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ENGINEERING DEVELOPMENT OF
AN ABSORPTION PROCESS FOR
THE CONCENTRATION AND COLLECTION OF
KRYPTON AND XENON
SECOND SUMMARY PROGRESS REPORT
JULY THROUGH DECEMBER, 1967

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UNION CARBIDE CORPORATION
NUCLEAR DIVISION

UNION
CARBIDE

Operating the

OAK RIDGE GASEOUS DIFFUSION PLANT • OAK RIDGE NATIONAL LABORATORY
OAK RIDGE Y-12 PLANT • PADUCAH GASEOUS DIFFUSION PLANT

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UNION CARBIDE CORPORATION
NUCLEAR DIVISION
Oak Ridge Gaseous Diffusion Plant
Oak Ridge, Tennessee

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ABSTRACT

One of the most direct methods for stripping krypton and xenon from contaminated gas streams is selective absorption in a fluorocarbon solvent, such as refrigerant-12. A development program is under way at the Oak Ridge Gaseous Diffusion Plant to establish the engineering scale-up data required for design of plants using the absorption technique for processing gases containing radioactive krypton and xenon isotopes. The scope of the work includes pilot plant testing, conceptual design studies for various plant-scale applications of the process, and optimization studies. During this report period, construction and procurement of the pilot plant equipment items were essentially completed, and installation was begun. The conceptual design effort has been temporarily reduced pending collection of pilot plant data to guide the selection of promising plant operating conditions. The basic material balance model used in the optimization work has been constructed, programmed, and tested; and equipment sizing and costing routines are currently being developed for incorporation into the material balance code.

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ENGINEERING DEVELOPMENT OF AN ABSORPTION PROCESS
FOR THE CONCENTRATION AND COLLECTION OF KRYPTON AND XENON
SECOND SUMMARY PROGRESS REPORT, JULY THROUGH DECEMBER, 1967

With the current rapid growth in the number of nuclear power installations, it is increasingly apparent that gas streams containing radioactive isotopes of the fission product gases, krypton and xenon, will need to be safely processed to allow innocuous venting to the atmosphere both in expected large-scale nuclear fuel reprocessing operations and in a nuclear reactor excursion situation, should such occur. Also, integral noble gas stripping systems will probably be required for treating blanket gases in some reactor types now being considered. One of the most direct methods for removing krypton and xenon is selective absorption of these elements from a compressed, contaminated gas stream using a chilled fluorocarbon solvent, such as refrigerant-12 (dichlorodifluoromethane).

A development program is under way at the Oak Ridge Gaseous Diffusion Plant to provide the engineering data required for the design of plant-scale absorption systems. The previous progress summary report for this project is:

Merriman, J. R., Pashley, J. H., and Smiley, S. H., Engineering Development of An Absorption Process for the Concentration and Collection of Krypton and Xenon, Summary of Progress Through July 1, 1967, Union Carbide Corporation, Nuclear Division, Oak Ridge Gaseous Diffusion Plant, December 19, 1967 (K-1725).

As noted in the earlier progress report, the ORGDP program was initially divided into three areas: (1) pilot plant testing to collect engineering performance data, (2) mobile unit design to investigate the feasibility of portable plant systems for emergency use, and (3) optimization studies. The increased interest in noble gas release control, however, has indicated that an expansion of the project scope would be beneficial. Consequently, the conceptual design area noted above in association with the mobile unit has been enlarged somewhat to emphasize design studies of absorption systems for a variety of krypton-xenon removal applications including fixed systems as well as that for the reactor emergency situation.

SUMMARY

The purpose of the ORGDP noble gas collection program is the development on an engineering scale of an absorption process for the separation of radioactive krypton and xenon from contaminated gas streams. The scope of the work includes pilot plant testing, conceptual design work, and process optimization studies.

The essential steps in this continuous noble gas recovery process are absorption at a relatively low temperature and high pressure, followed by one or more stripping operations conducted at higher temperatures and lower pressures. The effluents from the final stripper unit are a gas product stream, highly concentrated in krypton and xenon, and an essentially pure solvent stream suitable for recycle to the absorber unit.

During this report period, emphasis has been placed on estimating pilot plant flows and stream concentrations for column operating conditions differing from those used in the reference design case⁽¹⁾, and on evaluating alternative flow sheet options. In addition, a few scoping calculations were made to investigate the possibility of using a higher boiling fluorocarbon solvent, refrigerant-11, as a substitute for refrigerant-12, the suggested process solvent. Use of refrigerant-11 would permit operation at higher temperatures, decreasing refrigeration loads appreciably.

