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USE OF IN-LINE MONITORS FOR PROCESS
CONTROL OF THE HANFORD PUREX PLANT

H. M. Jones and R. Y. Lyon

OPERATIONS SUPPORT ENGINEERING
CHEMICAL PROCESSING DIVISION
ATLANTIC RICHFIELD HANFORD COMPANY

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ABSTRACT

USE OF IN-LINE MONITORS FOR PROCESS

CONTROL OF THE HANFORD PUREX PLANT

Gamma, Alpha, Neutron, Photometer, Conductivity, and Fluoride In-Line Monitors have been developed to provide process control for the Hanford Purex Fuels Reprocessing Plant. The installation and operating experiences of each monitor are described. Most of these concepts should be adaptable to commercial reprocessing plants.

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I. INTRODUCTION

Processing of nuclear fuels irradiated in the Hanford reactors is conducted by the Atlantic Richfield Hanford Company for the Atomic Energy Commission at Richland, Washington. Chemical separation of plutonium, uranium, and neptunium from fission products is accomplished in the Purex Plant. Due to the highly radioactive nature of the material being handled, essentially all operations are conducted remotely in heavily shielded concrete cells. As a result, it is necessary to rely heavily on remote instrumentation, process stream samples, and in-line monitoring systems for adequate process control. In-line monitors are defined as those which are installed directly on or in a process stream or a continuously flowing sample stream.

During the early years of radiochemical processing all characterization of process streams for control purposes was performed by laboratory analysis of samples obtained by remote sampling equipment located in an area accessible to operating personnel. As a result of the extended time required for some critical analyses, it became necessary to supplement the laboratory analyses by installing in-line monitors to provide continuous indication of changing process conditions. The first monitoring systems were installed in conjunction with the samplers since they were more accessible than the remote cell equipment for routine maintenance and modification. At a later time some monitors were installed in the remote cells.

This paper describes several Purex Plant in-line monitor systems which have permitted operation of the plant under conditions which

would have been extremely difficult if not impossible without them. Most of these concepts should be adaptable to commercial processing facilities.

II. PROCESS DESCRIPTION

In the Purex Plant the irradiated fuel element cladding (aluminum or Zircaloy) is removed with appropriate chemical solutions which are discarded to underground waste storage tanks. The exposed uranium metal is then dissolved with a nitric acid solution. The resulting nitrate solution, of uranium, plutonium, neptunium, and fission products, is processed through several pulse column cycles of solvent extraction, to separate and purify the desired products. The solvent used is 30 volume percent tributyl phosphate (TBP) - 70 percent normal paraffin hydrocarbon (NPH).

The major fission product decontamination and partitioning of the plutonium from uranium and neptunium are accomplished in the First Decontamination and Partition Cycle (Figure 1). Additional fission product decontamination is achieved in the Second and Third Plutonium Cycles (Figure 2), and the Second Uranium Cycle (Figure 3). Neptunium and residual plutonium are separated from uranium in the Second Uranium Cycle, and routed via the aqueous 2DW stream to the Backcycle Waste System. The Backcycle Waste System also receives aqueous wastes from the Second Plutonium Cycle (2AW), Third Plutonium Cycle (3AW), and Second Neptunium Cycle for concentration and recycle. Part of the concentrated backcycle waste stream (3WB) is routed to the First Decontamination and Partition Cycle for product recovery; the remainder is recycled through the Second Neptunium Cycle, in which neptunium is continuously

accumulated and decontaminated from plutonium. This accumulation phase is continued until a sufficient quantity of neptunium is contained in the system to warrant a processing campaign through a batch ion exchange system for final purification and concentration.

The aqueous waste stream (HAW) from the First Decontamination and Partition Cycle, containing virtually all of the fission product activity entering the process, is concentrated for volume reduction and partial recovery of its nitric acid content. The concentrated waste is further denitrated by sugar treatment prior to subsequent processing in separate facilities. The plutonium, neptunium, and uranium products are shipped from the Purex Plant as nitrates in nitric acid solution.

III. GENERAL DESCRIPTION OF IN-LINE MONITORS

Components and operating functions common to the various in-line monitors are described below. The individual monitors are described in more detail later in the paper.

