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REDOX IODINE AND NITRIC ACID ABSORBERS

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REDOX IODINE AND NITRIC ACID ABSORBERS

Prepared by

D. J. Stoker & C. A. Rohrmann

August 2, 1955

This document consists
of 25 pages

Process Engineering Sub-Section
Design Section
Engineering Department
General Electric Company
Hanford Atomic Products Operation

This document has been reviewed
and approved by the appropriate
members of the Process Engineering
Sub-Section as a scope basis for
back-up iodine retention facilities
combined with nitric acid recovery
from Redox dissolver off-gas.

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REDOX IODINE AND NITRIC ACID ABSORBERS

INTRODUCTION

A desirable radio-iodine emission goal for all HAPC has recently been set at one curie per day maximum. At the same time it was suggested that a more relaxed limit of ten curies per week, with no more than three in any one day, would probably be satisfactory⁽¹⁾.

To assure the achievement of these goal figures in the separations plants it was deemed necessary to either "cool" the irradiated material a greater length of time than is presently done before processing, or provide more efficient, iodine retention facilities⁽²⁾. Increased power levels, higher production rates, and an increase in the awareness of radio-iodine emissions, have all coupled together to make present facilities generally inadequate when processing material aged less than about 100 days. Several alternate methods of providing additional iodine retention facilities for Redox were preliminarily scoped and presented for consideration⁽³⁾. It was decided that the most logical course of action would be a step-wise approach. First, the emissions of iodine during slug dissolving would be reduced as they constitute the greatest quantity of iodine released. Second, the emissions of iodine during coating removal would be reduced. The ammonia or possibly chlorine present in this gas is believed to be a factor in iodine emissions during jacket removal. Third, the emission from the vessel vent system would be reduced.

PURPOSE

The purpose of this report is to present a scope design for improving iodine emission control at Redox.

SUMMARY

Since the dissolver off-gases are the greatest potential source of iodine, back-up iodine removal facilities on these gas streams are necessary to insure against multi-curie bursts. The emissions from the other off-gas vent systems are of low magnitude and may eventually warrant retention facilities.

The most economical method of providing back-up iodine removal facilities for the dissolvers is to combine acid recovery and iodine removal in a single outside installation. The specific features of this scope design are summarized as follows:

1. Back-up iodine removal will be effected by one caustic scrubber. During coating removal, the dissolver off-gases would be routed through the caustic scrubber. During slug dissolving the off-gases would be routed through an acid recovery unit first, and then through the caustic scrubber. The chemical cost for the caustic necessary to accomplish iodine removal (assuming the

- (1) Letter, "Current Views on the I¹³¹ Emission Limits", H. M. Parker to J. E. Maider, April 4, 1955.
- (2) HW-36819, "Iodine Emission Control from Separations Processes and Flow-sheets for Improved Emission Control", R. E. Smith, May 23, 1955.
- (3) HW-37368, "Interim Report Concerning Design Alternatives for Reducing Iodine Emissions at Redox", D. J. Stoker, June 24, 1955.

SUMMARY (Cont'd)

acid gas has first passed through the acid recovery unit) amounts to approximately \$14,000 per year at nominal Phase III rates (average of 300 tons of uranium per month).

2. The back-up, iodine retention facility will enable Redox to process 75 day cooled material at predicted power levels and Phase III instantaneous rates with total daily radio-iodine emissions of approximately 0.3 curies from the dissolvers.
3. The iodine removal facility is estimated to have a project cost of \$320,000.
4. The caustic scrubber precludes the need for ammonia scrubbers for decontaminating coating removal off-gases. Ammonia scrubbers for Redox have been estimated to cost about \$150,000.
5. The acid recovery unit consists of a gas cooler, a bubble-cap-tray, absorber tower, and a recovered-acid, storage tank. The unit will yield 50% acid for reuse in the dissolvers and give an overall mole ratio of 2.4 moles of nitric acid consumed per mole of uranium dissolved (0.63 pounds of nitric acid per pound of uranium). The present Redox up-draft condensers are yielding a mole ratio of 5.0 (1.32 pounds of nitric acid per pound of uranium).
6. The estimated project cost for the acid recovery facility is \$480,000. This investment would be paid back when 9370 tons of uranium have been processed in Redox using acid recovery. This gives a payout period of 2.7 years at nominal Phase III rates or 36.5 percent return on the investment.
7. The entire acid recovery and iodine removal facility is designed for contact maintenance and will not affect canyon operation.

RECOMMENDATIONS

It is recommended that iodine removal facilities combined with acid recovery be installed on the Redox dissolver off-gas lines as per the attached scope. Specifically this should include:

1. Design and construction of a building and pit to house the new equipment (SK-2-5929).
2. Design and fabrication of nitric acid absorption equipment. This equipment will include a bubble-cap tower (SK-2-1894), gas cooler (SK-2-1903), and a recovered-acid, storage tank.
3. Design and fabrication of a caustic scrubber for iodine removal (SK-2-5927).
4. Design and installation of new equipment and tie-ins with existing lines for the reception of dissolver off-gases, the discharge of scrubbed gases, and the delivery of concentrated acid to the canyon as shown on the Engineering Flow Diagram (SK-2-5928).