The pilot plant instrumentation flow sheet has been prepared; also, a few modifications of earlier equipment designs were made, primarily because it was found that some existing equipment items could be altered and incorporated in the absorption pilot plant system. Construction and procurement of the pilot plant equipment items and instrumentation are now essentially complete, and installation is well under way.

The conceptual design study effort has been temporarily reduced; this work will be resumed when pilot plant data become available to indicate preferred operating conditions or when new study cases are formulated.

A mathematical model of the absorption process for use in the optimization studies has been constructed, programmed, and tested. Currently, equipment sizing and costing routines are being developed for incorporation into the material balance code.

PROJECT DEFINITION

The purpose of the ORGDP noble gas collection program is the development on an engineering scale of an absorption process for the separation of radioactive krypton and xenon from contaminated gas streams. The scope of the work includes the design, construction, and operation of a pilot plant system which will be run for a sufficient period of time to demonstrate feasibility and to provide engineering data. Concurrently, conceptual design and optimization studies are also being undertaken.

In the previous progress report, design criteria assumed for the purpose of developing preliminary equipment configurations and cost evaluations for a mobile absorption system were listed. At present, it is expected that these criteria will continue to be used as ground rules for future mobile unit design work. Attention is also now being given to development of similar sets of guidelines for other krypton-xenon removal

problems, such as those encountered in power reactor fuel reprocessing and in treating blanket gases for certain types of nuclear reactors. This additional aspect of the project was only recently initiated, however, and preliminary problem definitions are not yet available.

PILOT PLANT STUDIES

One of the most direct methods for stripping krypton and xenon from contaminated air streams is selective absorption in a fluorocarbon solvent, such as refrigerant-12. The process can readily be made continuous, because the essential steps are conventional gas-liquid contacting operations.

As noted previously⁽¹⁾, the ORGDP pilot plant flow sheet involves an initial krypton-xenon absorption step, at a relatively low temperature and high pressure, followed by fractionating and stripping operations conducted at higher temperatures and lower pressures to concentrate further and then evolve the noble gas product. Temperatures and pressures recommended for these processing steps on the basis of earlier Brookhaven National Laboratory experiments⁽²⁾ with refrigerant-12 are minus 94°F and 14 atmospheres for absorption, 32°F and 3 atmospheres for fractionation, and 10°F and 2 atmospheres for stripping. The pilot plant design, however, is flexible enough to permit operation at a variety of temperature and pressure conditions, such as from minus 100°F to ambient temperature and up to 40 atmospheres in the absorber.

Flow Sheet Development

K. E. Habiger

During this report period, emphasis has been placed on estimating pilot plant flows and stream concentrations for column operating conditions differing from those used in the reference design⁽¹⁾, and on evaluating alternate flow sheet options. In addition, a few scoping calculations were made to investigate the possibility of using a higher boiling fluorocarbon solvent, refrigerant-11, as a substitute for refrigerant-12, the suggested process solvent.

COLUMN PERFORMANCE STUDIES

The pilot plant material balance code was used to predict pilot plant performance under conditions where each of the columns and flash units is operated at various conditions, including those of the reference design case. The purpose of these calculations was to aid in planning pilot plant testing operations and to point out any need for last-minute design changes. In general, the results of the calculations showed that each of the equipment items mentioned can be operated at a variety of

temperatures, pressures, and liquid-to-gas flow ratios, while equaling or improving on the reference design product specifications.

Considering the three columns used in the pilot plant, the calculations showed that the concentrations of krypton and xenon in the product are least sensitive to fractionator operating conditions. If the fractionator is operated at lower-than-normal L/G ratios, the result is an increase in the recycle gas flow from the column to the absorber and a corresponding decrease in the quantity of absorbed gas fed to the stripper. It might appear that this action would result in a decrease in the total amount of product krypton and xenon; this is not necessarily true, however, since the increased recycling of the fractionator off-gas to the absorber generally increases the krypton and xenon concentrations in the absorber feed gas, so that comparably higher concentrations in the solvent stream leaving the absorber and, subsequently, the fractionator are achieved. Conversely, if the fractionator is operated at higher-than-normal L/G ratios, the result is a decreased gas flow from the column. In this case, more gas remains dissolved and is passed on to the stripper, and the result is an increased product flow rate. Although the overall noble gas concentration factors are altered in these instances, the actual amounts of product krypton and xenon remain essentially unchanged, since the increases or decreases in product flow are due almost entirely to variations in the nitrogen and oxygen contents.

