PHASE SEPARATION--
A SIMPLE PROVEN METHOD OF FILTER SLUDGE CONCENTRATION

Channing A. Gerber
Niagara Mohawk Power Corporation

Robert L. Harkins
HPD Incorporated
1717 N. Naper Boulevard
Naperville, Illinois 60566

ABSTRACT

Niagara Mohawk, Nine Mile Point NPS, installed and has operated for one and a half years, a Phase Separator System which takes backwash from various filter sources and thickens them to a concentrate for disposal. This simple two step process provides clean effluent which is further volume reduced in the radwaste evaporator or if the effluent is turbid then it is returned for reprocessing. The thickener underflow has regularly produced solids discharge of 50%-65% by weight which then is sent directly to solidification.

BACKGROUND

Niagara Mohawk's Nine Mile Point Nuclear Station Unit 1 is a 610 MWe BWR which went into commercial operation in 1969. The plant currently has installed six precoatable filters. Two in the Reactor Clean-up System, two in the Fuel Pool Filter, one Drain Filter and one Waste Collector Filter. This equipment is basically as originally installed. The Floor Drain Filter is being revamped to be used as a Waste Collector Filter. Floor Drain and Chemical Waste are not filtered prior to being processed in the High Solids Evaporator, since this only produces more waste with little benefit.

In addition to the above filter blowdown, backwash from the Reactor Clean-up and Fuel Pool Filter Sludge Tanks is transferred to the Waste Filter Sludge Tank. This is a 9000 gallon horizontal cylindrical tank equipped with a blower for agitation and a 20 gpm centrifugal transfer pump.

The original equipment for processing filter backwash was a horizontal centrifuge after the collector tank. The dewatered filter sludge dropped into a hopper where the sludge was discharged into 55 gallon drums for disposal. This equipment was initially augmented by a travelling belt filter whose dewatered sludge was handled the same as the centrifuge. Eventually use of the centrifuge was discontinued in favor of the travelling belt filter due to operational problems with the centrifuge.

In 1978, it was determined that the existing equipment for processing filter backwash did not reliably dewater the sludge to a satisfactory volume for disposal. This, as well as high exposure for operations and maintenance personnel (10 man rem/year), led Niagara Mohawk to investigate other methods which would accomplish two major tasks while meeting three goals (Fig. 1).

Task 1. Because of the existing equipment and its rating a 20 gpm throughput was necessary to enable the Radwaste Facility to meet backwash processing demands that were included in the original design.

TEST OBJECTIVES

The tasks
1. Process the total filter backwash at 20 gpm.
2. Provide a pumpable slurry for solidification or in-cask dewatering.

The goals
1. To size the equipment so that it could be retrofitted into available space on the lower elevations of the Waste Building.
2. Minimize the number of moving parts.
3. Design the equipment with ALARA in mind.

Fig. 1. Tasks and Goals.

Task 2. The filter sludge that was discharged from the existing equipment was not pumpable, at least not by reasonable means. NMPC required a compromise between a slurry that could be pumped and one that could be solidified economically, if required.

Goal 1. The two elevations below grade (el 248', el 236'-6") were virtually empty, having been designed for future expansion of the drum storage conveyor system. This area was considered ideal for this application since it would involve minimal interference with existing systems and require installation of very little additional shielding as well as being close to the Filter Sludge Storage Tank.

Goal 2. The selected system had to be reliable while assuring simple operation and maintenance. Previous equipment contained many moving parts and operated at high speeds. NMPC needed to have a more passive system as opposed to the existing brute force method.

Goal 3. Operation and maintenance of the new equipment had to minimize radiation exposure. Neither of the original units were really of "nuclear design". ALARA wasn't in the vocabulary when this equipment was designed.

PHASE SEPARATOR DEVELOPMENT

HPD Incorporated was approached by Niagara Mohawk to assist them in the development of an improved filter sludge system. The primary objectives were to provide a system which had minimum operating equipment, was easily maintainable (low radiation exposure) and provide a significantly dewatered sludge. Based upon earlier developmental testing, it was determined that a sludge concentrating system consisting of two steps was feasible. This system initially had one clarifier vessel discharging into one thickener vessel. The clarifier vessel was designed to accept the full load of filtrate sludge and with the addition of a minute quantity (ppm) of flocculant agent effect quickly an excellent separation of phases. The bottoms would then discharge to the thickener and the clarifier overflow being released either to the evaporation sump or back to the sludge filter tank.

