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# Exhibit 2

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 24

**Extended Power Uprate** 

Response to RAI SPSB-C-35

VYC-1924, Rev. 0

Total number of pages in Exhibit 2 (excluding this cover sheet) is 89

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#### YANKEE NUCLEAR SERVICES DIVISION CALCULATION/ANALYSIS FOR

# TITLE <u>DE&S Calc. DC-A34600-006,"Vermont Yankee ECCS Suction Strainer Head Loss</u> <u>Performance Assessment.RHR and CS Debris Head Loss Calculations".</u>

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CALCULATION NUMBER VYC-1924

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COMPUTER CODES: NONE (SEE DE&S CALC COVER SHEET)

See Page II

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#### Calculation/Analysis Review - DE&S Calc:DC-A34600-06

Calc No. VYC-1924 Revision No. 0

The following calculation (or Technical report) was done by a Vendor as part of a Contract to Vermont Yankee. All work on this document was done under the Vendors approved QA program. The purpose of using this VY calculation number and cover sheet is for entering the document into the VY Information Management System. Reviews, Approvals, and Software control are handled under the Vendor's QA program.

Company's Name:	DE&S
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# REFERENCES\*: EDCR 97-423, VYS-049rev2,

\*For a complete list of references see DE&S Calculation Section 7.0



# CALCULATION COVER SHEET

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CALCULATION NUMBER: DC-A34600.006 REV: 1									
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PROJECT NAME: ECCS Suction Strainer Replacement									
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### **1.0 PURPOSE/OBJECTIVE**

The purpose of this calculation is to determine the head loss across the newly designed emergency core cooling system (ECCS) inlet suction strainers at the Vermont Yankee nuclear station as a result of debris accumulation following a postulated loss of coolant accident (LOCA). The new ECCS strainers were designed to trap debris generated during a LOCA (fibrous insulation, reflective metallic insulation (RMI), particulate, etc.) that was greater than 1/8<sup>th</sup> inch in size and preclude its transport to the ECCS pumps, spray nozzles, etc. Head loss calculations are required to verify that the new strainers are of sufficient size to maintain adequate net positive suction head (NPSH) to the ECCS pumps, even under limiting debris load and pump flow conditions.

This calculation will tabulate the head losses that result from several different flow scenarios for Residual Heat Removal (RHR) and Core Spray (CS) operation following a LOCA. The analysis will account for the different types of debris present in the drywell and suppression pool and/or generated as a result of a LOCA. The primary debris sources at Vermont Yankee are insulation that is dislodged from drywell piping by the break flow, such as RMI, NUKON®, Temp-Mat<sup>TM</sup>, FiberMat, and Armaflex. In addition, sludge initially present in the suppression pool, dirt and rust within containment, and coatings dislodged by the force of the LOCA jet all represent particulate debris that could contaminate the ECCS water supply, deposit on the strainer, and increase the pumping head loss. Finally, the Vermont Yankee containment has significant quantities of unqualified coatings that can fail as a result of the LOCA environmental conditions and transport to the suppression pool and possibly to the strainers therein. Each of these debris sources will be explicitly addressed in this calculation. It should be emphasized that the calculated results do not include a contribution from the clean strainer head loss. The contribution of the clean strainer to total system head loss is tabulated in the Vermont Yankee specification document VYS-049 " Specification for RHR and CS Suction Strainers" [Betti, 1997].

In addition to providing conservative, test-related estimates of strainer head loss for a number of ECCS system flow scenarios, the calculation also provides parametric analyses of the variation in calculated head loss with varying debris loading, ECCS pump flow rate, and suppression pool temperature. These results can be used by Vermont Yankee staff to evaluate the impact on strainer head loss of possible future plant design changes.

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# 2.0 CALCULATION METHODS

To determine the hydraulic performance of replacement ECCS suction strainers during a postulated LOCA event, it is necessary to quantify:

- The quantity of insulation material damaged by the LOCA and subsequently transported to the suppression pool,
- The quantity of particulate debris generated by the LOCA or already present in the drywell and transported to the suppression pool,
- The transport of debris within the suppression pool (deposition on the strainers or sedimentation on the suppression pool floor), and
- The head loss associated with a given quantity of debris transported to the strainer for a given flow rate and temperature.

In general, the debris transported to the suppression pool at Vermont Yankee will be an arbitrary combination of:

- fibrous insulation debris (NUKON, Temp-Mat, and FiberMat),
- small particulate (sludge, rust, dirt/dust, LOCA jet-induced coatings debris, and failed unqualified Inorganic Zinc [IOZ]coatings),
- fragments of Armaflex insulation,
- relatively large paint chips due to failed unqualified coatings,
- and RMI debris.

All, part, or none of these debris types could be deposited on the ECCS strainer. The quantity of insulation debris transported to the suppression pool, the quantity of particulate debris in the suppression pool, and the deposition of these debris constituents to the RHR and CS strainers under a range of ECCS flow conditions were provided in the Vermont Yankee specification VYS-049 [Betti, 1997]. These quantities will be used directly for strainer sizing purposes. Thus, this calculation focuses exclusively on the determination of head loss associated with flow through debris on the strainer.

The methodology used to determine head loss due to fibrous debris, small particulate, and Armaflex fragments is described in Section 2.1. The methodology used to determine head loss due to RMI debris is discussed in Section 2.2. Each of these contributions to head loss are considered separately, and the total head loss is determined by summing the two individual contributions. Finally, the impact of large paint chips on strainer head loss is considered in Section 2.3

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# 2.1 Head Loss Methodology for Fibrous Debris with Entrained Particulate

The methodology used for determining head loss across a fiber/particulate debris bed is based on the modeling approaches presented in the NRC-sponsored NUREG/CR-6224, *Parametric Study of the Potential for BWR ECCS Strainer Blockage due to LOCA Generated Debris* [Zigler, et al, 1995]. This explicitly accounts for all important parameters and phenomenology including:

- Mixtures of different fibrous and particulate debris constituents,
- Available strainer surface area, which may change with time for a stacked disk strainer design as the gap interstitials fill with debris,
- Compression of the fiber bed as a function of the pressure drop across the fiber bed, and
- Filtration (trapping) of less than 100% of the particulate debris transported to the strainers as a function of fibrous debris thickness.

The following sections present:

- A summary description of the head loss methodology,
- A discussion of the filtration model for small particulate debris,
- A discussion of how mixtures of fibrous debris constituents are modeled,
- A discussion on the treatment of Armaflex insulation,
- Rationale for choice of NUREG/CR-6224 correlation in lieu of URG/CDI algorithm, and
- Discussion of experimental verification

# 2.1.1 Summary Description

The NUREG/CR-6224 head loss correlation is described in detail in Appendix B to NUREG/CR-6224 [Zigler, *et al*, 1995] and is a semi-theoretical head loss model. The correlation is based on the theoretical and experimental research for the pressure drops across a variety of fibrous porous media carried out since the 1940s. The NUREG/CR-6224 head loss model, proposed for laminar, transient and turbulent flow regimes through mixed debris beds (i.e., debris beds composed of fibrous and particulate matter) is given by:

# $\Delta H = \Lambda [3.5 S_v^2 \alpha_m^{1.5} (1+57 \alpha_m^3) \mu U + 0.66 S_v \alpha_m/(1-\alpha_m) \rho U^2] \Delta L_m$

where,

 $\Delta H$  is the head loss, S<sub>v</sub> is the average surface to volume ratio of the debris,  $\mu$  is the dynamic viscosity of water, U is the approach velocity,

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 $\rho$  is the density of water,  $\alpha_m$  is the mixed debris bed solidity,  $\Delta L_m$  is the mixed debris bed thickness, and  $\Lambda$  is a unit conversion factor ( $\Lambda = 1$  for SI units).

The mixed debris bed solidity is given by:

$$\alpha_{m} = \left(1 + \frac{\rho_{f}}{\rho_{p}}\eta\right) \alpha_{o} \frac{\Delta L_{o}}{\Delta L_{m}}$$

where,

 $\alpha_o$  is the uncompressed fiber bed solidity,  $\Delta L_o$  is the theoretical (uncompressed) fibrous debris bed thickness,  $\eta = m_p/m_f$  is the particulate to fiber mass ratio of the debris bed,  $\rho_f$  is the fiber density, and  $\rho_p$  is the average particulate material density.

For  $N_p$  classes of particulate materials,  $m_p$  and  $\rho_p$  are defined by:

$$m_p = \sum_{i=1}^{N_p} m_i$$

and

$$\rho_{p} = \frac{\sum_{i=1}^{N_{p}} \rho_{i} V_{i}}{\sum_{i=1}^{N_{p}} V_{i}}$$

where  $m_i$ ,  $\rho_i$  and  $V_i$  are the mass, density and volume of a particulate material *i*.

Compression of the fibrous bed due to the pressure gradient across the bed is also accounted for. The empirical relation that accounts for this effect, which must be satisfied in parallel to the previous equation for the head loss, is given by (valid for  $(\Delta H/\Delta L_o) > 0.5$  ft-water/inch-insulation, below this value there is no compression):

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 $c = 1.3 c_o (\Delta H / \Delta L_o)^{0.38}$  for  $c \le 65 / (1+\eta) lb/ft^3$ .

where,

c is the compressed debris bed density (in lb/ft<sup>3</sup>), c<sub>o</sub> is the uncompressed insulation density (in lb/ft<sup>3</sup>), and  $\Delta H / \Delta L_o$  is the head loss in ft-water per inch of insulation.

For a calculated value of c greater than 65 / (1+ $\eta$ ) lb/ft<sup>3</sup>,  $\alpha_m$  is calculated directly by [Zigler, *et al*, 1995]:

 $\alpha_m = 65 \text{ lb/ft}^3/\rho_p$ 

where 65 lb/ft<sup>3</sup> is the macroscopic density of a granular media such as sand, gravel, or clay.

The NUREG/CR-6224 models were implemented by the U.S. Nuclear Regulatory Commission in the BLOCKAGE 2.5 computer code [Rao, *et al*, 1996], [Shaffer, *et al*, 1996], which is publicly available from the Oak Ridge National Laboratory code center. The BLOCKAGE 2.5 code includes an assessment of:

- the time-dependence of debris transport from the BWR drywell to the suppression pool,
- the buildup of debris on the strainers as a function of pump flow rate and pool water volume,
- the potential reduction in debris buildup as a result of sedimentation to the floor of the suppression pool,
- the potential reduction in the buildup of particulate debris as a result of less than perfect filtration of such particulate by the fibrous debris,
- and the head loss resulting from the flow through the deposited debris.

However, the BLOCKAGE 2.5 code was developed under the assumption that the surface area of the strainer could be treated as a constant, user-supplied input to the analysis, with the debris buildup being calculated as though the strainer could be represented as a flat surface with the same surface area. This simplifying assumption is valid in the case where one has a large surface area relative to the debris volume, such that only a thin debris layer would be calculated. However, in the case where one has a large volume of debris, with a complex strainer geometry involving stacked disks and curved surfaces, the BLOCKAGE 2.5 approach to debris deposition is no longer valid. There are two principal reasons for this:

1. A stacked disk strainer has a very large surface area relative to the overall strainer volume. With large volumes of fibrous debris, the interstitial gaps between the disks can become filled with debris.

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When that occurs, the effective surface area of the strainer for additional debris deposition is reduced to the circumscribed area of the strainer.

2. For thick layers of debris on the outside of a cylindrical shape, the debris thickness relative to the debris volume is a function of the surface curvature, and is less than the thickness that would result from deposition on a flat surface of the same area.

In light of these limitations in BLOCKAGE 2.5 and the unavailability of the BLOCKAGE 2.5 source code, ITS Corporation developed the HLOSS 1.0 code [Mast and Souto, 1997] to provide a computational tool that could be used to assess stacked-disk strainer performance under varying fiber loads with particulate debris. Thus, the HLOSS 1.0 code incorporates the following features:

- head loss estimates based on the head loss correlation presented in NUREG/CR-6224,
- time-dependent debris build-up on the strainers that may be input by the user based on strainer flow rate and pool water volume as in BLOCKAGE 2.5 (with all debris assumed to be suspended in the suppression pool at time zero),
- filtration efficiencies and sedimentation fractions that may be input by the user,
- use of the full strainer surface area for debris deposition until the gaps between the stacked disks are filled with debris,
- use of the strainer circumscribed area for further debris deposition after the gaps are filled,
- calculation of debris thickness on the outside of the circumscribed area that accounts for the surface curvature, and
- use of an averaging algorithm for the debris-specific surface area that climinates potential nonconservative results associated with a volume-weighted average in cases of large quantities of particles with low specific surface area.

As with BLOCKAGE 2.5, debris constituents are modeled strictly through the input of such physical parameters as density and particle characteristic size. Except for the debris bcd compression correlation, there is no adjustment of any correlation coefficients for different fiber types, particulate constituents, or strainer configuration.

One limitation in HLOSS 1.0 is the lack of an explicit model for debris sedimentation in the suppression pool following the early high-turbulence phase of a LOCA. However, since any impact of sedimentation had already been accounted for in the debris quantities specified in VYS-049, this limitation has no significance for these analyses.<sup>4</sup> Thus, the HLOSS 1.0 code was chosen to perform the fiber/particulate head loss calculations herein.

#### 2.1.2 Particulate Filtration Model

It has been shown experimentally that not all of the particulate debris reaching the strainer would be trapped or filtered by the fibrous debris on the strainer surface. The fraction of the debris particles

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approaching the strainer that are deposited and trapped within the fibrous debris bed is referred to as the filtration efficiency. Several experiments were conducted by the NRC to provide bounding estimates for the filtration efficiency of small particulate such as sludge [Rao and Souto, 1996]. Based on these experiments, a conservative upper-bound value of 0.50 was used for the particle filtration efficiency for debris bed thickness greater than 0.25 inches in the NUREG/CR-6224 analysis<sup>1</sup>. For debris bed thickness lower than 0.25 inches, the 0.50 filtration efficiency was deemed overly conservative and a linear variation for the filtration efficiency from 0 to 0.5 was used for theoretical thickness lower than 0.25 inches. For small particulate (2  $\mu$ m to 10  $\mu$ m), the dominant filtration mechanisms are impaction and interception, and the filtration efficiency is essentially the same for all particulate constituents with a diameter of 10 microns or less. For larger particulate, a filtration efficiency of 1.0 is conservatively assumed.

# 2.1.3 Treatment of Mixed Fiber Beds

The head loss correlation described in Section 2.1.1 is based on fibrous insulation material properties that include fiber density, debris density, and fiber diameter. In the case where more than one type of fibrous debris component is present, it is necessary to use average values for these parameters. In the calculations described herein, average values for the microscopic fiber density are determined using a debris volume weighted average. The average macroscopic density of the debris mixture is obtained by dividing the total debris mass by the total debris volume where the total debris volume is derived by using the observed estimated debris thickness from tests specifically conducted for Vermont Yankee at the Alden Research Laboratories (ARL) [Copus, 1998].

# 2.1.4 Impact of Armaflex Insulation Debris on Head Loss

Armaflex is a closed cell foam type insulation. Because of the closed cell construction, the as fabricated insulation floats and would not be expected to deposit on the strainer surface. However, the LOCA jet forces are expected to fragment some of this material, thereby impacting its buoyancy. This is particularly true if very small fragments are generated. For conservatism, it will be assumed herein that Armaflex will be fragmented into small (less than 1mm size) pieces that are transported to the suppression pool. Test results will then be used to determine whether or not this debris can transport to the strainer surface.

#### 2.1.5 Comparison to URG/CDI Head Loss Algorithm

Prior to adopting the NUREG/CR-6224 head loss correlation approach, ITS Corporation performed an independent assessment of all the available fibrous head loss correlations. These included:

<sup>1</sup> Note that the thickness in these experiments was less than 4 inches. For very thick beds, higher efficiencies may be expected but no experimental data is available.

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- Correlations documented in the OECD/CSNI International Task Group Report entitled "Knowledge Base for Emergency Core Cooling System Recirculation Reliability" [NEA, 1996].
- The GE/BWROG correlation "Passive Strainer Head Loss Prediction with Fibrous Debris" documented in NEDO-32686, *Utility Resolution Guidance for ECCS Suction Strainer Blockage* [BWROG, 1996], hereafter denoted URG.
- The NRC Semi-Theoretical Head Loss Model documented in NUREG/CR-6224.

All the correlations suffered from the generic problem of their applicability being limited to the data for which the correlation was developed. This was especially true for correlations developed prior to 1994, which, in general, did not address the effect of particulate in fibrous debris beds. ITS Corporation concentrated its efforts on performing a detailed review of the GE/BWROG URG fibrous head loss correlation and the NRC NUREG/CR-6224 fibrous head loss model.

Specific insights from the comparison of the URG correlation and NUREG/CR-6224 model include:

- 1) Flow velocity The URG correlation only has a first order term in U (laminar), whereas the NUREG/CR-6224 model has explicitly both laminar and turbulent (U<sup>2</sup>) terms.
- 2) Fiber diameter The surface to volume ratio of the fiber material is proportional to the inverse fiber diameter. The two analysis methods handle this effect the same way.
- 3) Bed porosity (solidity) Both analysis methods show increased head-loss with increasing bed solidity. However, the form of the dependence on solidity is somewhat different. Previous historical work (documented in NUREG/CR-6224) had shown that the form employed in the URG correlation was in fact more appropriate for head-loss through porous media than for head-loss through a fiber bed.
- 4) Strainer geometry Neither the URG correlation nor the NUREG/CR-6224 model explicitly accounts for strainer geometry. The URG model, in fact, was derived from data obtained from stacked disk as well as 60-point star strainer geometries, without attempting to determine what the effective strainer area was for a given experiment (the circumscribed area was used in developing the correlation). Consequently, it was determined that there was no basis for applying the URG correlation to arbitrary strainer geometries.

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5) Bed Compression – Unlike the NUREG/CR-6224 correlation, the URG algorithm does not explicitly account for fiber bed compression. This has been shown to be an important effect. In many of the tests used to "calibrate" the URG correlation, compression was certainly occurring, and the effect thereof was included (in an average sense) in the correlation coefficients. However, the form of the correlation does not allow one to determine whether this treatment is conservative under all conditions.

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6) Particulate Filtration – Unlike the NUREG/CR-6224 correlation, the URG algorithm does not explicitly account for particulate filtration. The effect of particulate debris is accounted for through the use of "Bump-Up Factors" that are functions of the debris quantities. Bump-up factors are not treated as being functions of debris quantity (or thickness). Thus, it is unclear whether the use of bump-up factors is conservative under all conditions.

Based on the above assessment, it was felt that there was a much better basis for using the NUREG/CR-6224 correlation. There is a much more extensive database to demonstrate the validity of that correlation (see below). In addition, because all-important phenomena are treated explicitly in a semi-theoretical manner, it is much easier to argue the conservatism associated with its application in a particular circumstance.

## 2.1.6 Experimental Validation of Head Loss Algorithm

The NUREG/CR-6224 model relies on fundamental characteristics of the debris bed composition, such as the bed thickness, average (microscopic) density, characteristic debris size, etc. Its results have been extensively validated for debris beds composed of fiberglass and simulated suppression pool sludge [Rao and Souto, 1996], as well as mineral wool fibrous materials [NEA, 1996]. The NUREG/CR-6224 model was also extensively validated in support of the OECD/CSNI International Task Group. The experimental data base [NEA, 1996] included:

- 1) NRC Experimental Head Loss Data NUREG/CR-6367
- 2) PP&L Head Loss Data
- 3) PCI Head Loss Data
- 4) NUREG/CR-2982 Head Loss Data
- 5) Vatenfall Development Co. Data Base
- 6) ABB-Atom, Sweden Head Loss Data Base
- 7) Forsmark Head Loss Data Base
- 8) Ringhals Head Loss Data Base
- 9) KKL Head Loss Data Base

In all cases, as reported in NEA/CSNI/R (95)11, "Knowledge Base for Emergency Core Cooling System Recirculation Reliability", the NUREG/CR-6224 model consistently predicted the experimental results within an acceptable error band.

In addition, a detailed analysis of the head loss testing done for the PCI stacked disk strainers at EPRI has been completed. These experiments were conducted for a wide range of fiber (NUKON) quantities, sludge to fiber mass ratios, and effective surface area (gap filling). Excellent agreement was obtained for model predictions both in the case of small fiber quantities (gaps not filled) as well as for large fiber quantities (gaps filled with additional fiber buildup on the circumscribed area of the

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strainer. These results have been summarized as part of the HLOSS 1.0 documentation [Mast and Souto, 1997] and presented to the NRC in a public meeting on February 18, 1997.

