END POINT MOISTURE DETECTION FOR DEWATERED MEDIA A NEW APPROACH

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ABSTRACT

Since free-standing water criteria were promulgated for dewatered low-level radioactive filter and/or ion-exchange waste media in 1980, many methods have been established to ensure compliance. Tests on simulated media have been conducted, and analogies then drawn to extrapolate results to dewatering media in the field. Usually, extended dewatering times have been utilized to provide a margin of safety. All methods use some correlation of test data and a field-measured dependent variable to predict the amount of moisture present in the media for end point determination.

This paper summarizes available methods for predicting media moisture content, and presents a new solution by employing in-situ moisture analysis of the media, eliminating the uncertainty of test data extrapolation. The system is applicable to sludges, precoats and resins.

INTRODUCTION

For nearly a decade, dewatering systems have been used to process waste at nuclear generating stations (Typical Dewatering System, Fig. 1). At the present time, dewatering is on the upswing; and as a greater number of containers is processed, the chances for a container exceeding the regulatory guidelines increase. Licensed generators are requiring a greater degree of assurance that the dewatered containers meet disposal site and NRC free-standing water criteria. Regulatory agencies at the disposal sites have become more vigilant in their efforts to ensure the criteria are met. At the Barnwell Site, liners are punched on a random basis to ensure they conform to the regulatory requirements.

Numerous attempts have been made to address the problem of "when is it dry enough"? Systems employing water drainage versus time, relative humidity of a recirculated airstream and water collection rates have been used, and are effective in many instances. However, the problem which appears to be very simple is in reality complex. Although using the same base media, no two waste generators supply the same media for dewatering. Neither media testing programs or modeling to perform a sensitivity analysis is feasible for all wastes. It would be prohibitively expensive and time-consuming. Tests of this type would require establishing the boundary conditions for each of the individual parameters affecting the test. Many full-scale evaluations requiring extensive sampling would be necessary to bracket all conditions.

Chem-Nuclear, recognized the problems associated with end point determination, and embarked on a program of in-container moisture detection. Research was initiated on a Moisture Detection System (MDS), which was required to measure the presence of interstitial and adsorbed water. This was accomplished by analyzing the electronic field coupling characteristics of a large volume of moist media surrounding a sensing probe located in the media. The presence of the water molecule creates a unique physical property which is monitored by this innovative approach. To date, Chem-Nuclear has evaluated a number of different media including mixtures at its testing facility in Barnwell, South Carolina, and has conducted field tests at two separate utilities.

In summary, a development program has been completed which demonstrates that an electronic in-container moisture detection system has been developed and tested. This system provides repeatable results and detects a completion point below the equilibrium of any media, or mixture of medias; thereby, ensuring much less than 1/2% free liquid in the container.

THE PROBLEM

Methods of Dewatering

Several process methods are currently used to remove the liquid from the container:

- Gravity drained and bottom water pickups.
- Centrifuge
- Filtration
- Compression
- Forced air drying

Some of the above mentioned processes work well with one type of media but may not work very well with another. Most plants use dramatically different filtrate media for diverse filtering applications. In addition, when the media are discharged to the disposal container, the different filtrate media may be mixed together. The filtrate itself may also contain quantities of unknown contaminants, such as micro-organisms, organic slimes, oils, etc. As generating stations attempt to improve their water quality and reduce the volume of disposed waste, new media will be developed to meet their goals. In addition, these plants will try varied combinations of existing or new media to improve their

