PROCESS ENGINEERING REPORT

OPERATING MANUAL

FOR SUPERVISORY PERSONNEL,

GREEN SALT PLANT

PART IX

SECTION NO. 5-3

JOB NO. 3004

of the

FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO

AEC CONTRACT AT(30-1)-1060

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GRUMMAN's SALT PLANT OPERATING MANUAL FOR

CONTINUOUS PROCESS

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GENERAL INTRODUCTION

This operating manual is designed for supervisory personnel to aid and assist them in formulating detailed instructions for operators and foremen. For clarity and convenience, it has been divided into discussions of integral parts of the process. The material has been divided into ten main categories, processing of uranium bearing material (Section 5-3:02) and auxiliary systems (Sections 5-3:03 through 5-3:07). An instrumentation section (Section 5-3:08) and a summary, entitled Integration of Systems (Section 5-3:09), have also been included. The table of contents gives this breakdown in detail.

Each section of the manual, exclusive of instrumentation and integration of systems, has been subdivided as follows:

1. Introduction
2. Process Description
3. Equipment Description
4. Safety
5. Operating Instructions

The introduction to each section presents the equations for the chemical reactions which occur, if any, and operating stoichiometric relationships.

The process description, where applicable, is a general description of the flow of material through the various steps of the process.

The equipment description presents a detailed description of major...
process equipment and its relation with other items of equipment.

The discussion of safety practices has been limited to those hazards which are particular to the processing at HPGC, such as radiation, and excludes those which are normal industrial hazards. An exception to this has been made in the case of safety practices for hydrofluoric acid handling.

The operating circumstances have been further subdivided as follows:

1. **Startup From An Empty System** - These procedures will apply for the initial startup or for startups after the system has been completely emptied.

2. **Startup From A Full System** - These procedures will apply for startups after normal shutdown has occurred or after brief repair periods. In some cases, the two procedures will be the same.

3. **Normal Operation** - These procedures will apply after the startup is complete and until shutdown occurs.

4. **Normal Shutdown** - These procedures will apply for shutdowns for weekends, holidays, or planned repairs, or at any time when sufficient time is available to carry them out.

5. **Emergency Shutdown** - These procedures will apply in the event of fire, explosion, enemy attack, or other catastrophes where there is insufficient time available to carry out the normal shutdown procedures.

An appendix is included in this manual, wherein will be found appropriate process flow diagrams and mechanical flow diagrams.
Uranium trioxide (orange oxide) is received from the ore refinery and is converted to uranium tetrafluoride (green salt) in this plant. The conversion of \( \text{UO}_3 \) to \( \text{UF}_4 \) takes place in two steps, reduction and hydrofluorination. The following equations show the two reactions which take place.

\[
\begin{align*}
(1) \quad \text{UO}_3 + \text{H}_2 & \rightarrow \text{UO}_2 + \text{H}_2\text{O} \\
(2) \quad \text{UO}_2 + 4\text{HF} & \rightarrow \text{UF}_4 + 2\text{H}_2\text{O}
\end{align*}
\]

**PROCESS DESCRIPTION**

The orange oxide is received from the ore refinery in mobile hoppers which are transferred to the fourth floor of the green salt building. The hoppers will contain approximately 13,500 pounds of orange oxide and are designed for convenient filling in the ore refinery and convenient discharge in the green salt building.

The reduction and hydrofluorination reactions are carried out in horizontal tubular furnaces. There are twelve banks of reactors, each consisting of one reduction furnace located above three hydrofluorination furnaces in a vertical plane. The furnaces are arranged in two sets of six banks on opposite sides of a center bay. The orange oxide from the hopper is discharged through a seal hopper to the feed end of the reduction furnace. The solids level and a nitrogen blanket in this seal hopper prevents hydrogen from escaping. The solid phase is passed through the reactor by a ribbon conveyor. The residence time in the reactor has been estimated at approximately two hours.
A mixture of hydrogen and nitrogen, which is produced by cracking ammonia, is used as the reducing agent and flows countercurrent to the solid phase. The present practice at Mallinckrodt Chemical Works, St. Louis, Mo. (1943), is to carry out the reaction at approximately 1200°F. Hydrogen will be used at approximately two and one-half times the theoretical amount and provision has been made to increase this amount to four times stoichiometric requirement. The excess hydrogen is burned and diluted with air, thereby being cooled so that it may be filtered in a conventional bag type dust filter.

The reduction product, brown oxide (UO₃), is discharged to a similar seal hopper, from which it flows to the first hydrofluorination furnace. The nitrogen seal on this hopper prevents hydrogen from entering the hydrofluorination furnaces and gaseous HF from passing up into the reduction furnace.

The three hydrofluorination furnaces are in series with the solid phase moved by ribbon conveyors as described previously. The estimated residence time in the three reactors is four hours. Anhydrous hydrofluoric acid vapor is used to convert UO₃ to UF₆ and flows countercurrent to the solid phase. Two and one-half times the theoretical requirement is used. The reaction is carried out at progressively higher temperatures, starting with approximately 650°F, at the feed end of the first furnace and ending with approximately 1100°F, at the discharge of the third furnace. These temperatures are based on present NSN practice.

The discharged HF from the reactors, containing water of reaction and nitrogen inleakage, is filtered in a porous carbon filter where entrained dust is removed. This dust is periodically returned to the first reactor, while the wet HF flows to the HF recovery system.
The product green salt is discharged through a seal weigh hopper to a water jacketed cooling screw where it is cooled to approximately 120°F. A countercurrent nitrogen sweep is maintained in the screw to remove residual HF from the solid. The cooling screw may discharge to either of two places, the packaging system or the return unit.

Product material may be rejected for two reasons, contamination or low contamination. By contamination is meant the presence of foreign material in the green salt which has been picked up during processing. Normally, the chief contaminants will be metallic, but during initial operations, scale, dirt, and the like, which will be in the system, will be carried out with the initial product and will make it unsatisfactory for further processing.

Operations at HW indicate that the largest single contributor to contamination is galling in the reactors. Galling is the abrasive action of the conveyor running on the reaction tube with the result that metallic particles of both are detached and carried along with the solid material. The conveyor in the reduction furnace is supported at both ends thereby minimizing contact with the reaction tube wall. The green salt screws, however, are only supported at one end with the floating end free to drag on the tube. It is advantageous to have a layer of solid material in the tube for the screw to ride on.

Slightly contaminated material can be blended off with good grade product.

Grossly contaminated material will be oxidised to $UO_2$ in the scrub plant for recycle to the refinery.

If analysis of samples taken show that the conversion to $UF_4$ has not been complete, the material is conveyed to a rerun unit and the entire process repeated. This rerun bank is similar to the production banks and will be used as such when it is not necessary to reprocess low conversion material.

The primary difference between the two is that the tube of the reduction furnace is constructed of Inconel. The reprocessing of green salt in the reduction furnace is made possible by the fact that $UF_4$ is stable under the conditions of the reduction reaction. The proper quantities of hydrogen and $HF$ for the rerun unit remain to be determined through experience.

Uncontaminated dust, which is collected by the dust collectors, will also be processed in the rerun unit. The mixture of brown and orange oxides from the brown oxide dust collectors will not be mixed with green salt from the green salt dust collectors. The materials from the two sources will be processed separately in the rerun bank as the dust collectors become filled.

When residues from the brown oxide collectors are being processed, no changes in operation will be made. However, when residues from the green salt collectors are being processed, the hydrogen flow to the reduction furnace may

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<th>Item</th>
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<tr>
<td>Assay</td>
<td>97.5% $UF_4$ minimum</td>
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<tr>
<td>Iron</td>
<td>0.0025%</td>
</tr>
<tr>
<td>Insoluble in Ammonium Oxide</td>
<td>1.3% maximum</td>
</tr>
<tr>
<td>Soluble in $H_2O$</td>
<td>2.5% maximum</td>
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be stopped. The rerun unit discharges to a packaging line, as does the production unit.

Material which meets specification is discharged to a weigh hopper from which it is conveyed to the packaging system. The particle size is first reduced in a micropulveriser to nominal 100 mesh. The material is received and weighed in a hopper and is discharged to a dustless blender designed to blend 1280 pounds of green salt per batch. The material from the blender is sampled automatically from the discharge stream.

One packaging unit is divided into two sections. The first is designed to package green salt in five and ten-gallon containers while the second handles thirty-gallon containers. Separate hoppers feed each section with material from the blender. The second packaging unit, serving six banks, packages in only the five or ten-gallon containers. Packaging is a semi-automatic operation in which the unit is set to discharge a predetermined quantity of product into the containers. The packaging unit will have an accuracy of ± 1/10 of 1 per cent. The filled containers are stacked on pallets and removed to the storage area provided. For initial operations, five-gallon pails will be filled with 150 pounds of green salt each.

If the analysis of the final packaged product shows that it is slightly above tolerance on metal contamination, the material may be returned to the system before the pulveriser and blended off with good material.

EQUIPMENT DESCRIPTION

The orange oxide is received from the ore refinery building in mobile hoppers, F27-151 to 250, which are placed on the first floor of the green salt building. There are 100 hopper to provide for the pair of ratios.
flexibility and interplant storage. Provisions are made for storage of three weeks' full production of orange oxide. At full production the hoppers will be disposed as follows:

1. Hoppers will be held in the refinery.
2. Hoppers will be stored on the ground floor of the green salt building.
3. Hoppers will be in an operating position in the green salt building.

The balance will be in transit, in the process of being filled, or in storage.

Each hopper consists of a 105-gallon type 301 stainless steel vessel, equipped with a Cenco valve at the bottom, and mounted on a four wheel carriage or dolly. Both the top and bottom of the hopper are sealed with safety plates while in transit.

The hoppers are raised to the top floor of the green salt building by the elevator, and then pulled by electric mule to either the east or west side of the building adjacent to the crane bay. The overhead crane lifts the hopper free from its carriage so that the safety plates may be removed. The crane carries the hopper and positions it on a weight indicator over the reactor bank which is to be charged. The hopper is sealed to the feed screw through a flexible rubber coupling and held in position by four pins, one in each of the four legs. A vibrator is attached to the hopper after it is positioned.

The twelve banks of reactors and the auxiliary equipment and instruments associated with them are essentially identical. Therefore, a description of only one bank, using the item numbers of the equipment in that bank, will be presented here. Bank number twelve will be described.
The orange oxide discharge conveyor, DH-34, is a 2-inch diameter horizontal screw type conveyor approximately 3 feet long and constructed of type 304 stainless steel. The vibrator on the orange oxide hopper and the discharge screw are interlocked.

The weight transmitter on the seal hopper controls the discharge rate by automatically switching the interlocked screw and vibrator on and off as the weight of material in the hopper reaches the maximum or minimum control points are determined for gas seal purposes. The variable speed drive for the screw permits close control of feed to the reactors. The discharge rate from the other weigh seal hoppers in the bank is controlled in a similar manner. The screw discharges to the orange oxide seal hopper, FH-103, through a short vertical downcomer. The seal hopper is a 27-gallon, rectangular, Monel vessel which is equipped with a vibrator and mounted on a weight transmitter. The vibrator is interlocked with a 2-inch furnace feed screw. This screw is constructed of type 304 stainless steel and discharges the material from the furnace feed hopper to the feed end of the furnace itself. Nitrogen gas is fed into the top of this hopper and acts as a seal in preventing the escape of hydrogen from the reactor.

The reduction furnace, DH-52, consists of a cylindrical, type 309, stainless steel tube, approximately 16 inches inside diameter and 22 feet long surrounded by refractory brick insulation.

The forward motion of the solid phase is produced by a ribbon type screw constructed of Hasteloy C. Flows are attached to the ribbons at intervals to assist in moving the powder. The ribbons contribute more to lifting the solid phase and dropping it through the gas phase than to producing
forward motion of the solid. The conveyor is stiffened by a 6-inch iron bar shaft which runs the length of the screw and is supported at both ends. The pitch of the primary helix is approximately 9 feet, but at the feed end of the screw, a secondary helix with a pitch of approximately 6 inches is superimposed on the primary one. This secondary section provides for better distribution of the feed.

The screw is driven by a 3/4 HP motor through a speed reducer, 60-61. The speed of the screw may be varied from 2.4 to 11.6 rpm to control the solid throughput. A torque recorder-controller is provided to record the torque on the screw and stops the screw and the flow of material to the reactor should excess torque develop. An alarm on the main control board will sound before the screw shuts down. Experiments will have to be conducted to determine the proper setting of the instrument to prevent twisting or breakage of the screw. The drive assembly is mounted on a mobile carriage which rests on tracks. The drive end of the reactor itself is similarly mounted. Provision is thus made for thermal expansion.

The reaction tube has four temperature zones. Temperature is controlled by the heating elements mounted on either side of the tube in four zones on the brick insulation. Each zone has eight elements, four to a side. The elements are controlled by a DAF Controller actuated by thermocouples attached to the bottom of the tube at the center of each zone. An indicating thermocouple is also attached close to the control couple.

The flow of hydrogen to the reactors is automatically controlled and recorded. Excess hydrogen as it issues from the furnace is burned in a jet with a pilot light. In the event of flame and pilot
light failure, a flame controller will shut off the fuel gas supply to the pilot, shut off the hydrogen feed to the furnace, and close the dust collector flue. The reactor will automatically be purged with nitrogen and the gases exhausted to atmosphere.

The brown oxide product from the end of the reactor is discharged to a vertical 3-inch diameter conveyor. A motor driven rotary valve in the line feeds the brown oxide to a seal hopper, 74-105. This hopper is a 15-gallon, rectangular, Monel vessel which is mounted on a weight transmitter and is equipped with a vibrator. Nitrogen gas is also introduced into this hopper to act as a seal against hydrofluoric acid vapors entering the reduction furnace and also to prevent hydrogen from entering the hydrofluorination furnaces.

A 2-inch diameter screw conveyor feeds the brown oxide from the seal hopper to the feed end of the first hydrofluorination furnace. The vibrator on the seal hopper is interlocked with this screw.

The three hydrofluorination furnaces, 74-54, 55 and 56, have the same configuration as the reduction furnace and differ only in minor structural details. The tube is constructed of Inconel while the screw is of the same materials as in the reduction furnace. Instead of the 6-inch diameter supporting shaft for the screw, a 3/4-inch diameter Inconel shaft is used except for the first 3 feet of this shaft which is 2 inches in diameter. The screw in the hydrofluorination furnace is supported only at the drive end. Bearing supports have been provided on the other end of the furnaces in the event that future operations indicate that support of both ends is advantageous.

The drive mechanisms of the first two reactors, 74-350 and 351,
respectively, are flamed, while that of the third, 49-51, is made so in the reduction furnace. Thermal expansion is compensated for in flexible couplings in the connections between the furnaces and the movable drivers on the lower furnace.

Arrangements for temperature measurement and control in the three furnaces are the same as those for the reduction furnace. Random objections existed, and meter the flows of HF to the twelve banks of reactors. Random samples were taken at the inlet and outlet of the furnace bank (except the HF pump) at these points to a pressure recorder-controller which is mounted on the main control board. Should the pressure at either of these points exceed a predetermined setting, the controller closes the HF flow control valves.