More recently, an experiment was performed at EPRI for the PCI stacked disk strainer using Temp-Mat rather than NUKON fibrous debris [Hart, 1997]. Comparison of the measured head loss with that predicted using the HLOSS 1.0 code showed agreement to within 20%, with the predicted result conservatively higher than that measured.

#### 2.2 Head Loss Methodology for RMI Debris

Given the deposition of a certain amount (and type) of RMI debris on the strainer, ITS Corporation uses a head loss correlation for stacked disk strainer head loss through an RMI debris bed based on that given in the BWROG URG [Diertl, *et al*, 1996]. This head loss correlation explicitly treats the effects of:

- the formation of a "saturated bed" of RMI foil debris the maximum theoretical debris bed which could be formed on the strainer, and
- different types of RMI foils.

The BWROG URG RMI head loss correlation is based on the head loss data obtained with several strainer geometries at the EPRI strainer test facility located in Charlotte, North Carolina. These tests [Diertl, 1996] were conducted with stainless steel RMI foil debris with characteristics similar to the RMI debris resulting from the USNRC sponsored full scale tests at the SIEMENS-KWU facility in Karlstein, Germany.

The URG based correlation to estimate the head loss due to RMI foil debris can be written as:

$$\Delta H = K_t K_p \frac{A_{RMI}}{A_c} U^2$$

where,

 $\Delta H$  is the head loss across the RMI bed (ft-water),

U is the fluid approach velocity (ft/sec) at the circumscribed surface of the strainer, which is given by  $Q/(450*A_c)$ ,

Q is the volumetric flow rate (gpm) through the strainer,

 $K_{t}\&K_{p}$  are experimentally determined constants that describe the head loss characteristics of the RMI,

 $A_{RMI}$  is the total (single-sided) surface area ( $ft^2$ ) of the RMI foil on the strainer,

 $A_c$  is the cylindrical circumscribed area (ft<sup>2</sup>) of the strainer (conservatively set equal to  $\pi DL$ ),

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- D is the outer diameter (ft) of the strainer, and
- L is the active length (ft) of the strainer.

An independent assessment of this correlation and the experimental data used to determine the proportionality constants [Heames, 1997] concluded that there was some question as to the defensibility of the value of those coefficients for some materials (aluminum vs. stainless steel). However, it was concluded that use of values for the two coefficients based on stainless steel foils would result in a conservative prediction of head loss that was defensible based on available data.

The URG also provides a methodology for determining whether a saturation thickness of RMI foils has been reached. The formula provided to determine the saturation bed thickness,  $\tau_s$ , is given by:

$$\tau_s = \frac{\sqrt{D L}}{2} \left[ \sqrt{\frac{2 U}{U_s}} - 1 \right]$$

where,

U<sub>s</sub> is the settling velocity (ft/sec) of the RMI foil type being analyzed.

The RMI foil quantity that corresponds to this saturation thickness,  $A_{max}$ , is then given by:

$$A_{\max} = \frac{\tau_s A_c}{K_t}$$

such that the smaller of the actual value of  $A_{RMI}$  or the saturation value of  $A_{max}$  is used in the prior expression for the RMI head loss.

The only additional constraint for the application of the URG based methodology to estimate head losses due to RMI debris is:

 $A_{RMI} / A_c \leq 40.$ 

Ratios beyond this value of 40 may not be justified based on the limited range of conditions previously tested.

ITS Corporation has performed a detailed independent review [Heames, 1997] of the RMI head loss correlation presented in the URG. The following conclusions were drawn:

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1) <u>Dependence Upon Flow Rate</u> - In applying the URG head loss correlation for RMI, ITS Corporation checks whether or not the calculated approach velocity is less than 2.0 ft/s for a stacked disk strainer (the upper bound of data that has been reported).

The correlation expresses head loss as a simple function of the square of the strainer flow rate (i.e., velocity), indicating head loss is governed by turbulent flow through the RMI debris. Analysis of the experimental data for fiber clearly shows that the measured head loss is a more complex function of velocity, with both viscous and inertial components. Analysis of the experimental data for RMI indicates the possibility of a similar complex relationship. However, the experimentally derived constant in the head loss correlation is set so that head losses larger than measured values (i.e., conservative values) are generated over the range of velocities investigated.

2) <u>Dependence on RMI Debris Loads</u> - In applying the URG head loss correlation for RMI, ITS Corporation checks whether or not the calculated RMI load is less than approximately 40 ft<sup>2</sup> of RMI per ft<sup>2</sup> of strainer circumscribed area (the upper bound of data that has been reported).

Correlation coefficients in the head loss equation were derived for a limited range of debris loads. As with any correlation, care must be exercised in extrapolating to regions outside the database. In order to ensure that the correlation developed for the stacked disk strainer is conservative relative to the available data, the anticipated RMI loads should not exceed the upper bound of the test data: 40 ft<sup>2</sup> of RMI per ft<sup>2</sup> of strainer circumscribed area

3) <u>Dependence on RMI Material</u> - In applying the URG head loss correlation for RMI, ITS Corporation assumes that all RMI debris will have the same debris head loss characteristics as the 2.5 mil stainless steel debris obtained by the USNRC at the Sicmens-KWU Karlstein steam blast test and tested at the EPRI facility. As such, ITS Corporation always employs the RMI proportionality constant determined in the EPRI full-scale tests irrespective of the RMI foil material type and thickness.

Experiments were conducted to measure the head loss across a representative full scale truncated cone strainer exposed to debris from two different types of 2.5 mil stainless steel RMI at the EPRI test facility. Significantly different head losses were measured for these two types of stainless steel debris. To ensure the head loss correlation generated conservative results, the correlation coefficients were developed to envelope measured head losses for both types of stainless RMI. Subsequently, experiments were performed at the CDI gravity head loss test facility (using a flat plate strainer) with the objective of comparing head loss for stainless RMI to head loss for other RMI materials, such as aluminum. This second series of experiments also re-examined the same two types of stainless RMI debris studied in the earlier truncated cone strainer experiments.

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Results of these tests also confirmed that the head loss for the two types of stainless debris are significantly different; however, the type of RMI that produced the larger head loss in the full scale EPRI tests produced the smaller head loss at the CDI gravity head loss test facility. The clear contradiction between the two sets of stainless RMI experiments raises questions about the technical basis of the factors (as derived from the gravity head loss tests) used to estimate the head loss for aluminum foils. In particular, the current data does not uniformly support the values for the head loss proportionality constants,  $K_p$ , applied in the URG correlation. Conservative strainer design implies the use of the largest proportionality constant (i.e., generate the largest pressure drop for all situations) and the use of the most prototypical experimental results. The RMI proportionality constant determined in the EPRI full scale tests satisfies both conditions and is thus used for <u>all</u> RMI debris, regardless of the actual material composition. For the case of a stacked disk strainer, this conservatism yields a value for  $K_t K_p = 0.0686$  ft-water/(ft<sup>2</sup>/sec<sup>2</sup>).

4) <u>Saturation Bcd Thickness</u> - The URG presents data on the RMI saturation bed thickness, bed thickness proportionality constant, and settling velocity for different RMI types. These data are used directly by ITS Corporation in the prediction of RMI head loss.

Thus, in summary, ITS Corporation implements the RMI head loss correlation proposed in the URG with the exception that the head loss proportionality constant for 2.5 mil stainless is used regardless of RMI type. It should be noted that neither of the bounding conditions (limitations on flow rate and debris load) identified above are reached for Vermont Yankee.

# 2.3 Head Loss Methodology for Large Paint Chips

The NUREG/CR-6224 head loss methodology characterizes the impact of any particulate on fibrous debris head loss through that particulate's impact on bed porosity and that particulate's impact on the average debris surface to volume ratio. This has been shown to work very well for small size particulate such as sludge. However, for paint chips that are very large (1/8<sup>th</sup> inch by 1/8<sup>th</sup> inch to 2 inches by 2 inches in size), there is no available experimental data to validate the NUREG/CR-6224 modeling approach.

Given the current uncertainty in head loss due to large paint chips, a series of tests were conducted for Vermont Yankee at ARL to better quantify the impact of large paint chips on strainer head loss [Johnson, 1997]. The results indicated that large paint chips could not deposit on the ECCS strainers for the combined Vermont Yankee DBA conditions of pool turbulence and ECCS inlet flow [Copus, 1998]. A specific methodology for determining the head loss under alternative suppression pool loading conditions was subsequently unnecessary since the predicted head loss in all cases was defined to be zero.

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# 2.4 Applicable Codes/Standards

The following codes and standards are applicable to this calculation: 1) 10CFR50, Appendix B, and 2) 10CFR21.

# 2.5 QA Requirements

This calculation is safety related and has been prepared and reviewed in accordance with DE&S procedure DPR-3.2 [DPR-3.2, 1997].

#### 2.6 Use of Software

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As previously discussed, calculations documented herein were performed using the HLOSS 1.0 computer code and the BLOCKAGE 2.5 computer code without new\_assumptions or coding modifications. These programs are verified and validated in accordance with the DE&S QA Program Procedure, DPR-3.5 [DPR-3.5, 1997] and are on the DE&S approved software list.

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#### 3.0 DESIGN INPUT DATA

This section describes the information used to determine the ECCS strainer head loss at Vermont Yankee. This information consists of strainer sizing data, plant specific flow and suppression pool temperature data, debris quantities, and debris material properties. As was mentioned previously, the debris quantities expected to be transported to the individual strainers have been calculated elsewhere for a range of ECCS system flow scenarios. Thus, the combinations of flow scenario/debris quantities provided in specification VYS-049 are simply repeated here.

#### 3.1 Strainer Data

The Vermont Yankee suppression pool has separate residual heat removal (RHR) system strainers and core spray (CS) strainers. Because the anticipated pump flows for the two systems are considerably different, and because the available NPSH margin for the CS and RHR pumps are different, optimized designs were developed for the CS and RHR strainers. A summary of the parameters that define the strainer geometry for each system [VY-ECCS, 1997-Rev.0 – 11/19/97] is provided in Table 1.

Parameter	RHR Strainers	CS Strainers
Fitting - Attachment to	Ram's Head [2 sides]	Elbow [1 side]
Penetration		
Active Length (in) per side	114.5	139
# of modules per side	2	2
Outer Diameter (in)	47	47
Gap Diameter (in)	26	26
Core Tube Diameter (in)	24	24
# of Disks per side	19	20
Disk Width (in)	2	2
Gap Width (in)	4.5	5.5

Table 1. Vermont Yankee: Strainer Module Geometry.

For both the RHR and CS strainers, the total length of the strainer requires that the strainers be fabricated in two sections (per side of the ram's head for RHR). The quoted active length represents the total length of the two modules in both cases. It has been assumed that the core tube design in the two modules will result in uniform flow along the entire length of both modules.

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#### 3.2 Suppression Pool Temperature/Pump Flow/Debris Specification

A range of expected CS and RHR strainer flow rates along with the associated suppression pool temperature and strainer debris loading were designated in Vermont Yankee Specification VYS-049 [Betti, 1997- Rev. 2, Change 1 – 11/12/97]. These quantities are summarized in Table 2 for the expected conditions following a Design Basis Accident (DBA) LOCA. A similar summary for the expected conditions following an Intermediate Break Accident (IBA) LOCA is provided in Table 3. The IBA LOCA is specified to generate very little fibrous debris (a  $\frac{1}{4}$ " layer of uncompressed NUKON is assumed) and larger quantities of unqualified coatings debris.

Strainer Parameter	Units	F	RHR System		CS System			
		Case	Case	Case	Case	Case	Case	Case
		1	2a	2b	3a	3b	3c	3d
Flow Rate	GPM	7400	14200	14200	4600	4000	4300	4600
Design Fluid	Dcg F	-173	164	170	164	173	173	173
Temperature								
NUKON	Lbm	258	174	235	74	152	159	159
Fibermat	Cu-ft	9.6	6.4	8.7	2.8	5.7	5.9	5.9
TempMat	Lbm	20.5	13.8	18.7	5.9	12.1	12.6	12.6
Armaflex	Cu-ft	16.5	11.1	15	4.8	9.7	10.2	10.2
Sludge	Lbm	546	366	497	156	322	336	336
	(dry)							
Rust Flakes	Lbm	35.3	23.7	32.2	10.1	20.8	21.7	21.7
LOCA Jet Coating	Lbm	61	41	55	18	36	37	37
Debris								
IOZ Coating	Lbm	70	47	64	20	42	43	43
Debris							_	
Non-IOZ Coating	Sq-ft	6619	6619	6619	2295	2295	2295	2295
Debris								
RMI Debris	Sq-ft	sat	sat	sat	sat	sat	sat	sat
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#### Table 2. Vermont Yankee: DBA LOCA Strainer Sizing Requirements.

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Strainer Parameter	Units	I	RHR Syst	em	CS System			
		Case	Case	Case	Case	Case	Case	Case
		4	5a	5b	6a	6b	6с	6d
Flow Rate	GPM	7400	14200	14200	4600	4000	4300	4600
Design Fluid	Deg F	173	164	170	164	173	173	173
Temperature								
NUKON	in	(1/4")	(1/4")	(1/4")	(1/4")	(1/4")	(1/4")	(1/4")
Fibermat	Cu-ft	0	0	0	0	0	0	0
TempMat	Lbm	0	0	0	0	0	0	0
Armaflex	Cu-ft	0	0	0	0	0	0	0
Sludge	Lbm	546	366	497	156	322	336	336
	(dry)		·					
Rust Flakes	Lbm	35.3	23.7	32.2	10.1	20.8	21.7	. 21.7
LOCA Jet Coating	Lbm	61	41	55	18	36	37	37
Debris								
IOZ Coating	Lbm	70	47	64	20	42	43	43
Debris								
Non-IOZ Coating	Sq-ft	8410	12966	12966	3665	5403	8081	8081
Debris								
RMI Debris	Sq-ft	sat	sat	sat	sat	sat	sat	sat

# Table 3. Vermont Yankee: IBA LOCA Strainer Sizing Requirements.

#### 3.3 Debris Characteristics

The debris characteristics relevant to the determination of strainer head loss are summarized in the following sections.

#### 3.3.1 Fiber Parameters

The NUREG/CR-6224 head loss correlation for fibrous debris head loss is based on the fiber diameter, the macroscopic debris density, and the microscopic fiber density. The macroscopic debris density is related to the as-fabricated blanket density, but may differ from this value depending upon the "severity" of destruction. For NUKON debris, the debris density appears to be close to the as-manufactured blanket density, and this assumption has been used in previous analyses using the HLOSS 1.0 code. TempMat and Fibermat, both of which are a higher density (lower porosity) material than NUKON, have lower initial debris densities than their as-fabricated blanket densities. However, this debris might be expected to re-compress to a density close to the initial blanket density as it collects on a strainer. Given these uncertainties, it is assumed that the debris density for a mixed

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fiber bed can be best approximated by the density observed in the C tests performed for Vermont Yankee at ARL [Copus,1997].

The as-manufactured fiber properties were summarized in the URG [Diertl, *et al*, 1996] for both NUKON and TempMat. Fibermat fiber properties were taken from the Carborundum Company Product Specification for this material [Carborundum, 1990]. Table 4 provides a summary of these parameters. The input values for the microscopic fiber density and debris mass are derived using the values from Table 4. The effective fiber diameter for the mixed fiber bed was approximated by using a value which reasonably predicts the head loss results observed in the C tests performed for Vermont Yankee at ARL [Copus, 1998]. The mixed bed debris density was based on C test observations [Copus, 1998].

Fiber Type	Fiber Diameter	Fiber Density	Blanket	Debris Density
			Density	
•	- (ft)	(lbm/cu-ft)	(lbm/cu-ft)	(lbm/cu-ft)
NUKON	2.33E-05	180	2.4	2.4 [IBA]
Fibermat	9.84E-06	170	6	
TempMat	2.93E-05	159	11.3	
Mixed Bed	2.70E-05	177	-	2.1 [DBA] <sup>2</sup>

# Table 4. Vermont Yankee: Fibrous Debris Material Properties.

# 3.3.2 Particulate Parameters

For those debris constituents modeled as particulate trapped within the fibrous debris bed using the NUREG/CR-6224 head loss correlation, the relevant parameters are the total volume and the characteristic size and shape of each debris constituent. Since particulate loads are typically expressed in terms of mass, the density of the particulate material is also needed.

The microscopic density of sludge, which is basically iron oxide, is  $324 \text{ lb/ft}^3$  [Zigler, *et al*, 1995]. The mass median diameter of the sludge particle size distribution is estimated to be 2.5  $\mu$ m [OG94-661-161, 1994]. This value represents the size distribution of the sludge in the suppression pool. However, the size distribution of the sludge particles actually deposited on the fibers in the debris bed has a mass median diameter much larger than the corresponding mass median diameter of the sludge particles in the suppression pool, as suggested by the SEM photographs of typical debris beds [Rao

<sup>2</sup> The mixed bed debris average density was estimated in the analysis of the tests specifically conducted for Vermont Yankee [Copus, 1998].

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and Souto, 1996], which show particle sizes on the order of 100  $\mu$ m. Consequently, in these calculations an average debris bed sludge particle diameter of 10  $\mu$ m will be conservatively used.

Rust flakes are also iron oxides, with a microscopic density of  $324 \text{ lb/ft}^3$ . Typically, rust flakes appear to be visually similar to small paint chips, with an equivalent thickness of at least 1 mil (25.4 µm). This value of 1 mil will be used herein.

The LOCA jet induced coatings debris is anticipated to be very small particulate because of direct jet impingement. Thus, a characteristic spheroid particle size of 10 micron is assumed for this debris constituent. All coatings, regardless of qualification, are assumed to fail if they are within the cone of a LOCA jet. Thus, an average density value for all coatings is used for this debris constituent. The URG suggests an average coatings density value of approximately 120 lb/ft<sup>3</sup>.

Unqualified IOZ coatings debris is expected to mostly be the zinc microspheres present in paint. Specification VYS-049 provides a recommended value of 10 micron for the characteristic particle size of this debris constituent. The URG provides a density of approximately 185 lb/ft<sup>3</sup> for IOZ coatings.

Armaflex insulation is not a particulate as installed in the drywell. In fact, Armaflex, which is a closed-cell foam type insulation with a density of less than 5 lb/ft<sup>3</sup>, is expected to float. In order for the Armaflex debris fragments not to float, they would have to have a density at least equal to that of water. Visual inspection of Armaflex shows that typical voids within the foam structure are on the order of 1-2 mm. Thus, for the voids to be destroyed, fragments of that characteristic size would have to be produced. Thus, Armaflex debris is conservatively modeled (smaller debris has a larger surface to volume ratio and a larger head loss component) as being of 1 mm characteristic size with a density comparable to that of water. An as-fabricated density of 5 lb/ft<sup>3</sup> is used to calculate the mass of Armaflex debris for the initial insulation volume specified. It should be noted that even after destruction in a high pressure LOCA jet, Armaflex debris is still expected to float. A simple table top experiment wherein a sample of Armaflex is violently shredded in a blender, completely destroying the as-manufactured character of the material, results in sub-millimeter size fragments that still float. Tests perfomed for Vermont Yankee at ARL confirmed that Armaflex could not be transported from the pool to the strainer and consequently the debris removal factor for Armaflex was assigned a value of zero.

The particulate debris characteristics used in this calculation are summarized in Table 5.

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Debris Type	Microscopic Density (lb/ft³)	Characteristic Size (micron)
Sludge	324	10
Rust	324	25
LOCA coating debris	120	10
IOZ coating debris	185	10
Armaflex	62	1000

#### Table 5. Vermont Yankee: Particulate Debris Characteristics

#### 3.3.3 RMI Parameters

Specification VYS-049 [Betti, 1997] lists the Vermont Yankee RMI to be comprised of 6 mil Al foils. Since a saturation thickness of such foils is to be considered in the analysis, no other information regarding these foils is required.

