

**Recommendations for Additional Design Development of Components for the  
SpinTek Rotary Microfilter Prior to Radioactive Service**

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**SAVANNAH RIVER SITE**

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## **Recommendations for Additional Design Development of Components for the SpinTek Rotary Microfilter Prior to Radioactive Service**

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## Reviews and Approvals

### Performing Organization

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D. T. Herman, SRTC, Waste Processing Technology	Date
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M. R. Poirier, SRTC Principal Investigator, Waste Processing Technology	Date
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S. D. Fink, Manager, Liquid Waste Processing Group	Date
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J. C. Griffin, Manager, Waste Processing Technology Section	Date
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### Customer Concurrence

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H. D. Harmon, SPP Technology Development Manager	Date
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P. C. Suggs, DOE Technology Development Lead	Date
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W. D. Kerley, WSRC Project Manager, Actinide Removal Project	Date
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S. J. Robertson, Manager, Closure Process Development	Date
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R. H. Spires, Manager, Salt Processing Program Engineering	Date
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## 1. Summary

The SpinTek rotary microfilter is being considered as an alternative to crossflow filtration. Prior testing evaluated the vendor's standard design for a 1-disk and 3-disk design. We noted several areas of improvement during the testing of the two filter systems that can be included in the 25-disk plant size unit. This report outlines several potential enhancements and improvements to the vendor's standard design which would extend the lifetime of the unit and increase the ability to perform maintenance for units deployed in radioactive service. The enhancements proposed in this report can be implemented to the current design with minimal impact to the cost and schedule of the purchase of the standard unit. An example of this is the replacement of the current mechanical seal with a bellows seal. The improvements proposed will require an extensive redesign of components found in the current system such as the filter chamber.

## 2. Introduction

The SpinTek rotary microfilter is being considered as an alternative to the crossflow filter. Though this filtration system carries some concerns with component durability and maintainability, its compact size and the small footprint required makes it possible to deploy the unit in existing facilities or requiring a minimal amount of new construction. This equipment could increase throughput of filtration with a relatively minimal capital investment.

Two filter units were purchased and tested by SRTC. The first unit used a single disk and testing used actual waste in the SRTC shielded cells. The second unit, using three disks, was installed at the University of South Carolina Filtration Research Engineering Demonstration (FRED) facility. During the testing and evaluation of the filtration system we identified several areas of potential improvement for deployment in radioactive service at SRS.

This study is intended to propose improvements on the vendor baseline design to increase the filter unit lifetime and enhance the filter maintainability in radioactive service based on our experience testing the smaller units. This work is funded by the National Energy Technology Laboratory to investigate alternative methods to treat tank waste at the Savannah River Site.<sup>1</sup>

## 3. Discussion

Personnel conducted testing with a single-disk unit SpinTek rotary microfilter in the SRTC shielded cells and a 3-disk pilot-scale unit at the FRED facility. Based on these experiences, we recommend several areas for improvement in the design prior to deployment in radioactive service. These modifications predominantly seek to extend the viable life cycle of the equipment in radioactive service. Two versions of the 25-disk rotary filter system are being considered for deployment in radioactive service. The first version is the standard unit currently available from SpinTek, referred to as the "off-the-shelf" version. The second version is a proposed design specifically tailored for deployment at the Savannah River Site. The "off-the-shelf" 25-disk SpinTek rotary microfilter will benefit from some degree of upgrading prior to deployment into radioactive service. The vendor, SpinTek, is currently preparing a conceptual design of a version of their 25-disk filter unit specifically tailored for deployment at the Savannah River Site.

Based on testing of the 1-disk and 3-disk SpinTek rotary microfilters, components that require attention prior to deployment include the following:

- manufacturing tolerances, especially for O-ring grooves,
- mechanical seals, and
- electronics and instrumentation.

These three elements do not effect the overall spatial requirements for the equipment. However, we recommend that these features be addressed prior to deployment of either a custom designed rotary filter or the current off-the-shelf design.

The equipment as it is currently designed is not optimized for radioactive service. As discussed above, there is potential to deploy the equipment with several small changes to the design. While not optimized, the filter could perform adequately if personnel will replace the filter system instead of repairing when significant maintenance becomes required. This philosophy of operation will reduce the design modifications necessary to allow remote maintenance in radioactive service. The ability to utilize the off-the-shelf filter will depend greatly on the lifetime of the equipment and the cost of failed equipment disposal.

If the project management team deems it necessary to perform extended maintenance on the filter, several design modifications will prove necessary. These modifications will make the equipment more serviceable in a radioactive environment.

