-506) before being routed to the BDS Unit. The Stripper Bottoms Pump (P-501A/B) sends a portion of the stripper bottoms stream through the Stripper Reboiler (H-501).

The Stripper Reboiler has an absorbed duty of 5.6 MM Btu/hr and uses refinery fuel gas or naphtha for firing.

Hydrogen Unit

A new steam reforming-type Hydrogen Unit will supply hydrogen for the HDS Unit. The unit size for this case is 1.5 MMSCF/D hydrogen. The hydrogen produced in the unit has a purity of 99.7+%. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit.

Sulfur Unit

The purge gas from the HDS Low Temperature Separator (V-502) and the off-gas stream from the HDS Stripper Overhead Accumulator (V-504) are combined and sent to the Thiopaq Sulfur Recovery Unit in which the H_2S is removed from the hydrocarbon gas before use as fuel gas. The Sulfur Unit converts the H_2S into elemental sulfur. The unit size for this case is 3.4 LTD. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit. The project does not include a storage area for the sulfur product to hold the sulfur between outhaul shipments.

BDS Unit (Inside Battery Limits)

The BDS process employs a selected strain of microorganisms (biocatalyst) which, through the action of produced enzymes, converts a portion of the sulfur contained in a liquid petroleum fuel into an oil-soluble compound, hydroxy biphenyl (HBP), which partitions to the diesel fuel, resulting in higher diesel yields. For the Petro Star BDS application, the petroleum fuel is diesel with a total sulfur content of 500 ppmw. Through processing in the BDS Unit, the sulfur content of the fuel is reduced to 10 ppmw.

For a complete description of the BDS Unit process, please refer to the *BDS Baseline Report and Cost Estimate*. The HDS/BDS combination case differs from the BDS Baseline description in the following ways:

- The petroleum fuel is diesel with a total sulfur content of 500 ppmw. Through processing in the BDS Unit, the fuel's sulfur content is reduced to 10 ppmw. (Overview section)
- The BDS Reactors provide a hydraulic residence time of approximately 12 minutes at the design flows. (Reaction section.)
- The diesel charge to the BDS Unit will normally come directly from the HDS Unit. (Feed section)

Utilities

Preliminary utility loads for the HDS Unit, Hydrogen Unit, Sulfur Unit, and the BDS Unit are contained in Appendix C.5.

Cost Estimate

Total Installed Cost

The conceptual cost estimate is based on installing a 6,000 bpd HDS Unit and a 6,000 bpd BDS Unit producing ULSD meeting the 10-ppmw sulfur requirement. The cost estimate is for the IBL portion of the desulfurization complex only. Based on equipment costs for the HDS and BDS Units and vendor quotes for the Hydrogen Unit and Sulfur Unit, the total installed cost estimate for the IBL portion of the desulfurization complex for the HDS/BDS Case is $43.3 million based on 2005 USGC pricing. The accuracy of the estimate is +50/-15%.

The cost estimate excludes other owner costs such as startup and commissioning costs, initial operator training, startup procedures, and pre-startup operator staffing. It also excludes licensing and royalty fees, and BDS R&D costs. The total installed cost includes a contingency of 25%. See Appendix C.6 for the Cost Estimate Basis and Cost Estimate.

Operating Cost and Capital Recovery

The total annual operating cost of the HDS and BDS Units for the HDS/BDS Case is $8,000,000. This cost is based on a 95% on-stream availability for each unit and includes the cost of chemicals, utilities, fuel, operating consumables, operating labor, maintenance expense, sulfur disposal, and taxes and insurance. The operating cost includes lost diesel sales due to the loss of diesel to naphtha/fuel gas (HDS Unit) and to biomass (BDS Unit). However, a credit is taken for the value of naphtha and fuel gas as refinery fuel in the HDS Unit.

The operating cost can also be expressed in terms of cents per gallon of ULSD, based on a 96.9% overall diesel yield. The total operating cost of the desulfurization complex for the HDS/BDS Case is 9.4 cents per gallon of ULSD. The basis and methodology for developing the operating cost and the operating cost in terms of cents per gallon can be seen in Appendix C.7.

Based on the expected TIC of the desulfurization complex, the incremental selling price for ULSD would need to be 10.1 cents per gallon higher to recover the capital in 5 years (excluding interest expense) and 9.4 cents per gallon higher to recover operating costs. Therefore, the total incremental selling price for ULSD would need to be 19.4 cents per gallon above normal diesel sale prices in order to pass the cost of the investment on to the consumer.

PRE FRAC CASE

The Pre Frac case includes the following proposed IBL facilities:

- A new 6,000 bpd Diesel Splitter
- A new 3,860 bpd HDS Unit
- A new 2,140 bpd BDS Unit
- A new Hydrogen Unit
- A new Sulfur Unit to treat the off-gas from the HDS Unit.

Diesel Splitter

Feed Section

Diesel feed comes directly from a refinery feed/product exchanger without being cooled or routed through an intermediate storage tank. The feed enters the Diesel Feed Drum, V-1, at 216°F. The feed drum provides 15 minutes of surge capacity and a stable level for the Diesel Feed Pump (P-1 A/B). See Appendix D.1 for the IBL Diesel Splitter process flow diagram and material balance. See Appendix D.2 for the Diesel Splitter equipment list and budgetary equipment data sheets.

The feed is pumped through Exchanger E-1 for preheating with tower bottoms. The feed is further preheated in E-2 with the tower overhead vapor stream. The feed is finally preheated to 540°F in E-3 by exchanging heat with the tower bottoms stream. The preheated feed from E-3 is sent to the Diesel Splitter Tower.

The Diesel Splitter (V-2) separates the diesel feed into a light diesel overhead stream and a heavy diesel bottoms stream. About two thirds of the diesel stream is recovered in the overhead product. The cut point for this light diesel overhead product is limited to a D-86 of 560°F in order to minimize the quantity of substituted dibenzothiophenes in this stream. Ensuring the HDS feed has less than 10 ppm substituted dibenzothiophenes allows a conventional HDS unit to be utilized to produce ULSD product. Cutting as deep as possible is desired to minimize the volume of feed to the BDS Unit while at same time concentrating the substituted dibenzo-thiophenes into an enriched BDS feed.

To achieve the desired separation, the Diesel Splitter employs 30 distillation trays. The tower is designed to operate with a tower top pressure of 10 psig to provide the necessary lift while limiting the temperature required at the bottom of the tower. Limiting the temperature at the bottom of the tower (to below 700°F) is important to avoid potential product degradation. The number of trays and reflux ratio for the Diesel Splitter were selected to provide a reasonable balance between tower diameter and energy consumption.

The Diesel Splitter bottoms are pumped via P-2 A/B and used to preheat the feed. The bottoms are cooled to 120°F in the Airfin Cooler (E-5) and on the BDS Unit for processing. A portion of the bottoms stream from P-2 A/B is sent to the Diesel Splitter Reboiler (H-1) which is a fired reboiler. The Diesel Splitter Reboiler has an absorbed duty of 17.8 MM Btu/hr and uses refinery fuel gas or naphtha for firing. The Diesel Splitter overhead vapor stream first goes to E-2 to preheat tower feed and then goes to the Airfin Condenser (E-4). The condensed overhead liquid goes to the Accumulator (V-3) and is pumped via P-3 A/B as reflux back to the tower top tray and also as feed to the HDS Unit feed drum.

An examination was made into the potential benefits of modifying the Diesel Splitting configuration by tailoring the streams coming from the upstream Crude Unit. An option was considered in which two diesel cuts were taken from the Crude Unit. Although the fractionation of these cuts would not be exact enough to directly be used at the HDS and BDS Units, the cuts could be fed to separate points in the Diesel Splitter, assisting separation in that tower. The results from this cursory examination showed only a modest reduction in tower diameter, however, and this option was not selected as a final configuration.

HDS Unit (Inside Battery Limits)

Feed Section

The 3,860 bpd of light diesel (4,240 ppmw total sulfur with low dibenzothiophenes) produced by the Diesel Splitter is taken directly into the HDS Unit without being cooled or routed through an intermediate storage tank. The diesel feed enters the Diesel Feed Drum (V-500) at 350°F. The feed drum provides 15 minutes of surge capacity and a stable level for the Diesel Feed Pump (P-500 A/B). See Appendix D.4 for the IBL HDS Unit's process flow diagrams and material balance. See Appendix D.5 for the HDS Unit equipment list and budgetary equipment data sheets.

The feed is pumped through two Reactor Feed/Bottoms Exchangers, Nos. 1 and 2 (E-500 and E-501), where it is preheated to 655°F. Makeup hydrogen from the Hydrogen Unit, described below, is compressed by the Makeup Hydrogen Compressor (C-500) and enters the diesel feed stream upstream of the first Reactor Feed/Bottoms Exchanger. Hydrogen-rich recycle gas enters the diesel feed stream upstream of the second Reactor Feed/Bottoms Exchanger.

The combined diesel and hydrogen feed stream to the HDS Reactor is heated to reaction temperature in the Diesel Charge Heater (H-500). The Diesel Charge Heater has an absorbed duty of 2.7 MM Btu/hr and uses refinery fuel gas or naphtha as its fuel source.

Reaction

The diesel and hydrogen feed stream enters the HDS Reactor (R-500) at 688°F and 620 psig at end-of-run (EOR) conditions. The catalyst in the reactor reduces the diesel sulfur content to 10 ppmw, and will effectively hydrogenate the most resistant sulfur species, 4,6 dibenzothiophenes. The hydrogenation reaction converts sulfur compounds to H_2S and also converts a small portion of the diesel to naphtha.

Post-Reaction Cooling

The hydrotreated diesel leaves the reactor at 716°F and 600 psig, and is cooled in the reactor feed/bottoms exchangers to 440°F. The diesel is further cooled in the Separator Feed/Bottoms Exchanger (E-502) to 428°F by preheating the bottoms stream from the Low Temperature Separator (V-502).

The diesel stream then enters the High Temperature Separator (V-501) to separate the diesel and naphtha from lighter hydrocarbons, hydrogen, and H_2S.

The bottoms stream from the High Temperature Separator is routed to the Naphtha Stripper (V-503) to separate the diesel from naphtha and sour hydrocarbon gas.

The overhead vapor from the separator is mixed with wash water to mitigate potential plugging and corrosion from ammonium sulfide salts which could otherwise precipitate in the air cooler. The overhead stream is then cooled to 120°F in the High Temperature Separator Overhead Cooler (E-503) and is then routed to the Low Temperature Separator (V-502). Like E-503, all coolers in the HDS Unit are air coolers to minimize the size of the cooling fluid system.

Low Temperature Separator

The Low Temperature Separator (V-502) separates the naphtha from lighter hydrocarbons, H_2S, and hydrogen. A water draw is included to remove sour wash water.

The hydrogen-rich overhead stream is recycled to the reactor feed stream via the Recycle Gas Compressor (C-501). An amine absorber is not required to treat the recycle gas because of the diesel feed's low sulfur content, the high purity of the makeup hydrogen gas, and consequently low H_2S content of the recycle gas.

Excess gas from the separator overhead is bled via pressure control to the Sulfur Unit's H_2S scrubbing section and is ultimately used as refinery fuel. The Low Temperature Separator pressure setting dictates the pressure level in the reactor system.

The bottoms stream is routed through the Separator Feed/Bottoms Exchanger (E-502) for preheating before entering the Naphtha Stripper (V-503) at the upper feed point. Because of the low flow rate of the Low Temperature Separator bottoms, the duty of the E-502 service is small; in the design phase, the size or need for an exchanger in this service could be optimized.

Naphtha Stripper

The Naphtha Stripper (V-503) separates naphtha and sour hydrocarbon gas from the diesel product. The bottoms stream from the Low Temperature Separator enters the stripper at 430°F via the Separator Feed/Bottoms Exchanger. The bottoms stream from the High Temperature Separator enters the stripper at 525°F via the Stripper Feed/Bottoms Exchanger, E-505.

The Naphtha Stripper employs 22 distillation trays to separate naphtha and sour hydrocarbon gas from the diesel product. The diesel yield from the stripper is approximately 95.6 volume percent of the diesel entering the HDS Unit.

The overhead from the stripper is condensed in the Stripper Overhead Condenser (E-504) and is collected in the Stripper Overhead Accumulator (V-504). The non-condensed sour gas from the accumulator is routed to the Sulfur Recovery Unit and the sweetened gas is ultimately used as refinery fuel. The Stripper Overhead Pump (P-502A/B) delivers the naphtha from the accumulator to the plant liquid fuel system. A part of the condensed naphtha is returned to the top tray of the stripper as a reflux stream.

The bottoms stream from the stripper is routed through the Stripper Feed/Bottoms Exchanger (E-505) where it is cooled to 523°F. The product diesel is further cooled to 120°F in the Diesel Product Cooler (E-506) before being routed to a product storage tank. The Stripper Bottoms Pump (P-501A/B) sends a portion of the stripper bottoms stream through the Stripper Reboiler (H-501). The Stripper Reboiler has an absorbed duty of 4.5 MM Btu/hr and uses refinery fuel gas or naphtha for firing.

Hydrogen Unit

A new steam reforming-type Hydrogen Unit will supply hydrogen for the HDS Unit. The unit size for this case is 1 MMSCF/D hydrogen. The hydrogen produced in the unit has a purity of 99.7+%. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit.

Sulfur Unit

The purge gas from the HDS Low Temperature Separator (V-502) and the off-gas stream from the HDS Stripper Overhead Accumulator (V-504) are combined and sent to the Thiopaq Sulfur Recovery Unit in which the H_2S is removed from the hydrocarbon gas before use as fuel gas. The Sulfur Unit converts the H_2S into elemental sulfur. The unit size for this case is 1.9 LTD. See the *HDS Baseline Case Report and Cost Estimate* for a process description and PFD for this unit. The project does not include a storage area for the sulfur product to hold the sulfur between outhaul shipments.

BDS Unit (Inside Battery Limits)

The BDS process employs a selected strain of microorganisms (biocatalyst) which, through the action of produced enzymes, convert a portion of the sulfur contained in a liquid petroleum fuel into a oil-soluble compound, hydroxy biphenyl (HBP), which partitions to the diesel fuel, resulting in higher diesel yields. For the Petro Star BDS application, the petroleum fuel is diesel with a total sulfur content of 6,311 ppmw. Through processing in the BDS Unit, the sulfur content of the fuel is reduced to 10 ppmw.

For a complete description of the BDS Unit process, please refer to the *BDS Baseline Report and Cost Estimate*. The Pre Frac case differs from the BDS Baseline description in the following ways:

- The petroleum fuel is diesel with a total sulfur content of 6,311 ppmw. Through processing in the BDS Unit, the fuel's sulfur content is reduced to 10 ppmw (Overview section)
- The diesel charge to the BDS Unit will normally come directly from the Diesel Splitter. (Feed section.)

Utilities

Preliminary utility loads for the BDS Unit, HDS Unit, Hydrogen Unit, and the Sulfur Unit are contained in Appendix D.8.

Cost Estimate

Total Installed Cost

The conceptual cost estimate is based on installing a 6,000 bpd Diesel Splitter, a 3,860 bpd HDS Unit and a 2,140 bpd BDS Unit, each producing ULSD meeting the 10-ppmw sulfur requirement. The cost estimate is for the IBL portion of the desulfurization complex only. Based on equipment costs for the Diesel Splitter, HDS Unit, and BDS Units and vendor quotes for the Hydrogen Unit and Sulfur Unit, the total installed cost estimate for the IBL portion of the desulfurization complex for the Pre Frac Case is $46.5 million based on 2005 USGC pricing. The accuracy of the estimate is +50/-15%.

The cost estimate excludes other owner costs such as startup and commissioning costs, initial operator training, startup procedures, and pre-startup operator staffing. It also excludes licensing and royalty fees, and BDS R&D costs. The total installed cost includes a contingency of 25%. See Appendix D.9 for the Cost Estimate Basis and Cost Estimate.

Operating Cost and Capital Recovery

The total annual operating cost of the BDS and HDS Units for the Pre Frac Case is $10,200,000. This cost is based on a 95% on-stream availability for each unit and includes the cost of chemicals, utilities, fuel, operating consumables, operating labor, maintenance expense, sulfur disposal, and taxes and insurance. The operating cost includes lost diesel sales due to the loss of diesel to naphtha/fuel gas (HDS Unit) and to biomass (BDS Unit). However, a credit is taken for the value of naphtha and fuel gas as refinery fuel in the HDS Unit.

The operating cost can also be expressed in terms of cents per gallon of ULSD, based on a 96.5% overall diesel yield. The total operating cost of the desulfurization complex for the Pre Frac Case is 12.1 cents per gallon of ULSD. The basis for developing the operating cost can be seen in Appendix D.10.

Based on the expected TIC of the desulfurization complex, the incremental selling price for ULSD would need to be 11 cents per gallon higher to recover the capital in 5 years (excluding interest expense) and 12.1 cents per gallon higher to recover operating costs. Therefore, the total incremental selling price for ULSD would need to be 23.1 cents per gallon above normal diesel sale prices in order to pass the cost of the investment on to the consumer.

APPENDICES

A. Raw Diesel Feed Properties and Sulfur Speciation

B. BDS/HDS Case

B.1. BDS Unit Process Flow Diagrams and Material Balance

B.2. BDS Unit Equipment List and Budgetary Equipment Datasheets

B.3. Sulfur Speciation in BDS Unit Diesel Product

B.4. HDS Unit Process Flow Diagrams and Material Balance

B.5. HDS Unit Equipment List and Budgetary Equipment Datasheets

B.6. Utility Requirements

B.7. Cost Estimate Basis and Cost Estimate

B.8. Operating Cost Estimates

C. HDS/BDS Case

C.1. HDS Unit Process Flow Diagrams and Material Balance

C.2. HDS Unit Equipment List and Budgetary Equipment Datasheets

C.3. BDS Unit Process Flow Diagrams and Material Balance

C.4. BDS Unit Equipment List and Budgetary Equipment Datasheets

C.5. Utility Requirements

C.6. Cost Estimate Basis and Cost Estimate

C.7. Operating Cost Estimates

D. Pre Frac Case

D.1. Diesel Splitter Process Flow Diagram and Material Balance

D.2. Diesel Splitter Equipment List and Budgetary Equipment Datasheets

D.3. Sulfur Speciation in Diesel Splitter Products

D.4. HDS Unit Process Flow Diagrams and Material Balance

D.5. HDS Unit Equipment List and Budgetary Equipment Datasheets

D.6. BDS Unit Process Flow Diagrams and Material Balance

D.7. BDS Unit Equipment List and Budgetary Datasheets

D.8. Utility Requirements

D.9. Cost Estimate Basis and Cost Estimate

D.10 Operating Cost Estimates

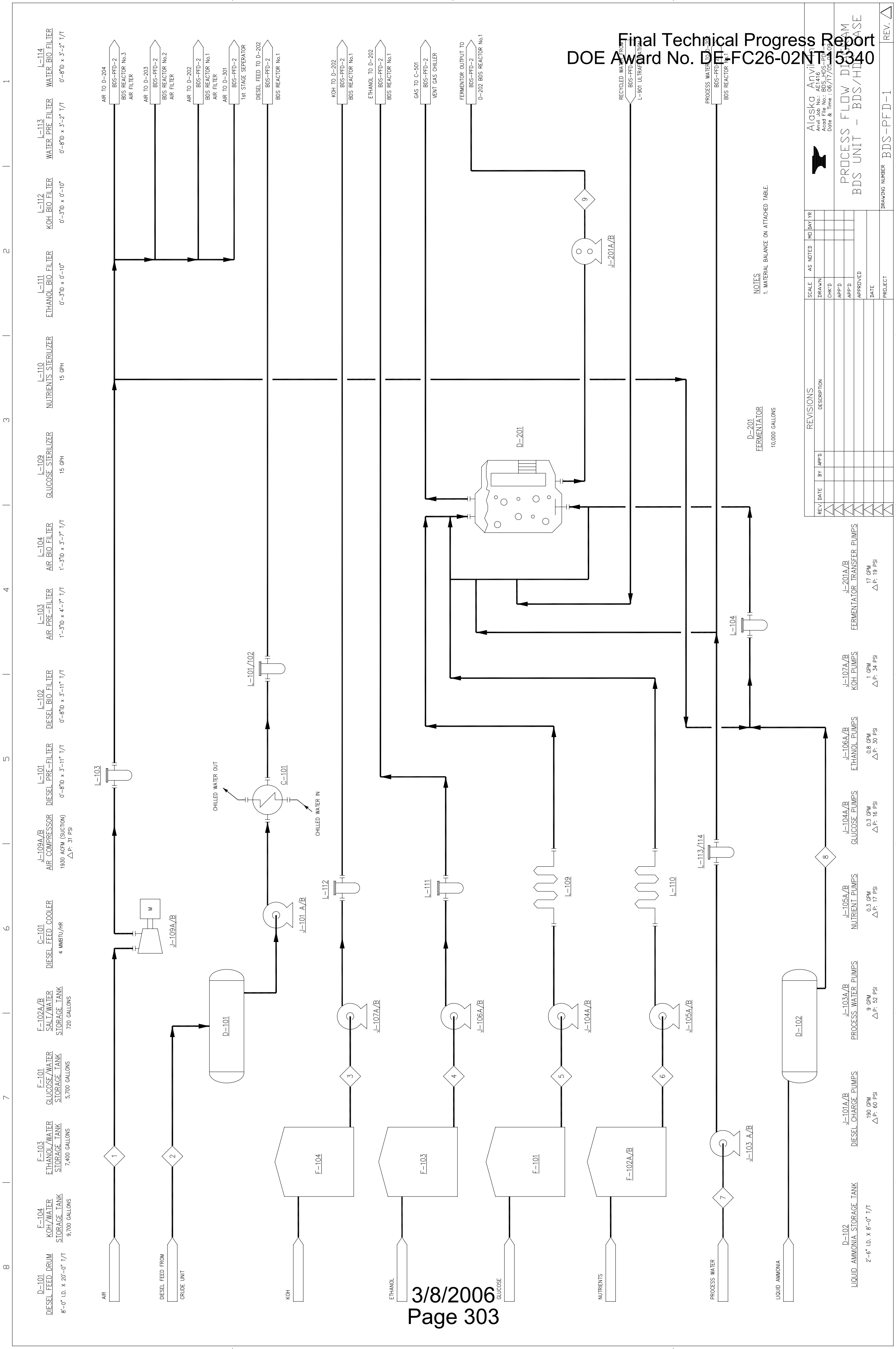
Appendix A – Raw Diesel Feed Properties and Sulfur Speciation

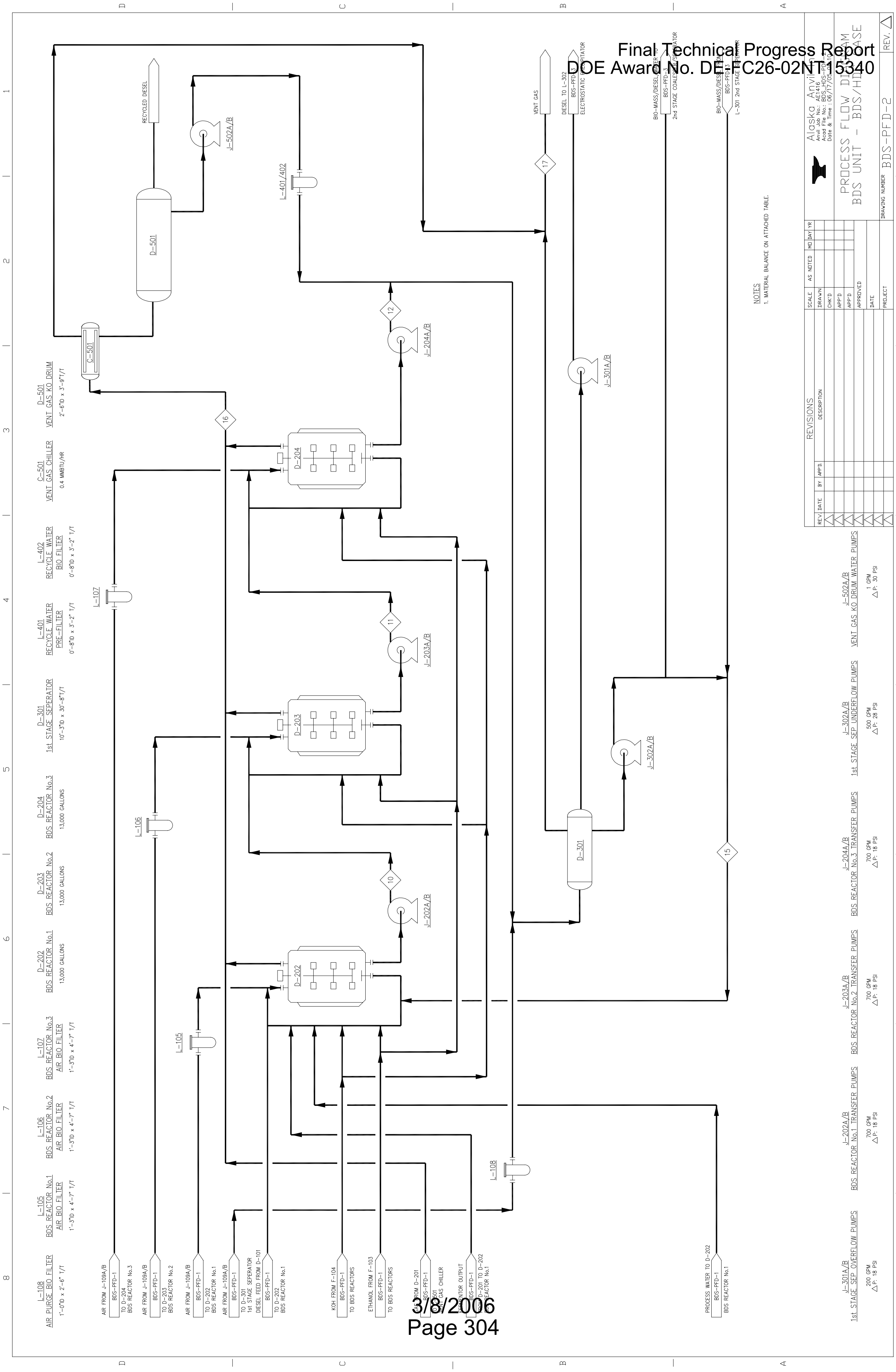
Diesel Feed Properties			
Test	**Units**	**Results**	**Specification**
Gravity @ 60°F, Min/Max	API	33.3	32-36
Flash Pt, Min.	Celsius	63.5 (146°F)	60 (140°F)
Cloud Pt, Max.	Celsius	-12.3 (10°F)	-9.5 (15°F)
Pour Pt, Max.	Celsius	-15 (5°F)	-12 (10°F)
Distillation			
IBP	Celsius	171 (340 °F)	Report
10% Recovery	Celsius	249 (480 °F)	Report
20% Recovery	Celsius	265 (509 °F)	Report
50% Recovery	Celsius	287 (549 °F)	Report
90% Recovery	Celsius	317 (603 °F)	282-338
Final Boiling Pt.	Celsius	336 (637 °F)	Report
Recovery	Vol %	99.9	Report
Residual	Vol %	0.1	Report
Loss	Vol %	0	Report
Viscosity @ 40 C, Min/Max	CSt	3.57	2.0-4.3
Ash, Max	Wt%	<0.001	0.01%
Carbon Residue on 10% Bottoms, Max	Wt%	0.08	0.35%
Btu Gross, Min	Btu/Gallon	139,190	136,000
Calculated Cetane, Min	Index	48	45
Copper Strip Corrosion, Max	Code	1a	3
Total Sulfur	Wt.%	0.500	0.500

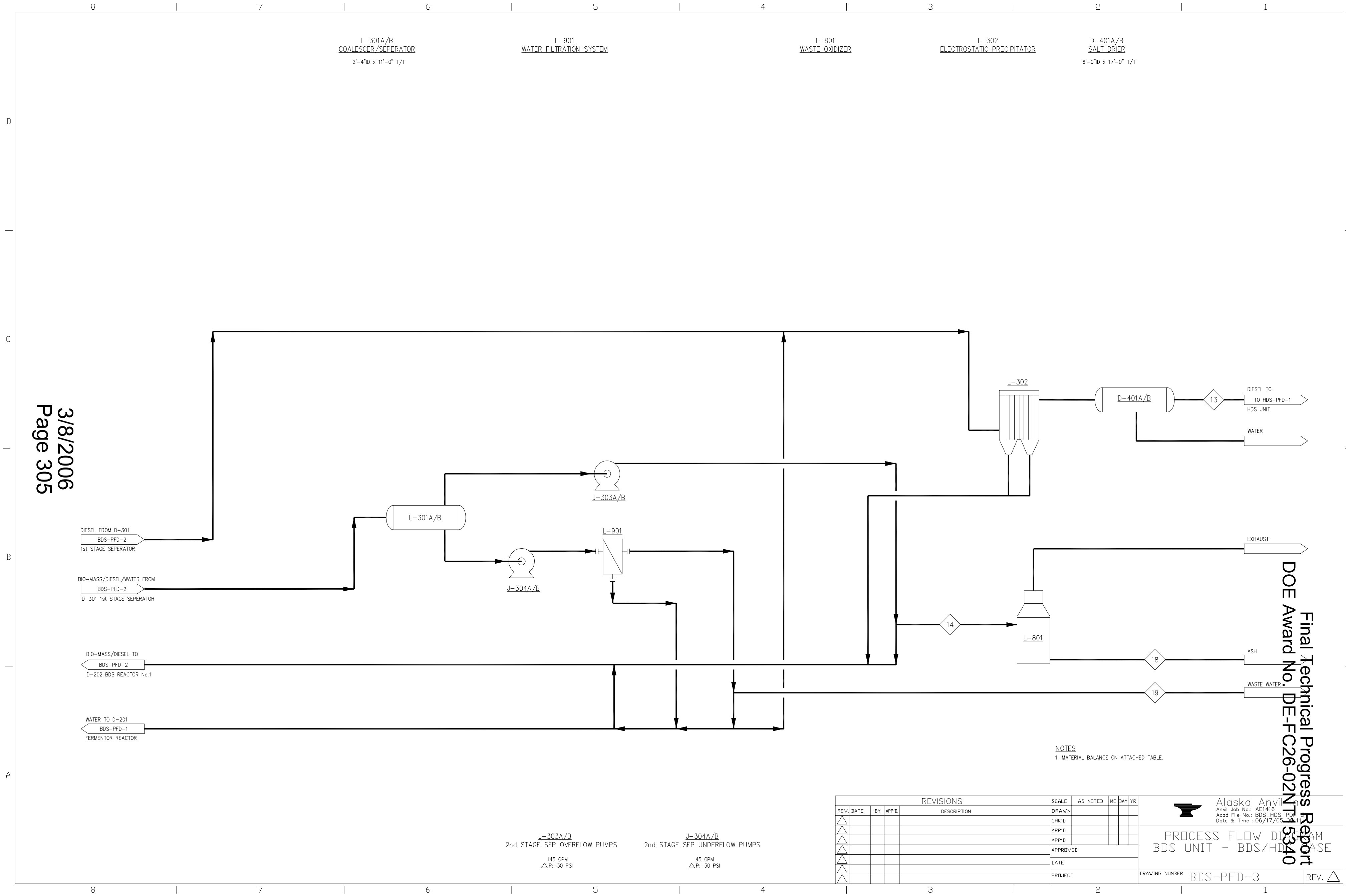
Raw Diesel Sulfur Speciation (Ratioed to 5,000 ppm*)			
Component	**ppm wt sulfur**	**Component**	**ppm wt sulfur**
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	2
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	29
Thiophene	<1	Trimethyl benzothiophene	119
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	354
Isobutyl mercaptan	<1	Dibenzothiophene	229
Ethyl sulfide	<1	4-Methyl benzothiophene	213
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	147
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	94
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	97
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	354
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	75
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	4
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

* Raw data from the speciation analysis ratioed to 5,000 ppm to reflect the design basis sulfur content.

Appendix B.1 – BDS Unit Process Flow Diagrams and Material Balance


D-101 DIESEL FEED DRUM 8'-0" I.D. x 20'-0" T/T
F-104 KOH/WATER STORAGE TANK 9,700 GALLONS
F-103 ETHANOL/WATER STORAGE TANK 7,400 GALLONS
F-101 GLUCOSE/WATER STORAGE TANK 5,700 GALLONS
F-102A/B SALT/WATER STORAGE TANK 720 GALLONS
C-101 DIESEL FEED COOLER 4 MMBTU/HR
J-109A/B AIR COMPRESSOR 1930 ACFM (SUCTION) ΔP: 31 PSI
L-101 DIESEL PRE-FILTER 0'-8"D x 3'-11" T/T
L-102 DIESEL BIO FILTER 0'-8"D x 3'-11" T/T
L-103 AIR PRE-FILTER 1'-3"D x 4'-7" T/T
L-104 AIR BIO FILTER 1'-3"D x 3'-7" T/T
L-109 GLUCOSE STERILIZER 15 GPH
L-110 NUTRIENTS STERILIZER 15 GPH
L-111 ETHANOL BIO FILTER 0'-3"D x 0'-10"
L-112 KOH BIO FILTER 0'-3"D x 0'-10"
L-113 WATER PRE FILTER 0'-8"D x 3'-2" T/T
L-114 WATER BIO FILTER 0'-8"D x 3'-2" T/T
D-102 LIQUID AMMONIA STORAGE TANK 2'-6" I.D. x 8'-0" T/T
J-101A/B DIESEL CHARGE PUMPS 190 GPM ΔP: 60 PSI
J-103A/B PROCESS WATER PUMPS 9 GPM ΔP: 52 PSI
J-105A/B NUTRIENT PUMPS 0.3 GPM ΔP: 17 PSI
J-104A/B GLUCOSE PUMPS 0.3 GPM ΔP: 16 PSI
J-106A/B ETHANOL PUMPS 0.8 GPM ΔP: 30 PSI
J-107A/B KOH PUMPS 1 GPM ΔP: 34 PSI
J-201A/B FERMENTATOR TRANSFER PUMPS 17 GPM ΔP: 19 PSI
D-201 FERMENTATOR 10,000 GALLONS
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
AIR
DIESEL FEED FROM CRUDE UNIT
KOH
ETHANOL
GLUCOSE
NUTRIENTS
PROCESS WATER
LIQUID AMMONIA
CHILLED WATER OUT
CHILLED WATER IN
AIR TO D-204 BDS-PFD-2 BDS REACTOR No.3 AIR FILTER
AIR TO D-203 BDS-PFD-2 BDS REACTOR No.2 AIR FILTER
AIR TO D-202 BDS-PFD-2 BDS REACTOR No.1 AIR FILTER
AIR TO D-301 BDS-PFD-2 1st STAGE SEPERATOR
DIESEL FEED TO D-202 BDS-PFD-2 BDS REACTOR No.1
KOH TO D-202 BDS-PFD-2 BDS REACTOR No.1
ETHANOL TO D-202 BDS-PFD-2 BDS REACTOR No.1
GAS TO C-501 BDS-PFD-2 VENT GAS CHILLER
FERMENTOR OUTPUT TO BDS-PFD-2 D-202 BDS REACTOR No.1
L-901 ULTRAFILTRATION
REVISIONS
Alaska Anvil
PROCESS FLOW DIAGRAM
BDS UNIT - BDS/HDS CASE
DRAWING NUMBER BDS-PFD-1


D-501
C-501
D-202
D-203
D-204
D-301
J-502A/B
J-204A/B
J-203A/B
J-202A/B
J-301A/B
J-302A/B
L-401/402
L-105
L-106
L-107
L-108
RECYCLED DIESEL
VENT GAS
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
L-108 AIR PURGE BIO FILTER
L-105 BDS REACTOR No.1 AIR BIO FILTER
L-106 BDS REACTOR No.2 AIR BIO FILTER
L-107 BDS REACTOR No.3 AIR BIO FILTER
D-202 BDS REACTOR No.1
D-203 BDS REACTOR No.2
D-204 BDS REACTOR No.3
D-301 1st STAGE SEPERATOR
L-401 RECYCLE WATER PRE-FILTER
L-402 RECYCLE WATER BIO FILTER
C-501 VENT GAS CHILLER
D-501 VENT GAS KO DRUM
J-301A/B 1st STAGE SEP OVERFLOW PUMPS
J-202A/B BDS REACTOR No.1 TRANSFER PUMPS
J-203A/B BDS REACTOR No.2 TRANSFER PUMPS
J-204A/B BDS REACTOR No.3 TRANSFER PUMPS
J-302A/B 1st STAGE SEP UNDERFLOW PUMPS
J-502A/B VENT GAS KO DRUM WATER PUMPS
PROCESS FLOW DIAGRAM
BDS-PFD-2


L-301A/B
COALESCER/SEPERATOR
2'-4"ID x 11'-0" T/T
L-901
WATER FILTRATION SYSTEM
L-801
WASTE OXIDIZER
L-302
ELECTROSTATIC PRECIPITATOR
D-401A/B
SALT DRIER
6'-0"ID x 17'-0" T/T
DIESEL FROM D-301
BDS-PFD-2
1st STAGE SEPERATOR
BIO-MASS/DIESEL/WATER FROM
BDS-PFD-2
D-301 1st STAGE SEPERATOR
BIO-MASS/DIESEL TO
BDS-PFD-2
D-202 BDS REACTOR No.1
WATER TO D-201
BDS-PFD-1
FERMENTOR REACTOR
J-303A/B
J-304A/B
DIESEL TO
TO HDS-PFD-1
HDS UNIT
WATER
EXHAUST
ASH
WASTE WATER
13
14
18
19
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
J-303A/B
2nd STAGE SEP OVERFLOW PUMPS
145 GPM
△P: 30 PSI
J-304A/B
2nd STAGE SEP UNDERFLOW PUMPS
45 GPM
△P: 30 PSI
REVISIONS
REV. DATE BY APP'D DESCRIPTION
SCALE AS NOTED MO DAY YR
DRAWN
CHK'D
APP'D
APP'D
APPROVED
DATE
PROJECT
Anvil Job No.: AE1416
DRAWING NUMBER BDS-PFD-3
REV.