# 3.3.4 Paint Chip Parameters

The parameters needed to characterize the large paint chip debris are the paint density, paint chip thickness, and paint chip size. Each of these parameters is provided in specification VYS-049. Rather than providing a single size, a range of sizes is provided. These parameters are summarized below:

Density -	94 lb/ft <sup>3</sup> (specific gravity	of 1.5)
Thickness -	15 mil (average)	
Size characterization -	1/8"x 1/8" to ½"x ½"	50%
	<sup>1</sup> / <sub>2</sub> " x <sup>1</sup> / <sub>2</sub> " to 1" x 1"	25%
	1" x 1" to 2" x 2"	25%

Results from the C test series performed for Vermont Yankee at ARL indicated that paint debris could not be removed effectively from the suppression pool and deposited on the strainer under the Vermont Yankee ECCS strainer flow conditions of 0.02 to 0.04 ft/sec. At all turbulence levels, no paint debris could deposit on the strainer at strainer flow velocities less than 0.12 ft/sec. Consequently, paint debris was assigned a debris removal factor of zero for these calculations.

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## 3.4 Miscellaneous Input Parameters

To perform a time dependent assessment of strainer head loss, or to estimate debris sedimentation subsequent to the termination of the high-energy chugging phase of the accident, the suppression pool volume is required as an input parameter. Specification VYS-049 provides a minimum value for this parameter of 68,000 cubic feet. (No such time dependent assessment has been included herein; the value is provided for information only).

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#### 4.0 Assumptions

- The debris types, quantities, and (selected) characteristics; system flow rates; and fluid temperatures used in this calculation are taken directly from *Specification For RHR and CS Suction Strainers*, *VYS-049* [Betti, 1997]. These values will be assumed to be applicable for this analysis without further verification.
- The debris bed is formed and distributed uniformly over the surface of a strainer module.
- For strainers involving multiple modules, the core tube design is assumed to result in uniform flow along the combined length of both modules.
- The debris bed is homogeneous in composition, i.e., the particulate-to-fiber mass ratio remains constant along the debris bed.
- Particulate debris IOZ, rust, sludge, and dirt/dust are assumed to be spherical for the purpose of determining a surface-to-volume ratio.
- The test data from the C tests performed at ARL for Vermont Yankee are most representative of the ECCS strainer conditions for the purpose of determining an effective fiber diameter and a debris bed density for the mixed fiber bed.

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### 5.0 CALCULATION RESULTS

Separate calculations are provided for the determination of head loss due to fiber/particulate debris and the determination of head loss due to RMI debris. In this calculation, head loss contribution due to large paint chip debris is set to zero based on test results.

## 5.1 Fiber/Particulate Head Loss Results

This section provides the results of calculations performed to determine ECCS suction strainer head loss due to the deposition of fibrous debris and entrained particulate. These results were obtained using the HLOSS 1.0 code, as discussed in Section 2. A complete description of HLOSS 1.0, including descriptions of input files and output files can be found in the HLOSS 1.0 reference manual [Mast and Souto, 1997].

Section 5.1.1 provides the supporting calculations needed to generate certain input values for the IHLOSS 1.0 code. Section 5.1.2 provides the base-case head loss results for the DBA LOCA conditions. Section 5.1.3 provides the base-case head loss results for the IBA LOCA conditions. Section 5.1.4 provides parametric results for head loss as a function of debris quantity, debris types, flow rate, and fluid temperature for the DBA scenarios.

# 5.1.1 Supporting Calculations

<u>Average Fibrous Debris Parameters:</u> As indicated in Section 2.1.3, it is necessary to determine average values for the mixed bed fiber diameter and mixed bed fibrous debris density. The first of these parameters,  $2.7 \times 10^{-5}$  ft, is calculated using a debris volume-weighted average of the individual values. The average fibrous debris density, 2.1 lb/ft<sup>3</sup> for the DBA conditions and 2.4 lb/ft<sup>3</sup> for the IBA conditions, were estimated based on the analysis of the tests specifically conducted for Vermont Yankee [Copus, 1998].

Strainer Length/Surface Area Adjustment: As noted in Section 3.1, both the CS and RHR strainers are being fabricated in two modules (per side of the rams head for RHR), because the total length of these strainers would preclude their installation in one section. The HLOSS 1.0 code does not have the flexibility to model multiple, unequal strainer module lengths per flow channel. However, this limitation is easily overcome by modeling the combined length of the two modules as the sum of the actual module lengths plus an additional (fictitious) gap section. The cylindrical piping segments within the gaps are made of perforated plate, and thus the fictitious gap will be modeled as having a perforated cylindrical surface. Since in reality the piping between strainer modules is solid, this results in HLOSS 1.0 calculating too high a total strainer surface area. This can be easily negated by inputting the appropriate surface area reduction (a standard input variable in HLOSS 1.0). This area reduction is simply given by (AR=3.14159\*gap-diameter\*gap-width). Table 6 summarizes the actual strainer dimensions along with the values used in HLOSS 1.0, for both the CS and RHR strainers.

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Parameter	RHR (per side	of Rams Head)	CS			
	Actual	Model	Actual	Model		
Length	114.5"	119"	139"	144.5"		
Area Reduction	0 sq-ft	2.55 sq-ft	0 sq-ft	3.12 sq-ft		
Total area	811 sq-ft	808 sq-ft	433 sq-ft	433 sq-ft		

Table 6. Ver	mont Yankee:	<b>Strainer Dimensions</b>	Used in HLOS	S 1.0 Analyses
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<u>Filtration Efficiency for Small Particulate Matter Debris:</u> A parameter that must be specified in the HLOSS 1.0 input is the effect of a less than perfect filtration efficiency on the debris removal factor. As will be shown below, the calculated debris thickness for all scenarios is on the order of three inches or less. Based on the NUREG/CR-6224 filtration efficiency model, the filtration efficiency for small particulate matter debris (i.e., of about 10  $\mu$ m in characteristic size) is 0.5. Although the initial filtration efficiency while the bed is thinner than  $\frac{1}{2}$ " is even lower, this effect was generally ignored for conservatism.

Note that these calculations conservatively ignore gravitational sedimentation onto the suppression pool floor for fibrous debris and particulate matter debris other than relatively large unqualified paint chips, which were shown to settle under the conditions at the ARL tests specifically conducted for Vermont Yankee [Copus, 1998]. To illustrate the conservatism associated with neglecting debris sedimentation, a limited calculation was conducted.

The HLOSS 1.0 computer code, used in this calculation note to estimate the head loss across a fibrous debris bed formed on the strainer surface, does not have mechanistic models for less than perfect filtration efficiency for particulate matter within the fibrous debris bed or for debris sedimentation onto the suppression pool floor. Instead, HLOSS 1.0 considers overall factors to account for filtration of particulate debris within the fibrous bed and debris sedimentation as part of the input data.

The BLOCKAGE 2.5 computer code, on the other hand, does have a mechanistic model for potential debris sedimentation onto the suppression pool floor. Hence, the BLOCKAGE 2.5 computer code is used in this calculation to illustrate the conservatism associated with neglecting gravitational sedimentation of debris onto the suppression pool floor. The following sections describe the rationale to model debris sedimentation using the BLOCKAGE 2.5 computer code, as well as the rationale used in this calculation to account for less than perfect filtration of particulate matter within the fibrous debris bed.

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In these calculations, it is considered that sedimentation of debris in the suppression pool can not occur during the high-energy phase of a LOCA, which is assumed to last for about 60 s [GE, 1981]<sup>3</sup>. In the settling tests performed for Vermont Yankee as part of the C test series at ARL, it was seen that after cessation of the high energy turbulence phase in the pool, the settling rates for fiber and paint debris were between 50% - 90% of those corresponding to the settling velocities for quiescent pools [Zigler, *et al*, 1995, p. B-30]. To have an upper bound, a turbulence correction factor of 0.5 which produces a settling history 2 times longer than that of the quiescent pool settling velocity was used in this calculation for each type of debris.

For fibrous debris and suppression pool sludge, the experimentally determined terminal settling velocity groups presented in the NUREG/CR-6224 study are used [Zigler, *et al*, 1995, pp. B-31 and B-33] as the baseline settling velocities. For dirt/dust particles, a single terminal settling velocity group, characterized by the median settling velocity determined for sludge (i.e., a terminal settling velocity of 0.01 ft/s (3 mm/s)) is used as a baseline value. No experimental data are available to estimate the sedimentation rate of rust flakes. However, with a characteristic size comparable to paint chips and a density factor between 2 and 3 higher, a very high sedimentation rate is expected for rust. For conservatism, a typical settling velocity for paint chips, 0.3 ft/s (90 mm/s), is used to characterize a single terminal settling velocity group for rust flakes.

Based on these considerations, the BLOCKAGE 2.5 computer code was used to provide guidance for the HLOSS 1.0 computer code calculations used in this analysis. To achieve this objective, the debris quantities and the flow rate conditions referred to in VY specification VYS-049 (pool volume =  $68000 \text{ ft}^3$ , total flow = 18600 gpm, total fiber = 502 lbm, total sludge = 772 lb, dirt = 50 lb, rust = 150 lbs) were used to prepare the BLOCKAGE 2.5 computer run presented in Attachment B. Note that the only purpose of this analysis with the BLOCKAGE 2.5 code is to estimate the debris sedimentation factors, which are not affected by the strainer dimensions or the total amounts of debris. Hence, the strainer dimensions and some of the debris amounts included in this BLOCKAGE 2.5 input data file are arbitrary and do not necessarily correspond to Vermont Yankee conditions.

The BLOCKAGE 2.5 calculations which provide additional support for the filtration factors used in the HLOSS 1.0 calculations are summarized in Table 7. The corresponding detailed BLOCKAGE 2.5 output file is presented in Attachment B.

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<sup>3</sup> The Mark I containment Load Definition Report [GE, 1981], the turbulent phase due to chugging for a DBA lasts 65 s (about 1 min), whereas the corresponding phase for an IBA lasts for 905 s (about 15 min).

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Debris Initially in		Settled on floor	Sedimentation	HLOSS 1.0 Debris		
	the Pool	or in piping	Fraction	Removal Factor due		
	[ft³]	[ft <sup>3</sup> ]		to filtration alone		
Fibrous	209	40.847	0.2	1		
Rust	0.154	0.142	0.9	l		
Flakes						
Dirt/Dust	1.0	0.509	0.5	0.5		
Sludge	2.4	1.211	0.5	0.5		

Table 7. V	VY:	<b>Debris Sedimentation Factors Calculated by BLOCKAGE 2.5</b>
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As indicated in Table 7, BLOCKAGE 2.5 calculations suggest that a factor of about 0.9 (or 90%) of the rust flakes (i.e., relatively large particulate matter debris) will settle onto the suppression pool floor following the highly turbulent conditions expected during blowdown, assuming that the turbulence level afterwards effectively reduces the settling velocity of these particles by a factor of 2 with respect to the average terminal settling velocity. Similarly, BLOCKAGE 2.5 calculations in Table 6 suggest that a factor of about 0.5 (or 50%) of the sludge or the dirt/dust particles will settle after the blowdown period. Note also that 20% of the relatively buoyant fiber debris tends to settle out of the pool. Although BLOCKAGE 2.5 calculations indicate greater amount of debris removal, the HLOSS 1.0 strainer performance analysis is conducted assuming no fibrous removal and only a 50% removal factor due to filtration (see Section 2.1.2) for small particulate matter debris.

# 5.1.2 Base Case Calculations – DBA LOCA Conditions

Using the design input parameters summarized in Section 3, along with the calculated parameters summarized in Section 5.1.1, each of the DBA LOCA flow/temperature/debris scenarios listed in specification VYS-049 was analyzed using the HLOSS 1.0 code. Although HLOSS 1.0 has the ability to perform time-dependent debris buildup and head loss calculations, only a simple steady-state head loss determination was made. (The time-dependence was already accounted for in the combination of parameters provided in specification VYS-049.)

The results of the HLOSS 1.0 analyses for all the DBA cases analyzed are presented in Table 8. Listed are the calculated head losses as well as the calculated debris thicknesses. The HLOSS 1.0 output files for each of these cases are provided in Attachment A:

It should be noted that some of the output labels for particulate debris constituents in HLOSS 1.0 are fixed, even though the actual material properties are user-defined inputs. Thus, the output parameters labeled "Dirt/Dust" actually correspond to LOCA jet-induced coatings debris, those labeled "Cal-Sil" correspond to Armaflex, and those labeled "Other" correspond to IOZ coatings debris.

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Calculated Parameter	Units	R	RHR System			CS System			
		Case	Case	Case	Case	Case	Case	Case	
		1	2a	26	<u> </u>	36	30	3d	
Head Loss	Ft water	0.33	0.19	0.48	0.09	0.21	0.30	0.32	
Debris thickness	inches	1.91	1.60	2.16	1.3	2.6	2.7	2.7	

# Table 8. Vermont Yankee: DBA LOCA Base Case Head Loss Results.

# 5.1.3 Base Case Calculations – IBA LOCA Conditions

The conditions specified for the IBA LOCA scenarios have a lower fiber/sludge debris ratio than the DBA conditions. The turbulent blowdown time is specified to be 900 seconds in this scenario and the sedimentation factor is conservatively assumed to be 1.0 (no sedimentation) for both fiber and sludge/rust/particulate. An initial fiber bed depth of  $\frac{1}{4}$  inch NUKON fiber is assumed with a bed density of 2.4 lb/ft<sup>3</sup>, an average fiber diameter of 2.33 x 10<sup>-5</sup> ft, and a microscopic fiber density of 180 lb/ft<sup>3</sup>. All of these input assumptions tend to conservatively pack the debris bed and result in higher calculated head loss values. Calculations for the IBA LOCA are presented in Table 9. A comparison between IBA calculations and DBA calculations indicates that the IBA case is comparable to the DBA case.

# Table 9. Vermont Yankee: IBA LOCA Case Head Loss Results.

Calculated Parameter	Units	RHR System			CS System			
		Case	Case	Case	Case	Case	Case	Case
		4	5a	5b	ба	6b	6c	6d
Head Loss	Ft	0.19	0.25	0.42	0.10	0.24	0.30	0.34
	water							
Debris thickness	inches	0.21	0.19	0.16	0.25	0.19	0.18	0.17

# 5.1.4 Parametric Calculations for DBA LOCA Conditions

The results presented in Section 5.1.3 represent the head loss estimates for the base case set of conditions from a strainer performance perspective. It is desirable to also know what the head loss would be for somewhat different sets of conditions, including the limiting cases of a perfect filtration efficiency for all particulate matter debris, regardless of their characteristic size.

• The fibrous debris quantities provided in specification VYS-049 and used herein represent the bounding estimates of debris generation. It is quite likely that a different break location would generate less fibrous debris, while keeping the total particulate debris (mostly sludge) source term essentially constant. In addition, this parametric analysis includes the possibility of having a

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110% fibrous insulation debris case. Accordingly, head loss estimates will be provided for varying fibrous debris loads down to a minimum value corresponding to an 1/8<sup>°</sup> layer of debris. At this thin of a debris layer, previous testing [Zigler, 1995] has shown that it is not possible to maintain a sufficiently uniform debris layer and that the associated head loss is very low.

- The temperatures specified in these calculations represent conservative, peak temperature estimates. Actual peak temperatures are expected to be lower. In addition, late in an accident, pool temperatures would start to decrease. Thus, head loss estimates will be provided for the temperature range of 40F to 180F.
- Flow rates may vary and will probably be lower. To understand how head loss varies with flow rate, head loss estimates will be provided for a range of flows [30-110%] of the nominal value.
- The amounts of sludge, qualified coating debris, paint chips, IOZ, and rust flakes provided in specification VYS-049 as input to the suppression pool could vary. Filtration through the fiber debris bed could also affect the amount of particulate debris in the fibrous debris bed. Head loss estimates are provided for particulate debris in the suppression pool which range from 50% to 300% of the amount in VYS-049.

Each of these parametric analyses was conducted for all seven of the base case DBA flow scenarios previously analyzed. The results are summarized in the following tables. These parametric results can be used to estimate the effect on head loss for the variation of the listed parameter over the range in its respective table. Combined effects of varying two parameters simultaneously or the effects of varying a parameter outside its range may not be reasonably predicted by extrapolation or combination of the tables. It should be noted that for the reduced fibrous debris quantity analyses, the particulate filtration efficiency used in these calculations was reduced according to the NUREG/CR-6224 algorithm for debris bed thicknesses less than ¼". The actual values used in the analyses are summarized in the appropriate tables.

Γ	Fiber	Volume	Debr	is Thicknes	S	Head Loss	Filtration		
	(CI	u ft)		(inches) (ft water)			Efficiency		
	176 (1.1	76 (1.1 base case)		2.5*		.41	.5		
	160 (bas	e case)		1.9*		.33	.5		
	144			2.1*		.21	.5		
	. 120			1.8		.12	.5		
_ [-	80			1.2		.12	.5		
	64			.96		.12	.5		
	48	· · · · · · · · · · · · · · · · · · ·		.72		.12	.5		
	40		1	.6		.13	.5		
	24			.36		.14	.5		
	8			.12		.09	.24		
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Table 10. Vermont Yankee: Case 1 - Head Loss as a Function of Fiber Volume.



\* Strainer gaps are full, transition from full strainer area to a smaller cylindrical area. An "effective" debris thickness is calculated which accounts for the amount of debris held under each condition.

Table 11. Vermont Yankee: Case 1 - Head Loss as a Function of Fluid Temperature.

Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.31
173	.33
160	.36
140	.42
120	.47
100	.59
80	.67
60	.97
40	1.4

 Table 12. Vermont Yankce: Case 1 - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
8000	.36
7400	.33
7000	.31
6000	.27
5000	.23
4000	.18
2000	.09

Table 13. Vermont Yankee: Case 1 - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.26	.33	.49	.66

Note: The 2x case also represents 100% filtration efficiency

#### Table 14. Vermont Yankee: Case 1 - Head Loss as a Function of Qualified Coatings fraction

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Table 15. Vermont Yankee: Case 1 - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.33	.33	.33	.33

Table 16. Vermont Yankee: Case 1 - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.33	.33	.33	.33

Table 17. Vermont Yankee: Case 1 - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.33	.33	.33	.33

Table 18. Vermont Yankee: Case 1 - Head Loss as a Function of IOZ fraction.

	Debris Fraction	.5x	1x	2x	3x		
	Head Loss (ft. water)	.32	.33	.36	.40		
.т.)							

Note: The 2x case also represents 100% filtration efficiency

Table 19. Vermont Yankee: Case 2a - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration
(cu ft)	(inches)	(ft water)	Efficiency
119 (1.1 base case)	1.8	.2	.50
108 (base case)	108 (base case) 1.6		.50
79	1.2	.18	.50
52	.8	.17	.50
35	.5	.17	.50
17	.25	.09	.25
8.5	.12 🚎	.04	.12

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Tame 20. Vermont Tankee, Case 2a - ficau 2055 as a runction of flutu Temperature	Table 20.	Vermont Yankee:	Case 2a	- Head Loss as a	<b>Function of Fluid Temperature</b>
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Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.17
164	.19
160	.2
140	.23
120	.27
100	.33
80	.41
60	.55
40	.82

## Table 21. Vermont Yankee: Case 2a - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
15000	.20
14200	.19
13500	.18
12000	.16
10000	.14
5000	.07

#### Table 22. Vermont Yankee: Case 2a - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	lx	2x	3x
Head Loss (ft. water)	.15	.19	.28	.39

Note: The 2x case also represents 100% filtration efficiency

# Table 23. Vermont Yankee: Case 2a - Head Loss as a Function of Qualified Coatings fraction

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Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.18	.19	.22	.25

Note: The 2x case also represents 100% filtration efficiency

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Table 24. Vermont Yankee: Case 2a - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.19	.19	.19	.19

Table 25. Vermont Yankee: Case 2a - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	. 1x	2x	3x
Head Loss (ft. water)	.19	.19	.19	.19

Table 26. Vermont Yankee: Case 2a - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.19	.19	.19	.19

Table 27. Vermont Yankee: Case 2a - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x ·	3x
Head Loss (ft. water)	.18	.19	.21	.23

Note: The 2x case also represents 100% filtration efficiency

Table 28. Vermont Yankee: Case 2b - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration
(cu ft)	(inches)	(ft water)	Efficiency
160 (1.1 base case)	1.9*	.66	0.50
145 (base case)	2.2*	.48	0.50
118	1.8	.24	0.50
95	1.4	.23	0.50
59	.88	.22	0.50
35	.53	.23	0.50
24	35	.16	0.35
12	.18	.08	0.18

\* Strainer gaps are full, transition from full strainer area to a smaller cylindrical area. An "effective" debris thickness is calculated which accounts for the amount of debris held under each condition.

