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**THE GENERAL ATOMIC
REPROCESSING PILOT PLANT:
ENGINEERING-SCALE DISSOLUTION
SYSTEM DESCRIPTION**

by
H. H. YIP

Prepared under
Contract EY-76-C-03-0167
Project Agreement No. 53
for the San Francisco Operations Office
Department of Energy

DATE PUBLISHED: APRIL 1979

GENERAL ATOMIC COMPANY

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GENERAL ATOMIC COMPANY

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ABSTRACT

In February 1978, a dissolver-centrifuge system was added to the cold reprocessing pilot plant at General Atomic Company, which completed the installation of an HTGR fuel head-end reprocessing pilot plant. This report describes the engineering-scale equipment in the pilot plant and summarizes the design features derived from development work performed in the last few years. The dissolver operating cycles for both thorium containing BISO and uranium containing WAR fissile fuels are included. A continuous vertical centrifuge is used to clarify the resultant dissolver product solution. Process instrumentation and controls for the system reflect design philosophy suitable for remote operation.

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1. INTRODUCTION

The fuel for a high-temperature gas-cooled reactor (HTGR) consists of small coated particles embedded in fuel elements made from graphite, which acts as a neutron moderator (Fig. 1-1). The reactor utilizes thorium by converting it to U-233. Thorium can be incorporated into the fuel in a number of ways. To optimize the thorium-uranium fuel cycle, a system of separate fuel particles has evolved. The two types of particles used are characterized by the coatings applied to them (Fig. 1-2): BISO particles are coated with a relatively porous buffer layer of carbon and then with a dense coating of pyrolytic carbon; TRISO coatings have a silicon carbide (SiC) coating placed between two layers of pyrolytic carbon. The SiC layer provides a means of separating the TRISO particles from the BISO particles in head-end reprocessing operations, and it enhances fission product retention in the fissile particles. BISO coatings are used for particles which are initially loaded only with thorium oxide; TRISO coatings are used for particles loaded with uranium. After irradiation, the BISO fertile particles contain quantities of U-233. Separation of the fertile particles from the fissile TRISO particles and subsequent recovery of the bred U-233 for use in refabricated fuel is an indispensable part of the recycle of HTGR fuel. The development and demonstration of this recycle technology is the goal of the Department of Energy (DOE) funded National HTGR Fuel Recycle Development Program.

In June 1976, General Atomic Company (GA) completed the construction of a cold engineering-scale dry head-end pilot plant (Fig. 1-3). By February 1978, a dissolver-centrifuge system was added, thereby completing the installation of an HTGR fuel head-end reprocessing pilot plant. The purpose of the plant is to demonstrate the feasibility of the technology on an acceptable scale. The dissolver-centrifuge system has subsequently completed initial design verification testing.

Fig. 1-1. HTGR fuel element

K72654

Fig. 1-2. HTGR coated fuel particles

Fig. 1-3. HTGR reprocessing cold pilot plant arrangement

This report describes the engineering-scale equipment in the pilot plant and summarizes the design features derived from the development work performed in the last few years. The background experimental information is available in Refs. 1-1 through 1-17. Appendix A contains the process flow diagrams and piping and instrumentation drawings, and Appendix B contains the major assembly drawings.

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2. HEAD-END REPROCESSING FLOW SHEET

The purpose of the head end of the reprocessing flow sheet is to prepare fuel for solvent extraction. It comprises fuel element size reduction, crushed fuel element burning, particle classification, particle crushing, crushed particle burning, dissolution, and solids-liquid separation. Unit operations are connected by the solids handling system (Fig. 2-1).

Fuel elements are reduced to $-4760\text{ }\mu\text{m}$ in a series of crushers (two overhead eccentric jaw crushers and one double-roll crusher) which are mounted in one frame; this system is referred to as the Uniframe. After screening, the crushed material is pneumatically conveyed to a product bunker and then to the feed bunker of the fluidized-bed crushed fuel element burner, which is referred to as the primary burner. The primary burner fluidizes crushed fuel elements with carbon dioxide and heats the initial charge with an induction heater. Oxygen is introduced to begin combustion, and cooling gas removes the heat of combustion transferred through the burner wall. The fluidized-bed temperature is maintained at around 900°C . Fine particles are entrained by the fluidized gas and recycled to the bed after separation from the gas; fresh feed is continuously added to the burner. The graphite and outer carbon coatings are burned off, and the product is conveyed to the primary burner product bunker. The burner operates on a semicontinuous basis, i.e., only a part of the bed is dumped at any one time, until the end of an operating campaign. If the product is within specification, it is transferred to the pneumatic classifier feed bunker; if it contains excess carbon or graphite, it can be recycled to the primary burner feed bunker. The burned-back fuel particles are fed into a moving air stream within a zigzag classification column.

FUEL ELEMENT SIZE-
REDUCTION SYSTEM

PRIMARY BURNER

PNEUMATIC
CLASSIFICATION

SECONDARY
BURNER

PARTICLE
CRUSHER

DISSOLVER / CENTRIFUGE

Fig. 2-1. Cold head-end layout

The light TRISO fissile particles are carried out of the top of the classifier, and the BISO particles, which are dense ThO_2 , fall out of the bottom, ready for dissolution and solvent extraction. In the event of unsatisfactory separation, particles from either or both classifier product bunkers can be recycled for reclassification.

The burned-back TRISO particles still contain inner carbon coatings which must be burned. They are conveyed to a particle crusher (where they are crushed), and the crushed particles are fed to the fluidized-bed crushed particle burner (or secondary burner), which combusts carbon and converts heavy metal carbides to oxides. The batch of feed is fluidized with carbon dioxide and induction heated prior to the introduction of oxygen. Product from the secondary burner is pneumatically transported to the secondary burner product bunker.