RECOMMENDATIONS (Cont'd)

5. Design and construction of cooling water supply and discharge piping, cooling-water disposal facilities, caustic disposal facilities, and other necessary utilities (SK-2-5929 and SK-2-5971).
6. Design and installation of instrumentation for remote control of the new facilities from the dissolver, panel boards.

DISCUSSIONA. Definition of Problem and Design Philosophy

Iodine emission limits are set so there is no possibility of contaminating off-site vegetation to an extent that animals or humans are subsequently harmed. Meteorological variables do not permit the exact evaluation of various size emissions in terms of calculated risks. A curie of I^{131} can be spread over a very small or very large area of land depending on the weather conditions. Therefore, emission limits are somewhat arbitrary, but nevertheless, as realistic as can be made under the circumstances. Primarily the present limits are set up so that multi-curie bursts of I^{131} are not standard practice, since it can be shown that prolonged multi-curie emissions are harmful to living matter in the surrounding area.

The emission of radio-iodine at Redox occurs at two places, namely, the dissolver off-gas systems, and the process vent systems. Experience has shown that emissions from the process vent systems are normally less than 0.1 curie of iodine per day. The only time that emissions greater than this have occurred was when mercury was added to the dissolvers to suppress iodine emission at that point. At this time there are no iodine removal facilities on the process vent systems and it is felt that none are required to meet present goal figures.

On the other hand it is not possible on the dissolver off-gas systems to meet the goal figures consistently with only the present iodine retention facilities. Normal emissions vary greatly depending upon the age and amount of metal dissolved and upon process conditions which are not yet fully understood. Experience has shown that multi-curie bursts from the dissolvers are not a rarity. Because of this fact it is felt that better control of iodine emissions on these systems are necessary to bring the Redox plant within the desired, emission limits.

If, as a design criteria, the desired Hanford limit of one curie per day is assumed, then the Redox share would be about 0.4 curies, assuming only Purex and Redox were operating. If it is assumed that all of the iodine dissolved is volatilized in the dissolver then under expected Redox loads (10 MW/T, 75 day cooling) 410 curies of I^{131} are volatilized for every ten dissolved. This would mean 5740 curies of I^{131} volatilized per day at Phase III instantaneous rates. To reduce this to approximately

DISCUSSION (Cont'd)

0.3 curies emitted would require a removal efficiency of at least 99.995%.

The philosophy which has to be adopted when investigating methods of improving iodine removal efficiency is one of never depending on a single unit to always give the necessary D.F. Previous experience has shown that reactor break-through cannot always be foreseen, and that it can be very small and still cause trouble. For example, a reactor with a 99.99% efficiency under expected Redox loads (14 T/D, 10 MW/T, 75 day cooling) would yield approximately 0.57 curies per day. If that efficiency dropped 1/10000 the emission for that day would have been about 1.2 curies, or over the desired HAPO emission limit.

Actually silver reactor efficiencies have been judged to be 99.5% and there is nothing presently known to improve their efficiencies. Therefore, the back-up facility has to have an efficiency of at least 99% when the primary reactor is at 99.5% to achieve a 99.995% retention. The back-up facility also has to have the capability of taking up any slack in the efficiency of the primary unit at break-through so the combined efficiency is always 99.995%.

It is probable that break-throughs of the most serious nature still reflect a 95% or better efficiency in the primary silver reactor. For example, assume the dissolving of a 5 ton charge of 4 MW/T material, 90 day cooled. If the efficiency of the reactor during this dissolution was 95% this would result in approximately 11.3 curies being discharged to the stack that day. Very seldom have Redox iodine emissions exceeded this figure and those few times have usually been associated with material cooled less than 90 days. Therefore, it is felt that the potential efficiency for a back-up reactor has to be 99.9% to guarantee combined efficiency of 99.995%.

To achieve the 99.995% efficiency using a single back-up unit and the criteria established above rules out much of the known iodine retention equipment. Since some type of back-up is needed at Redox to insure against large multi-curie emissions, it would seem desirable to reduce daily emissions to 0.4 curie if that installation was no costlier than an installation which would still insure against exceeding a more relaxed limit of ten curies per week.

B. Alternate Methods for Solving Problem

A report (HW-37368) outlines in detail the various design alternatives which were considered in addition to the one chosen. Briefly they were the following:

1. In-cell, back-up heaters and silver reactors and ammonia scrubbers. It was felt these installations complicated the cells unduly.

DISCUSSION (Cont'd)

2. Outside silver reactor and heater combined with in-cell ammonia scrubbers.
3. In-cell ammonia scrubbers combined with an outside acid recovery unit to which sufficient mercury salt has been added via reflux to complex any iodine. There is not sufficient existing technology to prove or disprove this installation.
4. Silver reactor or caustic scrubber for reducing iodine emissions from the process vent systems. Because of the small amount of iodine which is now emitted from these systems, any proposal for the retention of iodine at this point should be held in abeyance until a definite need is shown.