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Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.45
170	.48
160	.52
140	.61
120	.69
100	.86
80	1.1
60	1.4
40	2.2

Table 29. Vermont Yankee: Case 2b - Head Loss as a Function of Fluid Temperature.

#### Table 30. Vermont Yankee: Case 2b - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
15000	.51
14200	.48
13500	.45
12000	.40
10000	.34
5000	.17

Table 31. Vermont Yankee: Case 2b - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	lx	2x	3x
Head Loss (ft. water)	.38	.48	.71	1.02

Note: The 2x case also represents 100% filtration efficiency

## Table 32. Vermont Yankee: Case 2b - Head Loss as a Function of Qualified Coatings fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.45	.48	.54	.61

Note: The 2x case also represents 100% filtration efficiency

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Table 33. Vermont Yankee: Case 2b - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.48	.48	.48	.48

Table 34. Vermont Yankee: Case 2b - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.48	.48	.48	.48

Table 35. Vermont Yankee: Case 2b - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.48	.48	.48	.48

Table 36. Vermont Yankee: Case 2b - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.45	.48	.52	.57
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Note: The 2x case also represents 100% filtration efficiency

Table 37. Vermont Yankee: Case 3a - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration
(cu ft)	(inches)	(ft water)	Efficiency
52 (1.1 base case)	1.4	.09	0.50
47 (base case)	1.3	.09	0.50
33	.93	.08	0.50
18	.5	.08	0.50
7.5	.2	.03	0.20

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Table 38.	Vermont Y	ankec: Case	3a - Head	Loss as a I	Function of	f Fluid T	'emperature.

Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.08
164	.09
160	.09
140	.11
120	.12
100	.15
80	.19
60	.26
40	.35

#### Table 39. Vermont Yankce: Case 3a - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
5000	.1
4600	.09
4000	.08
2000	.04

Table 40. Vermont Yankee: Case 3a - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	lx	2x	3x
Head Loss (ft. water)	.07	.09	.13	.18

Note: The 2x case also represents 100% filtration efficiency

Table 41. Vermont Yankee: Case 3a - Head Loss as a Function of Qualified Coatings fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.08	.09	.10	.12
65 3T-1		1000/ 6	1	

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Note: The 2x case also represents 100% filtration efficiency

#### Table 42. Vermont Yankee: Case 3a - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.09	.09	.09	.09

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Table 43. Vermont Yankee: Case 3a - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	lx	2x	3x
Head Loss (ft. water)	.09	.09	.09	.09

Table 44. Vermont Yankee: Case 3a - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x ·
Head Loss (ft. water)	.09	.09	.09	.09

Table 45. Vermont Yankee: Case 3a - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.09	.09	.10	.11

Note: The 2x case also represents 100% filtration efficiency

Table 46. Vermont Yankee: Case 3b - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration	
(cu ft)	(inches)	(ft water)	Efficiency	
105 (1.1 base case)	2.2*	.32	0.50	
95 (base case)	2.6*	.21	0.50	
72	2.0	.14	0.50	
46	1.3	.13	0.50	
23	.6	.14	0.50	
7.5 .2		.06	0.20	

\* Strainer gaps are full, transition from full strainer area to a smaller cylindrical area. An "effective" debris thickness is calculated which accounts for the amount of debris held under each condition.

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Table 47.	Vermont	Yankee:	Case 3b	- Head	Loss as	a Fu	nction	of	Fluid	Ter	nperati	are

Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.2
173	.21
160	.23
140	.27
120	.3
100	.38
80	.48
60	.62
40	.86

## Table 48. Vermont Yankee: Case 3b - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
5000	.26
4000	.21
2000	.11

## Table 49. Vermont Yankce: Case 3b - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.17	.21	.32	.43

Note: The 2x case also represents 100% filtration efficiency

## Table 50. Vermont Yankee: Case 3b - Head Loss as a Function of Qualified Coatings fraction

Debris Fraction	.5x	lx	2x	3x			
Head Loss (ft. water)	.20	.21	.24	.27			
Note: The 2x case also represents 100% filtration afficiency							

Note: The 2x case also represents 100% filtration efficiency

Table 51. Vermont Yankee: Case 3b - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.21	.21	.21	.21

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Table 52. Vermont Yankee: Case 3b - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.21	.21	.21	.21

Table 53. Vermont Yankee: Case 3b - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
• Head Loss (ft. water)	.21	.21	.21	.21

Table 54. Vermont Yankee: Case 3b - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.20	.21	.23	.26

Note: The 2x case also represents 100% filtration efficiency

Table 55. Vermont Yankee: Case 3c - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration
(cu ft)	(inches)	(ft water)	Efficiency
108 (1.1 base case)	2.4*	.38	0.50
98 (base case)	2.7*	.28	0.50
72	2.0	.16	0.50
40 1.1		.15	0.50
24	.67	.16	0.50
8	.22	.07	0.22

\* Strainer gaps are full, transition from full strainer area to a smaller cylindrical area. An "effective" debris thickness is calculated which accounts for the amount of debris held under each condition.

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Table 56.	Vermont Yankee:	Case 3c - Head	Loss as a Function	of Fluid Temperature.
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Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.29
173	.3
160	.34
140	.39
120	.45
100	.56
80	.7
60	.91
40	1.3

## Table 57. Vermont Yankee: Case 3c - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
5000	.35
4300	.3
4000	.28
2000	.14

## Table 58. Vermont Yankce: Case 3c - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.24	.30	.45	.61
				·

Note: The 2x case also represents 100% filtration efficiency

## Table 59. Vermont Yankee: Case 3c - Head Loss as a Function of Qualified Coatings fraction

Debris Fraction	.5x	lx	2x	- 3x
Head Loss (ft. water)	.28	.30	.34	.39

Note: The 2x case also represents 100% filtration efficiency

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Table 60. Vermont Yankee: Case 3c - Head Loss as a Function of Rust Flakes fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.30	.30	.30	.30

Table 61. Vermont Yankee: Case 3c - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.30	.30	.30	.30

Table 62. Vermont Yankee: Case 3c - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.30	.30	.30	.30

Table 63. Vermont Yankee: Case 3c - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.20	.30	.33	.37

Note: The 2x case also represents 100% filtration efficiency

Table 64. Vermont Yankce: Case 3d - Head Loss as a Function of Fiber Volume.

Fiber Volume	Debris Thickness	Head Loss	Filtration
(cu ft)	(inches)	(ft water)	Efficiency
108 (1.1 base case)	2.4*	.41	0.50
98 (base case)	2.7*	.30	0.50
72	2.0	.17	0.50
40	1.1	.16	0.50
24	.67	.17	0.50
8	.22	.08	0.22

\* Strainer gaps have filled, transition to cylindrical area.

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Fluid Temperature	Head Loss
(Deg F)	(ft water)
180	.31
173	.32
160	.36
140	.42
120	.48
100	.59
80	.74
60	.96
40	1.3

Table 65. Vermont Yankee: Case 3d - Head Loss as a Function of Fluid Temperature.

## Table 66. Vermont Yankee: Case 3d - Head Loss as a Function of Pump Flow Rate.

Flow Rate	Head Loss
(GPM)	(ft water)
5000	.35
4600	.32
4000	.28
2000	.14

Table 67. Vermont Yankee: Case 3d - Head Loss as a Function of Sludge fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.25	.32	.48	.65
		10004 6		

Note: The 2x case also represents 100% filtration efficiency

Table 68. Vermont Yankee: Case 3d - Head Loss as a Function of Qualified Coatings fraction

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	30 -	-:32	.36	.41

Note: The 2x case also represents 100% filtration efficiency

Table 69. Vermont Yankee: Case 3d - Head Loss as a Function of Rust Flakes fraction.

		Debris Fra	ction	.5x	1x	2x	3x	]
	He	ad Loss (fi	. water)	.32	.32	.32	.32	
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Table 70. Vermont Yankee: Case 3d - Head Loss as a Function of Paint Chip fraction.

Debris Fraction	.5x	lx	2x	3x
Head Loss (ft. water)	.32	.32	.32	.32

Table 71. Vermont Yankee: Case 3d - Head Loss as a Function of ARMAFLEX fraction.

Debris Fraction	.5x	1x	2x	3x
Head Loss (ft. water)	.32	.32	.32	.32

Table 72. Vermont Yankee: Case 3d - Head Loss as a Function of IOZ fraction.

Debris Fraction	.5x	1x	2x	3x				
Head Loss (ft. water)	.31	.32	.35	.39				

Note: The 2x case also represents 100% filtration efficiency

In reviewing these results several conclusions can be reached.

- For the range of flow rates relevant to the Vermont Yankce strainer performance assessment, head loss is essentially a linear function of flow rate, indicating that flow through the debris bed is laminar.
- Because the flow through the debris is laminar, the temperature dependence of the head loss is proportional to the temperature dependence of the fluid viscosity.
- Variation in head loss as a function of fibrous debris quantity is not a simple function. Over most of the range explored, the variation in head loss is relatively small. The reason for this is the constant quantity of particulate debris assumed in these calculations. Thus, even at lower fiber quantities, the increasing particulate to fiber mass ratio keeps head loss nearly constant. At very low fiber quantities (less than ½" debris thickness), head loss shows the potential for increasing. However, the decreasing filtration efficiency for these thin debris beds becomes an important factor, such that overall head loss decreases as the minimum bed thickness of 1/8" is reached.
- For the ranges of particulate debris studied, head loss is totally insensitive to variations in rust flakes (due primarily to their small mass and small contribution to the surface to volume ratio), paint chips (due to their inability to accumulate effectively in the debris bed), and ARMAFLEX insulation (due to its inability to accumulate effectively in the debris bed). Head loss is relatively insensitive to the variations in the debris amounts of qualified coatings and IOZ due to their relatively small mass fractions in the debris bed. For the sludge debris amounts studied, head loss varies by approximately a factor of two if the amount in the suppression pool is increased by a factor of three.

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## 5.2 RMI Head Loss Results

Head loss due to a saturation bed thickness of RMI is calculated using the approach outlined in Section 2.2. To do this, we note that the average settling velocity, U<sub>s</sub>, for the 6 mil AL foils is 0.25 ft/sec [Diertl, *et al*, 1996]. Using the thickness constant for 6 mil Al foils given by  $K_t = 0.073$  ft [Diertl, *et al*, 1996], the saturation bed thickness,  $\tau_s$ , and subsequent head loss can then be calculated. The results of these calculations are shown in Table 72 for each of the seven cases analyzed.

Strainer Parameter	Units		RHR System			CS System				
		Case	Case	Case	Case	Case	Case	Case		
	ĺ	1	2a	2b	3a	3b	3c	3d		
D	(inches)	47	47	47	47	47	47	47		
L	(inches)	229	229	229	139	139	139	139		
A <sub>c</sub>	(sq ft)	234.8	234.8	234.8	142.5	142.5	142.5	142.5		
Q	(GPM)	7400	14200	14200	4600	4000	4300	4600		
U	ft/sec	0.07	0.13	0.13	0.07	0.06	0.07	0.07		
$\tau_{s}$	(ft)	0	0.16	0.16	0	0	0	0		
Head Loss	(ft-	0	0.003	0.003	0	0	0	0		
	water)									

## Table 73. Vermont Yankee: RMI Head Loss Calculation Results.

It should be noted that the length listed for the RHR strainer (Cases 1 and 2) corresponds to the combined length for both sides of the ram's head (since the total flow for both sides of the ram's head is also listed). By using the conservative definition of strainer surface area given in the URG (which ignores the area associated with the ends of the strainer), one calculates a strainer approach velocity for Case 2 that just barely exceeds half the RMI foil settling velocity. The associated head loss for the RMI foils is less than 0.005 ft-water, and is thus negligible. For all other cases analyzed, the RMI head loss is identically zero.

It should further be noted that use of the actual strainer circumscribed area for Case 2 (given as 279.7 sq ft in the HLOSS 1.0 output) would also result in a calculated strainer approach velocity that is less than half the RMI settling velocity. In that case, the calculated RMI head loss for Cases 2a and 2b would be identically zero.

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#### 6.0 SUMMARY AND CONCLUSIONS

A determination of the head loss across the newly designed ECCS inlet suction strainers at the Vermont Yankee nuclear station as a result of debris accumulation following a postulated loss of coolant accident (LOCA) has been presented. These analyses showed the following:

- Head loss due to RMI debris is negligible for both the RHR and CS strainers.
- Head loss due fibrous debris and entrained particulate is limited to 0.48 ft-water for the RHR strainers and 0.32 ft-water for the CS strainers under the specified DBA combinations of pump flow rate, debris loading, and fluid temperature.
- Calculated debris bed thicknesses are slightly greater than that required to fill the gaps in the stacked disk strainer design being used at Vermont Yankee.
- Head losses calculated in the "thin-bed regime", wherein particulate to fiber mass ratios are maximized, do not exceed the head losses calculated for the specified DBA cases.

In addition to the base-case results, a series of parametric analyses were presented to determine the effect on calculated head loss of varying fibrous debris loads, particulate debris loads, pump flow rate, and fluid temperature.

The results presented herein are considered to be quite conservative. In addition to conservatism built into the design input on debris source term and pump flow rates, there are several additional modeling assumptions that are known to be conservative. These include:

- At the low flow rates at the strainer surface, it has been observed that debris buildup will be nonuniform, resulting in a lower head loss than predicted.
- Settling of fiber was not considered. It has previously been shown that in the later stages of the accident (following termination of the chugging phase), sedimentation of both fiber and small particulate will occur [Zigler, *et al*, 1995].
- A source term for rust debris was included, even though it has been observed that similar fragments of paint debris will not deposit on the strainer.

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Rev.	Orig.	Date	Chkd.	Date	
1	PIM	8/6/98	FS.	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation
				•	Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations.
		Ì			<b>Project No.:</b> <u>A346</u>
		1		·	Calc. No.: <u>DC-A34600.006</u> Sht. <u>49</u> of 86



## ATTACHMENT A: BASE CASE HLOSS 1.0 OUTPUT FILES

Rev.	Orig.	Date	Chkd.	Date	
1	1 Asla	0/6/00		016100	Client/Project:Vermont Yankee Nuclear Power
1	p nm	8/0/98	TAS I	8/0/90	Corporation
					Title: Vermont Yankee ECCS Suction Strainer Head Loss
	1				Performance Assessment. RHR and CS Debris Head Loss Calculations.
				1	Project No.: <u>A346</u>
				1	Calc. No.: DC-A34600.006 Sht. 50 of 86



07-Jul-98 10:04:02

Strai	ner Head	Loss Cal	lculation	for Vermo	ont-Yankee - Case: 1 (DBA)
Time	Into the	Transie	nt (sec)	-	0.
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Rat ow Rate ion Pool emoved fi eposited nsity (1) scosity	F) (gpm) Volume (c rom Pool ( on Strain o/cu-ft) (lb/ft/sec	u-ft) frac) er (frac)	- 173.00 - 3700.00 - 7400.00 - 68000. - 1.000 500 - 60.73 246E-03
STRAI	NER PARA Strainer Length ( Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Su Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete: pe Diamete ipe Diamete ipe Diamete inder Pe f Disks ckness (i kness	r - Disk ( r - Gaps ( ter (in) erforation in) ness (in) Reduct (so duct (cu f a (sq ft) ea (sq ft) (cu ft)	in) in) Switch ft) ft) t)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
SUPPF	ESSION P	OOL DEBR	IS PARAMET e Ma	ERS:	FSP FDB
Fiber Sludg Dirt/ Rust Paint Cal S Other	ge 'Dust Flakes Chips Sil	(cu f 160.	t) (1 00 336 546 61 35 524 82 70	b) .00 .00 .30 .40 .50 .00	1.00       1.00         1.00       .50         1.00       .50         1.00       1.00         .00       1.00         .00       1.00         .00       1.00         .00       50
Rev.	Orig.	Date	Chkd.	Date	
1	PAM	8/6/98	丐	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation Title: Vermont Yankee ECCS Suction Strainer Head Loss
<b> </b>					Performance Assessment. RHR and CS Debris Head Loss Calculations Project No.: A346
<b> </b>					Calc. No.: <u>DC-A34600.006</u> Sht. <u>51</u> of 86
-				terrane and the second second	

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STRAIN Fiber Fiber Sludge Dirt/N Rust J Paint Cal S: Other Ave Pa Ave De	NER DEBR (macro) (micro) e Dust Flakes Chips il articles ebris Maximum H Compress	IS PARAM Volum (cu f 80.	ETERS: e Ma t) (1 95 1 42 1 13 5 00 00 00 70 1 dity - or -	ass 1b) ( 68.00 36.50 15.25 17.65 .00 17.50 86.90 .20 1.0	Density 1b/cu-ft) 2.10 177.00 324.00 120.00 324.00 94.00 62.00 185.00 267.98 0 0	Size (ft) .270E-04 .328E-04 .328E-04 .820E-04 .125E-03 .328E-02 .328E-04	SV (ft**-1) 148148.10 182882.20 182882.20 24390.24 16000.00 1828.82 182882.20 170503.00 158742.70	
HEAD I	LOSS SUM	MARY:	ad Loss	Velocit	v dto	dt	colidity	
		(ft	water) .33	(ft/sec	;) (in) 8 1.911	(in) 1.91	(frac) 1 .021	
		De	position	Flag =	cylindrical	depositi	on	
DEBRI	S SURFAC	E CONDIT	IONS:	_	052			
	Арргоаси	VEIUCIC	y (10/5)	_	.035	I		
					•			
					• .	•		
Rev.	Orig.	Date	Chkd.	Date				······································
1	PAN	8/6/98	FS	8/6/9	8 Client/P	roject:Vern ion	nont Yankee N	Iuclear Power
· · · ·		•		-	Title: Ve	rmont Yankee	ECCS Suction S	trainer Head Loss
<b>├</b> ──┼		·			Performan Project	<u>ce Assessmen</u> No.: <u>A346</u>	L KHK and CS D	ebris Head Loss Calculations
					Calc. No	.: <u>DC-A346</u>	500.006	Sht. 52 of 86

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07-Jul-98 10:07:38

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Strai	ner Head	Loss Ca	lculation	for Vermo	ont-Yankee - Case: 2a
Time	Into the	Transie	nt (sec)	-	0.
FLOW CONDITIONS: Temperature (Deg F) Strainer Flow Rate (gpm) Total Flow Rate (gpm) Suppression Pool Volume (cu-ft) Debris Removed from Pool (frac) Debris Deposited on Strainer (frac) Fluid Density (lb/cu-ft) Fluid Viscosity (lb/ft/sec)					- 164.00 - 7100.00 - 14200.00 - 68000. - 1.000 500 - 60.92 262E-03
STRAINER PARAMETERS: Strainer Type Length (in) Strainer Diameter - Disk (in) Strainer Diameter - Gaps (in) Inlet Pipe Diameter (in) Outlet Pipe Diameter (in) Inner Cylinder Perforation Switch Number of Disks Disk Thickness (in) Gap Thickness (in) Max Debris Thickness (in) Input Surf Area Reduct (sq ft) Input Circ Area Reduct (sq ft) Input Gap Vol Reduct (cu ft) Full Surface Area (sq ft) Circumscribed Area (sq ft)				in) Switch ft) ft) t)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
SUPPE	RESSION P	OOL DEBR	TS PARAMET	ERS:	
Fiber Sludg Dirt Rust Paint Cal S Other	je /Dust Flakes Chips Sil	Volum (cu f 108.)	e Ma t) (1 00 226 366 41 23 1026 55 47	ss b) .80 .00 .70 .00 .50 .00	FSP         FDB           1.00         1.00           1.00         .50           1.00         .50           1.00         1.00           .00         1.00           .00         1.00           .00         1.00           .00         1.00           .00         1.00
Rev.	Orig.	Date	Chkd.	• Date	
1	PIM	8/6/98	FS	8/6/98	Corporation
				••	THIE: Vermont Yankee ECCS Suction Strainer Head Loss
					Project No.: A346
┣───					Calc. No.: DC-A34600.006 Sht. 53 of 86
	l			L	