Furnace 49 from the hydrofluorination furnaces containing water of reaction, dust and nitrogen is filtered in a porous carbon atom filter, 49-60, to remove the solids, and then sent to either HF recovery or vented to the atmosphere. Both systems are described later. This filter is a steam-jacketed vessel containing fifteen porous carbon tubes with a total filtering area of 3.5 square feet. The jacket and head are heated with 100 psig steam. The filter is connected to the furnace outlet by a 10-inch diameter pipe equipped with a vibrator.

Periodically, the tubes become clogged with dust and the filter must be cleaned. This is done by backwashing the tubes with nitrogen. The nitrogen, for this purpose, is stored in a pump tank, 75-71, under 25 psig pressure. The dislodged dust falls back down the 10-inch riser to the reactor.

The solid phase from the upper reactor is discharged through a vertical 10-inch diameter discharge which feeds it to the feed end of the middle
reactor. A similar arrangement exists between the middle and lower reactors. The de-ammonizers are fabricated with a bellows section to compensate for thermal expansion. A sample port is provided in each de-ammonizer, and the samples are taken by sliding a small boat through a cock.

The product, green salt, from the lower reactor is discharged through a 3-inch diameter de-ammonizer with a bellows expansion section to a feed hopper, Ph-109. This hopper is a 29-gallon, Monel vessel, approximately 18 inches square. It is mounted on a weight transmitter and is equipped with a vibrator.

A 2 feet long 3-inch diameter feed screw is interlocked with the vibrator on the feed hopper and feeds the material to the cooling screw, Ch-420. The cooling screw is a 4-inch diameter water-jacketed Monel screw conveyor, approximately 10 feet long. Nitrogen gas is introduced into the screw and flows countercurrent to the solid phase to sweep out any residual HF vapor. Two discharge ports are provided in the cooling screw. If the material issuing from the furnace has been satisfactorily converted, the screw discharges it to the green salt weigh hopper, Ph-109. This hopper is a 590-gallon, cylindrical, stainless steel vessel with a conical bottom, mounted on a weight indicator. A vibrator is attached to the hopper. Should the material be below conversion specification, it is discharged instead to the versa conveyor, Ch-672, which transports it to the bad lot storage hopper, Ph-69. The bad lot storage hopper is identical with the green salt weigh hopper, Ph-109.

Since the hydrofluorination reaction is strongly exothermic, hot smoke appears in the reaction tubes. For this reason, provision is made for air
cooling the feed end of each hydrofluorination furnace. This cooling consists of a sliding gate in the bottom of the refractory shell and a duct at the top of the reactor. In this way, air may be circulated around the reaction tube by a blower. The blowers serve all 14 green salt reactors.

Dust hoods are placed over the bearings at each end of both the reduction and hydrofluorination furnaces. This is a safety measure to collect any dust which may arise when it is necessary to remove the screens for maintenance purposes.

The conveyor is an enclosed stainless steel flight conveyor, 1 inch in diameter with steel-backed-magnesium flights and a mild steel chain. A horizontal section, 68-375, transports the green salt from the reactor bank to a vertical lift section, 68-377, from which it is discharged to the packaging system. There are two packaging systems, each one handling the product from six banks of reactors.

A micropulverizer, 68-367, reduces the particle size to a nominal 100 mesh. The pulverizer is powered by a 15 HP motor and the feed screws by a 1/2 HP motor. The unit is provided with a vibration eliminator.

The green salt discharges to the blender feed hopper, 78-375. This hopper is a cylindrical 360-gallon, type 304 stainless steel vessel with a conical bottom. The hopper is mounted on a weight transmitter and is equipped with a vibrator. The micropulverizer may be by-passed, and the product discharged directly to the weigh hopper. Material from the dust collector is also introduced directly into this hopper.

The material from the feed hopper is dropped to a Sturtevant blender, 68-369, which is powered by a 30 HP motor. The blender itself consists of a
The materials enter the drum and are picked up by a series of revolving bucket sections and carried to the top of the blending chamber where they cascade and mix. Both the intake and discharge are at the same end of the machine. The discharge is closed by a gate during blending, and opened by a hand lever when the operation is complete.

The discharge from the blender is sampled with an automatic sampler, Gk-607. This sampler consists of a bin containing baffles and a support for the sample receiver. Part of the solid material is fed to the sample receiver by the baffles. The receiver is then withdrawn and its contents emptied into a chute which feeds the sample storage container.

As mentioned previously, the packaging unit proper is divided into two sections. Material for the five and ten-gallon unit, Gk-589, is collected in the smaller of two packaging hoppers, Fl-97. This hopper is a 250-gallon stainless steel vessel with a conical bottom. The larger hopper, Fl-101, which feeds the 30-gallon packaging unit, Gk-659, is a similar vessel but has a capacity of 350 gallons. Both hoppers are equipped with vibrators.

The large hopper discharges material directly to the 30-gallon containers. A motor driven star valve in the line controls the discharge rate. The containers are brought to the filling station on a roller conveyor. The drum is tared and placed in position under the discharge line. An air cylinder under the container raises it up inside a canvas dust hood and tight against a rubber gasket. After filling, the gross weight of the container is obtained on the scale provided. The 30-gallon containers will be filled with as much material as is conveniently possible. One control button raises the air cylinder, starts the vibrator, and starts the motor driven star valve.
The smaller hopper discharges directly to an inclined vibrating feeder which feeds a surge bin and is in turn discharged by a similar feeder. The five and ten-gallon packages are filled from this feeder through a funnel-like hopper. The containers are tared on a scale and raised directly from it by an air cylinder. The head of the container fits against a rubber gasket and is enclosed in a canvas dust hood. In operation, the surge bin, which is on a scale, is filled from the packaging hopper. The major part of the material is rapidly fed to the container which is then lowered and weighed. The balance of the material is added at a slow feed rate with the container in the lowered position. The unit is controlled from a push button panel.

Both units, exclusive of the packaging hoppers, are enclosed in a dust hood. The containers are then stacked as described previously.

Packaged material, which is slightly off grade with respect to metal contamination, is lifted by a hoist, Gh-806, and positioned over the reblend hopper, Gh-805. A drum dumper empties the contents of the containers into the hopper where it is blended off with the good material. Grossly contaminated packages are stacked on a pallet which is taken to the scrap plant by fork lift truck.

SAFETY

Radiation in this area is slight, but continuous exposure may prove hazardous. The extent of this exposure may be determined by patch badges worn by the operators.

The handling of HF, although common industrial practice, warrants special attention in view of its extremely hazardous nature. Workmen who handle HF should be thoroughly instructed regarding its physiological effects.
and the proper first aid treatment to apply in the event of contact with the acid.

The safety rules of the Sun Oil Company, pertaining to HF handling, are included in the Appendix. It is hoped that these rules will serve as a guide to the operator in establishing sound safety practices.

SAFETY PRECAUTIONS

The following discussion will be confined to Bank Number 12. The operation of other banks is similar.

Startup From an Empty System

Certain preliminary operations must be performed before the actual flow of process materials is started. These are as follows:

1. Bring furnaces up to temperature. This will require approximately four to six hours. Before the initial startup, a prolonged period of four or five days at operating temperature will be required to drive residual moisture from the equipment.

2. Place the mobile orange oxide hopper in its proper position over the reduction furnace.

3. Purge furnaces completely with nitrogen to remove air which may form an explosive mixture with hydrogen in the reduction furnace. Approximately 600 scf. will give five replacement volumes for the purge.

4. Manually charge the seal hoppers in the system to their operating level with the materials which they will contain during operation. Thus the orange oxide seal hopper, PH-103, will be charged with orange oxide, the brown oxide seal hopper, PH-105, with brown oxide, and the green salt seal hopper, PH-107, with green salt.
5. Maintain a nitrogen seal in the orange and brown oxide seal hoppers, PH-193 and PH-283, respectively.

6. Light the pilot flame on the hydrogen burner and place the flame controller in service.


The flow of process materials may now be started according to the following procedures:

8. Start hydrogen flow to the reduction furnace at the rate required by the anticipated feed rate. Check the hydrogen burner to be sure that the effluent is being burned.

9. Start the vibrator and screw on the mobile hopper and turn on the level controls on the orange oxide seal hopper, PH-103. The weight transmitter in the seal hopper will control the discharge rate through the interlocked screws and vibrators as described previously.

10. Start the main screw in the reduction furnace.

11. Open the Gano valve on the mobile hopper.

Orange oxide will now enter the furnace and be carried through by the screw. As mentioned previously, the residence time for the reduction reaction has been estimated at about two hours. Therefore, approximately two hours will elapse before brown oxide discharges from the furnace. The discharge may be determined by periodic sampling at the sample cock in the downcomer. When the brown oxide starts discharging, the following operations may be performed:

12. Start rotary screw feeder valve.
13. Start the main screws on the hydrofluorination furnaces.

14. Start HF flow through the reactors. When HF flow is established, test all joints for leakage with ammonia.

15. Start the vibrator on the 10-inch diameter riser to the Adams filter. This vibrator should be on whenever the furnaces are in operation.

16. Turn on the level controls on the brown oxide seal hopper, Fh-105. Brown oxide will now discharge to the first green salt reactor and be carried through by the screw. A residence time of about 1.3 hours has been estimated for each green salt reactor under normal operating conditions. Therefore, it will be approximately four hours before green salt discharges from the last reactor. The progress of the solid material through the furnaces may be determined by periodic sampling from the downcomers between the furnaces. However, the HF flow should be interrupted while sampling.

The material will be sampled as it issues from the lower green salt reactor to determine the percent conversion. If the percent conversion is too low, the green salt is discharged from the cooling screw to the rerun conveyor, Sh-672. This conveyor will transfer the material to the bad lot storage hopper, Fh-69, from which it will be fed to the rerun bank.

The following procedures describe the normal processing of material which meets conversion specifications.

17. When green salt is discharging to the green salt seal hopper, Fh-107, turn on the level controls on that hopper and start the cooling screw, Sh-410. Put cooling water on the jacket of the screw and start a nitrogen stream through the screw.

18. Brown salt will be discharged to the green salt seal hopper.
PB-109, where the product of 6h hours production at design rate can be held up.

19. When the hopper is full, or when it is desired to discharge product, open the Sense valve on the bottom of the hopper and start the horizontal and vertical flight conveyors, Ch-675 and Ch-677 respectively, and the micropulverizer, Ch-567. Green mix will now be discharging to the blender feed hopper, PB-95. Grinding in the micropulverizer may not be necessary, in which case the pulverizer should be by-passed.

20. When 1000 pounds (one blender batch) or more has accumulated in the blender feed hopper, PB-95, start the vibrator on the hopper and drop the batch to the blender, Ch-569, with the blender slowly rotating. An overall cycle time of approximately one hour is estimated for blending. This cycle consists of charging, blending, and discharging. Actual blending will require one-quarter hour to give a uniform batch.

21. When the batch is blended, start the automatic sampler, Ch-607, and discharge the blender to either of the packaging hoppers, PB-101 for the 20-gallon unit, Ch-659, or PB-97 for the five and ten-gallon unit, Ch-589. The normal package is a five-gallon can.

22. The vibrator on the small packaging hopper, PB-97, is interlocked with the control circuit for the packaging unit. Therefore, starting the sequence of operations at the push button panel will discharge the hopper to the packaging unit proper. The sequence of operations will be indicated by signal lights on the panel.

23. Take the filled containers from the roller conveyor and place them on a pallet.
As mentioned previously, considerable contamination is expected during the initial operations. Material which is slightly contaminated will be blended off with good material. Grossly contaminated material is to be sent to the scrap plant for reprocessing.

Startup From a Full System

This procedure will be the same as startup from an empty system except that the reduction furnace will begin to discharge shortly after the main screw is started. Also, the seal hoppers in the system will contain an operating level of solid material.

Normal Operation

The throughput rate of solid material is controlled by two factors, the screw speed and the depth of solid in the reaction tube. At a given charge rate of solid material to the reactor, the throughput rate may be controlled by screw speed between two limits. The upper discharge limit occurs with the screw operating as a "starved" screw; the speed of the screw is sufficient to handle as much or more than the amount of material that is being fed to the reactor. The lower limit occurs with a "choked" screw. In this condition, the speed of the screw is insufficient to carry through the amount of material being charged, consequently, material will accumulate in the tube.

The optimum screw speed and charge rate for any desired throughput rate will have to be determined by experience after operation is begun. The effect of torque on the screw will also have to be considered in determining the optimum operating conditions. An investigation of the torque limits at NW will be made and will be transmitted as an addendum to this manual for the guidance of the operator. Torque is measured by a wattmeter connected to the drive motor. The screw speed is indicated by the scale reading on the
speed reducer. This scale will have to be calibrated with a hand tachometer after the system is in operation.

The control of temperatures in the reactors is of primary importance for trouble-free operation. The correct temperatures to be maintained must be determined by experience. The following are the suggested temperature settings for the reactors:

Reduction Furnace: all four zones maintained at 1200°F.

Green Salt Reactor:
- Upper Furnace - 650°F, 750°F, 850°F, 950°F.
- Middle Furnace - 900°F, 960°F, 1030°F, 1100°F.
- Lower Furnace - 1080°F, 1175°F, 1160°F, 1100°F.

The control systems for HF and hydrogen have already been discussed.

Present practice at NWR is to use both HF and hydrogen at a mole ratio of two and one-half to one of the solid phase. These quantities are also recommended for FNE.

In the description of HF flow control, mention is made of pressure transmitters at the inlet and outlet of the three green salt reactors. This is primarily a safety consideration. The pressure recorder-controller should be set at about two psig. Excessive pressure on the instrument will usually indicate a plugged reaction tube.

The frequency of sampling of the material as it passes through the system will be determined by the operator. Sampling during initial operations will take place more frequently in order to obtain data which will aid in determining optimum operating conditions. Current NWR practice is to complete the cost of reaction in the first half reduction tube, increase the
conversion to 90 per cent in the second tube; and reach 95 per cent or better
conversion in the third tube.

The mobile orange oxide hoppers contain material enough for approxi-

dately 64 hours operation of one bank at design rate. They will, therefore,

be replaced about twice each week.

The Adams filter, SA-709, will blow down when the pressure drop

exceeds 15 inches of water. The procedure for blowing down the

filter is as follows:

1. Shut off IF flow to the reactors.

2. Close the inlet of the filter and the Genco valve in the 10-inch

diameter riser.

3. Check nitrogen pressure in the bump tank, Pb-71. It should be

about 25 psig.

4. Open the valve between the bump tank and the filter rapidly and

then close.

5. Vent the gaseous contents of the filter to the low pressure

scrubber.

6. Close the vent line and open the outlet line and the Genco valve.

The dust which was blown off the tubes will fall back to the first green salt

reactor.

7. Reestablish IF flow.

**Normal Shutdown**

The estimated time to perform the following operations if five hours.

1. Turn off the vibrators and screw on the mobile hopper and the

level sensors in the orange box and on the Pb-103. Shut the Genco valve
on the mobile hopper.