Several modifications can extend the interval between maintenance or make equipment maintenance more remote friendly. These modifications include:

- reducing the number of elastomer seals,
- reducing the number of parts,
- deployment of an all steel filter disk, and
- decoupling the motor drive from the filter disks.

## **4. Description of Proposed Enhancements**

This section describes the proposed improvements. They are based on experience with the startup and operation of a single disk SpinTek filtration unit in the Savannah River Technology Center's (SRTC) Shielded Cells with actual waste as well as a 3-disk SpinTek unit at the FRED facility using simulants. We anticipate full deployment would use the vendor's 25-disk unit. Our examination of this unit is limited to review of the vendor's manual and design information, interviews with the vendor, and consultation with commercial users. Additionally, the vendor is considering design enhancements aimed at mitigating the vulnerabilities identified by the authors.

### **Manufacturer Tolerances**

One area of concern on both the single and 3-disk units tested within this program involves the machining tolerances, especially the grooves cut for O-rings. Several of these grooves proved too deep resulting in the bottoming out of the O-rings. We discovered this flaw on the single disk unit tested at SRS. During assembly, the metal flange contacted the filter disk. Measurements showed that the O-ring grooves were cut too deep. The 3-disk unit at USC had the same problem. Personnel added several shims on both units to assure the O-rings seated properly and to ensure no breaches in the seals or passing of solids occurred during testing. We previously discussed this issue with the vendor. SpinTek informed WSRC that they addressed the issue by changing subcontracted machine shops and holding them to better tolerances. We recommend a quality inspection hold on this feature during any future procurement.

### **Mechanical Seals**

The 25-disk unit in its current design utilizes two water seals. We view the seals as the most prominent leak site and anticipate the seals will require maintenance at a high frequency. Previous experience at SRS with similar seals shows the reliability of this type of seal as less than desirable. Discussions with seal vendors resulted in the recommendation of an elastomer bellows seal using EPDM for the elastomer. One such seal is the John Crane Type I elastomer bellows seal. This seal style is also manufactured with an all metal bellows. The John Crane Company supplies the elastomer bellow seal for pumps in the commercial nuclear industry with the metal bellows seals deployed in pumps at SRS. Either the elastomer or metal bellow seal will provide an upgrade to the current vendor seal. Replacing the current seal found on the 25-disk filter unit should involve minimal changes during the manufacturing of the filter unit as both bellow

seals proposed are manufactured by the supplier of the current water seal and the change should be a simple substitution. It is anticipated that the new seal will remain in service longer than the standard water seal, thus increasing the availability of the filter system.

Interviews with a seal manufacturer resulted in a recommendation that SpinTek consider orienting the filter horizontally, if possible, to prevent solids from settling into one of the mechanical seals. A preferred design option would eliminate the seal at the bottom of the filter housing.

### **Instrumentation**

The operation of the single disk SpinTek filter in the SRTC Shielded Cells suffered numerous problems with the unit's instrumentation and control system. Initially, we expended a great effort re-wiring the electronics during startup of the equipment. We encountered significant signal interference problems that required the use of a signal conditioner as well as the separation of the power and instrument wires prior to deployment. The majority of the operational problems with this system resulted from failure of the instrumentation due to radiation and the caustic of the process fluid. The filter system is controlled by a PLC card manufactured by Automation Direct which receives input from a pressure transducer for system pressure, thermocouple for feed temperature, and a flow meter for feed flow rate. When these parameters are within a specified range the equipment logic controller allows the permeate valve to open thus allowing filtration. The loss of the instrumentation feedback causes the filter system to shut down. During testing with actual waste, the pressure transducer, an Ashcroft model K1, failed in seven weeks under radioactive testing conditions. The model K1 pressure transducer is manufactured with an elastomeric membrane. This transducer should be replaced with a transducer utilizing a stainless steel membrane and shielded wiring.

Testing continued only after artificially setting the input to the PLC using an external power source as input. We obtained the actual system readings from manual gauges installed prior to testing as a contingency for just such a failure. Over a three-month period, we found it necessary to replace all inputs to the PLC, other than the flow meter, with artificial input from outside sources.

The instruments discussed above need further development prior to deployment of a SpinTek rotary microfilter for routine radioactive service. Addressing each area will modify the standard design of the equipment slightly but, should not greatly affect the timing of deployment or significantly affect cost. In many cases modifications will require the substitution of components. While these changes will increase the interval between maintenance, they do little to improve the maintainability in a radioactive environment.

## **5. Design Improvements**

Additional re-engineering would also extend the service life of the unit and provide a means to perform maintenance and filter replacement. These changes in design represent more significant impacts on the cost and fabrication time. Areas of improvement to be considered include:

- eliminating one of the mechanical seals,
- reducing the number of elastomer seals,
- reducing the number of parts,
- deployment of an all steel filter disk, and
- evaluating the use of a decoupled drive.