Besides the various design alternatives the possibility of longer cooling to eliminate the iodine problem was considered. It has been stated that under future, separation loads metal will have to be "cooled" 115 days before it can be processed in existing facilities without exceeding the goal figures for iodine emission⁽²⁾. With Redox operating at Phase III rates an additional 40 days of cooling beyond the normal 75 day figure represents an additional \$19,000,000 worth of metal and fissionable materials in storage. Assuming interest on this additional capital is three percent this would represent \$570,000 a year which could be spent to eliminate this capital investment. The iodine retention facilities recommended will cost considerably less than \$570,000.

C. Justification for Design Alternate Recommended

The outside acid recovery unit with an attached caustic scrubber for iodine removal was chosen over the other technologically acceptable alternatives for the following reasons.

1. The iodine removal facilities are the cheapest. The back-up caustic scrubber installation is expected to be about \$300,000. less than back-up silver reactor installations with ammonia scrubbers. Operating cost differences of the two types of installations are minor when compared to capital cost differences. The estimated ready for use date on the combined acid recovery and caustic scrubber installation is 14 months after authorization. The estimated beneficial use date for the caustic scrubber part of the total installation is 10 months after authorization as compared with an estimated ready for use date of 8 months after authorization for the back-up silver reactor plus ammonia scrubber installation. This difference is not regarded as significant.
2. With the caustic scrubber it is known that ammonia will cause no problem. Redox experience indicates that the quantities of

(2) HW-36819, "Iodine Emission from Separations Processes and Flowsheets for Improved Emission Control", R. E. Smith, May 23, 1955.

DISCUSSION (Cont'd)

iodine coming from the existing silver reactors during coating removal can be effectively contained in the caustic scrubber.

3. The caustic scrubber assures meeting the desired goal at Redox using the criteria previously established in this report.
4. There will be no complication of piping or operation of the dissolver cells by this back-up iodine equipment.
5. Acid recovery is technically and economically feasible and by its use it is possible to take advantage of caustic scrubbing for iodine removal, without an associated, exorbitant raw material and waste disposal cost.
6. Contact maintenance, feasible on this equipment, was not considered feasible on the other proposals. It is believed a caustic scrubber can be flushed to permit contact maintenance whereas no method is known to flush a silver reactor.
7. If there are certain species of iodine which selectively by-pass the primary silver reactor, it is more probable that they would be retained in a caustic scrubber rather than a second silver reactor.
8. No other alternate provides the additional benefit of alleviating the problems associated with the discharge of nitrogen oxides to the atmosphere. While there are no firm data on the hazards associated with the intermittent exposure of personnel to concentrations in excess of the maximum permissible limit for a full-time exposure, the virtual elimination of the toxic material from the stack gas is a definite, industrial, hygienic improvement.

D. Scope of Outside Acid Recovery Unit and Caustic Scrubber

1. General Description of Process and Its Operation

The proposed arrangement is shown on the attached flow diagrams, SK-2-5928 and SK-2-5937. The entire facility is contact maintained.

During charging, the dissolver off-gases are routed directly through the jet pit and into the stack breeching as is presently done today. This is accomplished by having the on-off valves normally closed and the three way normally open for straight through flow. This would be position one on the valve selector switch to be located on the dissolver panel boards. This routing can also be used during maintenance of the caustic scrubber.

During coating removal, the dissolver off-gases are routed from the jet pit directly into the caustic scrubber for iodine removal. From the caustic scrubber the gases are routed back into the jet pit and thence to the stack. This is accomplished by position two on the

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selector switch which would have air on the three-way valve and the on-off valve located on the off-gas line to the scrubber. This routing would also be used during the uranium dissolution cycle when maintenance was being performed on the acid recovery unit.

During uranium dissolution the dissolver off-gases are routed from the jet pit, into the acid recovery unit, then the caustic scrubber, the jet pit, and finally back to stack. This is accomplished by position three on the selector switch which would have air on the three way valve and the on-off valve located on the off-gas line to the acid recovery unit. Any time gas is going into the acid recovery unit it has to be exhausted through the caustic scrubber.

The valving is arranged so that each dissolver off-gas line is independent of the others so far as which routing is desirable (for example through the pit directly to the stack or through one or both of the treatment units and thence to the stack). A selector switch for the choice of routings will be installed for each dissolver on its respective panel board.

Valving is provided so the gas lines to both the absorber and the scrubber can be water flushed should ammonium nitrate build up in these lines due to operating errors.

Caustic is recirculated in the scrubber tower by means of a pump located in the reservoir. A flow indicator alarm on the recirculation line will warn the operator in the 202-S of a flow failure. An installed spare pump is provided to assure the operating continuity of this unit. Motor switches and ammeters will be located on a panel board in 202-S.