STRAINER DEBRI Fiber (macro) Fiber (micro) Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Dobris Maximum F Compressi HEAD LOSS SUMM	S PARAME Volume (cu ft 54.0 .6 .2 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0	TERS: Mas (lb 0 113 4 113 8 91 9 10 4 11 0 0 6 11 7 125 ity - r -	s De ) (11 .40 .50 .25 .85 .00 .00 .75 .35 .200 1.00	ensity 2.10 177.00 324.00 120.00 324.00 5.00 62.00 185.00 267.89	Size (ft) .270E-04 .328E-04 .328E-04 .820E-04 .125E-03 .328E-02 .328E-04	SV (ft**-1) 148148.10 182882.20 182882.20 24390.24 16000.00 1828.82 182882.20 170493.80 158702.50		
	Hea (ft	d Loss V water) (	elocity ft/sec)	dto (in)	dt (in)	solidity (frac)		
	Der	.19 Scition E	.039	1.603	<b>1.60</b>	3.021		
	Dep	USILION F	1ag - 1.	mear depo	SILION			
DEBRIS SURFACE Approach	CONDITI Velocity	ONS: (ft/s)	-	.039	1			
					•			
					•			
				· .				
Due Locia I		Child					,	<u></u>
1 D./An	Date 8/6/98	Слка.	2/6/02	Client/P	roject: <u>Verr</u>	nont Yankee N	Nuclear Pow	er
- <b>P</b> <u>M</u> <b>M</b>		1>	0,0,70	Corporat	tion rmont Yanker	FCCS Suction S	Strainer Head I	220.
l				Performan	cc Assessmen	it. RHR and CS D	Debris Head Lo	ss Calculations
				Project	NO.: <u>A346</u>	600 00 <i>6</i>	Che ce	of 97
				Calc. No	.: <u>DC-A34(</u>	000.000	<u>5111</u>	01_00



07-Jul-98 10:09:26

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Strai	ner Head	Loss Ca	lculation	for Verm	ont-Yankee -	Case: 2	b-Base		
Time	Into the	Transie	nt (sec)	-	0.				
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Rate ow Rate ion Pool emoved f: eposited nsity (1) scosity	F) te (gpm) (gpm) Volume (c rom Pool ( on Strain b/cu-ft) (lb/ft/sec	u-ft) frac) er (frac	$ \begin{array}{rcrr} - & 170.00 \\ - & 7100.00 \\ - & 14200.00 \\ - & 68000. \\ - & 1.000 \\ - & .500 \\ - & .500 \\ - & 60.80 \\ - & .251E-03 \\ \end{array} $		-		
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner CP Number O Disk Thi Gap Thic Max Debr Input Su Input Ci Input Ga Full Sur Circumsc	METERS: Type in) Diamete. Diamete. pe Diame ipe Diame ipe Diame f Disks ckness (i kness (i kness (i is Thick rf Area rc Area p Vol Re face Are ribed Ar	r - Disk ( r - Gaps ( ter (in) eter (in) erforation in) ness (in) Reduct (so Reduct (so duct (cu f a (sq ft) ea (sq ft)	in) in) Switch (ft) (ft) it)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				
SUPPE Fiber Sludg Dirt/ Rust Paint Cal S Other	Total Ga RESSION P Dust Flakes Chips Sil	p Volume OOL DEBR Volum (cu f 145.	(CU IT) IS PARAMET e Ma t) (1 30 305 497 55 32 1026 75 64	ERS: 55 b) .13 .00 .00 .20 .00 .00 .00	- 56.44 FSP FDB 1.00 1.00 1.00 .50 1.00 1.00 .00 1.00 .00 1.00 1.00 .50				
Rev.	Orig.	Date	Chkd.	Date	1		•		
1	PYM	8/6/98	肟	8/6/98	Client/Project:Ver Corporation Title: Vermont Yank	ee ECCS S	uction Strai	lear Powe	<u>er</u> <u>.oss</u>
{				{	Project No.: A346	ent. RHR ar	nd CS Debr	is Head Lo	ss Calculations
					Calc. No.: DC-A34	4600.006		Sht. 55	of 86
		L	1	I			· · · · · · · · · · · · · · · · · · ·		

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STRAI Fiber Sludg Dirt/ Rust Paint Cal S Other Ave P Ave D	NER DEBR. (macro) (micro) e Dust Flakes Chips il articles ebris	IS PARAM Volum (cu f 72.	ETERS: e Ma: t) (1) 65 15: 86 15: 38 124 11 1: 05 10 00 00 00 09 16 63 170	ss D b) (1) 2.57 2.57 4.25 3.75 6.10 .00 .00 6.00 0.10	ensity b/cu-ft) 2.10 177.00 324.00 120.00 324.00 94.00 62.00 185.00 268.19	Size (ft) .270E-04 .328E-04 .328E-04 .820E-04 .125E-03 .328E-02 .328E-04	SV (ft**-1) 148148.10 182882.20 182882.20 24390.24 16000.00 1828.82 182882.20 170464.90 158737.40		
I	Maximum ) Compress:	bed Soli ion Facto	or ~	.200 1.00					
HEAD	LOSS SUMI	MARY: He (ft	ad Loss V water) .48	Velocity (ft/sec) .110	dto (in) 2.156	dt (in) 5 2.15	solidity (frac) 6 .021		
		Dej	position 1	Flag = t	ransition	·			
DEBRI	S SURFACI Approach	E CONDIT Velocit	IONS: y (ft/s)	-	.10:	3			
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							•		
				•					
							· ·		
Rev.	Orig.	Date	Chkd.	Date	- Cliont/E	Project+V/a-	nont Yankee N	uclear Powe	
1	PMM	8/6/98	肟	8/6/98	<u>Corpora</u>	tion	I allee IN	rowe	-
		· ····			Title: V	ermont Yankee nce Assessmen	ECCS Suction S t. RHR and CS De	trainer Head Lo ebris Head Los	oss s Calculations.
					Project	No.: <u>A346</u>	100 00 <i>1</i>	C1 -	. <b>f</b>
			<u> </u>		Calc. N	o.: <u>DC-A34(</u>	500.006	Sht. 56	01 86

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07-Jul-98 10:12:09

Strai	ner Head	Loss Cal	lculation	for Vermo	nt-Yankee - Caso: 3a
Time	Into the	Transie	nt (sec)	-	0.
FLOW	CONDITIO Temperat Strainer Total Flo Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Rat ow Rate ion Pool emoved f: eposited nsity (1) scosity	F) te (gpm) (gpm) Volume (c rom Pool ( on Strain b/cu-ft) (lb/ft/sec	u-ft) frac) er (frac) )	- 164.00 - 4600.00 - 4600.00 - 68000. - 1.000 - 1.000 - 60.92 262E-03
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Su Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete pe Diame ipe Diame inder P f Disks ckness (i kness (i is Thick rf Area rc Area p Vol Re face Are ribed Are p Volume	r - Disk ( r - Gaps ( ter (in) erforation in) ness (in) Reduct (sq Reduct (sq duct (cu f a (sq ft) ea (sq ft) (cu ft)	in) in) Switch ft) ft) t)	$ \begin{array}{rcrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$
SUPPH Fiber Sludd Dirt Rust Paint Cal S Other	ESSION P Je Dust Flakes Chips Sil	OOL DEBR Volum (cu f 46.	IS PARAMET e Ma t) (1 00 96 156 18 10 356 24 20	ERS: ss b) .60 .00 .10 .00 .00 .00	FSP         FDB           1.00         1.00           1.00         .50           1.00         .50           1.00         1.00           .00         1.00           .00         1.00           .00         1.00           .00         1.00
Rev	Oria	Dote	Chud	Date	·
1	PHM	8/6/98	FS	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation Title: Vermont Yankee ECCS Suction Strainer Head Loss
					Performance Assessment. RHR and CS Debris Head Loss Calculations. Project No.: A346
					Calc. No.: DC-A34600.006 Sht. 57 of 86

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STRAINER DEBRIS Fiber (macro) Fiber (micro) Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	PARAMETERS: Volume (cu ft) 46.00 .55 .24 .08 .03 .00 .00 .05 .40	Mass De (1b) (1b 96.60 96.60 78.00 9.00 10.10 .00 10.00 107.10	nsity Size /cu-ft) (ft) 2.10 177.00 .270E- 324.00 .328E- 120.00 .328E- 324.00 .820E- 94.00 .125E- 62.00 .328E- 185.00 .328E- 267.10	e SV (ft**-1) -04 148148.10 -04 182882.20 -04 182882.20 -04 24390.24 -03 16000.00 -02 1828.82 -04 182882.20 170560.40 158762.30	
Maximum Be Compressio	d Solidity - n Factor -	.200 1.00			
HEAD LOSS SUMMA	RY: Head Loss (ft water) .09	Velocity (ft/sec) .024	dto (in) 1.276	dt solidity (in) (frac) 1.276 .021	
	Depositio	n Flag = li	near deposition	n	
DEBRIS SURFACE Approach V	CONDITIONS: elocity (ft/s	) –	.024		
Rev. Orig.	Date Chkd.	. Date		Vermont Yankee N	Juclear Power
1 P//M 8	8/6/98 F3	8/6/98	Corporation		
			Performance Asse	ankee ECCS Suction S ssment. RHR and CS E	Strainer Head Loss Debris Head Loss Calculations.
			Project No.: A	346	
			Calc. No.: DC-	<u>A34600.006</u>	Sht. <u>58</u> of 86



13-Mar-98 16:29:49

Strai	ner Head	Loss Ca	lculation	for Vermo	nt-Yankee	- Case:	3b-with_10	0%_Nukon
Time	Into the	Transie	nt (sec)	-	0.			
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Rat ow Rate ion Pool emoved f: eposited nsity (1) scosity	F) (gpm) Volume (c rom Pool ( on Strain o/cu-ft) (lb/ft/sec	u-ft) frac) er (frac) )	- 173.00 - 4000.00 - 68000. - 1.000 - 1.000 - 60.73 246E-03			
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Ci Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete: pe Diame ipe Diame ipe Diame inder Pe f Disks ckness (1 kness (1) kness (1)	r - Disk ( r - Gaps ( ter (in) efforation in) ness (in) Reduct (sq Reduct (sq duct (cu f a (sq ft) ea (sq ft) (cu ft)	in) in) Switch (ft) (ft) t)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			
SUPPR	RESSION P	OOL DEBR Volum (cu f	IS PARAMET e Ma t) (1	ERS: ss b)	FSP F	DB		
Fiber	:	94.	40 198	.24	1.00 1	.00		
Sludg	je Dust		322	.00	1.00	.50		
Rust	Flakes		20	.80	1.00 1	.00		
Paint	Chips		356	.00	.00 1	.00		
Other	, TT		48	.00	1.00	.50		
Rev.	Orig.	Date	Chkd.	Date			······································	
1	PYIM	8/6/98	肟	8/6/98	Client/Project: Corporation	:Vermont Y	ankee Nuclea	ar Power
					Title: Vermont Y	ankee ECCS	Suction Strainer	r Head Loss
J					Performance Asse	ssment. RHR	and CS Debris l	Head Loss Calculations
	1				Project No.: A	<u>346</u>		
					Calc. No.: DC-	-A34600.00	<u>6</u> Sh	nt of 86

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STRAINER DEBRIS Fiber (macro) Fiber (micro) Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	PARAME Volume (cu ft 94.4 1.1 .5 .1 .0 .0 .0 .0 .0	TERS: Mas (1b 0 198 2 198 0 161 5 18 6 20 0 0 1 21 2 220	s De ) (11 .24 .24 .00 .00 .80 .00 .00 .80	ensity 2.10 177.00 324.00 120.00 324.00 94.00 62.00 185.00 267.76	Size (ft) .270E-04 .328E-04 .328E-04 .820E-04 .125E-03 .328E-02 .328E-04	SV (ft**-1) 148148.10 182882.20 182882.20 24390.24 16000.00 1828.82 182882.20 170543.50 158769.20		
Compressio	n Facto	or -	1.00					
HEAD LOSS SUMMA	RY: Hea (ft	nd Loss V water) ( .21	elocity ft/sec) .054	dto (in) 2.618	dt (in) 2.61	solidity (frac) 8 .021		
	Dep	osition F	lag = t	ransition				
DEBRIS SURFACE Approach V	CONDITI	CONS: / (ft/s)	-	.050		· · · · · · · · · · · · · · · · · · ·		
						. •		
Rev. Orig.	Date	Chkd.	Date			mont Venlee N		
1 PYM 1	8/6/98	Ŧ5	8/6/98	Corporat	roject: <u>veri</u>	nont rankee N	luclear Power	
				Title: Ve	ermont Yanke	e ECCS Suction S at. RHR and CS D	trainer Head Loss	alculations
\		_,		Project	No.: <u>A346</u>			
		· · · · · · · · · · · · · · · · · · ·		Calc. No	DC-A34	600.006	Sht. <u>60</u> 0	f 86



13-Mar-98 16:39:07

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Strai	ner Head	Loss Ca	lculation	for Vermo	ont-Yankee	- Case:	3c-with_1	00%_Nuka	n
Time	Into the	Transie	nt (sec)	-	0.				
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Rat ow Rate ion Pool emoved f eposited nsity (1) scosity	F) te (gpm) (gpm) Volume (c rom Pool ( on Strain b/cu-ft) (lb/ft/sec	cu-ft) (frac) her (frac) 2)	- 173.00 - 4300.00 - 4300.00 - 68000. - 1.000 - 1.000 - 60.73 246E-03				
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Ci Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete pe Diame ipe Diame linder Po f Disks ckness (i is Thick rf Area p Vol Re face Are ribed Are p Volume	r - Disk r - Gaps ter (in) eter (in) erforation in) ness (in) Reduct (so duct (so duct (cu f a (sq ft) ea (sq ft) (cu ft)	(in) (in) n Switch g ft) g ft) ft)	- 3 - 144.50 - 47.00 - 26.00 - 24.00 - 24.00 - 24.00 - 2.0000 - 5.5000 - 3.12 00 00 - 432.71 - 165.98 - 72.81	· · · · ·			
SUPPF	RESSION P	OOL DEBR Volum	IS PARAMET	TERS:	FSP I	FDB			
Fiber Sludg Dirt/ Rust Paint Cal S	ge /Dust Flakes Chips Sil	(cu f 98.	t) (1 40 200 330 31 21 350 350 51	LD) 5.64 5.00 7.00 L.70 5.00 L.00	1.00 1.00 1.00 1.00 1.00 .00	L.00 .50 .50 L.00 L.00 L.00			
Rev.	Orig.	Date	Chkd.	Date	Climet/Ducker	• <b>1</b> 7			
1	PYM	8/6/98	FS	8/6/98	Cuent/Project	vermont Y	ankee Nucl	ear Powe	
	····				Title: Vermont Performance Ass Project No.: A	Yankee ECCS essment. RHR \346	Suction Strain and CS Debris	ner Head Lo s Head Los	oss s Calculations
					Calc. No.: DC	-A34600.00	<u>6</u> S	ht. 61	of 86
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Other		43.00	1.00	.50			
STRAINER DEBRIS Fiber (macro) Fiber (micro) Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	PARAMETER. Volume (cu ft) 98.40 1.17 .52 .15 .07 .00 .00 .12 .86	S: Mass (1b) 206.64 206.64 168.00 18.50 21.70 .00 .00 21.50 229.70	Density (lb/cu-ft) 2.10 177.00 324.00 120.00 324.00 94.00 62.00 185.00 268.38	Size (ft) .270E-04 .328E-04 .328E-04 .820E-04 .125E-03 .328E-02 .328E-04	SV (ft**-1) 148148.10 182882.20 182882.20 24390.24 16000.00 1828.82 182882.20 170479.70 158720.30		-
Maximum Be Compressio	d Solidity on Factor	- i	200 .00				
HEAD LOSS SUMMA	ARY: Head L (ft wat)	oss Veloc er) (ft/s .30 .4	ity dto ec) (in) 058 2.72	dt (in) 9 2.72	solidity (frac) 9 .021		
	Deposi	tion Flag	= transition				
DEBRIS SURFACE Approach V	CONDITIONS 'elocity (f	: t/s)	05	3			
				•			
Rev. Orig	Date	hkd.	ate				
1 PMM	8/6/98 7	5 8/6	5/98 Client/J Corpora	Project:Verr tion	nont Yankee N	uclear Power	· ·
		N 2 N	Title: V Performa	ermont Yankee	ECCS Suction Site RHR and CS Di	trainer Head Lo ebris Head Loss	ss Calculations.
			Project	INO.: <u>A346</u>		<u> </u>	. <b>F</b>
			Calc. N	o.: DC-A34	500.006	Sht. 62	01 86



13-Ma 16:42 Strai	ar-98 2:37 Lner Head	l Loss Ca	lculation	for Vermo	ont-Yan	ikee –	Case: 3d-wit	h_100%_Nukon
Time	Into the	Transie	nt (sec)	-	0.			
FLOW	CONDITIC Temperat Strainer Total Fl Suppress Debris B Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Ra ow Rate ion Pool emoved f eposited nsity (1 scosity	(gpm) (gpm) Volume (c rom Pool ( on Strair b/cu-ft) (lb/ft/sec	cu-ft) (frac) her (frac) 2)	- 4 - 4 - 4 	173.00 600.00 68000. 1.000 1.000 60.73 46E-03		
STRAI	INER PARA	METERS:				_		
	Strainer	Type			-	3		
1	Strainer	Diamete	r - Disk (	(in)	-	47.00		
[	Strainer	Diamete	r - Gaps	in)	-	26.00		
	Inlet Pi	pe Diame	ter (in)		-	24.00		
	Inner Cy	linder P	erforation	Switch	-	1		
	Number c	fDisks				20		
	Disk Thi Gap Thic	Ckness ( kness (j	in)		-	2.0000		
1	Max Debr	is Thick	ness (in)		-	2.5000		
1	Input Su	rf Area	Reduct (so	ft)	-	3.12		
[	Input Ga	p Vol Re	duct (so	[ IC) [t]	-	.00		
	Full Sur	face Are	a (sq`ft)		-	432.71		
	Circumsc Total Ca	ribed Ar	ea (sq ft)		-	165.98		
1	IULAI Ga	p vorume			-	12.81		
SUPPF	RESSION P	OOL DEBR	IS PARAMET	ERS:				
		(cu f	e Ma t) (1	iss hl	FSP	FDB	•	•
Fiber		98.	30 206	5.43	1.00	1.00		
Slude	je		336	5.00	1.00	.50		
Rust	Flakes		21	.00	1.00	.50		
Paint	Chips		356	.00	.00	1.00		
Cal S	Sil		51	.00	.00	1.00		
ocner	•		43		1.00	.50		
							•	
STRAI	NER DEBR	UOJUm.	ETERS: e Mas	s Dor	eitv'	Si 70	eu	
1		(cu f	t) (1b	(1b)	'cu-ft)	(ft)	(ft**-1)	
Fiber	(macro)	98.	30 206	.43	2.10			
Slude	(micro)	1.	1/ 206 52 140	.43 1	.77.00	.270E-04	148148.10	
Dirt	Dust	•	15 18	.50 1	20.00	.328E-04	182882.20	
Rev.	Orig.	Date	Chkd.	Date				
1	DVAn	8/6/08		8/6/00	Client	/Project:Verr	nont Yankee N	Iuclear Power
	₩~ <i>  ' </i> /	0/0/20	75	0/0/90	Corpor	ration		
					Title:	Vermont Yanke	ECCS Suction S	trainer Head Loss
					Perform	ance Assessmen	t. RHR and CS D	ebris Head Loss Calculations.
1					Projec	et No.: A346		
					Calc.	No.: DC-A34	600.006	Sht. 63 of 86

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		ي الفصلية	
Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	.07 .00 .00 .12 .86 2	21.70 .00 21.50 229.70	324.00       .820E-04       24390.24         94.00       .125E-03       16000.00         62.00       .328E-02       1828.82         185.00       .328E-04       182882.20         268.38       170479.70         158726.50
Maximum Bed Compression	Solidity - Factor -	.200 1.00	
HEAD LOSS SUMMARY	Y: Head Loss (ft water) .32	Velocity (ft/sec) .062	dto dt solidity (in) (in) (frac) 2.726 2.726 .021
	Deposition	n Flag = tr	ansition
DEBRIS SURFACE CO Approach Ve	ONDITIONS: locity (ft/s)	. –	.057
	(		
			•
			-
			· ·
			•
Rev. Orig	Date Child	Date	
1 Ph/M 8/	6/98 <del>K</del>	8/6/98	Client/Project:Vermont Yankee Nuclear Power
· · · · · · · · · · · · · · · · · · ·			Title: Vermont Yankee ECCS Suction Strainer Head Loss
			Performance Assessment. RHR and CS Debris Head Loss Calculations. Project No.: A346
			Calc. No.: <u>DC-A34600.006</u> Sht. <u>64</u> of 86