A. Sampler Stations

The remote sampler stations are located in a sample gallery running the full length of the Purex Plant. These concrete and stainless steel enclosures range in size from 63 inches by 30 inches by 18 inches for the minimum shielding of stainless steel to 111 inches by 81 inches by 78 inches for the most heavily shielded concrete type. The enclosures contain the equipment necessary for obtaining highly radioactive samples from streams and vessels in the canyon cells with minimum exposure to personnel. Any liquid leaks from piping or equipment are confined to the enclosures and drain to a collection vessel

behind the shielding wall. Ventilation of the enclosures is provided by a separate vent header system which assures that air flow will be from the personnel area into the contaminated enclosure if a breach in the enclosure wall should occur.

Figure 4 shows the arrangement of a typical sampler station. Each sample enclosure contains an air operated jet for transfer of samples from the canyon vessel or stream through a sample cup and then through the jet back to the process vessel. Samples to be analyzed in the laboratory are taken from the sample cup by any one of several methods depending on the degree of radioactivity expected. For those enclosures which include in-line monitoring equipment, the monitor cells are inserted upstream of the sample cup.

B. In-Line Monitor Room

Electronic components for the early monitor systems were located in a pipe and operating gallery that runs the full length of the Purex building just above the sample gallery. Since this gallery contains pumps, flow measuring equipment, and chemical, steam, water and air lines for process use, the over-all atmosphere had a deleterious effect on the electronic components. In order to reduce equipment maintenance and improve the reliability of the electronic components, an air conditioned room was established on the same level as the sample gallery but in an uncontaminated area. Most of the electronic components for the present in-line monitor systems are now located in the In-Line Monitor Room. Any required

pre-amplifiers are located as close to the sensing head as practical since there are cable runs of 100-600 feet to the In-Line Monitor Room.

C. Gamma, Alpha, and Neutron Monitor Components

All gamma, alpha, and neutron in-line monitors have specially designed sensing heads located in a sample station, remotely on a canyon vessel, or in a non-radioactive process stream. Standard module electronic components meeting AEC specification TID-20893 are used to measure the signal from the sensor. Each system usually has a high voltage power supply (HV), amplifier (AMP), discriminator (DISC) or single channel analyzer, and linear count rate meter (CRM), all mounted in a standard bin located in the In-Line Monitor Room. Equipment manufactured by various suppliers, such as Canberra, Ortec, Hamner, and Tenelec, is used. The CRM output is transmitted to a General Electric strip chart recorder located in the Central Control Room.

D. Calibration of Monitors

The gamma, alpha and neutron monitors are calibrated using a Nuclear Data model ND-555-MCA, 128 channel analyzer mounted in a bin in the In-Line Monitor Room. The multi-channel analyzer includes a Teletype for data print-out.

A ^{133}Ba source is mounted in a movable lead shielded pig, and each gamma probe is placed in this pig and calibrated for 0 - 1.0 MEV over 128 channels. After calibration, the probe is re-installed in the monitoring position and a gamma scan of the

process solution is made with the multi-channel analyzer.

The alpha and neutron monitors are calibrated in place with process solution containing ^{239}Pu .

Calibration curves have been developed for all monitors, and are periodically checked against laboratory analyses.

E. Scaler-Teletype System

Certain plutonium-bearing stream monitors, which have recorders located in the Central Control Room are also connected to a Scaler-Teletype system to ensure reliability and redundancy of the measurements on those streams for criticality prevention. The Scaler-Teletype system is shown schematically in Figure 5. The Canberra Industries scaler system consists of: 1) blind scalers connected to the discriminator outputs of nine alpha and neutron monitors; 2) a blind timer for determining counting period; 3) a time of day clock; 4) a display scaler; 5) a Teletype scanner; 6) a timer to set cycle timing period; all located in the In-Line Monitor Room, and 7) a Teletype ASR-33 printer located in the Central Control Room. The following monitors are connected to the scaler system: 1BP alpha, 2AW alpha, 2BP alpha, 3AW alpha, 3WB neutron, three neutron monitors on the 1BX Column, and the 1BXP neutron monitor.

