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Work performed for
U.S. DEPARTMENT OF ENERGY
Fossil Energy
Office of Magnetohydrodynamics

Prepared for
Twentieth Symposium on the Engineering Aspects of Magnetohydrodynamics
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Abstract
An in-depth study was conducted, both under contract and in-house, to determine what, if any, improvements could be made on the oxidant supply system for combined cycle MHD power plants which would be reflected in higher thermal efficiency and a reduction in the cost of electricity, COE. The study included a systematic analysis of "air-separation" process variations which showed that the specific energy consumption could be minimized when the product stream oxygen concentration is about 70 mole percent. The use of advanced air compressors, having variable speed and guide vane position control, results in additional power savings. The study also led to the conceptual design of a new air separation process, sized for a 500 MW MHD plant, referred to as "internal compression." In addition to its lower overall energy consumption, potential capital cost savings have been identified for air separation plants using this process when constructed in a single large air separation train rather than multiple parallel trains, typical of conventional practice.

The effect of the lower energy consumption of the new air separation process on major MHD plant parameters such as thermal efficiency and magnetic efficiency of 0.6 percent while allowing more favorable tradeoffs between magnetic energy and oxygen system capacity.

I. Introduction
Oxygen enrichment of the MHD combustor oxidant stream at low and intermediate preheat temperatures has been identified as a viable alternative to systems using indirectly fired high temperature air heaters. These studies identified the attractiveness of MHD/steam power plants using intermediate temperature recuperative preheat and oxygen enrichment of the combustor oxidizer for early commercial MHD power plants. Detailed MHD plant performance calculations considering oxygen enriched MHD combustion air* showed that the energy consumption required for oxygen production has a significant impact on the overall results. Although energy consumption values required for oxygen production by air separation plants delivering a high purity oxygen product (above 99 mole percent O2) range from 280 to 300 kWh/ton of pure O2, considerable energy savings can be achieved by using a medium purity product (60 to 80 mole percent O2) for blending with air to produce the required MHD combustor oxidant stream whose oxygen concentration may range from 25 to 40 mole percent.

Such a "medium purity" air separation plant was placed in service by Linde A.G. for Thyssen Steel Works, Germany, in 1973.5 This plant delivers a 70,000 normal cubic meters per hour (nccm) (43,500 scfm) product stream at near atmospheric pressure containing 60 mole percent oxygen which is blended with air to form a blast furnace stream of 283,000 nccm (176,000 scfm) containing 30.6 mole percent oxygen. The plant's specific energy consumption (SEC) is reported at 224 kWh per ton of equivalent pure oxygen (TEPO).

The present study was managed by NASA LERC for DOE under Interagency Agreement No. EF-77-A-01-2874. The Lotepro Co. of New York, NY a subsidiary of Linde A.G., FRG (Germany) was the main contractor under contractDEN3-165. Also supplying data were Linde A.G. and a number of industrial compressor manufacturers; notably, Demag-Mannesman Co., Dresser Industries, Inc., MAN/GHH Co., Sulzer Brothers, Inc., and Transamericana De-Laval, Inc.

The study objectives and preliminary results have been reported on previously in its early stage. The main objective was to explore process variations for their potential reduction in SEC below the 224 kWh/TEPO quoted above. The work has recently been completed, and a comprehensive report is in preparation. The present section summarizes the main results of the study, including a brief description of a new air separation process applicable to thermodynamic cycles requiring pressurized oxidant streams, and its effect on the performance of a 500 MW combined cycle MHD power plant.

II. Cryogenic Air Separation Process
Before discussing the study results, a brief review of the basic cryogenic air separation process is in order.

Cryogenic air separation processes utilize the difference in boiling points of the various air components (principally N2 and O2) and the changes in boiling points with pressure to achieve component separation by fractional distillation. The basic process utilizes a number of auxiliary components (compressors, expanders, heat exchangers, adsorbers, switching valves) whose function is to change the state of the input air stream so that component separation can take place, and also to condition the output streams (product oxygen and nitrogen) to user requirements. The actual separation or rectification process is usually carried out in "double rectification columns" consisting of an upper compartment operated at low pressure (near atmospheric in most cases) and a lower compartment operated at higher pressure. The lower compartment is usually referred to as the medium pressure column, the upper, as the low pressure
mass transfer to occur in the two phase-two
components countercurrent flow environment
dictates the pressure difference between the two
columns and thereby specifies the process energy
input required for the Air Separation Unit (ASU)
air compressor. This is because nitrogen, which
at atmospheric pressure has a lower boiling point
than the desired product oxygen, must condense at
the top of the medium pressure column in order to
evaporate product oxygen at the bottom of the low
pressure column. The only way this requirement
can be met is for the condensation of N₂ to
take place at a (E) pressure higher than that of the
evaporating product O₂. It should be noted
that higher the desired O₂ concentration (purity)
of the product, which is collecting at
the bottom of the low pressure column, the
higher is the pressure difference requirement
between the two columns and the higher the
compressor power input for the same input air
flow.