The fuel particles are then ready for dissolution. The fertile ThO_2 kernels from the classifier underflow product bunker and the secondary burner product are pneumatically conveyed to the dissolver-surge bunkers for material accountability prior to dissolution. For fertile kernel dissolution, Thorex acid solution [13M HNO_3 / 0.05M KF / 0.1M $\text{Al}(\text{NO}_3)_3$] is used. The resultant 1M thorium-containing product solution is processed through the feed adjustment equipment prior to entering the solvent extraction process. However, for the reference fissile fuel ash, 2M HNO_3 is required to dissolve the heavy metal oxides. The resultant slurry, consisting of the insolubles and dissolved heavy metals, must be further clarified through a centrifuge, which separates the solids from the liquid. The mother liquor is then directly transferred to the solvent extraction system.

3. DISSOLVER-CENTRIFUGE SYSTEM

The 0.5-m dissolver-centrifuge system is an engineering-scale system comprised of a number of subsystems:

1. Dissolver.
2. Condenser.
3. Solids feed bunkers.
4. Centrifuge.
5. Repulp tank.
6. Chemicals makeup and product storage tanks.

Figures 3-1 through 3-3 show the system arrangement in the pilot plant. Stainless steel drip pans are provided to catch any spill of acid or solvent. A 1.016-tonne (1-ton) crane above the system is used for maintenance of the centrifuge, the repulp tank, and the dissolver. The dissolver-centrifuge subsystems are described below.

3.1. DISSOLVER

3.1.1. Dissolver Vessel

The dissolver is a 304L stainless steel vessel (0.5 m in diameter and 3 m in length) with a jacketed conical bottom and a jacketed cylindrical section. A flanged dissolver top is included in the design to allow for any addition of internals to the dissolver, if needed. Figure 3-4 shows a cross-sectional view of the dissolver. Steam is supplied to the bottom jacket to heat the contents of the vessel and to assist in agitation of the solution. The cylindrical side jacket provides steam heating or water cooling to maintain the desired solution temperature in the dissolver. The 90-degree conical bottom reduces material holdup in the dissolver and enhances steam jet transfer of slurries. As observed in steam jet

Fig. 3-1. 0.5-m dissolver-centrifuge system arrangement

781226

Fig. 3-2. Dissolver-centrifuge system (looking south) showing dissolver without insulation. The piping connecting to the dissolver supplies steam and cooling water to the bottom and side jackets.

781287

Fig. 3-3. Dissolver-centrifuge system viewed from upper deck

Fig. 3-4. Dissolver cross section

transfer tests, it is necessary to cool the dissolver solution to less than 60°C before transfer to ensure efficient slurry transport.

3.1.2. Product Removal

Product solution and the undissolved residues are removed from the dissolver by a submerged steam jet equipped with a short pickup tube, as shown in Fig. 3-5. The jet body consists of three threaded parts and can be disassembled for inspection of jet erosion, plugging, or corrosion. The short pickup tube together with the bottom conical geometry allows almost complete removal of the slurry from the dissolver. A decanting jet is available for use if it is desired only to remove dissolver solution from the dissolver. When the steam jet is not in use, a low purge gas flow is maintained to keep the opening from plugging.

3.1.3. Dissolver Solids Feed

Solids fuels are pneumatically conveyed from the secondary burner product bunker and the classifier product bunker to the two surge bunkers on top of the dissolver. The solids fuel is gravity fed to the dissolver in a batch. A rotary feeder also allows metering of the solids into the dissolver, if necessary, to permit reaction rate control. A clamp heater and a nitrogen purge are maintained in the feed chute to prevent bridging of solids caused by vapor condensation in the chute during the dissolution cycle.

3.1.4. Instrumentation

All process and instrument lines penetrate through the top of the dissolver. Samples may be withdrawn from the dissolver with a gas lift sampler. Instrument dip legs, thermocouples, a sampling gas lift, sparge lines, and submerged steam jets, which are susceptible to plugging or corrosion, can be removed from the dissolver through Tri-Clover quick disconnects (see Fig. 3-6).

SLURRY
PICKUP
TUBE

SLURRIES
DISCHARGE

STEAM
SUPPLY

Fig. 3-5. Submerged steam jet for slurry transfer from dissolver to centrifuge

Fig. 3-6. Dissolver top penetrations

In a reprocessing plant, a soluble neutron poison will be added for criticality control in the dissolver.

3.1.5. Operating Cycle

3.1.5.1. BISO Fuel Dissolution. Once separated from the TRISO fissile particles in the classifier, the BISO fertile stream is ready for dissolution. To reduce the dissolution time, excess BISO particles are added and the dissolution is stopped before the kernels have completely dissolved. This is called heel operation.

Two-hundred liters of Thorex solution [$13\text{M HNO}_3/0.05\text{M KF}/0.1\text{M Al(NO}_3)_3$] is prepared in the Thorex tank and is transferred by gravity to the dissolver. Then a total of 88 kg BISO kernels are added to the solution through a heated feed chute. The solution is brought to boiling at about 120°C by supplying steam to the dissolver cone. A sparge gas is maintained to promote agitation before the onset of boiling and to help volatilize iodine from the dissolver solution. When 60% of the feed (53 kg) has dissolved to yield a 1M thorium concentration, the solution is cooled with the cooling jacket.

With the sparge off, the mother liquor is decanted from the remaining solids and is transferred by steam jet to the product tank. Fresh Thorex is added to the dissolver containing the undissolved kernels. An amount of kernels equal to 60% of the first charge is added, and the slurry is brought to a boil. When 40% of the solids remain, the slurry is again cooled.

The mother liquor is decanted again, and more Thorex and feed are added. This cycle is repeated a number of times until the end of an accountability lot is reached or the insoluble content (cross-mixed fissile particles, SiC hulls, carbon, etc.) reaches a predetermined level.

At this point the mother liquor is decanted and sufficient Thorex is added to dissolve the remaining BISO kernel heel. On the complete dissolution, the entire contents are transferred by steam jet to the centrifuge for further product clarification.