A pH meter will control the addition of fresh caustic to the top of the tower. The pH meter will be located at the bottom of the tower and will keep the pot contents at a pH of 13 or 0.1 M caustic. The fresh 25% caustic will come from the 508 tank in the silo via an existing header in the north pipe gallery and a new stream traced header to the new building. The caustic will be made up in the 507 tank and jetted via a new jet to the 508 tank. A new weight factor alarm for the 508 tank will be located on the dissolver boards. The caustic wastes will overflow to the crib. Daily grab samples are expected to be taken in this waste.

Since heat is given off during the nitric oxide-caustic reaction, cooling coils are provided in the scrubber reservoir. Valving for this cooling water and a flow indicator are located in the new building.

If an operating error should enable the uranium dissolution gas to enter the caustic scrubber without first passing through the acid recovery unit this will cause no harm, except for the additional caustic which will be used and, therefore, wasted. A rapid increase

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in the use of the caustic will be one indication of this error. Another indication of this error will come from a temperature indicator alarm which will show a significant increase in the temperature of the caustic, requiring increased water flow to the coils.

Flushing of the scrubber with water, caustic or other chemicals will be possible by valving on the chemical addition line in the new building. Chemical flush solutions will come via a new line tied into the 202-S Building Wash Solution Header. A branch of this header is located in the north operating galleries.

To accomplish acid recovery it is necessary to cool the gases and bleed additional oxygen into the system in the form of air. The resulting mixture is fed into the bottom of the tower where in passing counter-currently to the reflux the gas is oxidized to nitrogen dioxide and absorbed. The recovered acid from the tower flows into a storage tank in a pit outside the new building. From there it can be pumped via the old oxidizer vent line into J-cell and then into any one of the dissolver cells via routings in B cell.

Quantity and quality of feed to the tower can vary markedly due to dissolver cycles. To assure a 50% bottoms product and a good recovery of the oxides, the reflux and the oxygen have to be varied to suit conditions. Of the two reflux is the most critical and it is controlled by the specific gravity of the acid on the next to bottom plate. The oxygen is controlled by the gas density. Operating experience will indicate what density ranges require no additional oxygen and what ranges require additional oxygen and roughly how much. It is not possible to predict accurately these density ranges now because of the uncertainty regarding the amount of air in the dissolver off-gases.

Cooling coils placed on the trays remove the heat of reaction from the liquid and thus keep the temperature favorable to increased equilibrium and reaction rates. The temperature of the absorber off-gas will control the total amount of water into the cooling coils and will thus effect economies in waste water disposed during periods of lean gas flow. Flow to individual plates is arbitrarily set by orifices in the piping.

The water requirement of the gas cooler is small (10 gpm) at peak oxide evolution rates, so it will be operated at these rates at all times. A flow indicator in the new building is provided to set flow. A temperature indicator or recorder will be located on the cooler off-gas stream.

For the acid recovery unit the only instrumentation to be located in 202-S will be the weight factor alarm and the specific gravity on the recovered acid storage tank, and the ammeter and motor switch on the recovered acid pump.

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DISCUSSION (Cont'd)

An on-off valve on each dissolver acid addition line controls the routing of acid. A valve selector switch will be located on each panel board for the control of acid to that dissolver. The normal position of the on-off valve will be closed and the selector switches will be hooked-up so that it is not possible to open the valves without first starting the acid pump. This should eliminate errors due to open valves.

If an operating error should enable the coating removal gas to enter the acid recovery unit no significant harm should result. A small amount of the acid will react with the ammonia to form ammonium nitrate solution. During this period of operating error less than 10% of the acid normally formed in the absorber would take the form of ammonium nitrate. It is doubtful if any instrumentation would show this operating error.

After the initial start-up of the acid recovery unit, it will be necessary to periodically check certain trays to ascertain chlorides build-up, if any. Sample taps are provided on trays five, six, and seven for chloride purges. Once the pattern of chlorides build-up has been found operating procedures can be set. This may mean no purges, periodic purges, or constant purges. An attempt should be made to coincide chloride purges with caustic discharge so the waste to crib will be in the pH range of 4 to 10.

Flushing of the recovery tower and the cooler will be possible through the reflux line. Valving in the reflux line will be provided so that flushing with chemicals other than water can be accomplished in the same manner as the caustic scrubber. A sample tap for occasional samples will be provided on the off-gas line from the caustic scrubber. A process radiation indicator will be located near the caustic scrubber.

2. Canyon Modifications (SK-2-1890 and SK-2-5928)

J Cell

One two-inch jumper is required to route the recovered acid from the old oxidizer vent line to a routing into B cell. This routing assumes the abandonment of the J-2 scrubber as per Project CG-621.

B Cell

One two-inch jumper is required in this cell to direct the flow of acid into both A and C cells.