Basic Air Separation Plant

A schematic of a conventional air separation
plant based on the process described above is
shown in figure 1. Its main components are:
- Air compressor, (CP)
- Adsorbers for the removal of water and
carbon dioxide, (WS, MS1, MS2)
- Expansion turbine for the production of
refrigeration, (T)
- Heat exchangers for cooling the air to
liquefaction temperature and warming the
oxygen and nitrogen products to ambient
temperature, (E)
- Rectification columns, (C₁ and C₂) and
condenser-evaporator, (K) for the separation
of air into O₂ and N₂ on the basis of
temperature and constant mole percentages of O₂,
which was varied from 25 to 40 mole
percent. Since MHD applications require combustor
oxidant O₂ concentrations (25 to 40 mole
percent) well below the product purities at which
compressor power is minimized, the more efficient
medium purity air separation processes are
compatible with MHD/steam power cycles. Based on
these results a plant delivering a 70 mol percent
O₂ product at one atmosphere was chosen for use
in the 200 MW Engineering Test Facility (ETF)
Conceptual Design.²

III. Process Study and Results

Summary of Process Variations

The approach used was to do a systematic
analysis of as many as 18 process variations for
an oxidant supply system sized for a 1000 MW
MHD/steam power plant. The oxidant supply system
included the air separation plant as well as the
final oxidant mixing chamber and oxygen enriched
air compressor. Delivery pressure of the oxidant
stream to the MHD combustor was specified at
8 atm and the O₂ concentration of the oxidant
stream was 30.6 mol percent. The process parameters varied in the study were product O₂
concentration which was ranged from 30.6 to 99.5
mol percent O₂, and the upper column pressure
which was varied from 1 atm to 8 atm, with the
high pressure cases also providing pressurized N₂
for power recovery. For each process
studied both total power consumption and relative
cost figures were obtained.

Results showed that the atmospheric upper
column pressure cases, in which the product is
mixed with ambient air prior to compression to
combustor pressure, were superior to the high
pressure upper column cases, both in total power
consumption and in capital cost. Figure 2 shows specific energy consumption, SEC, as a
function of product purity for the atmospheric
product cases. Note that the results represent a
tradeoff between the ASU input air compressor
flow requirement, which decreases with product
purity, and the ASU input air compressor
flow requirement, which decreases with product
purity. The SEC is shown to drop from 325
kWh/TEPO at 40 percent product purity to 195
kWh/TEPO at 70 to 80 percent purity and increase
to near 240 kWh/TEPO for the high purity product.

Hence the optimum (minimum compressor power)
tradeoff between compressor flow and pressure
ratio occurs at product purities between 70 to 80
percent. Since MHD applications require combustor
oxidant O₂ concentrations (25 to 40 mole
percent) well below the product purities at which
compressor power is minimized, the more efficient
medium purity air separation processes are

®
New Air Separation Process

Having considered the available variations of the basic process exemplified by the Thyssen Steel plant, we decided to explore the potential additional improvement in total power consumption for a process which utilizes pumping of the product in the liquid state to the final end use pressure, product vaporization at this pressure, followed by heating and mixing with a separately compressed air stream to obtain the desired oxidant O₂ concentration. Such a process may have significant advantages for end uses that require the process output stream to be delivered at a pressure which is above atmospheric. The conceptual design for such a process was developed jointly by NASA LeRC and Lotepro. The process is referred to as an "Internal Compression and Liquid Product Pumping" in an invention disclosure currently being prepared.

Process Energy Consumption and Capital Cost

To evaluate the potential advantages of the new process over the previously discussed optimized conventional process a study was conducted upon two oxidant supply systems sized for a 500 MWₑ MHD/steam plant, using the new process and the optimized conventional process (195 kWh/TEPO), respectively. A comparison of power consumption results and of the main process parameters is shown in tables I and II. Also, a block diagram comparing the main features of the two oxidant supply systems is shown in figure 3.