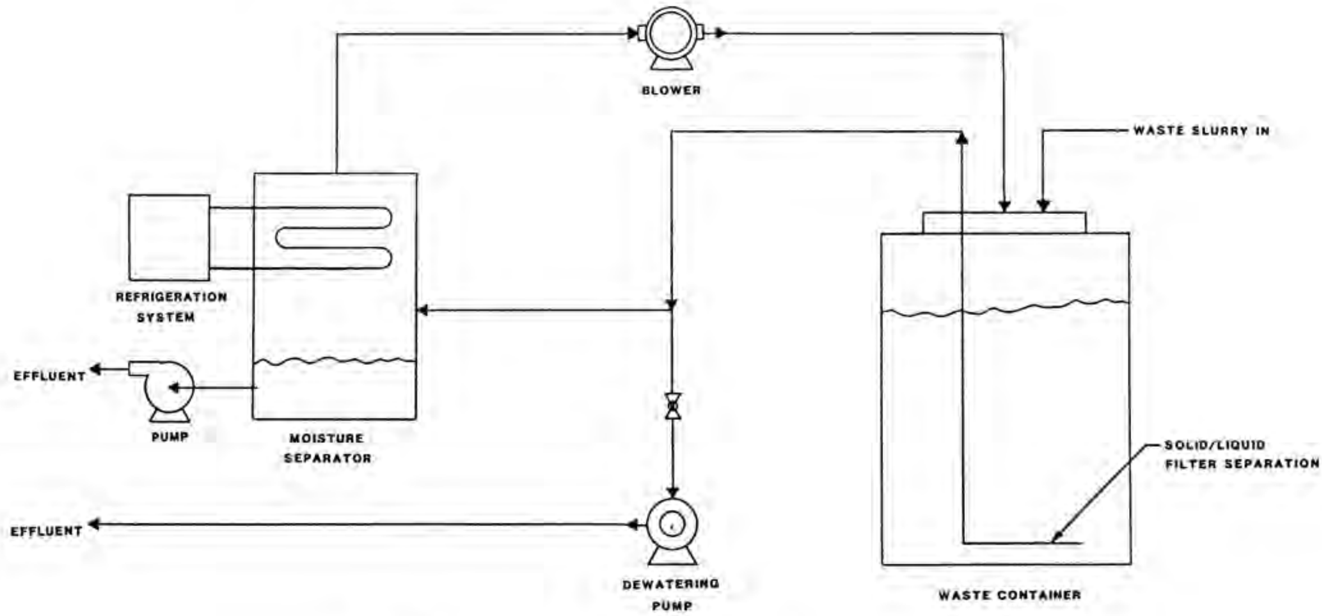

Fig. 1. Typical Dewatering & Drying Process System.

performance. The exact composition of the waste received is usually unknown, or at best, uncertain. Therefore, although a system may work very well in the test on a particular media, and the end point determination for that media may be valid, it is difficult to correlate the testing performed by a simulated development program with the actual media being delivered to the disposal container.

Sources of Drainable Liquid

Drainable liquid comes from two major sources:

- Low waste density areas containing large amounts of water.
- Interstitial voids within the media.

If the container is loaded properly from the bottom up with solids, the waste will have a uniform and high density. To achieve uniform density, the effectiveness of solids deposition during loading will need to be monitored, and process adjustments made accordingly.

Interstitial liquid is that liquid occupying the many void spaces in the media. It is bound by surface tension and capillary action. The majority of this liquid is removed during the loading phase, and residual quantities are removed during the drying phase. Interstitial liquid is the primary contributor to the amount of drainable liquid. Its amount and behavior in a specific media are difficult to predict, and can drain after completion of dewatering by condensation and/or vibration.

Another form of liquid in the container is adsorbed liquid which is at or below equilibrium within the media. Adsorbed liquid is not a contributor to drainable liquid.

THE SOLUTION

The ideal drainable liquid detection system should be capable of determining when all interstitial liquid has been removed from a large sample volume in the container. The system should also be capable of indicating when equilibrium has been reached.

The system Chem-Nuclear has developed and tested over the past year meets these moisture content requirements. It is not necessary to know the composition or equilibrium moisture content of the media in advance. The system is operated remotely from the process container, and does not require the taking of samples. The liquid activity in the container is displayed immediately with no time delay.

Description of Moisture Detection System (MDS)

The Chem-Nuclear moisture detection system continually monitors liquid activity in a dewatering liner during loading and dewatering. The MDS monitors actual media and liquid in the disposal container. The water activity and the resulting solid material formations are graphically represented on a recorder.

The Moisture Detection System (MDS) consists of 5 components: (Fig. 2)