2. Turn off the main screw in the reduction furnace.


4. Reduce the temperature setting to 600° F.

5. When the brown oxide seal hopper, Ph-105, stops discharging, shut off its level controls and the steam-water valve.

6. When green salt stops discharging from the first reactor shut off the main screw and reduce the temperature setting to 600° F. Periodic sampling will indicate when the discharge stops.

7. Reduce HF flow to one-half normal.

8. Shutdown the second green salt reactor in a similar manner when the discharge from it stops.

9. Reduce the HF flow to one-quarter normal.

10. When the green salt seal hopper, Ph-107, stops discharging, shut off its level controls and the cooling screw, Ch-110, and shutdown the reactor as above. Shut off the jacket water and nitrogen sweep to the cooling screw.

11. Close the outlet on the Adams filter to the recovery system and open the vent to the low pressure scrubber.

12. Shut off HF flow and purge with nitrogen. A small nitrogen flow should be maintained through the reactors.

13. Shut off the steam to the Adams filter. The filter is not blown down until after operation is resumed. If the filter is blown down with the screw stopped, the accumulation of solid material in the reaction tube would cause excessive torque when the screw is restarted.
Emergency Shutdown

1. Shut off the power to the main screws and reactor heating elements. The NH flow will be taken care of by the operator in the NF area; see Section 5-3:04. Failure of power to the flame controller will shut off the hydrogen flow and purge the reactor with nitrogen.
SECTION 5-3-03

AMMONIA DISSOCIATION AND NITROGEN GENERATION

INTRODUCTION

The function of this auxiliary system is to provide hydrogen gas for use as a reducing agent in the reduction of the orange oxide \(\text{UO}_2\) to the brown oxide \(\text{UO}_3\). Nitrogen gas is also generated in this area and is used for purging and sealing purposes in the process.

PLANT DESCRIPTION

Liquid ammonia is piped from storage tanks to a parallel bank of eight dissociators, each rated nominally at 2,000 scfh of dissociated ammonia. The vapor pressure of ammonia is used in transferring it from the storage tanks to the dissociators. Six of these units are necessary to produce hydrogen for maximum capacity of the plant, the remaining units are available as spares. Under normal operating conditions, a catalyst life of from 1½ to 3 years is anticipated, based on the vendor's data.

The liquid ammonia feed is vaporized before it enters the dissociators by exchanging heat with the hot effluent gases (nitrogen and hydrogen) from the dissociator. The vapor passes upward through a fixed catalyst bed and is decomposed. The catalyst chamber is electrically heated to provide the necessary heat for decomposition. The gas mixture is then used, as described in the preceding section in the reduction reaction.

Approximately 8 per cent of the nitrogen-hydrogen mixture is withdrawn to the nitrogen generator. The gas is mixed with air and burned to
remove the hydrogen, leaving a gas with a minimum nitrogen content of 99.0 per cent. Included in this product is the nitrogen from the air which is used for combustion. The wet nitrogen gas from the generator is compressed, cooled, and dried. This dry gas is then stored in two storage tanks for subsequent use in the plant, and in the metals, thorium, and reduction plants.

Ammonia Dissociation Equipment

The eight ammonia dissociators, E1-1 to E1-8, are identical. Each consists of a catalyst chamber surrounded by an insulated vessel, a vaporizer, and the necessary instruments and piping to provide proper control and operation of the unit.

The catalyst chamber is a nickel-chromium alloy vessel in which is placed a nickel catalyst. This case is enclosed in a steel cylinder which is lined with refractory brick. Heating elements are imbedded in the insulation to provide heat for the reaction. The vaporizer is mounted on the outside of the insulating cylinder and consists of a coil with a shell surrounding it. The hot effluent gases from the decomposer flow through the coil and exchange heat with liquid ammonia which flows upward in the shell. The ammonia vaporizes in the shell and flows to the bottom of the reactor. Auxiliary electric heating elements are also provided to supply the additional heat required for vaporisation and for initial vaporisation.

Each dissociator unit is provided with an individual control panel on which is mounted the controls and indicators necessary for continuous
Automatic operation. The items on each panel include the following:

1. A visual flowmeter for measuring dissociated ammonia output.
2. Four pressure gauges which indicate the pressure at the following points:
   a. Vaporizer outlet pressure
   b. Dissociator pressure
   c. Catalyst chamber outlet pressure
   d. Delivery pressure
3. An alarm bell indicating over or under temperatures in the catalyst chamber.
4. Indicating temperature controller for catalyst chamber.
5. Solenoid safety shut-off valve for power failure protection.
6. High and low pressure relief valves, vented to the atmosphere.
7. Outlet pressure reducing and regulating valve.
8. Ammonia pressure reducing and regulating valve.

Nitrogen Generation Equipment

The nitrogen generation unit, 8h-14, which is rated at 2,100 scfh, consists of a refractory lined combustion chamber with a water-jacketed shell. Auxiliary equipment includes a copper-tubed shell and tube gas cooler, a separator and trap for the removal of water of combustion, an air filter and gas strainer, a fuel gas pressure regulator, and an air pressure regulator. Air and gas flowmeters are included to measure the respective flows to the burner. Air is supplied by a blower and is mixed with the fuel gas by a nozzle mixing type burner.
Control of the composition of the generated gas is accomplished by automatic control of the fuel-air ratio by an air operated valve connected to a continuous, thermal conductivity gas analyzer. Control instruments are mounted on a panel board.

Safety equipment includes:

1. Vaporstat - A pneumatic operated electrical control which will automatically shut the unit down in the event of gas pressure failure.

2. Water flow switch - An electrical control which will shut the unit down in the event of low water flow to the combustion chamber cooling jacket.

3. Gas safety shut-off valve - An electrically operated valve which will shut off all fuel gas to the generator in the event of a power failure or through the action of the vaporstat or flow switch. Once shut off, the valve must be manually reset.

4. A relief valve to bleed generated gas to the atmosphere in the event the flow from the generator is decreased below 50% of capacity by decreased use downstream. This prevents dangerous back pressure being transmitted back through the system to the burners.

5. A flame detecting (protectoglow) system for the furnace.

The effluent gas from the combustion chamber is cooled in the shell and tube heat exchanger and compressed, using a single stage, double acting, horizontal, straight line, water-cooled compressor, 64-15. The compressor
is designed to compress 2,100 scfh of nitrogen gas from atmospheric to 50 psig. The hot compressed gas is cooled in an aftercooler and part of the water of combustion removed from it in a cyclone type moisture separator. Residual moisture is removed in a dual tower, adsorptive drier, CA-16, which dries the gas to a dew point not greater than minus 40°F.

One tower of the two is in operation at a time, while the desiccant in the other is being reactivated by electric heating. All operations, including tower reversals, are controlled by a program timer making operation fully automatic. An adsorptive prefilter is installed immediately preceding the drier to insure that the outlet gas stream is free of all liquid carry-over, oil vapors, scale, etc., which would contaminate the desiccant bed.

The dried nitrogen gas is stored in two 11,300-gallon carbon steel tanks, Fl-2 and Fl-3, under 50 psig, for further use.

**SPECFICATIONS**

Hazards from radioactivity do not exist in this area. The systems in the area are closed and therefore, under normal operating conditions no contact will be made with any process materials. Operating personnel should, however, exercise normal care and good judgement in operating the equipment.

Since mixtures of hydrogen and air are explosive in proportions of 4.1 per cent to 74.2 per cent hydrogen, leakage of hydrogen from the dissociators or associated piping would produce a very dangerous situation.
As a precaution, a continuous gas analyzer has been installed in the room. In the event that the hydrogen concentration approaches the critical value, an alarm will sound and an emergency exhauster will be started automatically. When the critical value is reached, all power in the area will be automatically shut off with the exception of emergency lighting and the exhauster motor which is explosion-proof.

Leakage of ammonia from the equipment produces danger of asphyxiation. Should an ammonia leak develop, the emergency exhauster should be started manually and the room evacuated immediately.

OPERATING INSTRUCTIONS

Start-up from an Empty System

Ammonia Dissociators

1. Before the initial start-up, a prolonged heating period will be required to drive residual moisture from the refractory casing. The cover will be open during this period. The temperature should be held at 600°F. for about two days and then raised slowly to 1750°F. during a three-day period.

   Turn on the main power control switch and the heating control switch on the dissociator panel. Set the temperature controller to 1000°F.

2. When the temperature reaches 1000°F., raise it in increments of 150°F. each 45 minutes until the operating temperature of 1750°F. is reached.

3. Turn on the switch for heating the vaporizer. A heating period of at least 15 minutes is required to bring the vaporizer to temperature before any ammonia is admitted to the unit. Vent valves for the dis-
sociator will be open during this heating up period.

4. The ammonia in the storage tanks will be under its own vapor pressure, vis. 150 to 170 psig. A pressure control valve reduces the liquid ammonia pressure at the header to approximately 50 psig.

5. After the tank valve and header valves are opened, open the liquid ammonia inlet valve to the vapors. The flow indicator will be bypassed until flow is established.

6. Dissociated ammonia is now ready for use in the reduction furnaces.

**Nitrogen Generator**

1. Start the jacket water and the gas analyzer. The air blower cannot be started unless water is flowing.

2. Start the air blower.

3. Manually open the main gas valve, which admits gas up to the solenoid gas safety shut-off valve. Open the valves on the pilot lines to the burner.

4. To insure complete purging of the system a time-delay (approximately five minutes) is provided before the protectoglow system may be started. After the time-delay has timed out, manually start the protectoglow and open the solenoid gas safety shut-off valve. The start button actuates a spark plug for ignition. Both the protectoglow starter and the solenoid valve must be held open until flame is established. Air and fuel gas proportionators will automatically fix the proper ratio of the two. Signal lights will indicate whether the flame has been established or not;
Normal Operation

Ammonia Dissociators

These units will operate automatically on the instruments provided.

The pressure gauges on the control panel will show the following approximate pressures during normal operations:

- Vaporizer outlet pressure: 50 psig.
- Dissociator pressure: 15 psig.
- Catalyst chamber outlet pressure: 15 psig.
- Delivery pressure: 5 psig.

Nitrogen Generator

This unit will operate automatically on the instruments provided.

The drier, 0h-16, will also operate automatically. The expected life of the desiccant, based on normal operation and elimination of foreign material, is approximately three years. It is recommended that the top of the desiccant bed be sampled at six-month intervals. If the sample is dark brown or black in color or indicates a gummy condition, the desiccant should be replaced. Light brown or slight discoloration, however, does not indicate need for replacement.

Normal Shutdown

Ammonia Dissociators

1. When the reduction furnace has stopped, the liquid inlet to the vaporizer may be closed.

2. Turn off the vaporizer switch, control switch, and main power switch.
a red light indicates no flame, while indicates that flame has been established. After 65 seconds, the safe-start network will automatically open the circuit on the protec-toglow relay if flame is not established. The protec-toglow relay must be reset manually. When flame is established, gas will be flowing through the moisture separator and will be analyzed continuously. A sample is then sent to the gas analyzer and the composition is sent to the following specifications:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>0.25 to 1.0%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.0%</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>0.0%</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Nitrogen and other inert gases Balance

the gas analyzer will open a valve which feeds the drier and storage tanks.

6. Start the cooling water on the compressor, Ch-15, and aftercooler and start the compressor. Energize the control and power circuits of the drier, Ch-16.

6. Nitrogen gas will now be dried and stored in the nitrogen storage tanks, Pr-2 and Pr-3.

Start up from a Full System

Amonia Dissociators

This procedure will be identical with start up from an empty system, except that the dissociator will be up to operating temperature.

Nitrogen Generator

This procedure will be identical with start up from an empty system, except that the gas analyzer will be on and warm.
3. Close the liquid header valve on the upstream side of the pressure control valve.

**Nitrogen Generator**

1. Shut off the compressor and cooling water. Gas will now vent through the relief valve to atmosphere.

2. Close the main gas valve.

3. After the unit has cooled, shut off the jacket water. This will automatically shut off the blower.

4. Shut off the gas analyzer.

5. Re-energize the dryer circuits.

**Hydrogen Drying**

**Ammonia Drying**

1. Shut the outlet of the storage tank.

2. Open the main power switch.

**Nitrogen Generator**

1. Shut off the main gas control valve. The low pressure switch will automatically shut the compressor off.
SECTION 5-3:04

HF VAPORIZING AND RECOVERY

INTRODUCTION

The primary function of this auxiliary system is to provide gaseous hydrofluoric acid for use in hydrofluorinating brown oxide (UO_2) to green salt (UF_4) according to the following equation:

\[ \text{UO}_2 + 4\text{HF} \rightarrow \text{UF}_4 + 2\text{H}_2\text{O} \]

In practice, an excess quantity of HF, to the extent of two and one half times the stoichiometric amount needed for the above reaction, is used for the conversion. The recovery of this excess as 70 per cent HF for resale and as AHF for recycle also constitutes an important function of the process in this area.

PROCESS DESCRIPTION

Liquid anhydrous hydrofluoric acid (AHF) is piped from tank farm storage to three parallel vaporizers. Two units are necessary for maximum capacity of the plant; the third is available as a spare. Air pressure on the storage tanks is used to transport the liquid. HF gas associates as its temperature is decreased. Therefore, in order to produce the monomer, gaseous HF from the vaporizers is superheated to approximately 220°F. The hot HF vapor is piped to twelve flow control stations from which it is fed to the appropriate green salt reactors.

The effluent gas from the reactors contains excess HF, water of reaction, nitrogen inleakage from sealing and purging, and entrained dust. The solid material is removed by filtration (see Section 5-3:02) and the wet gas is sent to the HF recovery system.
A partial condenser produces 70% aqueous HF from the wet gas by preferential condensation. This solution flows to a vapor-liquid disengager from which AHF is withdrawn as a vapor and the 70% solution flows to two rundown tanks through a seal leg. It is possible to adjust the concentration of HF to 70% per cent by addition of either water or AHF should such adjustment be necessary. The 70% per cent HF is transferred to storage in the tank farm and subsequently sold.

The vented HF vapor from the disengager flows to a final condenser where it is liquified. The nitrogen and uncondensed HF are vented to the scrubbing area. The AHF is collected in two rundown tanks from which it is blown to the tank farm and recycled.

**EQUIPMENT DESCRIPTION**

**HF Vaporizing**

The liquid HF from the tank farm enters the three vaporizers, Fk-78 to 80, which are steam-jacketed carbon steel vessels having a capacity of 250 gallons each. The jackets are heated using ten psig steam. The vaporization rate is controlled by the downstream demands for HF. If the demand is decreased, the increased back pressure in the vessel forces the liquid level down, decreasing the heat transfer area, and thus the vaporization rate. Conversely, should the demand increase, the liquid level rises and more vapor is produced due to the increased heat transfer area. Each vaporizer is equipped with an emergency vent system which consists of two parallel lines connected to a single outlet in the head of the vessel. Both lines are fitted with rupture disks and relief valves. A hand transfer valve joins the two lines with the vessel outlet. In the event that either
rupture disk fails, the valve is set manually so as to route the vent gases to the second line while the first is being repaired.