A-B-C Cells

A sum total in the three cells of nine jumpers, three jets, and three air-operated on-off valves will be required to control the flow of acid to each of the dissolvers. Because there are no spare connections on the dissolver tanks it is necessary to install a recirculation or dual nozzle on one of the tank nozzles. This means an existing jumper has to be rebuilt to accommodate the recirculation

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DISCUSSION (Cont'd)

nozzle. A metal solution jet-out jumper was picked and it will have the dip leg. It will be necessary to have an on-off valve in the acid feed jumper to each dissolver and an instrument air jumper to each valve.

Cold Side

Three on-off valve selector switches are necessary to control the acid flow to the dissolvers. In addition instrumentation relative to the operation of the new absorber facility will be located on a panel board adjacent to one of the three dissolver boards. This instrumentation was explained in the preceding section of this report.

3. Jet Pit Modifications (SK-2-5928) (H-2-8819-20)

The new dissolver off-gas diversion system consists of six on-off valves, three three-way valves and three jets. The selector switches for this valving were described above. The new jets will be modified in the existing pit and existing utility tie-ins will be modified to suit the new jets. The new valves may be placed either in the existing pit or in a new valve pit adjacent to the jet pit or a combination of both. Any new valve pit would be at grade elevation and would require a foot of concrete shielding.

It will be necessary to cut a hole in one side of the jet pit to divert the gas lines to the new building. It is planned that the diversion lines from and into the pit, and the new jet be installed as a unit. The stubs could then be blanked while the valving and new facilities etc. are constructed. The stubs could later be tied into the valving system. In this manner it is believed that work in the jet pit would be a minimum and that tie-ins to existing lines could be accomplished during planned shut-downs.

4. New Building, Utilities and Outside Piping (SK-2-5928, SK-2-5929 & SK-2-5871)

The gas treatment building consists of three distinct structures. Namely a 8' x 30' x 10' control room constructed of insulated metal panel, a 12' x 30' x 30' high concrete building with 12" thick walls which houses the acid absorber, gas cooler and caustic scrubber, and a 14' x 14' x 12' deep pit which contains the acid storage tank.

The caustic scrubber was placed in the building rather than in a pit because it is believed that the constant flushing of the tower and pot will exclude radiation build-up. The acid absorber and cooler are placed in the building because the radiation levels are not expected to cause any undue difficulties for maintenance. Experience with the TA-1 absorber here at Hanford and with the duPont absorber at Savannah River add credence to this decision. A shielding wall between the caustic scrubber and absorber was provided so that maintenance of one unit could be performed without affecting the operation of other units.

DISCUSSION (Cont'd)

The EFD (SK-2-5928) shows which instruments are to be located in the 202-S Building. The other instruments are to be located in the control room of the new facility. Sample taps for chloride purges and waste caustic are also located in the control room.

Ventilation and heating will be provided as shown on SK-2-5929. The 2,000 cfm flow will provide an air-change in each cell every three to four minutes.

Spray nozzles are required in the absorber and caustic scrubber cells to wash down the cell interior whenever such is required. This wash down water will flow to the new process crib to be provided.

Electricity and instrument air headers are adjacent to the new building. Approximately 500 feet of 4" cast-iron, raw-water piping has to be provided extending from a 4" header near the 202-S Building to the new building. A 1" black-iron pipe to carry caustic and a 1" stainless steel pipe for flush solutions from the 202-S pipe gallery to the new building are also required. This piping can be hung from existing posts carrying steam piping.

The neutralized caustic solution is periodically pumped to a small crib adjacent to the new building. The new process crib will also receive chloride purges if they are necessary, tower flushes and cell flushes when they are necessary. The normal flow of spent caustic to the crib is about 700 gpd but the crib is sized to hold up to 5000 gallons and will percolate about 1500 gpd. A cross section of this line crib is shown on SK-2-5971. A stub is provided in the crib line for future possible connection to another crib. A test well is also provided adjacent to the crib.

Disposal of the cooling water also requires a new disposal site. It is necessary to lay approximately 1400 feet of 8" vitrified, clay pipe to carry the water to a new open ditch. This ditch follows the contour line for approximately 2000 feet. Location and cross section of the ditch are shown on SK-2-5971.

5. Absorber Tower, Gas Cooler, Caustic Scrubber and Acid Catch Tank
(SK-2-1894, SK-2-1902, SK-2-5927)

The absorber tower is a contact-maintained twelve-tray, bubble-cap tower. The absorption and formation of acid takes place on the trays and the oxidation of nitric oxide takes place between the trays. Cooling coils placed on the trays remove the heat of reaction from the liquid and thus keep the temperature favorable to increased equilibrium and reaction rates. Gas hold-up times of two to three seconds are provided between the trays and liquid hold-up times of four to ten minutes are provided on the trays. Tray spacing was established at the bottom three plates of the column by an attempt to keep the heat loads balanced on the bottom trays. Tray spacing was established in the rest of the column by an attempt to get the optimum amount of oxidation taking place between the trays. At

DISCUSSION (Cont'd)

maximum instantaneous rates the calculated total pressure drop across the tower is 22 inches of water.

