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Title:	Large-Scale Head Loss Test Specification for Wolf Creek Generating Station	Client: Wolf Creek Nuclear Operating Corporation
		Project Identifier: WCN-021

Item	Cover Sheet Items	Yes	No
1	Does this Design Specification contain any open assumptions, including preliminary information that require confirmation? (If **YES**, Identify the assumptions.)	☐	☒
2	Does this Design Specification supersede an existing Design Specification? (If **YES**, Identify the superseded Design Specification.) **Superseded Design Specification No.** ______________________	☐	☒

Scope of Revision:
Issued for Client Review

Safety-Related ☒ **Non-Safety-Related** ☐

(Enter Name and Sign)

Originator: Patrick Romine	
Design Verifier: Ivan Zujovic	
Approver: Kip Walker	**Date:**

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DESIGN SPECIFICATION REVISION STATUS

REVISION	DATE	DESCRIPTION
A		Issued for Client Review

ATTACHMENT REVISION STATUS

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1.0 Purpose and Scope

During the sump recirculation phase after a loss-of-coolant accident (LOCA), the emergency core cooling system (ECCS) and containment spray (CS) pumps take suction from the containment sump and pump coolant to the reactor core and containment atmosphere, respectively. Fibrous and particulate debris, which consists of failed insulation and coatings, and latent debris could transport to the sump strainer. The strainers are designed to trap debris and prevent it from being transported into the ECCS and CS pumps and the piping and components downstream of those pumps. The trapped debris will accumulate on the surface area of the strainer and eventually inhibit flow through the strainer. In addition to insulation, coatings, and latent debris sources in containment, chemical reactions that occur in containment under post-LOCA conditions may result in precipitation of chemical products. Chemical precipitates may accumulate on the debris bed formed on the strainer.

Figure 1 shows the layout of the Wolf Creek Generating Station (WCGS) containment sump recirculation strainers designed by Performance Contracting Incorporated (PCI). The strainer system minimizes the debris quantity that enters the ECCS and CS systems during recirculation. The particular strainers shown in Figure 1 are the A Sump (North) and B Sump (South) (Ref. 3.9).

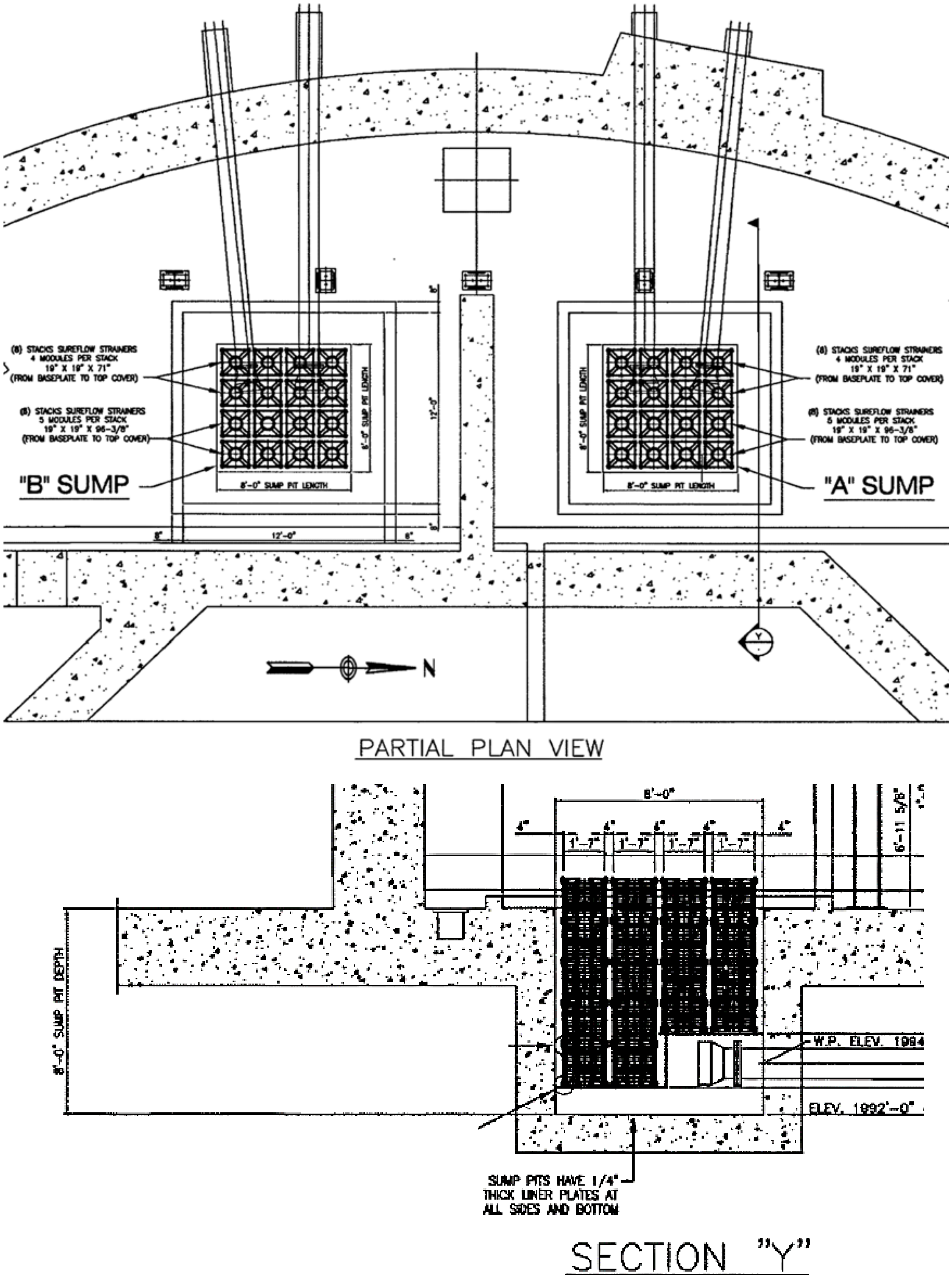


Figure 1: WCGS Containment Sump Strainer System General Arrangement

Inhibition of flow due to debris and chemical precipitate accumulation on the strainer results in a pressure loss across the strainer. The increased pressure loss will reduce the net positive suction head (NPSH) margin of the ECCS and CS pumps, increase the structural loading on the strainer assembly, and increase fluid degasification and void fractions which can challenge the performance and function of ECCS and CS pumps.

In response to Generic Letter (GL) 2004-02 (Ref. 3.2) pressurized water reactor (PWR) licensees and their strainer vendors have been conducting prototypical head loss testing to qualify the design of the strainers. The objective of the prototypical head loss testing is to determine the strainer potential peak head loss that could occur during the postulated LOCA. The testing consists of a prototypical scaled strainer. Appropriate debris surrogates will be used to simulate postulated debris sources inside the WCGS containment building. A surrogate will also be used to simulate the chemical precipitate products that are expected to form inside the containment building and transport to the strainer sump after a LOCA. In addition to debris load, other parameters that are important for proper scaling include the strainer surface area, dimensions of the PCI disk strainers, the number of strainers, the submergence level, and local fluid flow conditions.

Per NRC guidance (Ref. 3.5), a “fully-loaded case” and a “thin-bed” case should be considered for head loss testing. The fully-loaded case uses the quantity and mixture of debris based on the WCGS break analysis. The thin-bed case represents the minimum fibrous debris load that can result in high pressure losses across the strainer while considering the highest particulate debris load. This occurs when only enough fiber to form a thin layer of fibrous debris sufficient to filter particulate debris is transported to the containment sump. Particulate debris that is later transferred to the sump is captured by the thin-bed which reduces the overall porosity of the debris bed and drastically increases head loss.

This document develops the requirements for head loss testing of the strainers installed at WCGS necessary for the testing facility to plan and perform the head loss test for both “fully-loaded” and “thin-bed” conditions.

This test specification provides inputs and requirements for head loss testing. The Alden test plan describes how testing will be performed to meet the inputs and requirements. This test specification does not address sizing and design of the test strainer, which shall be finalized in the Alden test plan. As a result, the following quantities must be determined in the Alden test plan:

- Test flow rate
- Maximum allowable size for piping between test strainer and filter housings in order to maintain flow velocities ≥ 1 ft/s (see Section 6.1.3)
- Total number of debris batches required
- Debris introduction time for each debris batch
- Test debris quantity

2.0 Design Inputs

This section presents the required test inputs obtained from existing plant documents for WCGS strainer configuration, flow rate, sump pool parameters and debris loads.

2.1 WCGS Strainer

2.1.1 Strainer Configuration

There are two groups of vertically oriented strainer assemblies that fit into each of the two sumps, designated A and B, at WCGS. Each strainer supplies water to one residual head removal (RHR) pump and one CS pump. The strainer assemblies are identical to each other with respect to design, surface area, orientation, draw flow, and configuration. Each strainer train is comprised of sixteen strainer stacks with 4 inch gaps of separation between adjacent strainer stacks and between the end strainer stacks and pit walls. There are two types of strainer stacks, Type A and Type B, of which there are eight of each in a single strainer assembly. Type A stacks are comprised of three modules with eleven disks and one module with seven disks, while Type B stacks are comprised of five modules with eleven disks each, as seen in Figure 3 (Ref. 3.9, 3.11). The major components of a module are end strainer disks (those at the top and bottom of a module), intermediate strainer disks, gap disks, and a core tube. A distance of 3 inches separates the end disk faces of adjacent modules within a stack. Both the 7-disk and 11-disk modules are shown in Figure 2 (Ref. 3.10).

