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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20852-2738

Attention: John N. Hannon, Chief, Plant Systems Branch
Division of Systems Safety and Analysis

Subject: **Summary of Demonstration Testing for GE Active PWR Suction Strainer (GSI-191)**

Members of the NRC staff viewed demonstration-of-concept testing conducted by GE in a test facility in New Jersey on January 5th, 6th, and 7th. GE was requested to provide a summary of the demonstration testing for the GE Active PWR Suction Strainer to augment the NRC's trip report. Attached is a summary of the product demonstration for the GE Active Strainer to support the NRC's request. GE hopes this summary of the three days of demonstration testing meets the NRC's needs.

It is important to point out that this testing and the attached summary were not performed or prepared under the GE quality assurance program. Testing under the GE quality assurance program is under preparation and is planned for the second quarter of this year to support utility plant modification plans.

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If you have any questions about the information provided here, please let me know.

Sincerely,

George B Stramback
Manager, Regulatory Services

Project: 710

Attachment:
GE Active Strainer Product Demonstration Summary, Conducted January 5-7, 2005

cc: MB Fields USNRC (with attachment)
MR Johnson USNRC (with attachment)
DL Solorio USNRC (with attachment)
J Hamel - GE (with attachment)

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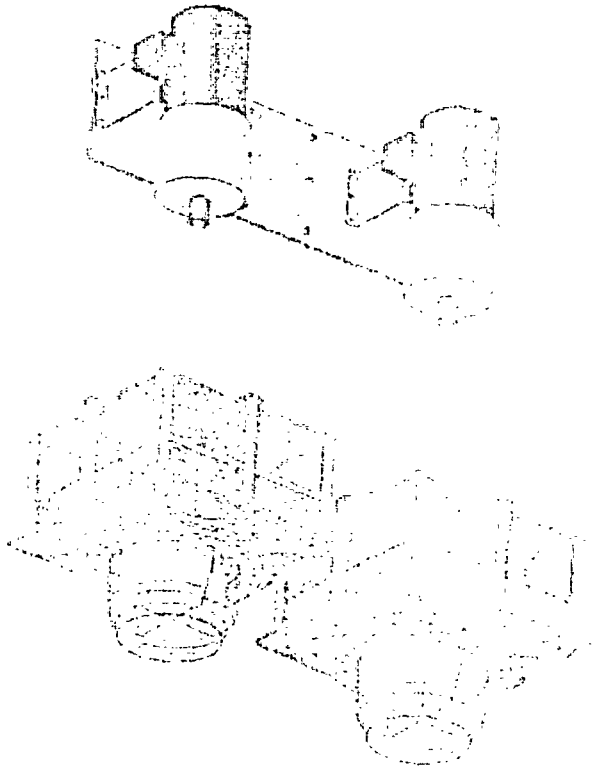
GE Active Strainer

Product Demonstration Summary



Conducted January 5-7, 2005

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INTRODUCTION

A demonstration of the Active Strainer was designed to highlight its viability as a solution to GSI-191. The demonstration lasted three days, each day showcasing a different design characteristic of the Active Strainer. The demonstration described herein will be followed by Appendix B compliant testing at a later date.

On the first day, the functionality of the Active Strainer was addressed. A low concentration test showed how the plow and brush of the Active Strainer sweep away debris from the top perforated plate. A high concentration test displayed the operation of the Active Strainer under a postulated peak load. By showing that the Active Strainer could meet design requirements at a postulated peak load, it is clear that the strainer can also meet the design requirements at all other (lower) loads.

The second day of the demonstration addressed the issue of debris buildup immediately around the strainer. It is necessary to understand where debris eventually settles after being swept by the plow and brush. The demonstration showed that debris buildup immediately around the strainer does not create an operability problem for the strainer.