3.1.5.2. WAR Fissile Fuel Dissolution. During secondary burner operations, the uranium oxycarbide core material of weak acid resin (WAR) fissile particles is converted to finely divided U_3O_8 . The principal reaction in the dissolution is

The evolution of nitrogen dioxide in dissolver operations is potentially troublesome because foaming may occur, with resultant handling problems. However, no vigorous reaction or foaming was observed when 2M nitric acid was added to the secondary burner ash charged to the bench-scale dissolver or during subsequent heating to the boiling point (104°C). Figure 3-7 shows a sample of WAR fissile ash before and after dissolution in the 0.13-m dissolver.

Based on the pilot plant study for WAR fissile ash, a batch fissile dissolver operating cycle has been developed. Solids feed to the dissolver is by batch (40 kg), and owing to the low bulk density (1.3 g/cm^3) of the solids, they are added before the introduction of dilute nitric acid at $\sim 25^\circ\text{C}$ to avoid poor mixing. Continuous metering of feed could be utilized, but this has the potential disadvantage of the feed bridging at the feed chute, especially if the fissile ash is wetted by condensation from boiling nitric acid.

Since peak NO_x concentration in the off-gas treatment system NO_x converter must be limited to less than 10,000 ppm, the process will be controlled at a lower temperature (i.e., below boiling), at least in the first few hours of the cycle, to control the reaction rate. After the

(a) WAR fissile secondary burner ash before dissolution

(b) WAR fissile dissolver residue after dissolution
consisting of SiC hulls and unbroken particles

Fig. 3-7. WAR fissile dissolver feed and residue

bulk of the uranium is dissolved, the solution temperature can be brought to the boiling point to dissolve as much residue as possible and to volatilize iodine. Since the dissolution curves at ambient and boiling temperature are widely separated, using temperature to control NO_x evolution is relatively effective. Sparge gas is required to promote mixing, especially in the nonboiling portion of the cycle. At the same time, the sparge gas dilutes the NO_x evolved in the reaction. In commercial operation, a soluble neutron poison would be included in the dissolver solution as a criticality precaution.

3.2. CONDENSER

The dissolver off-gas vents through a downdraft condenser, which condenses nitric acid vapor and cools the noncondensable to less than 60°C . The condensate is returned to the dissolver through a loop seal. The cooled noncondensable will be sent to the dissolver off-gas treatment system for further processing. The cooling water to the condenser is instrumented for flow and temperature measurements required for a heat balance. The reflux liquid temperature can be measured and the liquid can be sampled.

3.3. SOLIDS FEED BUNKERS

Solids fuel is pneumatically transferred from storage hoppers to the dissolver surge bunkers. These surge bunkers contain enough feed to process one dissolver batch. Load cells on which the bunkers rest provide material accountability. To assist burner ash flow, an aeration pad is provided in the cone section of the secondary burner and hopper. Mott sintered-metal blowback filters are required to protect the conveying blower from particulate contamination.

3.4. CENTRIFUGE

To separate the undissolved solids from the dissolver solution, a Sharples continuous vertical centrifuge is employed. In order to obtain

such a separation, it is necessary that the solid particles have a higher density than the liquid phase. The Sharples centrifuge (Model P-850 SUPER-D-CANTER) has a 0.1524-m (6-in.) bowl, rotates up to 8000 rpm, and develops up to 5400 g in centrifugal force. As shown in Figs. 3-8 and 3-9, the vertical centrifuge is mounted on a structural frame and is belt-driven by a constant speed 10-hp motor. The wetted surfaces are made of Type 316 stainless steel.

The vertical centrifuge differs in design from the horizontal units in more aspects than orientation. In the vertical design the bowl is suspended from the top, where the only seal is located. This "plumb bob" suspension allows the bowl to absorb slight imbalances through shifting of the axis of rotation. A horizontal unit is supported at both ends and cannot absorb imbalances, but instead reacts to give increased vibration. The ability of the vertical centrifuge to absorb imbalances also relaxes the tolerance required for balancing the bowl.

For remote operation in a hot cell, several features unique to the vertical design give it an advantage over the horizontal unit:

1. It requires less floor space.
2. Removal and replacement of the internals are simplified with a vertical orientation, and the vertical centrifuge is similar in design to the batch centrifuges used in remotely maintained facilities and would be easier to adapt to this service using existing technology.
3. The seal is not in contact with the process fluids, and the unit self-drains if stopped.

Figure 3-10 illustrates the operating principle of the vertical centrifuge. The feed slurry to be separated is introduced into the conveyor feed zone through an axially mounted feed tube. It then discharges

781227

Fig. 3-8. Sharples Model P-850 vertical centrifuge as installed on upper deck

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Fig. 3-9. Cross section of Sharples Model P-850 vertical centrifuge

Fig. 3-10. Operation of a continuous vertical centrifuge

from ports, located around the periphery of the feed zone, into the bowl. As solids separate out of the slurry, they are carried by centrifugal force to the wall of the bowl, where they are moved along the bowl wall by the conveyer over the inclined beach of the bowl extension and out the solids discharge ports located around the periphery of this extension. The solids then drop directly into a holding vessel which is directly coupled to the centrifuge casing. Any solids held up in the casing are flushed down with the casing-rinse spray nozzles as shown in Fig. 3-11.

A separate recirculating lubrication system supplies oil mist lubrication to the bearings and coolant to the main seals in the centrifuge. Although this lubrication system is placed next to the centrifuge in the pilot plant as shown in Fig. 3-12, it can be easily modified for installation outside a hot cell away from the centrifuge to avoid unnecessary degradation of the lubricant.

3.5. REPULP TANK

The repulp tank contains the solids discharged from the centrifuge and maximizes recovery of occluded heavy metals from the solids by rinsing with water or dilute acid. As shown in Fig. 3-13, the repulp tank is directly coupled to the bottom of the centrifuge. While the solids are in the tank, a gas sparge keeps them well mixed with the rinse solution. After a thorough rinse, the slurry is transported back to the dissolver either via a submerged jet or through the bottom drain valve.