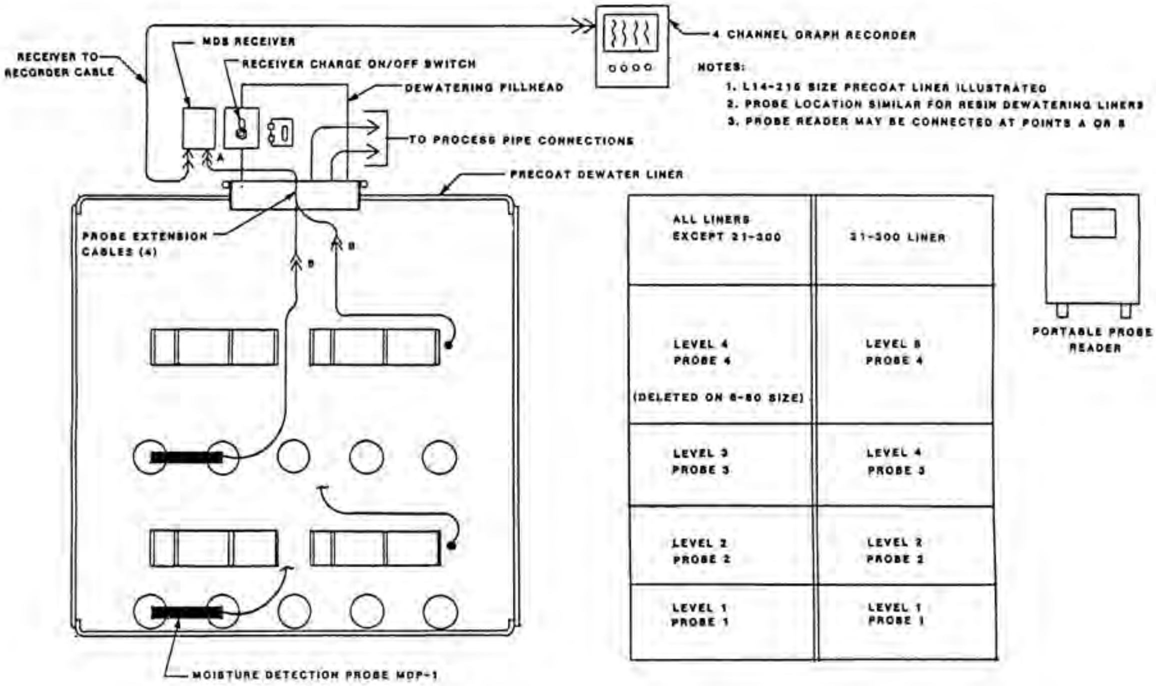

Fig. 2. CNSI Moisture Detection System (MDS).

1. Probes

   Moisture detection probes Type MDP-1. Four probes are used on precoat type containers and three probes are used on granular media containers. Each probe consists of a 1" PVC pipe capped on each end, and a section of coaxial type cable and plug.

2. Moisture Monitor

   Four channel electronic signal generating and receiving package housed in an enclosure which meets NEMA standards. Unit is battery operated with internal 110 VAC battery charging system.

3. Recorder

   Standard four pen, four channel graph paper recorder.

4. Probe Reader

   Portable single probe, single channel reader, battery operated with digital display.

System Operation

A coded electronic pulse is generated by the moisture monitor, and transmitted to the waste media by the probe. The magnitude of the reflected pulse is proportional to the moisture content in the media. The reflected pulse is sensed by the probe and transmitted back to the moisture monitor. The moisture monitor converts the sensed value to an analog voltage which is displayed and recorded. Each of the four displayed traces represents a separate and distinct location in the container.

The volume of media influencing each probe can be represented by a family of parabolas extending upward from the center line of the probe. Equal parabolas of influence measure a volume of 17 cubic feet for each probe. The pulse however, does not have a sharp cutoff, and the volume of diminished influence accounts for an additional 20 cubic feet. This can be related to several typical container sizes as shown in Table I and visually depicted in Fig. 3.

When the waste container is empty, the graph recorder reads zero, and all four pens track together.

When the waste slurry is first delivered to the container, the liquid content is very high. The high liquid to solid ratio results in a large voltage differential, and the pen representing the first probe is driven to the maximum output position. (Fig. 4) As more solids collect in the vicinity of the probe, the signal output is reduced. As the solids are densified, and liquid is displaced and withdrawn, the signal is reduced further. If water is added, the signal will reverse direction in proportion to the liquid in the vicinity of the probe.

When densification is complete, and the container is fully loaded, the gross dewatering process continues to remove remaining interstitial water. As the container is gross dewatered, the signal value is gradually reduced. At

TABLE I

Volume of Media Influencing Each Probe.

Typical Liner Size (Ft^3)	Approximate Volume of Media (Ft^3)	Approximate Volume Percent of Media Measured By Probe
300	305	29
195	186	40
170	160	42
120	114	48
80	76	58