The third day of the demonstration challenged the strainer to a much higher load than would normally be expected. A debris load, equal to 6 times the original postulated maximum debris load, was introduced to the strainer at one time. This portion of the demonstration showcased the flexibility of the strainer to perform under this significantly higher than postulated load.

ATTENDEES

Name	Affiliation
Hanry Wagage	NRC
David Solorio	NRC
Ralph Architzel	NRC
Shanlai Lu	NRC
Michael Johnson	NRC
John Hannon	NRC
Mark Giles	NRC
John Butler	NEI
Getachew Tesfaye	Constellation - Calvert Cliffs
Mark Kostelnik	Constellation - Calvert Cliffs
Andre Drake	Constellation - Calvert Cliffs
Dean Shah	Entergy - Indian Point
Lee Cerra	Entergy - Indian Point
Michael Kai	Dominion – Millstone
Marty Legg	Dominion – Millstone
Marty Badewitz	Dominion – North Anna / Surry
Mike Friedman	OPPD - Ft. Calhoun
Bernie Van Sant	OPPD - Ft. Calhoun
AK Singh	Sargent & Lundy
Lad Ricker	Proto Power
Edison Carmack	Southern Nuclear - Farley
Scott Wihlen	Constellation - Ginna
Brian Flynn	Constellation - Ginna
Cliff Po	Constellation - Ginna
Anjna Mehta	General Electric
Jeffrey Hamel	General Electric
Salvatore Cimorelli	General Electric
Barry Smith	General Electric
Bruce Kobel	General Electric
John Enneking	General Electric
George Stramback	General Electric
Andrew Kaufman	Continuum Dynamics
Alan Bilanin	Continuum Dynamics

TEST FACILITY DESCRIPTION

Apparatus

The test facility, as shown in Figure 1, consists of a test pool mounted on a platform above the floor grade. In the center of the test pool is recessed a rectangular sump that extends from the bottom of the pool to the floor grade.

Covering the sump is a steel platform. The top of the platform is covered in perforated plate, except for the middle 2' by 2' section over which the Active Strainer is mounted. This perforated platform can be blocked to ensure all flow goes through the Active Strainer. During the Day 1 and Day 2 demonstrations the perforated area was open to flow. During the Day 3 demonstration, the perforated area was closed.

The top view below shows the platform, test pool, strainer and sump with part of the return line shown. The elevation view shows more details of the strainer and indicates the location of the suction pipe in the sump. The return flow system is omitted for clarity.

