150 GPM Solids Removal System
Energy*Solutions* SRS-150 XUF™ Grand Gulf Operating Experience Update - 14454

W. Greg Broda
Ken Johnson
Energy*Solutions*
Suite 100, Center Point II
100 Center Point Circle
Columbia, SC 29210

ABSTRACT

The Energy*Solutions* 150 GPM Solids Removal System (SRS 150) with stainless steel cross-flow ultra-filtration (XUF™) technology is a reliable replacement for original plant installed back flushable pre-coat and pre-coatless filter systems. The SRS can be depended on to remove suspended solids greater than one (1) micron from liquid radwaste streams prior to processing through other technologies such as Ion-Exchange (IE) and/or Reverse Osmosis (RO), etc., without the disposal burden of the powdered resins or dead end filter elements. Utilizing this pre-treatment approach for demanding solids/iron removal, coupled with existing proven technologies, ensures successful production of reactor grade water, while decreasing the amount of radioactive water being discharged to the environment and decreasing the amount of radioactive waste that must ultimately be disposed of with the elimination of spent powdered filter medias.

XUF membrane surfaces are continuously swept by high speed flowing liquid so that accumulated solids are continuously swept away by the force of the flow and concentrated for disposal. This scrubbing action of the high speed flowing liquid increases performance, substantially delays membrane fouling and subsequent cleaning without the rapid reduction in flux as in typical dead end filtration elements. As a result, the XUF technology maximizes high flow, high shear, and high flux which equates to reliable high processing rates in heavy suspended solids environments and affords the possibility of near steady state operation.

The SRS 150, Solids Removal System was placed in service in December 2012 processing over 6 million gallons of various liquid influents from Grand Gulf Nuclear Generating Station. This also includes over 300 thousand gallons of river water intrusion. Operations of the SRS 150 during the first three quarters of 2013 have resulted in the savings of over 900 cubic feet of powdered resin disposal.

INTRODUCTION

In November, 2012, Energy*Solutions* completed operational testing with the Grand Gulf Nuclear Power Station's SRS-150 (Solids Removal System 150 gpm) filtration system. Designed as a pre-filter for deep bed ion exchange beds, reverse osmosis such as ALPS™ and Thermex™, the SRS-150 removes suspended and colloidal solids down to 0.5 microns from waste streams without the addition of filter overlays, or disposable filter elements. These removed solids are not returned to the radwaste processing systems.

CROSS FLOW ULTRA-FILTRATION TECHNOLOGY

Cross flow filtration (figure 1), employs a solid loop of water circulated at high velocity to continuously shear collected solids from the membrane face. Raw water injected into loop increases pressure driving water across microscopic membrane pores. Solids remain on the inside of the filter element with clean, filtered permeate leaving the system. Accumulated solids on the filter membrane are scrubbed off and returned to the high velocity recirculation loop. By utilizing a continuous, low flow let down of the recirculation loop, solids and water slurry are transferred to a shielded collection tank. As the loop looses liquid through the bleed off and clean permeate water outlet, more unfiltered water is injected into the high velocity loop to maintain pressure and volume. If 50 gallons per minute leaves as filtered permeate and one gallon per minute is bled off to the solids tank, the system introduces 51 gallons per minute of unfiltered influent to the high velocity water loop thanks to the incompressibility of water. Concentrated solids bled off from the high velocity loop collected in the solids collection tank continue to be concentrated up to a maximum of 30% by weight by a smaller Cross Flow Filter Stage. By dewatering the concentrated solids slurry by additional cross flow filtration, solids are never reintroduced to the plant.

By limiting solids build up on the filter membrane with the high velocity scrubbing action; permeate water flow remains near constant for much longer time than can be delivered from dead end filtration system. Membrane fouling does periodically require a chemical cleaning to restore system capacity. The

