LOCA INDUCED DEBRIS CHARACTERISTICS FOR USE IN ECCS SUMP SCREEN DEBRIS BED PRESSURE DROP CALCULATIONS

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Abstract

Pressure drop calculations across a LOCA induced fibrous debris bed have been successfully demonstrated to be accurate using the NUREG/CR-6224 semi-theoretical head loss correlation. One of the critical parameters needed for the NURE/CR-6224 correlation to predict the pressure drop across a fibrous debris bed are the characteristics of the debris constituents (density and characteristic size). This paper provides a brief description of the NUREG/CR-6224 head loss correlation and presents suggested debris characteristics of typical sources of debris found in American nuclear power plants for use in the correlation.

Background

Following a hypothetical loss of coolant accident (LOCA) caused by a postulated pipe break in containment, nuclear power plants will inject water into the reactor vessel to control core temperatures via the emergency core cooling system (ECCS). For boiling water reactors (BWRs) the water from the suppression pool is used whereas for pressurised water reactors (PWRs) borated water from a storage tank is first introduced and when that water is exhausted, the ECSS recirculates the water from the containment pool. In both cases, some of the debris generated by the postulated break could be transported to either the suppression pool (BWRs) or the containment sump (PWRs). A screen is usually installed in the ECCS suction of the suppression pool or sump to ensure that LOCA induced debris will not by entrained and clog ECCS components such as containment spray nozzles. The LOCA induced debris transported to the suppression pool or containment sump could then form a debris bed on the ECCS suction screen. Some early investigation of the possibility of clogging the ECCS suction was performed in the early 1980s by the USNRC [1]. Since the Barsebäck incident in 1992 [2] the operators and regulators of nuclear power plants have become increasingly aware that a debris bed could be formed at the ECCS suction screen and cause potentially unacceptable pressure drops thereby challenging the post-LOCA operation of the ECCS. Several experiments have been conducted around the world [1, 2, 3, 4] with the aim of developing a correlation that could be used to predict the pressure drop (head loss) across a debris bed formed on the surface of the ECCS suction strainer or sump screen. In the USA the NUREG/CR-6224 head loss correlation developed by the USNRC for fibrous debris beds has been used to estimate the head loss in over 50% of the USA BWR strainers,[1] was used in the series of recently published NUREG/CR associated with Generic Issue 191 [6], and has been adopted by the industry for use in PWR sump screen performance assessments [7]. The NUREG/CR-6224 head loss correlation does not apply to debris bed formed by debris generated with the damage and destruction of reflective metallic insulation (RMI). RMI head loss correlations can be found in References 3, 4, and 9. This paper provides a brief description of the NUREG/CR-6224 fibrous head loss correlation and presents recommended values of debris characteristics to be use in estimating head loss across a debris bed when using the NUREG/CR-6224 correlation.

NUREG/CR-6224 head loss correlation

The NUREG/CR-6224 head loss correlation is described in detail in "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris", Appendix B [5] 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:

$$\Delta H = \Lambda \left[3.5 \; S_v^2 \; \alpha_m^{1.5} \; \left(1 + 57 \; \alpha_m^3\right) \; \mu \; U + 0.66 \; S_v \; \frac{\alpha_m}{1 - \alpha_m} \; \rho_w U^2 \right] \Delta \; L_m \tag{1}$$

1. The NUREG/CR-6224 was used to estimate the performance of the BWR ECCS stacked disk suction strainers developed by Performance Contracting Inc. installed as replacement strainers in US and Taiwanese BWRs.

where,

ΔH is the head loss,

S_v is the surface to volume ratio of the debris particle,

μ is the dynamic viscosity of water,

U is the approach velocity,

ρ is the density of water,

α_m is the mixed debris bed solidity,

ΔL_m is the mixed debris bed thickness, and

Λ is a unit conversion factor (Λ = 1 for SI units).