Material Balance

BDS Unit Material Balance -- BDS/HDS Case

PFD Stream Number		1	2	3	4	5	6	7
Stream Number		Air	Diesel	NaOH	Ethanol	Glucose	Nutrients	Process Water
Stream Description		Air Feed	Diesel Feed	NaOH Feed	Ethanol Feed	Glucose Feed	Nutrient Feed	Process Water Feed
Phase		VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR		74483					
Aqueous Mass Flow	LB/HR			570	278	137	111	3981
Biomass Mass Flow	LB/HR							
Sulfur in HC	PPM		5000					
Total Mass Flow Rate	LB/HR	8000	74483	570	278	137	111	3981
Temperature	F	68	176	68	68	68	68	68
Pressure	PSIG	0	0	0	0	0	0	0
Standard Liq Flow	BPD		6000	26	21	8	8	274
Vapor Flow	MSCFH	108						
Wt % Vapor		100	0	0	0	0	0	0
MW								

PFD Stream Number		8	9	10	11	12	13	14
Stream Number		Liquid Ammonia	S-16	S-17	S-18	S-19	S-27	S-31
Stream Description		Liquid Ammonia Feed	Fermentor Output	R#1 Output	R#2 Output	R#3 Output	Diesel Product	Biomass Purge
Phase		LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR			126038	125829	125636	74229	244
Aqueous Mass Flow	LB/HR	9.8	7280	139821	140303	140407	0	418
Biomass Mass Flow	LB/HR		137	34543	34543	34543	0	130
Sulfur in HC	PPM			3910	3559	3470	3470	3470
Mass Flow Rate	LB/HR	9.8	7417	300402	300675	300585	74229	792
Temperature	F	-40	86	86	86	86	86	86
Pressure	PSIG	210	33.1	36.4	36.4	26.8	5	5
Standard Liq Flow	BPD	1	511	21817	21825	21815	5977	56
Vapor Flow	MSCFH							
Wt % Vapor		0	0	0	0	0	0	0
MW								

PFD Stream Number		15	16	17	18	19		
Stream Number		S-32	S-38	S-39	Ash	Waste Water		
Stream Description		Reactor Recycle	Reactor Air Effluent	Gas Purge	Incinerator Waste	Waste Water		
Phase		LIQUID	GAS	GAS	SOLID	LIQUID		
Hydrocarbon Mass Flo	LB/HR	51769	567					
Aqueous Mass Flow	LB/HR	128259	123			4746		
Biomass Mass Flow	LB/HR	34406						
Sulfur in HC	PPM	3470	3650					
Total Mass Flow Rate	LB/HR	214434	8173	7523	10	4746		
Temperature	F	86	86	60	68	86		
Pressure	PSIG	37.4	10	1	0	10		
Standard Liq Flow	BPD	15039				319		
Vapor Flow	MSCFH		102	99				
Wt % Vapor		0	100	100	0	0		
MW								

Appendix B.2 – BDS Unit Equipment List and Budgetary Equipment Datasheets

ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	D-101		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8'		
TANGENT TO TANGENT LENGTH, FT.	X	20'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	190		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	D-102		
SERVICE	X	Storage Tank		
FLUID	X	Liquid Ammonia		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	8'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	275		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	N/A		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	10'-3"		
TANGENT TO TANGENT LENGTH, FT.	X	30'-8"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	D-501		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	3'-9"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL

BUDGETARY DATA SHEET

STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	F-101		
SERVICE	X	Storage Tank		
FLUID	X	Glucose/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	8'-8"		
TANGENT TO TANGENT LENGTH, FT.	X	13'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
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O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	F-102 A/B		
SERVICE	X	Storage Tank		
FLUID	X	Salt/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	4'		
TANGENT TO TANGENT LENGTH, FT.	X	7'-8"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	F-103		
SERVICE	X	Storage Tank		
FLUID	X	Ethanol/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	9'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	14'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	Epoxy Resin		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
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ANVIL **BUDGETARY DATA SHEET**

STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS ULSD Baseline	**DATE**	3/29/2005

ITEM NUMBER	X	F-104		
SERVICE	X	Storage Tank		
FLUID	X	NaOH/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	10'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	15'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**	

ITEM NUMBER	X	J-101 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	140		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	190		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	61.3		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		60.1		
DIFFERENTIAL HEAD, FT		163.1		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	**PMD**
LOCATION	Alaska	**PROJECT NO.**	**AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE**	**3/29/05**

ITEM NUMBER	X	J-103 A/B (1)		
SERVICE (FLUID)	X	Process Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.997		
RATED FLOW (GPM)	X	9		
SUCTION PRESSURE, PSIG	X	5		
DISCHARGE PRESSURE PSIG	X	57.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	1		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		52.4		
DIFFERENTIAL HEAD, FT		121		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-104 A/B (1)		
SERVICE (FLUID)	X	Glucose/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.2		
RATED FLOW (GPM)	X	0.3		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.4		
DIFFERENTIAL HEAD, FT		31		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-105 A/B (1)		
SERVICE (FLUID)	X	Salts/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	0.25		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.8		
DIFFERENTIAL HEAD, FT		38.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-106 A/B (1)		
SERVICE (FLUID)	X	Ethanol/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.914		
RATED FLOW (GPM)	X	0.75		
SUCTION PRESSURE, PSIG	X	1		
DISCHARGE PRESSURE PSIG	X	31.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.4		
DIFFERENTIAL HEAD, FT		80.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-107 A/B (1)		
SERVICE (FLUID)	X	NaOH/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.53		
RATED FLOW (GPM)	X	1		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	35.9		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		34.3		
DIFFERENTIAL HEAD, FT		65.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**	

ITEM NUMBER	X	J-109 A/B		
FLUID	X	Air		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Screw		
TOTAL NUMBER OF MACHINES	X	2		
RATED CAPACITY (ACFM @ SUCTION)	X	1,930		
SUCTION TEMPERATURE ^{O}F	X	68		
SUCTION PRESSURE, PSIA	X	14.7		
DISCHARGE PRESSURE, PSIA	X	46		
GAS MOLECULAR WEIGHT	X	28.9		
'K' VALUE OF GAS	X			
MOL % HYDROGEN IN GAS	X	0		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	Water		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	175		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	155		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20°F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL

BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-201 A/B (1)		
SERVICE (FLUID)	X	Biomass/Salts/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	16.5		
SUCTION PRESSURE, PSIG	X	14.1		
DISCHARGE PRESSURE PSIG	X	33.1		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Rotary Lobe		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		19		
DIFFERENTIAL HEAD, FT		43.4		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-202 A/B (1)		
SERVICE (FLUID)	X	Biomass/Diesel/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.93		
RATED FLOW (GPM)	X	700		
SUCTION PRESSURE, PSIG	X	18.4		
DISCHARGE PRESSURE PSIG	X	36.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		44.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-301 A/B (1)		
SERVICE (FLUID)	X	Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	200		
SUCTION PRESSURE, PSIG	X	7		
DISCHARGE PRESSURE PSIG	X	25		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		48.9		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
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O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-302 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.96		
RATED FLOW (GPM)	X	500		
SUCTION PRESSURE, PSIG	X	9		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	10		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		28.4		
DIFFERENTIAL HEAD, FT		68.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-303 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	145		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-304 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	45		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	3		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	J-502 A/B (1)		
SERVICE (FLUID)	X	Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	1		
SUCTION PRESSURE, PSIG	X	3.6		
DISCHARGE PRESSURE PSIG	X	33.8		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.2		
DIFFERENTIAL HEAD, FT		69.8		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/29/05**

ITEM NUMBER	X	C-101		
SERVICE	X	Diesel Feed Cooler		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	1750		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	4		

REMARKS

ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)	**DATE 3/29/05**

ITEM NUMBER	X	C-501		
SERVICE	X	Vent Gas Chiller		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	500		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Air		
DESIGN PRESSURE, PSIG	x	50		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	0.4		

REMARKS

ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-101		
SERVICE	X	Diesel Pre-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-102		
SERVICE	X	Diesel Bio-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEI		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-103		
SERVICE	X	Air Pre-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEI		GF		
PORE SIZE, MICRON	X	1.0 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
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ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-104		
SERVICE	X	Air Bio-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	43"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEI		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
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ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-105		
SERVICE	X	Reactor Bio Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-108		
SERVICE	X	Air Purge Biofilter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	30"		
HOUSING DIAMETER, IN	X	12"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-111		
SERVICE	X	Ethanol Bio Filter		
FLUID	X	Ethanol/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-112		
SERVICE	X	NaOH Bio Filter		
FLUID	X	NaOH/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-113		
SERVICE	X	Water Pre Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-114		
SERVICE	X	Water Bio Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Pretreat (BDS/HDS Combo)		3/29/2005

ITEM NUMBER	X	L-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-4"		
TANGENT TO TANGENT LENGTH, FT.	X	11'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	24"ODx18"IDx120"L		
PACKING MATERIAL	X	Fiberbed Coalescer		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes 1'x2'		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Pretreatment	**DATE 6/11/05**

ITEM NUMBER	X	J-601 A/B (1)		
SERVICE (FLUID)	X	Water Chiller Pump		
TEMPERATURE OF FLUID	X	65		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.95		
RATED FLOW (GPM)	X	2000		
SUCTION PRESSURE, PSIG	X	2.5		
DISCHARGE PRESSURE PSIG	X	38.5		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	30		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		36		
DIFFERENTIAL HEAD, FT		81.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Pretreatment	**DATE 6/11/05**

ITEM NUMBER	x	C-601		
SERVICE	x	Chiller Exchanger		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	3790		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	8.6		

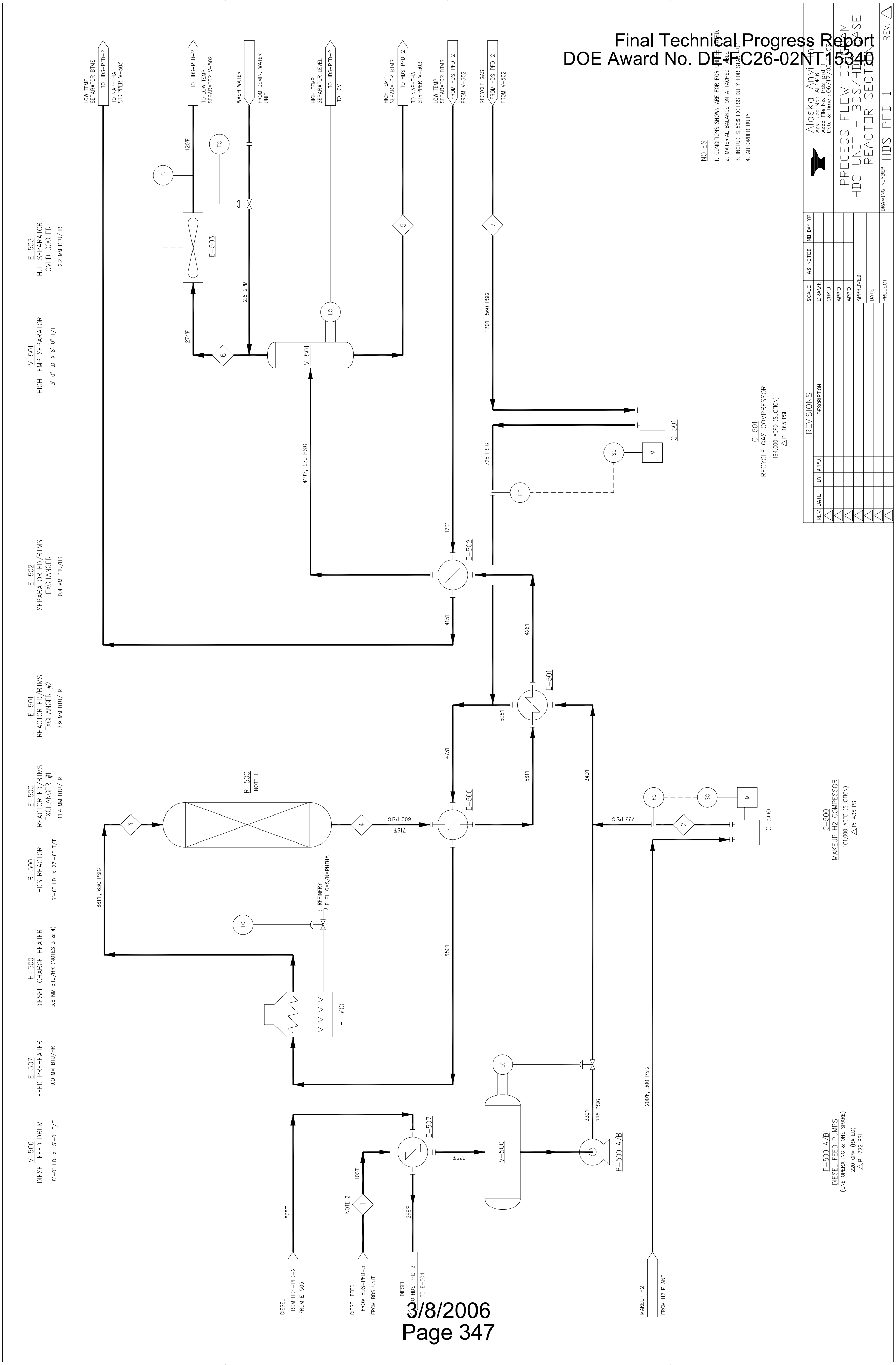
REMARKS

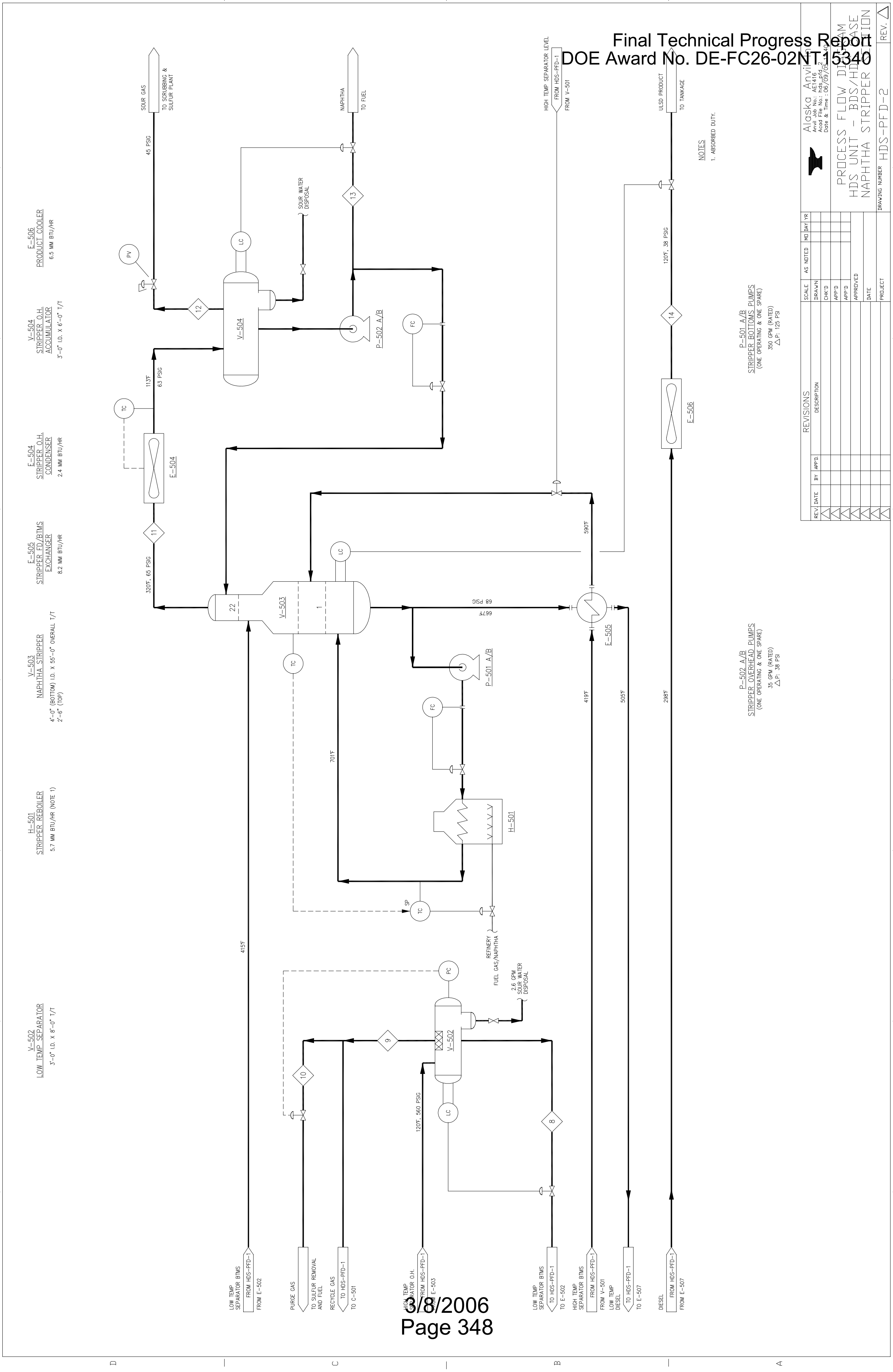
Appendix B.3 – Sulfur Speciation in BDS Unit Diesel Product

Sulfur Speciation in BDS Diesel Product

Component	ppm wt sulfur	Component	ppm wt sulfur
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	2
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	29
Thiophene	<1	Trimethyl benzothiophene	43
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	<1
Isobutyl mercaptan	<1	Dibenzothiophene	<1
Ethyl sulfide	<1	4-Methyl benzothiophene	<1
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	<1
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	<1
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	<1
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	<1
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	<1
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	<1
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

Appendix B.4 – HDS Process Flow Diagrams and Material Balance


Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT - BDS/HDS CASE
REACTOR SECTION
DRAWING NUMBER HDS-PFD-1
REV.
REVISIONS
NOTES
1. CONDITIONS SHOWN ARE FOR EOR UNLESS NOTED.
2. MATERIAL BALANCE ON ATTACHED TABLE.
3. INCLUDES 50% EXCESS DUTY FOR START-UP.
4. ABSORBED DUTY.
V-500
DIESEL FEED DRUM
8'-0" I.D. X 15'-0" T/T
E-507
FEED PREHEATER
9.0 MM BTU/HR
H-500
DIESEL CHARGE HEATER
3.8 MM BTU/HR (NOTES 3 & 4)
R-500
HDS REACTOR
6'-6" I.D. X 27'-6" T/T
E-500
REACTOR FD/BTMS
EXCHANGER #1
11.4 MM BTU/HR
E-501
REACTOR FD/BTMS
EXCHANGER #2
7.9 MM BTU/HR
E-502
SEPARATOR FD/BTMS
EXCHANGER
0.4 MM BTU/HR
V-501
HIGH TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
E-503
H.T. SEPARATOR
OVHD COOLER
2.2 MM BTU/HR
C-501
RECYCLE GAS COMPRESSOR
164,000 ACFD (SUCTION)
ΔP: 165 PSI
C-500
MAKEUP H2 COMPRESSOR
101,000 ACFD (SUCTION)
ΔP: 435 PSI
P-500 A/B
DIESEL FEED PUMPS
(ONE OPERATING & ONE SPARE)
220 GPM (RATED)
ΔP: 772 PSI
DIESEL FROM HDS-PFD-2 FROM E-505
DIESEL FEED FROM BDS-PFD-3 FROM BDS UNIT
DIESEL TO HDS-PFD-2 TO E-504
MAKEUP H2 FROM H2 PLANT
LOW TEMP SEPARATOR BTMS TO HDS-PFD-2 TO NAPHTHA STRIPPER V-503
TO HDS-PFD-2 TO LOW TEMP SEPARATOR V-502
WASH WATER FROM DEMIN. WATER UNIT
HIGH TEMP SEPARATOR LEVEL TO HDS-PFD-2 TO LCV
HIGH TEMP SEPARATOR BTMS TO HDS-PFD-2 TO NAPHTHA STRIPPER V-503
LOW TEMP SEPARATOR BTMS FROM HDS-PFD-2 FROM V-502
RECYCLE GAS FROM HDS-PFD-2 FROM V-502
REFINERY FUEL GAS/NAPHTHA
NOTE 1
NOTE 2
505°F
100°F
298°F
335°F
339°F 775 PSIG
200°F, 300 PSIG
650°F
681°F, 630 PSIG
719°F 600 PSIG
473°F
561°F
340°F
735 PSIG
505°F
426°F
415°F
419°F, 570 PSIG
120°F
725 PSIG
120°F, 560 PSIG
274°F
2.6 GPM
120°F


Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT - BDS/HDS CASE
NAPHTHA STRIPPER SECTION
DRAWING NUMBER HDS-PFD-2
REVISIONS
V-502 LOW TEMP SEPARATOR 3'-0" I.D. X 8'-0" T/T
H-501 STRIPPER REBOILER 5.7 MM BTU/HR (NOTE 1)
V-503 NAPHTHA STRIPPER 4'-0" (BOTTOM) I.D. X 55'-0" OVERALL T/T 2'-6" (TOP)
E-505 STRIPPER FD/BTMS EXCHANGER 8.2 MM BTU/HR
E-504 STRIPPER O.H. CONDENSER 2.4 MM BTU/HR
V-504 STRIPPER O.H. ACCUMULATOR 3'-0" I.D. X 6'-0" T/T
E-506 PRODUCT COOLER 6.5 MM BTU/HR
P-501 A/B STRIPPER BOTTOMS PUMPS (ONE OPERATING & ONE SPARE) 350 GPM (RATED) ΔP: 125 PSI
P-502 A/B STRIPPER OVERHEAD PUMPS (ONE OPERATING & ONE SPARE) 35 GPM (RATED) ΔP: 38 PSI
NOTES
1. ABSORBED DUTY.
SOUR GAS TO SCRUBBING & SULFUR PLANT
NAPHTHA TO FUEL
ULSD PRODUCT TO TANKAGE
HIGH TEMP SEPARATOR LEVEL FROM HDS-PFD-1 FROM V-501
SOUR WATER DISPOSAL
REFINERY FUEL GAS/NAPHTHA
2.6 GPM SOUR WATER DISPOSAL
LOW TEMP SEPARATOR BTMS FROM HDS-PFD-1 FROM E-502
PURGE GAS TO SULFUR REMOVAL AND FUEL
RECYCLE GAS TO HDS-PFD-1 TO C-501
HIGH TEMP SEPARATOR O.H. FROM HDS-PFD-1 FROM E-503
LOW TEMP SEPARATOR BTMS TO HDS-PFD-1 TO E-502
HIGH TEMP SEPARATOR BTMS FROM HDS-PFD-1 FROM V-501
LOW TEMP DIESEL TO HDS-PFD-1 TO E-507
DIESEL FROM HDS-PFD-1 FROM E-507
45 PSIG
113°F 63 PSIG
320°F, 65 PSIG
120°F, 38 PSIG
68 PSIG
667°F
590°F
419°F
505°F
298°F
701°F
415°F
120°F, 560 PSIG

Material Balance

HDS Unit EOR Material Balance -- BDS/HDS Case

Stream Number		1	2	3	4	5	6	7
Stream Description		ANS Feed	Make-up H2	Reactor Feed	Reactor Outlet	V-501 Liquid	V-501 Vapor + Wash Water	Recycle Gas
Phase		LIQUID	VAPOR	MIXED	MIXED	LIQUID	MIXED	VAPOR
Mass Flow Rate	LB/HR	75976	381	79681	79682	73812	7170	3324
Temperature	F	100	417	681	719	419	274	120
Pressure	PSIG	13	735	630	600	570	570	560
Standard Liq Flow	BPD	6029	n/a	4050	2984	5924	128	n/a
Vapor Flow	MSCFH	n/a	70.2	343.8	326.9	n/a	271.9	235.7
Wt % Vapor		0	100	36	53	0	78	100
MW		217.4	2.1	69.0	76.0	195.6	9.6	5.4

Stream Number		8	9	10	11	12	13	14
Stream Description		V-502 HC Liquid	V-502 Vapor	Purge Gas	Column Vapor to Condenser	Sour Gas	Naphtha	Diesel from E-505
Phase		LIQUID	VAPOR	VAPOR	VAPOR	VAPOR	LIQUID	LIQUID
Mass Flow Rate	LB/HR	2392	3486	162	10562	513	2641	73039
Temperature	F	120	120	120	320	113	113	120
Pressure	PSIG	560	560	560	65	63	104	38
Standard Liq Flow	BPD	206	n/a	n/a	n/a	n/a	239	5808
Vapor Flow	MSCFH	n/a	247.2	11.5	53.6	10.8	n/a	n/a
Wt % Vapor		0	100	100	100	100	0	0
MW		116.0	5.4	5.4	74.8	18.1	89.1	214.8

Appendix B.5 – HDS Unit Equipment List and Budgetary Equipment Datasheets

HDS Unit Equipment List

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
R-500	HDS Reactor	6'-6" ID X 27'-6" T/T w/ one bed of HR-526 Co Mo catalyst.	680 PSIG/FV	750°F/-20°F	SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-500	Diesel Feed Drum	8'-0" ID X 15'-0" T/T (Horizontal)	50 PSIG/FV	450/-20°F	Killed Carbon Steel
V-501	High Temperature Separator	3'-0" ID X 8'-0" T/T (Vertical)	620 PSIG/FV	450/-20°F	Killed Carbon Steel w/0.15" CA
V-502	Low Temperature Separator	3'-0" ID X 8'-0" T/T` (Horizontal w/ Boot)	610 PSIG/FV	450/-20°F	Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-503	Naphtha Stripper	2'-6" ID (Top), 4'-0" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays	125 PSIG/FV	750/-20°F	Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-504	Stripper O. H. Accumulator	3'-0" ID X 6'-0" T/T (Horizontal w/Boot)	125 PSIG/FV	370/-20°F	Killed Carbon Steel w/0.125" CA (PWHT)
E-500	Reactor Fd/Btms Exchanger #1	11.4 MM BTU/Hr, 2780 FT^2 w/ 2 shells, TEMA type CEU	Tubes: 650 PSIG Shell: 775 PSIG	770°F 700°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	Reactor Fd/Btms Exchanger #2	7.9 MM BTU/Hr, 2740 FT^2 w/2 shells, TEMA type CEU	Tubes: 640 PSIG Shell: 785 PSIG	600°F 530°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover Shell: Killed C. S. w/0.125" CA
E-502	Separator Fd/Btms Exchanger	0.4 MM BTU/Hr, 85 FT^2, double pipe.	Tubes: 630 PSIG Shell: 610 PSIG	450°F 450/-20°F	Tubes: Carbon Steel Shell: Carbon Steel
E-503	H. T. Separator Overhead Cooler	2.2 MM BTU/Hr 409 FT^2 (Bare Tube) 8,790 FT^2 Extended Surface, 5 HP Fan	Tubes: 620 PSIG	450°F	Seamless Carbon Steel tubes with aluminum fins
E-504	Stripper O. H. Condenser	2.4 MM BTU/Hr 405 FT^2 (Bare Tube) 8,740 FT^2 Extended Surface, 5 HP Fan	Tubes: 125 PSIG	370°F	Seamless Carbon Steel tubes with aluminum fins
E-505	Stripper Fd/Btms Exchanger	8.2 MM BTU/Hr 2,520 FT^2 w/2 shells, TEMA type CEU	Tubes: 620 PSIG Shell: 100 PSIG	640°F 720°F/-20°F	Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS Shell: CS w/0.25" CA, CS baffles
E-506	Product Cooler	6.5 MM BTU/Hr 1,700 FT^2 (Bare Tube) 36,520 FT^2 Extended Surface, 15 HP Fan	Tubes: 100 PSIG	450°F	Seamless Carbon Steel tubes with aluminum fins
E-507	Feed Preheater	9.0 MM BTU/Hr 1,030 FT^2 w/2 shells, TEMA type CEU	Tubes: 100 PSIG Shell: 100 PSIG	510°F 720°F/-20°F	Tubes: CS Shell: CS w/0.25" CA, CS baffles
H-500	Diesel Charge Heater	3.8 MM BTU/Hr Fired Heater, Convection Section shared w/ H-501	Tubes: 765 PSIG	750°F	Tubes: 9 Cr – 1 Mo w/ 0.1" CA

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
H-501	Stripper Reboiler	5.7 MM BTU/Hr Fired Heater, Convection Section shared w/ H-500	Tubes: 230 PSIG	770°F	Tubes: 5 Cr – ½ Mo w/ 0.1" CA
C-500	Makeup Hydrogen Compressor	Capacity: 100,944 ACFD Motor Driven Shaft HP: 112 BHP	Suction: 300 PSIG Disch: 735 PSIG	Suction: 200°F	Casing: killed C. S. Internals: CS
C-501	Recycle Gas Compressor	Capacity: 163,584 ACFD Motor Driven Shaft HP: 87 BHP	Suction: 560 PSIG Disch: 725 PSIG	Suction: 120°F	Casing: killed C. S. Internals: Stainless Steel
P-500 A/B	Diesel Feed Pump (One Operating + One Spare	Rated Capacity: 220 GPM Diff. Press: 772 PSI Head: 2333 feet Motor: 150 HP			Casing: killed C. S. w/ 0.125" CA Impeller: 12% chrome
P-501 A/B	Stripper Bottoms Pump (One Operating + One Spare	Rated Capacity: 350 GPM Diff. Press: 125 PSI Head: 481 feet Motor: 50 HP			Casing: killed C. S. w/ 0.2" CA Impeller: 12% chrome
P-502 A/B	Stripper Overhead Pump (One Operating + One Spare	Rated Capacity: 35 GPM Diff. Press: 38 PSI Head: 120 feet Motor: 5 HP			Casing: killed C. S. w/ 0.125" CA Impeller: 12% chrome

ANVIL **BUDGETARY DATA SHEET**

COMPRESSORS AND DRIVERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/27/05**

ITEM NUMBER	X	C-500		
FLUID	X	Makeup H2		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	100,944		
SUCTION TEMPERATURE ^{O}F	X	200		
SUCTION PRESSURE, PSIA	X	315		
DISCHARGE PRESSURE, PSIA	X	750		
GAS MOLECULAR WEIGHT	X	2.06		
'K' VALUE OF GAS	X	1.40		
MOL % HYDROGEN IN GAS	X	99.7		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	None		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	125		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	112		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20°F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
COMPRESSORS AND DRIVERS

CUSTOMER	Petorstar-- BDS/HDS Case	**PROJECT ENGINEER BGJ**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	HDS Unit	**DATE 5/27/05**	

ITEM NUMBER	X	C-501		
FLUID	X	Recycle Gas		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	163,584		
SUCTION TEMPERATURE ^{O}F	X	120		
SUCTION PRESSURE, PSIA	X	575		
DISCHARGE PRESSURE, PSIA	X	740		
GAS MOLECULAR WEIGHT	X	5.4		
'K' VALUE OF GAS	X	1.38		
MOL % HYDROGEN IN GAS	X	88.4		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	H2S, H2O		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVE, VALVES MATERIAL	M	Stainless Steel		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER, Motor HP	X	100		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER, BHP	X	87		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20 °F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	x	E-500		
SERVICE	x	Reactor Fd/Btms Exch #1		
TEMA TYPE	x	CEU		
SURFACE AREA (TOTAL) FT^2	x	2780		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	650		
DESIGN TEMPERATURE, ^{O}F	x	770		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	775		
DESIGN TEMPERATURE, ^{O}F	x	700 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo (3)		
DUTY, MMBTU/HR	O	11.4		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Type 1 1/4 Cr - 1/2 Mo for tubes and tube sheet and weld overlay 316 SS for tube sheet, channnel, cover & nozzles.
U tubes to be PWHT.
3) Clad w/ Type 321 SS , Baffles to be Type 304 SS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-501		
SERVICE	X	Reactor Fd/Btms Exch #2		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	2740		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	640		
DESIGN TEMPERATURE, ^{O}F	X	600		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	785		
DESIGN TEMPERATURE, ^{O}F	x	530 / -20		
MATERIAL OF CONSTRUCTION	x	Killed C. S. (3)		
DUTY, MMBTU/HR	O	7.9		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

(2) Use SA182 F11 (1 1/4 Cr - 1/2 Mo) for tubesheet + channel cover + nozzles and SA 387 Gr 11 for channel
Weld overlay tube sheet, channel cover, and channel with 321 SS.

(3) Use 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	x	E-502		
SERVICE	x	Separator Fd/Btms Exch		
TEMA TYPE	x	Double Pipe		
SURFACE AREA (TOTAL) FT^2	x	85		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel w/Hydrogen		
DESIGN PRESSURE, PSIG	x	630		
DESIGN TEMPERATURE, ^{O}F	x	450		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Hydrocarbon		
DESIGN PRESSURE, PSIG	x	610		
DESIGN TEMPERATURE, ^{O}F	x	450 / -20		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	O	0.4		

REMARKS

1) <u>UNLESS OTHERWISE NOTED</u>:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) USE DOUBLE PIPE EXCHANGER OR EQUAL.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-503		
SERVICE	X	H. T. Seprtr Ovrhd Clr		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Hydrocarbon Vapor/Water		
INLET TEMPERATURE	X	274		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	450		
DESIGN PRESSURE, PSIG	X	620		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	409		
EXTENDED SURFACE	X	8,790		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	SA179 (1)		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	2.2		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Killed carbon steel for the header.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-504		
SERVICE	X	Strpr Ovrhd Condenser		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	HC Vapor/Naphtha		
INLET TEMPERATURE	X	320		
OUTLET TEMPERATURE	X	113		
DESIGN TEMPERATURE, ^{O}F	X	370		
DESIGN PRESSURE, PSIG	X	125		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	405		
EXTENDED SURFACE	X	8,740		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note (1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	2.4		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-505		
SERVICE	X	Stripper Fd/Btms Exch		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	2,520		
NUMBER OF SHELLS	x	2		
TUBE SIDE				
FLUID	x	Diesel/Naphtha		
DESIGN PRESSURE, PSIG	x	620		
DESIGN TEMPERATURE, ^{O}F	X	640		
MATERIAL OF CONSTRUCTION	x	Note 2		
SHELL SIDE				
FLUID	x	Diesel Product		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	720/-20F		
MATERIAL OF CONSTRUCTION	x	Note 3		
DUTY, MMBTU/HR	O	8.2		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Channel is CS + 0.25" CA, Tube sheets are Type 410 SS, Tubes are 18 Cr - 8 Ni

3) Shell is CS + 0.25" CA, Baffles are CS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-506		
SERVICE	X	Product Cooler		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Diesel		
INLET TEMPERATURE	X	298		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	450		
DESIGN PRESSURE, PSIG	X	100		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	1,700		
EXTENDED SURFACE	X	36,520		
TYPE OF FINS	O			
FAN HORSEPOWER	X	15		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note 1		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	6.5		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) CS tubes with aluminum fins and killed CS header with 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	E-507		
SERVICE	X	Feed Pre-Heater		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	1030		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel Feed		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	510		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Diesel Product		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	720 / -20		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	O	9.0		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PROCESS HEATERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	H-500		
SERVICE	X	Diesel Charge Heater		
HEATER TYPE	X	Fired Heater (1)		
FLUID	X	Diesel w/Hydrogen		
TOTAL FLOW RATE, LB/HR	X	79,681		
LIQUID - GPM (OUTLET)	X	176		
DENSITY, LB/FT^3	X	36.0		
VISCOSITY, CP	X	0.08		
SPECIFIC HEAT, BTU/LB-°F	X	0.73		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.03		
VAPOR - MMSCFD (OUTLET)	X	8.25		
DENSITY, LB/FT^3	X	1.67		
VISCOSITY, CP	X	0.02		
SPECIFIC HEAT, BTU/LB-°F	X	0.77		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.11		
INLET TEMPERATURE	X	650		
OUTLET TEMPERATURE	X	681		
DESIGN TEMPERATURE (°F)	X	750		
DESIGN PRESSURE (PSIG)	X	765		
MATERIAL OF CONSTRUCTION	X	9 Cr - 1 Mo + 0.1" CA		
ABS DUTY, MMBTU/HR	X	3.8 (2)		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Includes 50% excess duty for startup.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PROCESS HEATERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	H-501		
SERVICE	X	Stripper Reboiler		
HEATER TYPE	X			
FLUID	X	Hydrotreated Diesel		
TOTAL FLOW RATE, LB/HR	X	91,853		
HEATER OUTLET CONDITIONS:				
LIQUID - GPM	X	164.4		
DENSITY, LB/FT^3	X	36.6		
VISCOSITY, CP	X	0.12		
SPECIFIC HEAT, BTU/LB-°F	X	0.76		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.03		
VAPOR - MMSCFD	X	1.95		
DENSITY, LB/FT^3	X	1.64		
VISCOSITY, CP	X	0.01		
SPECIFIC HEAT, BTU/LB-°F	X	0.65		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.02		
INLET TEMPERATURE	X	667		
OUTLET TEMPERATURE	X	701		
DESIGN TEMPERATURE (°F)	X	770		
DESIGN PRESSURE (PSIG)	X	230		
MATERIAL OF CONSTRUCTION	X	5 CR - 1/2 Mo (2)		
ABS DUTY, MMBTU/HR	X	5.7		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Add 0.1" CA

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/27/05**

ITEM NUMBER	X	P-500 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	335		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.76		
RATED FLOW (GPM)	X	220		
SUCTION PRESSURE, PSIG	X	3		
DISCHARGE PRESSURE PSIG	X	775		
NPSH AVAILABLE (FT)	X	10.6		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	killed C. S. (2)		
IMPELLER MATERIAL	M	12% chrome		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (MHP)	X	150		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	140		
DIFFERENTIAL PRESSURE, PSI		772		
DIFFERENTIAL HEAD, FT		2333		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/27/05**

ITEM NUMBER	X	P-501A/B (1)		
SERVICE (FLUID)	X	Stripper Btms Pump		
TEMPERATURE OF FLUID	X	667		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.60		
RATED FLOW (GPM)	X	350		
SUCTION PRESSURE, PSIG	X	71		
DISCHARGE PRESSURE PSIG	X	196		
NPSH AVAILABLE (FT)	X	11.1		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS + 0.2" CA		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	50		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	37		
Differential Pressure, PSIG	X	125		
Differential Head, Feet	X	481		

REMARKS

1) One operating pump + one spare
2) Minimum ambient -20 F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	**BGJ**
LOCATION	Alaska	**PROJECT NO.**	**AE1416**
PROCESS UNIT	HDS Unit	**DATE**	**5/27/05**

ITEM NUMBER	X	P-502 A/B (1)		
SERVICE (FLUID)	X	Stripper Ovrhd Pump		
TEMPERATURE OF FLUID	X	113		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.73		
RATED FLOW (GPM)	X	35		
SUCTION PRESSURE, PSIG	X	66		
DISCHARGE PRESSURE PSIG	X	104		
NPSH AVAILABLE (FT)	X	9.5		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	1		
Differential Pressure, PSIG	X	38		
Differential Head, Feet	X	120		
		API Standard		

REMARKS

1) One operating pump + one spare

2) With 0.125" CA. Min. ambient -20F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	R-500		
SERVICE	X	HDS Reactor		
FLUID	X	Diesel / Hydrogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	6' - 6"		
TANGENT TO TANGENT LENGTH, FT.	X	27' - 6"		
SKIRT HEIGHT (FT-IN)	X	Min		
DESIGN TEMPERATURE (°F)	X	750/-20 (4)		
DESIGN PRESSURE (PSIG)	X	680 (1)		
MATERIAL OF CONSTRUCTION	X	SA387 Gr. 11 (5)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	HR-526 Co-MO Catalyst		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
Catalyst VOLUME, FT^3	X	892 (3)		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Distributor and support grid		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) The packing is in one section with an internal distributor
3) The total weight of catalyst is 45190 lbs. The price is supplied by the catalyst vendor for the estimate.
4) Reactor is design temperature at 25°F above end of run. Reactors are generally designed for EOR operating temperature, but margin is added to be conservative.
5) Include 321 SS or 347 SS weld overlay. Internal trays may be 410 SS or 321 SS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	V-500		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	15' - 0"		
SKIRT HEIGHT (FT-IN)	X	Note 2		
DESIGN TEMPERATURE (°F)	X	450 / -20		
DESIGN PRESSURE (PSIG)	X	50 (1)		
MATERIAL OF CONSTRUCTION	X	SA-516-70		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	None		
NUMBER OF TRAYS	X	None		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) The horizontal vessel will be supported on saddles 10 feet above grade.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	V-501		
SERVICE	X	H. T. Separator		
FLUID	X	Hydrcrbn w/Hydogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	Min.		
DESIGN TEMPERATURE (°F)	X	450 / -20		
DESIGN PRESSURE (PSIG)	X	620 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS w/ 0.15" CA		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breakers		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	V-502		
SERVICE	X	Low Temp Separator		
FLUID	X	Hydrocarbon w/ H2/H2S		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	MIN		
DESIGN TEMPERATURE (°F)	X	450/-20		
DESIGN PRESSURE (PSIG)	X	610 (1)		
MATERIAL OF CONSTRUCTION	X	Killed C. S. (2)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	No		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Demister (2)		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (3)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) w/ 0.1" CA and PWHT. Demister to be 1' dia. Monel

3) Sour water removal

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	V-503		
SERVICE	X	Naphtha Stripper		
FLUID	X	Hydrotreated Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	TOP = 2'-6", BTM = 4'-0"		
TANGENT TO TANGENT LENGTH, FT.	X	55'-0" (3)		
SKIRT HEIGHT (FT-IN)	X	15'-0"		
DESIGN TEMPERATURE (°F)	X	750/-20 (BTM)		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Note 4		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	Valve Trays		
NUMBER OF TRAYS	X	22		
TRAY MATERIAL	X	410 S.S.		
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Vortex Breakers		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) VESSEL SHALL BE SWAGED ABOVE FEED
3) Length of top section = 25'-0", length of bottom section = 30'-0"
4) Vessel to be killed CS + 0.2" CA. Trays, tray supports, and downcomers are Type 410 SS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

S:\PetroStar\AE1416.AUX\subjob 43\Final BDS_HDS Case HDS\[V-503.xls]V-503

ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- BDS/HDS Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/27/2005

ITEM NUMBER	X	V-504		
SERVICE	X	Strpr O. H. Accumulator		
FLUID	X	Naphtha		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	6' - 0"		
SKIRT HEIGHT (FT-IN)	X	13' - 0"		
DESIGN TEMPERATURE (°F)	X	370/-20		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS Note (2)		
INSULATION (YES/NO)	X	No		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	None		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (sour water)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) Add 0.125" CA and PWHT.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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Appendix B.6 –Utility Requirements

Utility Requirements
BDS/HDS Case
6000 BPD Feed Rate, 10 ppmw Sulfur ULSD Product

	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr	Steam lb/hr
IBL HDS					
Feed Gas Compressor	65				
H2 Makeup Compressor	85				
Recycle Gas Compressor	65				
Charge Pump	105				
Stripper Reflux Pump	1				
Stripper Btms Circ	28				
Effluent Air Cooler	4				
Prod Stripper Condenser	4				
Prod Rundown Cooler	11				
Wash Water Injection Pump	1				
Charge Heater		4.8			
Prod Stripper Reboiler		7.1			
Wash Water Injection Pump			1300		
OBL					
H2 Plant	53	28.0		4721	
Sulfur Recovery	68				
Other OBL Allowance	118				
TOTAL HDS and OBL	**608**	**39.9**	**1300**	**4721**	

	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr	Steam lb/hr
BDS					
Total Plant	933		3981		14
TOTAL BDS	**933**		**3981**		**14**

PETRO STAR INC.