The vaporized HF is collected in a common header and flows to two superheaters, H-6 and 7, in parallel. In the feed lines to the superheaters, there are two ball check valves, Gv-20 and 31, which permit the gas to pass but stop liquid should the level in the tank be too high. The superheaters are shell and tube type exchangers having Monel tubes and a steel shell. The superheaters are designed to heat the HF from 82°F to 220°F using superheated steam on the shell side. The outlet pressure on each exchanger is controlled by a pressure recorder controller, PRCh-13 and 14. All lines between the superheaters and green salt reactors are steam traced to prevent the HF from cooling and reassociating.

**HF Recovery**

The dust laden gases, after passing through a porous carbon filter, are passed through a similar polishing filter and then through a Monel hair filter. There are two polishing filters, Qu-501 and Qu-503, and two hair filters, Fh-121 and Fh-120. One polishing and one hair filter in series process the effluent from one side of the plant or from six banks of reactors, while the other polishing filter serves the other six banks of reactors.

The polishing filters are constructed of Monel and contain 168 square feet of filtering area in a 48-inch diameter shell. The filter medium is porous carbon tubes. The jacket is steam heated using 100 psig steam.

The hair filter consists of Monel hair pads contained in a Monel box approximately 20 inches square. The unit is inserted in the line to remove any carbon particles from the other filters.
The filtered gas from the green salt reactors, containing approximately 3 per cent \( N_2 \), 18 per cent water, and the remainder \( HF \), are piped to the partial condenser, Et-8, through a steam traced line. The condenser is of the shell and tube type having three shells in series. The shells are carbon steel, the tubes are fine silver, and the tube sheets are silver lined Monel.

The gas enters the condenser and is cooled to condense a 70 per cent aqueous solution of \( HF \) in equilibrium with \( HF \) vapor. The temperature of the outlet stream is controlled at 143°F by a temperature recorder controller which regulates the rate of flow of the tempered water flowing on the shell side.

The cooling water for the partial condenser is recycled continuously by pumps, Qt-23 or Qt-24. It is cooled from approximately 193°F to 143°F or less by passing through the shell of a shell and tube, carbon steel exchanger, Et-9. The cooling medium on the tube side is water. The rate of flow of this cooling water is controlled by a temperature recorder controller on the outlet tempered water side. A 600-gallon, carbon steel surge tank, Ph-19, is also provided in the tempered water system. A level controller on this tank regulates the rate of make-up water to the system.

The liquid-gas stream flows from the partial condenser to a separator, Ph-81. This is a 425-gallon Monel vessel with a carbon steel jacket. Jacket cooling water is withdrawn from the cooled tempered water stream and flows back to the surge tank. The flow through the jacket is controlled manually.

The liquid in the separator flows from the bottom through a seal leg
to either one of two 70 per cent HF rundown tanks, FU-13 and FU-14. The pipe from the separator is water jacketed to cool the 70 per cent HF to below 100°F. Each rundown tank is a 625-gallon, agitated, Monel vessel with a water cooled carbon steel jacket. These tanks are vented to the scrubbing area and are also supplied with an emergency vent system like that described previously on the vaporizers. Provision is made for sampling the acid through an outlet in the head of the vessel. The liquid is expelled by air pressure. Should the concentration vary from 70 per cent HF, two storage-weigh tanks are provided; one containing AHF, FU-17, and the other containing water, FU-18. The AHF vessel is a 45-gallon carbon steel tank which is filled from the tank farm. The water tank is carbon steel and has a capacity of 40 gallons. The 70 per cent HF is periodically blown to tank farm storage with air pressure after the rundown tank is filled and sampled.

The HF vapor from the separator flows to the final condenser, Eh-10. This is a vertical shell and tube type exchanger having Monel tubes and shell. The HF vapor enters the tubes at 145°F, is cooled to -30°F, condensed, and the noncondensables (nitrogen and uncondensed HF) are vented to the scrubbing area. Freon 22 is used as a coolant on the shell side which is flooded. The Freon 22 is maintained at -40°F by a 50 ton, two stage refrigeration unit, Oh-19. The Freon level in the shell is controlled by a level controller, LCh-82, which regulates a valve in the inlet stream.

The liquid anhydrous HF at -30°F flows to either one of two rundown tanks, Fu-15 and 16. Each is a 625-gallon carbon steel vessel and is equipped with a venting system like that on the 70 per cent HF rundown tanks. The liquid HF that accumulates in these tanks is blown back to the
tank farm by air pressure.

SAFETY

Hazards from radiation do not exist in this area but HF, both anhydrous and aqueous, is an extremely corrosive liquid and considerable caution is necessary in handling it (see Section 5-3:01, "SAFETY").

In the event of equipment failure in the vaporizers, the AHF rundown tanks, or the 70 per cent rundown tanks, the contents of the leaking tank may be dumped into a 625-gallon carbon steel blow-back tank, PH-111. When the equipment has been repaired, the blow-back tank may be pressurized with air and its contents returned to storage.

OPERATING INSTRUCTIONS

Startup From An Empty System

HF Vaporising

1. A pressure of about 20 psig. should be on the AHF storage tank which is to be used. Should the vapor pressure of the AHF be insufficient to supply this, dry air will be used to pressurize the tank.

2. Admit steam to the vaporizer jackets and superheater. Check the steam tracers on all AHF and 70 per cent lines.

3. Put into service the pressure recorder-controllers, PRCh-13 & 1h, at the superheater outlet.

4. The inlet valve to the vaporizer(s) to be used may be slowly opened wide when the furnace operator gives notification that he is ready to receive HF. The flow of HF will be controlled by the furnace operator.

HF Recovery

Before any HF is brought in from the green salt reactors, the jacket
steam for the Adams polishing filter should be on, the tempered water system for the partial condenser and separator, and the refrigeration system for the total condenser must be operating properly. Detailed operating instructions for the refrigeration system are included in Section 5-2 of Part II of the specifications.

1. Fill the tempered water surge tank, Ph-19, until the level controller, LCh-9, shuts off the flow.

2. Sparge with steam until the temperature in the tank is 150° to 160°F.

3. Start the recirculating pump, either Oh-23 or 2h, and put the temperature recorder controller, TMC4-21h, into service. This instrument controls the cooling water rate in the tempered water cooler, Eh-9.

4. Divert part of the tempered water stream to the HF separator, Ph-5l, by opening the throttle valve, HUV4-7. This flow should be regulated so that a temperature of approximately 143°F is maintained in the separator.

5. The jacket cooling water to the 70 per cent rundown tank that is to be used, either Ph-13 or 14, should be started to maintain as low a temperature as possible in the tank. Start cooling water in the pipe jacket between the separator and the rundown tank.

6. Check to see if the high and low pressure scrubbers are operating satisfactorily.

7. Open the vents on the AHF and the 70 per cent HF rundown tanks to the high pressure scrubber and the vent on the final condenser to the low pressure scrubbers.

8. HF may now be admitted from the reactors. Place in service the
temperature recorder-controller, TRCh-215, which controls the tempered water rate to the partial condenser and the level controller, LCh-82, which controls the rate of flow of Freon 22 from the refrigeration system.

**Startup From A Full System**

**H Vaporizing**

This procedure is identical to that under Startup from Empty System.

**H Recovery**

This procedure is identical to that under Startup from Empty System except that the tempered water surge tank will already be charged.

**Normal Operation**

**H Vaporizing**

This system will operate essentially automatically on the instruments provided. The pressure recorder-controllers, PReCh-13 and 14, and the temperature recorders, TR-212 and 213, on the outlet superheaters streams are mounted on the HF recovery panel. Pressure at these points will be approximately 5 psig.

**H Recovery**

This system will operate essentially automatically except for periodically emptying the 70 per cent and anhydrous HF rundown tanks as they fill. Each of these tanks are equipped with annunciator level indicators which may be set to any desired level. When this level is reached, flow is manually transferred to the empty tank. The 70 per cent acid must be sampled before the tanks are blown down and their contents transferred to storage.

Should the concentration of HF in the aqueous acid be above or below
the 70.0 to 70.5 per cent specification, the concentration will be adjusted with either AHF or water from the storage-weigh tanks described previously. The weight indicators, WI-80 and 81, on the AHF and water tanks, respectively, indicate the weight of either that has been added to correct the concentration.

Before sampling the tanks, the agitators must be operated for a brief period to insure adequate mixing. The agitator should be left running during any addition of AHF or water that may be necessary. The addition should take place slowly so that any heat of solution may be dissipated safely.

The temperature recorder-controller, TRCh-215, on the tempered water outlet of the partial condenser and TRCh-214 on the cooling water outlet of the tempered water cooler are mounted on the HF recovery panel. Also mounted on this panel are a 24-point push-button temperature indicator and a 27-point annunciator which register control points in both the HF vaporizing and AHF recovery systems.

The polishing filter will be emptied through the bottom periodically as required. Also, the hair filters should be inspected periodically and cleaned when necessary.

Normal Shutdown

HF Vaporizing

The flow of HF will be gradually reduced by the furnace operator who will give notification in sufficient time for the necessary operations to be performed. As the flow is reduced, the level in the vaporizer will be forced down; when no flow is indicated on the flowmeters, the following
operations may be performed:

1. Close the inlet valve to the vaporizer; turn off the jacket steam.
2. Close the valve at the storage tank.

**HF Recovery**

None of the recovery system will be shut down until the HF flow to the reactors has been shut off and the exhaust gases from the reactors have been diverted to the scrubbing area.

1. Turn off the tempered water recirculating pump, G1-23 or G1-24, but leave water on the jacket of the 70 per cent rundown tank to prevent any acid which it contains from heating up.
2. Blow the contents of the AHF and 70 per cent rundown tanks to storage after sampling and adjusting the concentration.
3. Shutdown the refrigeration system.

**Emergency Shutdown**

**HF Vaporizing**

1. Shut off the AHF inlet valve to the vaporizer and turn off the steam to the jacket.
2. Shut off the outlet valve of the storage tank.
3. Open the nitrogen purge valves in the HF lines to the reactors.

**HF Recovery**

The recovery system will not be shut down.
SECTION 5-3:05
VENT GAS GATHERING AND NEUTRALIZING

INTRODUCTION

The function of this system is to gather all vent gases containing HF, neutralise the HF by caustic scrubbing, and recover any solids the vent streams may contain. These operations are necessary to reduce air pollution and to retain any uranium that is present in these gases.

PROCESS DESCRIPTION

The following pieces of equipment are vented to the scrubbing area:

1. AHF and 70% storage tanks in the tank farm.
2. AHF Vaporizer safety vents.
3. Feed lines to the reactors through relief valves.
5. AHF and 70% rundown tanks.
6. Final condenser.
7. AHF make up weigh tank.
8. Cooling screws.

The vent streams from the above listed sources may be divided into two classes, solids-free streams and streams containing entrained dust. The latter class originate at the reactors and Adams filters.

A spray tower type scrubber (high pressure scrubber) is provided to scrub the solids-free streams, while an ejector type unit (low pressure
scrubber) is used to handle the contaminated streams. A 45 per cent solution of KOH in water is used as the neutralizing agent in both cases.

The final condenser is vented to the low pressure scrubber as a precaution against a back pressure being transmitted to the condenser. Also, to provide for flexibility of operation, both the AHF and 70% rundown tanks may be vented to either of the scrubbers, although they will ordinarily operate with the high pressure unit.

The slurry from the low pressure scrubber is filtered in a leaf filter. The filtrate is discharged to the general sump, while the filter cake is sluiced off the leaves and partially dried in a batch centrifuge. The wet solids are packaged in 30-gallon drums and sent to the scrap plant.

**EQUIPMENT DESCRIPTION**

The high pressure scrubber, DH-51, is a Monel tower, 12 ft. 6 in. high, 3 ft. in diameter, equipped with seven nozzles in a vertical line up the side of the tower. Each nozzle is designed to spray 21 gallons per minute of 45 per cent KOH solution. The HF laden gases enter the tower at the bottom and contact the caustic sprays. The scrubbed gases are vented to the atmosphere.

The caustic solution discharges into the KOH recirculating tank, DH-20, which is located directly beneath the scrubber. This tank is a 1485-gallon carbon steel vessel. The caustic solution is recycled continuously by pump, DH-25 or DH-32, until the KOH concentration is below 0.3 lb./gallon.
The two low pressure scrubbers, Glh-33 and Glh-13, are connected in series and are Monel ejectors. The KOH solution is used in place of water to produce suction. A 75-gallon Monel tail tank, Fh-22 and Fh-6, is attached to each scrubber. The scrubbed gases are vented to the atmosphere while the caustic solution is discharged to an agitated 1875-gallon, carbon-steel KOH recirculation tank, Fh-82. The KOH solution is recycled continuously, until spent, by pumps Glh-37, Glh-26, or Glh-27.

The spent caustic stream is pumped by pumps, Glh-26 or Glh-27, to an agitated, 2700-gallon, carbon-steel sump tank, Fh-23. Slurry from the floor sumps is also discharged to this vessel with a 1000 gph steam ejector, Glh-599, using 100 psig steam.

The contents of the sump tank is pumped by Glh-38 to a vertical leaf type pressure filter, Glh-39. The filter body is a 244-gallon carbon-steel tank. The leaves are covered with nylon duck and are backed with stainless steel mesh. The total filtering area is approximately 122 square feet. The filtrate may be recycled to the sump tank or discharged to a 2450-gallon carbon-steel filtrate hold-up tank, Fh-24, from which it is pumped to the general sump through the contaminated sewer by pump Glh-l2.

Periodically, the filter cake must be sluiced off the leaves. A sluicing header in the filter directs jets of water to the filter leaves to wash the cake off. Pump, Glh-h0, is provided to supply water to the header at a minimum pressure of 60 psig.

As the filter cake is removed from the leaves, it drops to an agitated, 1100-gallon, carbon-steel slurry tank, Fh-83, where it is slurried and pumped by Glh-h1 to a batch centrifuge, Glh-hh, where excess water is removed.
A 120-gallon, carbon-steel slug tank, Fl-26, situated directly above the centrifuge receives the slurry. The basket of the centrifuge has sufficient capacity to hold the accumulated solids from several slugs. After about six slugs have been centrifuged, the cake is scraped from the basket and dropped through a chute, OL-45, from which the 30-gallon drums are filled and subsequently sent to the scrap plant. The filtrate from the centrifuge is recycled to the sump tank. Thief samples will be taken of the filled drums, and the drums will be weighed on the floor scale, WI4-75, before shipment of the cake to the scrap plant.

SAFETY

Radiation in this area is slight and confined mostly to cake handling. Continued exposure may prove hazardous and may be determined by exposure meter readings from patch badges worn by the operators.

Handling of KOH and solutions of KOH is a common industrial hazard and is covered by various safety codes.

OPERATING INSTRUCTIONS

Startup from an Empty System

It is necessary before starting the scrubbers to charge the 45% KOH solution to the KOH makeup tank, Fl-21, and charge the recirculation tanks on both scrubbers. The makeup tank should be kept full of fresh solution. (The makeup tank is provided for handling solid KOH.) Liquid level indicators on the recirculation tanks will indicate when the proper amount has been charged. If solid (flake) KOH is used, the caustic solution is made up by adding flake KOH to water in the makeup tank with agitation.
1. Start the agitators in both the high and low pressure scrubber recirculation tanks.