IV. GAMMA MONITORS

A. Sodium Iodide Monitors for ^{95}Zr - Nb and ^{106}Ru -Rh

The fission product concentrations of several process streams are measured by sodium iodide gamma monitors located at manual sample stations (Figure 6). Each monitor has a sample cell which holds 32 milliliters of solution, and is fabricated of KEL-F* or highly polished stainless steel to reduce background build-up.

*Trade Mark of 3M Co.

The sample cell is mounted in a lead "pig" for background shielding along with a sodium iodide crystal and phototube assembly. The assembly is an "Integral Line" fabricated by the Harshaw Chemical Co., and consists of a thallium-activated sodium iodide [NaI(Tl)] crystal, 2 inches thick by 1.75 inches in diameter, attached to a 2-inch RCA 6342A photomultiplier tube. The phototube is connected to a close coupled pulse transformer. The resulting signal is transmitted to the electronic components in the In-Line Monitor Room, and then to a recorder in the Central Control Room. Lead collimators are placed in front of the crystal in the "pig" on high level streams to reduce count rates and exposure to the phototube.

During operation, the sampler jet is turned off for five minutes every hour to measure the cell background, which usually varies less than ± 2 percent during a 20 to 30 day run period. Extremely high level gamma exposure for a long period can cause the background to rise and necessitate decontamination or replacement of the cell. Experience to date has been excellent with very few replacements required.

Development work is underway to improve the sample cell capability for maintaining a low background. Sample cells fabricated of KEL-F and highly polished stainless steel have given the most reliable service.

The major fission products which must be removed from the product streams in the Purex Plant are ^{95}Zr -Nb and, to a lesser extent, ^{106}Ru -Rh. Gross gamma monitoring systems, counting all gamma energies above 0.45 MEV are used to determine gamma activity of the product streams for each cycle, HAP (organic), 1BP (aqueous), and 2EU (aqueous) (Figures 1, 2, and 3).

There is also a monitor on the recycle organic stream (100) to the organic header. The 0.45 MEV cut-off point is used to discriminate against ^{131}I (0.364 MEV) and ^{239}Pu (0.38 and 0.41 MEV).

Depending on the amount of lead collimation used, fission product concentrations from 1×10^{-1} to 1×10^6 μCi ^{95}Zr -Nb plus ^{106}Ru -Rh per liter have been measured.

These monitors have been very helpful in controlling the operation of each cycle, particularly the HA Column. Since the feed solution to the HA Column is derived from three dissolvers, the uranium concentration varies slightly from batch to batch, thus changing organic saturation in the HA Column. This, in turn causes the fission product level in the HAP stream to vary. The HAP monitor is used as a guide for manual adjustment of feed rate to maintain the fission product level in the HAP stream at a minimum level consistent with low product losses via the HAW stream.

B. Iodine Monitors

The ^{131}I content of the off-gases from each of three dissolvers and from the dissolver off-gas acid recovery system is measured by gamma monitor systems similar to those described previously, except that a single channel analyzer is used instead of a discriminator. The analyzer window is set to measure 0.344 to 0.384 MEV which centers the ^{131}I peak at 0.364 MEV. The sample cell used is a modified one-liter stainless steel beaker coated with KEL-F. A water flush of the sample cell, programmed once per hour, normally keeps the cell background low, although an acetone flush is

occasionally required (~ once per year). The monitors are used to determine the effectiveness of the iodine adsorbers which are associated with each dissolver. The monitor on the acid recovery system provides an indication of the ^{131}I discharged to the atmosphere via a filter and the main building ventilation exhaust stack.

C. Neptunium Monitor

A gamma monitor similar to the iodine monitor is used to measure the effluent stream from the neptunium anion exchange column (Figure 7). The total product stream flows through the monitor sample cell. It has in addition to a single channel analyzer, a base line sweep generator that continuously varies the threshold setting of the pulse height analyzer from 10 to 0 volts, with a one percent window. Normal sweep time is 5 minutes. The analyzer is calibrated for 0 - 0.5 MEV over the 0-10 volt range using a ^{133}Ba source. The output of the CRM goes to a variable speed strip chart recorder operating at 12.5 MM per minute chart speed. Thus a normal scan covers about 2-1/2 inches of chart. Figure 8 shows typical loading and elution scans used to help differentiate between ^{228}Th and ^{237}Np which have about the same energy levels. The ^{228}Th peak is much broader than the ^{237}Np peak.