Results in table I show that the new process, in which the product from the upper column is pumped as a liquid to the desired pressure, evaporated and heated, and then mixed with air compressed in the blend air compressor, has a lower overall energy consumption than the optimized conventional process in which an atmospheric pressure product is mixed with ambient air and the resulting oxidant stream is compressed in the oxidant compressor (see figure 3). Note that the oxidant compressor (an axial/radial machine) must be rated for oxygen enriched air service which implies a small penalty on efficiency and cost, whereas the blend air compressor used in the new process only has to compress air, which is less hazardous, and therefore can be compressed more efficiently in a multi-stage axial machine.

Even though, as is shown in table II, the SEC at product pressure for the new process is higher (267 vs. 195 kWh/TEPO), the overall energy required to produce the desired oxidant is lower. The use of the new process would be equivalent to using a conventional process, delivering product at atmospheric pressure, which has an SEC of 178 kWh/TEPO. This equivalent SEC is plotted as a triangle in figure 2. Further gains can be realized with the new process if higher end use pressures are required.

Another result of the study was that one can construct large single train air separation plants (up to 6000 tons/day of contained O₂) rather than using multiple parallel trains. The tradeoff is between column rail shippability, overall system redundancy and the need for on-site fabrication of the large columns required. Relative costs for two air separation units using the new process to deliver the 4250 tons/day of contained O₂ required for the 500 MWₑ MHD plant, are shown in table III. One unit is based on the use of three trains and rail shippable columns of 13.5 ft diameter. The other is based on a field constructed single train with a 24.3 ft column diameter. The table shows that even though the single train requires on-site fabrication, the reduction in total number of components results in a relative capital cost savings of 11 percent.

Air Separation Plant Sizing

Care must be taken to determine the optimum O₂ content in the oxidant, as the following calculations will show, in order to minimize the oxidant plant cost. Based on preliminary calculations, the ASU was conservatively sized for 4260 tons/day of contained oxygen in order to deliver a 35 mol percent O₂ stream to the 500 MWₑ MHD plant. Figure 4 is a semi-logarithmic plot, which shows how the required O₂ tonnage increases with O₂ mol fraction in the oxidant, X. The figure also shows that the required ASU capacity is directly proportional to the "percent oxygen enrichment" parameter, PCTE (congruent curve displaced by a constant). The PCTE parameter is defined and its use is explained in the appendix.

IV. Calculation of 500 MWₑ MHD Power Plant Performance

The MHD plant performance was calculated following the methods described in previous papers. The power plant major cycle parameters are listed in table IV and the generator constraints are shown in table V. The bottom cycle performance was calculated using the PRESTO computer code. The bottom cycle is based on the study discussed in the ASME CSPEC, with steam conditions of 2400 psig/1000°F/1000°F. The channel was cooled using low pressure, low temperature feedwater. The oxidant compressor and ASU compressors are assumed to be driven by a single steam turbine. The generator operating conditions were selected to optimize the performance of the overall combined cycle power plant. This procedure was carried out for oxygen concentrations of 25, 30 and 35 mol percent in the oxidant, MPO, (i.e., x*100), and channel lengths of 10 m, 15 m and 20 m.

The overall plant thermal efficiency is plotted as a function MPO for the channel lengths considered in figure 5. Results are shown (figure 5a), for an air separation plant SEC of 224 kWh/TEPO, representing the Thyssen steel plant ASU technology and also for the new process (equivalent SEC of 178 kWh/TEPO) (figure 5b). The power plant thermal efficiencies are shown to be up to 0.7 percent higher for plants using the new process (figure 5b). Also, the oxidant O₂ concentration at which the maximum efficiency occurs (dashed curve) shifts to slightly higher levels. Thus, for the conventional process and a 15 m channel the maximum efficiency is about 43.7 percent, and it occurs at an MPO of 32 mol percent (figure 5a), whereas for the new process it rises to 44.3 percent at an MPO of 33.5 mol percent (figure 5b). Note that use of the optimized conventional air separation process
(195 kWh/TEPO), incorporated in the ETF and the CSPEC studies, would result in overall thermal efficiency values that are about halfway between the values given above.