New issues may be raised after a thorough evaluation of the 25-disk unit design.

### **Mechanical Seal**

The current 25-disk design uses two mechanical seals to the filter housing. One seal is for the filter driveshaft and the second is for the permeate outlet. The smaller units that we tested used a hollow shaft



and thus only one penetration through the filter housing. We discussed using the single seal configuration with the vendor and they feel that this approach is viable.

### **Elastomers**

Reducing the number of elastomers will require additional welding and possible consolidation of smaller parts. An example of an O-ring seal to be addressed on the 1-disk unit is the use of an O-ring for the concentric seal on the shaft. The O-ring provides a low-pressure seal in a concentric shaft arrangement. As the wear portion of the mechanical seal on the shaft wears down, the position of the O-ring will change. In this specific unit, the machining of the O-ring groove proved inappropriate and the seal failed. We recommend the vendor consider redesign of the shaft to allow the O-ring to be in compression rather than a concentric seal. It is unclear to us whether the configuration described here is utilized in the design of the other units but is included in this report as an illustration of design issues encountered.

The vendor might also replace several of the O-rings in the current design using welds. Specific examples include the O-rings sealing the filter disk membrane to the spacers. The use of a weld on a spacer on one side of the disk would eliminate 24 O-rings on the 25-disk unit. The location of the O-ring is illustrated in Figure 1.

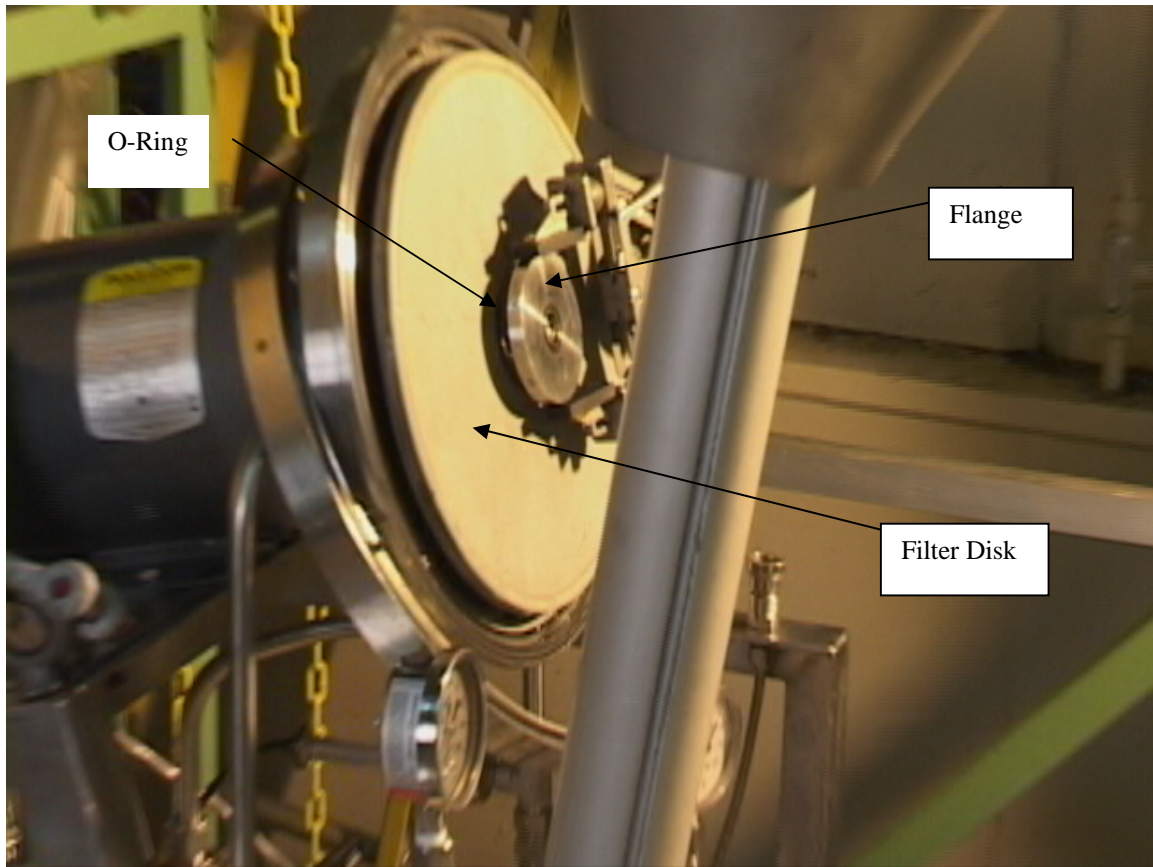


Figure 1. Removal of Flange from Single Filter Unit

Additionally, all elastomers in use on the SpinTek units are Viton®. Consultation with materials experts is currently ongoing to recommend a material specific to the application for the filter unit. Some of the alternative seal materials being considered are Grafoil and EPDM. The use of materials more compatible to the environment will extend the anticipated lifetime of the system.