D. Ion Chamber Gamma Monitors

Ion chamber gross gamma monitors are mounted in sleeves in the concrete shielding wall opposite about 20 canyon vessels. The sleeves terminate in the sample gallery, which allows contact maintenance of the ion chamber and cables.

A 3/16-inch steel plate isolates the canyon atmosphere from the ion chamber sleeve. The ion chamber is connected to a pico ammeter, in either the In-Line Monitor Room or control rooms, and then to the recorder in either of two control rooms. The monitor on the first cycle uranium product (1CU) concentrator has been quite effective in measuring the fission product content of the uranium stream from the partitioning cycle. The monitors on dissolver product centrifuges have been very helpful in measuring solids build-up and clean-out.

V. ALPHA MONITORS

The plutonium concentrations of several process streams are measured by alpha monitors located at manual sample stations (Figure 4). Each monitor has a stainless steel flow cell which encloses a scintillator, consisting of a 0.001-inch cerium-activated surface on a 1/4-inch thick by 3-inch diameter Vycor* type 7913 disc. The process stream is in direct contact with the activated surface. The scintillator is attached with epoxy cement to an EMI 96561KB photomultiplier tube. The phototube is connected to a pre-amplifier located within 10 feet of the detector. The amplified signal is transmitted to the electronic components located in the In-Line Monitor Room and from there to a recorder in the Central Control Room (Figure 6). In addition, four of the monitors are connected to the Scaler-Teletype system.

Early development work on glass scintillators was done by U. L. Upson ⁽¹⁾ and C. E. Huck, ⁽²⁾ with the most recent work done by O. H. Koski. ⁽³⁾ The first glass scintillators used had a 0.010-inch

*Trade Mark of Corning Glass Works

cerium-activated surface and were used on the waste stream from a plutonium anion exchange column. This contained $^{106}\text{Ru-Rh}$ at levels of about 1 to 25 uCi per liter which gave no interference to plutonium measurements. When a similar monitor was installed on the 2AW stream, beta interference occurred at a level of about 500 uCi $^{106}\text{Ru-Rh}$ per liter. The work of O. H. Koski showed that changing the thickness of the 2AW alpha monitor cerium-activated layer to about 0.001 inch, and with proper setting of the discriminator unit, ^{239}Pu concentrations as low as 1×10^{-4} gram per liter could be measured in the presence of 0.3 Ci $^{106}\text{Ru-Rh}$ per liter and 0.3 Ci $^{95}\text{Zr - Nb}$ per liter.

The range of measurement with the current sample cells has been 1×10^{-4} to 30 grams ^{239}Pu per liter. The higher ranges require the use of a single channel analyzer instead of a discriminator unit to allow only a portion of the energy spectrum to be measured, thus reducing the total counts. This technique reduces the lower measurable concentration level to about 0.1 gram ^{239}Pu per liter.

The alpha monitors are located on the 1BP, 1BSU, 2AW, 2BP, 3AF, 3AW and 3BW process streams (Figures 1 and 2). They are used for criticality prevention to ensure that the ^{239}Pu entering non-geometrically favorable vessels remains at safe levels. They are also used to keep ^{239}Pu losses from certain columns, such as in the 2AW and 3AW streams, at some fixed value in order to improve the fission product decontamination for that column. Since the streams are recycled, the plutonium is not truly lost. The monitors have been very helpful in maintaining tight control of the plutonium-bearing streams by allowing adjustments to be made quickly before analyses from manual

samples can be obtained.

Alpha scintillation monitors are used successfully in the Purex Plant since the ratio of plutonium isotopes for a given run period is known. Changes in the ^{239}Pu to ^{240}Pu ratio can change the total counts read by the glass scintillator since it measures any alpha present. Appropriate adjustments in interpretation of the data are therefore necessary. These monitors were used successfully during a recent thorium campaign to measure ^{233}U concentrations. New calibration curves were made, since the number of alpha particles emitted per gram are less for ^{233}U than for ^{239}Pu . The presence of ^{232}U could radically change the count rate since it produces considerably more alpha particles per gram. This problem was not experienced during the campaign, however, since the ^{232}U concentration was kept to a minimum.