The gas cooler is a transverse fin tube unit with cooling water in the tubes flowing counter-currently to the gas on the shell side. A small amount of strong acid will be formed in the condenser because the gas is cooled below its dew-point. The pressure drop through the shell is calculated to be 2.5 inches of water.

The caustic scrubber is a 30" diameter tower packed with 14 feet of 1 inch Raschig rings for contacting the caustic and gas and an additional 18" of packing for deentrainment. The caustic is recirculated by means of a pump located in a storage pot and a small amount is periodically bled-off to waste. Cooling coils are provided in the pot to take out the heat of reaction (caustic and nitrogen oxides) and to keep the temperature at about 130 to 160° F. in the tower. The cooling coils are sized to handle with the aid of pot agitation heat loads from rich dissolver off-gas fed directly to the scrubber. This condition will only exist if extended maintenance is required on the absorber. Pressure drop across the tower at peak flows is calculated to be not greater than 10" H₂O.

The acid recovery tank is a standard 10' O.D. x 10' high stainless steel tank. The tank has a pump flange and pipe flanges for the various connecting piping as outlined in the EFD, SK-2-5928.

COST INFORMATION AND ECONOMIC CONSIDERATIONS

The complete project cost for this proposal was estimated at \$800,000. A breakdown of the project cost is outlined on pages 16 and 17. This cost includes \$65,000 for design (page 15) and \$200,000 contingencies.

Of the total project cost, \$480,000 is attributable to the nitric acid recovery installation. At a production rate of 3600 tons of uranium per year (nominal Phase III rates) approximately 2,500 tons of nitric acid will be recovered for reuse. This recovery will amount to \$175,000 savings in raw acid consumption. This recovery amounts to a 36.5 percent return per year on the investment or a payout period of 2.7 years.

The chemical cost associated with operating the caustic scrubber is approximately \$14,300 per year at nominal Phase III production. The cost is based on the operation of the scrubber at a pH of 13 and the previous absorption of 87% of the acid gas.

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PROJECT		TYPE OF ESTIMATE	
Redox Iodine & Nitric Acid Absorbers		(A) ☒ STUDY STAGE	
DATE PREPARED	ESTIMATED BY	(B) ☐ DESIGN SCOPE	% COMPLETE
8-29-55	D. O. Webb	(C) ☐ FINAL DESIGN	% COMPLETE

ENGINEERING, INCLUDING SCOPING,
DETAILED DESIGN, AND DESIGN
SERVICES IN THE FIELD

ENGINEERING DESIGN 31,700

DRAFTING 16,000

PROJECT MANAGEMENT 5,000

SUB-TOTAL 52,700

ARCHITECT ENGINEERSENGINEERING ASSISTANCE TO HANFORD,
INCLUDING CONSULTANTS, ENGINEERING
ASSISTANCE CONTRACTORS, KAPL, GEL, ETC.ENGINEERING SERVICES (HANFORD)

TRAVEL AND LIVING

REPRODUCTION 1,000

ESTIMATING 600

LAYOUT AND SURVEY 500

OTHER

SUB-TOTAL 2,100

TEST MATERIALS AND EXPERIMENTAL TESTSCONTINGENCIES 10,200

TOTAL 65,000

DISTRIBUTION BY DESIGN STAGE

DESIGN SCOPE 1,700

DETAILED DESIGN 46,300

DESIGN SERVICES IN THE FIELD 6,800

CONTINGENCIES 10,200

TOTAL 65,000

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REDOX IODINE AND NITRIC ACID ABSORBERS
COST ESTIMATE

<u>DESCRIPTION</u>	<u>PHASE I-IODINE</u>	<u>PHASE II-NITRIC ACID</u>
Temporary Construction	\$ 5,000	\$
Building & Structure	20,000	30,000
Machinery & Equipment	65,000	160,000
Piping & Services	40,000	20,000
Electrical ()	6,000	0,000
Instrumentation)		
Material & Supplies	4,000	9,000
O.S. Facilities	15,000	
Plant Forces W.O. & H.C.S.O.H.	7,000	0,000
Test Well	3,000	
Equipment Usage	<u>10,000</u>	<u>10,000</u>
Sub-Total	\$ 175,000	\$ 245,000
Other Directs	13,000	22,000
Indirect & Fee	7,000	11,000
Construction Engineering	<u>5,000</u>	<u>7,000</u>
Sub-Total	\$ 200,000	\$ 285,000
Start-Up Cost	5,000	10,000
Design & Administrative	<u>35,000</u>	<u>65,000</u>
Sub-Total	\$ 240,000	\$ 360,000
Reserved for Contingency (40%)	<u>80,000</u>	<u>120,000</u>
Total Project Cost	\$ 320,000	\$ 480,000