For both the higher and lower energy consumption, figure 5 shows that there are tradeoffs between plant thermal efficiency, oxidant O₂ concentration and channel length. An additional tradeoff is shown in figure 6, which is a plot of magnetic energy stored in the channel volume as a function of plant thermal efficiency for the various oxidant O₂ mole fractions and channel lengths considered. The magnetic energy is proportional to magnet costs while the MPO can be related to costs associated with the oxidant supply system, as indicated in figure 4. Therefore these parameters should be minimized in an optimally designed combined cycle MHD plant, consistent with sufficiently high thermal efficiency, in order to achieve the lowest cost of electricity, COE. Comparison of figures 6a and 6b shows that not only is the thermal efficiency higher at all conditions for the lower oxygen production energy, but also that a given decrease in magnetic energy will result in a smaller sacrifice in thermal efficiency for the plant with the lower oxygen production energy requirement. For example, the plant thermal efficiency is about 44.40 percent (figure 6b) using a 20 m channel and an oxidant O₂ mole fraction of 0.30. For these conditions the magnetic energy is about 1150 megajoules (MJ). Reducing the channel length to 15 m, but increasing the O₂ mole fraction, x, to near 0.35 (actually 0.335 as per figure 5b) will result in a thermal efficiency of 43.2 percent, a loss of only 0.13 percent from the 44.4 percent figure quoted above. But the magnetic energy decreases dramatically from 1150 MJ to 675 MJ, equivalent to a 41 percent decrease. Of course, the above tradeoff implies an increase in the oxidant supply system capacity of about 24 percent.

The same tradeoff, based on the results shown in figure 6a for the higher oxygen production energy requirement, will result in a power plant thermal efficiency drop from 43.90 to 43.60 percent, the resulting loss of 0.3 percent being more than double the value quoted above.

Final system optimization will require additional studies of the type discussed above, once the relationship between component sizes and associated dollar values can be defined more clearly. However, the results of this study point out that one can obtain higher overall thermal efficiencies by using large, advanced technology, oxidant supply systems which offer significant savings in oxygen production costs. These systems will also allow more flexibility in the overall power plant optimization and therefore contribute in the attainment of the lowest potential COE for combined cycle MHD/steam power plants.

V. Concluding Remarks

The results of this study show that the oxidant production cost for a combined cycle MHD/steam power plant can be lowered by improvements to the oxidant supply system. A new air separation process based on internal compression and liquid pumping and configured for a 500 MWₑ MHD/steam power plant with a 7.22 atm oxidant delivery pressure was shown to achieve a 20 percent drop in total energy consumption below state of the art, medium purity air separation plants operating overseas. The new process also was shown to achieve a 9 percent drop below the energy requirement of optimized conventional technology air separation plants assumed for the CSPEC study. The energy consumption can be reduced further for plants requiring higher delivery pressures.

For the 500 MWₑ power plant, the reduced energy consumption for oxidant production was shown to result in an overall thermal efficiency increase of 0.6 percent which, when combined with projected capital cost savings identified in the study could bring about reasonable reductions in the plant COE. Future potential reductions in oxygen production costs will lead to additional improvements in MHD power plant performance.

References


| TABLE I: AIR SEPARATION POWER CONSUMPTION COMPARISON FOR 500 MW<sub>e</sub> PLANT |
|---------------------------------|-----------------|-----------------|
|                                  | OPTIMIZED CONVENTIONAL PROCESS* | NEW PROCESS |
| INPUT AIR COMPRESSOR, KW        | 30,590           | 29,630         |
| BOOST AIR COMPRESSOR, KW        | 0                | 13,410         |
| EXPANSION TURBINE (POWER RECOVERY), KW | -620          | -781           |
| PRODUCT PUMP, KW                | 0                | 86             |
| BLEND AIR COMPRESSOR, KW        | 0                | 36,135         |
| OXIDANT COMPRESSOR, KW          | 52,990           | 0              |
| TOTAL POWER CONSUMPTION, KW     | 82,960           | 78,480         |