### **Consolidation of Parts**

We also recommend reducing the number of parts and possibly consolidating internal parts. Reducing the number of pieces to be manipulated during maintenance will significantly simplify service of the

equipment as well as reduce the number of potential problem areas. An example worth evaluating is the manufacture of the filter stack as a single component. The disk stack in this approach is integrated with the turbulence promoters and the lid of the filter housing including the seal. In this design the greatest wear items, the mechanical seal and disks can be replaced as a single component if either fail. We show this concept as Figure 2.

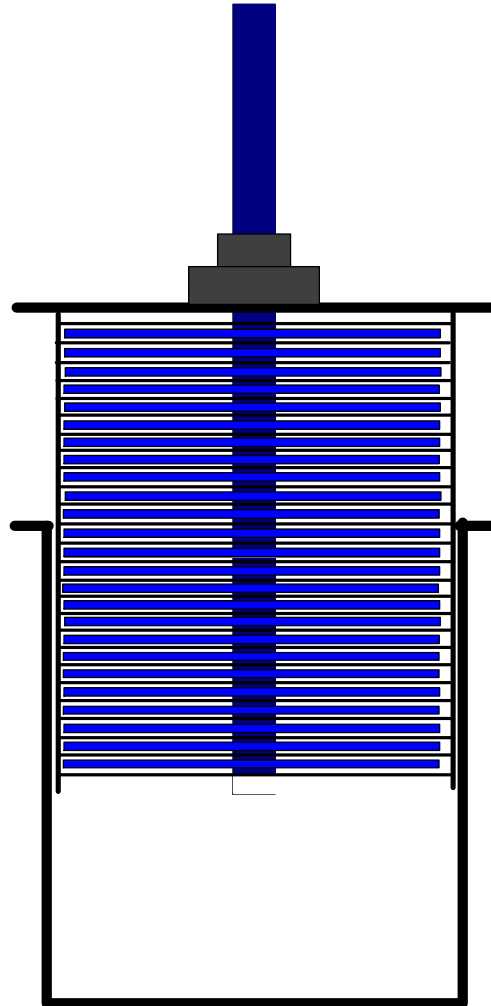


Figure 2. Proposed Filter Disk Stack Concept

The top flange could potentially be connected using a Hanford style connector, possibly allowing the change out of filter disks and mechanical seal in situ.

#### **Filter Disk**

Concerns exist about the durability of the filter disk itself. The current design uses a plastic support structure and epoxy as the assembly medium. Current testing is examining these materials to estimate the expected lifetime of service for the SRS application. If the anticipated durability is too short, a redesign of the filter disk will be required. This redesign could incorporate the welding of the porous membrane to a steel support plate thus allowing the filter disks to be constructed entirely of metal. An effort is currently underway to evaluate these changes.<sup>3</sup> The elimination of polymers will prevent the lifetime of the filter disk from being limited by the materials of construction.

### **Decoupling of the Drive**

A method to allow for easier removal of the filter disks for maintenance or replacement would be the implementation of a magnetic drive. De-coupling the motor from the filter cartridge would also simplify disassembly and maintenance on the filter system. Personnel could design the filter cartridge to utilize a Handford connector for positioning. With this design, it may be possible to change the filter disks as a single cartridge without transferring the filter to a maintenance area.

The same result can be obtained through the use of a conventional drive and coupling. However, disconnection of the coupling may prove problematic if the entire system is not moved to a maintenance area.

### **Additional Design Considerations**

The vendor should also improve guidance and design controls for assembly of the unit. Assembly of the single-disk unit is completed with the tightening of a nut. Vendor instructions are to secure until "tight". The vendor could not define torque values and limited attempts to measure the required value failed due to the accuracy of available equipment. The nut pushes against a spring used on the mechanical seal and therefore provides an impractical range of values. Early in testing the torque applied to this nut altered the spacing of the filtrate flowpath and consequently affected the filtration rate. Assembly of the unit should use reproducible techniques that provide a positive feedback such as a true torque value or position lock.

Additional engineering of this technology will provide a filter system that is reliable and simply maintained in a radioactive deployment. All items outlined in this memo are based on experience with testing of small units. A final evaluation of the actual system suggested for deployment by the vendor will be necessary to identify any additional changes that would prove appropriate for radioactive service.

## **6. References**

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