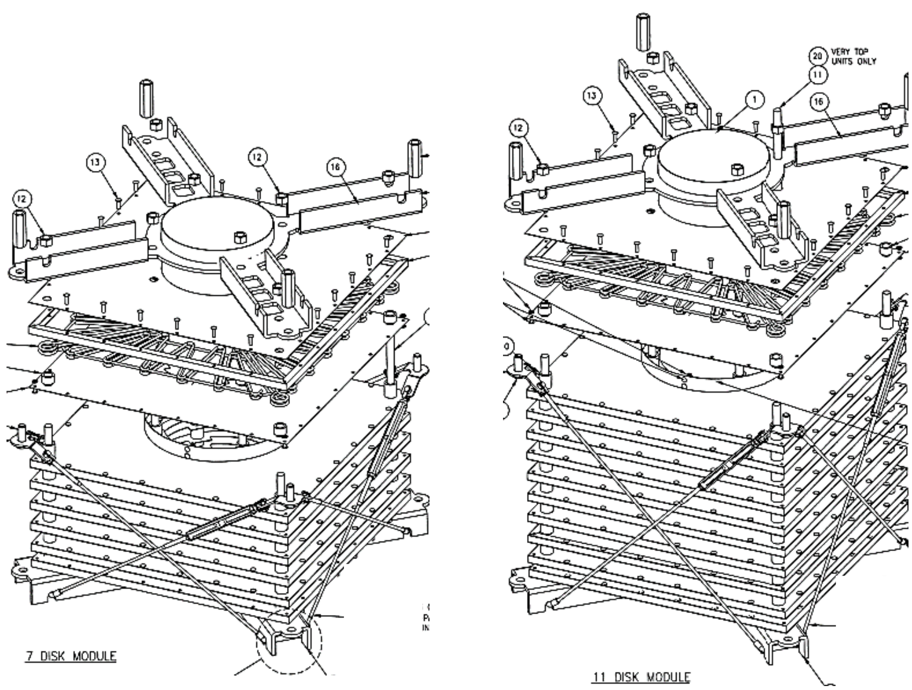


Figure 2: 7 Disk Module and 11 Disk Module

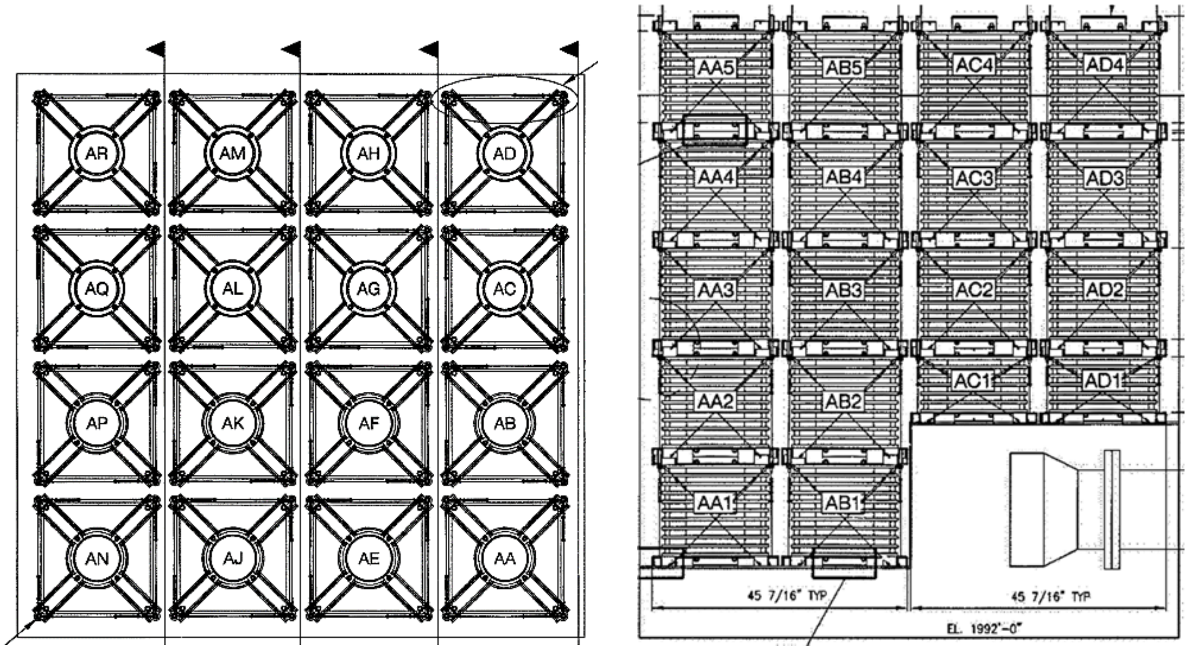


Figure 3: Sump A Strainer Plan and Section Views

Intermediate strainer disks are composed of two perforated plates that sandwich a wire grill and are connected about their perimeter by a perforated rim disk. The perforated plates of both the disk faces and the rim disk are 22 ga. ASTM A240 type 304 stainless steel with 0.045 inch diameter holes on 0.081 inch staggered centers (Ref. 3.17). The disk faces are 19” x 19” (Ref. 3.12 and 3.13) and are separated by a ½ inch gap, which is the width of the rim disk as well as the wire grill (Ref. 3.14). This results in a total disk thickness of 0.558 inches (Ref. 3.12 and 3.13). The wire grill configuration is detailed in Figure 4.

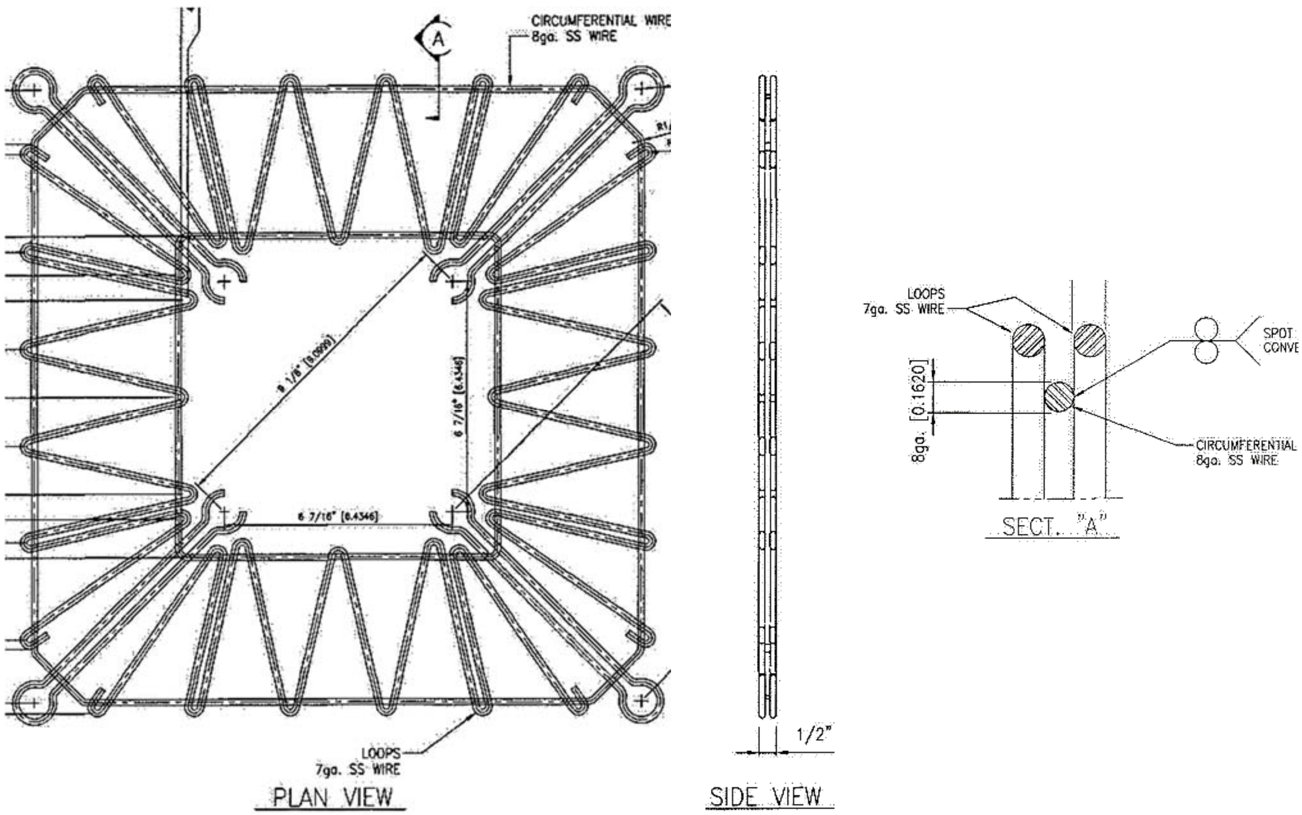


Figure 4: Wire Grill Details

Gap disks share the same base material, sheet thickness, and perforation pattern as the disk face and rim disk perforated plates. They have an outer diameter of 10.063 inches and surround the core tube, spanning the 1 inch gap between adjacent strainer disks. As seen in Figure 5, only 0.675 inches of the 1 inch gap is perforated (Ref. 3.14).