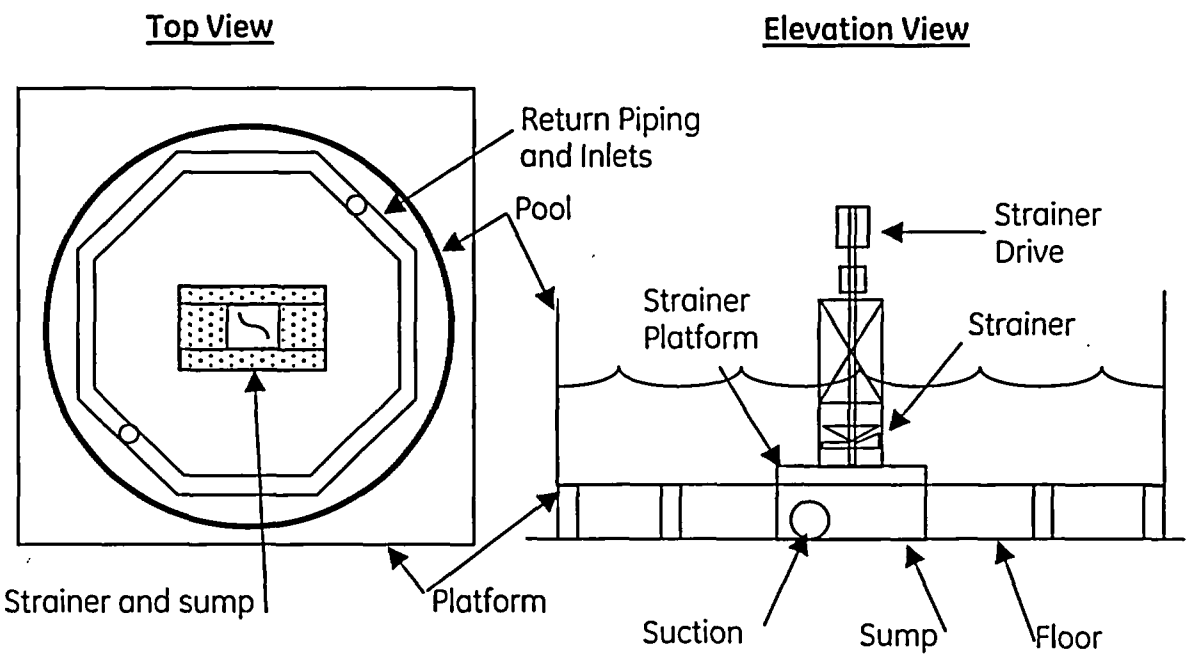

Figure 1: Schematic of Test Facility (Not to Scale)

The flow system is shown in Figure 2 below. A 4500 gpm rated pump circulates the water through the system. The outlet consists of 12" piping, connected to a venturi and then a control valve. After the control valve the piping is teed and reduced to feed an octagonal header near the bottom outside diameter of the pool. Holes drilled in the outside of this header return the flow into the pool. The holes can be plugged to adjust the flow distribution in the pool. The flow then travels from the pool to the strainer and down into the sump. Flow goes to an isolation valve and then returns to the pump.

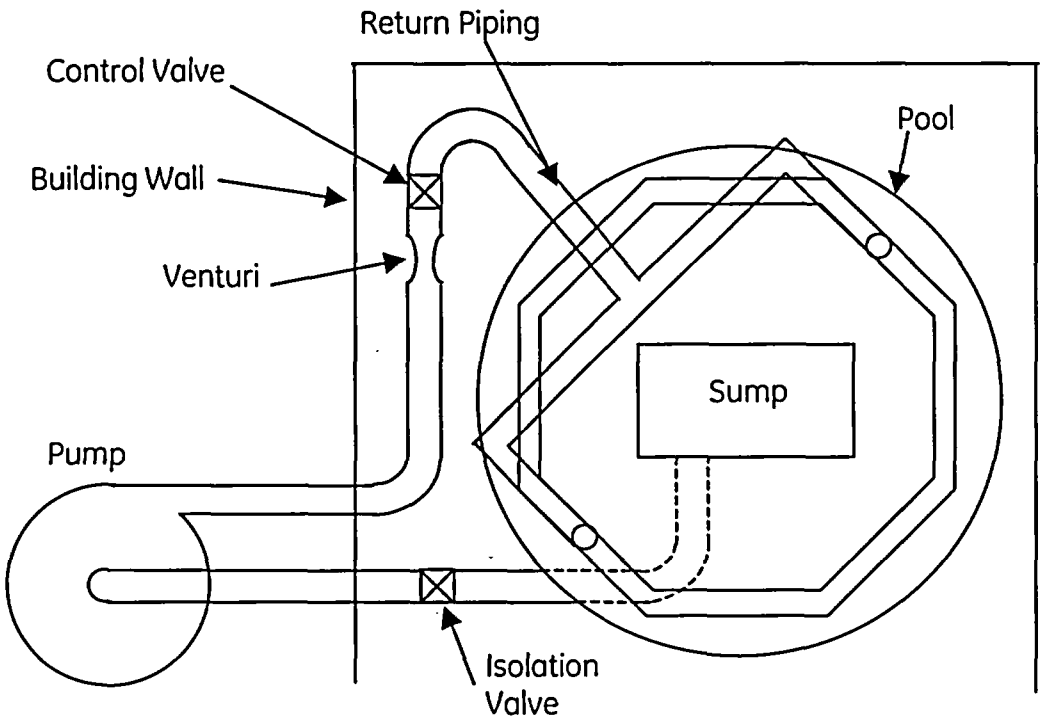

Figure 2: Flow Schematic (Not to Scale)