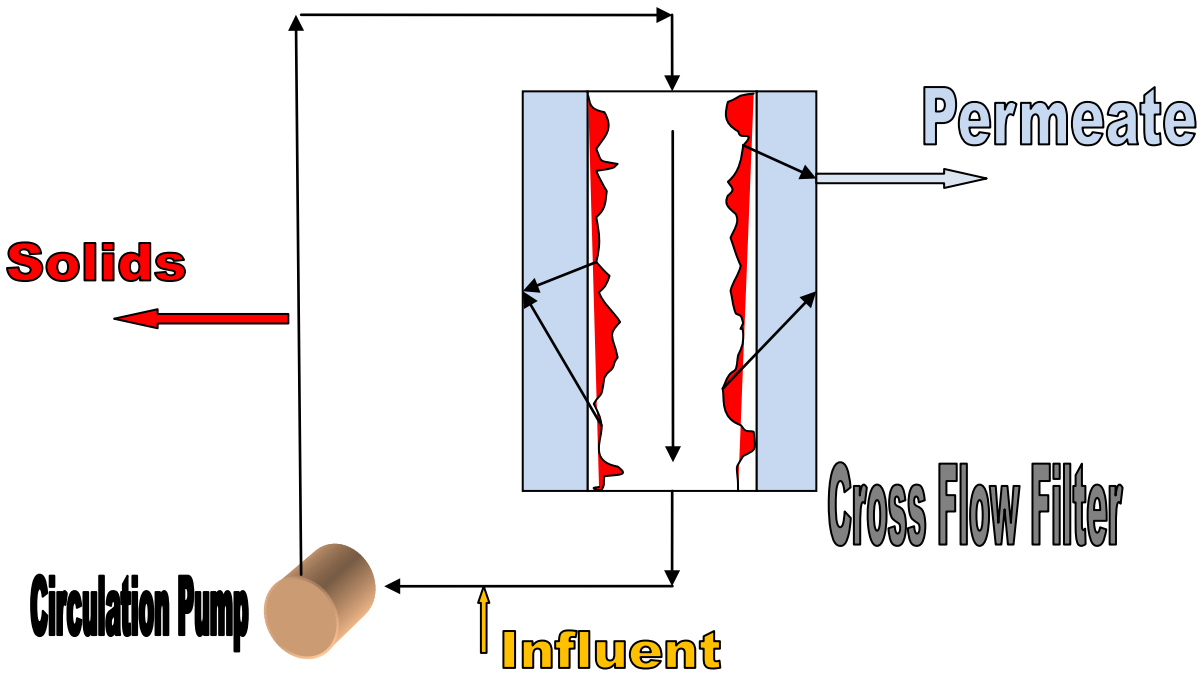


Figure 1— Cross Flow Filtration Loop.

SRS-150 utilizes stainless steel membranes that permit this aggressive chemical cleaning.

SRS-150 CROSS FLOW ULTRA-FILTRATION SYSTEM

At Grand Gulf, the SRS-150 consists of three crossflow ultra-filtration stages with sintered stainless steel membranes. Stages One and Two remove solids from the influent waste through concentration in the recirculation loop for transfer to the Concentrates Collection Tank. Stage three removes additional water from the Concentrates Collection Tank to greater than 30% solids by weight. These concentrated solids represent only the removed solids without the additional volume of filter aids such as powdered resins. Concentrated solids are pumped directly to disposal containers and not returned to plant collections such as waste phase separators where colloidal solids are carried over into collector tanks to be removed again.

Stages one and two receive liquids specifically targeted from the following sources:

- Floor Drains
- Condensate Filter Backwash
- Condensate Polisher Resin Cleanings
- Off Normal Plant Liquids (River Water, etc.)
- Pre-Coated Filter Backwash

These inputs were proven though onsite teamwork between Entergy and Energy*Solutions* to be the most difficult to process wastes. The largest volume of powdered resin waste was generated during the annual processing of 4.2 to 4.9 million gallons of high solids liquid collections.

Three months of pilot testing of over five thousand gallons of actual plant waste performed onsite utilizing a five gpm Cross Flow Ultra-filtration system proved the validity of the cross flow ultra-filtration approach. During the pilot scale testing, all concentrated solids removed from the liquid were returned to the batch feed tank in order to create an increasingly more challenging influent. Often the feed tank would end up with a greater than 30% total solids loading without appreciable reduction in clean water permeate (Figure 2).

Permeate Sample	B&W Iron (ppb)	X Ray Fluoroscopy (ppb)	Notes
10/27/2009 @ 1032	<10	2	30 min after backwash
10/27/2009 @ 1059	<10	2	1 hour after backwash
10/27/2009 @ 1130	<10	0	1.5 hours after backwash
10/27/2009 @ 1159	10	3	2 hours after backwash
10/27/2009 @ 1259	<10	0	3 hours after backwash
10/28/2009 @ 1208	25-50	21	10 min after backwash
10/28/2009 @ 1218	10-25	2	20 min after backwash
10/28/2009 @ 1228	10	0	30 min after backwash