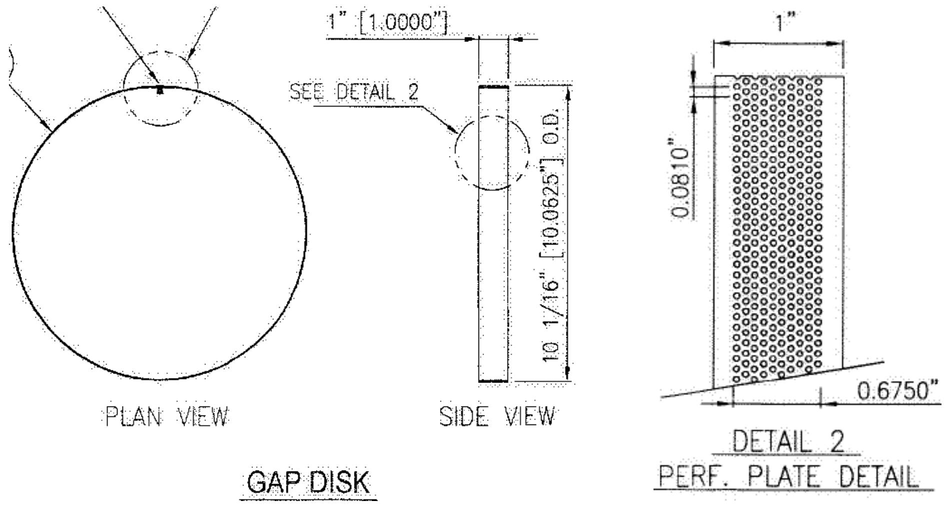


Figure 5: Gap Disk Details

The core tube has an outer diameter of 7.5 inches and is divided into sections, where one section of core tube belongs to each strainer stack module. Flow that penetrates the strainer disks and gap disks enters the core tube through rectangular perforations. The core tube is perforated with a row of four holes for each disk which are evenly spaced about its circumference so that the centers of adjacent holes are 90 degrees apart. The dimensions of the holes (width x length) vary continually through all sections of a stack, increasing in area from bottom (nearest the plenum) to top (Ref. 3.15).

The bottom of the core tubes interface with the top of the plenum. The plenum is located at the bottom of the sump and has two sections which have no barrier between them. The first section, on which the Type B strainer stacks sit, has a height of 1’-0 5/8”. The second section, on which the Type A strainer stacks sit, has a height of 3’-2”, which provides space for the ECCS suction pipes (see the section view of Figure 1).

The RHR and CS systems have independent pipes that protrude into the plenum and draw flow; the RHR suction is via a 14” line and the CS suction is via a 12” line (Ref. 3.11).

2.1.2 Strainer Location and Recirculation Flow Path

As shown in Figure 6, the WCGS sump strainers are located just outside of the bioshield wall and are separated by a wall that extends out from the bioshield wall for the full length of the sump pit. Each sump pit is located in a corner such that it has two sides that have walls within 4’-8” feet of the sump pit and two sides without adjacent walls nearby (Ref. 3.27). Additionally, each pit is surrounded by a curb that is 6” tall and 8” in width, such that the curb wall nearest the sump pit is 2’-0” beyond each side of the pit and the curb wall farthest from the sump pit is 2’-8” from the sump pit (Ref 3.16). However, the debris transport effects of these curbs were accounted for in the debris transport calculation and do not need to be modeled for the head loss test.

Figure 6: Isometric view of WCGS lower containment

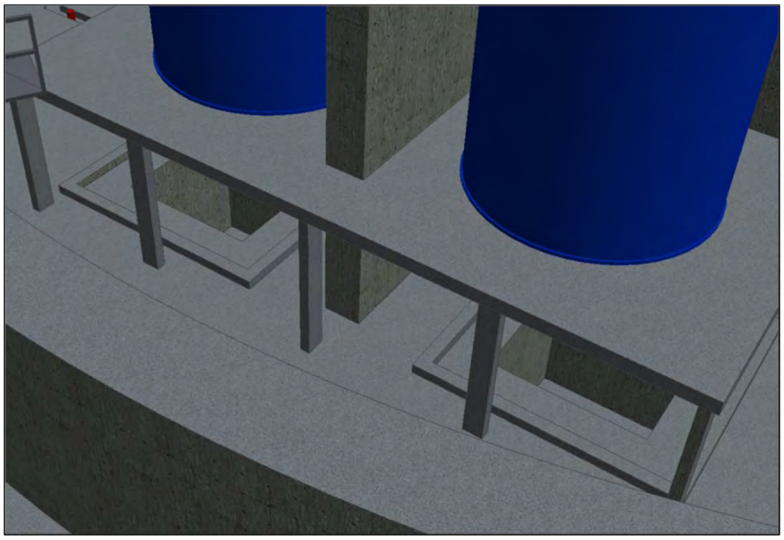


Figure 7: CAD model view of sump geometry

The area within the bioshield wall is connected to the area outside by a set of four passages, two of which have debris barrier doors to prevent debris from passing through to the sumps.

As a result, recirculation flow exits the area within the bioshield wall on the east end of containment, opposite from the sumps, and then flows to the sumps in the annulus. Figure 8 shows the path that the recirculation flow takes to each sump when both trains are in operation. In both sumps, the majority of the flow initially approaches from the north or south direction and then either enters the sump from the side of initial approach or circulates around the strainer until it enters the sump.

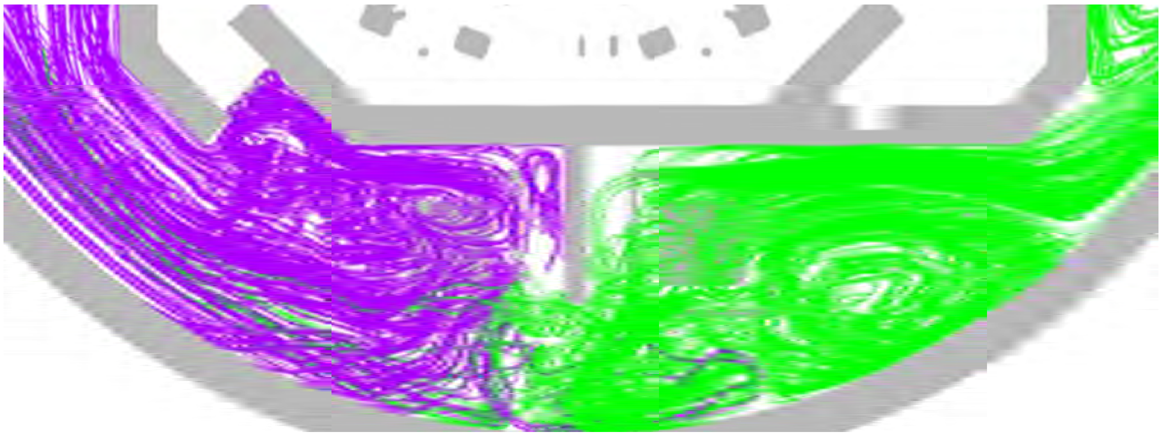


Figure 8: Sump Water Source Streamlines

2.2 Sump Pool Volume

The minimum sump water elevation for the event of a LBLOCA has been conservatively calculated to be 2,002.09' at ECCS switchover (Ref. 3.18, page 30).

Alternatively, the minimum sump water elevation for the same LBLOCA has been calculated to be approximately 2,002.43' at CS switchover (Ref. 3.18, page 32).

The highest point of the strainer is the top of the coupling on the top modules, which is at an elevation of 2,001'-1$^{13}/_{16}$" (Ref. 3.11). By subtracting the length of the coupling (2$^{1}/_{2}$", Ref. 3.10) and the thickness of the external debris stop ($^{1}/_{4}$", Ref. 3.10) on which the coupling rests, the elevation of the top disk is found to be 2,001'-1$^{13}/_{16}$" – 2½" – ¼" = 2,000'-11$^{1}/_{16}$" (2000.92') .

The resulting strainer submergence for a LBLOCA at the ECCS switchover is approximately 2,002.09'– 2,000.92' = 1.17'. The resulting strainer submergence for a LBLOCA at the CS switchover is approximately 2,002.43' – 2,000.92' = 1.51'.

The minimum sump water elevation for the event of a SBLOCA is assumed to be 2,001.42' at ECCS switchover (Assumption 4.2). As stated above, the top of the strainer is at 2,000.92'. Therefore, the top of the strainer is submerged by 0.5'.

2.3 Sump Pool Boron Concentration and pH

Post-LOCA sump pool chemistry conditions are taken from Reference 3.19 for two-train educator operation and a sump pool temperature of 86 °F. As shown in Reference 3.19 sodium hydroxide (NaOH) is used as the buffer to adjust the sump pool pH. The minimum recirculation sump pool pH of 8.73 results from the maximum boron concentration of 2,406 ppm and with a corresponding NaOH concentration of 2.7195 g/L (Ref. 3.19, Page 5). This water chemistry is reached shortly after switchover to recirculation.

The minimum sump pH is calculated in Reference 3.19 by assuming high contributions of water sources containing boron such as the refueling water storage tank, accumulators, and reactor cooling system. In the event of a LBLOCA, it is expected for these sources to have significant contribution to the sump water inventory.

2.4 Strainer Surface Area and Flow Rate

The calculated surface area of the sump strainer assemblies when completely submerged is 3,311.5 ft^2 each (Ref. 3.8). Per Reference 3.20 the surface area of miscellaneous debris is 7.1 ft^2, and per Reference 3.5 (Page 49), the wetted strainer flow area should be reduced by an equivalent 75% of the total single-sided surface area of tags. This results in a net strainer surface area of 3,306.2 ft^2. However, a sacrificial strainer of 15 ft^2 will be used for testing to provide operating margin. Therefore the net strainer surface area used for testing is 3,296.5 ft^2.

The greatest RHR pump sump recirculation flow rate occurs when a single RHR pump supplies water to the reactor cooling system (RCS) and to the high head safety injection pumps for both ECCS trains (Ref. 3.31). The RHR flow rate for this scenario is 4,880 gpm. The maximum flow rate of the CS pump is 3,950 gpm (Ref. 3.24, Page 2). The total maximum flow through a single strainer assembly is 8,830 gpm (3,950 gpm + 4,880gpm). To account for a 1% EDG over frequency and provide additional margin for test results, a flow rate of 9,100 gpm shall be used for testing a completely submerged strainer scenario.

Preliminary WCGS analysis indicates that containment sprays will be turned off prior to chemical precipitate formation in the post-LOCA sump. Therefore, the flow rate for testing during chemical precipitate debris addition shall be 5,150 gpm (9,100 gpm – 3,950 gpm).

