SPENT RESIN SAMPLE DEVICE - THE "RAIN GAUGE"

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Abstract

During construction of a 2-1250 MWt Westinghouse plant an assignment was given to provide a means to sample spent resin prior to shipment as defined in USNRC Regulatory Guide 1.21 (1). No guidelines or limitations were given as to method or expense. A goal was established to provide a truly representative sample of spent resin. The two existing methods of sampling were reviewed and determined to be either too expensive or unable to provide a truly representative sample. The new design provides that representative sample capability at minimal cost in dollars, man hours and Man Rems.

INTRODUCTION

Appendix A, section C of Regulatory Guide 1.21 states; "The total curie quantity and radionuclide composition of the solid waste shipped offsite should be determined." (1) Currently there are three methods that are used to make that determination when shipping spent resin to a disposal site:

1. Manual grab sample of the spent resin once its in a shipping container
2. Piston/plunger type sampler installed in the transfer line from the storage tank to the shipping container.
3. Design of the spent resin storage and transfer system in such a way that spent resin can be recirculated and then sampled, usually from the discharge of the recirc pump.

Of those methods;

1. Manual grab samples are usually associated with unnecessary Man Rem exposure and they do not provide a representative sample of the resin in the shipping container.
2. The piston/plunger type sampler extracts a small slug of a discrete segment of the slurry. Therefore, a truly representative sample of the entire resin slurry can not be obtained.
3. The spent resin storage and transfer system, if properly designed, will provide a uniform, representative sample. However, unless the system was originally designed and constructed to accommodate recirculation of the resin slurry, it may not provide the designed sample and redesign would be costly in dollar and Man Rem.

With this in mind four criteria were developed to design a spent resin sample device for plants not originally designed for recirculation of spent resin in a spent resin storage and transfer system;

1. The device must provide a truly representative sample.
2. The device requires no manual operation during sampling.
3. The device must have as few as possible moving parts to minimize potential failure.
4. Design and construction cost, both in dollars and Man Rem, must be kept as low as possible.

When the criteria are met, Regulatory Guide 1.21 (1) can be completely satisfied with minimum cost in both dollar and Man Rem.

CONCEPTUAL DESIGN

The rain gauge concept has been around for a long time and, because of its simplicity and its ability to obtain truly representative samples, it was selected. Basically it is a clear plastic or glass test tube with a flat bottom and graduated marks on the side of the test tube. The test tube is placed outside in an open area with no overhead obstructions. As a cloud rains on the general area where the test tube is placed, the rain indiscriminately fills the test tube to the same level as the surrounding area. For example, if rain falls into the test tube to a level of 5 centimeters, it can be accurately assumed that the surrounding area received the same amount. Had the cloud rained on 400,000 square meters (100 Acres), for example, the volume received would be:

Area x height = volume

400,000 square meters x .05 meters of rainfall = 20,000 cubic meters

Even though the rainfall volume in the rain gauge is .00002 cubic meters, it is a representative sample of the entire 20,000 cubic meters rainfall on the 400,000 square meters. The concept was applied to resin sampling by treating resin as the "rain" and development of the resin "Rain Gauge".

Initial concept was a 3/4 inch stainless steel pipe penetrating near the bottom of a spent resin storage tank, extending upward to approximately 30 centimeters below the spent resin return line nozzle (see Fig. 1). A cap would be placed on the top of the pipe with a small hole drilled in the center. Assuming that the tank would be completely full of water at the start of the transfer, as the spent resin entered the tank through the nozzle, collection of resin beads would begin immediately. Having the "Rain Gauge" approximately 30 centimeters below that nozzle, the drilled cap would catch