Alpha scintillation monitors have also been used in locations where the total process stream flowed through the alpha cell at pressures up to 60 psig. These were on waste streams from the final plutonium anion exchange columns (previously mentioned), which have been replaced by the Third Plutonium Cycle pulse columns.

VI. NEUTRON MONITORS

A. Plutonium Measurement

The plutonium concentrations of certain process streams are measured directly by neutron monitors located remotely on a vessel or a pipeline (Figure 9). One or two boron trifluoride (BF_3) tubes mounted in a paraffin moderator measure the neutrons resulting primarily from (α n) reactions in the process solution.

It was necessary to develop special coaxial connector heads to transmit the electronic signal from the BF_3 tubes through the concrete shielding wall to the electronic equipment located in the In-Line Monitor Room. The standard Hanford remote electrical wall connectors used for all other electrical systems in the canyon cannot handle the necessary high voltages (1500-2000 volts). The high voltage causes an electrical leakage called a corona discharge which appears as noise on the signal cable, and can be mistaken for a normal signal. Recently, coaxial cables have been installed directly from the BF_3 tubes through a pipe connector in the shielding wall to a pre-amplifier located in the pipe and operating gallery. Replacement of the cables on a one year cycle is expected to be necessary.

The neutron probes are used to measure ^{239}Pu concentrations of 1×10^{-2} gram per liter to 10 grams per liter. Even though the actual count rates obtained are relatively low (2-1000 counts per minute) for the ^{239}Pu values above, the monitors have proven quite reliable and helpful in determining ^{239}Pu concentrations in the various streams.

Neutron monitors are located on the HAF feed tank, the 1BX column, the 1BXP stream, and the 3WB recycle vessel (Figures 1 and 9). Only one probe was originally mounted on the 1BX column, and it could be raised or lowered by the remote crane to give a ^{239}Pu profile in the column. Three probes are now located five feet apart vertically on the lower section of the

column and provide instantaneous indication of changes in the ^{239}Pu profile. The monitors have been very helpful in detecting loss of plutonium-uranium partitioning during routine operation, thus allowing corrective action to be taken before the product streams were out of specifications. In addition, the monitors have allowed various nonroutine reductant tests to be made safely in the LBX column by indicating changes that could never have been detected by manual samples.

Neutron monitors are used successfully in the Purex Plant since the ratio of plutonium isotopes for a given run period is known, and only the nitrate form is present downstream of the dissolvers. Changes in the ^{239}Pu to ^{240}Pu ratio make a considerable difference in the number of neutrons emitted and must be taken into account when interpreting the calibration curves.

B. Cadmium Nitrate Monitor

A solution of cadmium nitrate, a neutron poison, is used as the motive fluid for a jet transferring high concentration ^{239}Pu solutions to a non-geometrically favorable vessel for rework of out-of-specification plutonium solutions through solvent extraction. The cadmium nitrate makeup tank is equipped with a neutron source mounted with a BF_3 tube at the bottom of the tank. The BF_3 tube signal is transmitted to a pre-amplifier located close by, then to electronic equipment in the In-Line Monitor Room, and finally to a recorder in the Central Control Room. As the cadmium nitrate concentration increases, it absorbs more

neutrons, so fewer are counted. A converter between the CRM and recorder reverses the signal so that an increase in the cadmium nitrate concentration causes a corresponding increase in the recorder reading (actual counts will decrease). The pump which supplies cadmium nitrate solution to the transfer jet is interlocked with the monitor so that the pump will not operate unless the cadmium nitrate concentration is above a minimum value. The range of measurement is 0-100 grams of cadmium nitrate per liter.