2.5 NPSH Margin and Strainer Structural Design Differential Pressure

Per Reference 3.23, the NPSH margin of the CS pump at a flow rate of 3,750.0 gpm is 71.42 ft.

Reference 3.22 uses a value for the debris laden strainer head loss of 1.724 ft to calculate a net positive suction head (NPSH) margin for the RHR pump of 2.78 ft. The debris laden strainer head loss includes a clean screen head loss of 0.642 ft (Ref. 3.23). The NPSH margin of the RHR pump, not accounting for debris head loss, is 3.862 ft (2.78 ft + 1.724 ft – 0.642 ft).

Since the NPSH margin of the RHR pump is less than the CS pump, the RHR pump margin will be used to determine the acceptable head loss for the test. The acceptable head loss for conventional debris introduction is 3.862 ft.

Per Reference 3.31 the structural differential design pressure of the WCGS strainer is 1.19 psid. Based on the results of the head loss test, the structural differential design pressure may be revised in the referenced calculation. A preliminary acceptable head loss for chemical debris introduction will be 2.38 psid and the final value will be provided by WCGS prior to introducing chemical debris to the test tank. The acceptable head loss is not anticipated to be greater than 6 psid.

2.6 Debris Type and Quantity

2.6.1 Fibrous and Particulate Debris

WCGS has the following fibrous debris types: Nukon, Cerablanket, latent fiber, and Thermo-Lag 330-1. Material characteristics for the fiber types of concern are summarized in Table 1 (Ref. 3.20, Page 31).

Table 1: Material Characteristics for Fiber Types (Ref. 3.20)

Debris Type	Macroscopic/Microscopic Density (lbm/ft^3)	Characteristic Size (μm)
Nukon	2.4/159	7
Cerablanket	8.0/158	3.20
Latent Fiber	2.4[1]	7[2]

WCGS has the following particulate debris sources: FOAMGLAS, qualified coatings (inorganic zinc or IOZ and epoxy), unqualified and degraded coatings (IOZ, epoxy, alkyds), fire barrier material (Thermo-Lag 330-1), and latent particulate debris (Ref. 3.20, Page 31). Material characteristics for the particulates types of concern are summarized in Table 2 below.

Table 2: Material Characteristics for Particulate Types

Debris Type	Microscopic Density (lbm/ft^3)	Characteristic Size (μm)
FOAMGLAS	156	10
IOZ	208 and 220	10
Epoxy	112,115, and 171	10
Alkyds	98	10
Thermo-Lag 330-1	43.6	10
Latent Particulate	169	17.3

A scatter plot of the particulate volume transported to the strainer versus fiber mass transported to the strainer for every postulated DEGB and partial break at WCGS is provided in Figure 9. Breaks with bounding particulate or fiber debris loads for various break sizes are identified as “Breaks of Interest” on this figure. Table 5 summarizes the debris loads of these breaks. Line sizes represent the internal diameter of the pipe if it is a DEGB or the size of the partial break.

[1] Per NEI 04-07 SER (Ref. 3.5, Page VII-3), the macroscopic density of latent fiber is 2.4 lbm/ft^3.
[2] See Assumption 4.1

Debris loads for breaks postulated inside the reactor cavity are represented by Point L and Point M. Point L represents the debris load from a 12" partial break at the nozzle. Point M combines the largest particulate and fiber debris load from a 26" partial break at the nozzle.

The debris loads outside the reactor cavity include Point A through Point K. Point A represents the largest debris load expected to occur for a DEGB on a 3 in. or smaller line or a 2 in. or smaller partial break on any line. Point B combines the largest particulate and fiber debris load for an 8.75 in. DEGB, and it represents the largest debris load for a DEGB on an 8.75 in. or smaller line. This debris load also bounds the debris load of an 8 in. or smaller partial break on any larger line.

Similarly, Point C combines the largest particulate and fiber debris load for an 11.188 in. and 10.5 in. DEGB. This point bounds the debris load from any break located on the surge line piping that connects the RCS with pressurizer. This debris load also bounds the debris load of a 12 in. or smaller partial break on any line.

Point D, Point E, Point F, Point G, and Point H combine the largest particulate and fiber debris loads for a 14 in., 17 in., 20 in., 23 in., and 26 in. partial break, respectively. Point I, Point J, and Point K combine the largest particulate and fiber debris loads for a 27.5 in., 29 in. and 31 in. DEGB, respectively. Table 5 provides the debris load quantities for all breaks of interest shown in Figure 9.

Table 3 provides the debris load that represents the plant's debris load margin documented in Reference 3.28 and should be used in the full debris load test. In addition to the latent fiber margin, a quantity of Nukon fines equivalent to about 40 feet 1.5" pipe insulated with 2" of Nukon is included in Table 3 as margin.

Table 3: WCGS Full Debris Load Head Loss Testing Margins

Debris Type	Margin Quantity
Latent Fiber	15.9 lbm
Latent Particulate	90.27 lbm
Unqualified Coatings (IOZ, Epoxy, Alkyds, OEM Coatings)	0.625 ft^3
Degraded Coatings	0.435 ft^3
Nukon Fines	15 lbm

Similarly, Table 4 provides the debris load to represent the plant's debris load margin documented in Reference 3.28 and should be used in the thin-bed test. No fiber margin is included in Table 4 because fiber debris is added until a filtering bed is formed for the thin-bed test, not until a specific fiber quantity is reached. A quantity of FOAMGLAS that is equivalent to 10% of the amount of FOAMGLAS generated at Point M is added as margin.

Table 4: WCGS Thin-bed Head Loss Testing Margins

Debris Type	Margin Quantity
Latent Particulate	90.27 lbm
Unqualified Coatings (IOZ, Epoxy, Alkyds, OEM Coatings)	0.625 ft^3
Degraded Coatings	0.435 ft^3
FOAMGLAS	0.026 ft^3

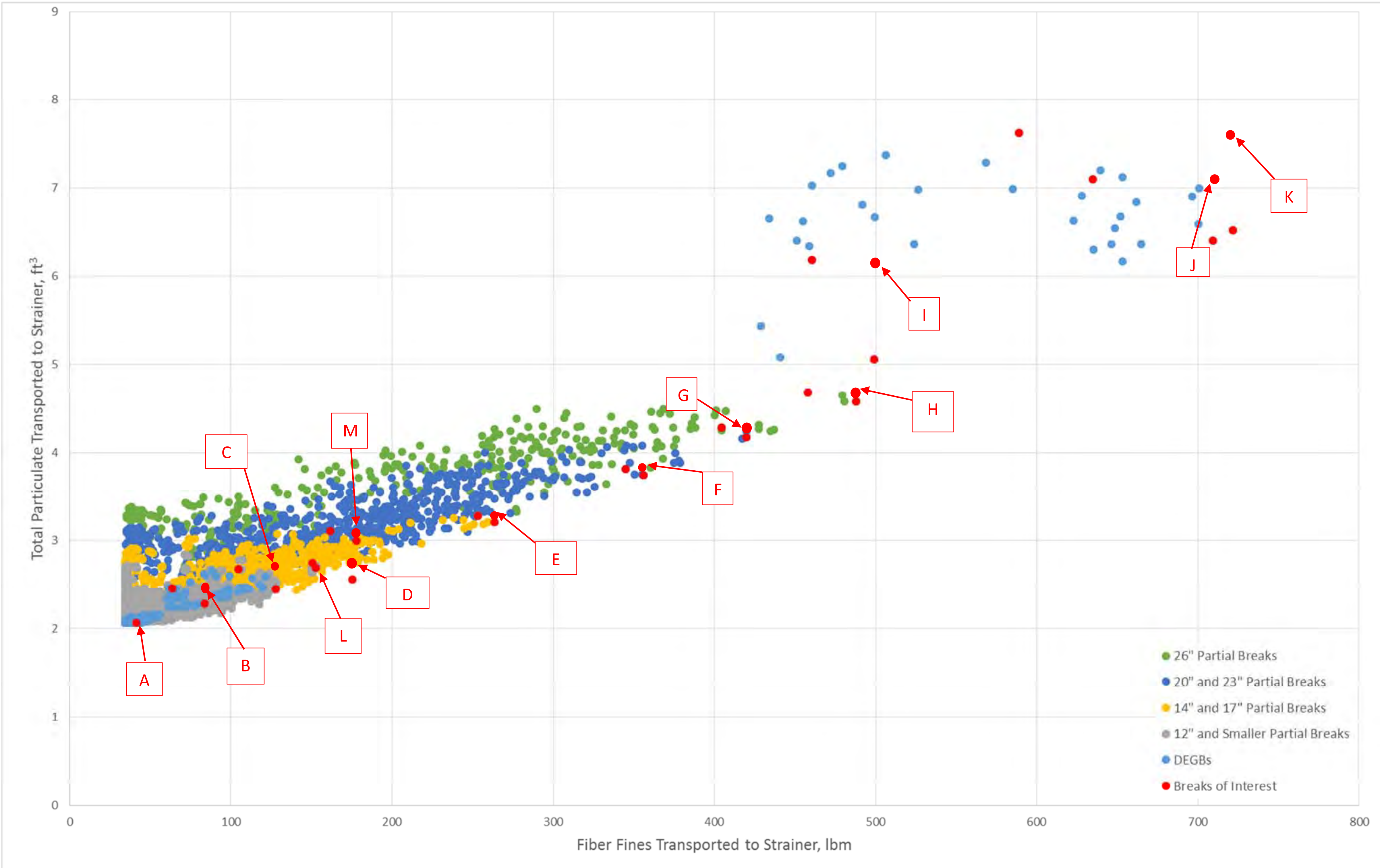


Figure 9: Total Particulate vs Fibrous Debris Load Transported to the Strainer for WCGS