31-Jul-98 11:20:27

Strai	.nor Head	Loss Ca	lculatio	n for Ve	rmont-Yan	ikee -	Case: 4		
Time	Into the	Transie	nt (sec)	-	0.				
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Ra ow Rate ion Pool emoved f eposited nsity (1 scosity	F) te (gpm) (gpm) Volume rom Pool on Stra: b/cu-ft) (lb/ft/se	(cu-ft) (frac) iner (fra ec)	- 3 - 7 - 7 ac)- 2	173.00 700.00 400.00 68000. 1.000 .500 60.73 246E-03			
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Su Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete pe Diame ipe Diame linder P f Disks ckness (i is Thick rf Area rc Area p Vol Re face Are ribed Ar p Volume	r - Disk r - Gaps ter (in) eter (in erforation in) ness (in Reduct (in Reduct (in duct (cu a (sq ft ea (sq ft)	(in) (in) on Switc sq ft) sq ft) ft) t)	- - - - - - - - - - -	$\begin{array}{c} 3\\119.00\\47.00\\26.00\\24.00\\.00\\1\\1\\9\\2.0000\\4.5000\\2.0000\\2.55\\.00\\.00\\404.32\\142.98\\56.44\end{array}$	· ·		-
SUPPR	RESSION P	OOL DEBR Volum	IS PARAM e l	ETERS: Mass	FSP	FDB			
Fiber	-	(cu f	t) 72	(1b) 40.13	1 00	1 00			
Sludg	je	10.	5	46.00	1.00	.50			
Dirt/	Dust			51.00	1.00	.50			
Paint	: Chips			.00	.00	.00	•		
Cal S	Sil -			.00	.00	.00	•		
Other	2		•	70.00	1.00	.50			
STRAI	INER DEBR	IS PARAM	ETERS:			• •			
1		Volum	e M	ass	Density	Size	SV		
Fiber	(macro)	(cu I 8.	36 (	20.06	10/Cu-It) 2.40	(12)	(IC**-1)		
Fiber	(micro)	•	11	20.06	180.00	.233E-04	171673.80		
Sludg	je (Dust	•	42 13	36.50	324.00	.328E-04	182882.20		
Rev	Orig	Date	Lo CPF4	12.22	120.00	.3286-04	102002.20	<u> </u>	
				Date	Client	t/Project:Ver	mont Yankee N	Juclear Power	r
1	PYM	8/6/98	TS 1	8/6/9		ration	mont i antroo i		
					Title:	Vermont Yanke	e ECCS Suction S	Strainer Head Lo	22
	ł		ļ		Perform	nance Assessme	nt. RHR and CS D	Debris Head Los	 s Calculations.
					Proje	ct No.: A346	<u></u>		
					Calc.	No.: <u>DC-A34</u>	600.006	Sht. 65	of 86
- Second Second		· · · · · · · · · · · · · · · · · · ·	****						



Rust Paint Cal S Other Ave D Ave D HEAD	Flakes Chips il articles ebris Maximum I Compress LOSS SUM	Ged Solic ion Facto MARY: Hea (ft	05 1 00 09 1 70 18 dity - or - ad Loss 7 water) .19	7.65 .00 .00 7.50 5.90 .200 1.00 Velocity (ft/sec) .020	324.00 94.00 62.00 185.00 267.98 dto (in) .248	.820E-04 .125E-03 .328E-02 .328E-04 dt (in) .209	24390.24 16000.00 1828.82 182882.20 170503.00 172644.40 solidity (frac) .115		
		Der	position 1	Flag = 1:	inear depo	sition			
DEBRI	S SURFAC	E CONDIT: Velocity	IONS: y (ft/s)	-	.020				
									1
							·		
,									
						·			
					·				
		•				•	•		•
					·				
Rev.	Orig.	Date	Chkd.	Date			······		
1	PHM	8/6/98	FS	8/6/98	Client/P Corporat	roject: <u>Vern</u> ion	ont Yankee N	uclear Power	
					Title: Ver Performance	rmont Yankee ce Assessment	ECCS Suction St RHR and CS De	trainer Head Loss ebris Head Loss C	Calculations.
\ \					Project l	No.: <u>A346</u>			
					Calc. No	.: <u>DC-A346</u>	00.006	Sht. <u>66</u> 0	f 86

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31-Jul-98 11:25:41

Strainer Head Loss Calculation for Vermont-Yankee - Case: 5a									
Time Into the Tra	ansient (sec)	<b>_</b>	0.						
FLOW CONDITIONS: Temperature Strainer Flo Total Flow I Suppression Debris Remov Debris Depos Fluid Densit Fluid Viscos	(Deg F) ow Rate (gpm) Rate (gpm) Pool Volume ( ved from Pool sited on Strai ty (lb/cu-ft) sity (lb/ft/se	cu-ft) (frac) ner (frac) c)	- 164.00 - 7100.00 - 14200.00 - 68000. - 1.000 500 - 60.92 262E-03						
STRAINER PARAMETERS:Strainer Type-3Length (in)-119.00Strainer Diameter - Disk (in)-47.00Strainer Diameter - Gaps (in)-26.00Inlet Pipe Diameter (in)-24.00Outlet Pipe Diameter (in)00Inner Cylinder Perforation Switch-1Number of Disks-19Disk Thickness (in)-2.0000Gap Thickness (in)-2.0000Input Surf Area Reduct (sq ft)-2.55Input Gap Vol Reduct (cu ft)00Full Surface Area (sq ft)-404.32Circumscribed Area (sq ft)-142.98Total Gap Volume (cu ft)-56.44									
SUPPRESSION POOL	DEBRIS PARAME Volume M	TERS:	FSP	FDB	•				
Fiber Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other	(cu ft) ( 16.72 4 36 4 2	1b) 0.13 6.00 1.00 3.70 .00 .00 7.00	1.00 1.00 1.00 1.00 .00 1.00	1.00 .50 .50 1.00 .00 .00 .50					
STRAINER DEBRIS PARAMETERS: Volume Mass Density Size SV									
Fiber (macro) Fiber (micro) Sludge Dirt/Dust	(cu rc) (1 8.36 2 .11 2 .28 9 .09 1	0.06 0.06 1.50 0.25 1	2.40         180.00       .233         324.00       .328         120.00       .328	E-04 1716 E-04 1828 E-04 1828	573.80 382.20 382.20				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Date Chkd. 16/98 75	Date 8/6/98	Client/Projec	t:Vermont	Yankee Nuc	clear Power			
		·	Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations						
			Project No.: <u>A346</u> Calc. No.: <u>DC-A34600.006</u> Sht. <u>67</u> of 86						

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Rev.	Orig.	Date	Chkd.	Date	
1	PAM	8/6/98	FS	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation
					Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations.
					<b>Project No.:</b> <u>A346</u>
				1	Calc. No.: <u>DC-A34600.006</u> Sht. <u>68</u> of 86


31-Ju1-98 11:29:12

Strainer Head Loss Ca	lculation fo	or Vermon	nt-Yankee	- Case:	5b		
Time Into the Transie	nt (sec) -	-	0.				
FLOW CONDITIONS: Temperature (Dec Strainer Flow Rate Total Flow Rate Suppression Pool Debris Removed f Debris Deposited Fluid Density (J Fluid Viscosity	(F) (gpm) Volume (cu- rom Pool (fr on Strainer b/cu-ft) (lb/ft/sec)	 ft) rac) r (frac) - -	- 170.00 7100.00 14200.00 - 68000. - 1.000 500 - 60.80 251E-03				
STRAINER PARAMETERS: Strainer Type Length (in) Strainer Diamete Strainer Diamete Outlet Pipe Diame Outlet Pipe Diame Number of Disks Disk Thickness (i Max Debris Thick Input Surf Area Input Circ Area Input Gap Vol Re Full Surface Are Circumscribed An Total Gap Volume	er - Disk (in er - Gaps (in eter (in) Perforation S in) n) Reduct (sq f Reduct (sq f educt (cu ft) ea (sq ft) rea (sq ft) e (cu ft)	n)	$\begin{array}{c} & & & & & & \\ & & & & & & \\ & & & & & $				
SUPPRESSION POOL DEBR Volum	NIS PARAMETER Ne Mass	RS: s	FSP I	FDB			
(cu f Fiber 16. Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other	(1b) 72 40.1 497.0 55.0 32.2 .0 64.0	) 13 00 20 20 00 00	1.00 1 1.00 1 1.00 1 1.00 1 .00 1 1.00 1	.50 .50 .00 .00 .00 .50			
STRAINER DEBRIS PARAN Volum	METERS: ne Mass	Dens	sity Siz	ze i	sv		
(cu f Fiber (macro) 8. Fiber (micro) 5ludge Dirt/Dust	t)     (1b)       36     20.0       11     20.0       38     124.2       11     13.7	(1b/c 06 06 18 25 32 75 12	cu-ft) (ft 2.40 30.00 .2331 24.00 .3281 20.00 .3281	E-04 1716 E-04 1828 E-04 1828	**-1) 73.80 82.20 82.20		
Rev. Orig. Date	Chkd.	Date	Client/Project	t:Vermont Y	ankee Nucl	ear Power	
1 //// 8/6/98	FS	8/6/98	Corporation				
			Title: Vermont	Yankee ECCS essment. RHR	Suction Strai	ner Head Los is Head Loss	SS Calculations.
			Calc. No.: DC	-A34600.00	<u>6</u>	Sht. <u>69</u>	of 86

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Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	.05 .00 .00 .09 .63	16.10 .00 .00 16.00 170.10	324.00 .820E-0 94.00 .125E-0 62.00 .328E-0 185.00 .328E-0 268.19	04 24390.24 03 16000.00 02 1828.82 04 182882.20 170464.90 172604.50	
Maximum Bed Compression	Solidity - Factor -	.200 1.00			
HEAD LOSS SUMMARY	Head Loss (ft water) .42	Velocity (ft/sec) .039	dto (in) (i .248	dt solidity in) (frac) .156 .142	
	Depositio	n Flag = li	near deposition		
DEBRIS SURFACE CC Approach Vel	ONDITIONS: .ocity (ft/s	) -	.039		
•					
			۰.		
Rev. Orig. D	ate Chkd	Date			
1 PMM 810	5/98 75	8/6/98	Client/Project:	ermont Yankee N	Juclear Power
		• • •	Title: Vermont Ya	nkee ECCS Suction S	Strainer Head Loss
<u> </u>			Project No.: A34	<u>ment. KHK and CS E</u>	vebris Head Loss Calculations
			Calc. No.: <u>DC-A</u>	34600.006	Sht. 70 of 86



31-Jul-98 11:37:32

Strainer Head	Loss Cal	lculation	for Verm	iont-Yanl	kee - (	Case: 6a		
Time Into the	Transie	nt (sec)	-	0.				
FLOW CONDITION Temperatu Strainer Total Flo Suppressi Debris Re Debris De Fluid Den Fluid Vis	NS: Tre (Deg Flow Rate ton Pool moved fr posited isity (1) cosity	F) (gpm) Volume (c rom Pool ( on Strain o/cu-ft) (lb/ft/sec	u-ft) [frac] ler (frac ;)	- 40 - 40 - 40 	164.00 500.00 500.00 58000. 1.000 1.000 60.92 52E-03			
STRAINER PARAM Strainer Length (i Strainer Strainer Inlet Pip Outlet Pi Inner Cyl Number of Disk Thic Gap Thick Max Debri Input Sur Input Cir Input Gap Full Surf Circumsor Total Gap	dETERS: Type in) Diamete: De Diamete: De Diamete: De Diamete: De Diamete: De Diamete: Disks kness (in ts Thickn of Area I c Area Area I c Area I c Area I c	r - Disk ( r - Gaps ( ter (in) eter (in) erforation in) ness (in) Reduct (so duct (so)duct (so duct (so)duct (s	(in) (in) Switch (ft) (ft) (t)		3 47.00 26.00 24.00 24.00 1 20 2.0000 5.5000 2.5000 3.12 .00 432.71 165.98 72.81	·		
SUPPRESSION PC	OOL DEBR	IS PARAMET	ERS:	FSP	FDB			
Fiber Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other	(cu f 9.)	() 00 21 156 16 10 20		1.00 1.00 1.00 .00 .00 1.00	1.00 .50 .50 1.00 .00 .00 .50	• •		
STRAINER DEBRI Fiber (macro) Fiber (micro)	IS PARAM Volum (cu fi 9.0	ETERS: e Mas t) (11 00 21 12 21	35 De >) (1b .60 .60	ensity b/cu-ft) 2.40 180.00	Size (ft) .233E-04	SV (ft**-1) 171673.80		
Dirt/Dust	••• • •		9.00	120.00	.328E-04	182882.20		
1 PMM	Date 8/6/98	Chkd. FS	Date 8/6/98	Client Corpor Title:	Project:Verr ration Vermont Yankee ance Assessmen	nont Yankee N ECCS Suction Si t. RHR and CS D	uclear Powe trainer Head L ebris Head Los	oss s Calculations.
				Projec Calc. I	t No.: <u>A346</u> No.: <u>DC-A346</u>	500.006	Sht. 71	_of 86



Rust Fl Paint C Cal Sil Other Ave Par Ave Deb Max Con	akes hips ticles ris ximum B mpressi	.( .( .C .C .4 ed Solid on Facto	)3 1 )0 )0 )5 1 10 10 lity - ,r -	0.10 .00 0.00 7.10 .200 1.00	324.00 94.00 62.00 185.00 267.10	.820E-04 .125E-03 .328E-02 .328E-04	24390.24 16000.00 1828.82 182882.20 170560.40 172576.10		
HEAD LO	SS SUMM	1ARY: Hea (ft	ad Loss water) .10	Velocity (ft/sec) .024	dto (in) .250	dt (in) ) .250	solidity (frac) ) .058		
ļ		Der	position	Flag = 1.	inear depc	osition .			
DEBRIS Ap	SURFACE	CONDITI Velocity	IONS: / (ft/s)	-	.024	1			
							•		•
						•			
			•						
Rev. I	Orig.	Date	Chkd	Date	<u> </u>	······································			
1	PIM	8/6/98	7S	8/6/98	Client/I Corporation	Project: <u>Vern</u> tion	nont Yankee N	uclear Power	
					•Title: V	ermont Yankee	ECCS Suction St t. RHR and CS De	trainer Head Lo ebris Head Loss	ss Calculations.
					Project	No.: <u>A346</u>			_
					Calc. No	o.: <u>DC-A34</u> 6	500.006	Sht. 72	of 86



31-Jul-98 12:21:19

Strainer Head	Loss Ca	lculation	for Verm	ont-Yan	kee –	Case: 6b		
Time Into the	Transie	nt (sec)	-	0.				
FLOW CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Ra ow Rate ion Pool emoved f eposited nsity (1 scosity	F) te (gpm) (gpm) Volume (c rom Pool ( on Strain b/cu-ft) (lb/ft/sec	u-ft) frac) er (frac)	- 4 - 4 - 4 	173.00 000.00 000.00 68000. 1.000 1.000 60.73 46E-03	•		
STRAINER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Su Input Ga Full Sur Circumsc Total Ga	METERS: Type in) Diamete pe Diame ipe Diame ipe Diame linder P f Disks ckness (i is Thick rf Area rc Area p Vol Re face Are ribed Ar p Volume	r - Disk ( r - Gaps ( ter (in) eter (in) erforation in) n) ness (in) Reduct (so duct (so duct (cu f a (sq ft) ea (sq ft) (cu ft)	in) in) Switch [ft] [ft] t)		$\begin{array}{c} 3\\ 144.50\\ 47.00\\ 26.00\\ 24.00\\ 24.00\\ 1\\ 20\\ 2.0000\\ 5.5000\\ 2.5000\\ 3.12\\ .00\\ 3.12\\ .00\\ 432.71\\ 165.98\\ 72.81 \end{array}$		·	<i>.</i>
SUPPRESSION P	OOL DEBR Volum	IS PARAMET e Ma	ERS:	FSP	FDB			
Fiber Sludge Dirt/Dust Rust Flakes Paint Chips Cal Sil Other	(cu f 9.	t) (1 00 21 322 36 20	b) .60 .00 .80 .00 .00 .00	1.00 1.00 1.00 .00 .00 1.00	1.00 .50 .50 1.00 .00 .00 .50			
STRAINER DEBR	IS PARAM Volum (cu f	ETERS: e Mas t) (11	s De: ) (lb	nsity /cu-ft)	Size (ft)	SV (ft**-1)		
Fiber (macro) Fiber (micro) Sludge Dirt/Dust	9.	00 21 12 21 50 161 15 18	. 60 . 60 . 00 . 00	2.40 180.00 324.00 120.00	.233E-04 .328E-04 .328E-04	171673.80 182882.20 182882.20		
Rev. Orig.	Date 8/6/98	Chkd. 73	Date 8/6/98	Client Corpor Title: Perform	/Project:Verr ration Vermont Yanker nance Assessmen	nont Yankee N e ECCS Suction St at. RHR and CS De	uclear Power trainer Head Lo ebris Head Loss	ss Calculations.
				Projec Calc. 1	rt No.: <u>A346</u> No.: <u>DC-A34</u>	500.006	Sht. <u>73</u>	of 86