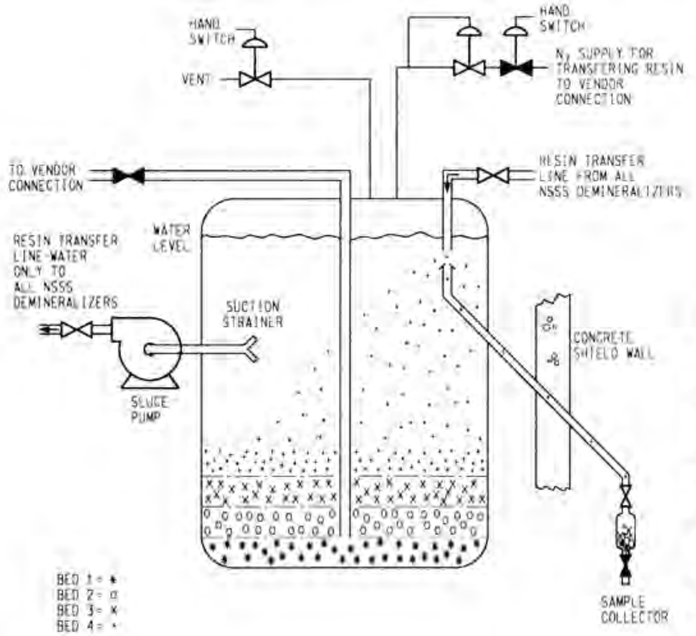

Fig. 1. Filling Empty Spent Resin Storage Tank.

a small number of the resin beads and, by gravitation, would drain them to a sample collector.

The problems with that concept were:

A. If, after testing, it was determined that the size of the hole in the cap had to be changed, man hour and, if at an operating plant, Man Rem would be excessive.

B. The location of the sample collection had to be outside of the spent resin storage tank room for radiation exposure considerations. That meant that a new penetration had to be made at a steep slope (less than or equal to 30° off vertical) so the 3/4" pipe would drain the resin beads to an adjacent room into the sample collector (see Figure 1).

C. Finally, the "Rain Gauge" would collect a representative sample from each specific resin bed as each bed was individually transferred into the spent resin storage tank. However, two complications arose:

i) if the system had the recirc capability and the volume of resin in the tank exceeded the volume being transferred out, a thorough recirculation of the tank would have to be made each time another bed of resin was transferred into the tank.

ii) if the system did not have the recirc capability it would have to be assumed that the same amount of each resin bed transferred into the tank would be transferred out. Because of the flow induced cone inside the tank (see Fig. 2), however, it cannot be assumed that the volume of resin being transferred out of the tank consists of sequential beds just like the beds that were transferred in (see Fig. 3).

After reviewing that design, it became obvious that the ideal sample point was downstream of the spent resin storage tank in the line used to transfer spent resin to the vendor supplied shipping container. If it was possible to gain a truly representative sample of the resin in that line while the slurry was being transferred, recirculation of the storage tank would not be necessary and the sequence of entry and volume of beds in the tank would be irrelevant. That is, if the "Rain Gauge" was in the transfer line, as long as the resin slurry continued a small percent of the resin would be collected. If the slurry was initially transferring anion resin from the bottom of the tank and as the transfer continued, cation resin slowly became the dominant resin in the slurry, that would show up on the collected sample.

With these factors in mind, the initial design and construction was performed and the device was installed in a spent resin transfer system immediately upstream of the vendor connection (see Fig. 4). As can be seen in Figure 5, the sample device is comprised of a 1/2 inch sample tube, plugged in one end with a slot cut in the side of the tube immediately below the plug. The slot was positioned to face upstream into the on-coming slurry. Additionally, as seen in Detail "A" of Fig. 5, the drilled opening in the bar stock was done with very close tolerance (i.e., ±.002 inches) in order to prevent resin beads and fines from lodging between the tube and the bar stock opening. This was done to minimize potential hot spots. As can be seen, the sample tube was held in place with a bored through swaglock fitting. On the open end of the sample tube is a ball valve followed by a quick disconnect, a ball valve, a gauge glass and finally another ball valve. The gauge glass was used for visual observation during slurry transfer. The two ball valves in sequence with a quick disconnect between them provided for easy removal of the gauge glass upon completion of the slurry transfer. The gauge glass and it contents would then be carried to the lab for analysis. A short section of tubing was added to the outlet of the bottom ball valve. That provided the capability of backwashing the sample tube in the event of a clogging of the sample slot or if a radiation hot spot developed in the tube. A bend was made in a vertical transfer line to allow