Table 5: Breaks of Interest Debris Loads for WCGS Transported to the Strainer (Ref. 3.28)

Weld Name (Break Location)	Point on Figure 9	Compartment	Pipe ID or Break Size	Thermolag 330-1		FOAMGLAS (ft^3)	Unqualified and Qualified Coatings (IOZ, Epoxy, Alkyds) (ft^3)	Latent Particulate (lbm)	LDFG (lbm)		Cerablanket (lbm)
				Fiber (lbm)	Particulate (ft^3)				Fines (Includes Latent Fiber)	Smalls	Fines[3]
BB-01-S405-05	A	SG_1_4	2.626	8.92	0.50	0.00	1.24	54.47	16.56	13.63	0.00
EP-01-FW307	-	SG_1_4	8.75	8.92	0.50	0.00	1.63	54.47	38.83	53.17	0.00
BB-01-S101-07	-	SG_1_4	8.75	8.92	0.50	0.00	1.46	54.47	58.74	99.37	0.00
-	B	-	-	8.92	0.50	0.00	1.63	54.47	58.74	99.37	0.00
BB-01-S001-6	-	SG_1_4	11.188	8.92	0.50	0.00	1.86	54.47	79.83	127.61	0.00
EJ-04-F025	-	SG_1_4	10.5	8.92	0.50	0.00	1.62	54.47	103.21	202.36	0.00
-	C	-	-	8.92	0.50	0.00	1.86	54.47	103.21	202.36	0.00
BB-01-F204	-	SG_2_3	14	8.92	0.50	0.00	1.77	54.47	87.45	156.81	0.00
BB-01-F105	-	SG_1_4	14	8.92	0.50	0.00	1.74	54.47	150.4	296.4	0.00
-	D	-	-	8.92	0.50	0.00	1.77	54.47	150.4	296.4	0.00
BB-01-F304	-	SG_2_3	17	8.92	0.50	0.00	2.11	54.47	145.14	290.16	0.00
BB-01-S202-02	-	SG_2_3	17	8.92	0.50	0.00	2.09	54.47	169.25	321.33	0.00
-	E	-	-	8.92	0.50	0.00	2.11	54.47	169.25	321.33	0.00
BB-01-S302-02	-	SG_2_3	20	8.92	0.50	0.00	2.58	54.47	222.67	453.46	0.00
BB-01-S202-02	-	SG_2_3	20	8.92	0.50	0.00	2.5	54.47	231.75	469.02	0.00
-	F	-	-	8.92	0.50	0.00	2.58	54.47	231.75	469.02	0.00
BB-01-S302-02	-	SG_2_3	23	8.92	0.50	0.00	3.04	54.47	278.12	578.49	0.00
BB-01-S202-02	-	SG_2_3	23	8.92	0.50	0.00	2.93	54.47	293.77	594.87	0.00
-	G	-	-	8.92	0.50	0.00	3.04	54.47	293.77	594.87	0.00
BB-01-S302-02	-	SG_2_3	26	8.92	0.50	0.00	3.43	54.47	331.68	707.35	0.00
BB-01-S202-02	-	SG_2_3	26	8.92	0.50	0.00	3.34	54.47	361.65	747.24	0.00
-	H	-	-	8.92	0.50	0.00	3.43	54.47	361.65	747.24	0.00
BB-01-F401	-	SG_1_4	27.5	8.92	0.50	0.00	5.35	54.47	435.65	934.23	0.00
BB-01-F201	-	SG_2_3	27.5	8.92	0.50	0.00	3.89	54.47	390.83	808.41	0.00
-	I	-	-	8.92	0.50	0.00	5.35	54.47	390.83	808.41	0.00
BB-01-S402-02	-	SG_1_4	29	8.92	0.50	0.00	6.28	54.47	610.12	1311.42	0.00
BB-01-F204	-	SG_2_3	29	8.92	0.50	0.00	5.16	54.47	583.11	1258.5	0.00
-	J	-	-	8.92	0.50	0.00	6.28	54.47	583.11	1258.5	0.00
BB01-S404-03	-	SG_1_4	31	8.92	0.50	0.00	6.8	54.47	564.15	1213.86	0.00
BB-01-F205	-	SG_2_3	31	8.92	0.50	0.00	5.28	54.47	595.57	1300.68	0.00
-	K	-	-	8.92	0.50	0.00	6.8	54.47	595.57	1300.68	0.00
BB-01-S201-02	L	RX	12	8.92	0.50	0.26	1.6	54.47	12.09	2.92	80.16
BB-01-S201-02	-	RX	26	8.92	0.50	0.26	2.02	54.47	21.23	24.49	80.16
BB-01-F103	-	RX	26	8.92	0.50	0.26	1.91	54.47	37.48	55.99	80.16
-	M	-	-	8.92	0.50	0.26	2.02	54.47	37.48	55.99	80.16

[3] Nukon will be used a surrogate for Cerablanket. See Assumption 4.3 for additional information.

2.6.2 Chemical Product Debris Load

Per Reference 3.29, the maximum amount of aluminum oxyhydroxide formed in containment sump at WCGS is 148 kg, and the maximum sump pool temperature that aluminum oxyhydroxide could form is 116.4°F. This chemical product quantity includes 200 ft^2 of aluminum surface area for margin.

3.0 References

3.1 NEI Document "ZOI Fibrous Debris Preparation: Processing, Storage, and Handling," Revision 1, January 2012, ML120481057

3.2 NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors," September 13, 2004

3.3 NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris," October, 1995

3.4 NEI 04-07, Volume 1, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0, December 2004

3.5 NEI 04-07, Volume 2, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Revision 0, December 6, 2004," Revision 0, December 2004

3.6 PWROG Document 32-9217765-000, Rev. 0, "PWR Strainer Fiber Bypass Quantity"

3.7 ASTM D1193-91, "Standard Specification for Reagent Water"

3.8 TDI-6002-01 / TDI-6003-01, Rev. 1, "SFS Surface Area, Flow & Volume – Wolf Creek / Callaway"

3.9 C-1016-00001, W03, "General Notes and Information"

3.10 C-1016-00006, W03, "7 and 11 Disk Module Assemblies"

3.11 C-1016-00003, W05, "Sections"

3.12 C-1016-00007, W05, "11 Disk Module Assembly"

3.13 C-1016-00008, W05, "7 Disk Module Assembly"

3.14 C-1016-00010, W05, "Sections & Details"

3.15 C-1016-00009, W04, "Master Core Tube Layout"

3.16 C-1016-00016, W04, "A-Sump Top Support Frame Assembly"

3.17 C-1016-00002, W05, "Master Project Bill of Materials"

3.18 WES-009-CALC-001, Rev. 1, "Wolf Creek/Callaway Post-LOCA Containment Water Level Calculation"

3.19 EN-03-W-002-CN001, Rev. 2, "Wolf Creek Containment Sump pH"

3.20 WCN019-CALC-003, Rev. 1, “Wolf Creek Debris Generation Calculation” [DRAFT]

3.21 ARC-689, Rev. 1, “ECCS Flow Model”

3.22 EJ-30 CN-002, Rev. 3, “RHR Pumps A & B NPSH”

3.23 EN-33, Rev. 2, “Containment Spray Pump NPSH”

3.24 EN-05-W, Rev. 0, “Containment Spray Additive Eductor Parameters”

3.25 M-10EN, Rev. 5, “Containment Spray System”

3.26 Wolf Creek USAR, Rev. 27, “Chapter 6: Engineered Safety Features.”

3.27 C-1016-0050, “Door Barrier @ Loop “A” Location Plan Elevations and Sections” Revision 8

3.28 WCN019-CALC-011, Rev. 0, “Wolf Creek Debris Quantity Summary Calculation” [DRAFT]

3.29 WCN019-CALC-010, Rev. 0, “Wolf Creek GSI-191 Containment Sump Pool Chemical Product Generation Calculation” [DRAFT]

3.30 WCAP-16530-NP-A, March 2008, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191”

3.31 PCI-5304-S01, Rev. 4, “Structural Evaluation of the Containment Sump Strainers”

3.32 AN-97-056, Rev. 0, “RHR Flow during Cold Leg Recirculation (GL-97-04)”

4.0 Assumptions

4.1 Latent fiber is assumed to have the same as-fabricated density and hydraulic properties as Nukon per the Safety Evaluation of NEI 04-07 (Ref. 3.5, Page VII-3).

4.2 The minimum sump water elevation for the event of a SBLOCA is assumed to be 2,001.42’ at ECCS switchover. WCGS is updating their ECCS procedure to increase sump level for SBLOCAs.

4.3 Nukon is assumed to be used as a surrogate for Cerablanket for head loss testing.

5.0 Test Parameters

This section outlines the parameters that are relevant to the scope of the WCGS large-scale head loss testing. All relevant parameters are first summarized in Table 6 before being discussed in more detail in the subsections. Two tests are required to be performed: a full-load and a thin-bed head loss test. An optional contingency test may be performed.