3.6. CHEMICALS MAKEUP AND PRODUCT STORAGE TANKS

All chemical storage and product storage tanks are free-standing, made of Type 304L stainless steel, and bottom-drained. A gas sparge or a recirculating pump is used to mix the contents. All tanks are vented to the vessel off-gas system.

135-36-211-7

Fig. 3-11. Vertical continuous centrifuge solids discharge

781286

Fig. 3-12. Centrifuge lubrication system

135-36-211-29

Fig. 3-13. Repulp vessel being lifted into position for coupling with centrifuge

3.7. PROCESS INSTRUMENTATION AND CONTROL

The dissolver-centrifuge system can be operated manually from the control panel next to the centrifuge shown in Fig. 3-14. The panel houses the centrifuge and dissolver controls, relays, and power supply. For liquid level and specific gravity monitoring, manometers and differential pressure transducers are used.

Alternatively, the dissolver-centrifuge system can be operated entirely inside the central control room from two control cabinets, where data logging and push-button control can be carried out without leaving the room. Alarms and automatic protection are also provided. Figures 3-15 and 3-16 show the features on the control cabinets.

PORTABLE
MULTIPOINT
RECORDER

CONTROL PANEL
HOUSING CENTRIFUGE
AND DISSOLVER
CONTROLS, RELAYS,
AND POWER SUPPLY

INSTRUMENT RACK FOR
FLOWMETERS, DIFFERENTIAL
PRESSURE TRANSMITTERS,
AND CONTROL VALVES

MANOMETERS FOR
LIQUID LEVEL AND
SPECIFIC GRAVITY
MEASUREMENT

781288

Fig. 3-14. Instrumentation and control panels for dissolver-centrifuge system

790155

Fig. 3-15. Control cabinets inside central control room

Fig. 3-16. Control cabinet slope-face control layout

APPENDIX A
PROCESS FLOW DIAGRAMS
AND
PIPING AND INSTRUMENTATION DRAWINGS

FERTILE BISO CAMPAIGN

STREAM NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TYPE OF FLOW	BATCH	BATCH	BATCH	BATCH	BATCH	SEMI-CONT			SEMI-CONT	SEMI-CONT															
TOTAL LIQUID FLOW L	85	135	1115	200		200	876		160	199.8															
TH O ₂ FRESH FEED					52.8																				
TH O ₂ REEL					55.2																				
THORIUM K ₂					99	1.17			1.17	1.17															
FISSILE PARTICLES K ₂					0.88	0.88	0.88																		
CARBON K ₂					1.7	1.7	1.7																		
UO ₂ K ₂				10.4	13	0.7			0.7	0.7															
F ⁻ K ₂	17	29		0.05		0.05			0.05	0.05															
Al K ₂	17		1.5	0.1		0.1			0.1	0.1															
Ca K ₂	17			0.075		0.075			0.075	0.075															
H ₂ O GPM												16	10	10											
SPARGE M ₂ SCFH								52.8									1720	52.8	1720						
TEMPERATURE °C						45						170	29	29	35			60							
FLOW						2 GPM			2 GPM	2 GPM	1720														

TRISO FISSILE (WAR) CAMPAIGN

STREAM NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
TYPE OF FLOW			BATCH	BATCH	BATCH	SEMI-CONT	SEMI-CONT			SEMI-CONT										BATCH					
TOTAL LIQUID FLOW L			1672	200		200				200										200	1653				
TOTAL SOLIDS FEED K ₂					48.5																				
URANIUM					10.54	52.4				52.4															
SO ₂ C K ₂					30	30	30													30					
TA O ₂ PARTICLES K ₂					3.5	3.5	3.5													6.3					
CARBON K ₂					0.1	0.1	0.1																		
UNBROKEN FISSILE PARTICLE					0.172	0.204	0.204																		
OTHER SOLIDS K ₂					2.51	2.51	2.51																		
UO ₂ K ₂				10.4	12.5	2				2															
H ₂ O												16 GPM	11 GPM	10 GPM							1653				
TOTAL GAS/VAPOR FLOW																			93.8						
NO ₂																			46.174						
SPARGE M ₂ SCFH								292										1	292	6					
TEMPERATURE °C						50						170	29	29	35				60						
FLOW						2 GPM						37.12 GPM													

NOTES

1. SYMBOLS & TERMINOLOGY PER GA GUIDE STANDARDS GA-3.3 & GA-2.4

PROCESS FLOW - ABP/AM DISSOLVER CENTRIFUGE SYSTEM		GENERAL ATOMIC COMPANY	
PROJECT NO. 574101		SHEET 2 OF 2	
DATE: 10/25/64		BY: [Signature]	
CHECKED BY: [Signature]		APPROVED BY: [Signature]

5261003
STEAM GENERATOR
600W CAPACITY (THERMAL)
34PSI MAX PRESSURE

5261008
DISSOLVER
106 GAL CAPACITY
20 IN DIA x 9 FT HT

5261025
CONDENSER
5 1/2 IN DIA x 28 1/2 IN LG

CATEGORY	COMPONENT NUMBER	COMPONENT NAME
EQUIPMENT	5261003, 5261008, 5261025	STEAM GENERATOR, DISSOLVER, CONDENSER
PIPING	5261003-5261008, 5261008-5261025	STEAM GENERATOR, DISSOLVER, CONDENSER
VALVES	5261003-5261008, 5261008-5261025	STEAM GENERATOR, DISSOLVER, CONDENSER
INSTRUMENTS	5261003-5261008, 5261008-5261025	STEAM GENERATOR, DISSOLVER, CONDENSER

NOTES

- THREE POSITION SELECTOR SWITCH (STEAM EXHAUST COOLING) VALVES ENERGIZED AS SHOWN BELOW
- STEAM H/265, H/266, H/267
- COOLING H/268, H/269, H/270
- DRAIN (NO VALVES ENERGIZED)