2. Start the proper pumps to recirculate the caustic solution. The scrubbers are now in operation and vent gases may be admitted.

**Startup from a Full System**

This procedure is identical with that outlined above except that the recirculation tanks are already full.

**Normal Operation**

The equipment in the scrubbing area will be operating at all times during plant operation and will be placed in service before any other operations are undertaken.

Each nozzle on the high pressure scrubber is equipped with a flow indicator. Two alarms, one for the top four nozzles and one for the bottom three, are provided. The alarm will sound in the event that flow is stopped in any nozzle and a signal light will appear on the HF recovery annunciator panel.

The recirculating KOH solution is periodically sampled, and when the concentration of KOH reaches 0.30 pounds per gallon, the solution must be replaced. The spent caustic from the high pressure scrubber is discharged to the sewer by pump, 04-42, while that from the low pressure scrubber is pumped to the sump tank, F4-23, where it is mixed with sump liquor. The agitator in the sump tank, F4-23, should be on whenever there is liquid in the tank. The contents of the sump tank should be alkaline. If such is not
the case, enough caustic solution should be added from the low pressure scrubber system so that the solution is alkaline to litmus paper.

The following is the sequence of operations to be performed in operating the filter and centrifuges:

1. Line up the flow so that slurry in the sump tank may be pumped to the filter and the filtrate recycled to the sump tank.
2. Turn on pump Qh-30, and continue to recycle the filtrate until it is absolutely clear. When clear, the filtrate may be pumped to the filtrate hold-up tank. If the filtrate does not clear in a reasonable time, filter aid may be added to the sump tank.
3. When the filtrate stops flowing, shut down the pump and drop the liquid in the filter tank into the slurry tank.
4. Start pump, Qh-40, and sluice the cake off with water. The cake will also drop to the slurry tank.
5. When the sluicing operation is complete, the filtration cycle may be repeated.
6. When the contents of the slurry tank are reslurried with the agitator, start the slurry pump, Qh-41, and recycle the slurry between the slurry tank and the slug tank.
7. Check to see that the unloading plow is in the uppermost position and that the skimmer is away from the centrifuge basket.
8. With the basket revolving at "slow" speed, slowly feed slurry to the basket.
9. When the basket is full, stop the feed and increase the speed to "fast".
10. When maximum speed is reached, skim off the water level in
the basket. This liquid will be recycled to the sump tank
together with filtrate from the basket.
11. Repeat the above operations until the basket is loaded.
12. Operate at high speed for approximately ten minutes, then
stop the basket and plow out the cake with the basket re-
volving at slow speed.
13. The cake will fall through the centrifuge discharge chute and
into a 30-gallon drum.

Normal Shutdown

The scrubbing area will remain in operation until all other units
have been completely shut down, and the facilities are no longer required.
1. Clean out the centrifuge.
2. Shut down the pumps and agitators that are in operation.

Emergency Shutdown

1. The equipment in this area will remain in operation.
   The pumps and agitators in the area may be operated from an
   emergency power system should the normal power fail.
SECTION 5-3106
DUST COLLECTION

INTRODUCTION

This section of the manual describes the functions and operation of exhaust ventilation equipment and components thereof.

The proper and efficient operation of this equipment has a direct bearing on:

1. The maintenance of a safe and clean working atmosphere
2. The maintenance of uninterrupted production

Equipment covered in this section embraces local and general exhaust ventilation, including vacuum cleaning and vacuum conveying from this equipment.

PROCESS DESCRIPTION

Local ventilation as pertinent to the general operation of the plant is carried out by the following general methods:

(a) Exhaust ventilation of dust producing operations at the source by ductwork connections to Hersey type dust collectors. Filtered air from the collectors is, in all cases, exhausted to the outside.

(b) Special vacuum cleaning of equipment for the purpose of collecting valuable materials when equipment is shut down for repairs or any other purpose.

(c) Regular vacuum cleaning of dust, spillage and accumulations occurring during operations.
(d) Pneumatic conveying of collected dust and dry materials
from dust collector hoppers to the vacuum cleaners

(e) Ventilation of production equipment for the removal of
heat and fumes.

EQUIPMENT DESCRIPTION

Dust Collectors

All of the dry dust collectors, Dk-2, Dk-3, Dk-4, Dk-5 and Dk-7, are
of the Harvesy type and have virgin-wool hard-pressed felt filter bags, the
quantity of which is indicated below under the individual collector descrip-
tion. Each individual bag is surrounded by one blow-ring, there being
several blow-rings mounted in a single carriage. The blow-rings in these
units travel up and down the bags, blowing air through the felt bags from a
circumferential slot in the inner periphery of each ring on the downward
stroke only. Source of cleaning air is one or two (depending on the size of
the collector) positive displacement air pumps, complete with motor and V-belt
drive. Each air pump is equipped with an oil-bath type filter on the inlet.
The blow-rings are driven up and down by a chain and sprocket arrangement con-
nected to a 37 hp motor mounted outside the collector housing. Rotation of
the drive motor is reversed by a limit switch when the blow-ring carriage
approaches its upper and lower limits of travel. The limits of reversal can
be adjusted by resetting the stops on the limit switch tripping cable. The
blow-ring carriages in these units are counterweighted, either by reverse
travel of adjacent carriages or by means of suitable suspended weights.

Each dust collector includes an exhauster, the size and capacity of
which is indicated under the individual description of each collector.
Those collectors which handle uncontaminated dust have all surfaces that come in contact with the dust fabricated of Monel or stainless steel. One or more storage hoppers are provided in each collector. Large access doors are located on each of two sides of the collectors, top and bottom, for easy access, and maintenance of filter bags and integral mechanical components. Light sockets are provided within the housing for illumination of the interior. Transparent inspection ports are provided for observation of internal operation during usage.

Each hopper of all dust collectors except G4-2, is fitted with a rotary air-lock valve and equipped with a 1/4 hp. drive motor. Item G4-2 is equipped with a manually operated air-swept valve.

Each collector is provided with the following instrumentation:
(a) Differential pressure recorder (0-10 inches water gauge range) to indicate differential pressure across the filter bags.
(b) Temperature recorder and temperature controller for inlet plenum temperature - on Item G4-3 only.
(c) Dust density indicator located in exhaust stack to detect escape of any dust through the filter.
(d) Push-button starters on the control panel, with a selector switch to enable control of any motor if necessary for maintenance or testing.
(e) Various operational limit switches, blast-gate limit switches, etc.

**Dust Collector, G4-2, for Contaminated Green Salt**
Collects dust from - housings around pulverizers, G4-567 & G4-568,
packaging enclosures, Qk-589, Qk-590, Qk-659 & Qk-735, drum dumper, Qk-805, and discharge from vacuum producer, Qk-663.

Collected dust is discharged to the vacuum collector, Qk-ll

Bags - Quantity - 12, Size - 18 in. diameter x 14 in. long.

Hoppers - Quantity - 2, Capacity-18 cubic feet each.

Air blower motor - 7 1/2 H.P., 1800 RPM

Blowing drive motor - 3/4 H.P., 37 RPM

Exhauster motor - 25 H.P., 1800 RPM

Operating capacity - 6800 CFM

Material of construction - Mild steel

Dust Collector, Qk-3, for Uncontaminated Orange and Brown Oxide

Collects dust from - hydrogen burners, furnace feed hoppers, bad lot storage hopper, re-run hopper and brown oxide reactor tube pulling connections.

Collected dust is discharged to the bad-lot hopper, Fh-69.

Bags - Quantity - 2h, Size - 18 in. diameter x 14 in. long.

Hoppers - Quantity - 4, Capacity - 18 cubic feet each.

Air blower - Two - each with 7 1/2 H.P., 1800 RPM motor

Blow-ring drive motors - 1 H.P., 37 RPM, Quantity - 2

Exhauster motor, 75 H.P., 1800 RPM

Operating Capacity - 14,500 CFM at 180°F.

Material of construction - Monel and stainless steel.

Dust Collector, Qk-4, for Uncontaminated Green Salt from #1 Packaging Line

Collects dust from - pulverizer, Qk-568, weigh hopper, Fh-74, blender,
Qu-570, surge hopper, Ph-75, sampler, Gl-607, and packaging unit, Gl-589.

Collected dust is discharged back into the packaging line.

Bags - Quantity - 4, Size - 18 in. dia. x 132 in. long.

Hoppers - Quantity - 1, Capacity - 12 cubic feet.

Air blower motor - 3 H.P., 1800 RPM

Blow-ring drive motor - 1/3 H.P., 37 RPM

Exhauster motor, 7/2 H.P., 1800 RPM

Operating Capacity - 1425 CFM.

Material of Construction - Monel and stainless steel.

Dust Collector, Gl-5, for Uncontaminated Green Salt from #2 Packaging Line

Collects dust from - pulverizer, Gl-567, weigh hopper, Ph-95, blender, Gl-569, sampler, Gl-607, and packaging units, Gl-590 and Gl-659, and drum dumper, Gl-605.

Collected dust is discharged back into the packaging line.

Bags - Quantity - 4, Size - 18 in. dia. x 132 in. long

Hoppers - Quantity - 1, Capacity - 12 cubic feet.

Air blower motor - 3 H.P., 1800 RPM.

Blow-ring drive motor - 1/3 H.P., 37 RPM

Exhauster motor, 7/2 H.P., 1800 RPM.

Operating Capacity - 2300 CFM.

Material of construction - Monel and stainless steel.

Dust Collector, Gl-7, for Uncontaminated Green Salt from Reactors

Collects dust from the tube pulling connections on the green salt reactors and exhaust from vacuum producer, Gl-664.
Collected dust is discharged to the bad-lot hopper, FH-69.

Bags - Quantity - 12, Size - 18" dia. x 132" long.

Hoppers - Quantity - 2, Capacity - 18 cubic feet each.

Air blower motor - 7½ H.P., 1800 RPM

Blow-ring Drive Motor - 3/4 H.P., 37 RPM.

Exhauster motor - 15 H.P., 1800 RPM.

Operating Capacity - 2000 CFM.

Material of construction - Monel and stainless steel.

Vacuum Cleaning Equipment

All of the vacuum cleaning collectors, GL-9, GL-10, and GL-11, are of the combination type having a primary centrifugal dust separator and a secondary bag type filter contained in one housing. The lower part of the housing acts as a storage hopper. Each collector is equipped with an external device for manually shaking the bags, a manually operated device for de-bridging the material collected in the storage hoppers, and a Gemco valve for discharging the collected dust.

The collectors together with vacuum producers, GL-663 and GL-664, piping, and cleaning tools constitute a complete system. The vacuum producers are constructed of sheet metal or cast housings with multi-stage turbine type impellers of sheet or cast aluminum connected through a flexible coupling to an electric motor.

Each system is equipped with the following instrumentation:

(a) A manometer (0-12 inches of water range) on each collector to indicate differential pressure across filter bags.
(b) An open end manometer (0-12 inches of mercury range) on each vacuum producer to indicate suction vacuum.

(c) Various blast gate limit switches, etc.

**Vacuum Collecting Systems for Uncontaminated Dust**

Collector G4-9 handles dust collected from the inside of the green salt reactors (exclusive of product scale which would be grossly contaminated) and from the polishing filters, G4-803 & G4-804.

Collected G4-10 handles dust collected from the inside of the orange and brown oxide reactors, also exclusive of product scale which is grossly contaminated.

Collected dust is discharged to the bad-lot hopper, Flt-69.

Bag area - 19¾ square feet (in each collector).

Bag material - Orlon

Hopper Capacity - 25 cubic feet

Material of construction - stainless steel.

Exhauster - Item G4-664

Exhauster motor - 25 H.P., 3600 RPM.

Exhauster capacity - 300 CFM @ 10.5" Hg., or 450 CFM @ 9.7 in. Hg.

No. of conveying lines handled simultaneously - 2.

Exhausts air to collector G4-7 or to the atmosphere.

Tools furnished - Special nozzles and hose for cleaning interior of reactors.

**Vacuum Collecting System for Contaminated Dust**

Collector, G4-11, handles dust collected during general clean-up of floors, walls, product scale on inside of reactors, and machinery...
and conveying of dust collected in collector Qf-2.

Collected dust is discharged to the reject dust storage hopper, Ph-102.

Bag area - 28 1/4 square feet.
Bag material - Cotton

Hopper capacity - 30 cubic feet

Material of construction - Carbon steel

Exhauster - Item Qh-663

Exhauster motor - 30 H.P., 3600 RPM.

Exhauster capacity - 400 cfm @ 9 in. Hg.

700 cfm @ 8.3 in. Hg.

No. of conveying lines handled simultaneously - 6 - 1 1/2 in. dia. or 3-2 in. dia.

Exhausts air to collector Qh-2 or to the atmosphere.

Tools furnished - Hose, brushes and nozzles for general clean-up.

**Leak Gas Exhauster, Qh-705 and Qh-706**

These centrifugal type exhausters draw air from around the shaft glands on both ends of the green salt cooling screws, the drive end of the green salt reactors and both ends of the hydrofluorination reactors in order to exhaust any hydrogen fluoride that might leak through the glands. Each exhauster has a capacity of 3150 cfm is equipped with a 3 H.P., 1800 RPM motor. The air is exhausted to the atmosphere.

**Furnace Cooling Fans, Qh-731 and Qh-732**

These centrifugal high temperature fans exhaust air from the cooling chamber around the first zone of each green salt reactor to provide cooling.
Whenever necessary for temperature control. A temperature indicator is provided in the inlet plenum of each fan. The exhausted air is either discharged to the atmosphere or back into the building to provide supplemental heat for winter operation through diverting dampers furnished for this purpose. Each fan has a capacity of 4,950 cfm at 400°F and is equipped with a 25 H.P., 1800 RPM motor and V-belt drive.

**Cooling Air Damper, GH-802**

This damper operates in conjunction with dust collector, GH-3, to automatically provide outside air for dilution when required for cooling the air entering the collector. The damper, multi-blade, opposed acting, is fabricated of stainless steel.

**SAFETY**

Guards have been provided for all belt driven equipment. These should always be in place when equipment is operating.

The radiation from the dust which is handled is slight but continued exposure may prove hazardous and may be determined by patch badges worn by the operators.

Masks should be worn by operators and maintenance men when working in the collectors.

**OPERATING INSTRUCTIONS**

**Start-Up From an Empty System**

The dust collectors should be checked to make sure that the blow-ring mechanism operates properly. This can be done by operating the blow-ring drive motor for at least one complete up and down travel of the blow-ring carriage. After the blow-ring drive mechanism has been satisfactorily
operated, the air blower can be started to check its operation. Both the blow-ring drive motor and the air blower motor controls have selector switches that can be set to the "manual" position for the checking operation. After the checking has been completed, the selector switches should be turned to "automatic" position so as to be automatically controlled as described below.