Table 6: Head Loss Test Parameters (values derived in Sections 5.1 through 5.7)

Variable	Values for Testing	
	Thin-Bed	Full-Load
Fiber Type	Nukon (Section 5.1)	Nukon (Section 5.1)
Fiber Quantity	See Section 5.3.2	See Section 5.3.1
Fiber Preparation	All fibrous fine debris shall be prepared using high-pressure water jets in accordance with the NEI guidance (see Section 6.2.3). Small pieces shall be prepared with a method that meets the requirements of Section 6.2.3.	
Particulate Type	Pulverized acrylic, silica flour, PCI Dirt/Dust Mix (Section 5.2)	
Particulate Quantity	See Section 5.3.2	See Section 5.3.1
Chemical Precipitate Type	Aluminum Oxyhydroxide (AlOOH) (See Section 5.4)	
Chemical Precipitate Quantity	See Section 2.6.2	
Chemical Precipitate Preparation	WCAP-16530-NP-A (Ref. 3.30)	
Water Chemistry	2,406 ppm Boron, 2.7195 g/L (Section 5.5)	
Water Temperature	120°F (Section 5.6)	
Approach Velocity (ft/s)	0.00615/0.00348 (Section 5.7)	
Perforate Plate Configuration	The perforated plates of the test strainer shall have the same properties (e.g., opening diameter, arrangement and thickness) as the actual strainer at the plant (Section 6.1.1).	
Flow Condition Approaching Strainer	Sizing of the test strainer shall ensure flow conditions approaching the test strainer are comparable to the actual strainer (Section 6.1.1).	

5.1 Fiber Type

As shown in Section 2.6.1, WCGS has the following fibrous debris types: Nukon, Cerablanket, and latent fiber. Latent fiber will be substituted by Nukon as a result of equivalent density and hydraulic properties (see Section 4.1).

Thermolag 330-1 is no longer commercially available. Per Reference 3.20 Thermolag 330-1 contains fiber and particulate, but there is no specific information available on the type of fiber. Since Thermolag 330-1 was applied similar to a coating, it is believed that the fibers were relatively short. Nukon fines prepared in accordance with Section 6.2.3 will tend to have a distribution of short to long fiber lengths. Longer fiber lengths are expected to be more easily captured by the strainer, which increases head loss, compared to short fibers. Nukon will be used as a surrogate for Thermolag 330-1 fiber.

5.2 Particulate Type

As shown in Section 2.6.1, WCGS has the following particulate debris types: FOAMGLAS, IOZ, Epoxy, Alkyds, Thermo-Lag 330-1, and latent particulate.

The particulate surrogate used to represent IOZ, epoxy, and alkyds will be pulverized acrylic or silica flour. Since coating debris loads used for testing are scaled by volume, the density of IOZ is not a parameter for debris load scaling. Pulverized acrylic or silica flour with a mean size distribution of 10 microns will be used as a surrogate for IOZ, epoxy, and alkyds. Since the surrogate has a similar particle size and density to epoxy and alkyds it will have similar transport properties in the test loop.

As stated in Section 5.2, Thermolag 330-1 contains fiber and particulate. Per Reference 3.20 (Page A-25), one of the components of Thermolag 330-1 is silica. There is no additional information on the other particulate types in the fire barrier material. Silica flour or pulverized acrylic with a mean size distribution of 10 microns will be used as surrogate for Thermolag 330-1 particulate, which is consistent with the particle size for failed coatings identified in Reference 3.5.

PCI Dirt/Dust mix will be used as the surrogate for latent particulate. This mix was specifically developed as a surrogate for head loss testing to represent latent particulate found in containment of nuclear plants.

Per Reference 3.4, FOAMGLAS is a brittle cellular insulation. Information on the chemical composition of FOAMGLAS is not available, but since it is a cellular glass it is reasonable to expect that it contains silicate compounds. For the purpose of head loss testing, silica flour or pulverized acrylic with a mean size distribution of 10 microns will be used as a surrogate.

5.3 Particulate and Fibrous Test Debris Quantities

5.3.1 <u>Full-Load Head Loss Test</u>

The purpose of the full load test is to measure the head losses for debris loads that are representative in debris quantity and composition to those in the plant. Section 2.6.1 summarizes the break locations that result in the largest debris loads transported to the strainer for each respective break size.

Point B represents the largest debris load for a DEGB or partial break less than or equal 8.75 in. (internal diameter) that is outside of the reactor cavity. Once Point B has been tested, debris batches should be added to test Point C. If the measured head loss exceeds 80% of the acceptable head loss provided in Section 2.5, then additional conventional debris load batches shall only be added with ENERCON and WCGS approval. The margin debris load batch, provided in Table 3, may be added after Point C has been reached with ENERCON and WCGS approval. If the measured head loss is determined to be acceptable, debris batches should be incrementally added to test Point D, Point E, Point F, Point G, Point H, Point I, Point J and Point K.

Point L and Point M represent breaks inside the reactor cavity which contain Cerablanket. Since Nukon will be used as surrogate for Cerablanket (Assumption 4.3), the debris loads for breaks inside the reactor cavity can be bounded by the tested debris loads for breaks outside the reactor cavity in the full-load test.

5.3.2 Thin-Bed Head Loss Test

The purpose of the thin bed test is to form a particulate filtering debris bed with minimal fiber. The thin bed test particulate debris load shall be informed by the results of the Full-Load Head Loss Test and consider the margins provided in Table 4. This test will only use Nukon fines as a fibrous debris surrogate, and all of the particulate shall be added to the test tank before the addition of Nukon fines. Fibrous debris batches shall continue to be added to the test until the tank has cleared and/or complete strainer coverage is observed.

5.3.3 Contingency Test

An optional contingency test may be performed based on the results of the first two tests.

5.4 Chemical Product Debris Loads

The chemical product debris loads provided in Section 2.6.2 shall be scaled to the test strainer surface area for the full-load head loss test, thin-bed test, and any of the optional tests. Chemical debris loads for other break debris loads selected by preliminary results of the full-load test may be provided to Alden by a design input letter.

5.5 Test Water Chemistry

The water chemistry provided in Section 2.3 for the WCGS post containment sump shall be used (Boron concentration of 2,406 ppm and NaOH concentration of 2.7195 g/L). The resulting pH of the test solution should be around 8.73.

5.6 Fluid Temperature

The head loss testing will be performed at a nominal water temperature of 120°F before adding chemical precipitates. Testing at 120°F is more prototypical of post-LOCA sump temperatures than room temperature but does not present significant safety risks to the testing personnel and is achievable using PVC piping. Past testing at Alden also showed that testing at higher temperatures resulted in less floating fiber due to less dissolved gas and subsequent reduction in air bubble formation. Temperature sweeps shall be performed at points where the debris bed is required to be characterized prior to chemical debris addition (i.e. once conventional debris introduction is complete). Debris bed characterization is required for scaling head loss test results to higher temperatures and lower flowrates.

The aluminum oxyhydroxide, shall be added when the test loop temperature is below 100°F.

5.7 Approach Velocity

Average approach velocity is calculated by dividing the volumetric flow rate through a section of strainer by the area of the perforated plates that comprise it. The WCGS strainer is designed such that the average approach velocity for each strainer stack is equivalent.

For a total flow rate of 9,100 gpm (RHR and CS pumps taking flow from strainer) and a strainer surface area of 3,296.5 ft^2 (Section 2.4) when completely submerged, the approach velocity for the strainer assembly is determined to be 0.00615 ft/s.

For a total flow rate of 5,150 gpm (RHR pump only taking flow from the strainer), the approach velocity of the strainer assembly is determined to be 0.00348 ft/s.

5.8 Test Cases

As previously stated, a full-load and thin-bed head loss test shall be performed. An optional contingency test may also be performed, if necessary.

The testing shall be designed to quantify the head loss of a strainer that is prototypical to that installed at WCGS. In general, it is expected that a given quantity of fibrous, particulate, and chemical debris is batched into a test tank for each test. The debris-laden water shall then be circulated by a pump through the test strainer and other components along the flow loop. The following subsections contain additional requirements pertaining to test apparatus, test preparation, and test control which shall be incorporated into the Alden test plan.

6.1 Requirements on Test Apparatus

6.1.1 <u>Test Strainer</u>

The test strainer for the large-scale WCGS head loss testing shall be sections of the strainer assembly, representative of those installed at the plant, which maintains the configuration of the strainer assembly. When sizing the test strainer, the following requirements must be considered.

1. Approach velocity of the test strainer shall match that of the actual strainer modules at the plant (see Section 5.7).

2. Key dimensions (e.g., opening diameter, opening pitch, thickness, and width) of the perforated plates used for the test strainer shall match those of the actual strainer at the plant.
3. The spacing between external faces of two neighboring disks must be equal to that of the actual strainer (1" from face to face, see Section 2.1).
4. The flow conditions approaching the strainer disks and the friction head loss inside the plenum, core tube, and strainer disks must be similar to those of the plant strainers.
5. The test tank shall be configured to match so that the stack to stack and stack to pit wall distance match those of the actual plant strainer.

6.1.2 Debris Introduction System

Debris shall be added to the test tank away from the test strainer as reasonably achievable. The introduction system shall be designed to minimize splashing, which may result in loss of debris, and to avoid significant effect on the system flow rate.

6.1.3 Strainer Suction Piping

The piping connecting the test strainer to the pump and from the pump to the test tank must meet the following requirements (excluding vertically-mounted piping with downward travelling flow, as settlement will not be an issue):

1. Flow velocity greater than 1 ft/s shall be maintained to assure complete fiber transport. This requirement is based on NEI 04-07 (Ref. 3.4, Page 4-29) which indicates that a velocity of 0.25 ft/s can lift Nukon fibers over a 2” curb while a velocity of 0.34 ft/s can lift Nukon fibers over a 6” curb.

2. There shall be no sudden and significant flow area expansions or contractions on horizontal pipes along the flow path as these may facilitate fiber and particulate settling and accumulation in front of the area of change.

6.1.4 Test Loop Pump

The pump shall be sized to provide sufficient head to circulate water through the test loop while meeting test specifications. Specifically, the pump shall be capable of maintaining a flow rate such that requirements of Section 6.3.1 are met and the required strainer approach velocity is satisfied (see Section 5.7). Test pumps shall be capable of reducing and/or increasing the test loop flow rate required to perform flow sweeps that may be used to characterize the debris bed. The pump shall be capable of operating with the test loop temperature requirements stated in Section 5.6.