ULTRA LOW SULFUR DIESEL
BDS / HDS COMBINATION CASES
IBL ONLY

PHASE 1 ESTIMATE BASIS
REVISION 0

ALASKA ANVIL NO. AE1416

JUNE 2005

ALASKA ANVIL
INCORPORATED

ESTIMATE BASIS GOAL

This Estimate Basis identifies information, qualifications, exceptions, and assumptions used in developing the cost estimate.

ESTIMATE BASIS PURPOSE

During the estimate review process, the project team uses the Estimate Basis for the following purposes:

- As a checklist of items to consider during estimate preparation.
- To document what is included and not included in the cost estimate.
- To assess cost risks of estimate components.
- As part of the decision support package for assessing the BDS process feasibility.

GENERAL INFORMATION

- The purpose of the project estimate is to determine if the ULSD BDS process is economically viable as a standalone process or in combination with an HDS Unit. These three (3) estimate scenarios address the BDS / HDS Combination cases.
- Estimate type:
  - The estimate was developed using equipment based factored estimates for Inside Battery Limits (IBL) costs.
  - There is a separate equipment-factoring summary for the BDS, HDS, and Pre Frac Equipment (Pre Frac Case Only)
  - Most of the equipment pricing was derived from the ICARUS estimating program. Pricing for BDS equipment marked with an asterisk (*) was provided by Pelorus.
  - The cost of the Hydrogen and Sulfur Units were factored off licensor quotes obtained for the standalone HDS case.
  - Outside Battery Limits (OBL) costs have been excluded from this estimate.
- The project will be installed in a brownfield location within the Valdez Alaska Refinery.

PROCESS BASIS

Facility Data

- Facility type – Ultra Low Sulfur Diesel Treating Complex, which includes:
  - Diesel Biodesulfurization Unit
  - Diesel Hydrotreating Unit
  - Hydrogen Production Unit
  - Sulfur Unit
  - Diesel Splitter (Pre Frac Case Only)

Design Basis

Product specification – Feed 6,000 bpd of untreated diesel to produce 10-ppmw sulfur maximum ultra low sulfur diesel.

COST BASIS

Labor, Indirects, Equipment, and Bulk Materials

- Included in the equipment factor.

Project Services

- Estimated based on 15 percent of TIC for the BDS, HDS, and Pre Frac units; engineering costs for the Hydrogen and Sulfur Units was included in the licensor pricing.

Owner Services

Not included in the TIC cost. Historically, owner services will cost from 5 to 7 percent of TIC, not including licensing, royalties, or catalyst.

Escalation

Project is based on 2005 costs. No escalation is included.

Location Factor

All costs for this estimate have been developed from a U.S. Gulf Coast (USGC) basis. No location factor is included.

Other Costs

- Catalyst and chemical initial charge has been added as an additional line item.
- CEMS, air preheating, and burner management allowances have been added to the fired heater costs.

ASSUMPTIONS

- Process licensing and royalty costs are not included.
- Assumes fully installed pump spares, but no warehouse spares.

PROJECT COST & SCHEDULE ESTIMATE SUMMARY

CLIENT: PetroStar
PROJECT: PetroStar Valdez ULSD - BDS/HDS Combo
STAGE: Phase 1

CLIENT PROJECT NO.:
ANVIL PROJECT NO.: AE1416
REV NO.: 0

CLIENT PE: J. Boltz
ANVIL PE: L. Nace
Date: 6/17/05

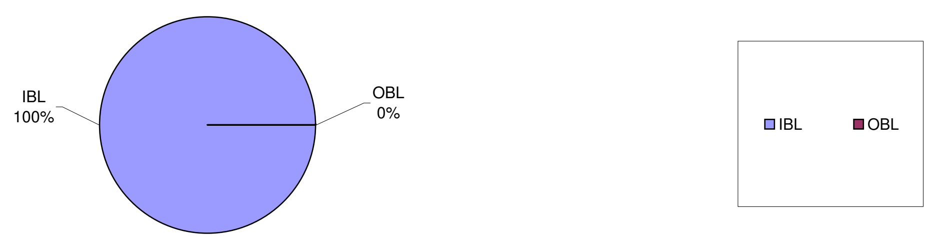
PROJECT DESCRIPTION:	PROJECT RISKS:
Install Ultra Low Sulfur Diesel Complex.	

PROJECT COST ESTIMATE SUMMARY

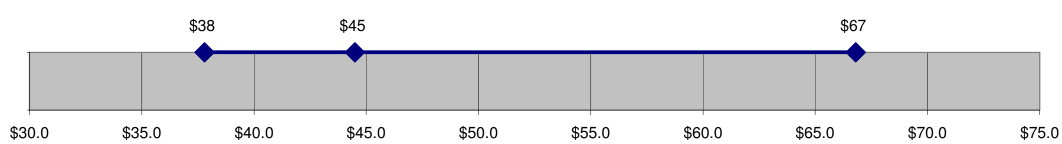
	TOTAL PROJECT COST - Valdez
COST ESTIMATE STRUCTURE	
COST ESTIMATE PARAMETERS	
Estimate Classification	Phase 1
Estimating Method	Factored/ROM
COST ESTIMATE SUMMARY	
Expected Cost ($MM)	**$ 44.5**
High Range ($MM)	**$ 66.8**
Low Range ($MM)	**$ 37.8**

PROJECT COST ESTIMATE ANALYSIS

Total Project Expected Cost Component Analysis



Total Project Cost Profile ($MM)



PROJECT SCHEDULE ESTIMATE ANALYSIS

Total Project Schedule

	PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5
Target Completion Dates	2Q2005	TBD	TBD	TBD	4Q2010
Current Progress	↓				
PROJECT TIMELINE	***PHASE 1***	***PHASE 2***	***PHASE 3***	***PHASE 4***	***PHASE 5***

Petro Star Ultra Low Sulfur Diesel (6000 BPD) Project - Valdez Refinery

IBL Impact Matrix - 2005$ - Total Installed Costs USGC

Scenario: BDS/HDS Combo

IBL Component	HDS Unit	BDS Unit	Hydrogen Unit	Sulfur Unit	Total Cost $MM
	Diesel hydrotreater, feed rate of 6000 B/D, producing ULSD (10 ppmw sulfur)	Biodesulfurization unit, feed rate of 6000 BPD, producing LSD	1.7 MMSCF/D H2 Production Plant.	Thiopaq process to be used for 2.4 T/D. Will also need sulfur storage / handling	
Cost Basis	Factored equipment based estimate	Factored equipment based estimate	Ratio'd from Baseline HDS Case	Ratio'd from Baseline HDS Case	
High Range Cost, $ MM	$21.5	$32.7	$8.7	$3.9	$66.8
Expected Cost, $ MM	$14.3	$21.8	$5.8	$2.6	$44.5
Low Range Cost, $ MM	$12.2	$18.5	$4.9	$2.2	$37.8

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - BDS/HDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COMPRESSORS						
C-500	1	Makeup Hydrogen Compressor	$182,000	2.8	$509,600	Reciprocating, 70 CFM, 125HP Motor, CS
C-501	1	Recycle Gas Compressor	$176,100	2.8	$493,080	Reciprocating, 114 CFM, 100HP Motor, CS Casing, SS Piston
		SUB-TOTAL	**$358,000**		**$1,003,000**	
EXCHANGERS						
E-500	1	Reactor Fd/Btms Exchanger #1	$122,600	4.0	$490,400	Shell & Tube Heat Exchanger, 2780 SF, 2 Shells, Shell Mat'l 1.25CR-1/2MO w/ 321SS Cladding, Tube Mat'l 1.25CR-1/2MO w/ 316SS Weld Overlay on tube sheet, channel, cover, nozzles.
E-501	1	Reactor Fd/Btms Exchanger #2	$83,000	4.0	$332,000	Shell & Tube Heat Exchanger, 2740 SF, 2 Shells, Shell Mat'l CS, Tube Mat'l 1.25CR-1/2MO w/ 321SS Weld Overlay on tube sheet, channel cover, channel.
E-502	1	Stripper Fd/Btms Exchanger	$8,700	4.0	$34,800	Double Pipe Heat Exchanger, 85 SF, 1 Shell, CS
E-505	1	Stripper Fd/Btms Exchanger	$107,000	4.0	$428,000	Shell & Tube Heat Exchanger, 2520 SF, 2 Shells, Shell Mat'l CS, Tube Mat'l 304SS
E-507	1	Feed Pre-Heater	$34,400	4.0	$137,600	Shell & Tube Heat Exchanger, 1030 SF, 2 Shells, Shell Mat'l CS, Tube Mat'l CS
		SUB-TOTAL	**$356,000**		**$1,423,000**	
AIR COOLERS						
E-503	1	H. T. Separator Overhead Cooler	$42,500	4.0	$170,000	Air Cooler, Forced, 409SF Bare tube, Single Fan 5HP, CS
E-504	1	Stripper O. H. Condenser	$35,900	4.0	$143,600	Air Cooler, Forced, 405SF Bare tube, Single Fan 5HP, CS
E-506	1	Product Cooler	$72,500	4.0	$290,000	Air Cooler, Forced, 1700SF Bare tube, Single Fan 15HP, CS
		SUB-TOTAL	**$151,000**		**$604,000**	
FURNACES						
H-500	1	Diesel Charge Heater	$249,000	2.5	$610,050	Vertical Fired Heater, 3.8 MMBTU/HR, 9CR-1MO
H-500	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-500	1	Preheating	$40,000	1.0	$40,000	
H-500	1	Burner Management	$30,000	1.0	$30,000	
H-501	1	Stripper Reboiler	$288,300	2.5	$706,335	Vertical Fired Heater, 5.7 MMBTU/HR, 5CR-1/2MO
H-501	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-501	1	Preheating	$40,000	1.0	$40,000	
H-501	1	Burner Management	$30,000	1.0	$30,000	
		SUB-TOTAL	**$877,000**		**$1,756,000**	
PUMPS						
P-500 A/B	2	Diesel Feed Pump	$237,800	5.0	$1,189,000	API Centrifugal Pump, 220GPM, 0.76 SG, 2333 Ft. Head, CS Case, 12%CR Impeller, 150HP Motor
P-501 A/B	2	Stripper Bottoms Pump	$54,200	5.0	$271,000	API Centrifugal Pump, 350GPM, 0.60 SG, 481 Ft. Head, CS Case, 12%CR Impeller, 50HP Motor
P-502 A/B	2	Stripper Overhead Pump	$43,400	5.0	$217,000	API Centrifugal Pump, 35GPM, 0.73 SG, 120 Ft. Head, CS Case, 12%CR Impeller, 5HP Motor
		SUB-TOTAL	**$335,000**		**$1,677,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - BDS/HDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COLUMNS						
R-500	1	HDS Reactor	$262,500	4.4	$1,155,000	Vertical Reactor Column, 6'-6" Dia x 27'-6" T-T, SA387 Gr 11 w/ 321SS Cladding, One Dist. Trays for Catalyst, Catalyst price included below
V-503	1	Naphtha Stripper	$50,900	4.4	$223,960	Vertical DBL Dia Trayed Column, Top (2'6" Dia x 25'-0"T-T) & Btm (4'-0" Dia x 30'-0" T-T), CS
V-503	1	Naphtha Stripper Trays	$48,700	2.7	$131,490	22 Valve Trays, 410SS
		SUB-TOTAL	**$362,000**		**$1,510,000**	
VESSELS						
V-500	1	Diesel Feed Drum	$35,200	4.2	$147,840	Horizontal, 8'-0" Dia x 15'-0" T-T, CS, 10% internals
V-501	1	High Temperature Separator	$16,600	4.2	$69,720	Vertical, 3'-0" Dia x 8'-0" T-T, CS, 10% internals
V-502	1	Low Temperature Separator	$16,100	4.2	$67,620	Horizontal, 3'-0" Dia x 8'-0" T-T, CS, PWHT, Boot, 10% internals
V-504	1	Stripper O. H. Accumulator	$12,800	4.2	$53,760	Horizontal, 3'-0" Dia x 6'-0" T-T, CS, PWHT, Boot, 10% internals
		SUB-TOTAL	**$81,000**		**$339,000**	
SKID PACKAGES / ALLOWANCES						
	1	Sulfur Analyzer	$250,000	1.0	$250,000	
		SUB-TOTAL	**$250,000**		**$250,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$176,000		$176,000	
		SUB-TOTAL	**$176,000**		**$176,000**	
		TOTAL	**$2,946,000**		**$8,738,000**	

DESIGN SERVICES (% of TIC)	**15%**	**$**	**2,141,000**
OWNER'S SERVICES & COSTS (not included)			
HDS REACTOR CATALYST		**$**	**397,000**
MISC. CATALYST, CHEMICALS INITIAL CHARGE		**$**	**200,000**
ESCALATION (not included)			
UNADJUSTED COST ESTIMATE (UCE)		**$**	**11,476,000**
UNALLOCATED PROVISION (UAP) *contingency*		**$**	**2,824,000**
EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*		**$**	**14,300,000**
HIGH RANGE *TOTAL INSTALLED COST (TIC)*		**$**	**21,500,000**
LOW RANGE *TOTAL INSTALLED COST (TIC)*		**$**	**12,200,000**

S:\PETRSTAR\AE1416\PMC\Phase 1 Estimate\BDS HDS Combo\[Valdez ULSD BDS HDS Combo Est Rev 0.xls]Estimate Data

***Note: Field Cost Multiplier includes the following bulk material and installation labor: Civil, Concrete, Structural, Piping, Electrical, Instrumentation, Insulation, Fireproofing, Painting, and Testing.**

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - BDS/HDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
SHELL & TUBE HEAT EXCHANGERS						
C-101	1	Diesel Feed Cooler	$31,500	4.0	$126,000	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1750SF, CS
C-501	1	Vent Gas Chiller	$18,100	4.0	$72,400	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 500SF, CS
C-601	1	Water Chiller	$49,000	4.0	$196,000	8.6 MM BTU/Hr, 3790 SF w/ 1 shell, TEMA type AES, Tubes: CS , Shell: CS
		SUB-TOTAL	**$99,000**		**$394,000**	
PRESSURE VESSELS						
D-101	1	Diesel Feed Drum	$39,300	4.2	$165,060	1(ea) - Horizontal Vessel, 8'0" DIA x 20'-0" T-T, CS
D-102	1	Liquid Ammonia Storage Tank	$11,000	4.2	$46,200	1(ea) - Horizontal Vessel, 2'6" DIA x 8'-0" T-T, CS, Insulated(safety)
D-201*	1	Fermentor Reactor	$173,000	4.2	$726,600	1(ea) - 10,000 gal airlift fermenter
D-202*	1	BDS Reactor #1	$279,000	4.2	$1,171,800	1(ea) - 13,000 gal airlift reactor
D-203*	1	BDS Reactor #2	$279,000	4.2	$1,171,800	1(ea) - 13,000 gal airlift reactor
D-204*	1	BDS Reactor #3	$279,000	4.2	$1,171,800	1(ea) - 13,000 gal airlift reactor
D-301	1	Diesel / Water / Biomass Separator	$112,400	4.2	$472,080	1(ea) - Horizontal Vessel, 10'3" DIA x 30'-8" T-T, 304SS, w/ overflow baffle
D-401A/B	2	Salt Drier	$62,600	4.2	$262,920	2(ea) - Horizontal Vessel, 6' DIA x 17' T-T, CS
D-501	1	Diesel / Water Separator	$9,600	4.2	$40,320	1(ea) - Horizontal Vessel, 2'6" DIA x 3'-9" T-T, CS, w/ overflow baffle
L-301	2	Oil/Water Separator	$41,800	4.2	$175,560	2(ea) - Horizontal Vessel, 2'4" DIA x 11'-0" T-T, SS, w/ Fiberbed Coalescer 24" OD x 18" ID x 120" long.
		SUB-TOTAL	**$1,287,000**		**$5,404,000**	
PACKAGED SKIDS/SYSTEMS						
D-205*	1	Seed Tank A	$94,000	2.5	$235,000	Packaged Seed Fermenter System
D-206*	1	Seed Tank B	$328,000	2.5	$820,000	Packaged Seed Fermenter System
J-109A/B	2	Air Compressor	$354,600	2.5	$886,500	2(ea) - Air Compressor, Screw, 1930ACFM, CS body/internals, 175HP Motor Driven
L-109*	1	Glucose Sterilizer	$47,000	2.5	$117,500	1(ea) - Packaged 15 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-110*	1	Nutrients Sterilizer	$47,000	2.5	$117,500	1(ea) - Packaged 15 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-302*	1	Electrostatic Precipitator	$442,000	2.5	$1,105,000	1(ea) - Packaged ESP Unit

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
L-601*	1	Water Chiller	$536,000	2.5	$1,340,000	1(ea) - Packaged propane refirigeration unit complete w/ compressor, driver, lube oil system, KO drum & all necessary instr. & controls.
L-801*	1	Waste Oxidizer	$324,000	2.5	$810,000	1(ea) - Packaged horizontal thermal oxidizer w/ high intensity burner, refractory lined chamber & stack.
L-901*	1	Water Filtration System	$235,000	2.5	$587,500	1(ea) - Cross flow filtration system for water purification
		SUB-TOTAL	**$2,408,000**		**$6,019,000**	
ATMOSPHERE STORAGE TANKS						
F-101	1	Glucose / Water Storage Tank	$21,900	2.9	$63,510	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 8'-8" DIA x 13' T-T, Epoxy Resin coated CS
F-102A/B	2	Salt / Water Storage Tank	$20,200	2.9	$58,580	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 4' DIA x 7'-8" T-T, Epoxy Resin coated CS
F-103	1	Ethanol / Water Storage Tank	$24,000	2.9	$69,600	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 9'-*6" DIA x 14' T-T, Epoxy Resin coated CS
F-104	1	NaOH / Water Storage Tank	$26,600	2.9	$77,140	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 10'-6" DIA x 15' T-T, Epoxy Resin coated CS
		SUB-TOTAL	**$93,000**		**$269,000**	
PUMPS						
J-101A/B	2	Diesel Charge Pump	$55,000	4.5	$247,500	2(ea) - API Centrifugal Pump, 190 gpm, 163 ft. Head, 15HP Motor driven, CS, 1 operating, 1 installed spare
J-103A/B	2	Process Water Pump	$6,400	4.5	$28,800	2(ea) - Centrifugal Pump, 9 gpm, 121 ft. Head, 1HP Motor driven, CS, 1 operating, 1 installed spare
J-104A/B	2	Glucose/Water Pump	$6,100	4.5	$27,450	2(ea) - Diaphragm Pump, 0.3 gpm, 31 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-105A/B	2	Salts/Water Pump	$11,800	4.5	$53,100	2(ea) - Diaphragm Pump, 0.25 gpm, 39 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-106A/B	2	Ethanol/Water Pump	$13,600	4.5	$61,200	2(ea) - Diaphragm Pump, 0.75 gpm, 81 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-107A/B	2	Potassium Hydroxide Pump	$14,200	4.5	$63,900	2(ea) - Diaphragm Pump, 1 gpm, 65 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-201A/B	2	Fermentor Transfer Pump	$16,600	4.5	$74,700	2(ea) - Rotary Lobe Pump, 16.5 gpm, 43 ft Head, 0.5HP Motor, 304SS, 1 operating, 1 installed spare
J-202A/B	2	BDS Reactor No1 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-203A/B	2	BDS Reactor No2 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-204A/B	2	BDS Reactor No3 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-301A/B	2	1st Stg Sep Overflow Pump	$47,600	4.5	$214,200	2(ea) - API Centrifugal Pump, 200 gpm, 49 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-302A/B	2	1st Stg Sep Underflow Pump	$18,400	4.5	$82,800	2(ea) - Centrifugal Pump, 500 gpm, 68 ft. Head, 10HP Motor driven, 304SS, 1 operating, 1 installed spare

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
J-303A/B	2	2nd Stg Sep Overflow Pump	$11,800	4.5	$53,100	2(ea) - Centrifugal Pump, 145 gpm, 72 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-304A/B	2	2nd Stg Sep Underflow Pump	$10,200	4.5	$45,900	2(ea) - Centrifugal Pump, 45 gpm, 72 ft. Head, 3HP Motor driven, 304SS, 1 operating, 1 installed spare
J-502A/B	2	Vent Gas KO Drum Wtr Pump	$8,600	4.5	$38,700	2(ea) - Centrifugal Pump, 1 gpm, 70 ft. Head, 0.5HP Motor driven, CS, 1 operating, 1 installed spare
J-601 A/B	2	Chilled Water Pump	$19,800	4.5	$89,100	API Centrifugal Pump, 2000GPM, 0.95 SG, 81.7 Ft. Head, CS Case, 12%CR Impeller, 30HP Motor
		SUB-TOTAL	**$304,000**		**$1,369,000**	
FILTERS						
L-101	1	Diesel Pre-Filter Vessel	$5,210	4.2	$21,882	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 1.5um pore size
L-102	1	Diesel Pre-Filter Vessel	$5,280	4.2	$22,176	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 0.2um pore size
L-103	1	Air Pre-Filter Vessel	$11,400	4.2	$47,880	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - GF element, 30" long, 1.0um pore size
L-104	1	Air Bio-Filter Vessel	$11,125	4.2	$46,725	1(ea) - Filter housing, 316L SS, 43" T-T x 15" Dia. w/ 5 (ea) - PTFE element, 10" long, 0.01um pore size
L-105	1	BDS Reactor #1 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-106	1	BDS Reactor #2 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-107	1	BDS Reactor #3 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-108	1	Air Purge Bio-Filter Vessel	$7,011	4.2	$29,446	1(ea) - Filter housing, 316L SS, 30" T-T x 12" Dia. w/ 3(ea) - PTFE element, 10" long, 0.01um pore size
L-111	1	Ethanol Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-112	1	NAaOH Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-113	1	Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-114	1	Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
L-401	1	Recycle Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-402	1	Recycle Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
		SUB-TOTAL	**$91,000**		**$384,000**	

PROJECT: PetroStar Valdez ULSD - BDS/HDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
FREIGHT		Freight Allowance (7% Equip Cost)	$300,000		$300,000	
		SUB-TOTAL	**$300,000**		**$300,000**	
		TOTAL	**$4,581,643**		**$14,140,000**	

DESIGN SERVICES	**15%**	**$**	**3,250,000**
OWNER'S SERVICES & COSTS (provided by owner)		**$**	**-**
INITIAL CHEMICAL CHARGE		**$**	**76,000**
ESCALATION (provided by owner)		**$**	**-**
UNADJUSTED COST ESTIMATE (UCE)		**$**	**17,466,000**
CONTINGENCY		**$**	**4,334,000**
EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*		**$**	**21,800,000**

S:\PETRSTAR\AE1416\PMC\Phase 1 Estimate\BDS HDS Combo\[Valdez ULSD BDS HDS Combo Est Rev 0.xls]Estimate Data

***Note: Equipment pricing by Pelorus.**

Appendix B.8. Operating Cost Estimates

BDS/HDS Case -- BDS Unit Operating Costs for 6,000 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 776,268	0.9	933 kw 0.1 $/kwH	From Pelorus
Utility - steam	$ 875	0.0	14 lb/hr 7.5 $/1000 lb	From Pelorus
Chemicals	$ 1,200,865	1.4		From Pelorus
Cost of Loss Diesel Production	$ 368,919	0.4	99.6% yield on diesel at $1.07/gallon	From Pelorus
Total volume related costs	**$ 2,346,927**	**2.7**		

Basis:		
diesel feed:	252000	gal/day
On-stream availability:	95	%
Diesel yield (% of feed)	99.6	%

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint	From Pelorus
Contract Services	$ 109,000	0.1	0.5% of TIC	From Pelorus
Operating Supplies	$ 180,000	0.2	Filters and Membranes	From Pelorus
Maintenance and T/A Costs	$ 327,000	0.4	1.5% of TIC, 2 - 3 Year T/A Cycle	From Pelorus
Insurance & Taxes	$ 545,000	0.6	2.5% of TIC	From Pelorus
Total fixed costs	**$ 1,622,350**	**1.9**		

Basis:		
BDS Total Installed Cost:	21.8	$MM

Total Operating Cost:	2005$/year	cent/gal (ULSD)
	$ 3,969,277	**4.6**

BDS/HDS Case -- HDS Unit Operating Costs for 6,000 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 505,978	0.6	608 kw 0.1 $/kwH	
Utility - fuel	$ 937,889	1.1	22.5 MMBTU/H 5 $MMBTU	
Utility - H2 plant feed	$ 722,350	0.9	17.36 MMBTU/H 5 $MMBTU	
Sulfur Disposal	$ 279,619	0.3	2.4 tons/day 0.15 $/Lb	Assuming the sulfur can be disposed of locally.
Chem - fuel additives	$ 106,875	0.1	Lubricity Improver	
Chem - sulfur plant	$ 92,432	0.1	Caustic & Nutrients for sulfur	
Cost of lost diesel production	$ 924,290	1.1	96.3% yield on diesel at $1.07/gallon	Yield losses on diesel minus credit for the resulting naphtha & LPG Fuel.
Total volume related costs	**$ 3,569,433**	**4.2**		

Basis:
diesel feed: 252000 gal/day
On-stream availability: 95 %
Diesel yield (% of feed) 96.3 %

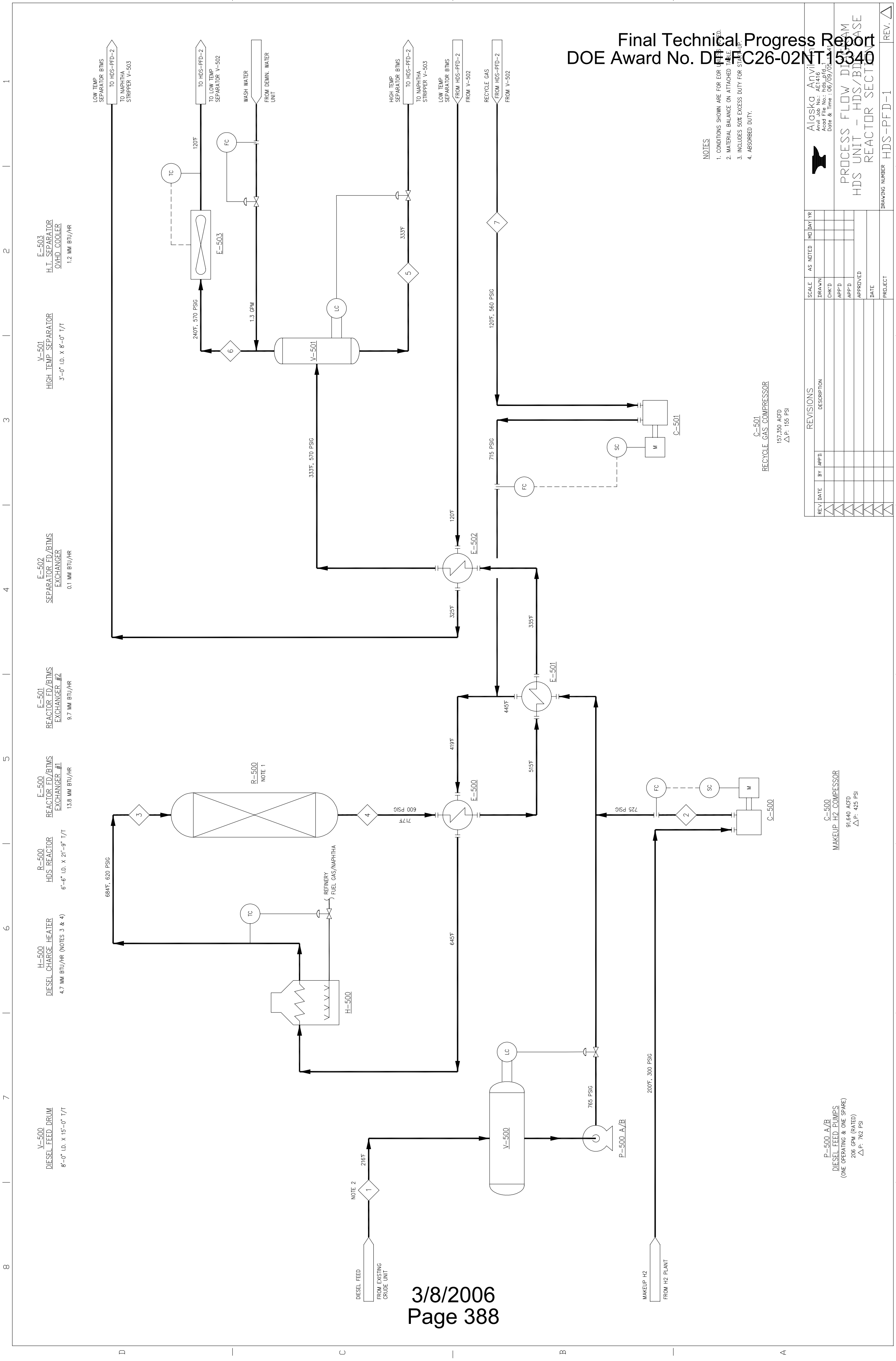
Fixed Costs (not volume dependent)

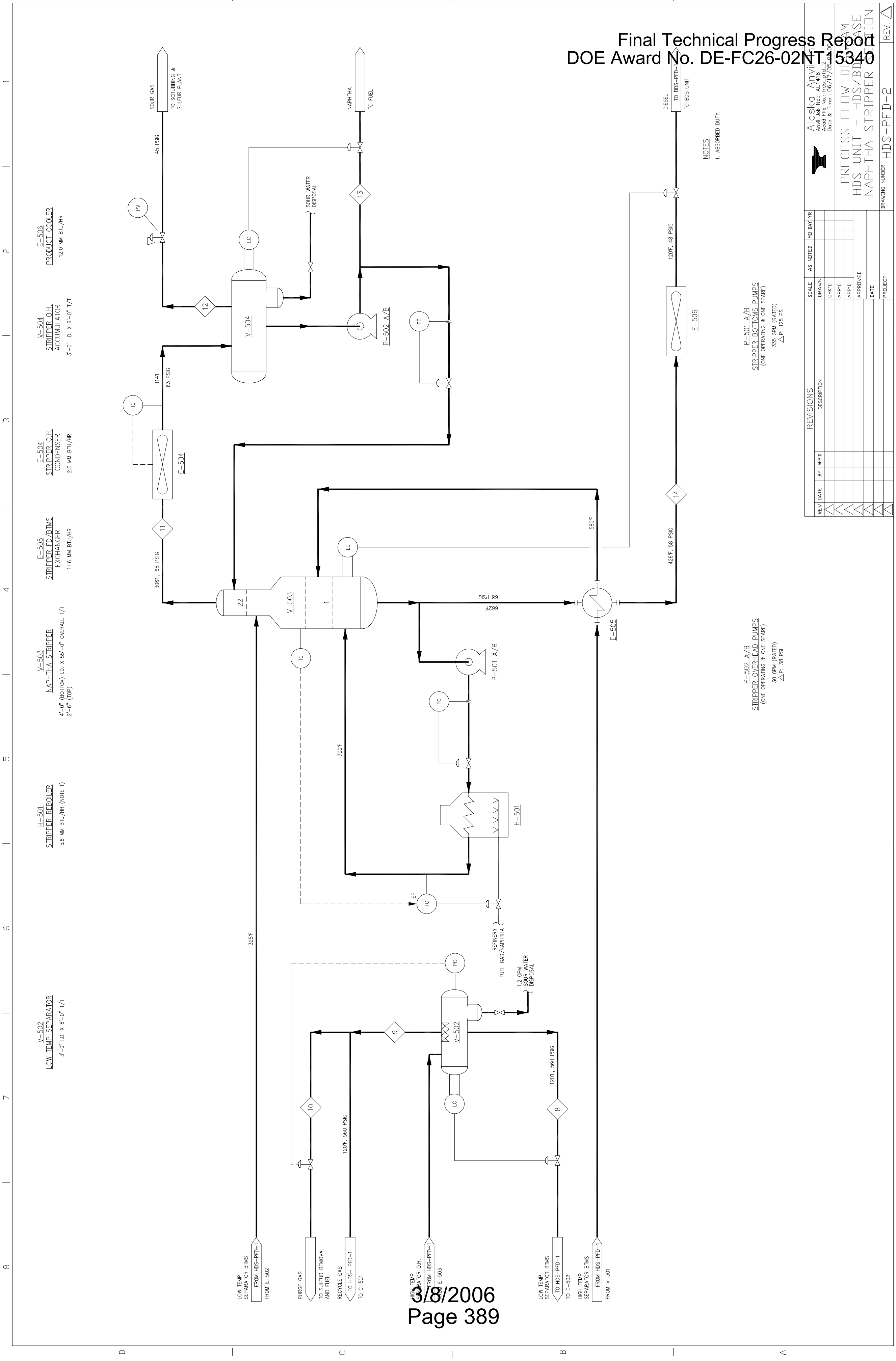
Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint	
Contract Services	$ 150,000	0.2	All disciplines including laboratory	
Operating Supplies	$ 200,000	0.2	Laboratory and other ovhd	May be somewhat volume dependendent
Maintenance	$ 200,000	0.2	Excluding TA costs	
Turnaround costs	$ 150,000	0.2	Amortized per year cost	Two to Three year turnaround assumed
Insurance & Taxes	$ 567,500	0.7	2.5% of TIC	Based on expected TIC of IBL plant
Catalyst	$ 133,333	0.2	Amortized per year cost	
Total fixed costs	**$ 1,862,183**	**2.2**		

Basis:
HDS, H2, Sulfur Plant Total Insta 22.7 $MM

Total Operating Cost:	2005$/year	cent/gal (ULSD)
	$ 5,431,617	**6.5**

Appendix C.1 – HDS Unit Process Flow Diagrams and Material Balance


V-500
DIESEL FEED DRUM
8'-0" I.D. X 15'-0" T/T
H-500
DIESEL CHARGE HEATER
4.7 MM BTU/HR (NOTES 3 & 4)
R-500
HDS REACTOR
6'-6" I.D. X 21'-9" T/T
E-500
REACTOR FD/BTMS EXCHANGER #1
13.8 MM BTU/HR
E-501
REACTOR FD/BTMS EXCHANGER #2
9.7 MM BTU/HR
E-502
SEPARATOR FD/BTMS EXCHANGER
0.1 MM BTU/HR
V-501
HIGH TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
E-503
H.T. SEPARATOR OVHD COOLER
1.2 MM BTU/HR
P-500 A/B
DIESEL FEED PUMPS
(ONE OPERATING & ONE SPARE)
206 GPM (RATED)
ΔP: 762 PSI
C-500
MAKEUP H2 COMPRESSOR
91,640 ACFD
ΔP: 425 PSI
C-501
RECYCLE GAS COMPRESSOR
157,350 ACFD
ΔP: 155 PSI
NOTES
1. CONDITIONS SHOWN ARE FOR EOR UNLESS NOTED.
2. MATERIAL BALANCE ON ATTACHED TABLE.
3. INCLUDES 50% EXCESS DUTY FOR START-UP.
4. ABSORBED DUTY.
DIESEL FEED
FROM EXISTING CRUDE UNIT
MAKEUP H2
FROM H2 PLANT
REFINERY FUEL GAS/NAPHTHA
LOW TEMP SEPARATOR BTMS
TO HDS-PFD-2
TO NAPHTHA STRIPPER V-503
TO HDS-PFD-2
TO LOW TEMP SEPARATOR V-502
WASH WATER
FROM DEMIN. WATER UNIT
HIGH TEMP SEPARATOR BTMS
TO NAPHTHA STRIPPER V-503
LOW TEMP SEPARATOR BTMS
FROM HDS-PFD-2
FROM V-502
RECYCLE GAS
FROM V-502
216°F
765 PSIG
200°F, 300 PSIG
645°F
684°F, 620 PSIG
717°F
600 PSIG
725 PSIG
515°F
419°F
445°F
335°F
325°F
120°F
333°F, 570 PSIG
715 PSIG
120°F, 560 PSIG
333°F
240°F, 570 PSIG
1.3 GPM
REVISIONS
Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT - HDS/BDS BASE
REACTOR SECTION
HDS-PFD-1


E-506
PRODUCT COOLER
12.0 MM BTU/HR
V-504
STRIPPER O.H. ACCUMULATOR
3'-0" I.D. X 6'-0" T/T
E-504
STRIPPER O.H. CONDENSER
2.0 MM BTU/HR
E-505
STRIPPER FD/BTMS EXCHANGER
11.6 MM BTU/HR
V-503
NAPHTHA STRIPPER
4'-0" (BOTTOM) I.D. X 55'-0" OVERALL T/T
2'-6" (TOP)
H-501
STRIPPER REBOILER
5.6 MM BTU/HR (NOTE 1)
V-502
LOW TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
SOUR GAS
TO SCRUBBING & SULFUR PLANT
45 PSIG
NAPHTHA
TO FUEL
SOUR WATER DISPOSAL
DIESEL
TO BDS UNIT
NOTES
1. ABSORBED DUTY.
P-502 A/B
STRIPPER OVERHEAD PUMPS
(ONE OPERATING & ONE SPARE)
30 GPM (RATED)
ΔP: 38 PSI
P-501 A/B
STRIPPER BOTTOMS PUMPS
(ONE OPERATING & ONE SPARE)
335 GPM (RATED)
ΔP: 125 PSI
114°F
63 PSIG
306°F, 65 PSIG
580°F
426°F, 58 PSIG
120°F, 48 PSIG
68 PSIG
662°F
700°F
325°F
REFINERY FUEL GAS/NAPHTHA
1.2 GPM SOUR WATER DISPOSAL
120°F, 560 PSIG
LOW TEMP SEPARATOR BTMS FROM E-502
PURGE GAS TO SULFUR REMOVAL AND FUEL
RECYCLE GAS TO C-501
HIGH TEMP SEPARATOR O.H. FROM E-503
LOW TEMP SEPARATOR BTMS TO E-502
HIGH TEMP SEPARATOR BTMS FROM V-501
REVISIONS
PROCESS FLOW DIAGRAM
HDS UNIT - HDS/BDS CASE
NAPHTHA STRIPPER SECTION
DRAWING NUMBER HDS-PFD-2

Material Balance

HDS Unit EOR Material Balance -- HDS/BDS Case

Stream Number		1	2	3	4	5	6	7
Stream Description		ANS Feed	Make-up H2	Reactor Feed	Reactor Outlet	V-501 Liquid	V-501 Vapor + Wash Water	Recycle Gas
Phase		LIQUID	VAPOR	MIXED	MIXED	LIQUID	MIXED	VAPOR
Mass Flow Rate	LB/HR	75427	346	79224	79224	74970	4883	3451
Temperature	F	216	413	684	717	333	240	120
Pressure	PSIG	3	725	620	600	570	570	560
Standard Liq Flow	BPD	6000	n/a	4008	3163	6032	31	n/a
Vapor Flow	MSCFH	n/a	63.8	328.6	307.7	n/a	246.1	226.9
Wt % Vapor		0	100	37	50	0	92	100
MW		217.9	2.1	71.2	78.5	194.7	6.9	5.8

Stream Number		8	9	10	11	12	13	14
Stream Description		V-502 HC Liquid	V-502 Vapor	Purge Gas	Column Vapor to Condenser	Sour Gas	Naphtha	Diesel from E-505
Phase		LIQUID	VAPOR	VAPOR	VAPOR	VAPOR	LIQUID	LIQUID
Mass Flow Rate	LB/HR	695	3566	116	8988	636	1911	73115
Temperature	F	120	120	120	306	114	114	426
Pressure	PSIG	560	560	560	65	63	104	58
Standard Liq Flow	BPD	61	n/a	n/a	n/a	n/a	173	5830
Vapor Flow	MSCFH	n/a	234.5	7.6	47.8	11.0	n/a	n/a
Wt % Vapor		0	100	100	100	100	0	0
MW		108.9	5.8	5.8	71.4	22.0	86.1	214.8