The dust collector exhauster motors can be started by pressing one of the push-button controls provided for that purpose. Whenever the collectors have been allowed to cool down for a long period of time, the exhausters should be allowed to operate for about 30 to 60 minutes before the dust source is started in order to heat the collector and get rid of any condensation that may be in the collector.

When first operating a new collector or after the filter bags have been replaced, the pressure drop across the bags is very low (about 1 inch H$_2$O). The blast gate on the discharge of the exhauster should be partially closed to reduce the capacity of the exhauster which would be overloaded due to the higher quantity of air handled at the lower pressure. There is also danger of burning out the exhauster motor due to the overload. After the filter cake is built-up on the bags and the blow-ring mechanism is operating automatically, the blast gate should be set in its normal operating position.

The vacuum cleaning systems can be started by pushing the "start" button on the push-button controls provided for this purpose. It is advisable to close the blast gate on the inlet of the vacuum producer when starting so as to allow the starting to take place at no load conditions. Each vacuum producer discharges its air to a dust collector as noted under equipment.
description or to an exhaust stack. There is a chain operated, packed stem blast gate in the discharge duct to the collector which is normally open, and an identical blast gate in the discharge duct to the exhaust stack which is normally closed. The blast gate in the discharge stack from the dust collector exhaust is normally open. By means of electrical limit switches mounted on the blast gates, the vacuum producer cannot be started unless the blast gates are in the positions noted above and the dust collector exhaust is operating. In the case the dust collector is not operating, the vacuum producer can be started only by reversing the positions of the blast gates.

The leak gas exhausters and the furnace cooling fans are started by pushing the "Start" button on the push-button controls furnished for that purpose.

**Start-Up From a Full System**

In order to start the dust collectors after a short shutdown period or whenever the collectors are at operating temperature, it is only necessary to start the exhauster by means of the push-button and turn the blow-ring system selector switches to "Automatic" position. The collector must be in operation before the equipment they serve is started.

Vacuum systems are started as noted under "Startup From an Empty System".

The leak gas exhausters and the furnace cooling fans are started as noted under "Startup From an Empty System". These fans must be in operation when the equipment they serve is started.

**Normal Operation**

The various dust collection systems are to be run continuously as
long as the production equipment served by the collectors is operating. In all but one case, collector 6k-7, the stoppage of the collector will cause sufficiently adverse conditions that the production equipment must be manually shut down.

After the collector exhaustors have been started and blow-ring drive and air blower selector switches set in "Automatic" positions, the operation of each collector is entirely automatic. The instrumentation affects this control in the following manner:

(a) The differential pressure recorder constantly indicates and records the pressure differential across the filter bags. In addition, the recorder accomplishes the following controls and signals:

(1) The blower motor and the blow-ring drive motor are automatically started when the differential pressure across the filter bags exceeds 4.0 inches water gauge, and are stopped when the differential pressure drops below 3.0 inches water gauge.

(2) A light flashes when the differential pressure drops below 1.0 inches water gauge, thus indicating either a broken or leaking filter bag, the pressure line to the dirty dust plenum is clogged, or the exhauster is not operating. If this light flashes when the collector is new or after bags have been replaced, it is because the pressure drop across new bags before cake is built up is often less than 1 inch water gauge.

(3) A light will flash and an alarm is sounded when the differential pressure exceeds 8.0 inches water gauge, thus indicating that the bag cleaning mechanism is not operating properly.
(b) The dust density indicator detects an excess of dust in the exhaust stack and flashes a light and sounds an alarm when the maximum allowable density is exceeded. This would occur if a filter bag breaks. A temporary indication might happen after repairs are made to a collector if excess dust is not cleaned from the interior of the collector after the repairs are completed.

Blast gates are provided at all connections to the dust collection systems to allow balancing of the systems and to permit shutting off part of a system if part of the process equipment is not being operated. As a general rule, the blast gates should remain in one position after they are properly adjusted.

The storage hoppers on all collectors except the contaminated green salt dust collector, Gh-2, can be emptied by the operation of the rotary valves provided on the hopper outlets. Only one hopper on each collector should be emptied at one time. The frequency of the emptying will be better ascertained after the plant is in operation, but will probably be required at least once during each shift. It should not be necessary to shut down the collectors during the emptying operation. The rotary valves are started and stopped by using the push-button controls provided for this purpose.

The contaminated green salt dust collector, Gh-2, should be operated whenever any of the packaging equipment is in use or when the contaminated vacuum system is operating. In order to empty the storage hoppers of this collector, the collector should first be shut down and the dust then conveyed to the contaminated vacuum collector, Gh-11, through the air-swept valves provided for this purpose. During this time, the vacuum producer, Gh-663,
should discharge to the exhaust stack. The air-swept valve should be opened only far enough to cause a small flow of dust from the collector hopper to assist in conveying the dust.

The uncontaminated orange-brown oxide dust collector, C-3, should be operated whenever any of the process equipment associated with this collector is in use. In addition, to the instrumentation noted above, this collector is equipped with a temperature indicator and a temperature recording controller which indicates the temperature in the inlet plenum and accomplishes the following control to protect the filter bags:

(a) If the temperature exceeds 160°F, the cooling air damper, Q-802, is gradually open through a modulating control to provide outside air for cooling the gases exhausted from the hydrogen burners. It is calculated that a maximum of 8000 cfm of air should be drawn from this source.

(b) At a temperature of 190°F, a light will flash and an alarm is sounded to indicate excessive temperature.

(c) If the temperature exceeds 200°F, the controller automatically switches the dampers over the hydrogen burners from the dust collection position to exhaust the atmosphere. The dampers must be reset manually after the trouble is corrected.

(d) In addition to the above, if the temperature exceeds 200°F, the controller automatically shuts off the hydrogen supply and stops the process.

This collector has duct work connections to both ends of the reduction reactors for the purpose of collecting dust during the removal of a tube. Only one pair of these connections is to be used at one time. Before the blast gates on these connections are opened, the reactors should be thoroughly
purged with nitrogen and the product cooled to handling temperature in order to protect the collector filter bags.

The duct work is arranged so that there are three headers along the north and south sides of the building, one for the hydrogen burners, one for the hopper vents, and one for the tube-pulling connections. A blast gate is provided at the end of each header to allow the installation of additional reactors, or to furnish additional air for cooling or dust conveying if found necessary.

It should be noted that the header from the hydrogen burners is so arranged that a gas cooler can be installed if it is found that bag damage occurs during operation. However, before installing a gas cooler, it would be well to try filter bags made of HCE treated Orlon which will withstand higher temperatures.

The uncontaminated green salt collector, Gh-4, will operate when its associated process equipment is in use.

The uncontaminated green salt collector, Gh-5, will operate when its associated process equipment is in use. In normal operation the blast gate in the duct connection to drum dumper, Gh-805, will be closed. When the drum dumper is in use, its blast gate should be opened and the blast gates in the duct connections to the packaging units, Gh-590 and Gh-659, and the surge hoppers, Ph-97 and Ph-101, should be closed in order to provide sufficient air volume to operate the drum dumper.

The uncontaminated green salt dust collector, Gh-7, will operate when the vacuum producer, Gh-663, is in use or tube-pulling operation on the green salt reactors is taking place. There are duct work connections to
both ends of each green salt reactor for the purpose of collecting dust during the removal of a tube. Only one pair of connections is to be used at one time. Before the blast gates on these connections are opened, the reactors should be thoroughly purged with nitrogen and the product be allowed to cool to handling temperature in order to protect the collector filter bags.

The vacuum cleaning systems require the following special operational care:

(a) The filter bags should be manually shaken whenever the differential pressure indicated on the manometer exceeds 9.0 inches water gauge. The system can remain in operation during the process.

(b) The dust collected in the storage hoppers should be discharged at least once during each work shift if the system was used during that shift. Before dumping the dust, the vacuum producer should be stopped and the valve connecting the air discharge line to the associated dust collector must be closed. The dust can then be discharged by operating the Gemco valve on the bottom of the vacuum collector. The de-bridging device should be shaken if the collected material does not flow from the hopper.

(c) A mercury manometer is provided on the suction line to the vacuum producer to indicate the suction. The valve in the connection to the manometer should be closed when the instrument is not being read to prevent loss of mercury due to suction surges.

(d) Extra precautions must be taken against drawing any liquid or moist dust into a vacuum system to prevent the caking of dust in piping or collector.
The uncontaminated dust vacuum collectors, GL-9 and GL-10, together with the vacuum producer, GL-664, are to be operated only when necessary for removing product from inside the reactors. Since each collector is to be used for cleaning one type of dust, only one collector shall be used at one time. The chain operated blast-gate valves on the suction line between each collector and the vacuum producer should be closed when a collector is not being used. When cleaning the interior of a reactor, care should be taken to draw in sufficient air with the material to provide conveying velocity.

Two special hoods have been provided for use when the reactor inspection ports are opened. These hoods should be clamped around the ports before the port covers are removed and connected to a vacuum cleaner hose, so that the dust collected in the port openings will be drawn away from the ports by the vacuum system. The polishing filters, GL-803 and GL-804, are cleaned by the vacuum system in the following manner:

(a) The filters should first be purged with nitrogen.

(b) Remove the copper blind flange under the Gemco valve, GL-803 or GL-804, and attach the pipe flange to the valve.

(c) With the vacuum producer, GL-664, operating together with vacuum collector, GL-9, open the plug valve under the polishing filter to introduce air for conveying the dust.

(d) Gradually open the Gemco valve to allow the dust to fall into the air stream.

The contaminated dust vacuum systems, GL-11 and GL-663, are to be operated continuously as long as process equipment is in use. This system is to be used for general clean-up and should be available at all times for
Emergency Shutdown

All equipment will remain in operation. In case of power failure, all equipment will automatically stop, since emergency power is not supplied to any of the equipment.
SECTION 5-3107
HEATING AND VENTILATION

INTRODUCTION

This section of the manual presents the information necessary to satisfactorily operate the heating and ventilating systems in the green salt plant.

PROCEDURE INSTRUCTION

Heating and ventilation is carried out by the following general methods:

1. Combination heating and air make-up systems consisting of automatic self-cleaning air filters, non-freon type heating coils and fans which draw air from outdoors and filter, heat and distribute the air as required in the various areas.

2. Heating systems which heat recirculated air either by unit heaters consisting of steam coils and propeller type fan which circulate heated air by blowing the air over the coil, or by convectors which heat confined spaces by convection and radiation.

3. General exhaust systems consisting of fans with ductwork, propeller type fans or roof ventilators.

4. Emergency exhaust ventilation consisting of propeller fans or roof ventilators together with automatic air inlet louvre dampers.
EQUIPMENT DESCRIPTION

Specific functional areas, and their heating and ventilating equipment are as follows:

**Wpa Room**

Heating is supplied by a unit heater, Gk-762, recirculating room air only and controlled by room thermostat.

Normal ventilation is by propeller fan, Gk-793, which is controlled by a manual switch, and which will be operated constantly.

Emergency ventilation is furnished by propeller fan, Gk-794, and automatic louvre damper, Gk-795, which are operated by a hydrogen detector.

**Unit Heater, Gk-762** - Consists of 1/20 H.P. explosion proof motor, propeller fan, standard steam coil, casing and adjustable louvres. Capacity is 50,000 Btu/hr.

**Exhaust Fan, Gk-792** - Consists of 1/4 H.P. explosion proof motor, propeller fan, and frame. Capacity is 2000 CFM.

**Exhaust Fan, Gk-794** - Consists of 1 H.P. explosion proof motor, propeller fan, frame and automatic louvre damper. Capacity is 10,000 CFM.

**Louvre Damper, Gk-795** - Consists of multi-louvres and frame with provisions for automatic damper operator.

**Refrigeration Room**

Heating is supplied by a unit heater, Gk-763, recirculating room air only and controlled by room thermostat.

Ventilation for cooling air is supplied by a propeller fan, Gk-792, operated by room thermostat.
Unit Heater, Qk-763 - Consists of 1/20 H.P. motor, propeller fan, frame and automatic louvre damper. Capacity is 5,000 Btu/hr.

Exhaust Fan, Qk-792 - Consists of 1/3 H.P. motor, propeller fan, frame and automatic louvre damper. Capacity is 5,000 CFM.

Area

Make up air is supplied by a heating unit, Qk-764, and is to be operated constantly. The air is filtered, heated, and distributed to the area by ductwork and adjustable grilles. Control is by room and discharge air thermostats and modulating steam valve.

The air filter, Qk-765, is the automatic self-cleaning oil type and contains a traveling filter curtain, curtain drive and motor, oil pump and motor, oil filter cartridge and controls. Oil from the air filter sump is pumped through the oil filter removing the sludge and returned to the filter sump for re-use.

Normal ventilation is provided by an exhaust fan, Qk-767, and controlled by a manual switch. Air from the area is exhausted through grilles and duct work and discharged to the atmosphere. This system is to operate constantly.

Emergency exhaust is provided by a fan, Qk-769, together with an automatic louvre damper, Qk-774, and by a roof mounted ventilator, Qk-770, with an automatic louvre damper, Qk-773. Manual control switches located adjacent to the doorways leading to the outside stairway operate the proper exhaust fan. Both fans should not be used simultaneously.

Heating unit, Qk-764, and filter, Qk-765, constitute one system.
### Heating Unit, QH-764 -

1. Fan and motor section
   - a. 5 H.P. motor, 10,000 cfm fans.

2. Non-freeze coil

### Filter, QH-765 -

1. Filter curtain
2. Oil Filter
   - a. 1/3 H.P. motor, one cartridge
3. 1/6 H.P. motor, timer, relay, etc.

### Exhaust Fan, QH-767 - Consists of centrifugal fan with 3 H.P. motor and V-belt drive. Capacity is 10,000 cfm.

### Exhaust Fan, QH-769 - Consists of propeller fan, frame, automatic louvre damper, and 5 H.P. motor. Capacity is 30,000 cfm.

### Roof Ventilator, QH-770 - Consists of propeller fan, casing, automatic damper, and 5 H.P. motor. Capacity is 30,000 cfm.

### Louvre Damper, QH-773 - Consists of multi-louvres and frame with provisions for automatic damper operator.

### Louvre Damper, QH-774 - Consists of multi-louvres and frame with provisions for automatic damper operator.

### Stairway No. 1

Heat is furnished by convectors, QH-775, QH-776, and QH-777. Manual control is provided.

### Convectors, QH-775, QH-776 and QH-777 - Each convector is two rows high with \( \frac{1}{2} \) in. x \( \frac{1}{2} \) in. fins, 24 fins per inch, and 2 in. diameter pipe.
all steel. Item Qk-775 is 16 ft. long, and items Qk-776 and Qk-777 are 12 ft. long.

Toilet Room

Heat is provided by convectors Qk-786 and Qk-789. Manual control is provided.

Convectors, Qk-786 and Qk-787 - Each convector is two rows high with \( \frac{1}{4} \) in. x \( \frac{1}{4} \) in. fins, 24 fins per inch, and 2 in. diameter pipe, all steel. Item Qk-786 is 8 ft. long and item Qk-787 is 16 ft. long.