| TABLE II: AIR SEPARATION PROCESS PARAMETER COMPARISON FOR 500 MW<sub>e</sub> PLANT |
|---------------------------------|-----------------|-----------------|
|                                  | OPTIMIZED CONVENTIONAL PROCESS* | NEW PROCESS |
| Input Air Flow, mm<sup>3</sup>/sec* | 154.75          | 154.75         |
| Input Air Pressure, atm          | 3.95             | 3.93            |
| Boost Air Flow, mm<sup>3</sup>/sec | ---              | 63.89          |
| Boost Air Pressure, atm          | ---              | 15.99          |
| Boost Air Temp, K                | ---              | 465            |
| Upper Column Pressure, atm       | 1.0              | 1.0             |
| Product O<sub>2</sub> Content, mol pct. | 70              | 70             |
| Product Pressure, atm            | 1.0              | 7.22           |
| Product Flow, mm<sup>3</sup>/sec | 44.7             | 44.7           |
| Product Flow, tons O<sub>2</sub>/day | 4250            | 4250           |
| Blend Air Flow, mm<sup>3</sup>/sec | 111.3           | 111.3          |
| Blend Air Pressure, atm          | 1.0              | 7.22           |
| Blend Air Temperature, K         | 1.0              | 540            |
| Oxidant Flow, mm<sup>3</sup>/sec | 156.0            | 156.0          |
| Oxidant O<sub>2</sub> Content, mol pct | 35              | 35             |
| Oxidant Pressure, atm            | 7.22             | 7.22           |
| Oxidant Temperature, K           | 544              | 516            |
| SEC at Prod. Press, kWh/TEPO     | 195              | 267            |
| SEC Corrected to P=atm, T=544K, kWh/TEPO | 195          | 178            |

* To convert mm<sup>3</sup>/sec to scfm, multiply by 5787.

| TABLE III: COLUMN SIZE AND CAPITAL COST COMPARISONS FOR TRIPLE VS. SINGLE TRAIN ASU FOR 500 MW<sub>e</sub> PLANT |
|----------------------------------------------------------|-----------------|-----------------|
| Column Dia,* m(ft)                                       | 4.10 (13.5)     | 7.40 (24.3)     |
| Relative Turnkey Cost                                    | 1.00            | 0.89            |

*Assumed limit for rail shippability is 4270 mm (14 ft)
### TABLE IV: MAJOR CYCLE PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal type</td>
<td>Montana Rosebud</td>
</tr>
<tr>
<td>Moisture content of coal delivered to combustor, percent</td>
<td>5</td>
</tr>
<tr>
<td>Oxidizer preheat temperature, K (F)</td>
<td>867 (1500)</td>
</tr>
<tr>
<td>Combustor pressure, atm</td>
<td>Selected to maximize plant efficiency</td>
</tr>
<tr>
<td>Combustor heat loss, percent HHV of coal</td>
<td>5</td>
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<tr>
<td>Combustor oxidizer-fuel ratio relative to stoichiometric</td>
<td>0.90</td>
</tr>
<tr>
<td>Combustor slag rejection, percent</td>
<td>80</td>
</tr>
<tr>
<td>Generator type</td>
<td>Faraday</td>
</tr>
<tr>
<td>Potassium-coal mass ratio</td>
<td>0.0859</td>
</tr>
<tr>
<td>MHD Generator inlet Mach number</td>
<td>0.8</td>
</tr>
<tr>
<td>Diffuser pressure recovery coefficient</td>
<td>0.6</td>
</tr>
<tr>
<td>Diffuser exit pressure, atm</td>
<td>1.0</td>
</tr>
<tr>
<td>MHD generator length, meters</td>
<td>10, 15, 20</td>
</tr>
<tr>
<td>Cycle compressor polytropic efficiency</td>
<td>0.90</td>
</tr>
<tr>
<td>Sulfur removal by seed, percent</td>
<td>70</td>
</tr>
<tr>
<td>Final oxidizer-fuel ratio relative to stoichiometric</td>
<td>1.05</td>
</tr>
<tr>
<td>Stack temperature, F</td>
<td>250</td>
</tr>
<tr>
<td>Air separation plant compressor power requirement, kW-hr/ton of equivalent pure oxygen added</td>
<td>224, 178</td>
</tr>
<tr>
<td>Pressure drop from compressor exit to combustor, percent of compressor exit pressure</td>
<td>0.1</td>
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### TABLE V: GENERATOR CONSTRAINTS

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Value</th>
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<tbody>
<tr>
<td>Maximum axial electric field, kV/m</td>
<td>2.5</td>
</tr>
<tr>
<td>Maximum transverse electric field, kV/m</td>
<td>4.0</td>
</tr>
<tr>
<td>Maximum transverse current density, A/cm²</td>
<td>1.0</td>
</tr>
<tr>
<td>Maximum Hall parameter</td>
<td>4.0</td>
</tr>
<tr>
<td>Maximum magnetic field, T</td>
<td>6.0</td>
</tr>
</tbody>
</table>
APPENDIX: OXIDANT MIXTURE COMPOSITIONS

When air is mixed with the product delivered by medium purity air separation plants the resulting compositions, even at the same O₂ mole fractions, will be different from those of pure oxygen and air mixtures. This is illustrated in tables A1 and A2 which show respective compositions in terms of the mole and mass fractions of the three major constituents, N₂, O₂, and Ar.