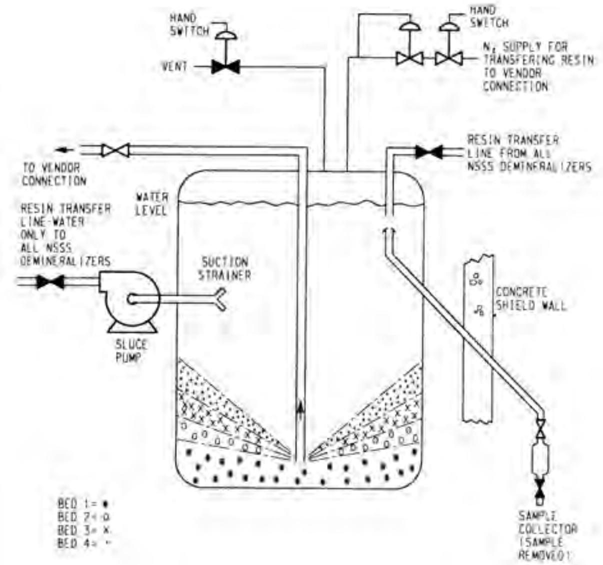

Fig. 2. Transfer of a Portion of Resin Beds to the Vendor Cask.

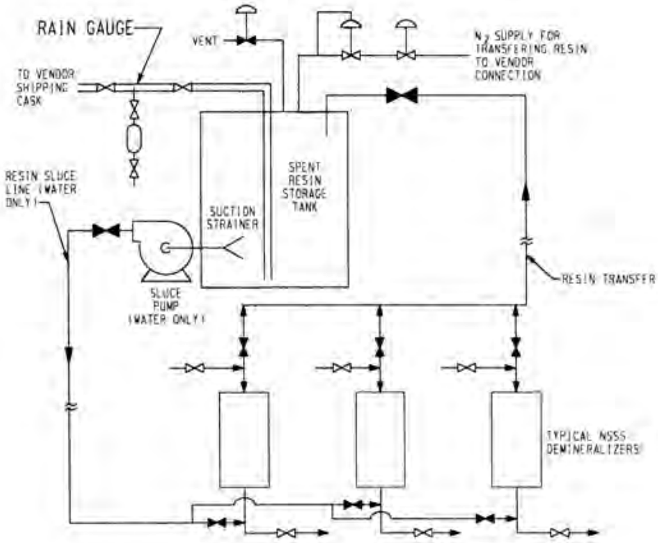

Fig. 4. Rain Gauge Arrangement.

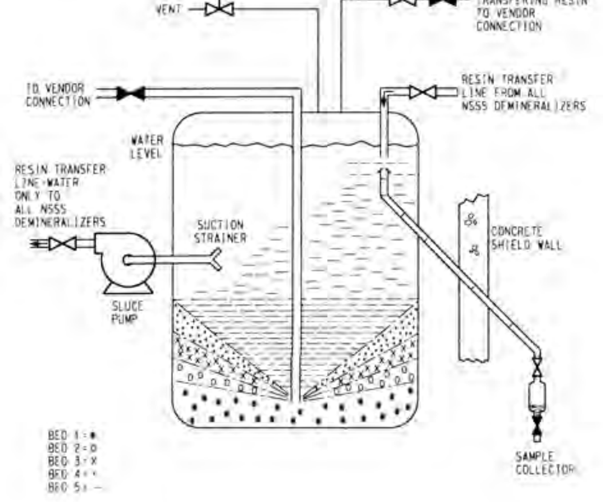

Fig. 3. Filling Spent Resin Storage Tank With Portion of Previous Beds Remaining.

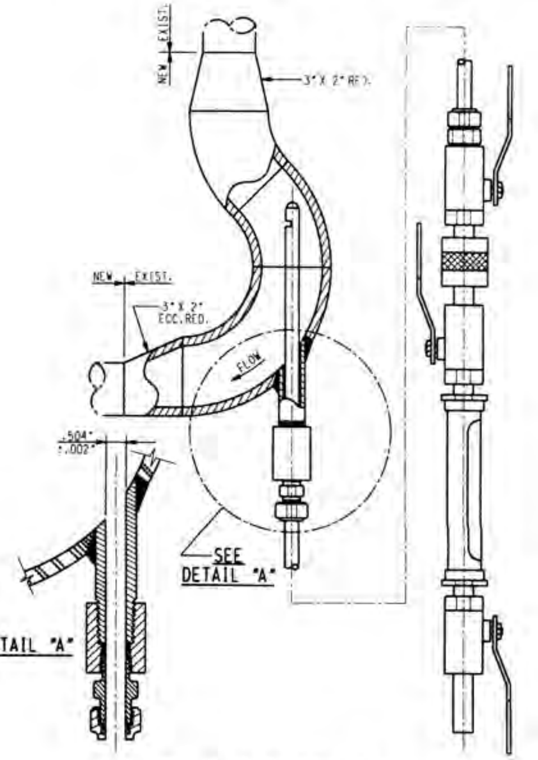

Fig. 5. Initial Design.

vertical insertion of the sample tube and to redirect the flow of the slurry into the slot in the side of the tube.