The thickener would accept several dumps of clarifier bottoms sludge from the clarifier on a timed basis. When the thickener had been filled with concentrated sludge, the system would be ready to final dump. The dump would occur by remote operation of a ram type discharge valve. In order to assure sludge fluidity and pumpability, shear had to be effected. Thus a two level agitator mixer was considered rather than a single level.

Two thickeners were incorporated into the final design based upon the overall physical constraints of the existing building (Fig. 5) and by the need to maximize the retention time of the sludge in the thickener vessels. Each thickener has a discharge line from the clarifier, each with an automatic ball valve which cycles on a timed basis. Each thickener can hold several dumps from the clarifier.

Due to physical height constraint and satisfactory fluidity tests ram valves were not needed on the clarifier, only on the thickener bottom. Ball valves have proven to be sufficient on the clarifier. However, there are air sparge points at the bottom on both the clarifier and each thickeners.

In order to assure fluidity and gravity flow of bottoms from the clarifier a 60 deg cone bottom was incorporated. The thickener, however, due to height limitations has a sloped bottom. Based on the overall head pressure and ability of the agitator and recirculation pump to fluidize the solids, sludge flow is assured.

Also included in the design to help determine load concentration was the installation of load cells for each thickener and used as a check to anticipate high turbidity level to pump out the sludge concentrate from the thickener.

A final consideration from the initial design to actual operating concept was to install a recirculation line and use the sludge discharge pump to bring sludge from the bottom of the tank to the top to further insure the fluidity of the solids at the time of dump.

The decision to add flocculating agent was made based upon initial studies by HPD as directed by Niagara Mohawk, on several flocculant agents. In order to maximize the mixing of floc agent with the clarifier stream the floc agent was added into the transfer line from the sludge tank to the clarifier vessel thus upon entry into the clarifier vessel maximum mixing had already occurred and time for settling would be optimized within the clarifier vessel. The floc tests were conducted by standard jar settling method and preliminary results indicated that 60% solids by volume could be obtained from thickener underflow.

Process Design (Fig. 2), an existing 9000 gallon filter sludge storage tank receives filter sludges

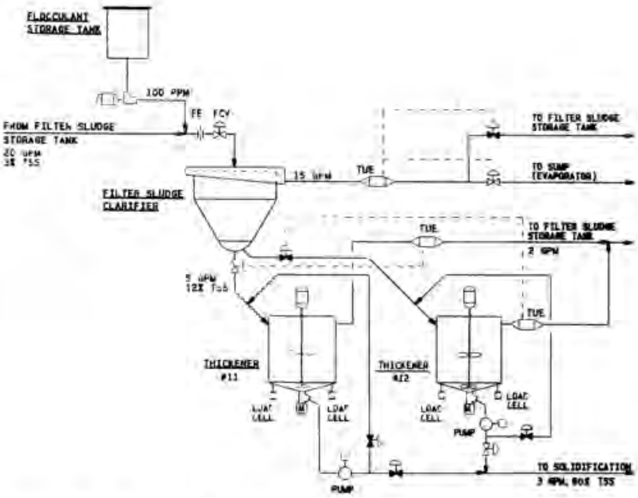

Fig. 2. Phase Separation Flow Diagram.

from several sources. When this sludge tank is full, the contents are pumped to the phase separator filter sludge clarifier vessel, either continuously or intermittently based upon level control. A 3% TSS feed from filter sludge tank is pumped at approximately 20 gpm to the clarifier vessel with the flocculant agent being added at a maximum concentration of 150 ppm. As the filter sludge tank transfer pump is started, the flocculant storage tank agitator mixer and floc addition pump are started to pump a precontrolled amount of flocculant into the transfer line from the sludge tank to the clarifier vessel. Thus during the entire transfer the flocculant mixing is maximized in its run from tank to clarifier, thus assuring maximum wetting of the filter sludge. This flocculant wetted sludge is metered through a flow control valve and discharged into the top of the clarifier vessel.