Office - South End

Heat is furnished by convectors, Qk-807, Qk-808 and Qk-809. Manual control is provided.

Convectors, Qk-807, Qk-808 and Qk-809 - Each convector is one row high with \( \frac{1}{4} \) in. x \( \frac{1}{4} \) in. fins, 24 fins per inch, and 2 in. diameter pipe, all steel. Item Qk-807 is 13 ft. long, item Qk-808 is 10 ft. long, and Item Qk-809 is 15 ft. long.

Electrical Vault

Ventilation for heat removal is supplied by roof exhaust fan, item Qk-796, controlled by a room thermostat.

Roof Ventilation, Qk-796 - Consists of propeller fan, casing, automatic damper, 2 H.P. motor and V-belt drive. Capacity is 13,800 cfm.

Green Salt Area

West Side

Make-up air is supplied by heating unit Qk-751, controlled by room and discharge air thermostats and modulating steam valve. The air is
filtered, heated and distributed to the area by ductwork and adjustable grilles. This system is to operate constantly.

The air filter, QU-750, is the automatic self-cleaning oil bath type and includes a traveling filter curtain, curtain drive and motor, oil pump and motor, oil filters and controls. Oil from the air filter pump is pumped through the oil filter, removing the sludge and returned to the sump for re-use. Operation is automatic.

**East Side**

Make-up air is supplied by a heating unit, QU-756, and an air filter, QU-755, identical size, operation, and control with the west side unit.

**General Area**

Two motor driven roof ventilators, QU-771 and QU-772, are to be used for general exhaust of this area. The ventilators are controlled by manual switches. It is necessary to open the dampers contained in the ventilators by pulling chains provided for this purpose before starting the ventilators.

Three vertical discharge unit heaters, QU-759, QU-750 and QU-761, are used for counteracting cold air that may enter the building when doors are opened. They are located at the northwest, southwest and southeast corners of the room, respectively. Control is by room thermostat.

Two duplex condensate return units, QU-790 and QU-791, return all condensate, other than that from convectors on the lower level of the building, to the boiler house. Each pump on each unit handles 30 GPM against a 40 lb. head. Should the load on any one unit exceed 30 GPM, the second pump automatically cuts in.
Filter, QH-750 -
(1) Filter curtain
(2) Oil filter
   a. 1/3 H.P. motor, two cartridges
(3) 1/6 H.P. motor, timer, relay, etc.

Heating Unit, QH-751 -
(1) Fan and motor section
   a. 10 H.P. motor, 22,000 cfm. fans
(2) Non-freeze coil

Filter, QH-755, and heating unit, QH-756, constitute one system.

Filter, QH-755 - Identical to QH-750.

Heating Unit, QH-756 - Identical to QH-751.

Roof Ventilators, QH-771 and QH-772 - Each consists of propeller fan, casing, bird screen, manually operated damper, and 5 H.P. motor. Capacity of each ventilator is 30,000 cfm.

Unit Heaters, QH-759, QH-760 and QH-761 - Each consists of 1/2 H.P. motor, propeller fan, standard steam coil, casing and adjustable air diffuser. Capacity of each heater is 206,000 Btu/hr.

Duplex Condensate Return Units, QH-790 and QH-791 - Each unit consists of two - two H.P. motors, two turbine pumps, two starters, two automatic selector switches, two float switches, receiver, pressure gauge, thermometer, and interconnecting wiring. Each pump handles 30 GPM against 10 psig. head.
SAFETY

Guards have been provided for all belt-driven equipment and all wall-mounted propeller fans. These should always be in place when equipment is operated.

OPERATING INSTRUCTIONS

Startup from an Empty System

All similar systems operate in the same manner, but independently of one another.

1. Set controls on condensate return unit to "Automatic" position.
2. Close all switches furnishing electric power for the motors and controls and open the air line valves for the pneumatic controls.
3. Turn on the heating units at the appropriate wall switches.
4. Turn on the unit heaters at the appropriate wall switches.
5. Turn on the exhaust fans at the appropriate wall switches.
6. Check controls on emergency exhaust fans.

Startup from a Full System

This procedure will be identical with startup from an empty system.

Normal Operation

The operation of heating units and unit heaters is entirely automatic after they are started.

Normal Shutdown

1. Shut off the main steam supply to all heating equipment.
2. Shut off the power to all ventilation equipment and the condensate return units.
Emergency Shutdown

All equipment will remain in operation except the air make up systems and general exhaust systems.
SECTION 5-3:08

INSTRUMENTATION

The main control board is two hundred and thirty six feet long and is divided into thirteen major units. Twelve of these units are identical and the remaining section is general in nature.

One of the twelve units will be described in detail and considered typical.

Bank 1 consists of five individual panels plus half of an adjacent panel. Panel CB4-1 controls the reduction furnace of Bank No. 1. On it are mounted four Leeds and Northrup temperature indicating controllers and four Leeds and Northrup DAT Relays. These instruments control the four heating zones of the furnace. In addition to controlling temperature there is a high temperature contact in each instrument. The four contacts (one per instrument) are connected in parallel so that if any zone exceeds a predetermined temperature, an alarm sounds on an annunciator located on panel CB4-5. Panel CB4-2 is similar in operation to CB4-1 and controls temperature in the first green salt furnace. Panels CB4-3 and CB4-4 control the temperatures in the second and third green salt furnaces respectively.

Panel CB4-5 has an annunciator with eighteen positions available although only twelve are used. They are suitably marked and inspection will show what field condition needs attention. The annunciator has its individual warning horn which can be silenced by operating the re-set button mounted below it. On this panel is a sixteen point temperature recorder which records temperatures by means of thermocouples attached adjacent to these thermocouples.
which actuate the indicating controllers. There is also a differential pressure recorder showing the pressure drop across the Adams filter. A flow recorder controller for hydrogen and one for HF are mounted on this panel. They record flows of the respective gases. The flow may be controlled from this instrument.

Panel CBk-6 has a duplicate set of instruments which are for use on Banks 1 and 2. The left hand half of this panel is for bank No. 1. A torque recorder, TR-423, gives an indication of the torque developed at each of the four main screws. If the torque is unusually high, an alarm sounds and if it continues to increase to a dangerously high value, the four motors will shut down. This is accomplished by interconnections between this panel and the electrical load center.

The remaining instrument for Bank No. 1 is the pressure recorder controller, PRC-h12, on panel CBk-6. This is a two pen pressure recorder controller connected to the HF system at the entrance and exit of the furnaces. If either pen goes above the set index, a relay is actuated which shuts off control air to the HF control valve. Air from the diaphragm of this valve is bled to atmosphere allowing the control valve to close thus shutting off the HF supply. This relay, mounted behind PRC-h12, is a latch type relay so that the HF gas cannot re-cycle. The latch extends through the panel and must be reset manually to reestablish HF flow. One side of the relay energises an alarm to warn of HF shutdown.

On the general process panel, CBk-67A and B, there is a forty-eight point temperature indicator and a twenty-seven point unit annunciator. These are used to measure temperatures and receive warnings from various points.
throughout the plant that concern the operation of accessory equipment.

**HF RECOVERY BOARD**

The HF recovery board is composed of two panels. On the left hand unit is an annunciator suitably tagged to show location of unusual conditions in and around the HF area. The temperature recorders, TRU-212 and 213, are actuated from a thermal bulb in the HF system after the superheater. TRU-214 controls water flow to heat exchanger EH-9. TRU-215 controls tempered water flow to partial condenser EH-8.

On the right hand panel under the annunciator, pressure recorder controllers, FRU-13 and LH, control regulating valves in the HF headers to process. The flow meter, FRU-69, measures the total amount of steam used in the building. TIU-228 is a forty-eight point temperature indicator connected to miscellaneous thermocouples throughout the recovery area.

In the recovery system, but not connected to the recovery panel, are level indicators on vessels FU-13, 14, 15 and 16. The locally mounted bubbler system works on the principle of balancing a hydrostatic head with air and measuring the air pressure. The tanks will have to be calibrated with the pressure gauge in service. A safety feature is incorporated which will shut off air to the purge system and prevent back pressure from pushing liquid HF into the air supply.

**WEIGHT INDICATOR PANELS**

For transfer of materials from one furnace to another, use is made of intermediate hoppers and screw feeders. The purpose of the controls at these stations is two-fold. In the orange oxide feed hopper the feed from the storage hopper is controlled as well as the level in the feed hopper. Control
is maintained by means of a pneumatic cylinder which carries half the load of
the hopper. The air pressure required to maintain a fixed position of the
pneumatic cylinder or transmitter is an indication of the load on the transmit-
ter. Air pressure is measured by a gauge on the weight control panel and
the same air line goes to two Mercoid pressure switches. These switches in
turn shut off the feed motor, sound alarms or start feed motor as the condi-
tions require. A safety feature is built into the weight control instrumen-
tation which shuts down the emptying feed hopper in order to always maintain
a seal of material within the hopper and thus prevent gases from the furnaces
from escaping through the feed screw. The positioning of Mercoid switching
will have to be by field calibration and the reading of the pressure gauge
will have to be correlated with the material level before the plant is put
into operation.

MISCELLANEOUS PANELS

Hydrogen Burner

The hydrogen burner instrumentation is perhaps the most complex
arrangement of control devices in the plant if the number of related parts
is considered.

Strictly speaking, the hydrogen burner is an open ended pipe which
acts as the exhaust for the gases coming from the reduction furnace. The
hydrogen burner includes the pilot light, its control, protectoglo relay, and
related accessories. The hydrogen burner with its accessory equipment will
perform the following functions:

1. Burn excess H₂ from the reduction reactors

2. Provide a pilot light using natural gas to ignite excess H₂ when
it issues in a combustible mixture.

3. Provide a high tension spark to ignite the natural gas.

4. Provide means to shut off $H_2$ to furnace should both flames be extinguished.

5. Purge furnace with $N_2$ in the event of flame failure.


7. Provide means to shunt hot gases from dust collector duct to roof vent if dust collector $CH-3$ is not operating.

8. Operate dampers to shunt hot gases to roof vent in case collected air to $CH-3$ becomes too hot.

9. Sound alarm at individual annunciator panel if $H_2$ burner is shut off.

**Operation of $H_2$ Burner**

On starting up, dust collector $CH-3$ should be operating. An auxiliary contact in the starter of $CH-3$ will close and energise a relay at the $H_2$ burner control panel. There is also a normally closed contact in TRCH-232 which is in series with the dust collector, $CH-3$, contacts mentioned above. This will shift dampers in the dust collector duct and allow gases to go to the dust collector instead of the roof stack when the protectoglo is in operation. When the start button is pushed on the $H_2$ burner panel, the high tension transformer is energised and the gas pilot valve is opened. The pilot light should light and once flame is established, a common solenoid valve admits air to two pilot diaphragm valves. The common solenoid is labeled $XC-V_2$. The diaphragm valve $XC-V_2$ is a three way valve. With air on the diaphragm a through passage is provided for control air from the flow.
controller to the main H₂ valve, FC-V. Hydrogen can now pass to the furnace. Air also goes from XD-V₂ to XC-V₄ which closes on air pressure and shuts off H₂ to furnace. Alarm contacts within the protectoglo relay open and the signal to the annunciator is deenergised.

In the event that the dust collector shuts down or the temperature to the dust collector is too high, the stock damper are reversed and exhaust gases go to the roof. The protectoglo will not shut down nor will the H₂ flow be shut off.

The high tension transformer will be on only as long as the start button is held in. If the natural gas does not ignite in forty seconds a thermostat within the protectoglo locks open and must be re-set manually after a cooling period. If the natural gas flame and the H₂ flame both go out, there is no automatic re-light. The cycle must be started manually.

Dust Collectors

The operation of the dust collectors, Qk-2, 3, 4, 5 and 7, is controlled by a pressure recorder controller on an adjacent panel. The PDRC has three sets of contacts. The first set, operating with no differential across the filter, will actuate an alarm on the main control board. The second set of contacts operates a blower and blow ring motor between limits set by experience. If the dust collector bag is not cleared sufficiently by the blow ring and the differential pressure increases to an undesirable figure, contacts are actuated to sound an alarm on the annunciator at the main control board.

In case of a break in the dust collector bags an electric eye in the exhaust of the collector detects a rise in dust density. The dust density
meter is connected to an alarm unit on the general process annunciator.

On the dust collector, control board is a temperature recorder controller. The bulb of the thermal element is in the incoming duct to this collector. In case of high temperature, the gases normally going to this collector are shunted direct to the atmosphere. See description of hydrogen burner.

**Nitrogen Generator**

The nitrogen generator panel has a protectoglo relay as a flame failure device. A time delay relay is also mounted on the panel. When the blower is started on the N₂ generator the time delay relay is started. This is to provide a purge period before gas is admitted to the generator. After a pre-set time the protectoglo circuit is closed and a red light lights at the generator. When gas is admitted and flame is established, the red light goes out and a white light lights. Ignition to light the gas is maintained only as long as the start button is held in. Additional safety devices include a water flow switch, high pressure switch in compressor line and a low pressure switch to prevent the compressor from operating when gas from the generator is not available. Flame failure will be noted on the annunciator panel in the general process section of the main control board.

A gas analyser has been connected by means of a solenoid valve to two diaphragm valves one of which is normally open, the other normally closed. This arrangement permits gas of correct analysis to go to the storage tank or, if contaminated, to atmosphere. The gas analyser continuously tests for hydrogen and is set to divert the gas to atmosphere when H₂ goes above 1.0 per cent. To assure absence of O₂ in the gas, the hydrogen content should be
0.25 per cent or slightly higher.

**Hydrogen Detector**

In the dissociation area there is a hydrogen detector with sensing cells mounted near the roof. This instrument, panel mounted, is continually sampling the atmosphere for hydrogen. At 25 per cent of L.E.L. (least explosive limit) an alarm on the annunciator at the HF recovery panel will be energized. If no corrective measures are taken and the L.E.L. goes to 50 per cent, electrical equipment in the area will be shut down with the exception of the exhaust fan on the roof. An air operated louvre is also actuated by the relay of the hydrogen detector to assure ventilation when the roof fan starts.

**Feed Screw Torque Recorders**

Provided for each of the 12 banks of furnaces is a torque recorder (total 12). The torque recorder applied to a particular bank is a 4 point instrument which records the torque delivered to the 4 feed screws in the furnace bank. It is essentially a watt meter receiving its impulses from thermal convertors on the power leads to each drive motor. The recorder measures the electric loads on the feed screw drive motors and records the results successively with approximately five seconds between points. Each recorder is provided with alarm contacts which will sound an alarm should the torque on an individual screw raise to too high a value. Should the torque on any screw continue to increase to a higher set value all feed screws on that bank automatically stop. These alarms and cut off points are adjustable, the alarm, of course, always being set lower than the cut off point.
The drive motors are connected to the feed screws by speed reducers. Since they are so connected, a given electrical load on the drive motor does not represent the same torque on the feed screw when the speed of rotation of the screw is varied. Therefore, if the speed of the screw is changed the alarm and cut off points on the recorders will have to be altered accordingly.