Similarly, calculations have shown that the product concentrations and flows are not very sensitive to changes in the flash unit operating conditions. Flashing a large fraction of the input to each unit, however, can result in excessive coolant loads on the associated condensers. On the other hand, operation of the flashers so that only a small fraction of the input liquid is volatilized requires low flash temperatures; the colder liquid exit streams, used as feed to the fractionator and stripper columns, could introduce sharp axial temperature gradients in these units. The pilot plant tests will include evaluation of the proper operating parameters for the flash chambers.

FLOW SHEET VARIATIONS

One major modification to the reference design flow sheet has been investigated recently. It was thought that, in some cases, the separation of krypton and xenon from air mixtures might be carried out satisfactorily in two columns instead of three, resulting in a simplified flow sheet and corresponding capital investment savings. Accordingly, the pilot plant material balance code was modified to simulate a two-column process.

In the two-column system, the operation of the absorber remains essentially unchanged. The second column is operated as a stripper at temperatures, pressures, and L/G ratios slightly higher than those suggested for the reference design stripper. The major portion of the off-gas from the stripper column is recycled to the absorber, while a small side stream is diverted and collected as product. The results of these calculations have shown that the concentrations of krypton and xenon in

the recycle stream and, thus, the product stream, are large enough to warrant further consideration of this operating mode. The pilot plant can be operated to test the two-column concept, and an experimental evaluation of this scheme will be made in some of the pilot plant runs.

SOLVENT CHANGES

A few preliminary calculations have been made to estimate the feasibility of using, as the process solvent, a fluorocarbon, refrigerant-11, which boils at much higher temperatures than refrigerant-12. Since solubility data for refrigerant-11 are not available, it was assumed first that the solubilities of krypton, xenon, and other air constituents in refrigerant-11 are the same as for refrigerant-12 and also that these solubilities could be extrapolated to higher temperatures. Although based on somewhat questionable assumptions, the scoping calculations did indicate a potential for using refrigerant-11 in a process based on operating all three columns near room temperature. Since the refrigerant load for such a process would be considerably decreased, further evaluation of refrigerant-11, including some pilot plant testing, appears to be justified.

Equipment Design

M. J. Stephenson

The basic design of equipment items for the pilot plant was essentially completed during the first report period⁽¹⁾. As previously mentioned, sizing of the pilot plant components was based on the criterion of processing up to 15 scfm of air at absorber pressures as high as 40 atmospheres. A few alterations of the original designs were made during the report period, however, primarily because it was found that some available equipment items could be modified and employed in the pilot plant system. These design changes are detailed in the following sections.

FEED GAS COOLERS

In the reference flow sheet case, the feed gas coolers reduce the absorber inlet gas temperature from 80°F to around minus 55°F by interchanging 2,500 Btu/hr with the krypton-xenon depleted absorber off-gas stream. The coolers adapted for this purpose are a horizontal shell-fin tube heat exchanger followed by a second unit containing four U-tube exchangers.

The first gas cooler is a double pipe exchanger with a hairpin shape. The shell consists of two parallel 6-foot 6-1/2-inch lengths of 2-inch pipe welded to a curved return section. The single exchanger tube has an outside diameter of 1 inch and is finned with 20 longitudinal 1/2-inch by 0.035-inch fins on two 6-foot sections. The tube enters the end of one of the shell sections, makes a 180-degree bend in the return section,

and passes through the other shell pipe. The effective finned heat transfer surface area is about 20 square feet. The shell side inlet and exit connections are made using standard couplings welded to ports provided in the shell sections. Because of its steel construction, operating temperatures for this exchanger will be limited to above minus 20°F.

The second gas interchanger, used downstream of the finned tube exchanger, consists of four U-tube exchangers connected in series and packaged in a single insulated container. Each U-tube exchanger is formed by bending a 6-foot length of 1-1/2-inch-outside-diameter stainless steel 304-L tubing containing a single concentric section of 7/8-inch-outside-diameter tubing. Each separate unit provides approximately 1 square foot of heat transfer surface area.