The clarifier vessel (Fig. 3) is a cylindrical straight-sided vessel with a 60 deg cone. It is made of 304 L stainless steel with a Number 4 polish on the wetted surfaces for maximum decontamination. The overall volume of the thickener tanks is sufficient to safely hold and process one batch from the sludge filter tank in approximately one hour. After the necessary wetting with the flocculant and allowed settling time the concentrate is ready to be discharged to one of the two thickener tank vessels.

At the bottom of the clarifier at the axial point and at an offset point are individual discharge lines. Each with a controlled ball valve to discharge directly to the appropriate thickener tank. The bottoms concentrate is approximately 12% solids by weight, and gravity flows direct into one of the two thickener tanks. The determination as to which thickener tank is made by the operator based upon availability of either thickener tank.

As each draw from the clarifier occurs, the available thickener tank volume is incrementally increased with the wetted settled sludge. The clarifier overflow is monitored by a turbidity element which is

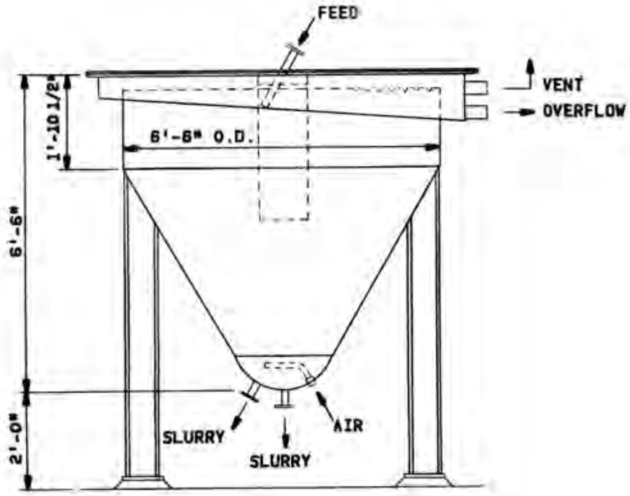

Fig. 3. Phase Separation Clarifier.

interlocked back to the feed line to the clarifier. This continues until the overflow high turbidity alarm is signalled. At a turbidity upset, the flow of sludge to the clarifier is stopped. Based upon turbidity quality of the overflow, the supernatent from the clarifier is either directed back to the filter sludge storage tank or to sumps to be final processed at the HPD evaporator.

The thickener has a rectangular straight side design with sloped bottom (Fig. 4). The thickener has a significant settling period so that maximum settling and action of flocculant agent and water/sludge phase separation is assured. The high turbidity interlocks with the clarifier bottoms dump valve associated with the appropriate thickener to prevent further discharge of sludge to the thickener. At this time, the alternate thickener tank may be selected. Key lock switches controlling the inlet valves to the thickener tanks allow isolation and protection of the batch for process control purposes. The contents of the thickener tanks may be routed to one of three points for final processing.

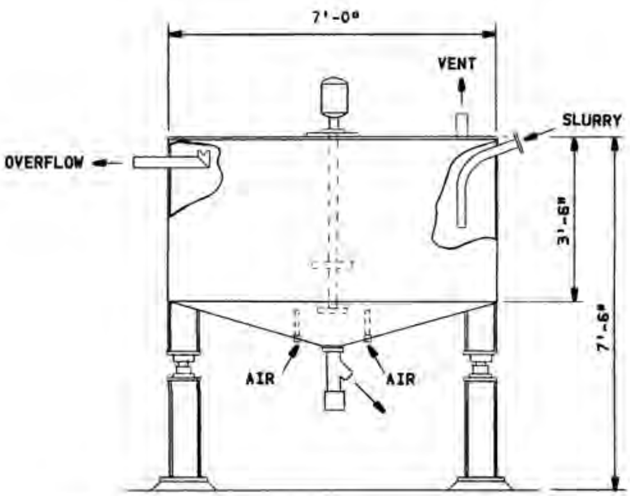

Fig. 4. Phase Separation Thickener.

Once the thickener tank has been emptied of its concentrated sludge, the tank is washed down and the lines are flushed with the washings returned to the filter sludge storage tank.

Just prior to the dump of concentrated thickener tank sludge (at about 60% total solids by weight) the operator initiates a fluidizing action by turning on the mixer agitator at the bottom of the tank. Secondly, the valves are switched to recycle sludge from the bottom through the singular discharge ram valve back to the top of the thickener tank and the diaphragm pump is started. These two steps assure maximum pumpability during the emptying and transfer to solidification. Sampling takes place in this mode also.