Discussion of the Scaling of Velocities

Because head loss is proportional to the square of the fluid velocity approaching the strainer, true performance data can be gathered by maintaining full-scale velocities. Full-scale approach velocities on a scaled Active Strainer are achieved by adjusting the pump flow rate to yield the same mass flow rate per unit area as in a plant-specific application.

Because the Active Strainer used in the demonstration is approximately half the diameter of a full-scale strainer, the test flow was approximately one quarter of the design flow rate for the plant under consideration.

Therefore, while the test facility is scaled, the head loss data gathered is full-scale.

DEMONSTRATION DESCRIPTION

Day 1: Low and Maximum Loads

Low Concentration Demonstration

The demonstration began with a low concentration demonstration. The purpose of this demonstration was to demonstrate the behavior of debris in the immediate vicinity of the plow and brush of the Active Strainer.

Different types of debris were inserted directly into the path of the rotating plow and brush, via a debris insertion tube. The different types of debris were added individually to allow viewers to clearly see the plow, brush and debris interactions for each type of debris.

The types of debris added, in order of insertion, were:

- Transco Fiber (Low density fiber)
- TempMat Fiber (High density fiber)
- RMI (crumpled into small and large pieces)
- Paint Chips

Other beyond design basis materials were tested as well, including typical foreign material such as tie wraps, duct tape and plastic bags.

Both types of fiber were pre-soaked and shredded to simulate the state of debris post-LOCA. The crumpled RMI and paint chips were also soaked.

The passive area of the strainer platform (see Figure 1) was blocked with plexi-glass such that all flow was forced to go through the Active Strainer only.

Viewers were able to see this portion of the demonstration both by viewing the test tank and via an underwater camera system.

Maximum Load Demonstration

The next portion of the demonstration involved subjecting the strainer to a postulated maximum load. This demonstration highlights the performance of the Active Strainer under a prototypical peak load, for a representative plant configuration.

Before beginning the demonstration, a presentation was made regarding the Maximum Load methodology. This presentation describes the method by which the peak load on the Active Strainer was determined. This methodology is GE Proprietary and is not described in this report.

After the presentation, the maximum load of debris calculated for a representative plant was fed to the Active Strainer. The debris was fed to the strainer within close

proximity of the strainer, to be sure that the entire peak load was transported to the strainer, as opposed to initially settling on the floor. Through several other tests, it was shown that at prototypical approach velocities, heavy or dense debris does not transport to the top perforated plate of the strainer. Typically, these types of debris remain on the floor on or near any open passive area.

As in the Low Concentration Demonstration, debris was shredded and soaked, such that fiber does not remain buoyant in water.

During this demonstration, the strainer platform passive surface area (see Figure 1) was kept open to demonstrate the preferential deposition of debris on passive surfaces. The maximum debris load was increased by a factor of three to conservatively compensate for the preferential deposition of the debris on the passive surface.

The debris load was as follows.

- Transco (low-density fiber)
- Paint Chips
- Calcium Silicate
- Simulated Chemical Effects

While this demonstration was running, viewers were able to track head loss, motor RPM, motor torque and flow rate.

This demonstration was run until the pool reached a steady state condition: most debris had settled to the pool floor or onto the passive surfaces.

Chemical Effects and Particulate Demonstration

This final part of the demonstration addressed Active Strainer operation with a particulate load and with chemical effects.

The simulated chemical effects solution used was based on a mixture recommended by Bruce Letellier of LANL and John Gisclon of the Energy Power Research Institute (EPRI). Due to insufficient data regarding chemical effects, the amount fed to the strainer was approximately equal to the amount of particulate.