INITIAL TESTING

After initial adjustments and procedure revisions, testing began by transferring 850 liters (30 cubic feet) of cation resin through the vendor connections into some open bins. During that transfer 40 ml of resin was collected in the gauge glass. Had the 850 liters (30 cubic feet) bed been a highly radioactive bed (i.e., CVCS let down demineralizers), the 40 ml sample would be too much to manage because of the radiation level.

Additionally, because there had been previous transfers of anion resin and because of piping design, some anion resin had settled out in some pockets in the piping. Therefore, when this transfer was begun some of the settled out anion resin was mixed and transferred with the cation resin. Consequently, visual inspection of the bins revealed a small percent (approximately 1%) of the anion throughout the resin. The collected sample, however, had noticeably more anion interspersed with the cation. This questioned the accuracy of the sample. However, it was discovered that during the testing, the sample tube had been rotated 180°. Since anion resin is lighter than cation, the eddy current directed more anion resin into the slot than cation. As long as the slot faced the oncoming slurry, there was no differentiation between heavier and lighter resin.

Finally, during the slurry transfer there were some leaks around the quick disconnect and when the transfer was complete and the quick disconnect was disconnected, a small amount of the transfer liquid was sprayed on personnel around the sample device.

The following corrections were made prior to the final test:

1. The slot size in the sample tube was reduced. The first sample slot produced 40 ml sample from 850 liters (30 cubic feet) resin

$$\frac{40ml}{850\ell x1{,}000ml/\ell}=.0047\%$$

   That was deemed acceptable. If resin transferred to a shipping container totaled approximately 4,532 liters (160 cubic feet) (maximum of a shipping cask) the sample would be 80 ml of the spent resin.

2. The location of the slot with respect to the interior of the piping was changed. (see Fig. 6). The slot was placed to face the oncoming slurry after it had changed direction twice. This took advantage of the secondary flow developed when fluid flowing in pipe changes direction (see Fig. 7) (2).

3. The quick disconnect and one of the two ball valves

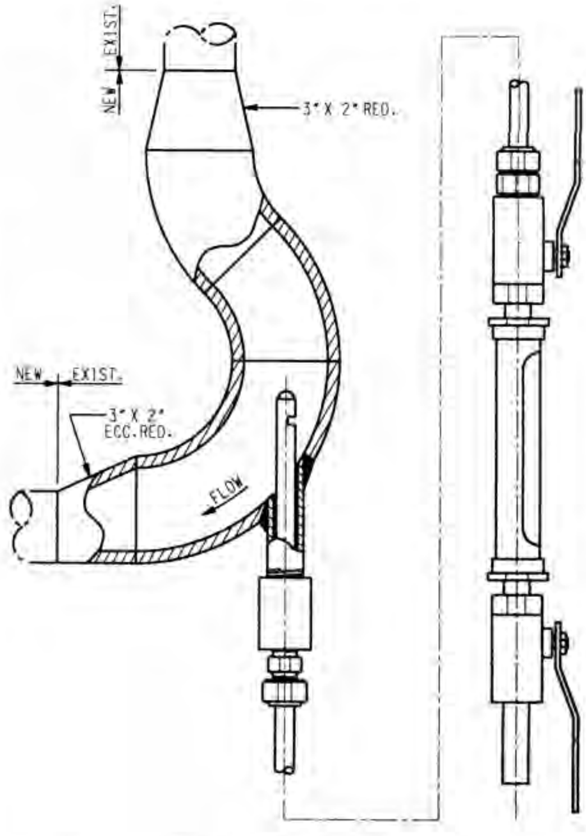

Fig. 6. Initial Design W/Modifications.