HIGH REPROCESSING COLD PROT PLANT		P&ID DIAGRAM		05M DISSOLVER		CENTRIFUGE SYSTEM	
GENERAL ATOMIC COMPANY		DATE: 10/1/68		BY: J. W. B. / J. W. B.		CHECKED: J. W. B. / J. W. B.	
PROJECT: 5261001		SHEET: 8 OF 8		SCALE: 1/2" = 1'-0"		APPROVAL LEVEL: 1

A-13

APPENDIX B
MAJOR ASSEMBLY DRAWINGS

- NOTES:
1. POSITION & ALIGN LOWER BEARING HOUSING OF LOAD CELL ASSEMBLY (ITEM 24) THEN RE-USE DRILL & TAP FOR ITEM 50 IN TO MATCHED PATTERN OF FRAME (ITEM 3) & PLACES
 2. POSITION & ALIGN ITEMS 26 & 27, THEN TRANSFER DRILL ITEM 27 FOR ITEM 30
 3. POSITION ITEM 3 PER DIMENSIONS SHOWN ON Dwg. NO. PE 9-204, TRANSFER DRILL FOR ITEM 53

8	55	1/2 LOCKWASHER	SST	304
8	54	1/2 WASHER	SST	304
8	53	1/2 BUNG 2"x1 1/2" LG. HEX HD	SST	304
24	52	3/8 LOCKWASHER	SST	304
24	51	3/8 WASHER	SST	304
24	50	3/8 BUNG 2"x1 1/2" LG. HEX HD	SST	304
12	49	3/16 BUNG 2"x1 1/2" LG. HEX HD	SST	304
6	48	3/16 BUNG 2"x1 1/2" LG. HEX HD	SST	304
14	47	1/4 LOCKWASHER	SST	304
18	46	3/16 WASHER	SST	304
45				
4	44	3/8 BUNG 2"x1 1/2" LG. HEX HD	SST	304
4	43	3/8 BUNG 2"x1 1/2" LG. HEX HD	SST	304
12	42	3/8 LOCKWASHER	SST	304
12	41	3/8 WASHER	SST	304
12	40	3/8 BUNG 2"x1 1/2" LG. HEX HD	SST	304
2	39	LL16 S51 FEMALE CONNECTION 2"	SST	304
1	38	JS175 UNIVERSAL JOINT, BARE 12 1/2"	SST	304
1	37	JS175 UNIVERSAL JOINT	SST	304
1	36	W94743 REDUCER		
1	35	15663200 MOTOR		
1	34	34 SHAFT	SST	304
2	33	33 GUSSET 1/2 TMA R	SST	304
1	32	32 PLATE 3/8 TMA	SST	304
1	31	BRACKET DET ASSY (MOTOR)		
2	30	30 FLANGE 2" 150° SLIP ON	SST	304
1	29	29 PIPE 2" SCH 40S, 5 1/2" LG.	SST	304
1	28	28 SPACER, SPOOL DET ASSY		
12	27	5261017 5261017		
12	26	5201116 5201116		
2	25	25 BRACKET LOAD CELL (RANDOM)		
6	24	117276 LOAD CELL ASSY		
1	23	23 PIN LOCATING (SHORT)	SST	304
1	22	22 PIN LOCATING (LONG)	SST	304
2	21	21 FLANGE 1" 150° SLIP ON	SST	304
2	20	20 PIPE 1" SCH 40 2' LG.	SST	304
1	19	19 CROSS 1" SCH 40S	SST	304
1	18	18 ROTATOR		
2	17	17 BELLOWS		
2	16	5261021 5261021		
1	15	15 (3311) 15 (3311)		
2	14	14 PULVERIZER (C/MORA)		
1	13	13 METER		
1	12	12 CENT. FUSE		
1	11	5261008 5261008		
1	10	5261006 5261006		
1	9	5261005 5261005		
1	8	5261004 5261004		
1	7	5261003 5261003		
1	6	5261002 5261002		
1	5	5261001 5261001		
1	4	5261015 5261015		
1	3	5261017 5261017		
1	2	5261017 5261017		
1	1	5261001 5261001		

HTGR RE-200 COLD PILOT PLANT
SYSTEM GENERAL ARRANGEMENT
(DISSOLVER CENTRIFUGE)

GENERAL ATOMIC COMPANY

DATE: 10/1/68
BY: [Signature]
CHECKED: [Signature]
APPROVED: [Signature]

5261001 B

1 SHEET OF 2

B-5

19 SCALE = 1/2
RENORM PULVER VALVE
2, TYPE N, #3311

10 SCALE = 1/2
RENORM STANDARD PIPE
FLANGE 2, 150' SLIP ON TYPE

25 SCALE = 1/2
RENORM BRACKET
ITEM

18 SCALE = 1/2

34 SCALE = 1/2

SECTION A-A

20 SCALE = 1/2

SECTION B-B

SCALE = FULL

DET. 10
SHEET 1 OF 2

REV	BY	DATE	DESCRIPTION
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
14	14	14	14
15	15	15	15
16	16	16	16
17	17	17	17
18	18	18	18
19	19	19	19
20	20	20	20
21	21	21	21
22	22	22	22
23	23	23	23
24	24	24	24
25	25	25	25
26	26	26	26
27	27	27	27
28	28	28	28
29	29	29	29
30	30	30	30
31	31	31	31
32	32	32	32
33	33	33	33
34	34	34	34
35	35	35	35
36	36	36	36
37	37	37	37
38	38	38	38
39	39	39	39
40	40	40	40
41	41	41	41
42	42	42	42
43	43	43	43
44	44	44	44
45	45	45	45
46	46	46	46
47	47	47	47
48	48	48	48
49	49	49	49
50	50	50	50
51	51	51	51
52	52	52	52
53	53	53	53
54	54	54	54
55	55	55	55
56	56	56	56
57	57	57	57
58	58	58	58
59	59	59	59
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62	62	62	62
63	63	63	63
64	64	64	64
65	65	65	65
66	66	66	66
67	67	67	67
68	68	68	68
69	69	69	69
70	70	70	70
71	71	71	71
72	72	72	72
73	73	73	73
74	74	74	74
75	75	75	75
76	76	76	76
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78	78	78	78
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81	81	81	81
82	82	82	82
83	83	83	83
84	84	84	84
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86	86	86	86
87	87	87	87
88	88	88	88
89	89	89	89
90	90	90	90
91	91	91	91
92	92	92	92
93	93	93	93
94	94	94	94
95	95	95	95
96	96	96	96
97	97	97	97
98	98	98	98
99	99	99	99
100	100	100	100