The particulate used in the demonstration was Calcium Silicate. The amount chosen for the demonstration was also determined through the use of the Maximum Load model.

The chemical and particulate were added to the pool in close proximity to the strainer after the system reached steady state conditions. They were not added earlier due to the loss of visibility in the pool.

Day 2: Gradually Increasing Loads

The purpose of the demonstration on Day 2 was to show that the Active Strainer could handle loads beyond the postulated maximum load. In a real-life, LOCA scenario, the strainer will not ONLY be challenged to the maximum load: the strainer will need to handle load after to the maximum load, albeit smaller loads.

To demonstrate this, the same maximum load used on Day 1 was first added to the test strainer. After reaching the steady state, another incremental fibrous debris load was added. This process was repeated two more times.

Furthermore, as the loads were added, the debris bed that formed on the passive surface area on the strainer platform was measured. This was done by viewing rulers mounted at several locations surrounding the strainer. Once the steady state was reached after every addition of debris, the debris bed thickness was measured.

The debris load was as follows:

- Transco (low-density fiber) – 1st debris load introduced
- 3 equal increments of Transco – 2nd, 3rd and 4th debris loads introduced

Day 3: Significantly Higher than Postulated Debris Loads

The demonstration on Day 3 aimed to load the strainer significantly beyond the postulated maximum debris load. For this demonstration, the entire load that had been added on Day 2 was added to the test tank at one time. Moreover, a different plant-specific load was introduced. The new load was added to the Day 2 full debris load.

The horizontal surface area of the passive strainer platform (see Figure 1) was blocked during this demonstration. Only the vertical passive area (four 6" high x 2' long areas), immediately below the top perforated plate of the Active Strainer was open. By keeping the strainer platform covered, no credit at all can be taken for passive suction since all of the flow was going through the Active Strainer.

Furthermore, during this demonstration a simulated wall and column was placed in proximity of the Active Strainer. The wall and column were introduced to demonstrate Active Strainer functionality in close proximity of different containment structural configurations and constrictions. Visual observations were made regarding debris movement and settling near the wall and column. A top view of the pool, modified with the wall and column is shown below:

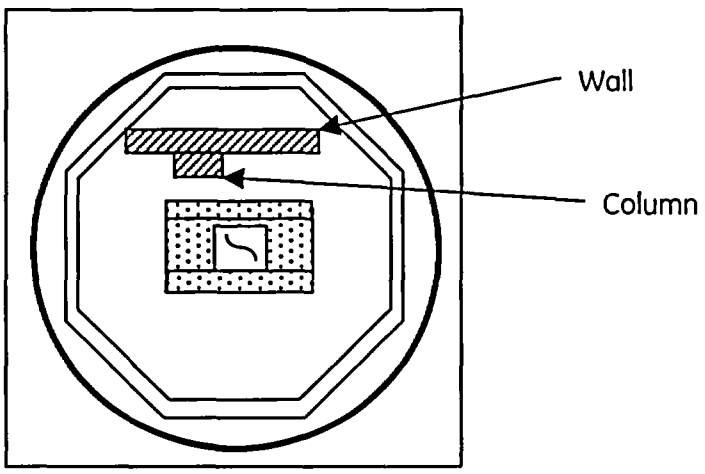

Figure 3: Top View of Pool with Wall and Column (Not to Scale)

The debris load was as follows:

- TempMat (high-density fiber)
- Transco (low-density fiber)
- Paint Chips
- Calcium Silicate

- Simulated Chemical Effects

RESULTS

Day 1: Low and Maximum Loads

Low Concentration

The Active Strainer removed and prevented formation of a debris bed on the Active Strainer perforated plate surface. Some debris remained entrained by the plow and brush but was shortly thereafter ejected, falling to the strainer platform or pool floor.