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REDOX IODINE AND NITRIC ACID ABSORBERS
ENGINEERED EQUIPMENT

	<u>DESCRIPTION</u>	<u>AMOUNT</u>
1	Caustic Scrubber	\$ 26,000
1	HNO ₃ Absorber	95,000
1	Gas Cooler	6,000
1	5,000 Gal. S/S Strg. Tank	18,000
1	50 GPM at 75' head S/S Vert. Pump	5,000
2	25 GPM at 25' Head I.B. Vert. Pump	2,000
3	75 GPM S/S Jets	1,500
22	Conn. Female	9,000
3	2" S/S Air Oper. Valves	2,000
6	6" S/S Control Valves	7,500
3	6" 3-way Control Valves S/S	12,000
3	6" S/S Jets	6,000
	S/S Pipe, Valves, Fittings, & Misc.	40,000
	Instruments & Electrical	10,000
	Freight, Handling, etc.	<u>10,000</u>
	Total	\$ 250,000

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MATERIAL BALANCE

DESIGN BASIS: ABSORBER - MAXIMUM GAS EVOLUTION FROM TWO DISSOLVERS - 2000 MU DISSOLVED PER HOUR
CAUSTIC SCRUBBER - ONE DISSOLVER ON COATS, TWO ON CUTS; ACID RECOVERY - IN CELL SILVER REACTOR 95% EFFK

STREAM	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
TEMPERATURE °F	32.5	85	85	85	85	70	85	85	85	85	32.5
DENSITY g/ft ³	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088
PHASE	VAPOR	LIQUID	VAPOR	VAPOR	VAPOR	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
COMPONENTS lb/hr											
AMMONIA											30
NITROGEN	445		445	890	1,335						515
OXYGEN	135		135	270	85						140
NITROGEN DIOXIDE	1,160		1,160	2,320	35						
NITRIC ACID	250		250	500	105						
WATER	155	120	45		45	1,845	1,720	1,845	4,000	7,200	70
SODIUM NITRATE											
SODIUM HYDROXIDE											
TOTAL	2,125	120	1,930	1,160	1,615	1,845	3,440	3,690	5,000	72,000	775
gal/hr											
SCFM	365		325	280	365						175
CUYD OF 111 DAY	287				287						1

INTEGRATED NORMAL DAILY QUANTITIES-BASIS:

INSTANTANEOUS DAILY RATE - 14 TPD 10 MW/ 75 DAY COOLED 95.5% EFFICIENCY
51% ACID RECOVERY BASED ON 5 MOL ACID CONSUMED PER MOL U D

COMPONENTS lb/HR											
NITROGEN DIOXIDE AS NO ₂	18,800				2,100						
NITRIC ACID		1,500				17,500		13,250			
NITROGEN		1,500				20,000		17,500	12,000	70,000	
AMMONIA											60
SODIUM NITRATE											
TOTAL		3,000				30,000	37,500	30,750	120,000		
gal/hr		400				4,000	4,750	3,850	15,000		
CUYD OF 111 DAY	287				287						1

1. SHADED EQUIPMENT & HEAVY LINES ARE NEW
LIGHT LINES & EQUIPMENT NOT SHADED ARE
EXISTING

CELL SILVER REACTOR
SOLVED

100	N.B.		
		6,750	5550
		80	1,450
	80		
		3,150	
		2,270	7,400
		970	625
2.1	13	20.12	100,000
			15,000

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

DESCRIPTION		REV. BY	DATE	FOR	DATE
REVISIONS					
DWG. NO.	SK-2-5937	PROJECT NUMBER		REV. NO.	0
SCALE	NONE	ATTACHMENTS			
DESIGNED BY	J. A. GIBSON	CHECKED BY	TEN	DATE	
DRAWN BY	J. A. GIBSON	APPROVED BY			
CHECKED BY	J. A. GIBSON				
DATE	11/22/54				
PURPOSE	See 11/22/54				
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
PROCESS FLOW DIAGRAM COMBINED NITRIC ACID RECOVERY & IODINE REMOVAL FACILITIES - REDOX					
SK-2-5937					

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[illegible]

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REVISIONS		DATE	BY	APP'D	REV
3K-2-5929					0
SCALE 1/4" = 1'-0"		ATTACHMENT 1			
DESIGNED BY: [Signature]		CHECKED BY: [Signature]			
DRAWN BY: [Signature]		APPROVED BY: [Signature]			
DATE: 11 DEC		PROJECT: 60-101308			
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATING GENERAL ELECTRIC					
NEW BUILDING EQUIPMENT ARRANGEMENT & VENTILATION DIAGRAM COMBINED HNO ₃ RECOVERY & IODINE REMOVAL					

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'A' CELL

'B' CELL

'C' CELL

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'A' CELL

NOTE
1 SHADED EQUIPMENT & HEAVY LINES ARE NEW
LIGHT LINES & EQUIPMENT NOT SHADED ARE
EXISTING.