6.1.5 Instrumentation

The Alden test plan shall specify the accuracy and measurement range of the instrumentation required. The following parameters shall be measured during the test preparation or during testing.

1. Test strainer head loss (during testing)
2. Test flow rates (during testing)
3. Water temperature (during testing)
4. Test water pH (preparation of test water)
5. Water conductivity (preparation of test water)
6. Weight of test fiber batches (preparation of debris)
7. Weight of test particulate batches (preparation of debris)
8. Volume and concentration of chemical surrogate batches (during testing)

6.1.6 Test Loop Air Entrainment

Prior to starting large-scale testing, the test loop shall be water solid with minimal amount of air entrainment. Bubble formation shall be minimized and have little to no effect on fiber debris surrogate transport and settling. It is strongly recommended that the loop (or portions thereof) is pneumatically pressure-tested prior to starting large-scale testing. Air intrusion into the test loop shall be checked during shakedown testing.

6.2 Requirements on Test Preparation

6.2.1 Test Water

As discussed in Section 5.5, the large-scale head loss test shall use borated and buffered water as the test solution. The test solution shall be prepared using deionized (DI) water which shall have a conductivity less than 5 micro-S/cm at 25°C, consistent with “Type IV” laboratory reagent water per ASTM Standard D1193 (Ref. 3.7).

6.2.2 Preparation of Test Loop

Prior to any testing, thorough shakedown of the test loop shall be performed. The shakedown should include (but not be limited to) the following:

1. Perform leakage tests on all components and connections of the test loop, including all vent valves, dead ends, and isolation valves.
2. Confirm the test loop can perform satisfactorily at the highest test flow rate.
3. Demonstrate appropriate level of mixing inside the test tank to minimize settling of debris and disturbance to the debris bed on the strainer.
4. Confirm that the debris introduction system performs satisfactorily at the highest introduction rate required for the tests.

5. Verify the test rig's capability to heat up and cool down if required by the test plan.
6. Check instrumentation installation and calibration.
7. Confirm the debris preparation system's capability to work as desired.

At the beginning of each test, the test loop shall be thoroughly cleaned. The cleaning may be performed by running the test loop through filter bags, which can be inspected periodically until no residual debris is observed visually. The filter bags used for cleaning may be discarded.

Prior to the test, all instrumentation devices and the data gathering system must be verified to be functioning properly.

6.2.3 Debris Preparation

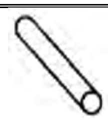
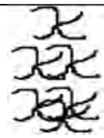
Prior to debris processing, Alden shall confirm that the debris materials have been heat treated appropriately. Use the heat treatment guidance provided in NEI protocol (Ref. 3.1) as criteria to determine if materials have been heat treated appropriately. If the debris materials need to receive heat treatment as part of the debris preparation process, Alden shall submit a heat treatment procedure to ENERCON for review.

Appropriate test solution shall be used for debris preparation. Fiber fines shall be prepared per the NEI protocol (Ref. 3.1). During the separation of the test quantity from the bulk quantity of debris (Ref. 3.1 Section 6.6), care shall be taken to prevent the creation of debris shards. The processed fiber shall then be inspected by the test engineer to ensure that it contains mainly "Class 2" fibers per Table B-3 of the NUREG/CR-6224 standard (Ref. 3.3, see Table 7 below).

For small pieces of fibrous debris, the test engineer shall ensure that the prepared debris contains fibers between Class 3 and fibrous pieces of 6" in length. Furthermore, the small pieces of fiber shall be processed such that there is a distribution of fibers among all sizes between Class 3 and that of fibrous pieces up to 6" in length.

The fiber processed per the above instructions should be readily dispersed in water. Each processed fiber batch shall be photographed on a light table for record-keeping.

Table 7: NUREG/CR-6224 Description of Processed Fiber Classes

Class No.	Description	
1		Very small pieces of fiberglass material, "microscopic" fines which appear to be cylinders of varying L/D.
2		A single flexible strand of fiberglass, essentially acts as a suspended strand.
3		Multiple attached or interwoven strands that exhibit considerable flexibility and which due to random orientations induced by turbulence drag could result in low fall velocities.

Chemical precipitate debris shall be produced in accordance with the instructions in Reference 3.30. Documentation shall be provided to show that the requirements for preparation of chemical debris in Reference 3.30 were met.

6.3 Requirement on Test Control

6.3.1 Clean Strainer Head Loss

Prior to debris introduction for the first debris laden head loss test, a clean strainer head loss measurement of the test system shall be recorded for a range bounding the flow rates that will be used during head loss testing.

6.3.2 Flow Control

For all test cases, the flow rate shall be consistently maintained at +5/-0% of the prescribed test flow rate. Care shall be taken to prevent the variation in flow rate from causing excessive disturbance to the debris bed on the strainer. If the differential pressure across the test strainer becomes larger than the design limit of the test system, the flow rate shall be reduced or the test terminated. The design limits will be established in the Alden test plan. Flow rate shall be varied when a flow sweep is required to characterize the debris bed (i.e. after conventional debris introduction is complete and at the end of test after adding all chemical debris).

6.3.3 Test Solution Temperature

For all test cases, the test solution temperature shall be maintained consistently within +/-5°F of the prescribed test temperature. A temperature sweep shall be performed at points where debris bed characterization is required.

6.3.4 Test Strainer Submergence

For the full-load test, the strainer submergence shall be maintained as close to that of the actual strainer for a LBLOCA as possible (i.e., from 1.17’ to 1.51’ per Section 2.2). One exception is, when the total debris quantity added to the test tank reaches or exceeds Point A in Table 5, the submergence of the test strainer shall be reduced gradually to 0.5'. If vortexing is observed, the test tank water level and flow rate shall be recorded in the test log. Water level shall then be increased until vortexing is no longer observed, and this water level shall also be recorded in the test log. Afterwards, the submergence shall be returned to the 1.17' – 1.51' range before continuing debris addition.

For the thin-bed test, submergence shall be maintained as close to that of the actual strainer for a LBLOCA as possible (i.e., from 1.17' to 1.51' per Section 2.2) and adequate to prevent vortexing, fully submerge the debris bed, and reduce impact to debris transport to the strainer. If vortexing is observed, the test tank water level and flow rate shall be recorded in the test log. If the submergence of the strainer is less than 1.17', the water level in the tank shall be increased until the submergence is at least 1.17'.

Proposed deviations to the values above by Alden shall require adequate justification in the test plan.

6.3.5 Test Debris Quantity

Test debris loads for the full-load head loss test and the thin-bed head loss test are discussed in Section 5.3.

6.3.6 Conventional Debris Introduction

For the full-load head loss test, fibrous debris and particulate debris shall be mixed together and added to the test loop in homogeneous debris batches. Fines should be substituted for smalls except for the last debris load point tested. Smalls should only be added to the test after all of the fiber fines have been added to the test loop. For example when performing the full-load head loss test, debris is added to reach Point B. Once Point B is reached, debris is added to reach Point C. Therefore, smalls should not be used when testing Point B. Fines should be substituted for the quantity of smalls at Point B. When testing Point C, all the fines of this break should be added first. Once all of the fines have been added, smalls may be added for Point C.

For the last debris load point tested, fine fibrous debris with particulate and small fibrous debris with particulate shall be added in separate batches. To ensure adequate homogeneity, the particulate debris should be split between the batches proportional to the weight of fibrous debris in each batch. For example, a debris point with 30% fines and 70% small pieces should have the particulate debris load split 30/70 and added to its respective intermediate batch .

Debris loads for the 8.75 in. DEGB (Point B) and 11.188 in. DEGB (Point C) should be tested as described in Section 5.3.1. After testing Point B and Point C, and if the measured head loss is acceptable (see Section 2.5), additional debris batches may be added to test Point D, Point E, Point F, Point G, Point H, Point I, Point J, and Point K. If a head loss measurement is required after adding a debris batch, the requirements of Section 6.3.8 shall be met.

For the thin-bed test, all of the particulate debris must be added to the test loop prior to adding the fibrous debris. Nukon fines shall be added to the test loop in batches equal to the amount required to form uniform 1/16" theoretical debris bed on the test strainer. Fiber batches shall continue to be added until the strainer is covered and/or a thin-bed effect is observed.

6.3.7 Chemical Debris Introduction

Chemical product surrogates shall be added to the test loop after conventional debris (fiber and particulate) additions have been completed for the head loss test. Incremental batches of chemical product surrogate shall be added to the test loop. The incremental additions should be small or slow enough to avoid rapid increases in head loss during the test. Chemical additions shall continue until the additions do not result in an increase in strainer head loss or the total chemical quantity is the scaled equivalent of the total plant chemical debris load. Documentation shall be provided to show that the requirements for preparation of chemical products in Reference 3.30 were met.

6.3.8 Head Loss Measurement

At points during the test where a head loss measurement is required for a debris load, a period of time, not less than 5 PTOs and where the increase in strainer head loss is less than 1% in two consecutive 30 minute intervals, shall be observed before continuing or terminating the test. After adding chemical products to the test loop, adequate head loss data shall be collected to estimate the strainer head loss at 30 days .

6.3.9 Tank Turbulence Level

The turbulence level inside the testing tank shall be maintained high enough to prevent non-representative settling of small pieces and maximize transport of fiber fines to the test strainer. The turbulence level close to the test strainer shall be carefully controlled to avoid disturbances to the debris bed formed on the strainer. Such a level of turbulence shall be maintained throughout each test.

6.3.10 Treatment of Settled Debris

Debris settling greater than 1' away from the strainer is considered to be non-representative. If non-representative debris settling is observed during a test, additional agitation should be provided to minimize non-representative settling. Such activities shall be documented in the test log (e.g., when, where and for how long the agitation is performed). Agitation must not disturb the debris bed on or around the test strainer. Debris that has settled non-representatively shall be photographed, noted in the test log, and quantified.