Appendix C.2 – HDS Unit Equipment List and Budgetary Equipment Datasheets

HDS Unit Equipment List

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
R-500	HDS Reactor	6'-6" ID X 21'-9" T/T w/ one bed of HR-526 Co Mo catalyst.	670 PSIG/FV	750°F/-20°F	SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-500	Diesel Feed Drum	8'-0" ID X 15'-0" T/T (Horizontal)	50 PSIG/FV	275/-20°F	Killed Carbon Steel
V-501	High Temperature Separator	3'-0" ID X 8'-0" T/T (Vertical)	620 PSIG/FV	380/-20°F	Killed Carbon Steel w/0.15" CA
V-502	Low Temperature Separator	3'-0" ID X 8'-0" T/T` (Horizontal w/ Boot)	610 PSIG/FV	350/-20°F	Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-503	Naphtha Stripper	2'-6" ID (Top), 4'-0" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays	125 PSIG/FV	750/-20°F	Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-504	Stripper O. H. Accumulator	3'-0" ID X 6'-0" T/T (Horizontal w/Boot)	125 PSIG/FV	350/-20°F	Killed Carbon Steel w/0.125" CA (PWHT)
E-500	Reactor Fd/Btms Exchanger #1	13.8 MM BTU/Hr, 4500 FT^2 w/ 2 shells, TEMA type CEU	Tubes: 650 PSIG Shell: 765 PSIG	770°F 700°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	Reactor Fd/Btms Exchanger #2	9.7 MM BTU/Hr, 2840 FT^2 w/2 shells, TEMA type CEU	Tubes: 640 PSIG Shell: 775 PSIG	540°F 470°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover Shell: Killed C. S. w/0.125" CA
E-502	Separator Fd/Btms Exchanger	0.1 MM BTU/Hr, 33 FT^2, double pipe.	Tubes: 630 PSIG Shell: 610 PSIG	360°F 360/-20°F	Tubes: Carbon Steel Shell: Carbon Steel
E-503	H. T. Separator Overhead Cooler	1.2 MM BTU/Hr 246 FT^2 (Bare Tube) 5240 FT^2 Extended Surface, 5 HP Fan	Tubes: 620 PSIG	350°F	Seamless Carbon Steel tubes with aluminum fins
E-504	Stripper O. H. Condenser	2.0 MM BTU/Hr 371 FT^2 (Bare Tube) 7713 FT^2 Extended Surface, 5 HP Fan	Tubes: 125 PSIG	350°F	Seamless Carbon Steel tubes with aluminum fins
E-505	Stripper Fd/Btms Exchanger	11.6 MM BTU/Hr 3160 FT^2 w/3 shells, TEMA type CEU	Tubes: 620 PSIG Shell: 100 PSIG	630°F 710°F/-20°F	Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS Shell: CS w/0.25" CA, CS baffles
E-506	Product Cooler	12.0 MM BTU/Hr 2330 FT^2 (Bare Tube) 49860 FT^2 Extended Surface, 20 HP Fan	Tubes: 100 PSIG	450°F	Seamless Carbon Steel tubes with aluminum fins
H-500	Diesel Charge Heater	4.7 MM BTU/Hr Fired Heater, Convection Section shared w/ H-501	Tubes: 755 PSIG	750°F	Tubes: 9 Cr – 1 Mo w/ 0.1" CA
H-501	Stripper Reboiler	5.6 MM BTU/Hr Fired Heater, Convection Section shared w/ H-500	Tubes: 230 PSIG	770°F	Tubes: 5 Cr – ½ Mo w/ 0.1" CA

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
C-500	Makeup Hydrogen Compressor	Capacity: 91640 ACFD Motor Driven Shaft HP: 100 BHP	Suction: 300 PSIG Disch: 725 PSIG	Suction: 200°F	Casing: killed C. S. Internals: CS
C-501	Recycle Gas Compressor	Capacity: 157350 ACFD Motor Driven Shaft HP: 80 BHP	Suction: 560 PSIG Disch: 715 PSIG	Suction: 120°F	Casing: killed C. S. Internals: Stainless Steel
P-500 A/B	Diesel Feed Pump (One Operating + One Spare	Rated Capacity: 206 GPM Diff. Press: 762 PSI Head: 2182 feet Motor: 150 HP			Casing: killed C. S. w/ 0.125" CA Impeller: 12% chrome
P-501 A/B	Stripper Bottoms Pump (One Operating + One Spare	Rated Capacity: 335 GPM Diff. Press: 125 PSI Head: 481 feet Motor: 50 HP			Casing: killed C. S. w/ 0.2" CA Impeller: 12% chrome
P-502 A/B	Stripper Overhead Pump (One Operating + One Spare	Rated Capacity: 30 GPM Diff. Press: 38 PSI Head: 120 feet Motor: 5 HP			Casing: killed C. S. w/ 0.125" CA Impeller: 12% chrome

ANVIL

BUDGETARY DATA SHEET

COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	500 ppm HDS	**DATE 4/15/05**

ITEM NUMBER	X	C-500		
FLUID	X	Makeup H2		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	91,640		
SUCTION TEMPERATURE ^{O}F	X	200		
SUCTION PRESSURE, PSIA	X	315		
DISCHARGE PRESSURE, PSIA	X	740		
GAS MOLECULAR WEIGHT	X	2.06		
'K' VALUE OF GAS	X	1.40		
MOL % HYDROGEN IN GAS	X	99.7		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	None		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	125		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	100		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS
1) Will be subject to -20°F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	500 ppm HDS	**DATE 4/15/05**

ITEM NUMBER	X	C-501		
FLUID	X	Recycle Gas		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	157,350		
SUCTION TEMPERATURE ^{O}F	X	120		
SUCTION PRESSURE, PSIA	X	575		
DISCHARGE PRESSURE, PSIA	X	730		
GAS MOLECULAR WEIGHT	X	5.77		
'K' VALUE OF GAS	X	1.39		
MOL % HYDROGEN IN GAS	X	87.0		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	H2S, H2O		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVE, VALVES MATERIAL	M	Stainless Steel		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER, Motor HP	X	100		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER, BHP	X	80		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20 °F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-500		
SERVICE	X	Reactor Fd/Btms Exch #1		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	4500		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	650		
DESIGN TEMPERATURE, ^OF	X	770		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	765		
DESIGN TEMPERATURE, ^OF	x	700 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo (3)		
DUTY, MMBTU/HR	O	13.8		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Type 1 1/4 Cr - 1/2 Mo for tubes and tube sheet and weld overlay 316 SS for tube sheet, channnel, cover & nozzles.
U tubes to be PWHT.
3) Clad w/ Type 321 SS , Baffles to be Type 304 SS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	BGJ
LOCATION	Alaska		**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS		**DATE**	4/15/2005

ITEM NUMBER	X	E-501		
SERVICE	X	Reactor Fd/Btms Exch #2		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	2840		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	640		
DESIGN TEMPERATURE, ^{O}F	X	540		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	775		
DESIGN TEMPERATURE, ^{O}F	x	470 / -20		
MATERIAL OF CONSTRUCTION	x	Killed C. S. (3)		
DUTY, MMBTU/HR	O	9.7		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

(2) Use SA182 F11 (1 1/4 Cr - 1/2 Mo) for tubesheet + channel cover + nozzles and SA 387 Gr 11 for channel
Weld overlay tube sheet, channel cover, and channel with 321 SS.

(3) Use 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-502		
SERVICE	X	Separator Fd/Btms Exch		
TEMA TYPE	X	Double Pipe		
SURFACE AREA (TOTAL) FT^2	x	33		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel w/Hydrogen		
DESIGN PRESSURE, PSIG	x	630		
DESIGN TEMPERATURE, ^{O}F	X	360		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Hydrocarbon		
DESIGN PRESSURE, PSIG	x	610		
DESIGN TEMPERATURE, ^{O}F	x	360 / -20		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	O	0.1		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) USE DOUBLE PIPE EXCHANGER OR EQUAL.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-503		
SERVICE	X	H. T. Seprtr Ovrhd Clr		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Hydrocarbon Vapor/Water		
INLET TEMPERATURE	X	240		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	350		
DESIGN PRESSURE, PSIG	X	620		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	246		
EXTENDED SURFACE	X	5,240		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	SA179 (1)		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	1.2		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Killed carbon steel for the header.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-504		
SERVICE	X	Strpr Ovrhd Condenser		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	HC Vapor/Naphtha		
INLET TEMPERATURE	X	306		
OUTLET TEMPERATURE	X	114		
DESIGN TEMPERATURE, ^{O}F	X	350		
DESIGN PRESSURE, PSIG	X	125		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	371		
EXTENDED SURFACE	X	7,713		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note (1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	2.0		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-505		
SERVICE	X	Stripper Fd/Btms Exch		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	3,160		
NUMBER OF SHELLS	x	3		
TUBE SIDE				
FLUID	x	Diesel/Naphtha		
DESIGN PRESSURE, PSIG	x	620		
DESIGN TEMPERATURE, $^O F$	X	630		
MATERIAL OF CONSTRUCTION	x	Note 2		
SHELL SIDE				
FLUID	x	Diesel Product		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, $^O F$	x	710/-20F		
MATERIAL OF CONSTRUCTION	x	Note 3		
DUTY, MMBTU/HR	O	11.6		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Channel is CS + 0.25" CA, Tube sheets are Type 410 SS, Tubes are 18 Cr - 8 Ni

3) Shell is CS + 0.25" CA, Baffles are CS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	E-506		
SERVICE	X	Product Cooler		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Diesel		
INLET TEMPERATURE	X	426		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	450		
DESIGN PRESSURE, PSIG	X	100		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	2330		
EXTENDED SURFACE	X	49860		
TYPE OF FINS	O			
FAN HORSEPOWER	X	20		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note 1		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	12.0		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) CS tubes with aluminum fins and killed CS header with 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
PROCESS HEATERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	H-500		
SERVICE	X	Diesel Charge Heater		
HEATER TYPE	X	Fired Heater (1)		
FLUID	X	Diesel w/Hydrogen		
TOTAL FLOW RATE, LB/HR	X	79,224		
LIQUID - GPM (OUTLET)	X	175		
DENSITY, LB/FT^3	X	35.6		
VISCOSITY, CP	X	0.07		
SPECIFIC HEAT, BTU/LB-°F	X	0.74		
THERMAL COND., $BTU/HR-FT^2$-°F	X	0.03		
VAPOR - MMSCFD (OUTLET)	X	7.89		
DENSITY, LB/FT^3	X	1.73		
VISCOSITY, CP	X	0.02		
SPECIFIC HEAT, BTU/LB-°F	X	0.76		
THERMAL COND., $BTU/HR-FT^2$-°F	X	0.11		
INLET TEMPERATURE	X	645		
OUTLET TEMPERATURE	X	684		
DESIGN TEMPERATURE (°F)	X	750		
DESIGN PRESSURE (PSIG)	X	755		
MATERIAL OF CONSTRUCTION	X	9 Cr - 1 Mo + 0.1" CA		
ABS DUTY, MMBTU/HR	X	4.7 (2)		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Includes 50% excess duty for startup.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PROCESS HEATERS

CUSTOMER	HDS/BDS Study		**PROJECT ENGINEER**	BGJ
LOCATION	Alaska		**PROJECT**	AE1416
PROCESS UNIT	500 ppm HDS		**DATE**	4/15/2005

ITEM NUMBER	X	H-501		
SERVICE	X	Stripper Reboiler		
HEATER TYPE	X			
FLUID	X	Hydrotreated Diesel		
TOTAL FLOW RATE, LB/HR	X	86,969		
HEATER OUTLET CONDITIONS:				
LIQUID - GPM	X	156.4		
DENSITY, LB/FT^3	X	36.5		
VISCOSITY, CP	X	0.12		
SPECIFIC HEAT, BTU/LB-°F	X	0.76		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.03		
VAPOR - MMSCFD	X	1.84		
DENSITY, LB/FT^3	X	1.64		
VISCOSITY, CP	X	0.01		
SPECIFIC HEAT, BTU/LB-°F	X	0.65		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.02		
INLET TEMPERATURE	X	662		
OUTLET TEMPERATURE	X	700		
DESIGN TEMPERATURE (°F)	X	770		
DESIGN PRESSURE (PSIG)	X	230		
MATERIAL OF CONSTRUCTION	X	5 CR - 1/2 Mo (2)		
ABS DUTY, MMBTU/HR	X	5.6		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Add 0.1" CA

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	500 ppm HDS	**DATE 4/15/05**

ITEM NUMBER	X	P-500 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	216		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.81		
RATED FLOW (GPM)	X	206		
SUCTION PRESSURE, PSIG	X	3		
DISCHARGE PRESSURE PSIG	X	765		
NPSH AVAILABLE (FT)	X	10.6		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	killed C. S. (2)		
IMPELLER MATERIAL	M	12% chrome		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (MHP)	X	150		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	131		
DIFFERENTIAL PRESSURE, PSI		762		
DIFFERENTIAL HEAD, FT		2182		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	500 ppm HDS	**DATE 4/15/05**

ITEM NUMBER	X	P-501A/B (1)		
SERVICE (FLUID)	X	Stripper Btms Pump		
TEMPERATURE OF FLUID	X	662		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.60		
RATED FLOW (GPM)	X	335		
SUCTION PRESSURE, PSIG	X	71		
DISCHARGE PRESSURE PSIG	X	196		
NPSH AVAILABLE (FT)	X	11.1		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS + 0.2" CA		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	50		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	35		
Differential Pressure, PSIG	X	125		
Differential Head, Feet	X	481		

REMARKS

1) One operating pump + one spare
2) Minimum ambient -20 F.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER BGJ**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		500 ppm HDS	**DATE 4/15/05**	
ITEM NUMBER	X	P-502 A/B (1)		
SERVICE (FLUID)	X	Stripper Ovrhd Pump		
TEMPERATURE OF FLUID	X	114		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.73		
RATED FLOW (GPM)	X	30		
SUCTION PRESSURE, PSIG	X	66		
DISCHARGE PRESSURE PSIG	X	104		
NPSH AVAILABLE (FT)	X	9.5		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	1		
Differential Pressure, PSIG	X	38		
Differential Head, Feet	X	120		
		API Standard		

REMARKS

1) One operating pump + one spare

2) With 0.125" CA. Min. ambient -20F.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	R-500		
SERVICE	X	HDS Reactor		
FLUID	X	Diesel / Hydrogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	6' - 6"		
TANGENT TO TANGENT LENGTH, FT.	X	21' - 9"		
SKIRT HEIGHT (FT-IN)	X	Min		
DESIGN TEMPERATURE (°F)	X	750/-20 (4)		
DESIGN PRESSURE (PSIG)	X	670 (1)		
MATERIAL OF CONSTRUCTION	X	SA387 Gr. 11 (5)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	HR-526 Co-MO Catalyst		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
Catalyst VOLUME, FT^3	X	670 (3)		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Distributor and support grid		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) The packing is in one section with an internal distributor

3) The total weight of catalyst is 37290 lbs. The price is supplied by the catalyst vendor for the estimate.

4) Reactor is design temperature at 25°F above end of run. Reactors are generally designed for EOR operating temperature, but margin is added to be conservative.

5) Include 321 SS or 347 SS weld overlay. Internal trays may be 410 SS or 321 SS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	V-500		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	15' - 0"		
SKIRT HEIGHT (FT-IN)	X	Note 2		
DESIGN TEMPERATURE (°F)	X	275 / -20		
DESIGN PRESSURE (PSIG)	X	50 (1)		
MATERIAL OF CONSTRUCTION	X	SA-516-70		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	None		
NUMBER OF TRAYS	X	None		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) The horizontal vessel will be supported on saddles 10 feet above grade.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	V-501		
SERVICE	X	H. T. Separator		
FLUID	X	Hydrcrbn w/Hydogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	Min.		
DESIGN TEMPERATURE (°F)	X	380 / -20		
DESIGN PRESSURE (PSIG)	X	620 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS w/ 0.15" CA		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breakers		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	V-502		
SERVICE	X	Low Temp Separator		
FLUID	X	Hydrocarbon w/ H2/H2S		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	MIN		
DESIGN TEMPERATURE (°F)	X	350/-20		
DESIGN PRESSURE (PSIG)	X	610 (1)		
MATERIAL OF CONSTRUCTION	X	Killed C. S. (2)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	No		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Demister (2)		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (3)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) w/ 0.1" CA and PWHT. Demister to be 1' dia. Monel

3) Sour water removal

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	V-503		
SERVICE	X	Naphtha Stripper		
FLUID	X	Hydrotreated Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	TOP = 2'-6", BTM = 4'-0"		
TANGENT TO TANGENT LENGTH, FT.	X	55'-0" (3)		
SKIRT HEIGHT (FT-IN)	X	15'-0"		
DESIGN TEMPERATURE (°F)	X	750/-20 (BTM)		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Note 4		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	Valve Trays		
NUMBER OF TRAYS	X	22		
TRAY MATERIAL	X	410 S.S.		
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Vortex Breakers		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) VESSEL SHALL BE SWAGED ABOVE FEED
3) Length of top section = 25'-0", length of bottom section = 30'-0"
4) Vessel to be killed CS + 0.2" CA. Trays, tray supports, and downcomers are Type 410 SS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	500 ppm HDS	**DATE**	4/15/2005

ITEM NUMBER	X	V-504		
SERVICE	X	Strpr O. H. Accumulator		
FLUID	X	Naphtha		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	6' - 0"		
SKIRT HEIGHT (FT-IN)	X	13' - 0"		
DESIGN TEMPERATURE (°F)	X	350/-20		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS Note (2)		
INSULATION (YES/NO)	X	No		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	None		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (sour water)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) Add 0.125" CA and PWHT.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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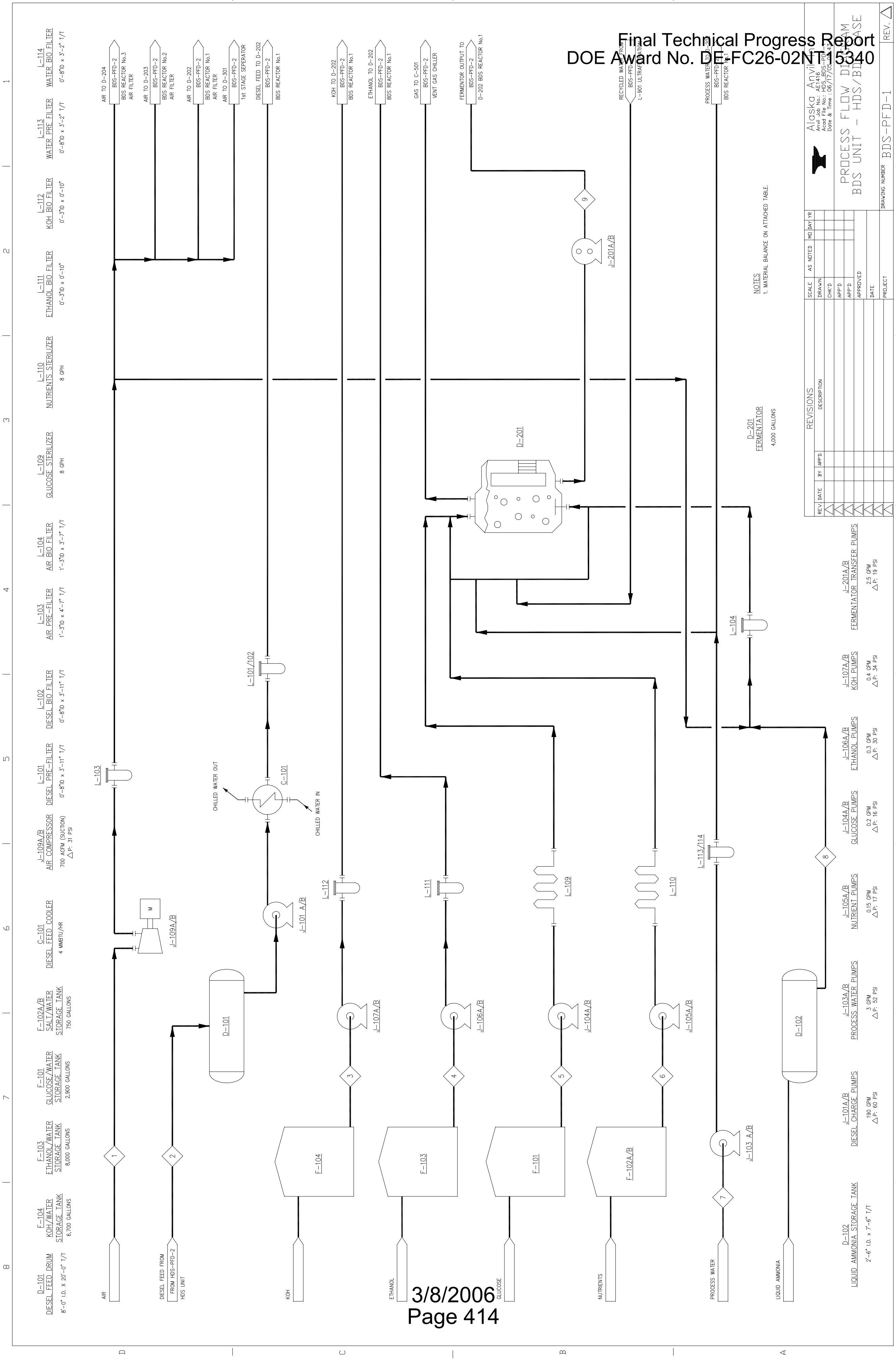
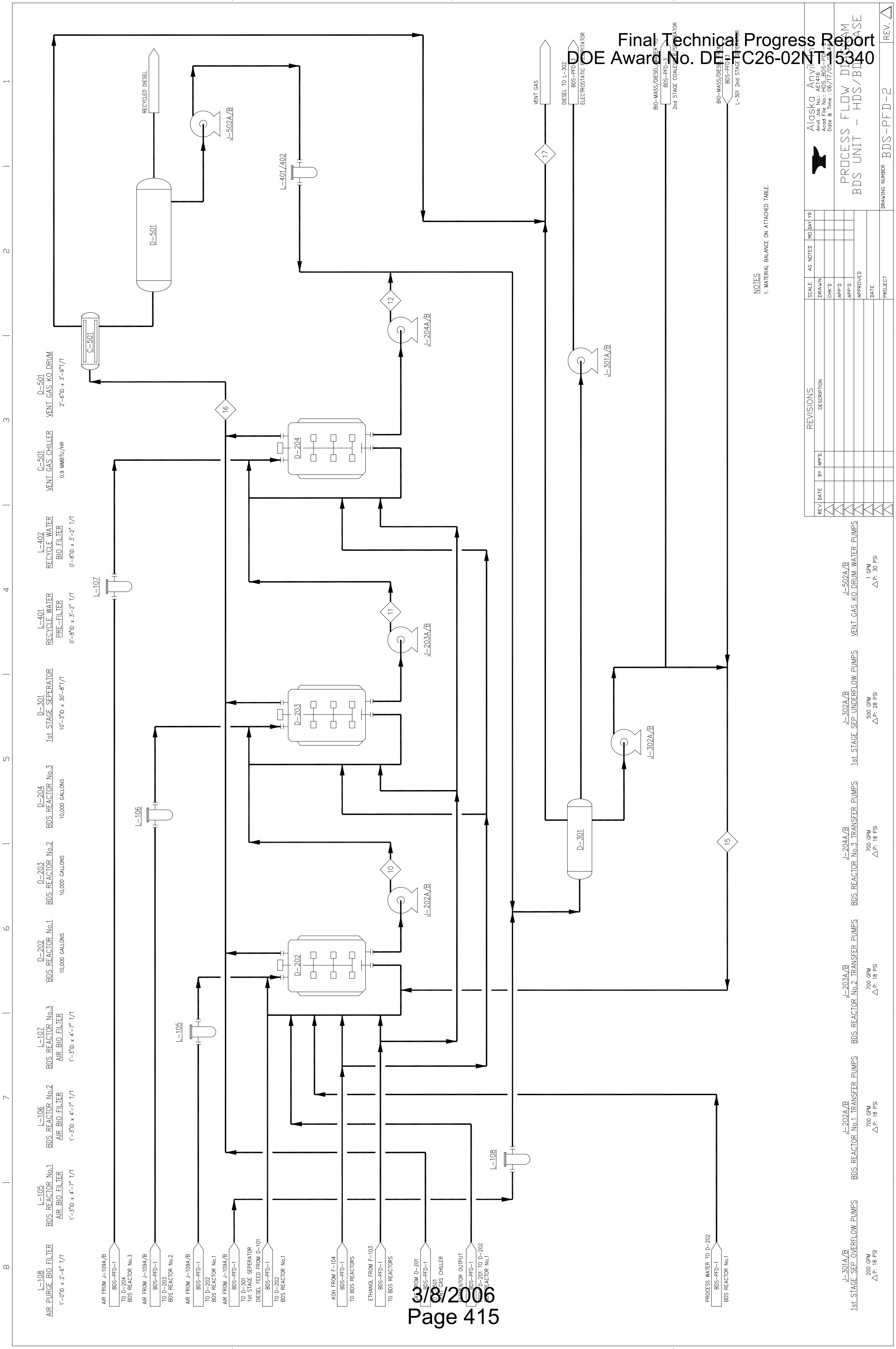
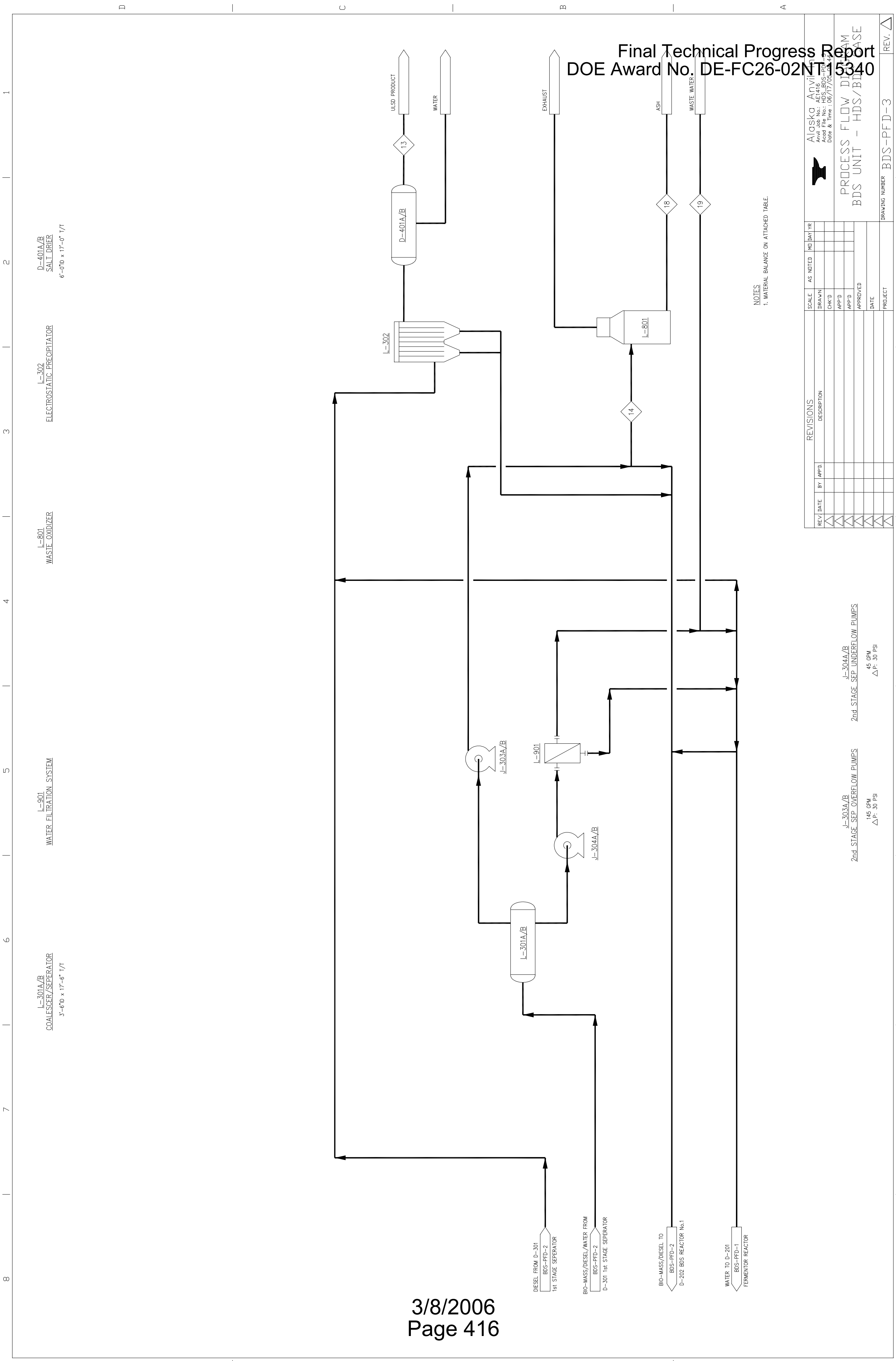
Appendix C.3 – BDS Unit Process Flow Diagrams and Material Balance


PROCESS FLOW DIAGRAM
BDS UNIT - HDS/BDS CASE
BDS-PFD-1
Alaska Anvil
D-101 DIESEL FEED DRUM 8'-0" I.D. x 20'-0" T/T
F-104 KOH/WATER STORAGE TANK 6,700 GALLONS
F-103 ETHANOL/WATER STORAGE TANK 8,000 GALLONS
F-101 GLUCOSE/WATER STORAGE TANK 2,900 GALLONS
F-102A/B SALT/WATER STORAGE TANK 750 GALLONS
C-101 DIESEL FEED COOLER 4 MMBTU/HR
J-109A/B AIR COMPRESSOR 700 ACFM (SUCTION) ΔP: 31 PSI
L-101 DIESEL PRE-FILTER 0'-8"D x 3'-11" T/T
L-102 DIESEL BIO FILTER 0'-8"D x 3'-11" T/T
L-103 AIR PRE-FILTER 1'-3"D x 4'-7" T/T
L-104 AIR BIO FILTER 1'-3"D x 3'-7" T/T
L-109 GLUCOSE STERILIZER 8 GPH
L-110 NUTRIENTS STERILIZER 8 GPH
L-111 ETHANOL BIO FILTER 0'-3"D x 0'-10"
L-112 KOH BIO FILTER 0'-3"D x 0'-10"
L-113 WATER PRE FILTER 0'-8"D x 3'-2" T/T
L-114 WATER BIO FILTER 0'-8"D x 3'-2" T/T
D-102 LIQUID AMMONIA STORAGE TANK 2'-6" I.D. x 7'-6" T/T
J-101A/B DIESEL CHARGE PUMPS 190 GPM ΔP: 60 PSI
J-103A/B PROCESS WATER PUMPS 3 GPM ΔP: 52 PSI
J-105A/B NUTRIENT PUMPS 0.15 GPM ΔP: 17 PSI
J-104A/B GLUCOSE PUMPS 0.2 GPM ΔP: 16 PSI
J-106A/B ETHANOL PUMPS 0.3 GPM ΔP: 30 PSI
J-107A/B KOH PUMPS 0.4 GPM ΔP: 34 PSI
J-201A/B FERMENTATOR TRANSFER PUMPS 2.5 GPM ΔP: 19 PSI
D-201 FERMENTATOR 4,000 GALLONS
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
REVISIONS
AIR
DIESEL FEED FROM HDS UNIT
KOH
ETHANOL
GLUCOSE
NUTRIENTS
PROCESS WATER
LIQUID AMMONIA
CHILLED WATER OUT
CHILLED WATER IN


L-108 AIR PURGE BIO FILTER 1'-0"D x 2'-6" T/T
L-105 BDS REACTOR No.1 AIR BIO FILTER 1'-3"D x 4'-7" T/T
L-106 BDS REACTOR No.2 AIR BIO FILTER 1'-3"D x 4'-7" T/T
L-107 BDS REACTOR No.3 AIR BIO FILTER 1'-3"D x 4'-7" T/T
D-202 BDS REACTOR No.1 10,000 GALLONS
D-203 BDS REACTOR No.2 10,000 GALLONS
D-204 BDS REACTOR No.3 10,000 GALLONS
D-301 1st STAGE SEPERATOR 10'-3"D x 30'-8"T/T
L-401 RECYCLE WATER PRE-FILTER 0'-8"D x 3'-2" T/T
L-402 RECYCLE WATER BIO FILTER 0'-8"D x 3'-2" T/T
C-501 VENT GAS CHILLER 0.9 MMBTU/HR
D-501 VENT GAS KO DRUM 2'-6"D x 3'-9"T/T
J-301A/B 1st STAGE SEP OVERFLOW PUMPS 200 GPM ΔP: 18 PSI
J-202A/B BDS REACTOR No.1 TRANSFER PUMPS 700 GPM ΔP: 18 PSI
J-203A/B BDS REACTOR No.2 TRANSFER PUMPS 700 GPM ΔP: 18 PSI
J-204A/B BDS REACTOR No.3 TRANSFER PUMPS 700 GPM ΔP: 18 PSI
J-302A/B 1st STAGE SEP UNDERFLOW PUMPS 500 GPM ΔP: 28 PSI
J-502A/B VENT GAS KO DRUM WATER PUMPS 1 GPM ΔP: 30 PSI
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
REVISIONS
DRAWING NUMBER BDS-PFD-2
VENT GAS
RECYCLED DIESEL
AIR FROM J-109A/B
KOH FROM F-104
ETHANOL FROM F-103
PROCESS WATER TO D-202


ULSD PRODUCT
WATER
EXHAUST
ASH
WASTE WATER
D-401A/B
L-302
L-801
L-901
J-303A/B
J-304A/B
L-301A/B
D-401A/B SALT DRIER 6'-0"D x 17'-0" T/T
L-302 ELECTROSTATIC PRECIPITATOR
L-801 WASTE OXIDIZER
L-901 WATER FILTRATION SYSTEM
L-301A/B COALESCER/SEPERATOR 3'-6"D x 17'-6" T/T
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
J-304A/B 2nd STAGE SEP UNDERFLOW PUMPS 45 GPM ΔP: 30 PSI
J-303A/B 2nd STAGE SEP OVERFLOW PUMPS 145 GPM ΔP: 30 PSI
DIESEL FROM D-301 BDS-PFD-2 1st STAGE SEPERATOR
BIO-MASS/DIESEL/WATER FROM BDS-PFD-2 D-301 1st STAGE SEPERATOR
BIO-MASS/DIESEL TO BDS-PFD-2 D-202 BDS REACTOR No.1
WATER TO D-201 BDS-PFD-1 FERMENTOR REACTOR
REVISIONS
Alaska Anvil
PROCESS FLOW DIAGRAM
BDS UNIT - HDS/BDS CASE
DRAWING NUMBER BDS-PFD-3

Material Balance

BDS Unit Material Balance -- HDS/BDS Case

PFD Stream Number		1	2	3	4	5	6	7
Stream Number		Air	Diesel	NaOH	Ethanol	Glucose	Nutrients	Process Water
Stream Description		Air Feed	Diesel Feed	NaOH Feed	Ethanol Feed	Glucose Feed	Nutrient Feed	Process Water Feed
Phase		VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR		74483					
Aqueous Mass Flow	LB/HR			200	100	75	60	1200
Biomass Mass Flow	LB/HR							
Sulfur in HC	PPM		500					
Total Mass Flow Rate	LB/HR	3000	74483	200	100	75	60	1200
Temperature	F	68	176	68	68	68	68	68
Pressure	PSIG	0	0	0	0	0	0	0
Standard Liq Flow	BPD		6000	9	7.5	4.3	4.1	82
Vapor Flow	MSCFH	40						
Wt % Vapor		100	0	0	0	0	0	0
MW								

PFD Stream Number		8	9	10	11	12	13	14
Stream Number		Liquid Ammonia	S-16	S-17	S-18	S-19	S-27	S-31
Stream Description		Liquid Ammonia Feed	Fermentor Output	R#1 Output	R#2 Output	R#3 Output	Diesel Product	Biomass Purge
Phase		LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR			126160	125966	125775	74271	195
Aqueous Mass Flow	LB/HR	4.8	1007	140620	140771	140805	0	335
Biomass Mass Flow	LB/HR		74	30602	30602	30602	0	92
Sulfur in HC	PPM			117	35	9	9	9
Mass Flow Rate	LB/HR	4.8	1081	297382	297338	297182	74271	623
Temperature	F	-40	86	86	86	86	86	86
Pressure	PSIG	210	33.1	36.4	36.4	26.8	5	5
Standard Liq Flow	BPD	0.5	71	21295	21287	21274	5983	44
Vapor Flow	MSCFH							
Wt % Vapor		0	0	0	0	0	0	0
MW								

PFD Stream Number		15	16	17	18	19		
Stream Number		S-32	S-38	S-39	Ash	Waste Water		
Stream Description		Reactor Recycle	Reactor Air Effluent	Gas Purge	Incinerator Waste	Waste Water		
Phase		LIQUID	GAS	GAS	SOLID	LIQUID		
Hydrocarbon Mass Flo	LB/HR	51876	567					
Aqueous Mass Flow	LB/HR	138224	47			1372		
Biomass Mass Flow	LB/HR	30528						
Sulfur in HC	PPM	9	55					
Total Mass Flow Rate	LB/HR	220628	3443	2844	14	1372		
Temperature	F	86	86	60	68	86		
Pressure	PSIG	37.4	10	1	0	10		
Standard Liq Flow	BPD	15148				89		
Vapor Flow	MSCFH		39	38				
Wt % Vapor		0	100	100	0	0		
MW								

Appendix C.4 – BDS Unit Equipment List and Budgetary Equipment Datasheets

ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	D-101		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	8'		
TANGENT TO TANGENT LENGTH, FT.	X	20'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	190		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	D-102		
SERVICE	X	Storage Tank		
FLUID	X	Liquid Ammonia		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	7'-6"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	275		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	N/A		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	10'-3"		
TANGENT TO TANGENT LENGTH, FT.	X	30'-8"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS/HDS	**DATE**	6/2/2005

ITEM NUMBER	X	D-501		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	3'-9"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	F-101		
SERVICE	X	Storage Tank		
FLUID	X	Glucose/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	7'		
TANGENT TO TANGENT LENGTH, FT.	X	10'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	F-102 A/B		
SERVICE	X	Storage Tank		
FLUID	X	Salt/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	4'		
TANGENT TO TANGENT LENGTH, FT.	X	8'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	F-103		
SERVICE	X	Storage Tank		
FLUID	X	Ethanol/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	12'-8"		
TANGENT TO TANGENT LENGTH, FT.	X	8'-6"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	Epoxy Resin		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	F-104		
SERVICE	X	Storage Tank		
FLUID	X	NaOH/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	9'		
TANGENT TO TANGENT LENGTH, FT.	X	14'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS ULSD Baseline	**DATE 3/17/05**

ITEM NUMBER	X	J-101 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	140		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	190		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	61.3		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		60.1		
DIFFERENTIAL HEAD, FT		163.1		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		HDS/BDS	**DATE 6/2/05**	
ITEM NUMBER	X	J-103 A/B (1)		
SERVICE (FLUID)	X	Process Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.997		
RATED FLOW (GPM)	X	3		
SUCTION PRESSURE, PSIG	X	5		
DISCHARGE PRESSURE PSIG	X	57.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		52.4		
DIFFERENTIAL HEAD, FT		121		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-104 A/B (1)		
SERVICE (FLUID)	X	Glucose/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.2		
RATED FLOW (GPM)	X	0.2		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.4		
DIFFERENTIAL HEAD, FT		31		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-105 A/B (1)		
SERVICE (FLUID)	X	Salts/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	0.15		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.8		
DIFFERENTIAL HEAD, FT		38.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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O = PROCESS INFO OPTIONAL
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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-106 A/B (1)		
SERVICE (FLUID)	X	Ethanol/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.914		
RATED FLOW (GPM)	X	0.3		
SUCTION PRESSURE, PSIG	X	1		
DISCHARGE PRESSURE PSIG	X	31.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.4		
DIFFERENTIAL HEAD, FT		80.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**	

ITEM NUMBER	X	J-107 A/B (1)		
SERVICE (FLUID)	X	NaOH/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.53		
RATED FLOW (GPM)	X	0.4		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	35.9		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		34.3		
DIFFERENTIAL HEAD, FT		65.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-109 A/B		
FLUID	X	Air		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Screw		
TOTAL NUMBER OF MACHINES	X	2		
RATED CAPACITY (ACFM @ SUCTION)	X	700		
SUCTION TEMPERATURE ^{O}F	X	68		
SUCTION PRESSURE, PSIA	X	14.7		
DISCHARGE PRESSURE, PSIA	X	46		
GAS MOLECULAR WEIGHT	X	28.9		
'K' VALUE OF GAS	X			
MOL % HYDROGEN IN GAS	X	0		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	Water		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	65		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	58		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS
1) Will be subject to -20°F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**	

ITEM NUMBER	X	J-201 A/B (1)		
SERVICE (FLUID)	X	Biomass/Salts/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	2.5		
SUCTION PRESSURE, PSIG	X	14.1		
DISCHARGE PRESSURE PSIG	X	33.1		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Rotary Lobe		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		19		
DIFFERENTIAL HEAD, FT		43.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-202 A/B (1)		
SERVICE (FLUID)	X	Biomass/Diesel/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.93		
RATED FLOW (GPM)	X	700		
SUCTION PRESSURE, PSIG	X	18.4		
DISCHARGE PRESSURE PSIG	X	36.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	15		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		44.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		HDS/BDS	**DATE 6/2/05**	
ITEM NUMBER	X	J-301 A/B (1)		
SERVICE (FLUID)	X	Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	200		
SUCTION PRESSURE, PSIG	X	7		
DISCHARGE PRESSURE PSIG	X	25		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		48.9		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-302 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.96		
RATED FLOW (GPM)	X	500		
SUCTION PRESSURE, PSIG	X	9		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	10		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		28.4		
DIFFERENTIAL HEAD, FT		68.4		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-303 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	145		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:

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O = PROCESS INFO OPTIONAL
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BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-304 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	45		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	3		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	J-502 A/B (1)		
SERVICE (FLUID)	X	Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	1		
SUCTION PRESSURE, PSIG	X	3.6		
DISCHARGE PRESSURE PSIG	X	33.8		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.2		
DIFFERENTIAL HEAD, FT		69.8		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	x	C-101		
SERVICE	x	Diesel Feed Cooler		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	1750		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	4		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS/BDS	**DATE 6/2/05**

ITEM NUMBER	X	C-501		
SERVICE	X	Vent Gas Chiller		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	1200		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Air		
DESIGN PRESSURE, PSIG	x	50		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	0.9		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-101		
SERVICE	X	Diesel Pre-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-102		
SERVICE	X	Diesel Bio-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-103		
SERVICE	X	Air Pre-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		GF		
PORE SIZE, MICRON	X	1.0 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-104		
SERVICE	X	Air Bio-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	43"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-105		
SERVICE	X	Reactor Bio Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-108		
SERVICE	X	Air Purge Biofilter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	30"		
HOUSING DIAMETER, IN	X	12"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEI		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-111		
SERVICE	X	Ethanol Bio Filter		
FLUID	X	Ethanol/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-112		
SERVICE	X	NaOH Bio Filter		
FLUID	X	NaOH/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-113		
SERVICE	X	Water Pre Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-114		
SERVICE	X	Water Bio Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS/BDS	**DATE**	6/2/2005

ITEM NUMBER	X	L-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	17'-6"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	24"ODx18"IDx120"L		
PACKING MATERIAL	X	Fiberbed Coalescer		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes 1'x2'		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Postreatment	**DATE 6/11/05**

ITEM NUMBER	X	J-601 A/B (1)		
SERVICE (FLUID)	X	Water Chiller Pump		
TEMPERATURE OF FLUID	X	65		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.95		
RATED FLOW (GPM)	X	2000		
SUCTION PRESSURE, PSIG	X	2.5		
DISCHARGE PRESSURE PSIG	X	38.5		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	20		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		36		
DIFFERENTIAL HEAD, FT		81.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Posttreatment	**DATE 6/11/05**

ITEM NUMBER	X	C-601		
SERVICE	X	Chiller Exchanger		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	2335		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	5.3		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

Appendix C.5 – Utility Requirements

Utility Requirements
HDS/BDS Case
6000 BPD Feed Rate, 10 ppmw Sulfur ULSD Product

IBL HDS	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr
Feed Gas Compressor	55			
H2 Makeup Compressor	75			
Recycle Gas Compressor	60			
Charge Pump	100			
Stripper Reflux Pump	1			
Stripper Btms Circ	26			
Effluent Air Cooler	4			
Prod Stripper Condenser	4			
Prod Rundown Cooler	15			
Wash Water Injection Pump	1			
Charge Heater		5.9		
Prod Stripper Reboiler		7.0		
Wash Water Injection Pump			630	
OBL HDS				
H2 Plant	47	24.7		4166
Sulfur Recovery	96			
Other OBL Allowance	118			
TOTAL HDS and OBL	**602**	**37.6**	**630**	**4166**

BDS	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr	Steam lb/hr
Total Plant	586		1200		8
TOTAL BDS	**586**		**1200**		**8**

Appendix C.6 – Cost Estimate Basis and Cost Estimate

PETRO STAR INC.