Maximum Load

Plant-Specific Debris Load

Shortly after the debris was placed around the strainer, the head loss peaked at approximately 7.5" of water column. The torque also peaked at approximately 11 *ft-lbs*, corresponding to 0.15 *hp*.

The peak lasted for approximately 25 minutes, after which the head loss and torque returned to lower steady-state values. Head loss remained steady at under 6 in until the next material was added. Torque continuously decreased to a minimum of 3 ft-lbs.

Note that the data above is from non-Appendix B preliminary testing.

Chemical Effects and Calcium Silicate

The simulated chemical effects were added approximately three hours after continuous strainer operation on Day 1. As predicted, head loss and torque peaked again to similar peak values as during the plant-specific maximum load demonstration.

Shortly thereafter, the Calcium Silicate was introduced. No significant head loss or torque peaks were observed.

Day 2: Gradually Increasing Loads

This demonstration began similarly to the Day 1 maximum load demonstration: the calculated maximum debris load of low-density fiber was introduced to the strainer. Although head loss and torque values peaked briefly, both quickly returned to lower steady-state values. Head loss peaked at 7.5" and torque peaked to 9 *ft-lbs*. Eventually, the debris settled mostly onto the perforated plate of the strainer platform and on the floor of the pool.

After approximately 60 *min*, a second incremental low-density fibrous load was introduced to the pool. The previous debris load was still present in the pool. Again, head loss and torque briefly peaked to similar values as after the initial load was introduced.

It should be noted that the process of adding additional debris stirs up settled debris. By stirring up this debris, the overall resultant debris load is somewhat increased. This increased debris load probably accounts for the observed, small, short-term differences as more debris is added.

This process was repeated two more times, showing similar results. The head loss and torque peak generally lasted a short time as each debris load was added to the pool.

Comparing to the original plant-specific maximum debris load, the total amount of debris added during this demonstration represents approximately four times the postulated maximum debris load.

While head loss and torque measurements were being taken, the perforated plate debris bed thickness also was measured. The thickness was measured when the steady state was reached after each addition of debris. It was noted that after the passive perforated plates were saturated with debris, i.e., no flow could pass through the debris bed, the debris bed thickness did not change. Instead, most debris settled on the floor of the pool and small, light fibers remained water-borne.

Note that the data above is from non-Appendix B preliminary testing.

The head loss and torque values are summarized in the following figure.