6.3.11 Treatment of Floating Debris

After adding each batch of debris to the tank, any significant amount of floating debris (>~1 g) shall be collected, mixed in a bucket and re-introduced to the test tank in the same manner as the bulk batch. At least 5 PTOs shall be run after the re-introduction to allow the re-introduced debris to reach the strainer. At the end of the test, small quantities of residual floating debris shall be collected and quantified.

7.0 Test Documentation and Records

This test specification provides the inputs and requirements to the WCGS large-scale head loss testing. A test plan and various test procedures will be developed by Alden and approved by ENERCON. Documentation shall be provided in the test plan and/or test procedure demonstrating how the requirements of this specification were met. The test procedures shall provide prescriptive step-by-step instructions and require signed documentation for the execution of each step. ENERCON and the plant will have the option to witness the performance of critical steps.

A test log shall be created to record key testing activities and observations as required by the test procedure, including, but not limited to, flow adjustments, debris addition (beginning and completion), agitation (including time and duration), adjustments to test tank water levels, and all other actions that affect the testing environment. The test logs shall describe the activities in adequate details without recourse to the test engineer. The test log should also include written documentation of the test conditions be as required as a backup to the electronic data acquisition record.

A test report shall be prepared to document the test system setup, instrumentation, test conditions and test results. The test report shall include analysis for scaling the strainer head loss with temperature and flow rate.

8.0 Test Performance Deviations

Any deviations from the test specification, test plan and test procedures shall be approved by the Alden test engineer with concurrence from the ENERCON and utility representatives.

9.0 Material Handling Requirements

The testing activities outlined in this document involve the use of various insulation materials, boric acid, NaOH, and AlOOH. All applicable requirements in the Safety Data Sheet (SDS) shall be followed when handling the insulation and other test materials and components.

10.0 Quality Assurance

In accordance with ENERCON's QA program, Alden is on ENERCON's Approved Suppliers List. Therefore, all testing activities and document preparation shall be performed under Alden's Appendix B QA program, which shall meet the requirements of 10 CFR 50, Appendix B and 10 CFR Part 21.

DRAFT

ENERCON Excellence—Every project. Every day.	**DESIGN SPECIFICATION PREPARATION CHECKLIST**	**PAGE NO. 1 of 2** **DESIGN SPEC. NO.** WCN-021-DSPEC-003 **REVISION A**

	CHECKLIST ITEMS	YES	NO	N/A
	GENERAL REQUIREMENTS			
1.	If the Design Specification is being performed to a client procedure, is the procedure being used the latest revision?	☐	☐[1]	☒
2.	Are the proper forms being used and are they the latest revision?	☒	☐[1]	☐
3.	Have the appropriate client review forms/checklists been completed?	☐	☐[1]	☒
4.	Are all pages properly identified with a Design Specification number, Design Specification revision and page number consistent with the requirements of the procedure?	☒	☐[1]	☐
5.	Is all information legible and reproducible?	☒	☐[1]	☐
6.	Is the Design Specification presented in a logical and orderly manner?	☒	☐[1]	☐
7.	Is it possible to alter an existing Design Specification instead of preparing a new Design Specification for this situation?	☐	☒	☐
8.	If an existing Design Specification is being used for design inputs, are the key design inputs, assumptions and engineering judgments used in that Design Specification valid and do they apply to the Design Specification revision being performed?	☐	☐[1]	☒
9.	Is the format of the Design Specification consistent with client procedures and expectations?	☒	☐[1]	☐
10.	Were design input/output documents properly updated or identified for update, to reference this Design Specification?	☐	☐[1]	☒
11.	Can the Design Specification logic, methodology and presentation be properly understood without referring back to the originator for clarification?	☒	☐[1]	☐
	PURPOSE			
12.	Does the Design Specification provide a clear and concise statement of purpose?	☒	☐[1]	☐
13.	Does the Design Specification provide a clear statement of quality classification?	☒	☐[1]	☐
14.	Is the reason for development and the end use of the Design Specification stated?	☒	☐[1]	☐
15.	Does the Design Specification provide the basis for information found in the plant's license basis?	☐	☒	☐
16.	If so, is this documented in the Design Specification?	☐	☐	☒
17.	Does the Design Specification provide the basis for information found in the plant's design basis documentation?	☐	☒	☐
18.	If so, is this documented in the Design Specification?	☐	☐	☒
19.	Does the Design Specification otherwise support information found in the plant's design basis documentation?	☐	☒	☐
20.	If so, is this documented in the Design Specification?	☐	☐	☒
21.	Has the appropriate design or license basis documentation been revised, or are the change notice or change request documents being prepared for submittal?	☐	☐[1]	☒
	DESIGN INPUTS			
22.	Are design inputs clearly identified?	☒	☐[1]	☐

	CHECKLIST ITEMS	YES	NO	N/A
23.	Are design inputs retrievable?	☒	☐[1]	☐
24.	If not, have they been added as attachments?	☐	☐[1]	☒
25.	If Attachments are used as design inputs or assumptions are the Attachments traceable and verifiable?	☐	☐[1]	☒
26.	Are design inputs clearly distinguished from assumptions?	☒	☐[1]	☐
27.	Are input sources (including industry codes and standards) appropriately selected?	☒	☐[1]	☐
28.	Are input sources (including industry codes and standards) consistent with the quality classification and objective of the Design Specification?	☒	☐[1]	☐
29.	Are input sources (including industry codes and standards) consistent with the plant's design and license basis?	☒	☐[1]	☐
30.	Are input values reasonable and correctly applied?	☒	☐[1]	☐
31.	Are design input sources approved?	☒	☐[1]	☐
32.	Does the Design Specification reference the latest revision of the design input sources?	☒	☐[1]	☐
33.	Were all applicable plant operating modes considered?	☒	☐[1]	☐
	ASSUMPTIONS			
34.	Are assumptions reasonable/appropriate to the objective?	☒	☐[1]	☐
35.	Is adequate justification/basis for all assumptions provided?	☒	☐[1]	☐
36.	Are any engineering judgments used?	☐	☒	☐
37.	Are engineering judgments clearly identified as such?	☐	☐[1]	☒
38.	If engineering judgments are utilized as design inputs, are they reasonable and can they be quantified or substantiated by reference to site or industry standards, engineering principles, physical laws or other appropriate criteria?	☐	☐[1]	☒

Note:

1. Provide justification for answers to these questions and provide clarification of answers where needed.

Question	Justification or Clarification

Design Specification Originator:

Name Date

DRAFT

ENERCON Excellence—Every project. Every day.	**DESIGN VERIFICATION PLAN AND SUMMARY SHEET**	**PAGE NO. 1 of 1**
		DESIGN SPEC. NO. WCN-021-DSPEC-003
		REVISION A

Safety-Related ☒ Non-Safety-Related ☐	**Document Verified: WCN -021-DSPEC-003 Rev. A**
	Design Verification Number[1]: N/A Rev[1]. N/A

Design Verification Method and Scope:

Design inputs will be verified by comparing the documented input with the source references and checking the validity of the reference for the intended use. All source references are in the list of references and are referenced specifically where they are used. All assumptions will be evaluated and verified to determine if they are based on sound engineering principles and practices. The methodology, results, and conclusions will be verified.

Design Verification Summary:

I have come to the following conclusions:

1. The methodology, design inputs, and approach are appropriate for the specification.
2. The assumptions, test parameters, and technical requirements are reasonably based on verified source references and design inputs.
3. The assumptions, test parameters, and technical requirements have been independently verified.

The document content is clear and concise.

Based on the above summary, the design document is determined to be acceptable.

(Print Name and Sign)

Design Verifier:	Ivan Zujovic	**Date:**
Approver[2]:	Kip Walker	**Date:**

Note 1: This field only applies to Design Verifications requiring a unique identifier number. Otherwise, mark as N/A.

Note 2: DEM approval required for Design Verifications performed by Originator’s Supervisor.

DRAFT

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Document Verified: WCN-021-DSPEC-003 **Rev. A**

Design Verification Number[1]: N/A **Rev[1]. N/A**

Item	CHECKLIST ITEMS	Yes	No [2]	N/A
1	**Design Inputs** – Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis and incorporated in the Design Document?	☒	☐	☐
2	**Assumptions** – Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	☒	☐	☐
3	**Quality Assurance** – Were the appropriate QA classification and requirements assigned to the Design Document?	☒	☐	☐
4	**Codes, Standards, and Regulatory Requirements** – Were the applicable codes, standards and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?	☒	☐	☐
5	**Construction and Operating Experience** – Have applicable construction and operating experience been considered?	☒	☐	☐
6	**Interfaces** – Have the design interface requirements been satisfied, including interactions with other Design Documents?	☒	☐	☐
7	**Methods** – Was the Design Document methodology appropriate and properly applied to satisfy the Design Document objective?	☒	☐	☐
8	**Design Outputs** – Was the conclusion of the Design Document clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs?	☐	☐	☒
9	**Acceptance Criteria** – Are the acceptance criteria incorporated in the Design Document sufficient to allow verification that the design requirements have been satisfactorily accomplished?	☒	☐	☐
10	**Computer Software** – If a computer program or software is used, have the requirements of CSP 3.03 for calculations or the applicable process CSP and CSP 3.09 been met?	☐	☐	☒
11	**Open Assumptions** – Is the Design Document free of open assumptions or preliminary information that shall be confirmed at a later date?	☒	☐	☐
12	**Lessons Learned** – Have problems with this design known from prior application been considered and resolved?	☒	☐	☐

COMMENTS:	
(***Print Name and Sign***)	
Design Verifier: **Ivan Zujovic**	**Date:**

Note 1: This field only applies to Design Verifications requiring a unique identifier number.

Note 2: Written justification for all “No” answers shall be provided in the Comments field.