ULTRA LOW SULFUR DIESEL
BDS / HDS COMBINATION CASES
IBL ONLY

PHASE 1 ESTIMATE BASIS
REVISION 0

ALASKA ANVIL NO. AE1416

JUNE 2005

ALASKA ANVIL
INCORPORATED

ESTIMATE BASIS GOAL

This Estimate Basis identifies information, qualifications, exceptions, and assumptions used in developing the cost estimate.

ESTIMATE BASIS PURPOSE

During the estimate review process, the project team uses the Estimate Basis for the following purposes:

- As a checklist of items to consider during estimate preparation.
- To document what is included and not included in the cost estimate.
- To assess cost risks of estimate components.
- As part of the decision support package for assessing the BDS process feasibility.

GENERAL INFORMATION

- The purpose of the project estimate is to determine if the ULSD BDS process is economically viable as a standalone process or in combination with an HDS Unit. These three (3) estimate scenarios address the BDS / HDS Combination cases.
- Estimate type:
  - The estimate was developed using equipment based factored estimates for Inside Battery Limits (IBL) costs.
  - There is a separate equipment-factoring summary for the BDS, HDS, and Pre Frac Equipment (Pre Frac Case Only)
  - Most of the equipment pricing was derived from the ICARUS estimating program. Pricing for BDS equipment marked with an asterisk (*) was provided by Pelorus.
  - The cost of the Hydrogen and Sulfur Units were factored off licensor quotes obtained for the standalone HDS case.
  - Outside Battery Limits (OBL) costs have been excluded from this estimate.
- The project will be installed in a brownfield location within the Valdez Alaska Refinery.

PROCESS BASIS

Facility Data

- Facility type – Ultra Low Sulfur Diesel Treating Complex, which includes:
  - Diesel Biodesulfurization Unit
  - Diesel Hydrotreating Unit
  - Hydrogen Production Unit
  - Sulfur Unit
  - Diesel Splitter (Pre Frac Case Only)

Design Basis

Product specification – Feed 6,000 bpd of untreated diesel to produce 10-ppmw sulfur maximum ultra low sulfur diesel.

COST BASIS

Labor, Indirects, Equipment, and Bulk Materials

- Included in the equipment factor.

Project Services

- Estimated based on 15 percent of TIC for the BDS, HDS, and Pre Frac units; engineering costs for the Hydrogen and Sulfur Units was included in the licensor pricing.

Owner Services

Not included in the TIC cost. Historically, owner services will cost from 5 to 7 percent of TIC, not including licensing, royalties, or catalyst.

Escalation

Project is based on 2005 costs. No escalation is included.

Location Factor

All costs for this estimate have been developed from a U.S. Gulf Coast (USGC) basis. No location factor is included.

Other Costs

- Catalyst and chemical initial charge has been added as an additional line item.
- CEMS, air preheating, and burner management allowances have been added to the fired heater costs.

ASSUMPTIONS

- Process licensing and royalty costs are not included.
- Assumes fully installed pump spares, but no warehouse spares.

PROJECT COST & SCHEDULE ESTIMATE SUMMARY

CLIENT: PetroStar	**CLIENT PROJECT NO.:**	**CLIENT PE: J. Boltz**
PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo	**ANVIL PROJECT NO.: AE1416**	**ANVIL PE: L. Nace**
STAGE: Phase 1	**REV NO.: 0**	**Date: 6/17/05**

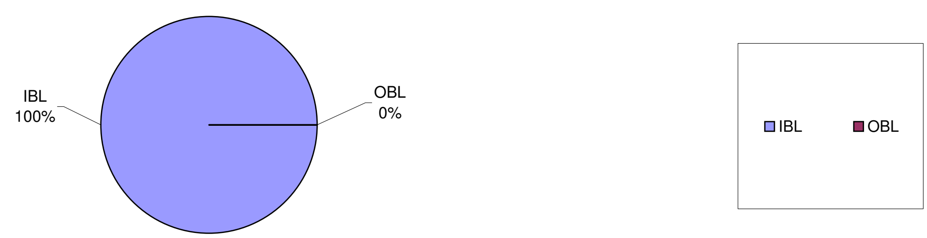
PROJECT DESCRIPTION:	**PROJECT RISKS:**
Install Ultra Low Sulfur Diesel Complex.	

PROJECT COST ESTIMATE SUMMARY

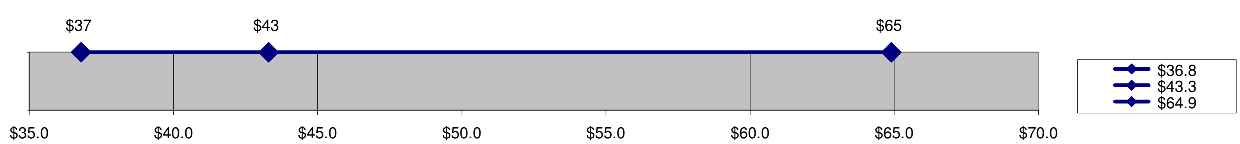
	TOTAL PROJECT COST - Valdez
COST ESTIMATE STRUCTURE	
COST ESTIMATE PARAMETERS	
Estimate Classification	Phase 1
Estimating Method	Factored/ROM
COST ESTIMATE SUMMARY	
Expected Cost ($MM)	**$ 43.3**
High Range ($MM)	**$ 64.9**
Low Range ($MM)	**$ 36.8**

PROJECT COST ESTIMATE ANALYSIS

Total Project Expected Cost Component Analysis

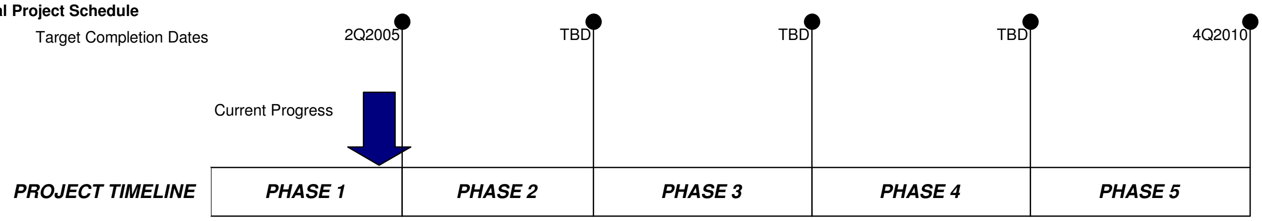


Total Project Cost Profile ($MM)



PROJECT SCHEDULE ESTIMATE ANALYSIS

Total Project Schedule



Petro Star Ultra Low Sulfur Diesel (6000 BPD) Project - Valdez Refinery

IBL Impact Matrix - 2005$ - Total Installed Costs USGC

Scenario: HDS/BDS Combo

IBL Component	HDS Unit	BDS Unit	Hydrogen Unit	Sulfur Unit	Total Cost $MM
	Diesel Hydrotreater, feed rate of 6000 BPD, producing LSD	Biodesulfurization Unit, feed rate of 6000 BPD, producing ULSD (10 ppmw S)	1.5 MMSCF/D H2 Production Plant.	Thiopaq process to be used for 3.4 T/D. Will also need sulfur storage / handling	
Cost Basis	Factored equipment based estimate	Factored equipment based estimate	Ratio'd from Baseline HDS Case	Ratio'd from Baseline HDS Case	
High Range Cost, $ MM	$22.2	$29.4	$8.2	$5.1	$64.9
Expected Cost, $ MM	$14.8	$19.6	$5.5	$3.4	$43.3
Low Range Cost, $ MM	$12.6	$16.7	$4.6	$2.9	$36.8

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COMPRESSORS						
C-500	1	Makeup Hydrogen Compressor	$182,000	2.8	$509,600	Capacity: 64 CFM, Motor Driven, Shaft HP: 100 BHP, Motor Size: 125 HP, Casing: killed C. S., Internals: CS
C-501	1	Recycle Gas Compressor	$176,100	2.8	$493,080	Capacity: 109 CFM, Motor Driven, Shaft HP: 80 BHP, Motor Size: 100 HP, Casing: killed C. S., Internals: Stainless Steel
		SUB-TOTAL	**$358,000**		**$1,003,000**	
EXCHANGERS						
E-500	1	Reactor Fd/Btms Exchanger #1	$203,700	4.0	$814,800	13.8 MM BTU/Hr, 4500 FT2 (total) w/2 shells, TEMA type CEU, Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	1	Reactor Fd/Btms Exchanger #2	$119,800	4.0	$479,200	9.7 MM BTU/Hr, 2840 FT2 (total) w/2 shells, TEMA type CEU, Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover, Shell: Killed C. S. w/0.125" CA
E-502	1	Separator Fd/Btms Exchanger	$8,200	4.0	$32,800	0.1 MM BTU/Hr, 33 FT2, double pipe, Tubes: Carbon Steel, Shell: Carbon Steel
E-505	1	Stripper Fd/Btms Exchanger	$144,400	4.0	$577,600	11.6 MM BTU/Hr, 3,160 FT2 (total) w/3 shells, TEMA type CEU, Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS, Shell: CS w/0.25" CA, CS baffles
		SUB-TOTAL	**$476,000**		**$1,904,000**	
AIR COOLERS						
E-503	1	H. T. Separator Overhead Cooler	$40,100	4.0	$160,400	1.2 MM BTU/Hr, 246 FT2 Bare Tube, 5,240 FT2 Extended, Shaft HP: 5 BHP, Seamless Carbon Steel tubes with aluminum fins.
E-504	1	Stripper O. H. Condenser	$37,200	4.0	$148,800	2.0 MM BTU/Hr, 371 FT2 Bare Tube, 7,713 FT2 Extended, Shaft HP: 5 BHP, Seamless Carbon Steel tubes with aluminum fins.
E-506	1	Product Cooler	$81,000	4.0	$324,000	12.0 MM BTU/Hr, 2,330 FT2 (Bare Tube), 49,860 FT2 Extended, Shaft HP: 20 BHP, Seamless Carbon Steel tubes with aluminum fins.
		SUB-TOTAL	**$158,000**		**$633,000**	
FURNACES						
H-500	1	Diesel Charge Heater	$277,300	2.5	$679,385	4.7 MM BTU/Hr, Fired Heater, Convection Section shared w/ H-501, Tubes: 9 Cr – 1 Mo w/ 0.1" CA
H-500	1	CEMS	$100,000	1.5	$150,000	
H-500	1	Preheating	$40,000	1.0	$40,000	
H-500	1	Burner Management	$30,000	1.0	$30,000	
H-501	1	Stripper Reboiler	$288,300	2.5	$706,335	5.6 MM BTU/Hr, Fired Heater, Convection Section shared w/ H-500, Tubes: 5 Cr – ½ Mo w/ 0.1" CA
H-501	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-501	1	Preheating	$40,000	1.0	$40,000	
H-501	1	Burner Management	$30,000	1.0	$30,000	
		SUB-TOTAL	**$906,000**		**$1,826,000**	
PUMPS						
P-500 A/B	2	Diesel Feed Pump	$232,000	5.0	$1,160,000	API Centrifugal Pump, 206GPM, 0.81 SG, 2182 Ft. Head, CS Case, 12%CR Impeller, 150HP Motor
P-501 A/B	2	Stripper Bottoms Pump	$54,400	5.0	$272,000	API Centrifugal Pump, 335GPM, 0.60 SG, 481 Ft. Head, CS Case, 12%CR Impeller, 50HP Motor
P-502 A/B	2	Stripper Overhead Pump	$44,400	5.0	$222,000	API Centrifugal Pump, 30GPM, 0.73 SG, 120 Ft. Head, CS Case, 12%CR Impeller, 5HP Motor
		SUB-TOTAL	**$331,000**		**$1,654,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo | **CLIENT: PetroStar**
ANVIL NO: AE1416 | **DATE: 6/17/05**
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COLUMNS						
R-500	1	HDS Reactor	$233,100	4.4	$1,025,640	6'-6" ID X 21'-9" T/T w/one bed of HR-526 Co Mo catalyst, SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-503	1	Naphtha Stripper	$50,900	4.4	$223,960	2'-6" ID (Top), 4'-0" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays, Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-503	1	Naphtha Stripper Trays	$48,700	2.7	$131,490	Valve Trays, SS410
		SUB-TOTAL	**$333,000**		**$1,381,000**	
VESSELS						
V-500	1	Diesel Feed Drum	$34,600	4.2	$145,320	8'-0" ID X 15'-0" T/T (Horizontal), Killed Carbon Steel
V-501	1	High Temperature Separator	$15,500	4.2	$65,100	3'-0" ID X 8'-0" T/T (Vertical), Killed Carbon Steel w/0.15" CA
V-502	1	Low Temperature Separator	$16,100	4.2	$67,620	3'-0" ID X 8'-0" T/T` (Horizontal w/ Boot), Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-504	1	Stripper O. H. Accumulator	$12,800	4.2	$53,760	3'-0" ID X 6'-0" T/T (Horizontal w/Boot), Killed Carbon Steel w/0.125" CA (PWHT)
		SUB-TOTAL	**$79,000**		**$332,000**	
SKID PACKAGES / ALLOWANCES						
	1	Sulfur Analyzer	$250,000	1.0	$250,000	
		SUB-TOTAL	**$250,000**		**$250,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$202,000		$202,000	
		SUB-TOTAL	**$202,000**		**$202,000**	
		TOTAL	**$3,093,000**		**$9,185,000**	

DESIGN SERVICES (% of TIC)	15%	$	2,204,000
OWNER'S SERVICES & COSTS (not included)			
HDS REACTOR CATALYST		$	241,000
MISC. CATALYST, CHEMICALS INITIAL CHARGE		$	200,000
ESCALATION (not included)			
UNADJUSTED COST ESTIMATE (UCE)		$	11,830,000
UNALLOCATED PROVISION (UAP) *contingency*		$	2,970,000
EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*		$	14,800,000
HIGH RANGE *TOTAL INSTALLED COST (TIC)*		$	22,200,000
LOW RANGE *TOTAL INSTALLED COST (TIC)*		$	12,600,000

S:\PETRSTAR\AE1416\PMC\Phase 1 Estimate\HDS BDS Combo\[Valdez ULSD HDS BDS Combo Est Rev 0.xls]Estimate Data

***Note: Field Cost Multiplier includes the following bulk material and installation labor: Civil, Concrete, Structural, Piping, Electrical, Instrumentation, Insulation, Fireproofing, Painting, and Testing.**

ANVIL CORPORATION

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
SHELL & TUBE HEAT EXCHANGERS						
C-101	1	Diesel Feed Cooler	$31,500	4.0	$126,000	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1750SF, CS
C-501	1	Vent Gas Chiller	$25,600	4.0	$102,400	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1200SF, CS
C-601	1	Water Chiller	$41,200	4.0	$164,800	5.3 MM BTU/Hr, 2335 SF w/ 1 shell, TEMA type AES, Tubes: CS , Shell: CS
		SUB-TOTAL	**$98,000**		**$393,000**	
PRESSURE VESSELS						
D-101	1	Diesel Feed Drum	$39,300	4.2	$165,060	1(ea) - Horizontal Vessel, 8'0" DIA x 20'-0" T-T, CS
D-102	1	Liquid Ammonia Storage Tank	$10,900	4.2	$45,780	1(ea) - Horizontal Vessel, 2' 6" DIA x 7' 6" T-T, CS, Insulated(safety)
D-201*	1	Fermentor Reactor	$170,000	4.2	$714,000	1(ea) - 4,000 gal airlift fermenter
D-202*	1	BDS Reactor #1	$230,000	4.2	$966,000	1(ea) - 10,000 gal airlift reactor, S/C Field Erected.
D-203*	1	BDS Reactor #2	$230,000	4.2	$966,000	1(ea) - 10,000 gal airlift reactor, S/C Field Erected.
D-204*	1	BDS Reactor #3	$230,000	4.2	$966,000	1(ea) - 10,000 gal airlift reactor, S/C Field Erected.
D-301	1	Diesel / Water / Biomass Separator	$112,400	4.2	$472,080	1(ea) - Horizontal Vessel, 10'3" DIA x 30'-8" T-T, 304SS, w/ overflow baffle
D-401A/B	2	Salt Drier	$62,600	4.2	$262,920	2(ea) - Horizontal Vessel, 6' DIA x 17' T-T, CS
D-501	1	Diesel / Water Separator	$9,600	4.2	$40,320	1(ea) - Horizontal Vessel, 2'6" DIA x 3'-9" T-T, CS, w/ overflow baffle
L-301	2	Diesel / Water / Biomass Separator	$61,600	4.2	$258,720	2(ea) - Horizontal Vessel, 316L SS, 3' 6" Dia. x 17' 6" T-T, 24"ODx18"IDx120"L Fiberbed Coalescer, Overflow Baffle and 1'x2' Boot
		SUB-TOTAL	**$1,156,000**		**$4,857,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PACKAGED SKIDS/SYSTEMS						
D-205*	1	Seed Tank A	$94,000	2.5	$235,000	Packaged Seed Fermenter System
D-206*	1	Seed Tank B	$328,000	2.5	$820,000	Packaged Seed Fermenter System
J-109A/B	2	Air Compressor	$266,000	2.5	$665,000	2(ea) - Air Compressor, Screw, 700 ACFM, CS body/internals, 65HP Motor Driven
L-109*	1	Glucose Sterilizer	$33,000	2.5	$82,500	1(ea) - Packaged 8 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-110*	1	Nutrients Sterilizer	$33,000	2.5	$82,500	1(ea) - Packaged 8 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-302*	1	Electrostatic Precipitator	$448,000	2.5	$1,120,000	1(ea) - Packaged ESP Unit
L-601*	1	Water Chiller	$401,000	2.5	$1,002,500	1(ea) - Packaged propane refirigeration unit complete w/ compressor, driver, lube oil system, KO drum & all necessary instr. & controls.
L-801*	1	Waste Oxidizer	$280,000	2.5	$700,000	1(ea) - Packaged horizontal thermal oxidizer w/ high intensity burner, refractory lined chamber & stack.
L-901*	1	Water Filtration System	$212,000	2.5	$530,000	1(ea) - Cross flow filtration system for water purification
		SUB-TOTAL	**$2,095,000**		**$5,238,000**	
ATMOSPHERE STORAGE TANKS						
F-101	1	Glucose / Water Storage Tank	$15,400	2.9	$44,660	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 7' DIA x 10' T-T, Epoxy Resin coated CS
F-102A	1	Salt / Water Storage Tank	$10,200	2.9	$29,580	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 4' DIA x 8' T-T, Epoxy Resin coated CS
F-102B	1	Salt / Water Storage Tank	$10,200	2.9	$29,580	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 4' DIA x 8' T-T, Epoxy Resin coated CS
F-103	1	Ethanol / Water Storage Tank	$25,200	2.9	$73,080	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 12 8"' DIA x 8' 6"' T-T, Epoxy Resin coated CS
F-104	1	NaOH / Water Storage Tank	$23,100	2.9	$66,990	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 9' DIA x 14' T-T, Epoxy Resin coated CS
		SUB-TOTAL	**$84,000**		**$244,000**	

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PUMPS						
J-101A/B	2	Diesel Charge Pump	$55,000	4.5	$247,500	2(ea) - API Centrifugal Pump, 190 gpm, 163 ft. Head, 15HP Motor driven, CS, 1 operating, 1 installed spare
J-103A/B	2	Process Water Pump	$6,400	4.5	$28,800	2(ea) - Centrifugal Pump, 3 gpm, 121 ft. Head, .5HP Motor driven, CS, 1 operating, 1 installed spare
J-104A/B	2	Glucose Pump	$11,400	4.5	$51,300	2(ea) - Diaphragm Pump, 0.2 gpm, 31 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-105A/B	2	Nutrients Pump	$10,600	4.5	$47,700	2(ea) - Diaphragm Pump, 0.15 gpm, 39 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-106A/B	2	Ethanol Pump	$12,200	4.5	$54,900	2(ea) - Diaphragm Pump, .3 gpm, 81 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-107A/B	2	Potassium Hydroxide Pump	$12,600	4.5	$56,700	2(ea) - Diaphragm Pump, .4 gpm, 65 ft. Head, Hydraulic, 304SS, 1 operating, 1 installed spare
J-201A/B	2	Fermentor Transfer Pump	$11,200	4.5	$50,400	2(ea) - Rotary Lobe Pump, 2.5 gpm, 43 ft Head, 0.5HP Motor, 304SS, 1 operating, 1 installed spare
J-202A/B	2	BDS Reactor No1 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-203A/B	2	BDS Reactor No2 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-204A/B	2	BDS Reactor No3 Transfer Pump	$21,400	4.5	$96,300	2(ea) - Centrifugal Pump, 700 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-301A/B	2	1st Stg Sep Overflow Pump	$47,600	4.5	$214,200	2(ea) - API Centrifugal Pump, 200 gpm, 49 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-302A/B	2	1st Stg Sep Underflow Pump	$18,400	4.5	$82,800	2(ea) - Centrifugal Pump, 500 gpm, 68 ft. Head, 10HP Motor driven, 304SS, 1 operating, 1 installed spare
J-303A/B	2	2nd Stg Sep Overflow Pump	$11,800	4.5	$53,100	2(ea) - Centrifugal Pump, 145 gpm, 72 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-304A/B	2	2nd Stg Sep Underflow Pump	$10,200	4.5	$45,900	2(ea) - Centrifugal Pump, 45 gpm, 72 ft. Head, 3HP Motor driven, 304SS, 1 operating, 1 installed spare
J-502A/B	2	Vent Gas KO Drum Wtr Pump	$8,600	4.5	$38,700	2(ea) - Centrifugal Pump, 1 gpm, 70 ft. Head, 0.5HP Motor driven, CS, 1 operating, 1 installed spare
J-601 A/B	2	Chilled Water Pump	$19,800	4.5	$89,100	Centrifugal Pump, 2000GPM, 0.95 SG, 81.7 Ft. Head, CS Case, 12%CR Impeller, 20HP Motor
		SUB-TOTAL	**$300,000**		**$1,350,000**	

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
FILTERS						
L-101	1	Diesel Pre-Filter Vessel	$5,210	4.2	$21,882	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 1.5um pore size
L-102	1	Diesel Pre-Filter Vessel	$5,280	4.2	$22,176	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 0.2um pore size
L-103	1	Air Pre-Filter Vessel	$11,400	4.2	$47,880	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - GF element, 30" long, 1.0um pore size
L-104	1	Air Bio-Filter Vessel	$11,125	4.2	$46,725	1(ea) - Filter housing, 316L SS, 43" T-T x 15" Dia. w/ 5 (ea) - PTFE element, 10" long, 0.01um pore size
L-105	1	BDS Reactor #1 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-106	1	BDS Reactor #2 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-107	1	BDS Reactor #3 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-108	1	Air Purge Bio-Filter Vessel	$7,011	4.2	$29,446	1(ea) - Filter housing, 316L SS, 30" T-T x 12" Dia. w/ 3(ea) - PTFE element, 10" long, 0.01um pore size
L-111	1	Ethanol Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-112	1	NAaOH Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-113	1	Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-114	1	Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
L-401	1	Recycle Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-402	1	Recycle Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
		SUB-TOTAL	**$91,000**		**$384,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$268,000		$268,000	
		SUB-TOTAL	**$268,000**		**$268,000**	
		TOTAL	**$4,092,593**		**$12,730,000**	

ANVIL CORPORATION

PROJECT: PetroStar Valdez ULSD - HDS/BDS Combo
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
		DESIGN SERVICES		15%	$ 2,930,000	
		OWNER'S SERVICES & COSTS (provided by owner)			$ -	
		INITIAL CHEMICAL CHARGE			$ 45,000	
		ESCALATION (provided by owner)			$ -	
		UNADJUSTED COST ESTIMATE (UCE)			$ 15,705,000	
		CONTINGENCY			$ 3,895,000	
		EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*			$ 19,600,000	

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***Note: Equipment pricing by Pelorus.**

Appendix C.7. Operating Cost Estimates

HDS/BDS Case -- HDS Unit Operating Costs for 6,000 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 500,984	0.6	602 kw 0.1 $/kwH	
Utility - fuel	$ 927,903	1.1	22.3 MMBTU/H 5 $MMBTU	
Utility - H2 plant feed	$ 636,633	0.7	15.3 MMBTU/H 5 $MMBTU	
Sulfur Disposal	$ 396,127	0.5	3.4 tons/day 0.15 $/Lb	Assuming the sulfur can be disposed of locally.
Chem - fuel additives	$ 106,875	0.1	For All ULSD Produced	
Chem - sulfur plant	$ 130,946	0.2	Caustic & Nutrients for sulfur	
Cost of lost diesel production	$ 699,584	0.8	97% yield on diesel at $1.07/gallon	Yield losses on diesel minus credit for the resulting naphtha & LPG Fuel.
Total volume related costs	**$ 3,399,053**	**4.0**		

Basis:
diesel feed: 252000 gal/day
On-stream availability: 95 %
Diesel yield (% of feed) 97.2 %

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint	
Contract Services	$ 150,000	0.2	All disciplines including laboratory	
Operating Supplies	$ 200,000	0.2	Laboratory and other ovhd	May be somewhat volume dependendent
Maintenance	$ 200,000	0.2	Excluding TA costs	
Turnaround costs	$ 150,000	0.2	Amortized per year cost	Two to Three year turnaround assumed
Insurance & Taxes	$ 592,500	0.7	2.5% of TIC	Based on expected TIC of IBL plant
Catalyst	$ 80,000	0.1	Amortized per year cost	
Total fixed costs	**$ 1,833,850**	**2.2**		

Basis:
HDS, H2, Sulfur Plant Total Insta 23.7 $MM

Total Operating Cost:	2005$/year	cent/gal (ULSD)
	$ 5,232,903	**6.2**

HDS/BDS Case -- BDS Unit Operating Costs for 6,000 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 487,853	0.6	586 kw 0.1 $/kwH	From Pelorus
Utility - steam	$ 470	0.0	8 lb/hr 7.5 $/1000 lb	From Pelorus
Chemicals	$ 486,879	0.6		From Pelorus
Cost of Loss Diesel Production	$ 265,352	0.3	99.7% yield on diesel at $1.07/gallon	From Pelorus
Total volume related costs	**$ 1,240,554**	**1.4**		

Basis:
diesel feed: 252000 gal/day
On-stream availability: 95 %
Diesel yield (% of feed) 99.7 %

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.5	1 op post (24/7) + 1 maint	From Pelorus
Contract Services	$ 98,000	0.1	0.5% of TIC	From Pelorus
Operating Supplies	$ 176,000	0.2	Filters and Membranes	From Pelorus
Maintenance and T/A Costs	$ 294,000	0.3	1.5% of TIC, 2 - 3 Year T/A Cycle	From Pelorus
Insurance & Taxes	$ 490,000	0.6	2.5% of TIC	From Pelorus
Total fixed costs	**$ 1,519,350**	**1.7**		

Basis:
BDS Total Installed Cost: 19.6 $MM

Total Operating Cost:	2005$/year	cent/gal (ULSD)
	$ 2,759,904	**3.2**

Appendix D.1 – Diesel Splitter Process Flow Diagram and Material Balance

V-1
DIESEL CHARGE DRUM
7'-0" I.D. X 15'-0" T/T

E-1
DIESEL SPLITTER
FEED/BOTTOMS EXCHANGER
3.3 MM BTU/HR

E-2
DIESEL SPLITTER
FEED/OVHD EXCHANGER
9.1 MM BTU/HR

E-3
DIESEL SPLITTER
FEED/BOTTOMS EXCHANGER
2.0 MM BTU/HR

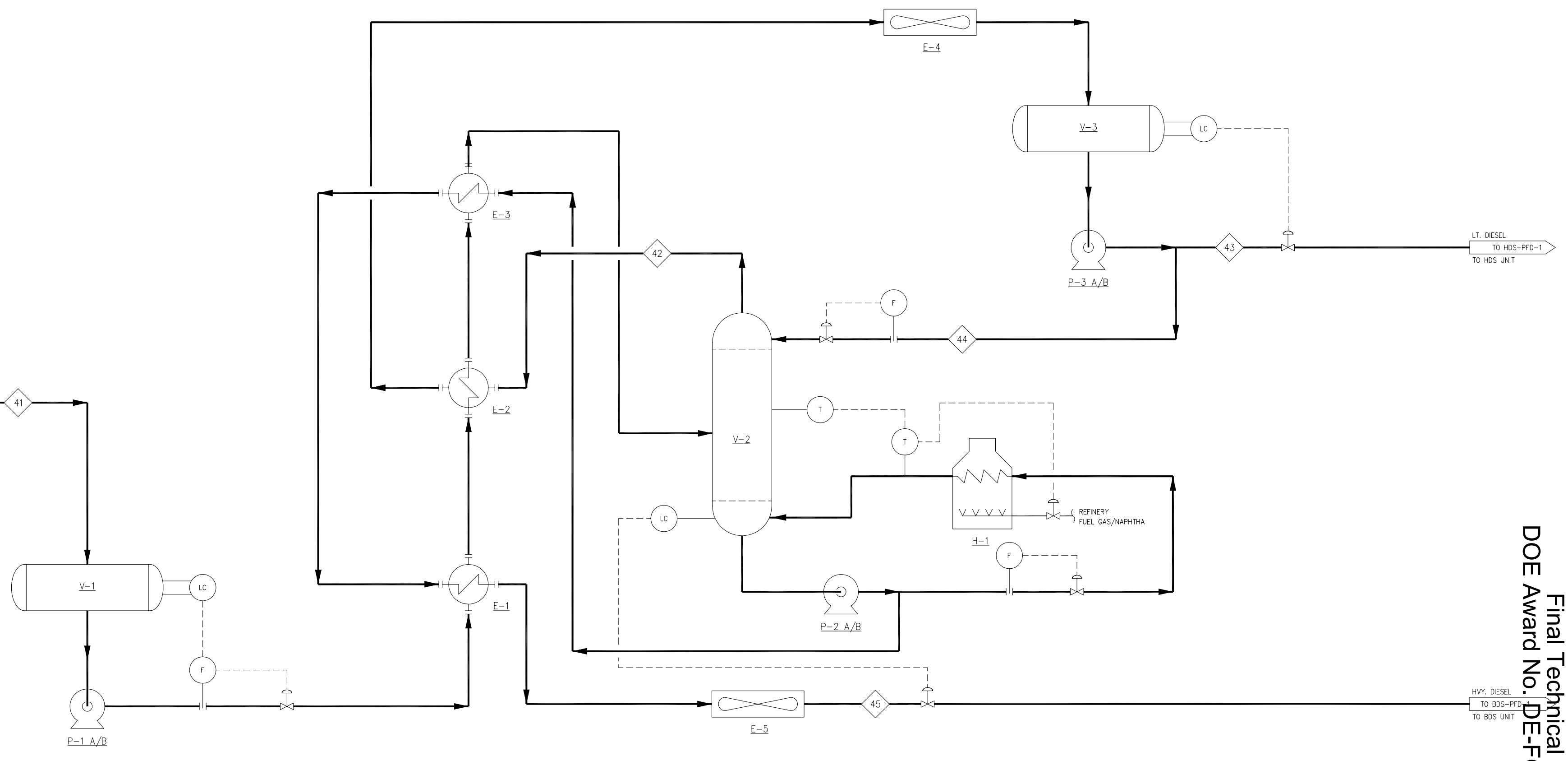
V-2
DIESEL SPLITTER
7'-0" I.D. X 82'-0" T/T
w/30 VALVE TRAYS

H-1
DIESEL SPLITTER REBOILER
17.8 MM BTU/HR (ABSORBED)

E-4
DIESEL SPLITTER
OVHD CONDENSER
11.2 MM BTU/HR

E-5
DIESEL SPLITTER
BOTTOMS COOLER
3.5 MM BTU/HR

V-3
DIESEL SPLITTER
OVHD ACCUMULATOR
6'-0" I.D. X 12'-0" T/T



P-1 A/B
DIESEL SPLITTER CHARGE PUMPS
(ONE OPERATING & ONE SPARE)
206 GPM (RATED)
△P: 90 PSI

P-2 A/B
DIESEL SPLITTER BOTTOMS PUMPS
(ONE OPERATING & ONE SPARE)
1406 GPM (RATED)
△P: 85 PSI

P-3 A/B
DIESEL SPLITTER OVHD PUMPS
(ONE OPERATING & ONE SPARE)
290 GPM (RATED)
△P: 70 PSI

REVISIONS

REV.	DATE	BY	APP'D	DESCRIPTION

SCALE AS NOTED | MO | DAY | YR
DRAWN
CHK'D
APP'D
APP'D
APPROVED
DATE
PROJECT

Alaska Anvil
Anvil Job No.: AE1416
Acad File No.: prefrac_pfd
Date & Time: 06/17/05

PROCESS FLOW DIAGRAM
DIESEL SPLITTER
PRE FRAC CASE

DRAWING NUMBER PREFRAC-PFD-1
REV. △

Material Balance

Diesel Splitter Material Balance -- Pre Frac Case

Stream Number		41	42	43	44	45
Stream Description		ANS Feed	Diesel Splitter OVHD	Light Diesel	Diesel Splitter Reflux	Heavy Diesel
Phase		LIQUID	VAPOR	LIQUID	LIQUID	LIQUID
Mass Flow Rate	LB/HR	75960	95923	47961	47961	28004
Temperature	F	216	559	380	380	120
Pressure	PSIG	20	10	72	72	68
Standard Liq Flow	BPD	6021	n/a	3852	3852	2169
Vapor Flow	MSCFH	n/a	183.2	n/a	n/a	n/a
Wt % Vapor		0	100	0	0	0
MW		216.7	198.7	198.7	198.7	256.6

Appendix D.2 – Diesel Splitter Equipment List and Budgetary Equipment Datasheets

Diesel Splitter Equipment List

Item	Service	Description	Design Conditions Pressure Temp.	Metallurgy
E-1	Diesel Splitter Feed/Bottoms Exchanger	3.3 MM BTU/Hr, 450 FT2 w/1 shell, TEMA type AEU	Tubes: 125 PSIG, 680°F Shell: 120 PSIG, 400°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo Shell: 1 ¼ Cr – ½ Mo
E-2	Diesel Splitter Feed / Overhead	9.1 MM BTU/Hr, 1640 FT2 w/1 shell, TEMA type AEU	Tubes: 120 PSIG, 550°F Shell: 75 PSIG, 610°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo Shell: 1 ¼ Cr – ½ Mo
E-3	Diesel Splitter Feed / Bottoms	2.0 MM BTU/Hr, 620 FT2 w/1 shell, TEMA type AEU	Tubes: 125 PSIG, 750°F Shell: 120 PSIG, 600°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo Shell: 1 ¼ Cr – ½ Mo
E-4	Diesel Splitter Ovhd Condenser	11.2 MM BTU/Hr 603 FT2 Bare Tube 12800 FT2 Extended Shaft HP: 15 BHP	Tubes: 75 PSIG, 610°F	Seamless Carbon Steel tubes with aluminum fins
E-5	Diesel Splitter Bottoms Cooler	3.5 MM BTU/Hr 729 FT2 Bare Tube 15500 FT2 Extended Shaft HP: 15 BHP	Tubes: 125 PSIG, 450°F	Seamless Carbon Steel tubes with aluminum fins
H-1	Diesel Splitter Reboiler	17.8 MM BTU/Hr Fired Heater	Tubes: 150 PSIG, 750°F	Tubes: 9 Cr – 1 Mo w/ 0.1" CA
P-1A/B	Diesel Splitter Charge Pump	Rated Capacity: 206 GPM Diff. Press: 90 PSI Head: 257 feet Motor: 20 HP		Casing: killed C. S. w/0.125" CA Impeller: 12% chrome
P-2A/B	Diesel Splitter Bottoms Pump	Rated Capacity: 1406 GPM Diff. Press: 85 PSI Head: 305 feet Motor: 125 HP		Casing: killed C. S. w/0.125" CA Impeller: 12% chrome
P-3A/B	Diesel Splitter Reflux Pump	Rated Capacity: 290 GPM Diff. Press: 70 PSI Head: 188 feet Motor: 20 HP		Casing: killed C. S. w/0.125" CA Impeller: 12% chrome
V-1	Charge Drum	7'-0" ID X 15'-0" T/T (Horizontal)	50 PSIG/FV 275/-20°F	Killed Carbon Steel w/0.2" CA
V-2	Diesel Splitter Tower	7'-0" ID X 82'-0" T/T w/ 30 valve trays	75 PSIG/FV 610 °F (top) and 750 °F (bottom)	Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-3	Diesel Splitter Overhead Accumulator	6'-0" ID X 12'-0" T/T` (Horizontal)	75 PSIG/FV 610/-20°F	Killed Carbon Steel w/ 0.2" CA

ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/16/2005

ITEM NUMBER	X	E-1		
SERVICE	X	Diesel Splitter Feed / Bottoms		
TEMA TYPE	X	AEU		
SURFACE AREA (TOTAL) FT^2	x	450		
NUMBER OF SHELLS	x	One		
TUBE SIDE (Note 1)				
FLUID	x	Heavy Diesel		
DESIGN PRESSURE, PSIG	x	125		
DESIGN TEMPERATURE, ^{O}F	X	680		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo		
SHELL SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	120		
DESIGN TEMPERATURE, ^{O}F	x	400 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo		
DUTY, MMBTU/HR	O	3.3		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/16/2005

ITEM NUMBER	X	E-2		
SERVICE	X	Diesel Splitter Feed / Overhead		
TEMA TYPE	X	AEU		
SURFACE AREA (TOTAL) FT^2	x	1640		
NUMBER OF SHELLS	x	One		
TUBE SIDE (Note 1)				
FLUID	x	Diesel Feed		
DESIGN PRESSURE, PSIG	x	120		
DESIGN TEMPERATURE, ^OF	X	550		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo		
SHELL SIDE				
FLUID	x	Light Diesel		
DESIGN PRESSURE, PSIG	x	75		
DESIGN TEMPERATURE, ^OF	x	610 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo		
DUTY, MMBTU/HR	O	9.1		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER HDS/BDS Study — **PROJECT ENGINEER** AMH
LOCATION Alaska — **PROJECT** AE1416
PROCESS UNIT Prefractionation Option — **DATE** 5/16/2005

ITEM NUMBER	X	E-3		
SERVICE	X	Diesel Splitter Feed / Bottoms		
TEMA TYPE	X	AEU		
SURFACE AREA (TOTAL) FT^2	x	620		
NUMBER OF SHELLS	x	One		
TUBE SIDE (Note 1)				
FLUID	x	Heavy Diesel		
DESIGN PRESSURE, PSIG	x	125		
DESIGN TEMPERATURE, ^{O}F	X	750		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo		
SHELL SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	120		
DESIGN TEMPERATURE, ^{O}F	x	600 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo		
DUTY, MMBTU/HR	O	2.0		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	E-4		
SERVICE	X	Diesel Splitter Ovhd Cond.		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Light Diesel		
INLET TEMPERATURE	X	520		
OUTLET TEMPERATURE	X	380		
DESIGN TEMPERATURE, ^{O}F	X	610		
DESIGN PRESSURE, PSIG	X	75		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	603		
EXTENDED SURFACE	X	12,800		
TYPE OF FINS	O			
FAN HORSEPOWER (EACH)	X	15		
NUMBER OF FANS	X	1		
MATERIAL OF CONSTRUCTION	X	(Note 1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	11.2		
LOUVERS (YES / NO)	O	Yes		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	No		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEE**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	E-5		
SERVICE	X	Diesel Splitter Bottoms Cooler		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Heavy Diesel		
INLET TEMPERATURE	X	360		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	450		
DESIGN PRESSURE, PSIG	X	125		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	729		
EXTENDED SURFACE	X	15,500		
TYPE OF FINS	O			
FAN HORSEPOWER (EACH)	X	15		
NUMBER OF FANS	X	1		
MATERIAL OF CONSTRUCTION	X	(Note 1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	3.5		
LOUVERS (YES / NO)	O	Yes		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	No		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PROCESS HEATERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	4/7/2005

ITEM NUMBER	X	H-1		
SERVICE	X	Diesel Splitter Reboiler		
HEATER TYPE	X	Fired Heater		
FLUID	X	Diesel		
TOTAL FLOW RATE, LB/HR	X	381,700		
LIQUID OUTLET - GPM	X	1260.7		
DENSITY, LB/FT^3	X	40.3		
VISCOSITY, CP	X	0.17		
SPECIFIC HEAT, BTU/LB-°F	X	0.71		
VAPOR OUTLET- MMSCFD	X	6.2		
DENSITY, LB/FT^3	X	0.69		
VISCOSITY, CP	X	0.01		
SPECIFIC HEAT, BTU/LB-°F	X	0.63		
THERMAL COND., $BTU/HR-FT^2$-°F	X	0.02		
INLET TEMPERATURE	X	663		
OUTLET TEMPERATURE	X	670		
DESIGN TEMPERATURE (°F)	X	750		
DESIGN PRESSURE (PSIG)	X	150		
MATERIAL OF CONSTRUCTION	X	9 Cr - 1 Mo + 0.1" CA		
ABS DUTY, MMBTU/HR	X	17.80		

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEEI**	AMH
LOCATION		Alaska	**PROJECT**	AE1416
PROCESS UNIT		Prefractionation Option	**DATE**	5/17/2005
ITEM NUMBER	X	P-1 A/B (Note 1)		
SERVICE (FLUID)	X	Diesel Splitter Charge Pump		
TEMPERATURE OF FLUID	X	216		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.803		
RATED FLOW (GPM)	X	206		
SUCTION PRESSURE, PSIG	X	3		
DISCHARGE PRESSURE PSIG	X	93		
NPSH AVAILABLE (FT)	X	10		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (Note 2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	20		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
Differential Pressure, PSIG	X	90		
Differential Head, Feet	X	257		

REMARKS

1) One operating pump + one spare

2) With 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	P-2 A/B (Note 1)		
SERVICE (FLUID)	X	Diesel Splitter Btms Pump		
TEMPERATURE OF FLUID	X	660		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.642		
RATED FLOW (GPM)	X	1406		
SUCTION PRESSURE, PSIG	X	12		
DISCHARGE PRESSURE PSIG	X	97		
NPSH AVAILABLE (FT)	X	11		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (Note 2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	125		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
Differential Pressure, PSIG	X	85		
Differential Head, Feet	X	305		

REMARKS

1) One operating pump + one spare
2) With 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION		Alaska	**PROJECT**	AE1416
PROCESS UNIT		Prefractionation Option	**DATE**	5/17/2005
ITEM NUMBER	X	P-3 A/B (Note 1)		
SERVICE (FLUID)	X	Diesel Splitter Ovhd Pump		
TEMPERATURE OF FLUID	X	380		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.86		
RATED FLOW (GPM)	X	290		
SUCTION PRESSURE, PSIG	X	7		
DISCHARGE PRESSURE PSIG	X	77		
NPSH AVAILABLE (FT)	X	10		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (Note 2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	20		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
Differential Pressure, PSIG	X	70		
Differential Head, Feet	X	188		

REMARKS

1) One operating pump + one spare
2) With 0.125" CA

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	V-1		
SERVICE	X	Charge Drum		
FLUID	X	Diesel Feed		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	7' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	15' - 0"		
SKIRT HEIGHT (FT-IN)	X	(Note 2)		
DESIGN TEMPERATURE (°F)	X	275 / -20		
DESIGN PRESSURE (PSIG)	X	50 (Note 1)		
MATERIAL OF CONSTRUCTION	X	(Note 3)		
INSULATION (YES/NO)		Yes		
TRAY OR PACKING TYPE	X	None		
NUMBER OF TRAYS	X	None		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) Vessels will be designed for Full Vacuum unless otherwise specified.
2) The horizontal vessel will be supported on saddles 10 feet above grade.
3) Vessel to be killed CS + 0.2" CA.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	V-2		
SERVICE	X	Diesel Splitter Tower		
FLUID	X	Crude Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	7' 0"		
TANGENT TO TANGENT LENGTH, FT.	X	82' 0"		
SKIRT HEIGHT (FT-IN)	X	15'-0"		
DESIGN TEMPERATURE (°F)	X	750 (bottom) / 610 (top)		
DESIGN PRESSURE (PSIG)	X	75 (Note 1)		
MATERIAL OF CONSTRUCTION	X	(Note 2)		
INSULATION (YES/NO)		Yes		
TRAY OR PACKING TYPE	X	Valve Trays		
NUMBER OF TRAYS	X	30		
TRAY MATERIAL	X	410 S.S.		
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Vortex breaker at base		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS
1) Vessel will be designed for full vacuum unless otherwise specified
2) Vessel to be killed CS + 0.2" CA. Trays and downcomers are Type 410 SS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	AMH
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	Prefractionation Option	**DATE**	5/17/2005

ITEM NUMBER	X	V-3		
SERVICE	X	Splitter Overhead accumulator		
FLUID	X	Light Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	6' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	12' - 0"		
SKIRT HEIGHT (FT-IN)	X	N/A		
DESIGN TEMPERATURE (°F)	X	610 / -20		
DESIGN PRESSURE (PSIG)	X	75 (Note 1)		
MATERIAL OF CONSTRUCTION	X	Killed CS (Note 2)		
INSULATION (YES/NO)		Yes		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	None		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) Add 0.2" CA

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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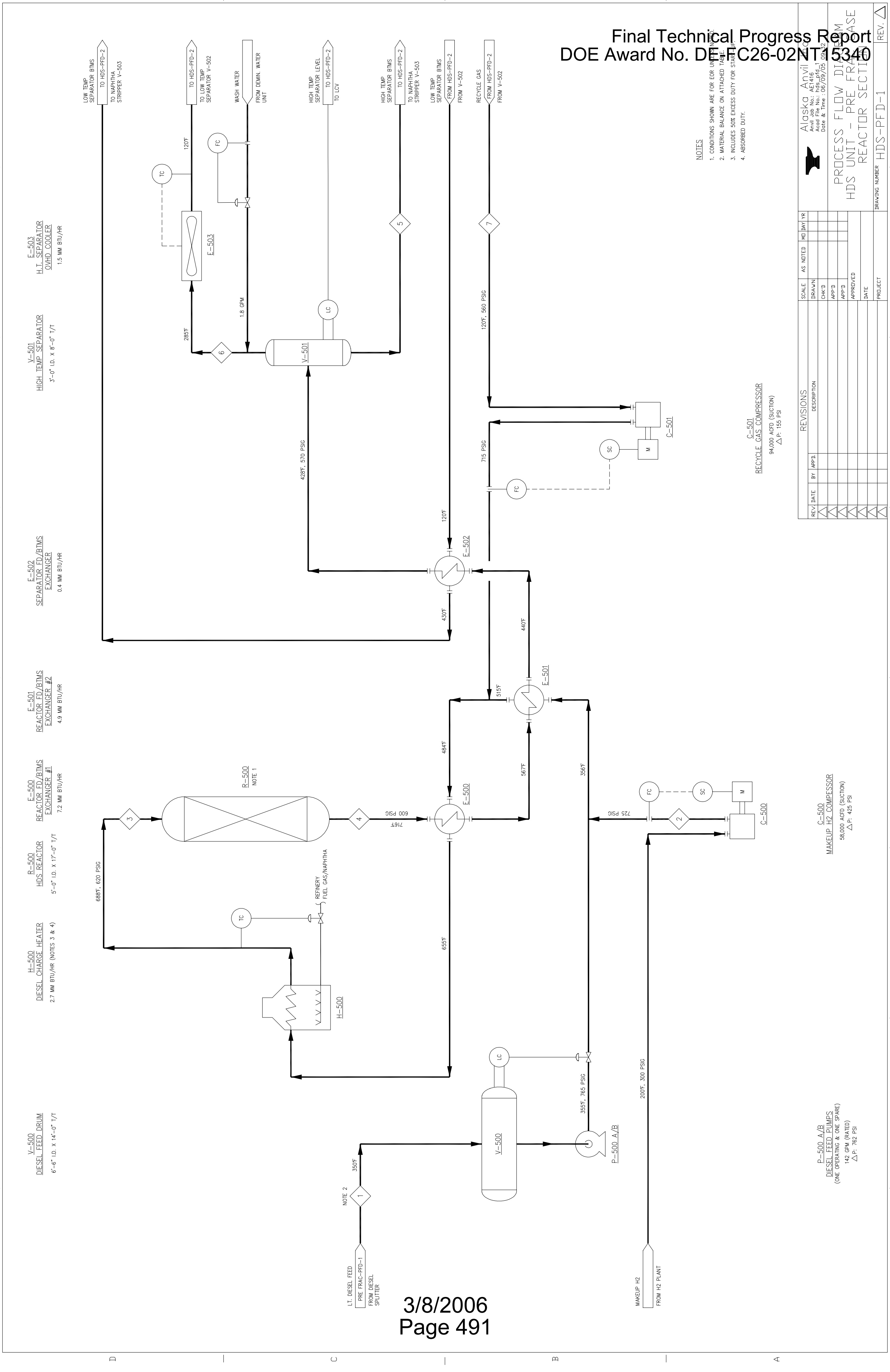
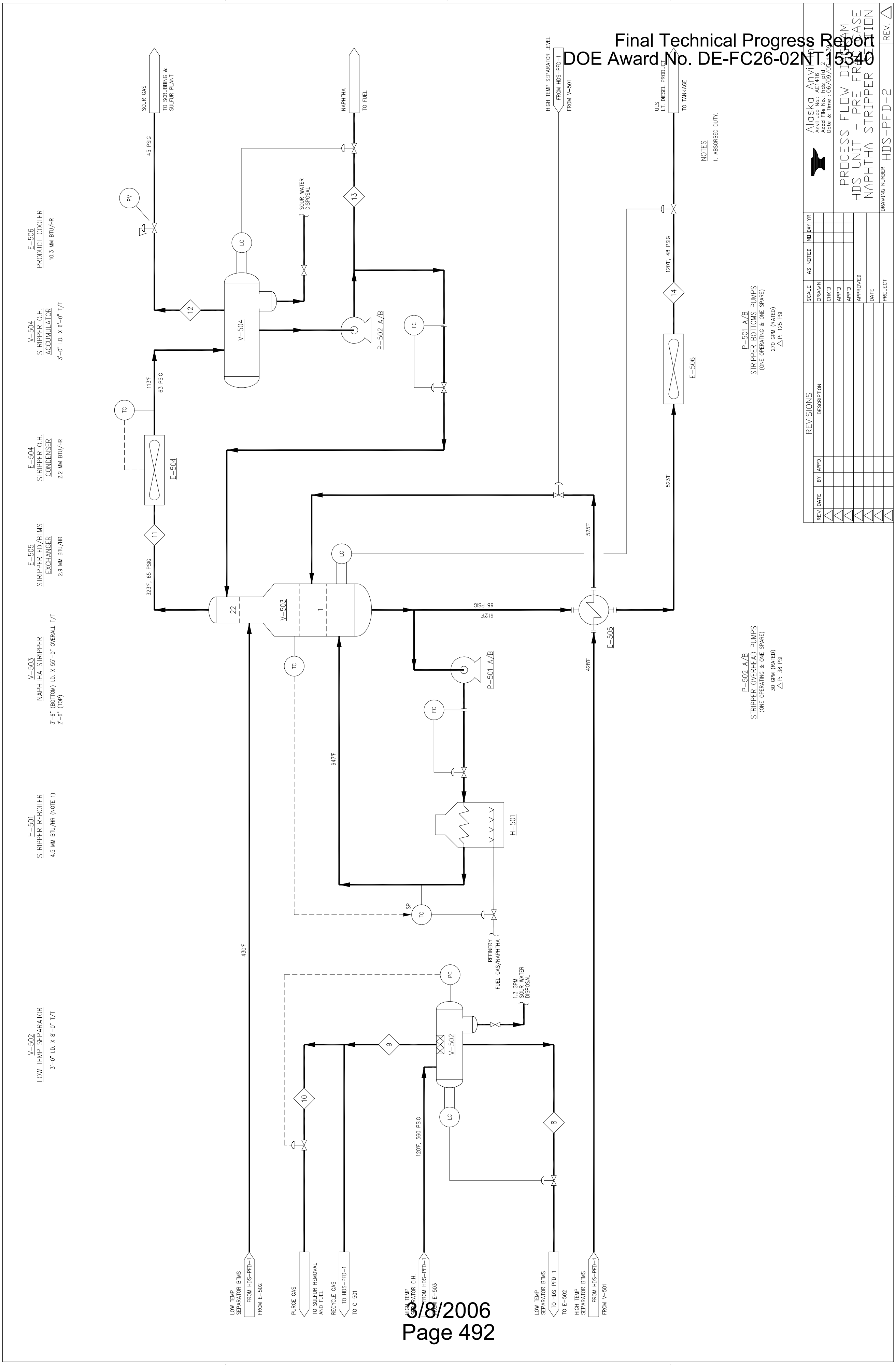
Appendix D.3 – Sulfur Speciation in Diesel Splitter Products

Light Diesel Sulfur Speciation (Feed to HDS) (Ratioed to 5,000 ppm*)			
Component	**ppm wt sulfur**	**Component**	**ppm wt sulfur**
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	<1
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	46
Thiophene	<1	Trimethyl benzothiophene	187
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	558
Isobutyl mercaptan	<1	Dibenzothiophene	162
Ethyl sulfide	<1	4-Methyl benzothiophene	4
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	<1
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	<1
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	<1
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	<1
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	<1
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	<1
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

Heavy Diesel Sulfur Speciation (Feed to BDS) (Ratioed to 5,000 ppm*)			
Component	**ppm wt sulfur**	**Component**	**ppm wt sulfur**
Hydrogen sulfide	<1	2-Ethyl thiophene	<1
Carbonyl sulfide	<1	2,5-Dimethyl thiophene	<1
Methyl mercaptan	<1	3-Ethyl thiophene	<1
Ethyl mercaptan	<1	2,4&2,-Dimethyl thiophene	<1
Dimethyl sulfide	<1	3,4-Dimethyl thiophene	<1
Carbon disulfide	<1	Methyl Ethyl thiophenes	<1
Isopropyl mercaptan	<1	Trimethyl thiophenes	<1
Ethyl sulfide	<1	Tetramethyl thiophenes	<1
tert-Butyl mercaptan	<1	Benzothiophene	<1
N-Propyl mercaptan	<1	Methyl benzothiophene	<1
Ethyl Methyl Sulfide	<1	Dimethyl benzothiophene	<1
Thiophene	<1	Trimethyl benzothiophene	<1
sec-Butyl Mercaptan	<1	Tetramethyl Benzothiophene	<1
Isobutyl mercaptan	<1	Dibenzothiophene	344
Ethyl sulfide	<1	4-Methyl benzothiophene	576
MN-butyl mercaptan	<1	3-Methyl DBZT+2-methyl DBZT	401
Dimethyl disulfide	<1	1-Methyl dibenzothiophene	258
2-Methyl thiophene	<1	4,6 Dimethyl dibenzothiophene	265
3-Methyl thiophene	<1	Dimethyl dibenzothiophene	968
Tetra-hydro thiophene	<1	Trimethyl dibenzothiophene	205
Ethyl methyl disulfide	<1	Tetramethyl dibenzothiophene	10
2-Methyl-tetra-hydro-thiophene	<1	Unidentified volatile sulfur	3,283

Appendix D.4 – HDS Unit Process Flow Diagrams and Material Balance


V-500
DIESEL FEED DRUM
6'-6" I.D. X 14'-0" T/T
H-500
DIESEL CHARGE HEATER
2.7 MM BTU/HR (NOTES 3 & 4)
R-500
HDS REACTOR
5'-0" I.D. X 17'-0" T/T
E-500
REACTOR FD/BTMS
EXCHANGER #1
7.2 MM BTU/HR
E-501
REACTOR FD/BTMS
EXCHANGER #2
4.9 MM BTU/HR
E-502
SEPARATOR FD/BTMS
EXCHANGER
0.4 MM BTU/HR
V-501
HIGH TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
E-503
H.T. SEPARATOR
OVHD COOLER
1.5 MM BTU/HR
C-501
RECYCLE GAS COMPRESSOR
94,000 ACFD (SUCTION)
ΔP: 155 PSI
C-500
MAKEUP H2 COMPRESSOR
58,000 ACFD (SUCTION)
ΔP: 425 PSI
P-500 A/B
DIESEL FEED PUMPS
(ONE OPERATING & ONE SPARE)
142 GPM (RATED)
ΔP: 762 PSI
NOTES
2. MATERIAL BALANCE ON ATTACHED TABLE.
3. INCLUDES 50% EXCESS DUTY FOR START UP.
4. ABSORBED DUTY.
REVISIONS
Alaska Anvil
PROCESS FLOW DIAGRAM
HDS UNIT - PRE FRAC BASE
REACTOR SECTION
HDS-PFD-1


PROCESS FLOW DIAGRAM
HDS UNIT - PRE FRACTIONATION
NAPHTHA STRIPPER SECTION
Alaska Anvil
DRAWING NUMBER HDS-PFD-2
REV.
REVISIONS
V-502
LOW TEMP SEPARATOR
3'-0" I.D. X 8'-0" T/T
H-501
STRIPPER REBOILER
4.5 MM BTU/HR (NOTE 1)
V-503
NAPHTHA STRIPPER
E-505
STRIPPER FD/BTMS EXCHANGER
2.9 MM BTU/HR
E-504
STRIPPER O.H. CONDENSER
2.2 MM BTU/HR
V-504
STRIPPER O.H. ACCUMULATOR
3'-0" I.D. X 6'-0" T/T
E-506
PRODUCT COOLER
10.3 MM BTU/HR
P-501 A/B
STRIPPER BOTTOMS PUMPS
(ONE OPERATING & ONE SPARE)
270 GPM (RATED)
P-502 A/B
STRIPPER OVERHEAD PUMPS
(ONE OPERATING & ONE SPARE)
30 GPM (RATED)
NOTES
1. ABSORBED DUTY.
SOUR GAS
TO SCRUBBING & SULFUR PLANT
NAPHTHA
TO FUEL
ULS LT. DIESEL PRODUCT
TO TANKAGE
HIGH TEMP SEPARATOR LEVEL
FROM HDS-PFD-1
FROM V-501
SOUR WATER DISPOSAL
REFINERY FUEL GAS/NAPHTHA
LOW TEMP SEPARATOR BTMS
FROM HDS-PFD-1
FROM E-502
PURGE GAS
TO SULFUR REMOVAL AND FUEL
RECYCLE GAS
TO HDS-PFD-1
TO C-501
HIGH TEMP SEPARATOR O.H.
FROM HDS-PFD-1
FROM E-503
LOW TEMP SEPARATOR BTMS
TO HDS-PFD-1
TO E-502
HIGH TEMP SEPARATOR BTMS
FROM HDS-PFD-1
FROM V-501

Material Balance

HDS Unit EOR Material Balance -- Pre Frac Case

Stream Number		1	2	3	4	5	6	7
Stream Description		Lt. Diesel Feed	Make-up H2	Reactor Feed	Reactor Outlet	V-501 Liquid	V-501 Vapor + Wash Water	Recycle Gas
Phase		LIQUID	VAPOR	MIXED	MIXED	LIQUID	MIXED	VAPOR
Mass Flow Rate	LB/HR	48196	216	50320	50321	46071	5140	1908
Temperature	F	350	442	688	716	428	285	120
Pressure	PSIG	3	725	620	600	570	570	560
Standard Liq Flow	BPD	3870	n/a	2066	1131	3753	129	n/a
Vapor Flow	MSCFH	n/a	39.8	214.9	217.6	n/a	157.2	135.1
Wt % Vapor		0	100	49	72	0	69	100
MW		197.9	2.1	71.4	77.3	174.3	11.8	5.4

Stream Number		8	9	10	11	12	13	14
Stream Description		V-502 HC Liquid	V-502 Vapor	Purge Gas	Column Vapor to Condenser	Sour Gas	Naphtha	Lt. Diesel
Phase		LIQUID	VAPOR	VAPOR	VAPOR	VAPOR	LIQUID	LIQUID
Mass Flow Rate	LB/HR	2285	1971	62	9710	379	2127	45843
Temperature	F	120	120	120	323	113	113	120
Pressure	PSIG	560	560	560	65	63	104	48
Standard Liq Flow	BPD	196	n/a	n/a	n/a	n/a	190	3699
Vapor Flow	MSCFH	n/a	139.5	4.4	47.9	7.9	n/a	n/a
Wt % Vapor		0	100	100	100	100	0	0
MW		115.5	5.4	5.4	77.0	18.2	88.6	191.7

Appendix D.5 – HDS Unit Equipment List and Budgetary Equipment Datasheets

HDS Unit Equipment List

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
R-500	HDS Reactor	5'-0" ID X 17'-0" T/T w/ one bed of HR-526 Co Mo catalyst.	670 PSIG/FV	750°F/-20°F	SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-500	Diesel Feed Drum	6'-6" ID X 14'-0" T/T (Horizontal)	50 PSIG/FV	450/-20°F	Killed Carbon Steel
V-501	High Temperature Separator	3'-0" ID X 8'-0" T/T (Vertical)	620 PSIG/FV	465/-20°F	Killed Carbon Steel w/0.15" CA
V-502	Low Temperature Separator	3'-0" ID X 8'-0" T/T (Horizontal w/ Boot)	610 PSIG/FV	465/-20°F	Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-503	Naphtha Stripper	2'-6" ID (Top), 3'-6" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays	125 PSIG/FV	700/-20°F	Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-504	Stripper O. H. Accumulator	3'-0" ID X 6'-0" T/T (Horizontal w/Boot)	125 PSIG/FV	375/-20°F	Killed Carbon Steel w/0.125" CA (PWHT)
E-500	Reactor Fd/Btms Exchanger #1	7.2 MM BTU/Hr, 1870 FT^2 w/ 2 shells, TEMA type CEU	Tubes: 650 PSIG Shell: 765 PSIG	770°F 705°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	Reactor Fd/Btms Exchanger #2	4.9 MM BTU/Hr, 1735 FT^2 w/2 shells, TEMA type CEU	Tubes: 640 PSIG Shell: 775 PSIG	600°F 540°F/-20°F	Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover Shell: Killed C. S. w/0.125" CA
E-502	Separator Fd/Btms Exchanger	0.4 MM BTU/Hr, 85 FT^2, double pipe.	Tubes: 630 PSIG Shell: 610 PSIG	465°F 465/-20°F	Tubes: Carbon Steel Shell: Carbon Steel
E-503	H. T. Separator Overhead Cooler	1.5 MM BTU/Hr 318 FT^2 (Bare Tube) 6829 FT^2 Extended Surface, 5 HP Fan	Tubes: 620 PSIG	465°F	Seamless Carbon Steel tubes with aluminum fins
E-504	Stripper O. H. Condenser	2.2 MM BTU/Hr 406 FT^2 (Bare Tube) 8733 FT^2 Extended Surface, 5 HP Fan	Tubes: 125 PSIG	375°F	Seamless Carbon Steel tubes with aluminum fins
E-505	Stripper Fd/Btms Exchanger	2.9 MM BTU/Hr 830 FT^2 w/1 shell, TEMA type CEU	Tubes: 620 PSIG Shell: 100 PSIG	575°F 670°F/-20°F	Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS Shell: CS w/0.25" CA, CS baffles
E-506	Product Cooler	10.3 MM BTU/Hr 1463 FT^2 (Bare Tube) 31640 FT^2 Extended Surface, 20 HP Fan	Tubes: 100 PSIG	550°F	Seamless Carbon Steel tubes with aluminum fins
H-500	Diesel Charge Heater	2.7 MM BTU/Hr Fired Heater, Convection Section shared w/ H-501	Tubes: 755 PSIG	760°F	Tubes: 9 Cr – 1 Mo w/ 0.1" CA
H-501	Stripper Reboiler	4.5 MM BTU/Hr Fired Heater, Convection Section shared w/ H-500	Tubes: 230 PSIG	710°F	Tubes: 5 Cr – ½ Mo w/ 0.1" CA

Item	Service	Description	Design Conditions		Metallurgy
			Pressure	Temp.	
C-500	Makeup Hydrogen Compressor	Capacity: 57312 ACFD Motor Driven Shaft HP: 71 BHP	Suction: 300 PSIG Disch: 725 PSIG	Suction: 200°F	Casing: killed C. S. Internals: CS
C-501	Recycle Gas Compressor	Capacity: 93744 ACFD Motor Driven Shaft HP: 54 BHP	Suction: 560 PSIG Disch: 715 PSIG	Suction: 120°F	Casing: killed C. S. Internals: Stainless Steel
P-500 A/B	Diesel Feed Pump (One Operating + One Spare	Rated Capacity: 142 GPM Diff. Press: 762 PSI Head: 2363 feet Motor: 125 HP			Casing: killed C. S. w/ 0.125” CA Impeller: 12% chrome
P-501 A/B	Stripper Bottoms Pump (One Operating + One Spare	Rated Capacity: 270 GPM Diff. Press: 125 PSI Head: 476 feet Motor: 40 HP			Casing: killed C. S. w/ 0.2” CA Impeller: 12% chrome
P-502 A/B	Stripper Overhead Pump (One Operating + One Spare	Rated Capacity: 30 GPM Diff. Press: 38 PSI Head: 119 feet Motor: 5 HP			Casing: killed C. S. w/ 0.125” CA Impeller: 12% chrome

ANVIL **BUDGETARY DATA SHEET**
COMPRESSORS AND DRIVERS

CUSTOMER Petrostar -- Pre Frac Case **PROJECT ENGINEER BGJ**
LOCATION Alaska **PROJECT NO. AE1416**
PROCESS UNIT HDS Unit **DATE 5/31/05**

ITEM NUMBER	X	C-500		
FLUID	X	Makeup H2		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	57,312		
SUCTION TEMPERATURE ^{O}F	X	200		
SUCTION PRESSURE, PSIA	X	315		
DISCHARGE PRESSURE, PSIA	X	740		
GAS MOLECULAR WEIGHT	X	2.06		
'K' VALUE OF GAS	X	1.40		
MOL % HYDROGEN IN GAS	X	99.7		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	None		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	100		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	71		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS
1) Will be subject to -20°F ambient conditions.

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET
COMPRESSORS AND DRIVERS

CUSTOMER	Petorstar-- Pre Frac Case	**PROJECT ENGINEER BGJ**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	HDS Unit	**DATE 5/31/05**	

ITEM NUMBER	X	C-501		
FLUID	X	Recycle Gas		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Recip		
TOTAL NUMBER OF MACHINES	X	One		
RATED CAPACITY (ACFD @ SUCTION)	X	93,744		
SUCTION TEMPERATURE ^{O}F	X	120		
SUCTION PRESSURE, PSIA	X	575		
DISCHARGE PRESSURE, PSIA	X	730		
GAS MOLECULAR WEIGHT	X	5.4		
'K' VALUE OF GAS	X	1.39		
MOL % HYDROGEN IN GAS	X	88.5		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	H2S, H2O		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVE, VALVES MATERIAL	M	Stainless Steel		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER, Motor HP	X	75		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER, BHP	X	54		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS
1) Will be subject to -20 °F ambient conditions.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-500		
SERVICE	X	Reactor Fd/Btms Exch #1		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	1870		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	650		
DESIGN TEMPERATURE, ^OF	X	770		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	765		
DESIGN TEMPERATURE, ^OF	x	705 / -20		
MATERIAL OF CONSTRUCTION	x	1 1/4Cr-1/2 Mo (3)		
DUTY, MMBTU/HR	O	7.2		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Type 1 1/4 Cr - 1/2 Mo for tubes and tube sheet and weld overlay 316 SS for tube sheet, channnel, cover & nozzles.
U tubes to be PWHT.
3) Clad w/ Type 321 SS , Baffles to be Type 304 SS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-501		
SERVICE	X	Reactor Fd/Btms Exch #2		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	1735		
NUMBER OF SHELLS	x	Two		
TUBE SIDE				
FLUID	x	Diesel w/ H2 (Rx Effluent)		
DESIGN PRESSURE, PSIG	x	640		
DESIGN TEMPERATURE, ^OF	X	600		
MATERIAL OF CONSTRUCTION	x	1 1/4 Cr - 1/2 Mo (2)		
SHELL SIDE				
FLUID	x	Diesel w/ H2 (Rx Feed)		
DESIGN PRESSURE, PSIG	x	775		
DESIGN TEMPERATURE, ^OF	x	540 / -20		
MATERIAL OF CONSTRUCTION	x	Killed C. S. (3)		
DUTY, MMBTU/HR	O	4.9		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

(2) Use SA182 F11 (1 1/4 Cr - 1/2 Mo) for tubesheet + channel cover + nozzles and SA 387 Gr 11 for channel
Weld overlay tube sheet, channel cover, and channel with 321 SS.

(3) Use 0.125" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-502		
SERVICE	X	Separator Fd/Btms Exch		
TEMA TYPE	X	Double Pipe		
SURFACE AREA (TOTAL) FT^2	x	85		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel w/Hydrogen		
DESIGN PRESSURE, PSIG	x	630		
DESIGN TEMPERATURE, ^{O}F	X	465		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Hydrocarbon		
DESIGN PRESSURE, PSIG	x	610		
DESIGN TEMPERATURE, ^{O}F	x	465 / -20		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	O	0.4		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) USE DOUBLE PIPE EXCHANGER OR EQUAL.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-503		
SERVICE	X	H. T. Seprtr Ovrhd Clr		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Hydrocarbon Vapor/Water		
INLET TEMPERATURE	X	285		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	465		
DESIGN PRESSURE, PSIG	X	620		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	318		
EXTENDED SURFACE	X	6,829		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	SA179 (1)		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	1.5		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Killed carbon steel for the header.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case		**PROJECT ENGINEER**	BGJ
LOCATION	Alaska		**PROJECT**	AE1416
PROCESS UNIT	HDS Unit		**DATE**	5/31/2005

ITEM NUMBER	X	E-504		
SERVICE	X	Strpr Ovrhd Condenser		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	HC Vapor/Naphtha		
INLET TEMPERATURE	X	323		
OUTLET TEMPERATURE	X	113		
DESIGN TEMPERATURE, ^{O}F	X	375		
DESIGN PRESSURE, PSIG	X	125		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	406		
EXTENDED SURFACE	X	8,733		
TYPE OF FINS	O			
FAN HORSEPOWER	X	5		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note (1)		
MAXIMUM BUNDLE LENGTH,FT.	X			
DUTY, 10^6 BTU/HR	O	2.2		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) Seamless CS tubes with aluminum fins. Killed CS header with 0.2" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-505		
SERVICE	X	Stripper Fd/Btms Exch		
TEMA TYPE	X	CEU		
SURFACE AREA (TOTAL) FT^2	x	830		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel/Naphtha		
DESIGN PRESSURE, PSIG	x	620		
DESIGN TEMPERATURE, ^OF	X	575		
MATERIAL OF CONSTRUCTION	x	Note 2		
SHELL SIDE				
FLUID	x	Diesel Product		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	670/-20F		
MATERIAL OF CONSTRUCTION	x	Note 3		
DUTY, MMBTU/HR	O	2.9		

REMARKS

1) UNLESS OTHERWISE NOTED:
TUBE PATTERN -- ROTATED SQUARE
MAXIMUM TUBE DIAMETER -- 3/4"
MAXIMUM TUBE BUNDLE LENGTH -- 20'
MAXIMUM BUNDLE DIAMETER -- 48"

2) Channel is CS + 0.25" CA, Tube sheets are Type 410 SS, Tubes are 18 Cr - 8 Ni

3) Shell is CS + 0.25" CA, Baffles are CS.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

S:\PetroStar\AE1416.AUX\subjob 45\Final Pre_Frac Case HDS\[H-501.xls]Sheet1

ANVIL

BUDGETARY DATA SHEET

AIR COOLED HEAT EXCHANGERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	E-506		
SERVICE	X	Product Cooler		
DRAFT (INDUCED, FORCED)	X	Forced		
FLUID	X	Diesel		
INLET TEMPERATURE	X	523		
OUTLET TEMPERATURE	X	120		
DESIGN TEMPERATURE, ^{O}F	X	550		
DESIGN PRESSURE, PSIG	X	100		
SURFACE AREA (SQUARE FEET)				
BARE TUBES	X	1,463		
EXTENDED SURFACE	X	31,460		
TYPE OF FINS	O			
FAN HORSEPOWER	X	20		
NUMBER OF FANS	X	TBD		
MATERIAL OF CONSTRUCTION	X	Note 1		
MAXIMUM BUNDLE LENGTH,FT.	X	32		
DUTY, 10^6 BTU/HR	O	10.3		
LOUVERS (YES / NO)	O	YES		
AUTO-VARIABLE FAN PITCH (YES/NO)	O	NO		

REMARKS

1) CS tubes with aluminum fins and killed CS header with 0.125" CA

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

S:\PetroStar\AE1416.AUX\subjob 45\Final Pre_Frac Case HDS\[E-506.xls]E-506 Rev B

ANVIL

BUDGETARY DATA SHEET
PROCESS HEATERS

CUSTOMER	Petrostar -- Pre Frac Case
LOCATION	Alaska
PROCESS UNIT	HDS Unit
PROJECT ENGINEER	BGJ
PROJECT	AE1416
DATE	5/31/2005

ITEM NUMBER	X	H-500		
SERVICE	X	Diesel Charge Heater		
HEATER TYPE	X	Fired Heater (1)		
FLUID	X	Diesel w/Hydrogen		
TOTAL FLOW RATE, LB/HR	X	50,320		
LIQUID - GPM (OUTLET)	X	94.4		
DENSITY, LB/FT^3	X	33.7		
VISCOSITY, CP	X	0.06		
SPECIFIC HEAT, BTU/LB-°F	X	0.75		
THERMAL COND., BTU/HR-FT^2-°F	X	0.03		
VAPOR - MMSCFD (OUTLET)	X	5.16		
DENSITY, LB/FT^3	X	2.27		
VISCOSITY, CP	X	0.02		
SPECIFIC HEAT, BTU/LB-°F	X	0.73		
THERMAL COND., BTU/HR-FT^2-°F	X	0.10		
INLET TEMPERATURE	X	655		
OUTLET TEMPERATURE	X	688		
DESIGN TEMPERATURE (°F)	X	760		
DESIGN PRESSURE (PSIG)	X	755		
MATERIAL OF CONSTRUCTION	X	9 Cr - 1 Mo + 0.1" CA		
ABS DUTY, MMBTU/HR	X	2.7 (2)		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Includes 50% excess duty for startup.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL

BUDGETARY DATA SHEET
PROCESS HEATERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	H-501		
SERVICE	X	Stripper Reboiler		
HEATER TYPE	X			
FLUID	X	Hydrotreated Diesel		
TOTAL FLOW RATE, LB/HR	X	70,882		
HEATER OUTLET CONDITIONS:				
LIQUID - GPM	X	125.9		
DENSITY, LB/FT^3	X	37.0		
VISCOSITY, CP	X	0.12		
SPECIFIC HEAT, BTU/LB-°F	X	0.73		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.03		
VAPOR - MMSCFD	X	1.68		
DENSITY, LB/FT^3	X	1.52		
VISCOSITY, CP	X	0.01		
SPECIFIC HEAT, BTU/LB-°F	X	0.63		
THERMAL COND., $BTU/HR\text{-}FT^2\text{-}°F$	X	0.02		
INLET TEMPERATURE	X	612		
OUTLET TEMPERATURE	X	647		
DESIGN TEMPERATURE (°F)	X	710		
DESIGN PRESSURE (PSIG)	X	230		
MATERIAL OF CONSTRUCTION	X	5 CR - 1/2 Mo (2)		
ABS DUTY, MMBTU/HR	X	4.5		

REMARKS

1) Dual fired heater with refinery fuel gas or naphtha. Heater to have radiant and convective section.