SOLVENT COOLER

The purpose of the solvent cooler is to facilitate the interchange of heat between the solvent streams entering and leaving the absorber. For this application, an existing stainless steel shell and tube heat exchanger was modified to meet the process requirements. The unit consists of a shell made from a 6-foot, 6-1/2-inch-long section of 8-inch stainless steel pipe with a tube bundle composed of nineteen, 1-inch-outside-diameter stainless steel 304-L tubes. The tubes are arranged on a 1-1/4-inch triangular pitch and are welded to 1-1/2-inch-thick tube sheets. Segmental baffles are spaced 1 foot apart. The heads of the exchanger are 8-inch standard weld caps, and all joints are seal welded. The heat transfer surface area available in this unit is 31 square feet.

FRACTIONATOR

To reduce solvent losses from the top of the fractionator column, both primary and secondary condensers are provided. The primary condenser is a U-tube heat exchanger. The shell is 70 inches long and is made from 4-1/2-inch-outside-diameter, heavy wall copper pipe. A 10-inch-diameter, 1-5/16-inch-thick flange is brazed to the shell at the tube sheet end, while the head end is capped with 4-1/2-inch-diameter plate. There is a 1-inch-diameter copper entering tube and an identical returning tube, each 5 feet 5 inches long with 5 feet finned at a spacing of eight fins per inch. Each fin is 1/4 inch high and 0.012 inch thick. The tubes are brazed to a tube return bend provided in the head end section and fixed into the tube sheet at the other. There are twenty-one vertical 1/16-inch-thick baffles staggered evenly on the two sides of the tubes. The condenser is positioned at an angle of about 15 degrees to the horizontal, with a vapor inlet nozzle at the lower head end and a gas outlet pipe at the top of the shell next to the tube sheet. A condensate return line is connected to the lower side of the shell below the vapor inlet point. The primary condenser heat transfer surface area is about 3.2 square feet.

The secondary condenser consists of a vertical tube bundle immersed in a refrigerated liquid bath. The bundle contains thirteen 3.5-foot-long, 1/4-inch-outside-diameter stainless steel tubes welded to 1/4-inch-thick, 3-1/2-inch-diameter tube sheets. Three-and-one-half-inch weld caps, with inlet end outlet nozzles, are fastened to each end. The condensing surface area provided is 2.3 square feet.

STRIPPER

The primary and final condenser systems adapted for the stripper are similar to those used for the fractionator. The primary condenser consists of two exchangers, each identical to the fractionator condenser, arranged in parallel.

The final condenser for the stripper column is, as before, a vertical tube bundle immersed with the fractionator final condenser in a refrigerated bath. The tube bundle contains thirty-seven 3.5-foot-long, 1/4-inch-outside-diameter stainless steel tubes connected to 1/4-inch-thick, 7-inch-diameter tube sheets. Seven-inch weld caps are located at each end. The heat transfer surface area for this unit is 6.5 square feet.

INSTRUMENTATION

During this report period, an instrument application diagram for the pilot plant was prepared. The instrument flow sheet is shown in figure 1, and explanations for the symbols used are listed in table I.

Construction, Procurement, and Installation

L. W. Anderson, D. L. Burkett

Construction of the pilot plant equipment items was completed during this report period. Photographs of some of the units are presented as figures 2, 3, 4, and 5. In figure 2, the stripper column and reboiler, the fractionator column and reboiler, and the absorber column are shown; figure 3 illustrates one of the two flash chambers which were fabricated; figure 4 is a photograph of the fractionator and stripper secondary condenser tube bundles, one of the primary condenser units, and the gas and solvent chillers; and figure 5 shows the solvent and gas heat interchangers.

Installation of the equipment has begun and is almost complete. Most of the instrumentation required initially has been procured, and delivery of the mechanical equipment items, i.e., the gas compressor and the liquid pumps, is expected soon.