VII. MONITORS USING PHOTOMETERS

A. Nitrite Monitors

Sodium nitrite is added to the Second Plutonium Cycle feed (2AF) tank to adjust the plutonium to Pu IV. A slight excess is usually added to assure complete oxidation of the plutonium, but a large excess is undesirable. Pu IV is extracted into the organic phase of the 2A column. If the plutonium is not oxidized, it will remain in the aqueous phase and exit the 2A column via the 2AW stream and be recycled to the 3WB concentrator, which is not geometrically favorable for high plutonium concentrations. On the other hand, if a large excess of sodium nitrite is added to the 2AF tank, the nitrite will be extracted into the organic phase and be transferred to the 1BXF tank via the 2BW stream. The nitrite will then enter the 1BX column where it will react with the ferrous sulfamate reductant added to the column for adjustment of the plutonium to Pu III. This will cause the plutonium to remain in the organic phase with the uranium, instead of being partitioned into the

aqueous phase away from the uranium.

It is very difficult to measure the sodium nitrite concentration in a stream such as the 2AF, particularly by an instrument that must handle radioactive solutions. A. L. Boldt (ARHCO) suggested the possibility of determining the nitrite concentrations indirectly by measuring the NO_2 in air that is purged through a mixture of nitric acid and sodium nitrite. R. D. Dierks ⁽⁴⁾ of Battelle-Northwest Laboratory studied the system in the laboratory and recommended a duPont 400 photometric analyzer for measurement of the gas phase NO_2 concentration. The equipment was installed in the 2AF tank sampler station (Figure 10), so that any leakage would be confined within the sampler station. The air-operated sample jet pulls a mixture of solution and in-bleed air through a liquid-gas separator so that only the gas phase passes through the photometer. The gas rejoins the liquid before passing through a manual sample cup and then back through the sample jet to the 2AF tank. An air purge can be valved through the photometer for a zero check of the instrumentation and a calibration filter is then moved into place to check the span. Calibration checks are made every two to three weeks.

The normal range of measurement is 5×10^{-5} to 5×10^{-3} M nitrite. Measurements as low as 1×10^{-6} M and as high as 3×10^{-2} M can be made with existing equipment. The light path of the photometer cell can be shortened to provide a higher range of measurement or lengthened to provide a lower range of measurement. This monitor is used as a guide for

manual adjustment of the sodium nitrite addition to the 2AF tank and has proven very reliable.

Tests in the laboratory by R. D. Dierks indicate that a system similar to the 2AF monitor could be used to measure nitrite concentrations as low as 1×10^{-3} M in an organic stream, which is much more difficult than measuring in an aqueous stream. A monitoring system is being installed on the 1BXF tank, but is not yet in operation.

B. Uranium Monitor

A Hanford-designed single-beam filter photometer developed by R. D. Dierks (5), Battelle-Northwest Laboratory, has been in operation on the 2DW stream for about 10 years. The normal range of measurement of the photometer is approximately 5 - 70 grams uranium per liter, however, different cell window spacings can be made to increase or decrease the range. The photometer is installed in a sampler station in a manner very similar to the 2AF nitrite monitor. However, the uranium monitor is much smaller because the uranium concentration in the solution is measured directly and the extra equipment for air separation and calibration is not required. Calibration is made with uranium present by using a calibration filter to give a wavelength of 535 millimicrons. The adsorption of this wavelength is unaffected by changes in uranium concentration. The monitor is used as a guide for manual adjustments of the 2DX rate to maintain a uranium loss of about 5 percent from the 2D column via the 2DW stream to improve fission

product decontamination and neptunium separation in the 2D column. The uranium in the 2DW stream is recycled through the backcycle waste system (3WB).

VIII. CONDUCTIVITY MONITORS

A monitor to measure nitric acid concentration in radioactive and non-radioactive streams was developed by O. H. Koski⁽⁶⁾, Battelle-Northwest Laboratory. An electrodeless conductivity type monitor was chosen as the most desirable design for remote installation and for radioactive solutions. The distinguishing features of the electrodeless conductivity system are as follows:

1. The fluid being monitored forms part of the one turn coupling circuit between a driven toroidal transformer and a pickup or receiver toroidal transformer.
2. The cell consists of an electrically non-conductive pipe over which the toroids are slipped, making the monitored fluid a section of the electrical loop coupling the toroids.
3. An external electrical shunt joining the cell end connections or an equivalent solution path completes the in-line portion of the apparatus.
4. The windings of the driver toroid are connected to a power source which induces a current in the secondary or solution loop. The current varies with the solution electrolytic conductivity and induces a voltage in the receiver toroid windings. The receiver toroid output after suitable amplification provides an electrical analog of the conductivity

of the solution.