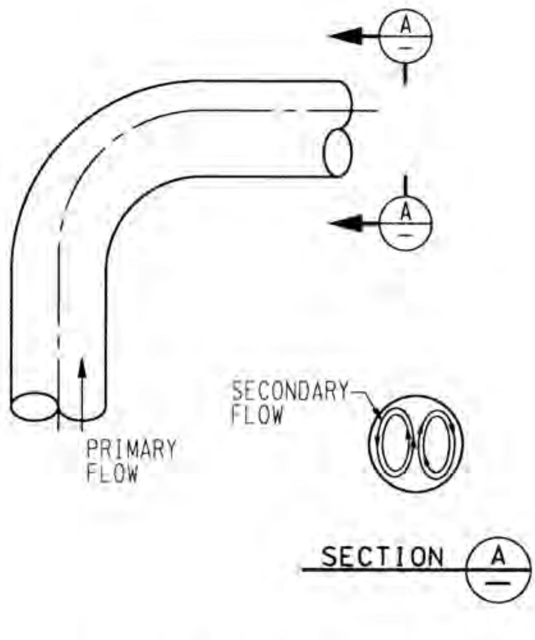

Fig. 7. Secondary Flow.

above the gauge glass were removed because of the potential of spreading contamination. A much simpler and more direct method of transferring the sample upon completion of the transfer is to place a container under the bottom ball valve and while the spent resin transfer system remains pressurized, momentarily opening the valve. The entire sample will immediately drop into the container.

FINAL TEST

With the above modifications completed, an additional test was performed. With that test, 2,266 liters (80 cubic feet) of mixed resin was transferred through the vendor connection into the open bins. During that transfer again 40 ml of resin was collected in the gauge glass. That sample produced 40 ml from 2,266 liters (80 cubic feet) resin

$$\frac{40ml}{2{,}2661x1{,}000ml}=.0018\%$$

That was deemed acceptable. If resin transferred to a shipping container totaled approximately 4,532 liters (160 cubic feet) (maximum of a shipping cask) the sample would be 80 ml of the spent resin.

The mixed bed was Graver GR-3 which is 4 parts cation, 5 parts anion and was compared with the 40 ml sample. The mixed resin was separated with a 2 to 5% brine solution in a 3 centimeter diameter 25 centimeters long test tube. Due to shrinkage, some dehydration, and lattice rearrangement, the sample volume changed to approximately 14 ml cation and approximately 16 ml anion. That is well within the normal range of mixed bed cation/anion percentage. Also, upon visual inspection of the open bins after this transfer, a thin layer of resin fines was floating on 60 to 70% of the water covering the resin in the bins. Consequently, the 40 ml sample also had a thin layer of resin finer floating on top of the water covering the sample. Therefore, this sample was considered truly representative. It produced the correct percent of cation, anion and indicated the presence of measurable resin fines.

LATEST DESIGN

After testing it was decided that future design should do nothing more than install the "Rain Gauge" in a horizontal run of resin transfer piping close to a 90° bend (i.e., within about 5 x bend radii). By not changing the diameter of the piping, the flow would remain turbulent or, at least transitional and the 90° elbow will provide the full affect of secondary flow (see Fig. 7) (2). Additionally, the gauge glass will be replaced with a sample bomb. That arrangement provides a larger sample capacity and the ability to shield the sample collector during transfer (see Fig. 8). Finally, this "Rain Gauge" sample device can be used for any particles which are in suspension in the transfer fluid as long as that when the transfer or flow stops, the particles settle out. It is not limited to resin sampling. The patent of this "Rain Gauge" sample device is pending.

ACKNOWLEDGEMENT

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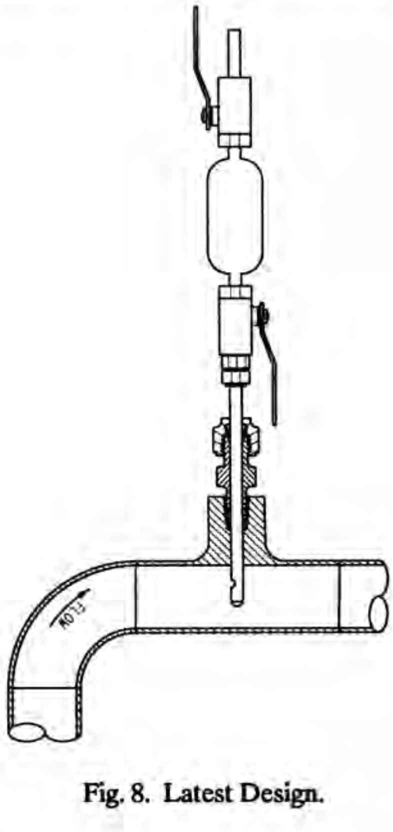

Fig. 8. Latest Design.