HTGR REPTD COLD PILOT PLANT
SYSTEM GENERAL
APPENDIX
DISSOLVER-CENTRIFUGE
5261001

B-9

1 ASSEMBLY

- NOTES:**
- 1 SOURCE: THE PFRAUDLER CO., ROCHESTER, N.Y., MODEL 402 CLOSED TOP, 100 GAL. CAPACITY OR EQUAL. FABRICATE AS SHOWN
 - 2 ITEM 3, DRILL 5/8 DIA. THRU, 1/2 NPT 5 PLACES
 - 3 ITEM 3, DRILL 7/16 DIA. THRU, 3/8 NPT 3 PLACES
 - 4 SOURCE: HOME INC., (GYROLON FLARELESS TUBE FITTING) CRESKILL, N.J. OR EQUAL
 - 5 ALL WELDED CONSTRUCTION U.O.S.
 - 6 ALL MATERIALS IN VESSEL WELDMENT TO BE 304L, INCLUDING SUPPORT LEGS
 - 7 DESIGN CONDITIONS, THOREX VESSEL:
PRESSURE, -0.4 PSIG TO +15 PSIG
TEMP AMBIENT
CONTENTS 850 LBS.
CORROSION ALLOW. .010 INCHES
 - 8 DESIGN & STAMP PER ASME SECTION VIII DIV. 1
CORROSION TEST PER ASTM A-262-70 (60% HNO₃ ENVIRONMENT)
 - 9 ALL MATERIAL THICKNESSES SHOWN IN B/M APPROX. ONLY & SUBJECT TO DETAIL DESIGN CALC.
 - 10 TOLERANCES TO BE ASSIGNED IN ACCORDANCE WITH FABRICATORS STANDARD MANUFACTURING PRACTICES

SPECIFICATION CONTROL DRAWING

1	13	GASKET	POLYETHYLENE
1	12	PIPE 4"	SST
1	11	CAP, PIPE 1"	
1/2	10	PIPE 2" SCH 40	
1	9	FLANGE, BLIND 4" 150"	
1/2	8	PIPE 1/2" SCH 40	
1	7	FLANGE, WELD'G. 2" 150" SOC. TP.	
2	6	FLANGE, WELD'G. 1" 150" SOC. TP.	
3	5	6CM6-316 CONNECTOR, MALE 3/8"	
5	4	8CM8-316 CONNECTOR, MALE 1/2"	
1/2	3	ROUND 1 1/2" DIA	
1/2	2	PIPE 1" SCH 40	
1	1	ASSEMBLY	
REQD/ASSEMBLY		LIST OF MATERIAL	
ITEM	PART NO.	DESCRIPTION	MATL
HTGR REPRO COLD PILOT PLANT			
THOREX TANK ASSEMBLY			
GENERAL ATOMIC COMPANY			
5261005 A			

ISSUED RELEASED

LTR	DATE	ISSUE DESCRIPTION	DR	INTL	DES.	APPD.	APPD.
A	12/77	FOR USE					
NEXT ASSY 5261001							

APP. LEVEL II

QWR. LEVEL II

B-11

NOTES:

- 1 3/8 NPT THRU ITEM 4, 3 PLACES FOR ITEM 8
- 2 1/4 NPT THRU ITEM 4, FOR ITEM 9
- 3 REMOVE BURRS & SHARP EDGES
- 4 SOURCE: GYROLOK DIV., HOKI INC. CRESSKILL, N.J., LOCAL, CASTLE CONTROLS INC., LA HABRA, CA.
- 5 DRILL 23/32 THRU, 1/2 NPT
- 6 ALL MATERIALS IN VESSEL TO BE 304L
- 7 DESIGN CONDITIONS: AL(NO₃), STORAGE TANK
PRESSURE -0.4 PSIG TO +15 PSIG
TEMP. AMBIENT
- 8 SOURCE: LADISH CO., CUDAHY, WISCONSIN OR EQUIV.
- 9 DIMENSIONS & TOLERANCES PER ANSI Y14.5
- 10 WELD BY MANUAL ARC, GMA OR GTA PROCESS
- 11 PENETRANT INSPECT ALL WELDS EXCEPT ITEMS 6 & 11. NO CRACK PERMISSIBLE ON L.P.
- 12 HYDROSTATIC PRESSURE TEST FOR TANK & JOINTS

REQD/ASSEMBLY		LIST OF MATERIAL			
ITEM	PART NO.	DESCRIPTION	MATL		
1	12	PIPE 1/2" IPS SCH 40	SST	304L	
1	11	ROUND 1/2 Ø	SST	304L	
1	10	8AMB-3/16 ADAPTOR			
1	9	4CMA-3/16 CONNECTOR 1/4 TUBE			
3	8	6CM6-3/16 CONNECTOR 3/8 TUBE			
1	7	ROUND 1 1/2 Ø		304L	
9/16	6	ANGLE 2 1/2 x 2 1/2 x 1/4			
9/16	5	PIPE 1" IPS SCH 40			
1	4	COVER 1/2" R			
1	3	25510 CAP 10" SCH 10S			
1	2	BODY 10" PIPE SCH 10S			
1	1	ASSEMBLY			
HTGR REPRO COLD PILOT PLANT					
AL(NO ₃) ₃ STORAGE TANK					
15 GAL. CAP					
GENERAL ATOMIC COMPANY					
DRAFTER: [Signature] DATE: [Date]					
DRAWING NUMBER: 5261006					
ISSUE: B					

DO NOT RELEASE
DO NOT RELEASE

DATE	REVISION	DESCRIPTION	DR	CHK	DES	APPD	APPD
10/1/77	1	REVISED PER ECD 100469					
10/1/77	2	APPROVED FOR CONST.					