Monitors have been installed on the HAS, HAW, 2AS and 3BP streams. These monitors can be operated with or without temperature compensation by means of a selector switch.

A flow-through type conductivity cell is installed on the HAS stream process piping in a contact-maintained area in the sample gallery (Figure 11). The signal from the cell is transmitted to an amplifier and recorder located in the Central Control Room. The HAS acidity is controlled at 2M to maintain low plutonium losses from the bottom of the HA Column. The normal range of measurement is from 1 to 3 M nitric acid. The monitor can be adjusted for higher or lower ranges and the span can be narrowed or widened.

A probe-type conductivity cell is located in a pot on the HAW line in the canyon behind the concrete shielding wall. Since this stream is very radioactive, the cell was fabricated of materials that will withstand radioactive damage for a minimum of two years. The signal wires from the cell are connected by means of an electrical jumper installed remotely by a crane to a canyon wall electrical head, and then via wires imbedded in the concrete shielding wall to a contact-maintained zone. The final wire run is to an amplifier and recorder located in the Central Control Room. This monitor has been helpful in controlling the acidity of the HAW stream by providing a guide for manual adjustments of the various streams primary the 3WB entering the HA Column. The HAW acidity is adjusted for optimization of

of fission product decontamination and plutonium and neptunium losses from the bottom of the HA Column. The normal range of measurement is 0-6M nitric acid, but the monitor can be adjusted to other ranges similarly to the HAS monitor.

The 3BP stream has a flow-through cell located in a sampler station with a sample jet pulling solution through the cell. The signal from the cell goes to an amplifier and recorder located in the control room. The acidity of the 3BP stream is controlled very closely to prevent plutonium polymer formation in the plutonium stripper.

The 2AS conductivity monitor is a modified Foxboro type probe but will be changed to an electrodeless type with a range of 0.5-1M nitric acid in the future. New monitors to be installed on process condensate streams in the near future will be capable of measuring as low as 0.01M nitric acid.

IX. FLUORIDE MONITOR

A fluoride monitor was developed to provide support for a process test of the use of fluoride to improve the ^{95}Zr - Nb decontamination (10-100 fold) in the HA Column when processing aluminum-clad fuel elements. An Orion specific ion electrode used with a Beckman Lazaran reference electrode was installed in the HAS stream (Figure 11). The Lazaran electrode allows operation at solution pressures of 15-20 psig with no problems. The signals from the electrode go to a digital readout amplifier located within 15 feet of the cell and then to a recorder in the Central Control Room.

The range of measurement is 1×10^{-4} to 3×10^{-2} M fluoride.

X. OTHER MONITORS

Most of the liquid and gas streams leaving the Purex Plant have either a gamma, beta, or alpha monitor depending on stream composition. Development work is being done on cells and detectors to provide lower detection limits and maintain low background readings.

Combustible gas analyzers are located on sample streams from each of the three dissolver off-gas systems and on the vent from the dissolver decladding storage vessel to assist in maintaining the concentration of ammonia and hydrogen below explosive limits while operating this equipment.

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FIGURE 1. FIRST DECONTAMINATION AND PARTITION CYCLE - IN-LINE MONITORS

FIGURE 2. SECOND AND THIRD PLUTONIUM CYCLES - IN-LINE MONITORS

FIGURE 3. FINAL URANIUM CYCLE - IN-LINE MONITORS

FIGURE 4. GAMMA AND ALPHA IN-LINE MONITORS - SAMPLER STATION

FIGURE 5. SCALER - TELETYPE SYSTEM

FIGURE 6. SCHEMATIC OF GAMMA AND ALPHA MONITOR SYSTEMS

FIGURE 7. CONTINUOUS GAMMA SCAN MONITOR
(NEPTUNIUM ANION EXCHANGE COLUMN)

FIGURE 8. NEPTUNIUM ANION EXCHANGE COLUMN GAMMA SCANS

FIGURE 9. NEUTRON MONITOR SYSTEM

FIGURE 10. NITRITE MONITOR SYSTEM

FIGURE 11. ELECTRODELESS CONDUCTIVITY AND FLUORIDE MONITORS