2) Add 0.1" CA

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/31/05**

ITEM NUMBER	X	P-500 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	350		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.74		
RATED FLOW (GPM)	X	142		
SUCTION PRESSURE, PSIG	X	3		
DISCHARGE PRESSURE PSIG	X	765		
NPSH AVAILABLE (FT)	X	10.6		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	killed C. S. (2)		
IMPELLER MATERIAL	M	12% chrome		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (MHP)	X	125		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	105		
DIFFERENTIAL PRESSURE, PSI		762		
DIFFERENTIAL HEAD, FT		2363		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/31/05**

ITEM NUMBER	X	P-501A/B (1)		
SERVICE (FLUID)	X	Stripper Btms Pump		
TEMPERATURE OF FLUID	X	612		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.60		
RATED FLOW (GPM)	X	270		
SUCTION PRESSURE, PSIG	X	71		
DISCHARGE PRESSURE PSIG	X	196		
NPSH AVAILABLE (FT)	X	11.2		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS + 0.2" CA		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	40		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	28		
Differential Pressure, PSIG	X	125		
Differential Head, Feet	X	476		

REMARKS

1) One operating pump + one spare
2) Minimum ambient -20 F.

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER BGJ**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	HDS Unit	**DATE 5/31/05**

ITEM NUMBER	X	P-502 A/B (1)		
SERVICE (FLUID)	X	Stripper Ovrhd Pump		
TEMPERATURE OF FLUID	X	113		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.74		
RATED FLOW (GPM)	X	30		
SUCTION PRESSURE, PSIG	X	66		
DISCHARGE PRESSURE PSIG	X	104		
NPSH AVAILABLE (FT)	X	9.4		
CONSTRUCTION (API,ANSI)	M	API Standard		
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	Killed CS (2)		
IMPELLER MATERIAL	M	12% Cr		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER, Motor HP	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
SHAFT BHP	X	1		
Differential Pressure, PSIG	X	38		
Differential Head, Feet	X	119		
		API Standard		

REMARKS

1) One operating pump + one spare

2) With 0.125" CA. Min. ambient -20F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	R-500		
SERVICE	X	HDS Reactor		
FLUID	X	Diesel / Hydrogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	5' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	17' - 0"		
SKIRT HEIGHT (FT-IN)	X	Min		
DESIGN TEMPERATURE (°F)	X	750/-20 (4)		
DESIGN PRESSURE (PSIG)	X	670 (1)		
MATERIAL OF CONSTRUCTION	X	SA387 Gr. 11 (5)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	HR-526 Co-MO Catalyst		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
Catalyst VOLUME, FT^3	X	311 (3)		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Distributor and support grid		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) The packing is in one section with an internal distributor
3) The total weight of catalyst is 15765 lbs. The price is supplied by the catalyst vendor for the estimate.
4) Reactor is design temperature at 25°F above end of run. Reactors are generally designed for EOR operating temperature, but margin is added to be conservative.
5) Include 321 SS or 347 SS weld overlay. Internal trays may be 410 SS or 321 SS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	V-500		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	6' - 6"		
TANGENT TO TANGENT LENGTH, FT.	X	14' - 0"		
SKIRT HEIGHT (FT-IN)	X	Note 2		
DESIGN TEMPERATURE (°F)	X	450 / -20		
DESIGN PRESSURE (PSIG)	X	50 (1)		
MATERIAL OF CONSTRUCTION	X	SA-516-70		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	None		
NUMBER OF TRAYS	X	None		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) The horizontal vessel will be supported on saddles 10 feet above grade.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	V-501		
SERVICE	X	H. T. Separator		
FLUID	X	Hydrcrbn w/Hydogen		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	Min.		
DESIGN TEMPERATURE (°F)	X	465 / -20		
DESIGN PRESSURE (PSIG)	X	620 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS w/ 0.15" CA		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breakers		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	V-502		
SERVICE	X	Low Temp Separator		
FLUID	X	Hydrocarbon w/ H2/H2S		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	8' - 0"		
SKIRT HEIGHT (FT-IN)	X	MIN		
DESIGN TEMPERATURE (°F)	X	465/-20		
DESIGN PRESSURE (PSIG)	X	610 (1)		
MATERIAL OF CONSTRUCTION	X	Killed C. S. (2)		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	No		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Demister (2)		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (3)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) w/ 0.1" CA and PWHT. Demister to be 1' dia. Monel

3) Sour water removal

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	V-503		
SERVICE	X	Naphtha Stripper		
FLUID	X	Hydrotreated Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	TOP = 2'-6", BTM = 3'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	55'-0" (3)		
SKIRT HEIGHT (FT-IN)	X	15'-0"		
DESIGN TEMPERATURE (°F)	X	700/-20 (BTM)		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Note 4		
INSULATION (YES/NO)	X	Yes		
TRAY OR PACKING TYPE	X	Valve Trays		
NUMBER OF TRAYS	X	22		
TRAY MATERIAL	X	410 S.S.		
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Vortex Breakers		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS
1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED
2) VESSEL SHALL BE SWAGED ABOVE FEED
3) Length of top section = 25'-0", length of bottom section = 30'-0"
4) Vessel to be killed CS + 0.2" CA. Trays, tray supports, and downcomers are Type 410 SS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	Petrostar -- Pre Frac Case	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	HDS Unit	**DATE**	5/31/2005

ITEM NUMBER	X	V-504		
SERVICE	X	Strpr O. H. Accumulator		
FLUID	X	Naphtha		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3' - 0"		
TANGENT TO TANGENT LENGTH, FT.	X	6' - 0"		
SKIRT HEIGHT (FT-IN)	X	13' - 0"		
DESIGN TEMPERATURE (°F)	X	375/-20		
DESIGN PRESSURE (PSIG)	X	125 (1)		
MATERIAL OF CONSTRUCTION	X	Killed CS Note (2)		
INSULATION (YES/NO)	X	No		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	Vortex Breaker		
LINING	X	None		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes (sour water)		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

2) Add 0.125" CA and PWHT.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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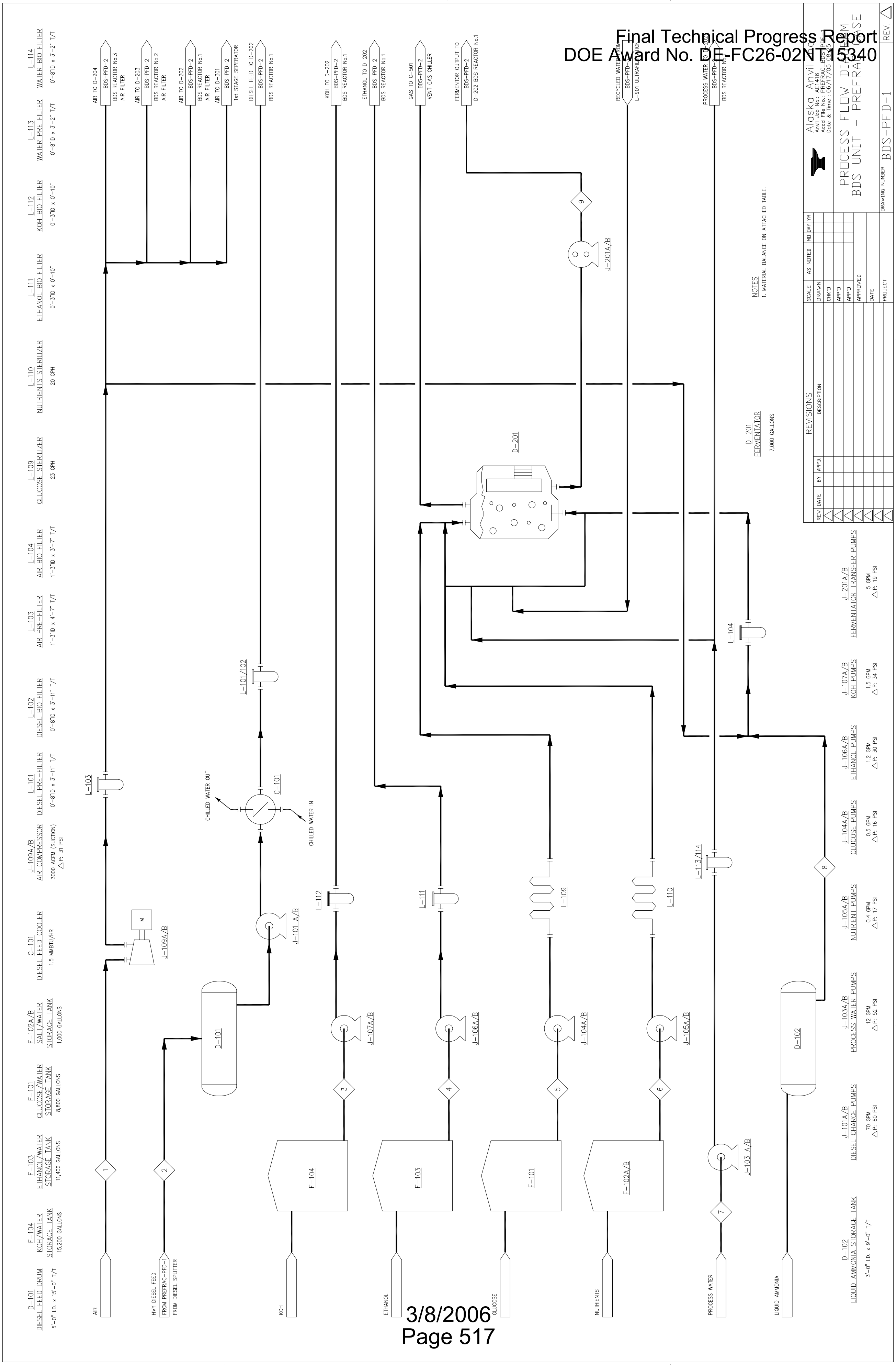
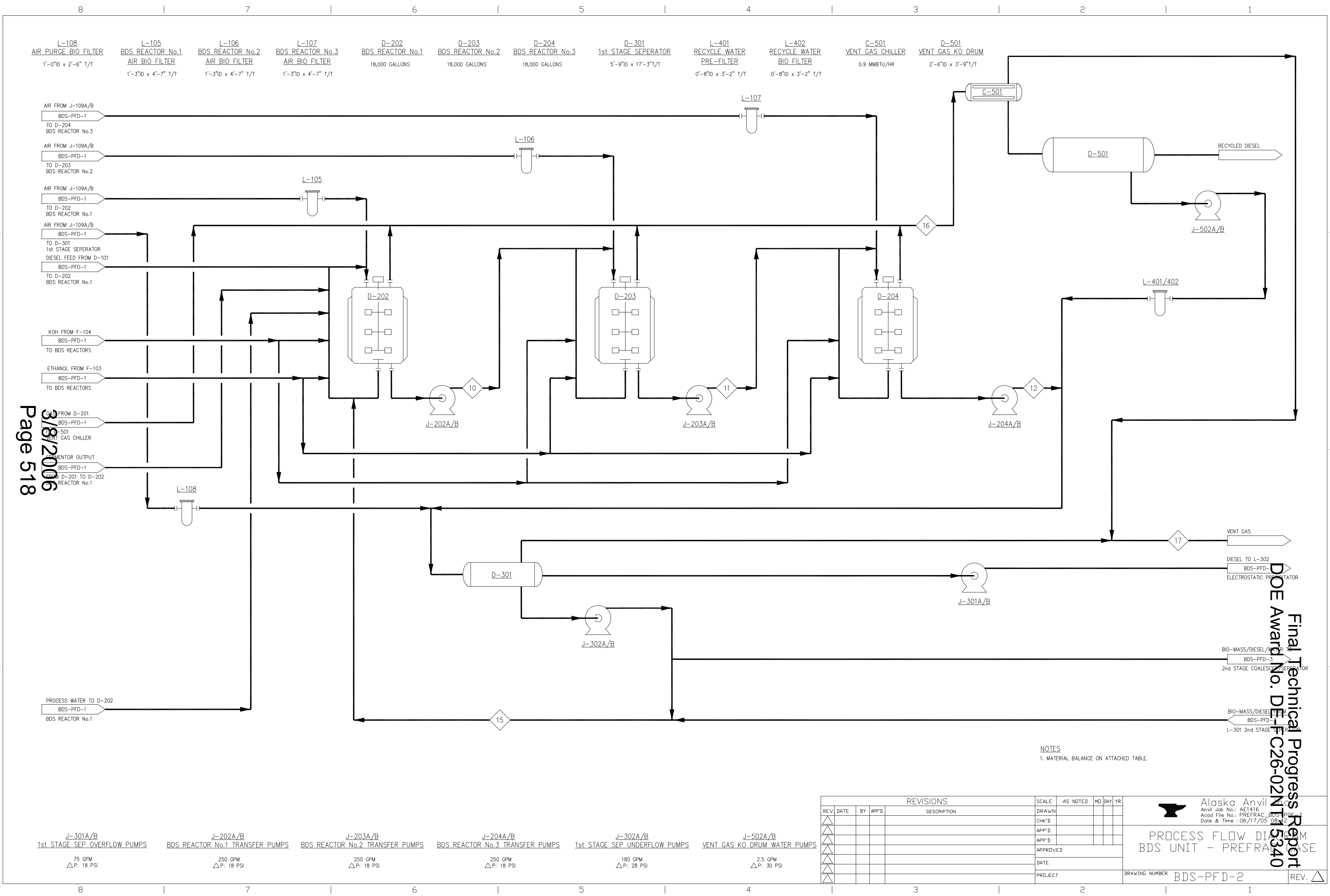
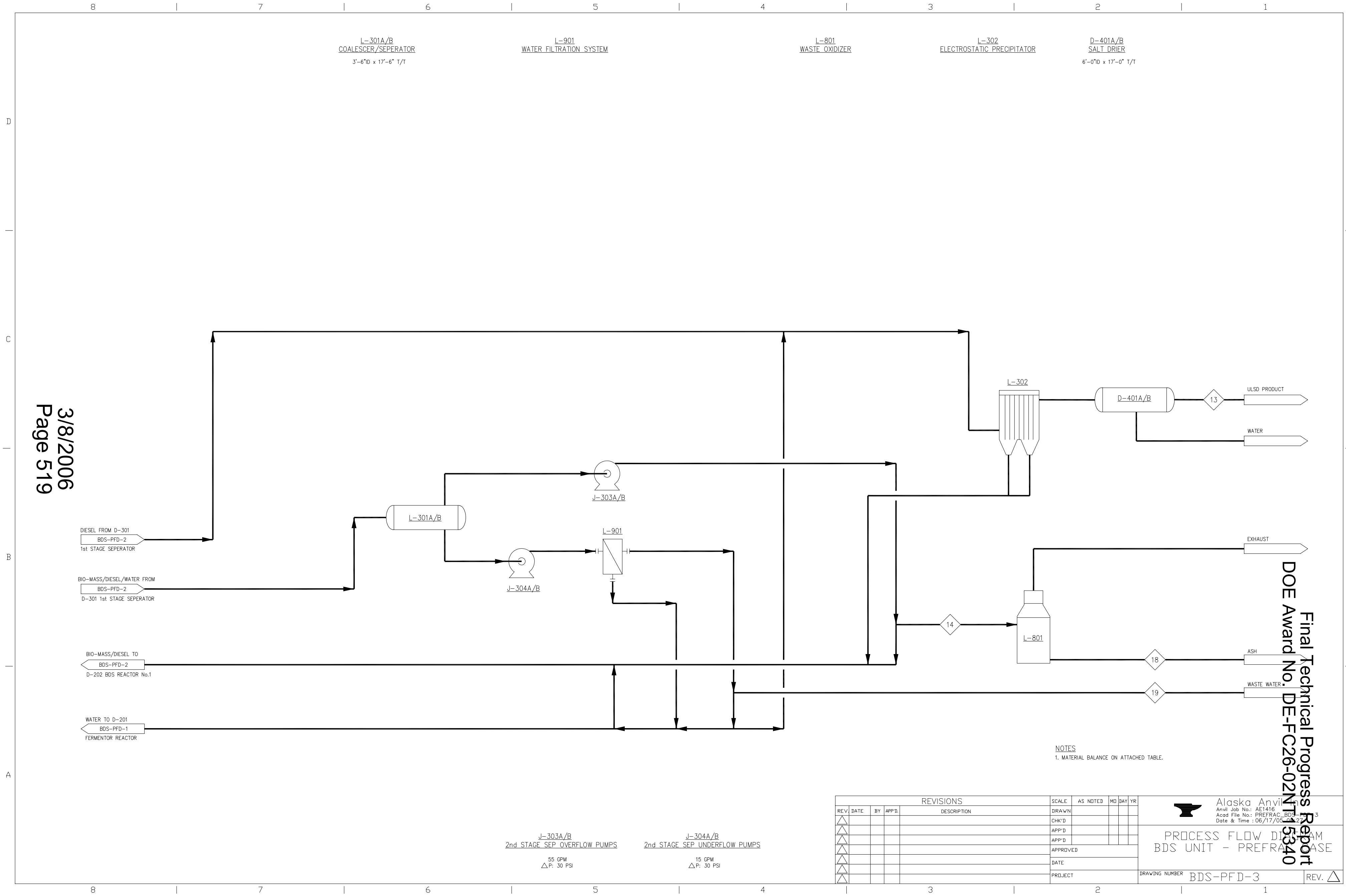
Appendix D.6 – BDS Unit Process Flow Diagrams and Material Balance


D-101 DIESEL FEED DRUM
5'-0" I.D. x 15'-0" T/T
F-104 KOH/WATER STORAGE TANK
15,200 GALLONS
F-103 ETHANOL/WATER STORAGE TANK
11,400 GALLONS
F-101 GLUCOSE/WATER STORAGE TANK
8,800 GALLONS
F-102A/B SALT/WATER STORAGE TANK
1,000 GALLONS
C-101 DIESEL FEED COOLER
1.5 MMBTU/HR
J-109A/B AIR COMPRESSOR
3000 ACFM (SUCTION)
ΔP: 31 PSI
L-101 DIESEL PRE-FILTER
0'-8"D x 3'-11" T/T
L-102 DIESEL BIO FILTER
0'-8"D x 3'-11" T/T
L-103 AIR PRE-FILTER
1'-3"D x 4'-7" T/T
L-104 AIR BIO FILTER
1'-3"D x 3'-7" T/T
L-109 GLUCOSE STERILIZER
23 GPH
L-110 NUTRIENTS STERILIZER
20 GPH
L-111 ETHANOL BIO FILTER
0'-3"D x 0'-10"
L-112 KOH BIO FILTER
0'-3"D x 0'-10"
L-113 WATER PRE FILTER
0'-8"D x 3'-2" T/T
L-114 WATER BIO FILTER
0'-8"D x 3'-2" T/T
AIR
HVY DIESEL FEED
FROM PREFRAC-PFD-1
FROM DIESEL SPLITTER
KOH
ETHANOL
GLUCOSE
NUTRIENTS
PROCESS WATER
LIQUID AMMONIA
AIR TO D-204
BDS-PFD-2
BDS REACTOR No.3
AIR FILTER
AIR TO D-203
BDS-PFD-2
BDS REACTOR No.2
AIR FILTER
AIR TO D-202
BDS-PFD-2
BDS REACTOR No.1
AIR FILTER
AIR TO D-501
BDS-PFD-2
1st STAGE SEPERATOR
DIESEL FEED TO D-202
BDS-PFD-2
BDS REACTOR No.1
KOH TO D-202
BDS-PFD-2
BDS REACTOR No.1
ETHANOL TO D-202
BDS-PFD-2
BDS REACTOR No.1
GAS TO C-501
BDS-PFD-2
VENT GAS CHILLER
FERMENTOR OUTPUT TO
BDS-PFD-2
D-202 BDS REACTOR No.1
RECYCLED WATER FROM
BDS-PFD-
L-901 ULTRAFILTRATION
PROCESS WATER TO D-202
BDS-PFD-2
BDS REACTOR No.1
CHILLED WATER OUT
CHILLED WATER IN
D-201
D-201 FERMENTATOR
7,000 GALLONS
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
D-102 LIQUID AMMONIA STORAGE TANK
3'-0" I.D. x 9'-0" T/T
J-101A/B DIESEL CHARGE PUMPS
70 GPM
ΔP: 60 PSI
J-103A/B PROCESS WATER PUMPS
12 GPM
ΔP: 52 PSI
J-105A/B NUTRIENT PUMPS
0.4 GPM
ΔP: 17 PSI
J-104A/B GLUCOSE PUMPS
0.5 GPM
ΔP: 16 PSI
J-106A/B ETHANOL PUMPS
1.2 GPM
ΔP: 30 PSI
J-107A/B KOH PUMPS
1.5 GPM
ΔP: 34 PSI
J-201A/B FERMENTATOR TRANSFER PUMPS
5 GPM
ΔP: 19 PSI
REVISIONS
REV
DATE
BY
APP'D
DESCRIPTION
SCALE
AS NOTED
DRAWN
CHK'D
APP'D
APPROVED
DATE
PROJECT
Alaska Anvil Inc.
PROCESS FLOW DIAGRAM
BDS UNIT - PREFRAC CASE
DRAWING NUMBER
BDS-PFD-1
REV.


L-108
AIR PURGE BIO FILTER
1'-0"ID x 2'-6" T/T
L-105
BDS REACTOR No.1
AIR BIO FILTER
1'-3"ID x 4'-7" T/T
L-106
BDS REACTOR No.2
AIR BIO FILTER
1'-3"ID x 4'-7" T/T
L-107
BDS REACTOR No.3
AIR BIO FILTER
1'-3"ID x 4'-7" T/T
D-202
BDS REACTOR No.1
18,000 GALLONS
D-203
BDS REACTOR No.2
18,000 GALLONS
D-204
BDS REACTOR No.3
18,000 GALLONS
D-301
1st STAGE SEPERATOR
5'-9"ID x 17'-3"T/T
L-401
RECYCLE WATER
PRE-FILTER
0'-8"ID x 3'-2" T/T
L-402
RECYCLE WATER
BIO FILTER
0'-8"ID x 3'-2" T/T
C-501
VENT GAS CHILLER
0.9 MMBTU/HR
D-501
VENT GAS KO DRUM
2'-6"ID x 3'-9"T/T
AIR FROM J-109A/B
BDS-PFD-1
TO D-204
BDS REACTOR No.3
AIR FROM J-109A/B
BDS-PFD-1
TO D-203
BDS REACTOR No.2
AIR FROM J-109A/B
BDS-PFD-1
TO D-202
BDS REACTOR No.1
AIR FROM J-109A/B
BDS-PFD-1
TO D-301
1st STAGE SEPERATOR
DIESEL FEED FROM D-101
BDS-PFD-1
TO D-202
BDS REACTOR No.1
KOH FROM F-104
BDS-PFD-1
TO BDS REACTORS
ETHANOL FROM F-103
BDS-PFD-1
TO BDS REACTORS
GAS FROM D-201
BDS-PFD-1
TO C-501
VENT GAS CHILLER
FERMENTOR OUTPUT
BDS-PFD-1
FROM D-201 TO D-202
BDS REACTOR No.1
PROCESS WATER TO D-202
BDS-PFD-1
BDS REACTOR No.1
L-105
L-106
L-107
L-108
L-401/402
C-501
D-501
RECYCLED DIESEL
J-502A/B
D-202
D-203
D-204
J-202A/B
J-203A/B
J-204A/B
10
11
12
15
16
17
D-301
J-301A/B
J-302A/B
VENT GAS
DIESEL TO L-302
BDS-PFD-
ELECTROSTATIC PRECIPITATOR
BIO-MASS/DIESEL/WATER TO
BDS-PFD-3
2nd STAGE COALESCER/SEPERATOR
BIO-MASS/DIESEL FROM
BDS-PFD-
L-301 2nd STAGE SEPERATOR
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
J-301A/B
1st STAGE SEP OVERFLOW PUMPS
75 GPM
△P: 18 PSI
J-202A/B
BDS REACTOR No.1 TRANSFER PUMPS
250 GPM
△P: 18 PSI
J-203A/B
BDS REACTOR No.2 TRANSFER PUMPS
250 GPM
△P: 18 PSI
J-204A/B
BDS REACTOR No.3 TRANSFER PUMPS
250 GPM
△P: 18 PSI
J-302A/B
1st STAGE SEP UNDERFLOW PUMPS
180 GPM
△P: 28 PSI
J-502A/B
VENT GAS KO DRUM WATER PUMPS
2.5 GPM
△P: 30 PSI
REVISIONS
REV. DATE BY APP'D DESCRIPTION
SCALE AS NOTED MO DAY YR
DRAWN
CHK'D
APP'D
APP'D
APPROVED
DATE
PROJECT
Alaska Anvil Inc.
Anvil Job No.: AE1416
Acad File No.: PREFRAC_BDS-PFD-2
Date & Time : 06/17/05 08:52
PROCESS FLOW DIAGRAM
BDS UNIT - PREFRAC CASE
DRAWING NUMBER BDS-PFD-2
REV.


L-301A/B
COALESCER/SEPERATOR
3'-6"ID x 17'-6" T/T
L-901
WATER FILTRATION SYSTEM
L-801
WASTE OXIDIZER
L-302
ELECTROSTATIC PRECIPITATOR
D-401A/B
SALT DRIER
6'-0"ID x 17'-0" T/T
ULSD PRODUCT
WATER
EXHAUST
ASH
WASTE WATER
13
14
18
19
J-303A/B
J-304A/B
DIESEL FROM D-301
BDS-PFD-2
1st STAGE SEPERATOR
BIO-MASS/DIESEL/WATER FROM
BDS-PFD-2
D-301 1st STAGE SEPERATOR
BIO-MASS/DIESEL TO
BDS-PFD-2
D-202 BDS REACTOR No.1
WATER TO D-201
BDS-PFD-1
FERMENTOR REACTOR
NOTES
1. MATERIAL BALANCE ON ATTACHED TABLE.
J-303A/B
2nd STAGE SEP OVERFLOW PUMPS
55 GPM
△P: 30 PSI
J-304A/B
2nd STAGE SEP UNDERFLOW PUMPS
15 GPM
△P: 30 PSI
REVISIONS
REV. DATE BY APP'D DESCRIPTION
SCALE AS NOTED
MO DAY YR
DRAWN
CHK'D
APP'D
APP'D
APPROVED
DATE
PROJECT
Alaska Anvil
Anvil Job No.: AE1416
DRAWING NUMBER BDS-PFD-3
REV.

Material Balance

BDS Unit Material Balance -- Prefractionation Case

PFD Stream Number		1	2	3	4	5	6	7
Stream Number		Air	Diesel	NaOH	Ethanol	Glucose	Nutrients	Process Water
Stream Description		Air Feed	Diesel Feed	NaOH Feed	Ethanol Feed	Glucose Feed	Nutrient Feed	Process Water Feed
Phase		VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR		26566					
Aqueous Mass Flow	LB/HR			860	420	205	167	5000
Biomass Mass Flow	LB/HR							
Sulfur in HC	PPM		6311					
Total Mass Flow Rate	LB/HR	12000	26566	860	420	205	167	5000
Temperature	F	68	176	68	68	68	68	68
Pressure	PSIG	0	0	0	0	0	0	0
Standard Liq Flow	BPD		2140	39	31	12	11	344
Vapor Flow	MSCFH	162						
Wt % Vapor		100	0	0	0	0	0	0
MW								

PFD Stream Number		8	9	10	11	12	13	14
Stream Number		Liquid Ammonia	S-16	S-17	S-18	S-19	S-27	S-31
Stream Description		Liquid Ammonia Feed	Fermentor Output	R#1 Output	R#2 Output	R#3 Output	Diesel Product	Biomass Purge
Phase		LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Hydrocarbon Mass Flo	LB/HR			44379	44284	44213	26108	384
Aqueous Mass Flow	LB/HR	14.7	1662	52895	53135	53175	0	710
Biomass Mass Flow	LB/HR		205	12143	12143	12143	0	205
Sulfur in HC	PPM			1728	257	10	10	10
Mass Flow Rate	LB/HR	14.7	1867	109417	109562	109531	26108	1300
Temperature	F	-40	86	86	86	86	86	86
Pressure	PSIG	210	33.1	36.4	36.4	26.8	5	5
Standard Liq Flow	BPD	1.4	128	7806	7806	7806	2103	90
Vapor Flow	MSCFH							
Wt % Vapor		0	0	0	0	0	0	0
MW								

PFD Stream Number		15	16	17	18	19		
Stream Number		S-32	S-38	S-39	Ash	Waste Water		
Stream Description		Reactor Recycle	Reactor Air Effluent	Gas Purge	Incinerator Waste	Waste Water		
Phase		LIQUID	GAS	GAS	SOLID	LIQUID		
Hydrocarbon Mass Flo	LB/HR	11938	199					
Aqueous Mass Flow	LB/HR	45764	183			6480		
Biomass Mass Flow	LB/HR	11938						
Sulfur in HC	PPM	10	666					
Total Mass Flow Rate	LB/HR	75622	11620	11297	30	6480		
Temperature	F	86	86	60	68	86		
Pressure	PSIG	37.4	10	1	0	10		
Standard Liq Flow	BPD	5190				420		
Vapor Flow	MSCFH		154	149				
Wt % Vapor		0	100	100	0	0		
MW								

Appendix D.7 – BDS Unit Equipment List and Budgetary Equipment Datasheets

ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	D-101		
SERVICE	X	Diesel Feed Drum		
FLUID	X	Diesel		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	5'		
TANGENT TO TANGENT LENGTH, FT.	X	15'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	190		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	BGJ
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	D-102		
SERVICE	X	Storage Tank		
FLUID	X	Liquid Ammonia		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3'		
TANGENT TO TANGENT LENGTH, FT.	X	9'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	275		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)		Yes (Safety)		
TRAY OR PACKING TYPE	X	N/A		
NUMBER OF TRAYS	X	N/A		
TRAY MATERIAL	X	N/A		
PACKING VOLUME, FT^3	X	N/A		
PACKING MATERIAL	X	N/A		
INTERNALS	X	N/A		
LINING	X	N/A		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	No		

REMARKS

1) VESSELS WILL BE DESIGNED FOR FULL VACUUM UNLESS OTHERWISE SPECIFIED

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	5'-9"		
TANGENT TO TANGENT LENGTH, FT.	X	17'-3"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	D-501		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	2'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	3'-9"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	30		
MATERIAL OF CONSTRUCTION	X	CS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	-		
PACKING MATERIAL	X	-		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	NO		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	F-101		
SERVICE	X	Storage Tank		
FLUID	X	Glucose/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	10'		
TANGENT TO TANGENT LENGTH, FT.	X	15'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	F-102 A/B		
SERVICE	X	Storage Tank		
FLUID	X	Salt/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	4'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	9'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	F-103		
SERVICE	X	Storage Tank		
FLUID	X	Ethanol/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	11'		
TANGENT TO TANGENT LENGTH, FT.	X	16'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	Epoxy Resin		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
STORAGE TANK

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	F-104		
SERVICE	X	Storage Tank		
FLUID	X	NaOH/Water		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Vertical		
DIAMETER, FT-IN	X	12'		
TANGENT TO TANGENT LENGTH, FT.	X	18'		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	ATM		
MATERIAL OF CONSTRUCTION	X	CS Internally Coated		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X			
PACKING MATERIAL	X			
INTERNALS	X			
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-101 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	140		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	70		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	61.3		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		60.1		
DIFFERENTIAL HEAD, FT		163.1		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-103 A/B (1)		
SERVICE (FLUID)	X	Process Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.997		
RATED FLOW (GPM)	X	12		
SUCTION PRESSURE, PSIG	X	5		
DISCHARGE PRESSURE PSIG	X	57.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	2		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		52.4		
DIFFERENTIAL HEAD, FT		121		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-104 A/B (1)		
SERVICE (FLUID)	X	Glucose/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.2		
RATED FLOW (GPM)	X	0.5		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.4		
DIFFERENTIAL HEAD, FT		31		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**	

ITEM NUMBER	X	J-105 A/B (1)		
SERVICE (FLUID)	X	Salts/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	0.4		
SUCTION PRESSURE, PSIG	X	1.2		
DISCHARGE PRESSURE PSIG	X	18		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		16.8		
DIFFERENTIAL HEAD, FT		38.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-106 A/B (1)		
SERVICE (FLUID)	X	Ethanol/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.914		
RATED FLOW (GPM)	X	1.2		
SUCTION PRESSURE, PSIG	X	1		
DISCHARGE PRESSURE PSIG	X	31.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.4		
DIFFERENTIAL HEAD, FT		80.7		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		BDS ULSD Baseline	**DATE 3/17/05**	
ITEM NUMBER	X	J-107 A/B (1)		
SERVICE (FLUID)	X	NaOH/Water		
TEMPERATURE OF FLUID	X	AMB		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.53		
RATED FLOW (GPM)	X	1.5		
SUCTION PRESSURE, PSIG	X	1.6		
DISCHARGE PRESSURE PSIG	X	35.9		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Diaphragm		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Hydraulic		
TYPE OF SPARE (MOTOR/TURBINE)	X	Hydraulic		
ELECTRIC POWER (HP)	X	N/A		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		34.3		
DIFFERENTIAL HEAD, FT		65.4		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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BUDGETARY DATA SHEET

COMPRESSORS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-109 A/B		
FLUID	X	Air		
TYPE (CENTRIFUGAL, RECIP.,ETC)	X	Screw		
TOTAL NUMBER OF MACHINES	X	2		
RATED CAPACITY (ACFM @ SUCTION)	X	3,000		
SUCTION TEMPERATURE ^{O}F	X	68		
SUCTION PRESSURE, PSIA	X	14.7		
DISCHARGE PRESSURE, PSIA	X	46		
GAS MOLECULAR WEIGHT	X	28.9		
'K' VALUE OF GAS	X			
MOL % HYDROGEN IN GAS	X	0		
CORROSIVE MATERIAL (H_20,HCL,H_2S, ETC)	X	Water		
CASING MATERIAL	M	CS (1)		
PISTON, SLEEVES, VALVES MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR,TURBINE, OTHER)	X	Motor		
ELECTRIC POWER (Motor Size, HP)	X	300		
STEAM CONDITIONS	X	N/A		
ESTIMATED SHAFT HORSEPOWER	X	260		
SPEED LIMITS, FEET/MIN. RPM	M			
SEPARATE LUBRICATION SYSTEM (YES/NO)	M			
GEAR REQUIRED (YES/NO)	M			
		API Standard		

REMARKS

1) Will be subject to -20°F ambient conditions.

LEGEND:

X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-201 A/B (1)		
SERVICE (FLUID)	X	Biomass/Salts/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	5		
SUCTION PRESSURE, PSIG	X	14.1		
DISCHARGE PRESSURE PSIG	X	33.1		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Rotary Lobe		
CASING MATERIAL	M	SS (3)		
IMPELLER MATERIAL	M	SS (3)		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		19		
DIFFERENTIAL HEAD, FT		43.4		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-202 A/B (1)		
SERVICE (FLUID)	X	Biomass/Diesel/Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.93		
RATED FLOW (GPM)	X	250		
SUCTION PRESSURE, PSIG	X	18.4		
DISCHARGE PRESSURE PSIG	X	36.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		44.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-301 A/B (1)		
SERVICE (FLUID)	X	Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.85		
RATED FLOW (GPM)	X	75		
SUCTION PRESSURE, PSIG	X	7		
DISCHARGE PRESSURE PSIG	X	25		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		18		
DIFFERENTIAL HEAD, FT		48.9		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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BUDGETARY DATA SHEET

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-302 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.96		
RATED FLOW (GPM)	X	180		
SUCTION PRESSURE, PSIG	X	9		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		28.4		
DIFFERENTIAL HEAD, FT		68.4		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-303 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	55		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	2		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	J-304 A/B (1)		
SERVICE (FLUID)	X	Water/Diesel/Biomass		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.94		
RATED FLOW (GPM)	X	15		
SUCTION PRESSURE, PSIG	X	7.7		
DISCHARGE PRESSURE PSIG	X	37.4		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	SS		
IMPELLER MATERIAL	M	SS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	1.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M	Double		
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		29.7		
DIFFERENTIAL HEAD, FT		72.2		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

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ANVIL **BUDGETARY DATA SHEET**
PUMPS AND DRIVERS

CUSTOMER		HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION		Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT		BDS Prefrac	**DATE 6/1/05**	
ITEM NUMBER	X	J-502 A/B (1)		
SERVICE (FLUID)	X	Water		
TEMPERATURE OF FLUID	X	86		
SPECIFIC GRAVITY AT TEMPERATURE	X	1.0		
RATED FLOW (GPM)	X	2.5		
SUCTION PRESSURE, PSIG	X	3.6		
DISCHARGE PRESSURE PSIG	X	33.8		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Cent		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	0.5		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		30.2		
DIFFERENTIAL HEAD, FT		69.8		

REMARKS
1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.
3) Wetted Parts

LEGEND:
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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	x	C-101		
SERVICE	x	Diesel Feed Cooler		
TEMA TYPE	x	AES		
SURFACE AREA (TOTAL) FT^2	x	500		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^OF	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	1.5		

REMARKS

ANVIL **BUDGETARY DATA SHEET**
SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefrac	**DATE 6/1/05**

ITEM NUMBER	X	C-501		
SERVICE	X	Vent Gas Chiller		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	1200		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Air		
DESIGN PRESSURE, PSIG	x	50		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	0.9		

REMARKS

ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-101		
SERVICE	X	Diesel Pre-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-102		
SERVICE	X	Diesel Bio-Filter		
FLUID	X	Diesel		
HOUSING LENGTH, IN	X	47"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-103		
SERVICE	X	Air Pre-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEI		GF		
PORE SIZE, MICRON	X	1.0 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-104		
SERVICE	X	Air Bio-Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	43"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-105		
SERVICE	X	Reactor Bio Filter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	55"		
HOUSING DIAMETER, IN	X	15"		
FILTER CARTRIDGE LENGTH	X	30"		
NUMBER OF UNITS	X	5		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-108		
SERVICE	X	Air Purge Biofilter		
FLUID	X	Air		
HOUSING LENGTH, IN	X	30"		
HOUSING DIAMETER, IN	X	12"		
FILTER CARTRIDGE LENGTH	X	10"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		PTFE		
PORE SIZE, MICRON	X	0.01 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-111		
SERVICE	X	Ethanol Bio Filter		
FLUID	X	Ethanol/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**
FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-112		
SERVICE	X	NaOH Bio Filter		
FLUID	X	NaOH/Water		
HOUSING LENGTH, IN	X	10"		
HOUSING DIAMETER, IN	X	2.5"		
FILTER CARTRIDGE LENGTH	X	5"		
NUMBER OF UNITS	X	1		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polyethersulfone		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-113		
SERVICE	X	Water Pre Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	1.5 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND: X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

FILTER

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	L-114		
SERVICE	X	Water Bio Filter		
FLUID	X	Water		
HOUSING LENGTH, IN	X	38"		
HOUSING DIAMETER, IN	X	8"		
FILTER CARTRIDGE LENGTH	X	20"		
NUMBER OF UNITS	X	3		
DESIGN TEMPERATURE (°F)	X	30		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION, HOUS	X	316L SS		
MATERIAL OF CONSTRUCTION, ELEMEN		Polypropylene		
PORE SIZE, MICRON	X	0.2 um		
	X			
	X			
	X			
	X			
	X			
	X			
	M			
	X			

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

PRESSURE VESSELS-ASME SECTION VIII

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER**	PMD
LOCATION	Alaska	**PROJECT NO.**	AE1416
PROCESS UNIT	BDS Prefrac	**DATE**	6/1/2005

ITEM NUMBER	X	D-301		
SERVICE	X	Oil/Water Separator		
FLUID	X	Diesel/Water/Biomass		
ASME SECT VIII DIV 1 OR 2				
POSITION ; HORIZONTAL, VERTICAL	X	Horizontal		
DIAMETER, FT-IN	X	3'-6"		
TANGENT TO TANGENT LENGTH, FT.	X	17'-6"		
SKIRT HEIGHT (FT-IN)	X			
DESIGN TEMPERATURE (°F)	X	150		
DESIGN PRESSURE (PSIG)	X	50		
MATERIAL OF CONSTRUCTION	X	SS		
INSULATION (YES/NO)				
TRAY OR PACKING TYPE	X			
NUMBER OF TRAYS	X			
TRAY MATERIAL	X			
PACKING VOLUME, FT^3	X	24"ODx18"IDx120"L		
PACKING MATERIAL	X	Fiberbed Coalescer		
INTERNALS	X	Overflow Baffle		
LINING	X	-		
PLATFORMS AND LADDERS	M			
BOOT (YES / NO)	X	Yes 1'x2'		

REMARKS

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL **BUDGETARY DATA SHEET**

PUMPS AND DRIVERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**	
LOCATION	Alaska	**PROJECT NO. AE1416**	
PROCESS UNIT	BDS Prefractionation	**DATE 6/11/05**	

ITEM NUMBER	X	J-601 A/B (1)		
SERVICE (FLUID)	X	Diesel Feed Pump		
TEMPERATURE OF FLUID	X	65		
SPECIFIC GRAVITY AT TEMPERATURE	X	0.95		
RATED FLOW (GPM)	X	2000		
SUCTION PRESSURE, PSIG	X	2.5		
DISCHARGE PRESSURE PSIG	X	38.5		
NPSH AVAILABLE (FT)	X			
CONSTRUCTION (API,ANSI)	M			
PUMP TYPE (CENTRIFUGAL, RECIP,ETC.)	X	Centrifugal		
CASING MATERIAL	M	CS		
IMPELLER MATERIAL	M	CS		
TYPE OF DRIVER (MOTOR/TURBINE)	X	Motor		
TYPE OF SPARE (MOTOR/TURBINE)	X	Motor		
ELECTRIC POWER (HP)	X	20		
STEAM CONDITIONS	X	N/A		
SEALS (SINGLE, DOUBLE, TANDEM)	M			
API SEAL FLUSH PLAN NUMBER	M			
		API Standard		
DIFFERENTIAL PRESSURE, PSI		36		
DIFFERENTIAL HEAD, FT		81.7		

REMARKS

1) One operating pump + one spare
2) 0.125" CA / Minimum design temperature is -20°F.