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NOT FOR CONSTRUCTION

NO.	DESCRIPTION	DATE OF	APPROVED BY	DATE
1	REVISIONS			
FORM SK-2-1050				
SCALE:		AS SHOWN		
DESIGNED BY: [Signature]		CHECKED BY: [Signature]		
DRAWN BY: [Signature]		APPROVED BY: [Signature]		
DATE: 06-03-60		PROJECT: 04-104-200		
U. S. ATOMIC ENERGY COMMISSION SANDHURST ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC				
CANYON MODIFICATIONS FOR REDOX NITRIC ACID RECOVERY SYSTEM				

8" NPS PIPE

1" NPS PIPE

TRAY #12

TRAY #11 & 12 ARE REMOVABLE

TRAY #11

TRAY #10

TRAY #9

TRAY #8

TRAY #7

TRAY #6

TRAY #5

5'0" O.D.

TRAY #4

TRAY #3

GASKET

TRAY #2

1" NPS PIPE

TRAY #1

8" NPS PIPE

8" NPS PIPE

ELEVATION

- NOTE
1. ALL MATERIALS SHALL BE STAINLESS STEEL TYPE 304-L IN ACCORDANCE WITH SPECIFICATION HW 5301-S LATEST REVISION & HWS 5506 REV. 2 PAR. 31
 2. FABRICATION SHALL BE IN ACCORDANCE WITH SPEC. HWS-5506
 3. OPERATING PRESSURE - SHELL - 60" Hg VACUUM COIL 100 PSI OPERATING TEMPERATURE SHELL 100°F COIL 75°F
 4. ALL TRAYS TO BE LEAK TIGHT & FREE FROM RETENTION POCKETS
 5. CAPS & TRAYS ARE TO BE LEVEL WITHIN $\pm \frac{1}{16}$ "

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

NO.	REVISIONS	REV. NO.	DATE	BY	CHKD.
SK-2-1894		0			
SCALE		APPROVALS			
DESIGNED BY		CHECKED BY			
DRAWN BY		DATE			
PROJECT		DO NOT EMB			
U. S. ATOMIC ENERGY COMMISSION HARFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
ABSORBER TOWER REDOX NITRIC ACID RECOVERY SYSTEM					
SK-2-1894

140723

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1" O.D. TUBE PASSES
2 COILS AS SHOWN

SECTION "A-A"

NOTE

1. ALL MATERIAL SHALL BE STAINLESS STEEL TYPE 304-L IN ACCORDANCE WITH SPEC. HW-8501-S LATEST REVISION AND HWS 8506 REV 2 PAR. 3.1
2. WELDING ROD TO BE TYPE 308-L IN ACCORDANCE WITH HWS-8700
3. FABRICATION SHALL BE IN ACCORDANCE WITH SPEC. HWS-8800
4. OPERATING PRESSURE SHELL 60" H₂O VAC COIL 100 PSIG
5. OPERATING TEMP SHELL 450°F COIL 250°F

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

REVISIONS		DATE		BY	
SK-2-1808					
SCALE		AS SHOWN			
DESIGNED BY		CHECKED BY			
DRAWN BY		APPROVED BY			
DATE		DATE			
PROJECT NO.		PROJECT NAME			
U.S. ATOMIC ENERGY COMMISSION		SANDHURST ATOMIC PRODUCTS OPERATION			
GENERAL		PLANT			
GAS COOLER		REDOX NITRIC ACID			
RECOVERY SYSTEM					
SK-2-1808

TYPICAL SECTION
DISTRIBUTOR RING

NOTES

- (a) ALL MAT'Y SHALL BE STAINLESS STEEL, TYPE 304L IN ACCORDANCE WITH SPEC. HW-3301 3, LATEST REVISION AND HWS-5506, REV. 1, PAR. 3.1.
- (b) WELDING ROD TO BE TYPE 308L IN ACCORDANCE WITH HWS-5188
- FABRICATION SHALL BE IN ACCORDANCE WITH SPEC. HWS-5506.
- OPERATING PRESSURE SHELL 60" H₂O VACUUM COIL 100 PSIG.
- PROVIDE EXTERNAL APPURTENANCES AS REQ'D.
- NOZZLE ORIENTATION MAY BE CHANGED TO SUIT BLDG. ARRET.

PACKING SUPPORT & HOLD DOWN GRATE
AS REQ'D.

APPROVED
FOR DESIGN
NOT FOR CONSTRUCTION

DESIGNED BY	DATE
CHECKED BY	DATE
APPROVED BY	DATE
SCALE	
PROJECT NO.	
REVISIONS	

REVISIONS		DATE	BY
NO.	DESCRIPTION		
1	SK-2-5927		
SCALE: NONE		APPROVALS	
DESIGNED BY: [Signature]		DATE: 8-22-67	BY: [Signature]
CHECKED BY: [Signature]		DATE: 8-29-67	BY: [Signature]
APPROVED BY: [Signature]		DATE: 8-29-67	BY: [Signature]
PROJECT NO. 11322			
DRAWING NO. DA 101305			
G. L. KROCK ENGINEERING CORPORATION KANSAS SPRING PRODUCTS DIVISION GENERAL ELECTRIC			
CAUSTIC SCRUBBER COMBINED HNO ₃ RECOVERY AND IODINE REMOVAL			
SCALE: NONE		PROJECT NO. SK-2-5927	

END

DATE FILMED

12 / 27 / 90