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HEAD LOSS SUMMARY:       Head Loss Velocity       dto       dt       solidity         (ft water)       (ft/sec)       (in)       (in)       (frac)         .24       .021       .250       .135         Deposition Flag = linear deposition         DEBRIS SURFACE CONDITIONS:       .021         Approach Velocity       (ft/s)       .021         Rev.       Orig.       Date       Chkd.       Date         1       PMM       8/6/98       F5       8/6/98         1       F5       8/6/98       Tilt: Yermont Yankce ECCS Suction Strainer Head Loss         Performance Assessment RHR and CS Debris Head Loss Calculations       Project No: A346       Cale. No: DC-A34600.006	Rust Paint Cal S Other Ave P Ave D	Flakes Chips il articles ebris Maximum Compress	Bed Soli ion Fact	06 2 00 11 2 82 22 dity - or -	20.80 .00 21.00 20.80 .200 1.00	324.00       .820E-04       24390.24         94.00       .125E-03       16000.00         62.00       .328E-02       1828.82         185.00       .328E-04       182882.20         267.76       170543.50         172685.60
Deposition Flag = linear deposition         DEBRIS SURFACE CONDITIONS: Approach Velocity (ft/s)       -       .021         Rev.       Orig.       Date       Chief, Date         1       Difference       Store       Store         1       Difference       Store       Store         1       Difference       Store       Store         1       Difference       Store       Title: Vermont Yankee Nuclear Power         Corroration       Title: Vermont Yankee ECCS Suction Strainer Head Loss         Performance Assessment. RHR and CS Debris Head Loss Calculations       Project No.: A346         1       Difference       Calc. No.: DC-A34600.006       Sht. 74_ of 86_	HEAD	LOSS SUM	MARY: He (ft	ad Loss water) .24	Velocity (ft/sec) .021	y dto dt solidity (in) (in) (frac) 1250 .193 .135
DEBRIS SURFACE CONDITIONS:       .021         Approach Velocity (ft/s)       -       .021         Rev.       Orig.       Date       Chkd.       Date         1       PMM       8/6/98       75       8/6/98         1       PMM       8/6/98       75       8/6/98         Client/Project:Vermont Yankee Nuclear Power Corporation       Client/Project:Vermont Yankee Nuclear Power Corporation         1       PMM       8/6/98       75       8/6/98         Vertice       Vertice       Project No: Nakee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations         1       Image: Project No: A346       Cale. No: DC-A34600.006       Sht. 74_ of 86_			De	position	Flag = 1	linear deposition
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}MM\$       8/6/98       \$\mathcal{TS}\$       8/6/98         1       \$\mathcal{P}MM\$       \$\mathcal{S}/98\$       \$\mathcal{TS}\$       8/6/98         1       \$\mathcal{P}MM\$       \$\mathcal{S}/98\$       \$\mathcal{TS}\$       \$\mathcal{P}\mathcal{O}/98\$         2       \$\mathcal{P}MM\$       \$\mathcal{S}/98\$       \$\mathcal{D}/98\$       \$\mathcal{P}\mathcal{D}/98\$         2       \$\mathcal{D}/98\$       \$\mathcal{D}/98\$       \$\mathcal{D}/96\$       \$\mathcal_D16\$	DEBRI	S SURFAC Approach	E CONDIT Velocit	IONS: y (ft/s)	-	.021
Rev.       Orig.       Date       Chkd.       Date         1       PM/M       8/6/98       #5       8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1       PM/M       8/6/98       #5       8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1       PM/M       8/6/98       #5       8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1       Image: State of the sta						
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}\mathcal{M}\]       \$8/6/98       \$\mathcal{F_5}\$       \$8/6/98         2       \$\mathcal{M}\]       \$\mathcal{F_5}\$       \$8/6/98       \$\mathcal{T_1}\$         2       \$\mathcal{M}\]       \$\mathcal{T_5}\$       \$8/6/98       \$\mathcal{T_1}\$         2       \$\mathcal{M}\]       \$\mathcal{M}\]       \$\mathcal{M}\]       \$\mathcal{M}\]         2       \$\mathcal{M}\]       \$\mathcal{M}\]       \$\mathcal{M}\]       \$\mathcal{M}\]         3       \$\mathcal\[]       \$\m						
Rev.       Orig.       Date       Chkd.       Date         1       \$\vee MM\$       \$\vee formance						
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       Client/Project: Vermont Yankee Nuclear Power Corporation         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       Client/Project: Vermont Yankee Nuclear Power Corporation         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       Client/Project: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{P}\mathcal{T}\mathcal{M}\$       \$\mathcal{P}\mathcal{T}\mathcal{M}\$         1       \$\mathcal{D}\mathcal{M}\mathcal{M}\$       \$\mathcal{P}\mathcal{T}\mathcal{M}\$       \$\mathcal{P}\mathcal{T}\mathcal{M}\$         1       \$\mathcal{D}\mathcal{M}\mathcal{M}\$       \$\mathcal{T}\mathcal{M}\$       \$\mathcal{T}\mathcal{T}\mathcal{M}\$         1       \$\mathcal{D}\mathcal{M}\mathcal{M}\$       \$\mathcal{T}\mathcal{M}\$       \$\mathcal{T}\mathcal{M}\$         1       \$\mathcal{D}\mathcal{M}\mathcal{M}\$       \$\mathcal{T}\mathcal{M}\$       \$\mathcal{M}\$         1       \$\mathcal{D}\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$         1       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$ <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td></td<>						
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_5\$       \$\mathcal{8}\left(6/98)\$       \$\mathcal{F}_5\$       \$\mathcal{8}\left(6/98)\$         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_5\$       \$\mathcal{8}\left(6/98)\$       \$\mathcal{F}_5\$       \$\mathcal{C}\mathcal{O}\mathcal{P}\mathcal{O}\mathcal{D}\mathcal{P}\mathcal{P}\mathcal{D}\mathcal{P}\mathcal{D}\mathcal{P}\mathcal{P}\mathcal{D}\mathcal{P}\mathcal{P}\mathcal{D}\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{L}\mathcal{D}\mathcal{L}\mathcal{D}\mathcal{P}\mathcal{D}\mathcal\mathcal{D}\mathcal{D}\math						•
Rev.       Orig.       Date       Chkd.       Date         1 $\rho$ M/M       8/6/98 $frs$ 8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho$ M/M       8/6/98 $frs$ 8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho$ M/M       8/6/98 $frs$ 8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho$ M/M       8/6/98 $frs$ 8/6/98       Corporation         1 $\rho$ M/M $rs$ $rs$ $rs$ $rs$ $rs$ 2 $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ 2 $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ 3 $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ $rs$ <						
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       Client/Project:Vermont Yankee Nuclear Power Corporation         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       Carporation         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       Carporation         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       Carporation         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       \$\mathcal{P}m_{10}\$         1       \$\mathcal{P}M_M\$       8/6/98       \$\mathcal{F_5}\$       8/6/98       \$\mathcal{P}m_{10}\$         2       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$         3       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$         4       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$         5       \$\mathcal{M}M_M\$       \$\mathcal{M}M_M\$						
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{Y}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_S\$       \$\mathcal{8}/6/98\$       Client/Project:Vermont Yankee Nuclear Power         1       \$\mathcal{Y}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_S\$       \$\mathcal{8}/6/98\$       Client/Project:Vermont Yankee Nuclear Power         1       \$\mathcal{Y}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_S\$       \$\mathcal{8}/6/98\$       Client/Project:Vermont Yankee Nuclear Power         1       \$\mathcal{Y}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_S\$       \$\mathcal{8}/6/98\$       Corporation         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{F}_S\$       \$\mathcal{8}/6/98\$       \$\mathcal{T}_S\$         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{S}/6/98\$       \$\mathcal{F}_S\$       \$\mathcal{S}/6/98\$         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{S}/6/98\$       \$\mathcal{T}_S\$       \$\mathcal{P}_Fformance Assessment. RHR and CS Debris Head Loss Calculations         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{P}_Fformance Assessment. RHR and CS Debris Head Loss Calculations         1       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{C}\$       \$\mathcal{A}_46\$         1       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{M}\$<						
Rev.       Orig.       Date       Chkd.       Date         1 $\rho \mu / \rho$ 8/6/98 $\mathcal{F}_5$ 8/6/98       Client/Project: Vermont Yankee Nuclear Power Corporation         1 $\rho \mu / \rho$ 8/6/98 $\mathcal{F}_5$ 8/6/98         1 $\rho \mu / \rho$ $\mathcal{F}_5$ 8/6/98 $\mathcal{F}_5$ 1 $\rho \mu / \rho$ $\mathcal{F}_5$ 8/6/98 $\mathcal{F}_5$ $\mathcal{F}_5$ 1 $\rho \mu / \rho \rho$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ 1 $\rho \mu / \rho \rho \rho \rho \rho$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$ $\mathcal{F}_5$						
Rev.       Orig.       Date       Chkd.       Date         1 $P H/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $P H/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $P H/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $P H/M$ $8/6/98$ $F_5$ $8/6/98$ Corporation         1 $P H/M$ $R/6/98$ $F_5$ $8/6/98$ Corporation         1 $P H/M$ $R/6/98$ $F_5$ $R/6/98$ Corporation         1 $P H/M$ $R/6/98$ $F_5$ $R/6/98$ $Performance Assessment. RHR and CS Debris Head Loss Calculations         1       P roject No.: A346       Calc. No.: DC-A34600.006       Sht 74 _ of 86 _   $						· · · ·
Rev.       Orig.       Date       Chkd.       Date         1 $\rho \mu / M$ $8/6/98$ $frs$ $8/6/98$ Client/Project: Vermont Yankee Nuclear Power Corporation         1 $\rho \mu / M$ $8/6/98$ $frs$ $8/6/98$ Client/Project: Vermont Yankee Nuclear Power Corporation         1 $\rho \mu / M$ $8/6/98$ $frs$ $8/6/98$ Client/Project: Vermont Yankee Nuclear Power Corporation         1 $\rho \mu / M$ $8/6/98$ $frs$ $8/6/98$ Client/Project: Vermont Yankee Nuclear Power Corporation         1 $\rho \mu / M$ $8/6/98$ $frs$ $8/6/98$ Client/Project: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations Project No.: A346         1 $\rho \mu / M$ $ref = 0$ $ref = 0$ 1 $ref = 0$ $ref = 0$ $ref = 0$ 1 $ref = 0$ $ref = 0$ $ref = 0$ 1 $ref = 0$ $ref = 0$ $ref = 0$						• • •
Rev.       Orig.       Date       Chkd.       Date         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{S}^{1/98}\$       \$\mathcal{S}^{1/98}\$       \$\mathcal{Client/Project:Vermont Yankee Nuclear Power} Corporation         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{S}^{1/98}\$       \$\mathcal{S}^{1/98}\$       \$\mathcal{Client/Project:Vermont Yankee Nuclear Power} Corporation         1       \$\mathcal{P}\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       \$\mathcal{Client/Project:Vermont Yankee Nuclear Power} Corporation         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       \$\mathcal{Client/Project:Vermont Yankee Nuclear Power} Corporation         1       \$\mathcal{M}\mathcal{M}\$       \$\mathcal{F}^{5}\$       \$\mathcal{8}/6/98\$       \$\mathcal{Client/Project:Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations         1       \$\mathcal{M}\$       \$\mathcal{M}\$       \$\mathcal{P}\$       \$						
Rev.       Orig.       Date       Chkd.       Date         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee Nuclear Power Corporation         1 $\rho M/M$ $8/6/98$ $F_5$ $8/6/98$ Client/Project:Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations Project No.: A346         1 $\rho M/M$ $\rho M/M$ $\rho M/M$ $\rho M/M$ 1 $\rho M/M$ $\rho M/M$ $\rho M/M$ $\rho M/M$						
1       PH/M       8/6/98       Fs       8/6/98       Client/Project: Vermont Yankee Nuclear Power Corporation         1       PH/M       8/6/98       Fs       8/6/98       Client/Project: Vermont Yankee Nuclear Power Corporation         1       PH/M       8/6/98       Fs       8/6/98       Client/Project: Vermont Yankee Nuclear Power Corporation         1       PH/M       8/6/98       Fs       8/6/98       Client/Project: Vermont Yankee Nuclear Power Corporation         1       PH/M       No.:       Performance Assessment. RHR and CS Debris Head Loss Calculations         Project No.:       A346       Calc. No.:       DC-A34600.006       Sht. 74 of 86_	Rev.	Orig.	Date	Chkd.	Date	
Title: Vermont Yankee ECCS Suction Strainer Head Loss         Performance Assessment. RHR and CS Debris Head Loss Calculations         Project No.: A346         Calc. No.: DC-A34600.006         Sht. 74 of 86	1	PHM	8/6/98	5	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation
Project No.: <u>A346</u> Calc. No.: <u>DC-A34600.006</u> Sht. <u>74</u> of 86_		· · · ·				Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment, RHR and CS Debris Head Loss Calculations
Calc. No.: <u>DC-A34600.006</u> Sht. <u>74</u> of 86						Project No.: <u>A346</u>
						Calc. No.: <u>DC-A34600.006</u> Sht. <u>74</u> of 86



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Strainer Head Loss C	alculation f	for Vermo	ont-Yan)	kee – (	Case: 6c		
Time Into the Transi	ent (sec)	-	Q.				
FLOW CONDITIONS: Temperature (De Strainer Flow R Total Flow Rate Suppression Poo Debris Removed Debris Deposite Fluid Density ( Fluid Viscosity	g F) ate (gpm) (gpm) l Volume (cu from Pool (: d on Straine lb/cu-ft) (lb/ft/sec)	u-ft) frac) er (frac) )	- 1 - 43 - 43 - 6 - 6 - 7 - 7 - 726	173.00 300.00 300.00 58000. 1.000 1.000 60.73 16E-03			
STRAINER PARAMETERS: Strainer Type Length (in)			- ;	3 L44.50			
Strainer Diamet Strainer Diamet Inlet Pipe Diam	er - Disk (: er - Gaps (: eter (in)	in) in)	-	47.00 26.00 24.00			
Inner Cylinder Number of Disks	Perforation	Switch	-	24.00 1 20			
Disk Thickness Gap Thickness (	(in) in)			2.0000			
Max Debris Thic Input Surf Area Input Circ Area	kness (in) Reduct (sq Reduct (sa	ft) ft)	- 2	2.5000 3.12 .00			
Input Gap Vol R Full Surface Ar	educt (cu f ea (sq ft)	t)	-	.00 432.71			
Circumscribed A Total Gap Volum	rea (sq ft) e (cu ft)		- :	165.98 72.81			
SUPPRESSION POOL DEB	RIS PARAMET	ERS: ss	FSP	FDB			
(cu Fiber 9 Sludge	11) (1) .00 21	b) .60 .00	1.00	1.00			
Dirt/Dust Bust Flakes	37 21	.00	1.00	.50	•		
Paint Chips Cal Sil	21	.00	.00	.00	•		
Other	43	.00	1.00	.50	-		
STRAINER DEBRIS PARA	METERS:	s Der	nsity	Size	SV		
(cu Fiber (macro)	ft) (1b	) (1b)	/cu-ft)	(ft)	(ft**-1)		
Fiber (micro)	.12 21	.60 1	180.00	.233E-04	171673.80		
Dirt/Dust	.52 168 .15 18	.50 1	524.00 120.00	.328E-04 .328E-04	182882.20		
Rev. Orig. Date	Chkd.	Date	Client	Project:Ver	nont Yankee N	uclear Power	
1 PMM 8/6/98	朽	8/6/98	Corpor	ration	none z unico Iv		:
	•		Title:	Vermont Yanke	ECCS Suction S	trainer Head Lo	ss Calculations
		· · · · · · · · · · · · ·	Projec	t No.: <u>A346</u>		Constructure LOS	
			Calc. I	No.: DC-A34	600.006	Sht. 75	of 86



Rust Paint Cal S Other Ave P Ave D	Flakes Chips Sil Particles Debris		.07 .00 .00 .12 .86	21 21 229	.70 .00 .00 .50 .70	324.00 94.00 62.00 185.00 268.38	.820E-04 .125E-03 .328E-02 .328E-04	24390.24 16000.00 1828.82 182882.20 170479.70 172644.30		
	Maximum   Compress:	Bed So Ion Fa	lidity ctor	-	.200 1.00	· .				
HEAD	LOSS SUMI	MARY:	Head Lo ft wate	ss V r) ( 30	elocity ft/sec) .022	dto (in) .25	dt (in) 0 .17	solidity (frac) 79 .151		,
1			Deposit	ion F	'lag = 1:	inear dep	osition			
DEBRI	S SURFAC	E COND Veloc	ITIONS: ity (ft	/s)	_	.02	2 <sup>.</sup>			
										-
										•
							<b>.</b>			
Rev.	Orig.	Date	Ch	kd.	Date					
1	PAM	8/6/9	8 7		8/6/98	Client/	Project: <u>Ver</u> ation	mont Yankee N	luclear Powe	ŗ
	- 11					Title: V	ermont Yanko	e ECCS Suction S	trainer Head Lo	oss s Calculations
						Project	No.: <u>A346</u>	an, krik and US D	COLIS MEAU LOS	
						Calc. N	lo.: <u>DC-A34</u>	1600.006	Sht. 76	of 86



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Strai	ner Head	Loss Ca	lculation	for Verm	ont-Yan	kee –	Case: 6d		
Time	Into the	Transie	nt (sec)	-	0.				
FLOW	CONDITIO Temperat Strainer Total Fl Suppress Debris R Debris D Fluid De Fluid Vi	NS: ure (Deg Flow Ra ow Rate ion Pool emoved f eposited nsity (1 scosity	F) te (gpm) (gpm) Volume (c rom Pool ( on Strain b/cu-ft) (lb/ft/sec	u-ft) frac) er (frac	- 4 - 4 1 	173.00 600.00 68000. 1.000 1.000 60.73 46E-03			
STRAI	NER PARA Strainer Length ( Strainer Strainer Inlet Pi Outlet P Inner Cy Number o Disk Thi Gap Thic Max Debr Input Su Input Su Input Ga Full Sur CircumsC Total Ga	METERS: Type in) Diamete pe Diame ipe Diame linder P f Disks ckness (i is Thick rf Area rc Area p Vol Re face Are ribed Ar p Volume	r - Disk ( r - Gaps ( ter (in) eter (in) erforation in) ness (in) Reduct (so Reduct (so duct (cu f a (sq ft) ea (sq ft) (cu ft)	in) in) Switch (ft) (ft) t)		$\begin{array}{c} 3\\144.50\\47.00\\26.00\\24.00\\24.00\\1\\20\\2.0000\\5.5000\\2.5000\\3.12\\.00\\432.71\\165.98\\72.81\end{array}$	·		
SUPPR	ESSION P	OOL DEBR Volum	IS PARAMET e Ma	ERS:	FSP	FDB			
Fiber Sludg Dirt/ Rust Paint Cal S Other	je /Dust Flakes Chips Sil	(cu f 9.	t) (1 00 21 336 37 21 43	b) .60 .00 .70 .00 .00 .00	1.00 1.00 1.00 1.00 .00 1.00	1.00 .50 .50 1.00 .00 .50	·		
STRAI	NER DEBR	IS PARAM	ETERS:	s De	nsitv	Size	SV		
Fiber Fiber Sludg Dirt/	(macro) (micro) e Dust	(cu f 9.	t) (1b 00 21 12 21 52 168 15 18	) (1b 60 60 00 50	/cu-ft) 2.40 180.00 324.00 120.00	(ft) .233E-04 .328E-04 .328E-04	(ft**-1) 171673.80 182882.20 182882.20		
Rev.	Orig.	Date 8/6/08	Chkd.	Date 8/6/09	Client	/Project:Ven	mont Yankee N	uclear Powe	r ·
	1)    (M)	0/0/20	75	0/0/20	Corpo Title: Perform	ration Vermont Yanke nance Assessmer	e ECCS Suction St nt. RHR and CS De	trainer Head Lo ebris Head Los	oss s Calculations.
					Projec	et No.: <u>A346</u>	<	<b>A</b>	<b>f</b> = c
					Calc.	No.: <u>DC-A34</u>	600.006	Sht. <u>77</u>	of 86

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Rust Flakes Paint Chips Cal Sil Other Ave Particles Ave Debris	.07 .00 .00 .12 .86	21. 21. 229.	70 00 00 50 70	324.00 94.00 62.00 185.00 268.38	.820E-04 .125E-03 .328E-02 .328E-04	24390.24 16000.00 1828.82 182882.20 170479.70 172644.30		
Maximum Be Compressio	n Factor	- -	.200 1.00					
HEAD LOSS SUMMA	RY: Head (ft wa	Loss Ve iter) (f .34	locity t/sec) .024	dto (in) .250	dt (in) .17	solidity (frac) 1 .158		
	Depos	ition Fl	ag = li	near depo	sition			
DEBRIS SURFACE Approach V	CONDITION Velocity (	IS: (ft/s)	_	.024				
								-
, i			·			-		
Rev. Orig.	Date	Chkd.	Date	Client/P	roicct:Ven	nont Yankee N	Juclear Pow	er
	8/6/98	FS	8/6/98	Corporat	ion			<u> </u>
				Performan	rmont Yanke	e ECCS Suction S at. RHR and CS D	Strainer Head I Debris Head La	<u>Loss</u> oss Calculations.
<b>├├├</b>				Project	No.: <u>A346</u>		Che an	<b></b>
				Laic. No	DU-A34	000.000	ont. 78	_ 01 86

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## **ATTACHMENT B: BLOCKAGE 2.5 OUTPUT FILES**

Rev.	Orig.	Date	Chkd.	Date	
1	PAM	8/6/98	<b>Ŧ</b> 5	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation
		aly₩, % *6			Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment. RHR and CS Debris Head Loss Calculations.
					Project No.: <u>A346</u>

관계·소리는 것 같은 것이 같은 것이 있는 것이 가지를 통했다. 문항 및 관계 방법 방법 것이 있는 것이 같은 것은 것을 통해 있는 것이 같이 있는 것이 같이 있는 것이 같이 있는 것이 없는 것이 있

影	DESS
mi	Duke Engineering & Services

Run: Plant Versi	VY : 'Set on: BLOC	tling 01 KAGE 2.5	•		(VY01.BLK )					
Debri NUREG	s Volume /CR-6224	s Input   Correla	by User tíon							
**** *****	******** *******	******** ******** *****	* * * * * * * * * * * * * * * * * * *	********	· * * * * * * * * * * * * * * * * * * *					
1	VOLUME-	1 Diam	.: 22.0	Loc: L						
* * * * * * * * * * * *	*******	*******	* * * * * * * * * * * * * * * * * * *	*********	***************************************					
Init	ial As-F	abricate	d Volume D	Data (ft3)	3)					
TYPE NK RF DD SD Tot	ORIGIN TG DW DW WW al	CLASS DE F P 3 P 1 P 3	NSITY DEE 2.40 209 24.00 0 56.00 1 24.00 2 212	BRIS         TRAN           0.00         209           0.15         0           0.00         1           2.38         2           2.53         212	ANSPORT FRACTION 09.00 1.000 0.15 1.000 1.00 1.000 2.38 1.000 12.53					
	CLASS Fibro Metal Parti Ignoz To	DE Dus 20 Lic .cle .ce Dtal 21	BRIS TF 9.00 2 0.00 3.53 0.00 2.53 2	ANSPORT 209.00 3.53 0.00 212.53	FRACTION 1.000 0.000 1.000 0.000					
Time	Time Dependent Results for Weld: VOLUME-1									
Time	e = 100	00.0 sec	, ( 166.6	567 min),	( 2.7778 hr)					
ECCS	DATA	Pool Tem	perature:	122.7 F	F Total ECCS Flow: 18800.0 GPM					
Pu	Pump Flow Rates (GPM) No. Module Total Pump 1 Pump 2 1 Loop1 18800. 14200. 4600.									
Cl	ean Stra No. Moc 1 Loc	diner NPS dule opl	H Margin ( Pu S	(ft-water) mp 1 F 97.19	r) Change Due to Temp: 2.81 Pump 2 97.19					
Rev.	Orig.	Date	Chkd.	Date						
1	Plim	8/6/98	#5	8/6/98	Client/Project: Vermont Yankee Nuclear Power Corporation Title: Vermont Verlage ECCS Survive Stationar Used Land					
[					Performance Assessment. RHR and CS Debris Head Loss Calculations Project No • A 346					
					Calc. No.: DC-A34600.006 Sht. 80 of 86					
I	t	1	1	1						