LEGEND:
X = PROCESS INFO REQUIRED
O = PROCESS INFO OPTIONAL
M = MECHANICAL INFO OPTIONAL

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ANVIL

BUDGETARY DATA SHEET

SHELL & TUBE HEAT EXCHANGERS

CUSTOMER	HDS/BDS Study	**PROJECT ENGINEER PMD**
LOCATION	Alaska	**PROJECT NO. AE1416**
PROCESS UNIT	BDS Prefractionation	**DATE 6/11/05**

ITEM NUMBER	X	C-601		
SERVICE	X	Chiller Exchanger		
TEMA TYPE	X	AES		
SURFACE AREA (TOTAL) FT^2	x	3790		
NUMBER OF SHELLS	x	One		
TUBE SIDE				
FLUID	x	Diesel		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	X	300		
MATERIAL OF CONSTRUCTION	x	CS		
SHELL SIDE				
FLUID	x	Water		
DESIGN PRESSURE, PSIG	x	100		
DESIGN TEMPERATURE, ^{O}F	x	300		
MATERIAL OF CONSTRUCTION	x	CS		
DUTY, MMBTU/HR	X	8.6		

REMARKS

Appendix D.8 – Utility Requirements

Utility Requirements
Pre Frac Case
6000 BPD Feed Rate, 10 ppmw Sulfur ULSD Product

	Power kW	Fuel Gas MMBTU/Hr	Process Water lb/hr	BFW lb/hr
IBL DIESEL SPLITTER				
Charge pump	11			
Splitter reflux/prod pump	12			
Splitter Btms Circ	70			
Splitter Ovhd Cond Airfin	8			
Prod rundown cooler	10			
Splitter Reboiler		22.2		
TOTAL DIESEL SPLITTER	**111**	**22.2**		

IBL HDS	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr
Feed Gas Compressor	38			
H2 Makeup Compressor	55			
Recycle Gas Compressor	40			
Charge Pump	80			
Stripper Reflux Pump	1			
Stripper Btms Circ	21			
Effluent Air Cooler	4			
Prod Stripper Condenser	4			
Prod Rundown Cooler	15			
Wash Water Injection Pump	1			
Charge Heater		3.4		
Prod Stripper Reboiler		5.6		
Wash Water Injection Pump			890	
OBL				
H2 Plant	31	16.5		2777
Sulfur Recovery	54			
Other OBL Allowance	118			
TOTAL HDS AND OBL	**462**	**25.5**	**890**	**2777**

BDS	Power kW	Fuel Gas MMBTU/hr	Process Water lb/hr	BFW lb/hr	Steam lb/hr
Total Plant	917		5000		21
TOTAL BDS	**917**		**5000**		**21**

Appendix D.9 – Cost Estimate Basis and Cost Estimate

PETRO STAR INC.

ULTRA LOW SULFUR DIESEL
BDS / HDS COMBINATION CASES
IBL ONLY

PHASE 1 ESTIMATE BASIS
REVISION 0

ALASKA ANVIL NO. AE1416

JUNE 2005

ALASKA ANVIL
INCORPORATED

ESTIMATE BASIS GOAL

This Estimate Basis identifies information, qualifications, exceptions, and assumptions used in developing the cost estimate.

ESTIMATE BASIS PURPOSE

During the estimate review process, the project team uses the Estimate Basis for the following purposes:

- As a checklist of items to consider during estimate preparation.
- To document what is included and not included in the cost estimate.
- To assess cost risks of estimate components.
- As part of the decision support package for assessing the BDS process feasibility.

GENERAL INFORMATION

- The purpose of the project estimate is to determine if the ULSD BDS process is economically viable as a standalone process or in combination with an HDS Unit. These three (3) estimate scenarios address the BDS / HDS Combination cases.
- Estimate type:
  - The estimate was developed using equipment based factored estimates for Inside Battery Limits (IBL) costs.
  - There is a separate equipment-factoring summary for the BDS, HDS, and Pre Frac Equipment (Pre Frac Case Only)
  - Most of the equipment pricing was derived from the ICARUS estimating program. Pricing for BDS equipment marked with an asterisk (*) was provided by Pelorus.
  - The cost of the Hydrogen and Sulfur Units were factored off licensor quotes obtained for the standalone HDS case.
  - Outside Battery Limits (OBL) costs have been excluded from this estimate.
- The project will be installed in a brownfield location within the Valdez Alaska Refinery.

PROCESS BASIS

Facility Data

- Facility type – Ultra Low Sulfur Diesel Treating Complex, which includes:
  - Diesel Biodesulfurization Unit
  - Diesel Hydrotreating Unit
  - Hydrogen Production Unit
  - Sulfur Unit
  - Diesel Splitter (Pre Frac Case Only)

Design Basis

Product specification – Feed 6,000 bpd of untreated diesel to produce 10-ppmw sulfur maximum ultra low sulfur diesel.

COST BASIS

Labor, Indirects, Equipment, and Bulk Materials

- Included in the equipment factor.

Project Services

- Estimated based on 15 percent of TIC for the BDS, HDS, and Pre Frac units; engineering costs for the Hydrogen and Sulfur Units was included in the licensor pricing.

Owner Services

Not included in the TIC cost. Historically, owner services will cost from 5 to 7 percent of TIC, not including licensing, royalties, or catalyst.

Escalation

Project is based on 2005 costs. No escalation is included.

Location Factor

All costs for this estimate have been developed from a U.S. Gulf Coast (USGC) basis. No location factor is included.

Other Costs

- Catalyst and chemical initial charge has been added as an additional line item.
- CEMS, air preheating, and burner management allowances have been added to the fired heater costs.

ASSUMPTIONS

- Process licensing and royalty costs are not included.
- Assumes fully installed pump spares, but no warehouse spares.

PROJECT COST & SCHEDULE ESTIMATE SUMMARY

CLIENT: PetroStar	**CLIENT PROJECT NO.:**	**CLIENT PE: J. Boltz**
PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario	**ANVIL PROJECT NO.: AE1416**	**ANVIL PE: L. Nace**
STAGE: Phase 1	**REV NO.: 0**	**Date: 6/17/05**

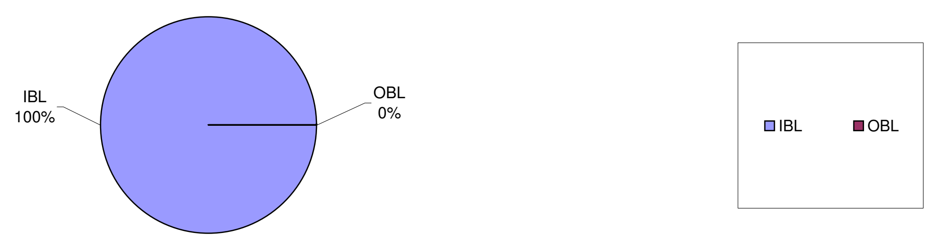
PROJECT DESCRIPTION:	**PROJECT RISKS:**
Install Ultra Low Sulfur Diesel Complex.	

PROJECT COST ESTIMATE SUMMARY

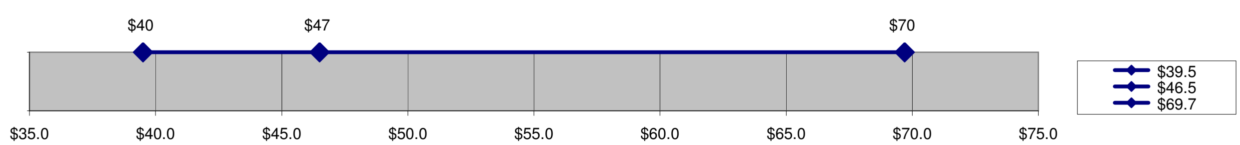
	TOTAL PROJECT COST - Valdez
COST ESTIMATE STRUCTURE	
COST ESTIMATE PARAMETERS	
Estimate Classification	Phase 1
Estimating Method	Factored/ROM
COST ESTIMATE SUMMARY	
Expected Cost ($MM)	**$ 46.5**
High Range ($MM)	**$ 69.7**
Low Range ($MM)	**$ 39.5**

PROJECT COST ESTIMATE ANALYSIS

Total Project Expected Cost Component Analysis



Total Project Cost Profile ($MM)



PROJECT SCHEDULE ESTIMATE ANALYSIS

Total Project Schedule

Target Completion Dates: 2Q2005, TBD, TBD, TBD, 4Q2010

Current Progress

PROJECT TIMELINE	***PHASE 1***	***PHASE 2***	***PHASE 3***	***PHASE 4***	***PHASE 5***
Target Completion Dates	2Q2005	TBD	TBD	TBD	4Q2010

Petro Star Ultra Low Sulfur Diesel (6000 BPD) Project - Valdez Refinery

IBL Impact Matrix - 2005$ - Total Installed Costs USGC

Scenario: Pre Frac

IBL Component	HDS Unit	BDS Unit	Pre Frac Unit	Hydrogen Unit	Sulfur Unit	Total Cost $MM
	Diesel Hydrotreater, feed rate of 3870 BPD, producing ULSD (10 ppmw S)	Biodesulfurization Unit, feed rate of 2140 BPD, producing ULSD (10 ppmw S)	Diesel Splitter, feed rate of 6000 BPD	1 MMSCF/D H2 Production Plant.	Thiopaq process to be used for 1.9 T/D. Will also need sulfur storage / handling	
Cost Basis	Factored equipment based estimate	Factored equipment based estimate	Factored equipment based estimate	Ratio'd from Baseline HDS Case	Ratio'd from Baseline HDS Case	
High Range Cost, $ MM	$17.4	$33.0	$9.8	$6.2	$3.4	$69.7
Expected Cost, $ MM	$11.6	$22.0	$6.5	$4.1	$2.3	$46.5
Low Range Cost, $ MM	$9.9	$18.7	$5.5	$3.5	$1.9	$39.5

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario **CLIENT: PetroStar**
ANVIL NO: AE1416 **DATE: 6/17/05**
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COMPRESSORS						
C-500	1	Makeup Hydrogen Compressor	$163,500	2.8	$457,800	Capacity: 39.8 CFM, Motor Driven, Shaft HP: 71 BHP, Motor Size: 100 HP, Casing: killed C. S., Internals: CS
C-501	1	Recycle Gas Compressor	$161,400	2.8	$451,920	Capacity: 65 CFM, Motor Driven, Shaft HP: 54 BHP, Motor Size: 75 HP, Casing: killed C. S., Internals: Stainless Steel
		SUB-TOTAL	**$325,000**		**$910,000**	
EXCHANGERS						
E-500	1	Reactor Fd/Btms Exchanger #1	$102,400	4.0	$409,600	TEMA Type CEU, 1870 FT2 w/2 shells, Tubes: 1 ¼ Cr – ½ Mo tubes and tube sheet and weld overlay 316 ss for tube sheet Shell: 1 ¼ Cr – ½ Mo clad w/ 321 SS, baffles to be 304 SS
E-501	1	Reactor Fd/Btms Exchanger #2	$63,400	4.0	$253,600	TEMA type CEU, 1735 FT2 (total) w/2 shells, Tubes: 1 ¼ Cr – ½ Mo for tubes and tube sheet, SA387 Gr 11 channel, weld overlay 321 SS tube sheet, channel, and channel cover, Shell: Killed C. S. w/0.125" CA
E-502	1	Separator Fd/Btms Exchanger	$8,700	4.0	$34,800	85 FT2, double pipe, Tubes: Carbon Steel, Shell: Carbon Steel
E-505	1	Stripper Fd/Btms Exchanger	$41,200	4.0	$164,800	2.9 MM BTU/Hr, 830 FT2 (total) w/1 shell, TEMA type CEU, Tubes: 18 Cr – 8 Ni, Channel is CS w/ 0.25" CA, tube sheets are 410 SS, Shell: CS w/0.25" CA, CS baffles
		SUB-TOTAL	**$216,000**		**$863,000**	
AIR COOLERS						
E-503	1	H. T. Separator Overhead Cooler	$40,600	4.0	$162,400	1.5 MM BTU/Hr, 318 FT2 Bare Tube, 6829 FT2 Extended, Shaft HP: 5 BHP, Seamless Carbon Steel tubes with aluminum fins.
E-504	1	Stripper O. H. Condenser	$36,000	4.0	$144,000	2.2 MM BTU/Hr, 406 FT2 Bare Tube, 8733 FT2 Extended, Shaft HP: 5 BHP, Seamless Carbon Steel tubes with aluminum fins.
E-506	1	Product Cooler	$63,000	4.0	$252,000	10.3 MM BTU/Hr, 1463 FT2 (Bare Tube), 31460 FT2 Extended, Shaft HP: 20 BHP, Seamless Carbon Steel tubes with aluminum fins.
		SUB-TOTAL	**$140,000**		**$558,000**	
FURNACES						
H-500	1	Diesel Charge Heater	$208,900	2.5	$511,805	2.7 MM BTU/Hr, Fired Heater, Convection Section shared w/ H-501, Tubes: 9 Cr – 1 Mo w/ 0.1" CA
H-500	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-500	1	Preheating	$40,000	1.0	$40,000	
H-500	1	Burner Management	$30,000	1.0	$30,000	
H-501	1	Stripper Reboiler	$255,900	2.5	$626,955	4.5 MM BTU/Hr, Fired Heater, Convection Section shared w/ H-500, Tubes: 5 Cr – ½ Mo w/ 0.1" CA
H-501	1	CEMS	$100,000	1.5	$150,000	Continuous Emission Monitoring System
H-501	1	Preheating	$40,000	1.0	$40,000	
H-501	1	Burner Management	$30,000	1.0	$30,000	
		SUB-TOTAL	**$805,000**		**$1,579,000**	
PUMPS						
P-500 A/B	2	Diesel Feed Pump	$230,400	5.0	$1,152,000	API Centrifugal Pump, 142GPM, 0.74 SG, 2363 Ft. Head, CS Case, 12%CR Impeller, 125HP Motor
P-501 A/B	2	Stripper Bottoms Pump	$49,400	5.0	$247,000	API Centrifugal Pump, 270GPM, 0.60 SG, 476 Ft. Head, CS Case, 12%CR Impeller, 40HP Motor
P-502 A/B	2	Stripper Overhead Pump	$42,200	5.0	$211,000	API Centrifugal Pump, 30GPM, 0.74 SG, 119 Ft. Head, CS Case, 12%CR Impeller, 5HP Motor
		SUB-TOTAL	**$322,000**		**$1,610,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario **CLIENT: PetroStar**
ANVIL NO: AE1416 **DATE: 6/17/05**
REV NO.: 0

HDS EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
COLUMNS						
R-500	1	HDS Reactor	$147,000	4.4	$646,800	5" ID X 17' T/T w/one bed of HR-526 Co Mo catalyst, SA387 Gr. 11 w/ 321 SS or 347 SS weld overlay. Internal trays are 410 SS or 321 SS
V-503	1	Naphtha Stripper	$45,900	4.4	$201,960	2'-6" ID (Top), 3' 6" ID (bottom) X 55'-0"T/T (Overall) w/ 22 valve trays, Killed Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-503	1	Naphtha Stripper Trays	$42,500	2.7	$114,750	Valve Trays, SS410
		SUB-TOTAL	**$235,000**		**$964,000**	
VESSELS						
V-500	1	Diesel Feed Drum	$27,000	4.2	$113,400	6'-5" ID X 14'-0" T/T (Horizontal), Killed Carbon Steel
V-501	1	High Temperature Separator	$17,400	4.2	$73,080	3'-0" ID X 8'-0" T/T (Vertical), Killed Carbon Steel w/0.15" CA
V-502	1	Low Temperature Separator	$17,200	4.2	$72,240	3'-0" ID X 8'-0" T/T` (Horizontal w/ Boot), Killed Carbon Steel w/ 0.1" CA (PWHT) and Monel Demister
V-504	1	Stripper O. H. Accumulator	$12,800	4.2	$53,760	3'-0" ID X 6'-0" T/T (Horizontal w/Boot), Killed Carbon Steel w/0.125" CA (PWHT)
		SUB-TOTAL	**$74,000**		**$312,000**	
SKID PACKAGES / ALLOWANCES						
	1	Sulfur Analyzer	$250,000	1.0	$250,000	
		SUB-TOTAL	**$250,000**		**$250,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$166,000		$166,000	
		SUB-TOTAL	**$166,000**		**$166,000**	
		TOTAL	**$2,533,000**		**$7,212,000**	

DESIGN SERVICES (% of TIC)	**15%**	**$**	**1,731,000**
OWNER'S SERVICES & COSTS (not included)			
HDS REACTOR CATALYST		**$**	**141,000**
MISC. CATALYST, CHEMICALS INITIAL CHARGE		**$**	**200,000**
ESCALATION (not included)			
UNADJUSTED COST ESTIMATE (UCE)		**$**	**9,284,000**
UNALLOCATED PROVISION (UAP) *contingency*		**$**	**2,316,000**
EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*		**$**	**11,600,000**
HIGH RANGE *TOTAL INSTALLED COST (TIC)*		**$**	**17,400,000**
LOW RANGE *TOTAL INSTALLED COST (TIC)*		**$**	**9,900,000**

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***Note: Field Cost Multiplier includes the following bulk material and installation labor: Civil, Concrete, Structural, Piping, Electrical, Instrumentation, Insulation, Fireproofing, Painting, and Testing.**

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
REV NO.: 0

BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
SHELL & TUBE HEAT EXCHANGERS						
C-101	1	Diesel Feed Cooler	$18,100	4.0	$72,400	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 500SF, CS
C-501	1	Vent Gas Chiller	$25,600	4.0	$102,400	1 (ea) - Shell & Tube TEMA type Heat Exchanger, AES, 1200SF, CS
C-601	1	Water Chiller	$49,000	4.0	$196,000	8.6 MM BTU/Hr, 3790 SF w/ 1 shell, TEMA type AES, Tubes: CS , Shell: CS
		SUB-TOTAL	**$93,000**		**$371,000**	
PRESSURE VESSELS						
D-101	1	Diesel Feed Drum	$23,000	4.2	$96,600	1(ea) - Horizontal Vessel, 5'0" DIA x 15'-0" T-T, CS
D-102	1	Liquid Ammonia Storage Tank	$13,000	4.2	$54,600	1(ea) - Horizontal Vessel, 3' 0" DIA x 9' 0" T-T, CS, Insulated(safety)
D-201*	1	Fermentor Reactor	$175,000	4.2	$735,000	1(ea) - 7,000 gal airlift fermenter
D-202*	1	BDS Reactor #1	$341,000	4.2	$1,432,200	1(ea) - 18,000 gal airlift reactor, S/C Field Erected.
D-203*	1	BDS Reactor #2	$341,000	4.2	$1,432,200	1(ea) - 18,000 gal airlift reactor, S/C Field Erected.
D-204*	1	BDS Reactor #3	$341,000	4.2	$1,432,200	1(ea) - 18,000 gal airlift reactor, S/C Field Erected.
D-301	1	Diesel / Water / Biomass Separator	$43,700	4.2	$183,540	1(ea) - Horizontal Vessel, 5'-9" DIA x 17'-3" T-T, 304SS, w/ overflow baffle
D-401A/B	2	Salt Drier	$62,600	4.2	$262,920	2(ea) - Horizontal Vessel, 6' DIA x 17' T-T, CS
D-501	1	Diesel / Water Separator	$9,600	4.2	$40,320	1(ea) - Horizontal Vessel, 2'-6" DIA x 3'-9" T-T, CS, w/ overflow baffle
L-301	2	Diesel / Water / Biomass Separator	$61,600	4.2	$258,720	2(ea) - Horizontal Vessel, 316L SS, 3' 6" Dia. x 17' 6" T-T, 24"ODx18"IDx120"L Fiberbed Coalescer, Overflow Baffle and 1'x2' Boot
		SUB-TOTAL	**$1,412,000**		**$5,928,000**	

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario
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BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PACKAGED SKIDS/SYSTEMS						
D-205*	1	Seed Tank A	$94,000	2.5	$235,000	Packaged Seed Fermenter System
D-206*	1	Seed Tank B	$328,000	2.5	$820,000	Packaged Seed Fermenter System
J-109A/B	2	Air Compressor	$428,800	2.5	$1,072,000	2(ea) - Air Compressor, Screw, 3000 ACFM, CS body/internals, 300HP Motor Driven
L-109*	1	Glucose Sterilizer	$60,000	2.5	$150,000	1(ea) - Packaged 23 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-110*	1	Nutrients Sterilizer	$60,000	2.5	$150,000	1(ea) - Packaged 20 gph continuous steam sterilizer system complete w/ preheater, heater, cooler, & holding coil
L-302*	1	Electrostatic Precipitator	$254,000	2.5	$635,000	1(ea) - Packaged ESP Unit
L-601*	1	Water Chiller	$533,000	2.5	$1,332,500	1(ea) - Packaged propane refirigeration unit complete w/ compressor, driver, lube oil system, KO drum & all necessary instr. & controls.
L-801*	1	Waste Oxidizer	$436,000	2.5	$1,090,000	1(ea) - Packaged horizontal thermal oxidizer w/ high intensity burner, refractory lined chamber & stack.
L-901*	1	Water Filtration System	$90,000	2.5	$225,000	1(ea) - Cross flow filtration system for water purification
		SUB-TOTAL	**$2,284,000**		**$5,710,000**	
ATMOSPHERE STORAGE TANKS						
F-101	1	Glucose / Water Storage Tank	$25,500	2.9	$73,950	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 10' DIA x 15' T-T, Epoxy Resin coated CS
F-102A	1	Salt / Water Storage Tank	$11,100	2.9	$32,190	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 4'-6" DIA x 9' T-T, Epoxy Resin coated CS
F-102B	1	Salt / Water Storage Tank	$10,200	2.9	$29,580	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 4'-6" DIA x 9' T-T, Epoxy Resin coated CS
F-103	1	Ethanol / Water Storage Tank	$28,200	2.9	$81,780	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 11-0" DIA x 16' 0" T-T, Epoxy Resin coated CS
F-104	1	NaOH / Water Storage Tank	$32,800	2.9	$95,120	1(ea) - Atm. Storage Tank, Flat Roof, Flat Bottom, 12'-0" DIA x 18' T-T, Epoxy Resin coated CS
		SUB-TOTAL	**$108,000**		**$313,000**	

ANVIL CORPORATION

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario
ANVIL NO: AE1416

CLIENT: PetroStar
DATE: 6/17/05
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BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
PUMPS						
J-101A/B	2	Diesel Charge Pump	$48,800	4.5	$219,600	2(ea) - API Centrifugal Pump, 70 gpm, 163 ft. Head, 5HP Motor driven, CS, 1 operating, 1 installed spare
J-103A/B	2	Process Water Pump	$6,400	4.5	$28,800	2(ea) - Centrifugal Pump, 12 gpm, 121 ft. Head, 2HP Motor driven, CS, 1 operating, 1 installed spare
J-104A/B	2	Glucose Pump	$13,000	4.5	$58,500	2(ea) - Diaphragm Pump, 0.5 gpm, 31 ft. Head, Hydraulic driven, 304SS, 1 operating, 1 installed spare
J-105A/B	2	Nutrients Pump	$12,600	4.5	$56,700	2(ea) - Diaphragm Pump, 0.4 gpm, 39 ft. Head, Hydraulic driven, 304SS, 1 operating, 1 installed spare
J-106A/B	2	Ethanol Pump	$14,600	4.5	$65,700	2(ea) - Diaphragm Pump, 1.2 gpm, 81 ft. Head, Hydraulic driven, 304SS, 1 operating, 1 installed spare
J-107A/B	2	Potassium Hydroxide Pump	$15,000	4.5	$67,500	2(ea) - Diaphragm Pump, 1.5 gpm, 65 ft. Head, Hydraulic driven, 304SS, 1 operating, 1 installed spare
J-201A/B	2	Fermentor Transfer Pump	$12,000	4.5	$54,000	2(ea) - Rotary Lobe Pump, 5 gpm, 43 ft Head, 0.5HP Motor, 304SS, 1 operating, 1 installed spare
J-202A/B	2	BDS Reactor No1 Transfer Pump	$13,600	4.5	$61,200	2(ea) - Centrifugal Pump, 250 gpm, 45 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-203A/B	2	BDS Reactor No2 Transfer Pump	$13,600	4.5	$61,200	2(ea) - Centrifugal Pump, 250 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-204A/B	2	BDS Reactor No3 Transfer Pump	$13,600	4.5	$61,200	2(ea) - Centrifugal Pump, 250 gpm, 45 ft. Head, 15HP Motor driven, 304SS, 1 operating, 1 installed spare
J-301A/B	2	1st Stg Sep Overflow Pump	$46,200	4.5	$207,900	2(ea) - API Centrifugal Pump, 75 gpm, 49 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-302A/B	2	1st Stg Sep Underflow Pump	$12,600	4.5	$56,700	2(ea) - Centrifugal Pump, 180 gpm, 68 ft. Head, 5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-303A/B	2	2nd Stg Sep Overflow Pump	$10,200	4.5	$45,900	2(ea) - Centrifugal Pump, 55 gpm, 72 ft. Head, 2HP Motor driven, 304SS, 1 operating, 1 installed spare
J-304A/B	2	2nd Stg Sep Underflow Pump	$8,600	4.5	$38,700	2(ea) - Centrifugal Pump, 15 gpm, 72 ft. Head, 1.5HP Motor driven, 304SS, 1 operating, 1 installed spare
J-502A/B	2	Vent Gas KO Drum Wtr Pump	$8,600	4.5	$38,700	2(ea) - Centrifugal Pump, 2.5 gpm, 70 ft. Head, 0.5HP Motor driven, CS, 1 operating, 1 installed spare
J-601 A/B	2	Chilled Water Pump	$19,800	4.5	$89,100	API Centrifugal Pump, 2000GPM, 0.95 SG, 81.7 Ft. Head, CS Case, 12%CR Impeller, 20HP Motor
		SUB-TOTAL	**$269,000**		**$1,211,000**	

A N V I L   C O R P O R A T I O N

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ANVIL NO: AE1416

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BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
FILTERS						
L-101	1	Diesel Pre-Filter Vessel	$5,210	4.2	$21,882	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 1.5um pore size
L-102	1	Diesel Pre-Filter Vessel	$5,280	4.2	$22,176	1(ea) - Filter housing, 316L SS, 47" T-T x 8" Dia. w/ 5(ea) - Polypropylene element, 30" long, 0.2um pore size
L-103	1	Air Pre-Filter Vessel	$11,400	4.2	$47,880	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - GF element, 30" long, 1.0um pore size
L-104	1	Air Bio-Filter Vessel	$11,125	4.2	$46,725	1(ea) - Filter housing, 316L SS, 43" T-T x 15" Dia. w/ 5 (ea) - PTFE element, 10" long, 0.01um pore size
L-105	1	BDS Reactor #1 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-106	1	BDS Reactor #2 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-107	1	BDS Reactor #3 Air Bio Filter Vessel	$12,420	4.2	$52,164	1(ea) - Filter housing, 316L SS, 55" T-T x 15" Dia. w/ 5(ea) - PTFE element, 30" long, 0.01um pore size
L-108	1	Air Purge Bio-Filter Vessel	$7,011	4.2	$29,446	1(ea) - Filter housing, 316L SS, 30" T-T x 12" Dia. w/ 3(ea) - PTFE element, 10" long, 0.01um pore size
L-111	1	Ethanol Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-112	1	NAaOH Bio-Filter Vessel	$1,308	4.2	$5,494	1(ea) - Filter housing, 316L SS, 10" T-T x 2.5" Dia. w/ 1(ea) - Polyethersulfone element, 5" long, 0.2um pore size
L-113	1	Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-114	1	Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
L-401	1	Recycle Water Pre-Filter Vessel	$2,850	4.2	$11,970	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 1.5um pore size
L-402	1	Recycle Water Bio-Filter Vessel	$2,892	4.2	$12,146	1(ea) - Filter housing, 316L SS, 38" T-T x 8" Dia. w/ 3(ea) - Polypropylene element, 20" long, 0.2um pore size
		SUB-TOTAL	**$91,000**		**$384,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$298,000		$298,000	
		SUB-TOTAL	**$298,000**		**$298,000**	
		TOTAL	**$4,554,693**		**$14,210,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario
ANVIL NO: AE1416

CLIENT: PetroStar
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BDS EQUIPMENT - FACTORING SUMMARY

EQUIP. ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
		DESIGN SERVICES	**15%**		**$ 3,270,000**	
		OWNER'S SERVICES & COSTS (provided by owner)			**$ -**	
		INITIAL CHEMICAL CHARGE			**$ 103,000**	
		ESCALATION (provided by owner)			**$ -**	
		UNADJUSTED COST ESTIMATE (UCE)			**$ 17,583,000**	
		CONTINGENCY			**$ 4,417,000**	
		EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*			**$ 22,000,000**	

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***Note: Equipment pricing by Pelorus.**

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario **CLIENT: PetroStar**
ANVIL NO: AE1416 **DATE: 6/17/05**
REV NO.: 0

PRE FRAC EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
EXCHANGERS						
E-1	1	Diesel Splitter Feed / Bottoms	$21,900	4.0	$87,600	3.3 MM BTU/Hr, 450 SF w/ 1 shell, TEMA type AEU, Tubes: 1 ¼ Cr – ½ Mo, Shell: 1 ¼ Cr – ½ Mo
E-2	1	Diesel Splitter Feed / Overhead	$38,500	4.0	$154,000	9.1 MM BTU/Hr, 1640 SF w/ 1 shell, TEMA type AEU, Tubes: 1 ¼ Cr – ½ Mo, Shell: 1 ¼ Cr – ½ Mo
E-3	1	Diesel Splitter Feed / Bottoms	$24,200	4.0	$96,800	2.0 MM BTU/Hr, 620 SF w/ 1 shell, TEMA type AEU, Tubes: 1 ¼ Cr – ½ Mo, Shell: 1 ¼ Cr – ½ Mo
		SUB-TOTAL	**$85,000**		**$338,000**	
AIR COOLERS						
E-4	1	Diesel Splitter Ovhd Cond.	$45,500	4.0	$182,000	11.2 MM BTU/Hr, 603 SF Bare Tube, 12,800 SF Extended, 15 HP, Seamless Carbon Steel tubes with aluminum fins.
E-5	1	Diesel Splitter Bottoms Cooler	$43,500	4.0	$174,000	3.5 MM BTU/Hr, 729 SF Bare Tube, 15,500 SF Extended, 15 HP, Seamless Carbon Steel tubes with aluminum fins.
		SUB-TOTAL	**$89,000**		**$356,000**	
FURNACES						
H-1	1	Diesel Splitter Reboiler	$507,700	2.5	$1,243,865	17.8 MM BTU/Hr, Vertical Fired Heater, Tubes: 9 Cr – 1 Mo w/ 0.1" CA
	1	CEMS	$100,000	1.5	$150,000	
	1	Preheating	$40,000	1.0	$40,000	
	1	Burner Management	$30,000	1.0	$30,000	
		SUB-TOTAL	**$678,000**		**$1,464,000**	
PUMPS						
P-1 A/B	2	Diesel Splitter Charge Pump	$39,400	5.0	$197,000	API Centrifugal Pump, 206GPM, 0.80 SG, 257 Ft. Head, CS Case, 12%CR Impeller, 20HP Motor
P-2 A/B	2	Diesel Splitter Bottoms Pump	$67,000	5.0	$335,000	API Centrifugal Pump, 1406GPM, 0.642 SG, 305 Ft. Head, CS Case, 12%CR Impeller, 125HP Motor
P-3 A/B	2	Diesel Splitter Ovhd Pump	$61,000	5.0	$305,000	API Centrifugal Pump, 290GPM, 0.86 SG, 188 Ft. Head, CS Case, 12%CR Impeller, 20HP Motor
		SUB-TOTAL	**$167,000**		**$837,000**	
COLUMNS						
V-2	1	Diesel Splitter Tower	$107,300	4.4	$472,120	7'-0" Dia. X 82'-0" T/T w/ 30 valve trays, Carbon Steel w/ 0.2" CA and Type 410 SS trays, supports, and downcomers
V-2	1	Diesel Splitter Tower Trays	$110,400	2.7	$298,080	Valve Trays, SS410
		SUB-TOTAL	**$218,000**		**$770,000**	
VESSELS						
V-1	1	Diesel Feed Charge Drum	$34,300	4.2	$144,060	7'-0" ID X 15'-0" T/T Horizontal Vessel, 50 PSIG, Full Vacuum, Carbon Steel w/ 0.2" CA
V-3	1	Splitter Overhead accumulator	$27,000	4.2	$113,400	6'-0" ID X 12'-0" T/T Horizontal Vessel, 75 PSIG, Full Vacuum, Carbon Steel w/ 0.2" CA
		SUB-TOTAL	**$61,000**		**$257,000**	
FREIGHT		Freight Allowance (7% Equip Cost)	$91,000		$91,000	
		SUB-TOTAL	**$91,000**		**$91,000**	
		TOTAL	**$1,389,000**		**$4,113,000**	

A N V I L   C O R P O R A T I O N

PROJECT: PetroStar Valdez ULSD - Pre Frac Scenario **CLIENT: PetroStar**
ANVIL NO: AE1416 **DATE: 6/17/05**
REV NO.: 0

PRE FRAC EQUIPMENT - FACTORING SUMMARY

EQUIPMENT ITEM NO.	QUAN-TITY	DESCRIPTION	TOTAL EQUIP. COST, $	*FIELD COST MULTI-PLIER	TOTAL FIELD COST, $	NOTES
		DESIGN SERVICES (% of TIC)	15%		$ 967,000	
		OWNER'S SERVICES & COSTS (not included)				
		MISC. CATALYST, CHEMICALS INITIAL CHARGE			$ 100,000	
		ESCALATION (not included)				
		UNADJUSTED COST ESTIMATE (UCE)			$ 5,180,000	
		UNALLOCATED PROVISION (UAP) *contingency*			$ 1,320,000	
		EXPECTED COST (P50 VALUE) *TOTAL INSTALLED COST (TIC)*			$ 6,500,000	
		HIGH RANGE *TOTAL INSTALLED COST (TIC)*			$ 9,800,000	
		LOW RANGE *TOTAL INSTALLED COST (TIC)*			$ 5,500,000	

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***Note: Field Cost Multiplier includes the following bulk material and installation labor: Civil, Concrete, Structural, Piping, Electrical, Instrumentation, Insulation, Fireproofing, Painting, and Testing.**

Appendix D.10. Operating Cost Estimates

Pre Frac Case -- Diesel Splitter Operating Costs for 6,000 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis		Comments
Utility - electricity	$ 92,374	0.1	111 kw	0.1 $/kwH	
Utility - fuel	$ 923,742	1.1	22.2 MMBTU/H	5 $MMBTU	
Total volume related costs	**$ 1,016,116**	**1.2**			

Basis:
diesel feed: 252000 gal/day
On-stream availability: 95 %
Overall ULSD yield (% of feed) 96.5 %

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 0	0.0	Covered by HDS Operator	
Contract Services	$ 0	0.0	Covered by HDS	
Operating Supplies	$ 0	0.0	Covered by HDS	May be somewhat volume dependendent
Maintenance and T/A cost	$ 97,500	0.1	1.5% of of TIC	
Insurance & Taxes	$ 162,500	0.2	2.5% of TIC	Based on expected TIC of IBL plant
Total fixed costs	**$ 260,000**	**0.3**		

Basis:
Diesel Splitter Capital Cost 6.5 $MM

Total Operating Cost:	**2005$/year**	**cent/gal (ULSD)**
	$ 1,276,116	**1.5**

Pre Frac Case -- HDS Unit Operating Costs for 3870 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 384,476	0.7	462 kw 0.1 $/kwH	
Utility - fuel	$ 635,385	1.2	15.3 MMBTU/H 5 $MMBTU	
Utility - H2 plant feed	$ 425,670	0.8	10.23 MMBTU/H 5 $MMBTU	
Sulfur Disposal	$ 221,365	0.4	1.9 tons/day 0.15 $/Lb	Assuming the sulfur can be disposed of locally.
Chem - fuel additives	$ 106,875	0.2	Lubricity Improver for All Diesel	
Chem - sulfur plant	$ 73,176	0.1	Caustic & Nutrients for sulfur	
Cost of lost diesel production	$ 721,762	1.3	95.6% yield on diesel at $1.07/gallon	Yield losses on diesel minus credit for the resulting naphtha & LPG Fuel.
Total volume related costs	**$ 2,568,709**	**4.8**		

Basis:
diesel feed: 162450 gal/day
On-stream availability: 95 %
ULSD yield (% of feed) 95.6 %

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	0.9	1 op post (24/7) + 1 maint	
Contract Services	$ 150,000	0.3	All disciplines including laboratory	
Operating Supplies	$ 200,000	0.4	Laboratory and other ovhd	May be somewhat volume dependendent
Maintenance	$ 200,000	0.4	Excluding TA costs	
Turnaround costs	$ 150,000	0.3	Amortized per year cost	Two to Three year turnaround assumed
Insurance & Taxes	$ 450,000	0.8	2.5% of TIC	Based on expected TIC of IBL plant
Catalyst	$ 47,000	0.1	Amortized per year cost	
Total fixed costs	**$ 1,658,350**	**3.1**		

Basis:
HDS, H2, Sulfur Plant Total Insta 18.0 $MM

Total Operating Cost:	2005$/year	cent/gal (ULSD)
	$ 4,227,059	**7.8**

Pre Frac Case -- BDS Unit Operating Costs for 2140 BPSD Diesel Feed

Volume Related Costs

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Utility - electricity	$ 763,039	2.5	917 kw 0.1 $/kwH	From Pelorus
Utility - steam	$ 1,313	0.0	21 lb/hr 7.5 $/1000 lb	From Pelorus
Chemicals	$ 1,809,086	5.9		From Pelorus
Cost of Loss Diesel Production	$ 574,668	1.9	98.3% yield on diesel at $1.07/gallon	From Pelorus
Total volume related costs	**$ 3,148,106**	**10.3**		

Basis:
diesel feed: 89880 gal/day
On-stream availability: 95 %
ULSD yield (% of feed) 98.3 %

Fixed Costs (not volume dependent)

Item	2005$/year	cent/gal (ULSD)	Basis	Comments
Payroll	$ 461,350	1.5	1 op post (24/7) + 1 maint	From Pelorus
Contract Services	$ 110,000	0.4	0.5% of TIC	From Pelorus
Operating Supplies	$ 68,000	0.2	Filters and Membranes	From Pelorus
Maintenance and T/A Costs	$ 330,000	1.1	1.5% of TIC, 2 - 3 Year T/A Cycle	From Pelorus
Insurance & Taxes	$ 550,000	1.8	2.5% of TIC	From Pelorus
Total fixed costs	**$ 1,519,350**	**5.0**		

Basis:
BDS Total Installed Cost: 22.0 $MM

Total Operating Cost:	**2005$/year**	**cent/gal (ULSD)**
	$ 4,667,456	**15.2**