Figure 1

PILOT PLANT INSTRUMENT APPLICATION DIAGRAM

TABLE I
KEY TO INSTRUMENTATION DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
FE-101	Flow to Absorber Gas Interchanger	Mass Flow Meter	0 to 25 scfm	
FI-101	Flow to Absorber Gas Interchanger	Mass Flow Indicator		
PI-102	Absorber Gas Interchanger Inlet Pressure	Pressure Gauge	0 to 600 psig	
TE-103	Temperature Gas From Aftercooler to Absorber Gas Interchanger	Copper-Constantan Thermocouple		
TE-104	Temperature Gas From Absorber Gas Interchanger	Copper-Constantan Thermocouple		
TE-105	Temperature Gas to Absorber Gas Interchanger	Copper-Constantan Thermocouple		
PT-106	Absorber Outlet Gas Pressure	Pressure Transmitter	0 to 600 psig	3 to 18 psi
PRC-106	Absorber Outlet Gas Pressure Control	Pressure Recorder-Controller	3 to 18 psi	3 to 18 psi
PCV-106	Absorber Outlet Gas Pressure Control	Control Valve Size 1/4-inch, CV = 0.25	3 to 18 psi	
PdT-107	Pressure Drop Across Absorber	Differential Pressure Transmitter	0 to 1 psi	3 to 18 psi
PdR-107	Pressure Drop Across Absorber	Pressure Recorder	3 to 18 psi	
FE-108	Flow to Gas Reservoir	Mass Flow Meter	0 to 25 scfm	
FI-108	Flow to Gas Reservoir	Mass Flow Indicator		
PI-109	Pressure Gas to Gas Reservoir	Pressure Gauge	0 to 600 psig	

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
TE-110	Temperature Gas to Gas Reservoir	Copper-Constantan Thermocouple		
PI-111	Gas Reservoir Pressure	Pressure Gauge	0 to 100 psig	
PI-112	Gas Reservoir Rupture Disc Pressure	Pressure Gauge		
TE-113	Temperature Inlet to Gas Chiller	Copper-Constantan Thermocouple		
TE-114	Temperature Gas from Chiller to Absorber	Copper-Constantan Thermocouple		
TE-115	Lower Internal Temperature Absorber	Copper-Constantan Thermocouple		
TE-116	Center Internal Temperature Absorber	Copper-Constantan Thermocouple		
TE-117	Upper Internal Temperature Absorber	Copper-Constantan Thermocouple		
TE-118	Upper Skin Temperature Absorber	Copper-Constantan Thermocouple		
TE-119	Lower Skin Temperature Absorber	Copper-Constantan Thermocouple		
TE-120	Temperature Fluid From Solvent Chiller to Absorber	Copper-Constantan Thermocouple		
LS-121	Absorber Reservoir Level	Level Switch		
LA-121	Absorber Reservoir Low Level Alarm	Alarm		
ECV-121	Absorber Reservoir Level Control	Three-Way Solenoid Valve		

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
LCV-121	Absorber Reservoir Level Control	Air-Operated Block Valve		
TE-122	Temperature Fluid to Solvent Chiller	Copper-Constantan Thermocouple		
TE-123	Temperature Fluid From Absorber to Solvent Interchanger	Copper-Constantan Thermocouple		
FE-124	Solvent Flow to Solvent Inter- changer	Turbine Flow Meter	0 to 2.5 gpm	
FI-124	Solvent Flow to Solvent Inter- changer	Turbine Meter Flow Indicator	0 to 2.5 gpm	
TE-125	Temperature Solvent to Solvent Interchanger	Copper-Constantan Thermocouple		
TE-126	Solvent Pump Inlet Temperature	Copper-Constantan Thermocouple		
FE-127	Flow from Fractionator Final Condenser to Compressor	Mass Flow Meter	0 to 5 scfm	
FI-127	Flow from Fractionator Final Condenser to Compressor	Mass Flow Indicator	0 to 5 scfm	
PI-128	Outlet Gas Pressure Fractionator Final Condenser	Pressure Gauge	0 to 200 psig	
TE-129	Outlet Gas Temperature Fractionator Final Condenser	Copper-Constantan Thermocouple		
PI-130	Absorber Rupture Disc Pressure	Pressure Gauge		

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

Symbol	Service	Description	Input Range	Output Range
TE-131	Fractionator Final Condenser Outlet Gas Temperature	Copper-Constantan Thermocouple		
TE-132	Fractionator Overhead Condenser Outlet Gas Temperature	Copper-Constantan Thermocouple		
TE-133	Fractionator Overhead Condenser Condensate Temperature	Copper-Constantan Thermocouple		
TE-134	Fractionator Flash Unit Outlet Temperature	Copper-Constantan Thermocouple		
PT-135	Fractionator Outlet Pressure	Pressure Transmitter	0 to 200 psig	3 to 18 psi
PCV-135	Fractionator Outlet Pressure Control	Control Valve Size 1/4-inch, CV = 0.10	3 to 18 psig	
PRC-135	Fractionator Outlet Pressure Control	Pressure Recorder-Controller	3 to 18 psig	3 to 18 psig
PdT-136	Fractionator Pressure Drop	Differential Pressure Transmitter	0 to 1 psi	3 to 18 psi
PdR-136	Fractionator Pressure Drop	Pressure Recorder	3 to 18 psig	
TE-137	Fractionator Upper Internal Temperature	Copper-Constantan Thermocouple		
TE-138	Fractionator Center Internal Temperature	Copper-Constantan Thermocouple		
TE-139	Fractionator Lower Internal Temperature	Copper-Constantan Thermocouple		