Calculations based on figures developed on the allowable torque from MW indicate that the alarm and cut off points should be set so that:

- 12 rpm-alarm at 3.2 hp load on motor - cut off at 4 hp load.
- 8 rpm-alarm at 2-1/2 hp load on motor - cut off at 3 hp load.
- 2 rpm-alarm at .6 hp load - cut off at .75 hp load.
SECTION 5-3:09
INTEGRATION OF SYSTEMS

The various systems which comprise the green salt plant have been discussed as units with little consideration being given to their inter-relationship. For the green salt plant to function properly, it is necessary for the operator to understand this inter-relationship and to integrate the operation of the various systems into a single operating unit.

The purpose of this section of the manual is to present the sequence in which the systems will be started up and shut down. The primary consideration in establishing the sequence was safety for both the operators in the plant and people in areas adjacent to the plant.

Operations which involve the heating up of major items of equipment will be started first to conserve time. Thus, the heating cycles for the ammonia dissociators and reactors will be started first. During this heating period, the following operations should be performed in the order in which they appear:

1. Start the scrubbing system.
2. Start the dust collection and ventilation systems.
3. Start the HF recovery system.
4. Start the ammonia dissociators after they have reached operating temperature.
5. Start the nitrogen generator.
6. Start HF flow to the vaporizers.
7. Start the flow of process materials after the reactors have reached operating temperature.
During a normal shutdown, the foregoing operations will be performed in reverse order. In an emergency, the scrubbing, dust collection, and HF recovery systems will remain in operation.

At present it is planned that the green salt plant will operate 24 hours per day, 5 days per week, and 52 weeks per year. However, the plant as designed is capable of operating 24 hours per day, 7 days per week, and 52 weeks per year.
SECTION 5-310

APPENDIX

SAFETY RULES FOR MEN WORKING IN HF ALKYLLATION UNIT

No person is permitted within the boundaries of the Alkylation Plant unless granted permission. Specifically the contactor section and the acid regeneration section which have the surrounding firewalls painted red with the restricted entry indicated by frequent signs. These restrictions apply to all persons other than the operators directly engaged in this area with the following exceptions:

1. Entry to the Acid Control Room via the fenced walkway is unrestricted.

2. Permission to enter the restricted operating areas shall be given by the shift foreman or operator in charge of the restricted area only when the individual is supplied with proper protective clothing. (This rule applies alike to visitors and employees of the company not directly assigned to work in the restricted area.)

3. There are certain points outside the restricted area where HF is present. These operating points are identified by warning signs with the type of protective clothing required for operating changes clearly indicated. (These points are mainly in the HF stripper section and they include shut-off cocks, a liquid level controller, a meter, and pressure gauges.)

4. Another point where occasional hazards may exist is the pre-treatment section. During the dumping of the Bauxite Towers,
warning signs will be erected and the area will be roped off.
The class of clothing to be used during this operation will
be C or D according to the type of work and will be decided
by the shift foreman and safety inspector.
Operators passing by the acid section without protective clothing
should observe the direction of the wind and make it a practice of going
around the area on the windward side when a high wind prevails. This is a
good practice in case of an accidental release of vapors.

Do not work on acid or acid hydrocarbon equipment without neutralizing
agents being available for immediate use. Neutralizing agents have been pro­
vided and small portable first aid kits for this purpose. Emergency first aid
kits are located at various places in the Alkylation Unit and a first aid room
and attendant is located in the change house.

If a large area of the skin is sprayed with acid or acid hydrocarbon
use the emergency shower immediately. Keep the affected area under the shower
at least ten minutes. After this first aid treatment should be given. All
burns whether large or small should be reported immediately.

Employees working outside the control house and acid area should wear
Neoprene gloves at all times. Release of HF whether accidental or otherwise
may leave a film of acid on any object contacted and touching these objects
will result in an acid burn. Gloves should be thoroughly washed in neutraliz­
ing barrel before attempting to remove from the hands. Do not wear gloves or
other clothing contaminated with HF acid in the control room. (KEEP CONTROL
ROOM FREE FROM ACID).

Tools and small equipment that comes in contact with acid should be
neutralised immediately in the Soda Ash bath and washed freely with water before resuming work.

Protective clothing should be worn at ALL TIMES when handling material removed from the acid area, until it is definitely known that the material has been neutralised.

Packing shall be removed from pumps and all types of valves at the acid area before transferring to shops for repair. Wear class C clothing while removing the packing. Place used packing in container provided for HF waste. (Cans are plainly marked.)

Pits around equipment should be washed when necessary. Wear class C clothing while washing pits. Any HF spilt on the ground shall be neutralised with soda ash and remove lime-stone to HF waste cans and add new lime-stone.

Fire will be extinguished in the same manner as on other units throughout the refinery, except that it will be very important that fires be approached and extinguished from the windward side. Shift foreman will direct all fire fighting in the acid area. In case of a major fire in the acid area it will be necessary to equip several men with class C clothing. The shift foreman must have access to clothing for this purpose.

CARE OF CLOTHING

Employees who are required to work in the Alkylation Plant have been furnished a locker in the change house, in which has been placed clothing to be worn on all work except class D.

When returning this clothing to the change room, the employee will remove it in the change room and turn it over to the change house attendant who will neutralize, wash and hang it up to dry, after which it will be placed
in the employee's locker.

If the employee feels that he has acid on the suit then he should go in and use the emergency shower or neutralizing bath before returning to the change house.

Employees who have an occasion to use the emergency suit will on completion of work neutralise suit under the emergency shower before returning to emergency equipment room.

**SAFETY PRECAUTIONS FOR VISITORS**

Persons who are not directly employed in the acid area are considered visitors and will not be permitted in the area without approval by the shift foreman.

It is the shift foreman's responsibility to see that all visitors are properly instructed and clothed before entering the acid area.

**CLASSIFICATION OF CLOTHING TO BE WORN IN NF ACID AREA**

**CLASS A**

Type of Work

Routine work under normal operating conditions; such as visually checking liquid level, pump and valve packing, reading meters and pressure gauges.

Protective Clothing Worn

Face shields and rubber gloves. A rubber hat or cap should be worn with face shield. Neoprene sole shoes.

**CLASS B**

Type of Work

Minor adjustments on acid or acid hydrocarbon such as opening or
closing valves for minor switches, changing pumps, checking bearings and lubrication and any job that requires an employee to work in close proximity to equipment in operation.

**Protective Clothing Worn**

Face shield, rubber gloves and apron with sleeves. Overalls and jacket may be worn instead of apron if preferred. Neoprene sole shoes.

**CLASS C**

**Type of Work**

Major adjustments on acid or acid hydrocarbon equipment; such as venting pumps or other equipment to the air for repair or cleaning; connecting and disconnecting acid lines, maintenance work, cleaning and catching samples.

**Protective Clothing Worn**

Rubber overalls and jacket, boots, gloves and acid hood. The hood shall be worn on all jobs where an operator is apt to be suddenly sprayed with acid or acid hydrocarbon. When in doubt as to your safety, play safe and wear the acid hood.

**CLASS D**

**Type of Work**

For extreme emergency cases; such as pump packing failure and other equipment failures, where it is necessary to close off the equipment to stop acid or acid hydrocarbon being sprayed into the air.

**Protective Clothing Worn**

Neoprene suit, outside air supply, complete body and respiratory protection.
Distribution of Protective Clothing

Protective clothing will be issued to the operators, pump mechanics, instrument men and electricians that are assigned to regular work in the acid area. This clothing will be for their personal use and shall be placed in their lockers (in change room) when going off duty, after being washed in neutralising bath and dried by change house attendant.

Standard clothing shall be issued as follows:

- One face shield
- One pair of rubber gloves
- Surgical type coat
- One rubber suit, overall and jacket type
- One chemical cartridge respirator

Rubber boots and shoes will be issued to operators and mechanics for their personal use.

Emergency protective clothing adjacent to acid control room:

- Three acid hoods
- Three rubber suits, overalls and jumper type
- Two Neoprene suits with outside air supply
- Two hundred feet of 3/8 inch air hose
- Life line

This clothing shall be placed adjacent to the acid control room. The operators shall check clothing daily and keep it well arranged at all times for immediate use in case of an emergency. Clothing that is damaged or missing must be reported to the shift foreman so it can be repaired or replaced.

Protective clothing for maintenance crews shall be issued to workmen
by the maintenance shift foreman at the time work is to be done. Clothing shall be issued according to classifications outlined in these rules. This clothing will be stored in the built-in closet in change room and maintenance crew will receive their clothing at change rooms.

**INSTRUMENT AND CONTROL EQUIPMENT**

In addition to regular refinery procedures the following additional precautions are to be taken during shutdowns, inspections and repairs.

(a) **Routine Inspection**
Four routine inspection the mechanic must wear class B clothing.

(b) **Minor Repairs and Adjustments**
Minor repairs and adjustments, which do not require opening any equipment containing acid, may be performed with the mechanic wearing class B clothing. In case it is necessary to operate any valves in order to make these minor repairs, the mechanic must wear class C clothing. It is permissible to remove rubber gloves to make the more delicate adjustments providing the part to be touched is first thoroughly neutralized in soda ash bath.

(c) **Major Repairs**
All of this equipment, which includes meters, control valves, pressure gauges, pressure transmitters, level controls, gauge glasses, and meter runs are provided with exhausting connections so that the acid and hydrocarbons contained may be evacuated. When doing this type of work, the mechanic must wear class C clothing. After the equipment has been completely exhausted by the operator and all valves inspected for condition and recent
lubrications, the equipment may be removed and placed in neutralizing baths. Water hose must be connected and readily available for washing down in case any acid is encountered during dismantling. In case of control valves, the packing must be removed before the valve leaves the unit area, neutralized and placed in HF waste can. If a control valve, pressure transmitter, level control or sample bomb is removed from service, blanks must be installed on the main vessel valves immediately after removal. These blanks are provided with one-half inch vent valves to atmosphere so that any valve leakage may be bled off before blank flange is removed. If parts require removal to the shop for repair, they must be thoroughly neutralized in the vat provided for this purpose for two hours before continuing work. Care must be taken that any scale from the equipment does not remain in contact with the skin.

**NOTES**

In addition to regular refinery procedure the following additional precautions are to be taken during shutdowns, inspections and repairs.

(a) **Routine Inspection, Oiling, etc.**

When doing this type of work, the mechanic must wear class B clothing. In case it is necessary to feel any part of the pump to detect abnormal operating conditions, the part to be touched must first be neutralized.

(b) **Minor Repairs**

The operator will purge the pump of acid with hydrocarbons and
evacuate vapors before permitting the mechanic to make minor repairs, such as repacking, changing bearings, etc. The mechanic must wear class C clothing. He must see that block valves on either side of pump are holding properly, and that all small Merco valves tied into the pump have recently been lubricated and are in good condition.

(c) Major Repairs

When performing this type of work, such as removing rotating element, pump case, etc., the mechanic must wear class C clothing. Check on all valves that tie into pumps should be made after the operator has purged and vented off as under (b). Blanks with vents must be inserted immediately after part is removed. Water hose should be connected and readily available before starting to dismantle pumps so that if any acid is encountered during dismantling, the pump can be completely washed down at once. In case shop repair is necessary on any part of the pump, this part must be placed in the neutralizing bath provided for this purpose and allowed to remain for a minimum of two hours before moving to the shop for further work. Care must be taken to prevent any scale which might be removed from the pump part remaining in contact with the skin.

DISMANTLING AND ASSEMBLY OF PIPING, VALVES, VESSELS, etc.

In addition to regular refinery procedure, the following additional precautions are to be taken during shutdowns, inspections and repairs.
The equipment to be dismantled must be drained of acid and purged with hydrocarbon and then evacuated to remove any vapors prior to the mechanic working on same. If any equipment is removed, blanks with vents must be inserted. Water hose must be made available for immediate use in case any acid is encountered during dismantling. All workmen must wear class C clothing. The insulation must be removed from all lines before they are removed from the unit area. All workmen must be careful not to allow any scale from inside the piping and fittings to come in contact with the skin. Workmen should occasionally dip gloves in neutralizing solution provided for this purpose while work is in progress. Sharp edges, etc., which might puncture or otherwise damage protective rubber clothing must be avoided.

**WELDING**

In addition to regular refinery procedure the following additional precautions are to be taken during shutdowns, inspections and repairs.

(a) **In Unit Area**

Welding carried on in the unit area may be done with the same precautions that are taken in any other operating area, and in addition, the workmen must wear class C clothing, with the regular welder's helmet substituted for the face shield. Goggles should be worn under helmet.

(b) **Shop Welding of equipment that has been in acid service.**

Any equipment that has been in acid must remain in the neutralizing bath provided for this service at least two hours prior to
In case it is necessary to remove a portion or all of a defective weld, the area to be removed must first be heated to approximately 600°F for fifteen minutes to drive out any contained acid.

**ELECTRICAL EQUIPMENT**

In addition to regular refinery procedure the following additional precautions are to be taken during shutdowns, inspections and repairs.

(a) **Routine Inspection**

Routine inspection may be made with the electrician wearing class B clothing.

(b) **Minor Adjustments and Repairs**

Minor adjustments and repairs such as adjusting motor starter parts, thermal relays, repair to light switches, and changing light bulbs can be made with the electrician wearing class B clothing.

(c) **Major Repairs**

When making major repairs, such as removing motors from pumps, etc., the electrician must wear class C clothing. Any electrical equipment removed from the unit area to the repair shop must be thoroughly neutralized.

**CLEANING UP AREA**

In addition to regular refinery procedure, the following additional precautions are to be taken during shutdowns, inspections and repairs.

Class C clothing should be worn. All refuse removed from the acid area must be dumped in the HP waste drum provided for this.
purpose. This material shall be removed to HF waste pit.

All acid spills should be covered with soda ash and then acid.
soda ash, and approximately three inches of lime stone fill shall
be shoveled into HF waste drum then area contaminated shall be
thoroughly washed down and refilled with fresh lime stone. Class
C clothing should be worn during this operation.

GENERAL CARE OF TOOLS AND MAINTENANCE EQUIPMENT

All tools and maintenance equipment used in the acid area must
be periodically dipped in neutralizing vat provided for this
purpose while work is continuing. After work is completed,
before this equipment is returned to the tool house, it must
first be neutralized for at least two hours in the vat provided
for this purpose and thoroughly inspected by the tool house
foreman.

CARE OF CLOTHING

ALL EMPLOYEES using safety clothing from change house lockers should
wash the clothing in one of the emergency shower houses or neutralizing
barrels before returning to the change room, if they have come in contact
with acid, where change house attendant will neutralize, wash, dry and place
same in lockers.

In the change house the safety clothing will be removed in the change
room placed in a basket and turned over to the change house attendant who will
wash, dry and then place it in the employee's locker. Gloves will be checked
for pin holes before placing in lockers.

Extreme care shall be exercised in carrying out above rules to prevent
HF acid burns while removing clothing, contaminating change room with HF acid and exposing others that may come in contact with clothing.

Rubber is a very critical material and all employees will be required to take the best possible care of the clothing.