The reason for the increase in concentration of argon along with that of oxygen in product streams, containing up to 95 mol percent O₂, arises from the fact that the medium purity air separation process removes nitrogen, but not argon, from the product. Argon can be separated from oxygen and collected in high purity plants which use an additional argon separation column.

In MHD applications the concentration of argon in the oxidant stream has a beneficial, albeit small effect on power output, because of the slight increase in plasma conductivity. In addition to composition, tables A1 and A2 also have column tabulations for mixture molecular weight, density, the ratio of contained O₂ to equivalent pure O₂ (which excludes any O₂ contributed by air), and a parameter identified as "Percent O₂ Enrichment", or PCTE. This parameter has been defined for N₂-O₂ mixtures as

\[ PCTE = 100 \times (1 - \frac{N/O}{3.26}) \]  

where N/O is the nitrogen/oxygen mass ratio in the oxidant. Equation (1) has been redefined here for multi-component mixtures as:

\[ PCTE = 100 \times (1 - \frac{R/O}{3.32}) \]  

where R/O is the ratio of the sum of non-oxygen mass fractions to the mass fraction of O₂.

Since PCTE is directly proportional to O₂ plant capacity, it is a useful parameter for scaling O₂ plant size when the O₂ mol fraction in the oxidant is changed while, keeping the product purity constant. Tables A1 and A2 show PCTE values for O₂ mol fractions ranging from 21 to 100 percent for ASU product-air and pure O₂-air mixtures, respectively. If the product purity is changed, the O₂ plant capacity scales inversely as the ratio of the new-to-old PCTE value.

Alternately, for a change in product purity, the new air separation plant capacity can be computed by multiplying by the direct ratio of "Contained O₂/pure O₂" values in tables A1 or A2.
### Table A1: Air Separation Plant Product Mixture Composition

<table>
<thead>
<tr>
<th>Oxygen (%)</th>
<th>Nitrogen (%)</th>
<th>Argon (%)</th>
<th>Mass (%)</th>
<th>Molecular Density</th>
<th>Cont.02/</th>
<th>Percent O2</th>
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<tr>
<td>21.00</td>
<td>78.064</td>
<td>.936</td>
<td>23.202</td>
<td>75.506</td>
<td>1.291</td>
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<td>1.115</td>
<td>27.450</td>
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<td>30.00</td>
<td>66.663</td>
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<td>1.819</td>
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<td>60.050</td>
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<td>40.00</td>
<td>58.217</td>
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### Table A2: Composition of Pure Oxygen and Dry Air Mixtures

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Figure 1. Basic air separation plant delivering product $O_2$ at atmospheric pressure.

Figure 2. Air separation process study results (Contract DEN 3-1651).
Figure 3. - Comparative block diagrams for 500 MW_e MHD oxidant supply systems.

Figure 4. - Air separation plant size variation for 500 MW_e MHD/steam plant. Product O_2 concentration is 70 mole percent.
Figure 5. 500 MW<sub>e</sub> MHD plant performance for various oxidant mixtures and channel lengths.

Figure 6. 500 MW<sub>e</sub> MHD plant optimization considering: magnet capacity, oxidant system capacity (O<sub>x</sub> and O<sub>y</sub>), and channel length, L.
An indepth study was conducted, both under contract and inhouse, to determine what, if any, improvements could be made on the oxidant supply system for combined cycle MHD power plants which would be reflected in higher thermal efficiency and a reduction in the cost of electricity (COE). The study included a systematic analysis of "air-separation" process variations which showed that the specific energy consumption could be minimized when the product stream oxygen concentration is about 70 mole percent. The use of advanced air compressors, having variable speed and guide vane control, results in additional power savings. The study also led to the conceptual design of a new air separation process, sized for a 500 MW \textsubscript{e} MHD plant, referred to as "Internal compression." In addition to its lower overall energy consumption, potential capital cost savings have been identified for air separation plants using this process when constructed in a single large air separation train, rather than multiple parallel trains, typical of conventional practice. The effect of the lower energy consumption of the new air separation process on major MHD plant parameters such as thermal efficiency and magnetic energy requirement was calculated for a range of channel lengths and for various oxidant stream compositions. The process was shown to bring about an increase in overall plant thermal efficiency of 0.6 percent while allowing more favorable tradeoffs between magnetic energy and oxygen system capacity.