Figure 2 — Pilot Test Suspended Iron Analysis

SRS-150 OPERATION UPDATES

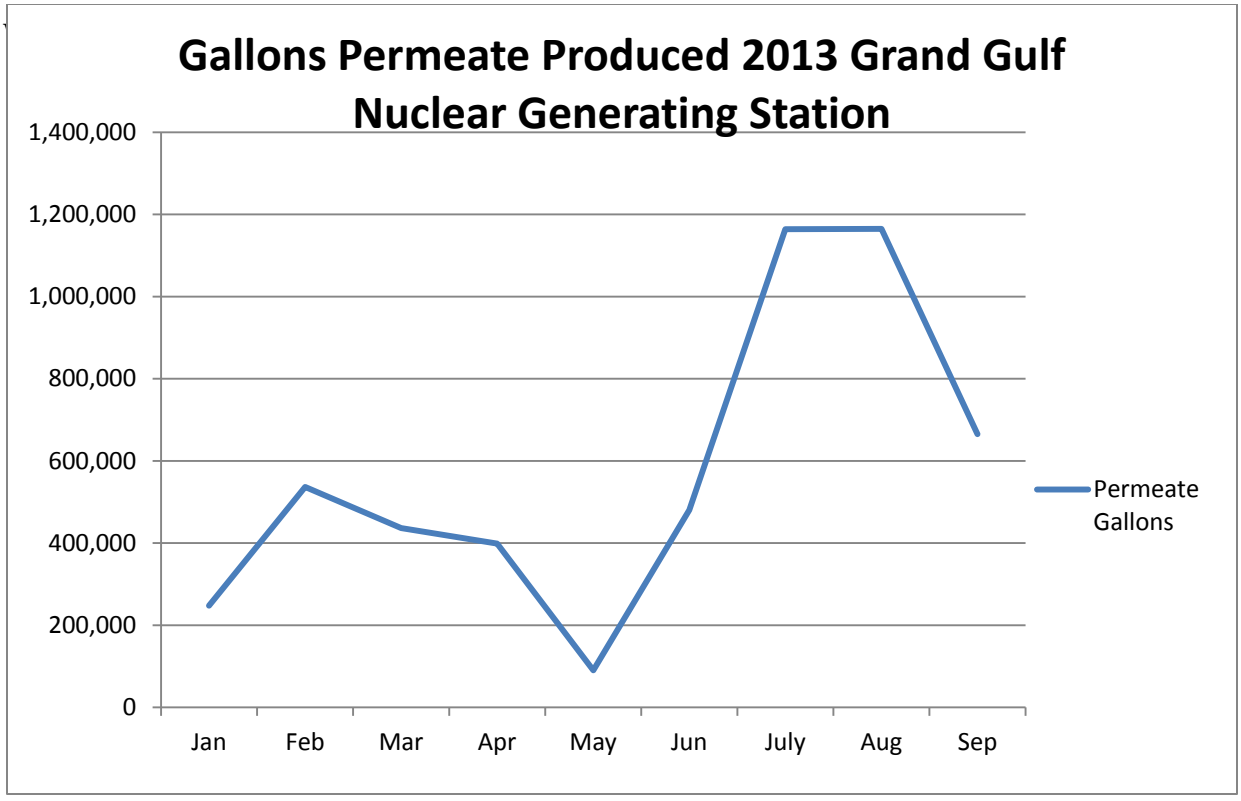
Permeate from the SRS-150 analysis results are consistently less than 10 ppb from each of the cross flow loops as well as the Stage Three Concentrates Collection Tank dewatering effluent (Picture 1).

Since being placed in service in December, 2012 the SRS-150 has processed over 6 million gallons of challenging waste influents including a three hundred thousand gallon river water intrusion incident (Graph 1). Grand Gulf Station has avoided generating over 900 cubic feet of powdered resin waste during the first three quarters of 2013 compared to the same period in 2012. Based on current disposal costs estimates, each operating month a savings of over $50,000 of disposal costs have been realized. This does not include the cost avoidance of powdered resin purchase.

Grand Gulf has benefited from an unexpected savings of dose and expense from not having to change out the Floor Drain Sample Tank inlet filters since placing the SRS-150 in service. Avoiding the monthly change out saves the associated personnel radiation exposure, work order generation, lock out/tag out (application and release), system venting/draining/refilling and replacement filter purchase.

Entergy was awarded the Nuclear Energy Institute Top Industry Practice (TIP) Process Award for the improved liquid radwaste processing utilizing the SRS-150 in 2013.

Picture 1 — After one million gallons processed. ***Left****-Permeate* ***Right*** *Recirculated Solids Effluent*



Graph 1 — 2013 Monthly Permeate Production Grand Gulf Nuclear Generating Station.

CONCLUSION

By removing nearly all suspended and colloidal solids utilizing a successful pre-filtration device allows downstream ion exchange deep beds useful life to be extended. Ion exchange technology is best used to remove ionic impurities to provide reactor grade recycled water or if needed, lowest achievable removal of radioactive nuclides prior to offsite release.

Collecting and concentrating removed suspended and colloidal solids without the addition of filter aids, reduces the final volume of disposed waste with the benefit of not reintroducing the solids back into the plant process streams. The future of nuclear power depends on continued plant efficiency and economy.