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
DECIMALS .XXX ± .005
FRACTIONS 5/16 ± .005
ANGLES ± 2°
ALL MACHINED SURFACES

NEXT ASSY
5261001

SCALE 1/4

APP. LEVEL II QAL III

5261006B

B-13

B-17

SECTION D-D
SCALE - 1/2

VIEW K-K
SCALE - FULL
WELD PREP TYP BOTH ENDS

DETAIL R
SCALE - 1/2

VIEW L-L
SCALE - FULL

26 SCALE - 1/2

29 SCALE - 1/2

28 SCALE - 1/2

SECTION E-E
SCALE - 1/2

DETAIL S
SCALE - 1/2

6 SCALE - FULL

ITEM	PART NO	DESCRIPTION	MATL/MATL SPEC
1		HTGR REFR COLD	
2		PILOT PLANT	
3		DISASSSEMBLY	
4		GENERAL ATOMIC COMPANY	
5		5261008	

B-19

- NOTES:
- 1 SOURCE: THE PFAUDLER CO.
ROCHESTER, N.Y., MODEL 602
CLOSED TOP, 300 GAL. CAPACITY
OR EQUAL. FABRICATE AS SHOWN
 - 2 ITEM 3, DRILL $\frac{3}{8}$ DIA. THRU, $\frac{1}{2}$ NPT
3 PLACES
 - 3 ITEM 3, DRILL $\frac{7}{16}$ DIA. THRU, $\frac{3}{8}$ NPT
3 PLACES
 - 4 SOURCE: HOKI INC. (GYROLOX FLARELESS
TUBE FITTING) CRESMILL, N.J.
OR EQUAL
6. ALL WELDED CONSTRUCTION U.O.S.
 7. ALL MATERIALS IN VESSEL WELDMENT TO BE
304L, INCLUDING SUPPORT LEGS
 8. DESIGN CONDITIONS, PRODUCT VESSEL:
PRESSURE, -0.4 PSIG TO +15 PSIG
TEMP. AMBIENT
CONTENTS 2550 LBS.
CORROSION ALLOW. .00 INCHES
 9. DESIGN & STAMP PER ASME SECTION VIII DIV. 1
CORROSION TEST PER ASTM A-262-70
 10. ALL MATERIAL THICKNESSES SHOWN IN B/M ARE
APPROX. ONLY & SUBJECT TO DETAIL DESIGN CALC.
 11. TOLERANCES TO BE ASSIGNED IN ACCORDANCE
WITH FABRICATORS STANDARD MANUFACTURING
PRACTICES

SPECIFICATION
CONTROL
DRAWING

					1	16	GASKET	POLYETHYLENE	
					1	15	CAP, PIPE 1"	SST	
					7/8	14	PIPE 4"		
					7/8	13	PIPE 2"		
					2	12	FLANGE, WELD $\frac{1}{2}$ " SOC. TYPE		
					1	11	FLANGE, WELD $\frac{1}{2}$ " SOC. TYPE		
						10			
						9			
					7/8	8	PIPE 1/2"		
					7/8	7	PIPE 1"		
					1	6	BLIND FLANGE 4"		
					3	5	6CM6-316 CONNECTOR MALE 3/8"		
					3	4	8CMB-316 CONNECTOR MALE 1/2"		
					7/8	3	ROUND 1 1/2 DIA.		
					7/8	2	PIPE 3"		
						1	ASSEMBLY		
				ITEM NO.	PART NO.		DESCRIPTION		MATERIAL

										REQD/ASSEMBLY										LIST OF MATERIAL									
										UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES: DECIMALS .XXX± .XX± FRACTIONS 2 ANGLES 5 ALL MACHINED SURFACES ✓										HTGR REPRO COLD PILOT PLANT									
																				PRODUCT TANK
																				GENERAL ATOMIC COMPANY SAN DIEGO, CALIFORNIA									
										NEXT ASSY 5261001										DRAWING NUMBER									
										SCALE 1/8"										5261012									
																				ISSUE									
																				A

24	12	WASHER FLAT 3/8	ST STL
24	11	WASHER LOCK 1/8	ST STL
14	10	HEX NUT 5/8 1/2	ST STL
24	9	BOLT HEX HD 3/8 1/2 1/4	ST STL
	8		
	7		
	6		
	5		
1	4	SHOET 1/2 IN	TEFLON
1	3	3/4 FIBERGLASS ROD BANNER	
1	2	5/8 1/2 1/3 B. VEEP BUSH BACK KEY	
1	1	ASSEMBLY	

[illegible]

B-31

B-33

- NOTES:
- 1 DESIGN CRITERIA:
SPRING RATE	25"/IN.
TEMPERATURE	100°F
PRESSURE	15 PSIG
AXIAL EXPANSION	1/16
VANSTONE FLANGE	2506
2" PIPE	
- 2 SOURCE: HYSpan PRECISION PRODUCTS
SAN DIEGO, CA.
HYSpan SERIES 2500 OR EQUAL
3. CONSTRUCTION TO BE IN ACCORDANCE
WITH VENDORS ACCEPTED STANDARDS
- 4 SUPPORT AS REQUIRED

				1	7	TUBE 1/4 O.D. x .035 WALL	SST	304L
				2	6	FLANGE		
				2	5	2506 VANSTONE FLANGE		
				2	4	COLLAR		
				1	3	LINER		
				1	2	BELLOWS	↑	↑
				1	1	ASSEMBLY		
				-1	1			
				ITEM	PART NO.	DESCRIPTION	MATL	
				REQD/ASSEMBLY		LIST OF MATERIAL		