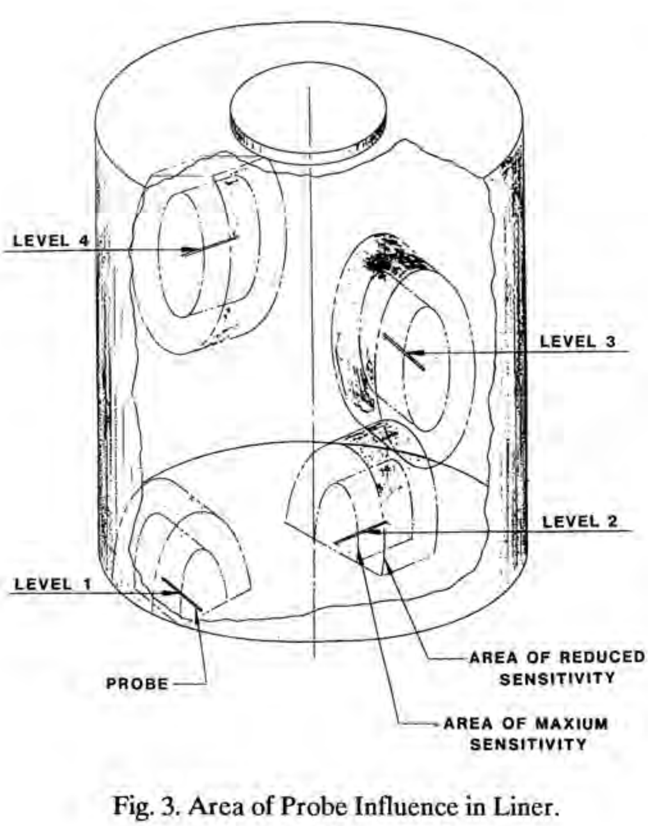

Fig. 3. Area of Probe Influence in Liner.

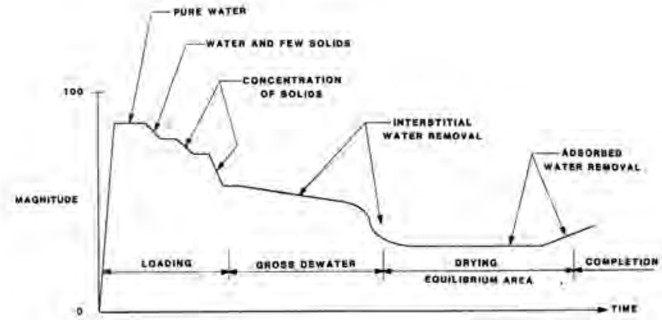

Fig. 4. Typical MDS Process Graph Recording.

the point when the majority of the interstitial water is withdrawn, the signal deflects rapidly toward zero. This drop is the indicator that interstitial water removal is almost complete for that respective area.

Gross dewatering may continue for a period of time, and the signal will remain steady. The drying system is then turned on. As the drying process proceeds, the signal remains steady while very small quantities of tightly bound interstitial water are collected and removed.

When all interstitial water and some adsorbed water have been removed, the signal level increases. This change is caused by mechanical decoupling of the waste particles due to the absence of all interstitial water.

Verification Prior to Shipment

After the dewatering process has been completed, a probe reader is attached to each probe cable end, and a moisture value is recorded for each probe. Prior to shipment, the probes are reattached to the portable reader and checked to make certain that no liquid has precipitated. If the probe reader moisture value indicates an appreciable increase in moisture over the previously recorded level, then the container would have to be re-processed prior to shipment.

Test Program

Chem-Nuclear has conducted numerous full-scale tests of the MDS System with our RDS-1000 (Rapid Dewatering System). The tests were conducted with full size (200 cubic feet) containers utilizing representative waste. The system has been tested with bead resin, precoat and waste mixtures.

The testing program was initiated in small scale tests with a single channel unit, and progressed up to the current four channel unit in full-scale containers. The entire test program was conducted under Chem-Nuclear's NRC approved *quality* assurance program.

The system has also been field tested at two nuclear utilities with actual waste and full size containers.

Testing has confirmed the following:

1. A substantial volume of media is analyzed by each probe, not just the media in the immediate area.

2. The probe is completely insulated from the media. The conductivity of the media does not effect the instrument.

3. The system reading is not effected by temperature, low-level nuclear radiation or electromagnetic fields.

4. The system displays changes in the liquid condition. Therefore, an absolute value at the start of dewatering is irrelevant.

5. The system provides a continuous, written record of the loading and dewatering process as a function of time.

6. The system uses break away connectors at the container interface for ALARA reasons.

7. The probe may be reconnected to an electronic reader at any time to verify moisture levels in reference to the level at the time of completion. Any movement of moisture in the container can be tracked by the system. If additional water enters the liner after processing, the system will detect that water and determine its location.

CONCLUSION

Chem-Nuclear has successfully developed and tested an electronic in-container moisture detection system which aids in loading a dewatering container for maximum and uniform density. The device also provides an effective graphical end point determination without relying on extrapolation of test data.