The supernatent overflow from the thickener is returned to the filter sludge storage tank, independent of turbidity for recycle thus assuring zero discharge of turbid water.

INSTALLATION

The available space was limited in space and access (Fig. 5). To insure that the Thickener Tanks would fit through the various openings and to insure proper orientation for maneuvering to the point of installation, a wooden template framework was built to the same dimensions as the Thickener Tanks. This represented the thickener as it would be passed through the confined area and eliminated the chance of injury to the workers as well as damage to the equipment and structure.

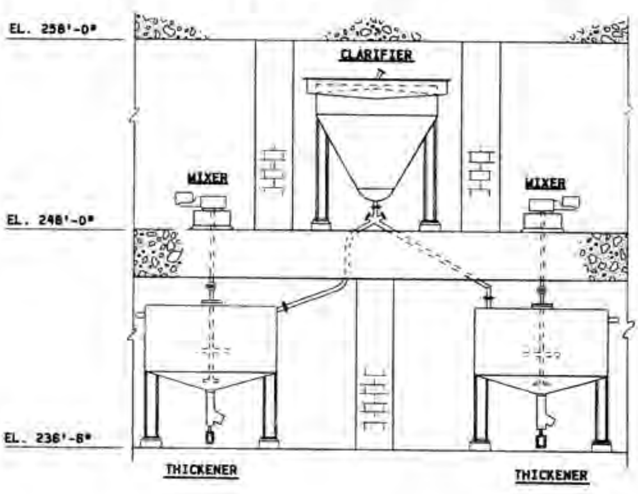

Fig. 5. Phase Separation Elevation.

It was necessary to remove a stairway, some conduit and a door frame to get the Thickener Tanks to their final destination. The floors in this area of the plant were 30" thick, so core drilling took some time. For the most part installation wasn't too much of a problem. We were unable to connect a return line to the filter sludge tank due to radiation levels in the tank room. A return line has since been run.

START-UP

A pre-operational test was initiated on July 20, 1983 and was completed a few days later. Several interface problems occurred which involved connections between the various tanks and the ventilation system. For instance, the vent was rigidly fastened to the ceiling, which prevented the load cells under the tank from functioning. Another problem that occurred was when the clarifier tank overflowed, water ran into the vent duct. These problems were easily resolved. Another more difficult problem arose with the magnetic flow meter, it just kept failing due to problems in the electronics. A sonic flowmeter was installed as a temporary replacement. A permanent replacement, a Taylor Wedge, was found which has performed flawlessly.

OPERATION

The filter sludge tank had overflowed on a regular basis and the overflow had to be processed in the evaporator due to the fact that the only way the tank contents could be processed was by dewatering in a HIC. The HIC had to be filled while inside a cask for shielding purposes and to avoid air transfers. Since the day of the completion of the Phase Separator preop, the Filter Sludge Tank has not overflowed; filter backwash is processed routinely.

Since the Floor Drain Filter housing is backwashed into the Filter Sludge Tank, we have had problems with the Flow Control Valve (to the clarifier) which is an eccentrically rotating spherical plug, plugging with debris from the floor drain system, i.e., ball point pens, etc. A variable speed motor installed on the feed pump has eliminated the need for the flow control valve. The sonic sludge density system on the Clarifier is so sensitive that it frequently trips the system when flow through the sensor has entrained air which is caused by operation of the clarifier outlet valves. This has been remedied by installing a time delay in the trip circuit. The overflow pipe enlargements on the Thickener Tank need flushing each time the High Turbidity set point is reached, otherwise that Thickener cannot be operated after it has been emptied. Remote flushing capability is going to be installed. NMPC has found that a spray header needs to be installed to clean the weir notches in the Clarifier. We are also considering adding a polymer blending and metering system that will adjust the metering rate according to Clarifier inlet flow. At the risk of making our simple system more complicated, the Radwaste Operations Group has submitted a Modification Request that will resolve the few operational problems as well as to optimize the overall operation of the system.

The amount of solids collected averages 60% by dry weight. A 1 liter bottle will contain about 10% clear water above the solids.

In conclusion, Niagara Mohawk feels that Phase Separator provides a simple method to concentrate filter backwash quickly to a point where it can be economically solidified or transferred for further volume reduction.