										REQUIREMENTS				LIST OF MATERIAL							
										UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES DECIMALS .XXX ± .00, XX ± .02 FRACTIONS ± 1/16 ANGLES ± ALL MACHINED SURFACES ✓				PROPRIETARY INFORMATION THIS DOCUMENT IS THE PROPERTY OF GENERAL ATOMIC CO AND WILL BE RETURNED UPON REQUEST OR WHEN NO LONGER NEEDED BY THE RECIPIENT. INFORMATION CON- TAINED HEREIN MAY NOT BE COM- MUNICATED TO OTHERS NOR MAY THE DOCUMENT BE COPIED IN WHOLE OR IN PART WITHOUT THE EXPRESS CONSENT OF GENERAL ATOMIC CO. SCALE 1/2				HTGR REPRO COLD PILOT PLANT			
A ALM 9-18-77 APPROVED FOR CONSTRUCTION J.T. 8-16-77 HY 132 8-8-77										NEXT ASSY 5261001				BELLOWS, B150 & PRODUCT ASH BUNKERS				GENERAL ATOMIC COMPANY SAN DIEGO, CALIFORNIA			
LTR		DATE		ISSUE DESCRIPTION				DR	CHK.	DES.	APPO.	APPO.	DRAWING NUMBER		ISSUE						
													5261021		A						

APR LEVEL I

QAL III

ASSEMBLY

- ## NOTES:
- 1 THIS WELD TO BE MADE IN FIELD AFTER
ITEM'S 2 & 3 ARE ASSEMBLED IN POSITION.
SEE COG ENGINEER
 - 2 ITEM 5 TO BE POSITIONED UNDER
PRODUCT TANK & WELDED IN FIELD.
SEE COG ENGINEER
 - 3 WELDED CONSTRUCTION
 - 4 ITEM 6 TO REPLACE PRESENT FLOOR
PAD AT BASE OF PRODUCT TANK, CUT
OFF HEIGHT FOR 2" PIPE TO BE
DETERMINED IN FIELD. SEE COG ENGINEER

				R	12	FLAT 1/8 x 1/2	SST	304
				R	11	ANGLE 1 1/2 x 1/2 x 1/8	SST	304
					1 10	DRIP PAN (HF) 20GA.(035)	SST	304
				1	9	PLATE 1/2		
				1	8	PLATE 1/2		
				1	7	PIPE 6" SCH 40,		
			4		6	FLANGE 2" SOC. TYPE WELD		
			/		5	PEDESTAL, PRODUCT TANK		
				1	4	GU'DE 20GA (.035)		
				1	3	DRIP PAN 20GA (.035)		
				1	2	DRIP PAN 20GA (.035)		
			/		1	ASSEMBLY		
			-6-5-1	ITEM	PART NO	DESCRIPTION	MATL	

REQD/ASSEMBLY										LIST OF MATERIAL									
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES: DECIMALS XXXX ± .0005 FRACTIONS 1/8 ± .005 ANGLES ± .2° ALL MACHINED SURFACES ✓										HTGR REPRO COLD PILOT PLANT NEXT ASSY 5261001 DRIP PAN ASSEMBLY GENERAL ATOMIC COMPANY SAN DIEGO, CALIFORNIA DRAWING NUMBER 5261022 ISSUED BY B									
B CHANGED PER ECO #503 A RPP. FOR COUST LTR DATE ISSUE DESCRIPTION DR CHK DES APPD APPD										SCALE 1/2 & NOTED

NOTES:
 1 REMOVE BURRS & SHARP EDGES
 2 FULL PENETRATION WELD

1	7	FLAT 1/2 x 2	STL	ASTM A501
1	6	FLAT 1/2 x 2	STL	ASTM A501
2	5	TUBE 4 x 4 x 1/4 WALL	STL	ASTM A501
1	4	PLATE 1/2	STL	ASTM A36
2	3	PLATE 3/4	STL	ASTM A36
1	2	TUBE 4 x 4 x 1/4 WALL	STL	ASTM A501
1	1	ASSEMBLY		
ITEM	PART NO.	DESCRIPTION	MATL	

REV	DATE	DESCRIPTION	DR	CHK	DES	APP	APP
ADD RELEASED							
ADD RELEASED							
ADD RELEASED							
LTR	DATE	ISSUE DESCRIPTION	DR	CHK	DES	APP	APP

HTGR REPRO COLD PILOT PLANT	
LIFTING BAR REPULP TANK	
GENERAL ATOMIC COMPANY	
DRAWING NUMBER	5261023 C

APP LEVEL I QAL II

1. BREAK ALL SHARP EDGES
2. ALL WELDED CONSTRUCTION UNLESS OTHERWISE NOTED

				54	17	WASHER, DIMPED *8	STL		
				54	16	*8-32UNF x 2.9 x 1/2 LG. FL HD.	STL		
				4	15	PANEL 11GA.(12), 20 1/4 x 25	ALUM	5052	
				6	14	ANGLE 1 x 1 x 1/4	STL	M1020	
				2	13	ANGLE 1 x 1 x 1/4 x T9	STL	M1020	
				3	12	FLAT 1/4 x 2	STL	M1020	
				2	11	FLAT 1/4 x 4	STL	M1020	
				2	10	PANEL, END UPPER 11GA.(12)	ALUM	5052	
				2	9	PANEL 11GA.(12), 16 x 20	STL	M1020	
				1	8	PANEL 11GA.(12) 16 x 81	ALUM	5052	
				6	7	ANGLE 1 x 1 x 1/4	STL	M1020	
				6	6	ANGLE 1 x 1 x 1/4			
				11	5	ANGLE 1 x 1 x 1/4			
				4	4	ANGLE 1 x 1 x 1/4			
				4	3	ANGLE 1 x 1 x 1/4			
				4	2	ANGLE 1 x 1 x 1/4			
					1	ASSEMBLY			
				-1					
				ITEM	PART NO.	DESCRIPTION	MATL		

[illegible]