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Foule	d Strain No. Mod 1 Loop	er NPSH I ule pl	Margin (ft Pu 9	:-water) Imp 1 P 15.73	'ump 2 95.73					
STRA	INER DEP	OSITION I	DATA							
No. 1	Module Loopl 16	Fiber 1 7.972 (	Volumes (1 Metal Pa 0.000 0.	Et3) irt. Igno 899 0.0	ore 1 100 40	Fiber 03.13	Masses ( Metal 1 0.00 2	lbm) Part. Ig 249.4	nore 0.0	
No. 1	F Module Loopl	'abricate Fiber l 2.4	d Densitie Metal Pa 0.5 27	es (lbm/ft art. Igno 7.5 0	:3) >re - 1 1.5	Rubbl Fiber 2.4	e Densit: Metal 1 0.5	ies (lbm/ Part. Ig 55.5	ft3) nore 0.5	
No. 1	Module Loopl	Material Fiber I 175.0	Densities Metal Pa 0.5 27	3 (1bm/ft3 art. Igno 7.5 0	3) >re   1.5 1.	Sp. Su Fiber .7E+05	Metal 0.0E+00	eas (ft2/ Part. 1.7E+05	ft3) Ignore 0.0E+00	
No. 1	Module Loopl 0	Mass M/F .00E+00	Ratios P/F 6.19E-01	Thick Theo. Ac 4.03	ness tual 4.55	(in) Metal 0.00	Head Fib&Prt 1.5	Loss (ft Metal T 0.0	) Otal 1.5	
DEBR	IS VOLUM	E DISTRI	BUTION DAT	ľA	Tra	ansport	Completio	on: 1.00	100	
No.	Туре	D ID Tra (f)	W Susp an. Poc t3) (ff	pend Po bl Co :3) (ft3/	ool onc. 'ft3)	Settle Floor (ft3)	ed Retain System (ft3)	n Deposi m Strai ) (ft3	.ted .ner )	
1	Nukon Group Group Group Group Group Group Group Group Group Group	NK 209. 1 0. 2 0. 3 0. 4 0. 5 0. 6 0. 7 0. 8 0. 9 0. 10 0. 11 0. 12 0.	002       0.2         431       0.2         149       0.2         110       0.6         081       0.6         060       0.6         044       0.6         033       0.6         024       0.6         018       0.6         010       0.6         027       0.6	196 2.8E 725 161 077 029 007 000 000 000 000 000 000 000	3E-06	40.833 0.079 0.087 0.093 0.096 0.094 0.088 0.078 0.066 0.054 0.042 0.127	3     0.00       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******       ******     ******	0 167.97 * 0.51 * 0.16 * 0.11 * 0.07 * 0.05 * 0.03 * 0.01 * 0.01 * 0.00 * 0.00 * 0.00 * 0.00	22 . 22 36 18 31 32 9 1 16 13 12 13	
2	Rust F Group	RF 0. 1 1.	154 0.0 000 ****	000 0.0C	0E+00	0.142 1.000	? 0.00 ) ******	0 0.01 * 1.00	L2 )0	
3	Dirt/D Group	DD 1. 1 1.	000 0.0 000 1.0	000 <b>1.0</b> 3 000	3E-09	0.505 1.000	9 0.24 ) 1.00	2 0.24 0 1.00	19 )0	
Rev.	Orig.	Date	Chkd.	Date	<u> </u>					
1	Plim	8/6/98	43	8/6/98	Clien Corpo	nt/Project	t:Vermont	Yankee Nu	uclear Powe	ŗ
×				1	Title	: Vermont `	Yankee ECC	S Suction St	rainer Head Lo	oss
, 	<b>.</b>	<b> </b>	<b> </b>	<b> </b>	Perfor	mance Asso	essment. RH	R and CS De	bris Head Los.	s Calculations.
L.	1	ł	ł	1	Proje	ect No.: <u>A</u>	1340			

Calc. No.: DC-A34600.006

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4 S	iludge S Group Group Group Group Group Group Group Group Group Group	D * * * * * * * * * * * * * * * * * * *	0.000	0.00 0.7 0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3 4.5 43 06 81 47 18 04 00 00 00 00 00 00 00	6E-08 1. 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	211 .025 .013 .022 .037 .056 .080 .104 .122 .130 .125 .107 .180	0.528 0.339 0.072 0.080 0.086 0.085 0.075 0.061 0.046 0.031 0.019 0.018	0.638 0.44 0.09 0.09 0.09 0.09 0.09 0.09 0.09	8 90 95 95 97 11 92 97 11 92 94 92		
DEBR	DEBRIS VOLUME RATE DATA											
No.	Туре	ID	DW Tran.	Sus	pended Pool	Settled Floor	Reta Syst	in em	Deposite Strainer	ed T		
1	Nukon	NK	(ft3/s) 0.00E+0	) (	ft3/s) 00E+00	(ft3/s) 9.84E-06	(ft3 0.00E	3/s) C+00	(ft3/s) 1.21E-04	l		
2	Rust F Dirt/D	RF DD	0.00E+00	0.	00E+00 00E+00	0.00E+00 3.17E-08	0.00E	C+00 C-09	0.00E+00 3.25E-08	) }		
4	Sludge	SD	0.00E+0	<b>0</b> .	00E+00	1.71E-07	2.39E	-07	1.43E-06	5		
Time												
FCCC	200 200	Pool	Tompored	-1170+	140 E	F Total F	,	•		DM		
ECCS	ECCS DATA FOOT TEMPERATURE: 140.5 F TOTAL ECCS Flow: 18800.0 GPM											
Pu	mp Flow No. Mod	Rates lule	(GPM) Total	Pu	mp 1	Pump 2						
	1 Loc	pl	18800.	14	200.	4600.						
Cl	ean Stra	iner 1	NPSH Ma	rgin (	ft-wate	r) Chang	e Due t	o Temp	⊃: <sup>′</sup> 5.	22		
	1 Loc	p1		9	4.78	94.78						
Fo	uled Str	ainer	NPSH M	argin	(ft-wat	er)			•			
	No. Mod 1 Loc	ule pl		Pu 9	mp 1 3.53	Pump 2 93.53			-			
STRA	INER DEF	OSITI	on data									
Volumes (ft3) Masses (lbm) No. Module Fiber Metal Part. Ignore Fiber Metal Part. Ignore 1 Loopl 168.147 0.000 0.901 0.000 403.55 0.00 250.2 0.0												
	Fabricated Densities (1hm/ft3) Pubble Densities (1hm/ft3)											
Rev.	Orig.	Date	e C	nkd.	Date							
1	PAM	8/6/9	¥8 -≢	5	8/6/98	Client/Pr Corporation	oject: <u>Ve</u> on	rmont	Yankee Nu	uclear Po	ower	
		•				Title: Ver	mont Yank	ee ECC	Suction St	rainer He	ad Loss	
						Project N	c Assessm	ent. KHF	c and CS De	oris Head	Loss Calculation	
						- Calc. No.	: DC-A3	- 4600.00	06	Sht.	82 of 86	
		I			l							



No.	Module	Fib	er 1	letal	Par	t. Igno	re	Fiber	Metal	L Pa	art.	Igno	ore		
1	Loopl	2	. 4	0.5	277	<b>.</b> .6 U	.5	2.4	0.5		5.6	(	0.5		
						111		<b>0</b> - 0.				-015			
		Mat	erial	Densi	.ties	(IDM/IL3	1	sp. st	urrace	e Area	AS (I	τ2/Γι	C3)		
No.	Module	Fib	er 1	letal	Par	ct. Igno	re	Fiber	Meta	11 1	Part	· · ·	Ignore		
1	Loop1	175	.0	0.5	27	/.6 0	.5 1	1.76+05	0.051	100	1./5+	05 1	0.06+00		
			Mace I	atio	-	Thick	nose	(in)	ŗ	l heat	0000	(f+)			
No	Module	м/	Mass I F	P/F		Theo. Ac	tual	Metal	Fibs	CPrt N	Metal		tal		
1	Loopl	0.00	E+00	6.20	5-01	4.04	4.85	0.00	1	1.2	0.0		1.2		
-	noobi e								-			-			
						•									
DEBF	RIS VOLUM	IE D	ISTRI	BUTION	I DATA	£	Tı	ransport	Comp]	letio	n: 1	.000	0		
				•	-						•				
N7-	() 		DV 00	N	Suspe	ena Po	01	Sectio	ea Ke	etain	Dep	OSIC	ea		
NO.	туре	ID	TIC (E)	an.	P001		-nc.	F 1001	r Sy	YSCEM	SC /	rain frain	er		
1	Nukan	NIZ	200 (1)			(112)	103	40 047	, ,	1103	1 60	147			
· -	Crown	1	209.0	431	0.00	JU J.92	6-09	40.04	7 ***	*****	100	512			
	Group	2	0.1	149	0.11	19		0.07	9 ***	****	ň	166			
	Group	จั	0.1	110	0.03	37		0.08	, 7 ***	****	ň	.116			
	Group	4	0.0	081	0:00	07		0.09	3 ***	****	õ	.078			
	Group	5	0.0	060	0.00	01		0.09	6 ***	****	Ō	.051			
	Group	6	0.0	044	0.00	00		0.09	4 ***	****	0	.032			
	Group	7	0.0	033	0.00	00		0.08	8 ***	*****	0	.019			
	Group	8	0.0	024	0.00	00		0.07	8 ***	****	0	.011			
1	Group	9	0.0	018	0.00	00		0.06	6 ***	****	0	.006			
	Group	10	0.0	013	0.00	00		0.05	4 ***	****	0	.003			
	Group	11	0.0	010	0.00	00		0.04	2 ***	****	0	.002			
	Group	12	0.0	027	0.00	00		0.12	7 ***	*****	0	.003			
2	Bust F	BF	0.	154	0 00	n n n	F+00	0 14	2 (	000	0	012			
	Group	1	1.0	000 1	*****	**	1.00	1.00	0 ***	*****	ĩ	.000			
		-							•		_				
ļ															
3	Dirt/D	DD	1.0	000	0.00	5.20	E-14	0.50	9 (	0.242	0	.249			
1	Group	1	1.0	000	1.00	00		1.00	0 :	1.000	1	.000			
	Sludge	en	0.0	000	0.00	1 1 2 2	10	1. 21	1 (	0 520	0	640			
4	Group	3D 1	****	***	0.00	69 I.J.	-10	0 02	5 (	0.329	0	450			
	Group	2	****	* * *	0.0	79		0.01	3 (	0.072	ő	. 090			
	Group	3	****	* * *	0.0	39	~	0.02	2 (	0.080	· ŏ	.095			
	Group	4	****	* * *	0.0	12		0.03	7 0	0.086	Ō	.095			
	Group	5	****	***	0.0	01		0.05	6 (	0.088	0	.086			
	Group	6	****	* * *	0.0	00		0.08	0. (	0.084	0	.071			
1	Group	7	****	* * *	0.0	00		0.10	4 (	0.075	0	.051			
1	Group	8	****	* * *	0.0	00		0.12	2 (	0.061	0	.032			
	Group	9	****	***	0.0	00		0.13	0 (	0.045	0	.017			
1	Group	10	****	* * *	0.0	00		0.12	5 (	0.031	0	.008			
1	Group	11	****	* * *	0.0	00		0.10	7 (	0.019	0	.004			
1	Group	12	****	***	0.0	00		0.18	0 (	0.018	0	.002			
Paul	0 ria		Date	<u>C</u> L1	<u>, 1</u>	Data	1								
1.CV.	Ung.	<u> </u>			<u>.u.</u>	Date	011-		*****		ran1	<b></b> .	100m D	~~	
1	DIA.	8/	6/98	+24		8/6/98		norrojec	u: vem	HOIL Y	ankee	5 INUC	lear row	<u>=1</u>	
1.	<i>¥ [[/M</i>	~			~		<u>Cor</u>	poration							
		T				• • • • •	Titl	e: Vermont	Yankee	ECCS	Suction	n Strai	iner Head I	ASS	
1	1				1		Perfe	mance Acc	ecomen	t RHP	and	S Dehr	is Head I o	se Calo	ulations
[	<u> </u>						D	tand NT-	A 2 1/		and Co		13 I ICau LU		
1	<b> </b> .	1					rro]	Ject 190.: <u>/</u>	4340						
	1	1					Cal	c. No.: DC	C-A346	500.00	6	1	Sht. 83	of 8	36
1	1	1		•	1		1				_				

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DEBRIS VOLUME RATE DATA Suspended Settled Retain Deposited DW No. Type ID Tran. Pool Floor System Strainer (ft3/s) (ft3/s)(ft3/s) (ft3/s) (ft3/s) 1.05E-08 1.64E-07 0.00E+00 0.00E+00 0.00E+00 NK 1 Nukon 0.00E+00 0.00E+00 0.00E+00 0.00E+00 Rust F RF 0.00E+00 2 2.73E-13 1.64E-12 0.00E+00 1.59E-12 3 Dirt/D DD 0.00E+00 6.94E-10 0.00E+00 0.00E+00 3.48E-10 4.16E-09 4 Sludge SD 21600.0 sec, ( 360.000 min), ( 6.0000 hr) Time = Pool Temperature: 143.3 F Total ECCS Flow: 18800.0 GPM ECCS DATA Pump Flow Rates (GPM) No. Module 1 Loopl Pump 1 Total Pump 2 18800. 14200. 4600. Clean Strainer NPSH Margin (ft-water) Change Due to Temp: 5.71 Pump 2 No. Module Pump 1 1 Loopl 94.29 94.29 Fouled Strainer NPSH Margin (ft-water) No. Module Pump 2 Pump 1 1 Loop1 93.07 93.07 STRAINER DEPOSITION DATA Volumes (ft3) Masses (1bm) Fiber No. Module Fiber Metal Part. Ignore Metal Part. Ignore 1 Loopl 168.147 0.000 0.901 0.000 403.55 0.00 250.2 0.0 Fabricated Densities (lbm/ft3) Rubble Densities (lbm/ft3) No. Module Fiber Metal Part. Ignore Fiber Metal Part. Ignore 55.6 0.5 2.4 0.5 277.6 0.5 2.4 · 0.5 1 Loopl Material Densities (lbm/ft3) Sp. Surface Areas (ft2/ft3) No. Module Fiber Metal Part. Ignore Fiber Metal Part. Ignore 0.5 1.7E+05 0.0E+00 1.7E+05 0.0E+00 0.5 277.6 1 Loopl 175.0 Mass Ratios Thickness (in) Head Loss (ft) Theo. Actual Metal Fib&Prt Metal Total No. Module M/F P/F 1 Loop1 0.00E+00 6.20E-01 4.04 4.89 0.00 1.2 0.0 1.2 Rev. Orig. Date Chkd. Date Client/Project: Vermont Yankee Nuclear Power Æ 8/6/98 8/6/98 1 Corporation Title: Vermont Yankee ECCS Suction Strainer Head Loss . . . Performance Assessment. RHR and CS Debris Head Loss Calculations.

 Project No.: <u>A346</u>

 Calc. No.: <u>DC-A34600.006</u>
 Sht. <u>84</u>

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DEBRIS VOLUME DISTRIBUTION DATA						Transport Completion: 1.0000						
No. 1	Type Nukon Group Group Group Group Group Group Group Group Group Group	ID NK 2 3 4 5 6 7 8 9 10 11 12	DW Tra (ft 209.0 0.4 0.1 0.1 0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0	N         Susj           an.         Point           23)         (fr           002         0.1           431         0.2           149         0.1           0431         0.2           0431         0.3           0430         0.1           0560         0.1           0544         0.1           0533         0.1           0544         0.1           0533         0.1           0518         0.1           013         0.2           010         0.1	pend 51 53) 500 849 112 033 5005 5000 5000 5000 5000 5000 5000	Po Co (ft3/ 1.37	ol nc. ft3) E-09	Settled Floor (ft3) 40.847 0.097 0.079 0.087 0.093 0.096 0.094 0.088 0.078 0.066 0.054 0.042 0.127	Retain System (ft3) 0.000 ***** ****** ****** ****** ****** *****	Deposited Strainer (ft3) 168.147 0.512 0.166 0.116 0.078 0.051 0.032 0.019 0.011 0.006 0.003 0.002 0.003		
2	Rust F Group	RF 1	0.1 1.0	154 0. 000 ****	000	0.00	E+00	0.142 1.000	0.000	0.012		
3	Dirt/D Group	DD 1	1.0	000 0. 000 1.	000 000	1.07	E-14	0.509 1.000	0.242 1.000	0.249 1.000		
4	Sludge Group Group Group Group Group Group Group Group Group	SD 1234 56789 10111 12	0.( ***** **** **** **** **** **** ****	000       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.         ***       0.	000 880 075 009 001 000 000 000 000 000 000	5.26	E-11	1.211 0.025 0.013 0.022 0.037 0.056 0.080 0.104 0.122 0.130 0.125 0.107. 0.180	0.529 0.339 0.072 0.080 0.086 0.088 0.088 0.084 0.075 0.061 0.045 0.031 0.019 0.018	0.640 0.450 0.090 0.095 0.095 0.086 0.071 0.051 0.032 0.017 0.008 0.004 0.002		
DEBF	RIS VOLUM	se ri	ATE DA	АТА			•					
No.	Туре	ID	ן דו	DW Su ran.	spenc Pool	aed 1	Settle Floor	a Re Sy	tain stem	Deposited Strainer		
Rev. 1	Orig. PYM	8/0	Date 6/98	Chkd. FS	8/	Date 6/98	Client Corpor Title: Perform	/Project: Tation Vermont Ya ance Assess	Vermont Y	ankee Nuclea Suction Straine and CS Debris J	ar Power r Head Los Head Loss	ss Calculations.
							Projec Calc. 1	t No.: <u>A3-</u> No.: <u>DC-A</u>	<u>46</u> 34600.00	<u>6</u> Sh	it. <u>85</u>	of 86



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1 2 3 4	Nukon Rust F Dirt/D Sludge	(1 NK 0.0 RF 0.0 DD 0.0 SD 0.0	ft3/s) DOE+00 0 DOE+00 0 DOE+00 0 DOE+00 0	(ft3/s) .00E+00 .00E+00 .00E+00 .00E+00	(ft3/s) (ft3/s) (ft3/s) 3.58E-09 0.00E+00 5.76E-08 0.00E+00 0.00E+00 0.00E+00 3.27E-13 5.59E-14 3.36E-13 1.34E-10 2.76E-10 1.65E-09
		SUMMAI	RY INFORMA	TION FOR W	WELD: VOLUME-1
He	ad Loss No. Moc 1 Loc	and NPSI iule I ppl	H Data (ft Max Head loss 1.54	-water) Minimum Pump 1 93.07	Fouled Strainer NPSH Margin Pump 2 93.07
Ti	mes When No. Moc 1 Loc	re Pump 1 dule opl	NPSH Margi	n Lost (se Pump 1 *******	ec) Pump 2 ******
				·	
					·
Rev.	Orig.	Date	Chkd.	Date	· · · · · · · · · · · · · · · · · · ·
1	pym	8/6/98	75	8/6/98	Client/Project:Vermont Yankee Nuclear Power Corporation
				1	Title: Vermont Yankee ECCS Suction Strainer Head Loss Performance Assessment, RHR and CS Debris Head Loss Calculations
<b></b>		1	1	1	Project No.: <u>A346</u>
					Calc. No.: <u>DC-A34600.006</u> Sht. <u>86</u> of 86

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