TABLE I
(Continued)

KEY TO INSTRUMENT DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
TE-140	Fractionator Upper Skin Temperature	Copper-Constantan Thermocouple		
TE-141	Fractionator Lower Skin Temperature	Copper-Constantan Thermocouple		
TE-142	Fractionator Flash Unit Internal Temperature	Copper-Constantan Thermocouple		
TE-143	Temperature Fluid From Solvent Interchanger to Fractionator Flash Unit	Copper-Constantan Thermocouple		
TE-144	Temperature Fluid From Solvent Interchanger to Fractionator Flash Unit	Copper-Constantan Thermocouple		
TE-145	Fractionator Reboiler Internal Temperature	Copper-Constantan Thermocouple		
TE-146	Fractionator Reboiler Skin Temperature	Copper-Constantan Thermocouple		
TA-146	Fractionator Reboiler Skin Temperature Alarm	Alarm Indicator		
LS-147	Fractionator Reboiler Level	Level Switch		
LA-147	Fractionator Reboiler Low Level Alarm	Alarm Indicator		
ECV-147	Fractionator Reboiler Level Control	Three-Way Solenoid Valve		

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
LCV-147	Fractionator Reboiler Level Control	Air-Operated Block Valve		
PI-148	Fractionator Rupture Disc Pressure	Pressure Gauge	0 to 200 psig	
TE-149	Temperature Fluid to Stripper Flash Unit	Copper-Constantan Thermocouple		
LS-150	Solvent Tank Low Level	Level Switch		
LA-150	Solvent Tank Low Level Alarm	Alarm Indicator		
TE-151	Solvent Tank Internal Temperature	Copper-Constantan Thermocouple		
TA-151	Solvent Tank Internal Temperature Alarm	Alarm Indicator		
TE-153	Stripper Reboiler Internal Temperature	Copper-Constantan Thermocouple		
LS-154	Stripper Reboiler Level	Level Switch		
LA-154	Stripper Reboiler Low Level Alarm	Alarm Indicator		
TE-155	Stripper Lower Internal Temperature	Copper-Constantan Thermocouple		
TE-156	Stripper Center Internal Temperature	Copper-Constantan Thermocouple		
TE-157	Stripper Upper Internal Temperature	Copper-Constantan Thermocouple		

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

<u>Symbol</u>	<u>Service</u>	<u>Description</u>	<u>Input Range</u>	<u>Output Range</u>
TE-158	Stripper Upper Skin Temperature	Copper-Constantan Thermocouple		
TE-159	Stripper Lower Skin Temperature	Copper-Constantan Thermocouple		
PdT-160	Stripper Pressure Drop	Differential Pressure Transmitter	0 to 1 psi	3 to 18 psi
PdR-160	Stripper Pressure Drop	Pressure Recorder	3 to 18 psi	
PT-161	Stripper Outlet Pressure	Pressure Transmitter	0 to 200 psig	3 to 18 psig
PRC-161	Stripper Outlet Pressure Control	Pressure Recorder-Controller	3 to 18 psig	3 to 18 psig
PCV-161	Stripper Outlet Pressure Control	Control Valve Size 1/4-inch, CV = 0.25	3 to 18 psig	
TE-162	Stripper Flash Unit Internal Temperature	Copper-Constantan Thermocouple		
TE-163	Stripper Flash Unit Outlet Gas Temperature	Copper-Constantan Thermocouple		
TE-164	Stripper Overhead Condenser Outlet Liquid Temperature	Copper-Constantan Thermocouple		
TE-165	Stripper Overhead Condenser Outlet Gas Temperature	Copper-Constantan Thermocouple		
TE-166	Stripper Final Condenser Outlet Gas Temperature	Copper-Constantan Thermocouple		
PI-167	Stripper Rupture Disc Pressure	Pressure Gauge	0 to 200 psig	