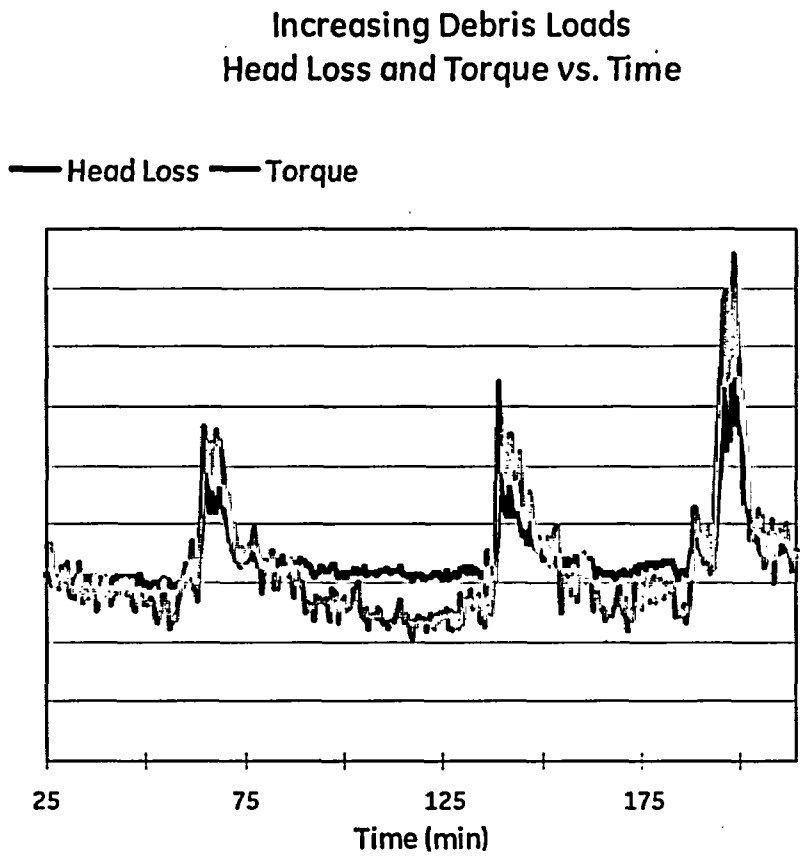

Figure 3 Head Loss and Torque vs. Time for the Day 2 Demonstration

Day 3: Significantly Higher than Postulated Debris Load

The demonstration on Day 3 simulated a different plant specific debris load, a different test pool configuration and additional debris to simulate a significantly higher debris load.

Like the previous two demonstrations, the head loss and torque showed peak values and then returned to steady-state values. However, because of the increased load, peak values lasted somewhat longer than previous cases. The peak values of head loss and torque are on the order of previously demonstrated peaks.

After the peaks occurred, the Active Strainer reached a steady state and head loss and torque returned to levels as previously demonstrated.

Furthermore, as mentioned earlier, the pool configuration was altered to simulate the containment pool at a different plant. By visual inspection, it was shown that there was no debris accumulation between the wall, column and strainer. Instead, debris settled on the other three sides around the strainer.

The head loss and torque values are summarized in the following figure.

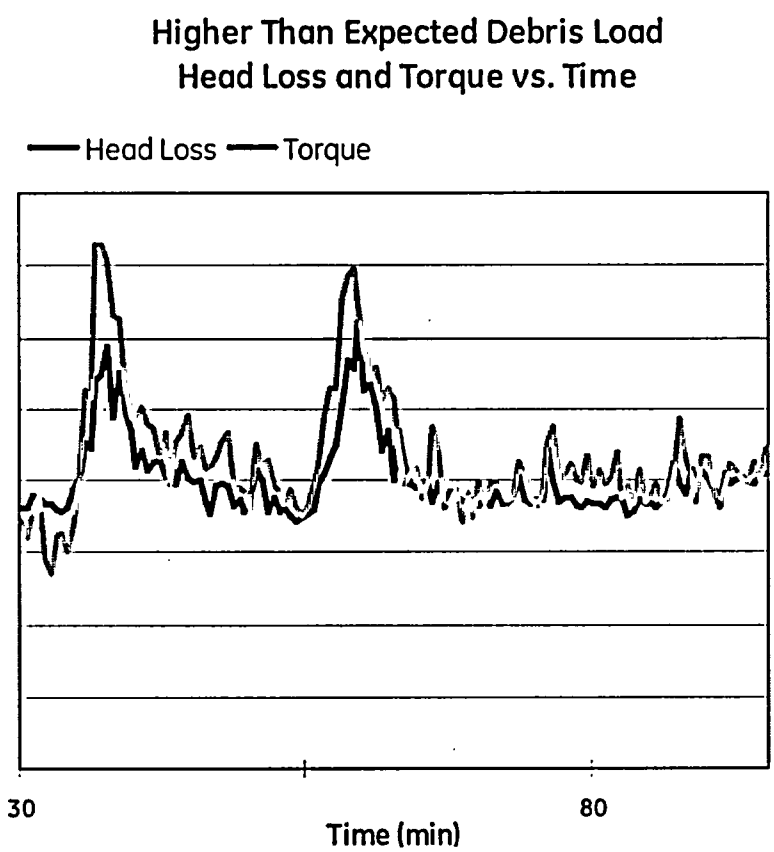

Figure 5 Head Loss and Torque vs. Time for the Day 3 Demonstration