TABLE I
(Continued)

KEY TO INSTRUMENTATION DIAGRAM

Symbol	Service	Description	Input Range	Output Range
TE-168	Product Temperature	Copper-Constantan Thermocouple		
PI-169	Product Pressure	Pressure Gauge	0 to 200 psig	
FE-170	Product Flow	Mass Flow Meter		
FI-170	Product Flow	Mass Flow Indicator	0 to 1000 scfm	
FE-171	Liquid Flow to Stripper	Turbine Flowmeter	0 to 2.5 gpm	
FI-171	Liquid Flow to Stripper	Indicator	0 to 2.5 gpm	
PI-172	Stripper Flash Unit Pressure	Pressure Gauge		
FE-173	Liquid Flow to Stripper Flash Unit	Turbine Flowmeter		
FI-173	Liquid Flow to Stripper Flash Unit	Indicator	0 to 2.5 gpm	
FE-174	Liquid Flow to Fractionator	Turbine Flowmeter	0 to 2.5 gpm	
FI-174	Liquid Flow to Fractionator	Indicator	0 to 2.5 gpm	
TR-176	System Temperatures	24-point Temperature Recorder for Copper-Constantan Thermocouples	- 120 to + 230°F	
TR-177	System Temperatures	24-point Temperature Recorder for Copper-Constantan Thermocouples	- 120 to + 230°F

Figure 2
PILOT PLANT COLUMNS AND REBOILERS

Left to Right: Stripper Column and Reboiler, Fractionator Column and Reboiler, and Absorber Column.

Figure 3
PILOT PLANT FLASH EVAPORATOR

Figure 4
PILOT PLANT HEAT EXCHANGERS

Left to Right: Foreground - Fractionator and Stripper Final Condensers, Typical Primary Condenser Unit; Background - Solvent and Gas Chillers.

Figure 5

PILOT PLANT HEAT EXCHANGERS

Left to Right: Solvent Interchange Cooler, Primary Gas Cooler,
and Secondary Gas Cooler.

Operation

It is still anticipated that pilot plant operation will begin early in calendar year 1968 with shakedown tests.

CONCEPTUAL DESIGN STUDIES

B. F. Crump, K. E. Habiger

After completing designs and cost estimates for two mobile absorption plants for emergency use⁽¹⁾, both of which were based on the BNL reference flow sheet, it was decided that more detailed design studies for the mobile unit should be deferred until the work could be concentrated in a more narrow range of operating conditions, as indicated by the results of the pilot plant testing program and by the optimization studies. Consequently, during this report period, the effort in this area was reduced and consisted primarily of assembling, for use in the optimization work, the cost data obtained as a part of the earlier design studies.

Design criteria for absorption systems intended for other applications, such as fuel reprocessing plant off-gas treatment, have not yet been sufficiently defined; accordingly, no conceptual design work has begun for these cases.

OPTIMIZATION STUDIES

S. Blumkin, E. Von Halle

A computer code has been written to evaluate the flows and multicomponent concentration gradients for the three-column process flow sheet shown schematically in figure 6. Input parameters for this program are operating temperatures and pressures in each column and condenser, liquid-to-gas flow ratios and the number of transfer units for each column, and the process feed rate and inlet gas composition. The output values consist of the flow rate and concentrations for the product, waste, and intercolumn streams.

It is intended next to develop and incorporate into the computer model relationships which will yield column dimensions and packing size from column flows and operating conditions. To complete the code for optimization studies, cost bases will be established and incorporated so that the capital construction cost of a facility corresponding to a given set of operating and separation parameters can be evaluated.

The final code will then be used to compare the assumed separation performance with pilot plant data, so that the code can be revised accordingly. Finally, in connection with the specified separation job to be accomplished, the code will be employed to optimize plant configuration and equipment size on a cost basis.

Figure 6
FLOW SHEET USED IN
OPTIMIZATION STUDY COMPUTER MODEL

STATUS AND FUTURE PLANS

It is anticipated that installation of the pilot plant equipment items can be completed in the very near future, and that shakedown tests can be initiated and finished within the next six months. The conceptual design study effort will continue at the current reduced level, pending pilot plant data collection or formulation of new study cases. Completion of the optimization study computer code, including material balance, equipment sizing, and plant costing features, is expected soon, so that initial case studies can probably be made during the next report period.

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