Each debris constituent has a surface-to-volume ratio associated with it based on the characteristic shape of that debris type. For typical debris types, we have

Cylindrically-shaped debris:

- fiber $S_v = 4/\text{diam}$
- lead-wool $S_v = 4/\text{diam}$

Spherically-shaped debris:

- sludge $S_v = 6/\text{diam}$
- dirt/dust $S_v = 6/\text{diam}$
- Cal-Sil $S_v = 6/\text{diam}$

Flakes (flat-plates):

- rust $S_v = 2/\text{thick}$
- paint chips $S_v = 2/\text{thick}$,

where "diam" is the diameter of the fiber or spherical particle, and "thick" is the thickness of the flake/chip. Other debris not listed above would have its surface-to-volume ratio calculated similarly based on one of the above characteristic shapes.

The mixed debris bed solidity is given by:

$$\alpha_m = \left(1 + \frac{\rho_f}{\rho_p}\eta\right)\alpha_o \frac{\Delta L_o}{\Delta L_m} \qquad (2)$$

where,

α_o is the as-fabricated fiber bed solidity,

ΔL_o is the theoretical (or as-fabricated) fibrous debris bed thickness,

$\eta = m_p/m_f$ is the particulate to fiber mass ratio in the debris bed,

ρ_f is the fiber density, and

ρ_p is the particulate material density.

For N_p classes of particulate materials, m_p and ρ_p are defined by:

$$m_p = \sum_{i=1}^{N_p} m_i \qquad (3)$$

and

$$\rho_p = \frac{\sum_{i=1}^{N_p} \rho_i V_i}{\sum_{i=1}^{N_p} V_i} \qquad (4)$$

where m_i , ρ_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 modelled. The 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):

$$c = 1.3\, c_o\, (\Delta H / \Delta L_o)0.38 \qquad (5)$$

where,

c is the compressed debris bed density (in lb/ft^3),

c_o is the as-fabricated insulation density (in lb/ft^3), and

$\Delta H/\Delta L_o$ is the head loss in ft-water per inch of insulation.

The compression is limited such that a maximum solidity, α_{max}, is not exceeded. In the NUREG/CR-6224 report, this maximum solidity is defined to be:

$$\alpha_{max} = 65\ lb/ft^3/\rho_p$$

which is equivalent to having a debris bed with a density of 65 lb/ft^3. Note that 65 lb/ft^3 is the macroscopic density of granular media such as sand, gravel or clay and is a reasonable value to use in case of iron oxide particles.

The NUREG/CR-6224 head loss correlation has been extensively validated for a variety of flow conditions and experimental facilities, types and quantities of fibrous insulation debris, and types and quantities of particulate matter debris. The test facilities include the Alden Research Laboratories (ARL) test loop [5], the Electric Power Research Institute (EPRI) facility, the five different experimental facilities used as part of the International Working Group (IWG) formed under the OECD Nuclear Energy Agency (NEA) [4], and the ARL chugging facility. The flow conditions have included approach velocities[2] from 0.06 ft/s (0.02 m/s) to 1.5 ft/s (0.5 m/s) and water temperatures from 50°F (10°C) to 130°F (55°C). The types of fibrous insulation material tested include NUKON™ and Temp-Mat®. The particulate matter debris tested includes iron oxide particles from 1 to 300 µm in characteristic size and paint chips. In all cases, the NUREG/CR-6224 head loss correlation results have bounded the experimental results.

The majority of these tests were performed with flat perforated plates [4]. Further, these tests involved a relatively uniform distribution of debris on the entire perforated plate. Consideration of a relatively uniform debris bed distribution on the strainers is appropriate and conservative. Furthermore, it can be shown [5] that assuming uniform distribution of debris results in higher head losses than for non-uniform distributions of debris.

In summary, the NUREG/CR-6224 head loss correlation is considered to be applicable to estimate the pressure drop due to mixtures of fibrous debris and particles. To implement this head loss algorithm for the estimating the head loss across a strainer or sump screen, the quantity and characteristics of the debris on each strainer and the temperature and velocity of the water flowing through the debris must be determined. Reference 8 is an example of the implementation of NUREG/CR-6224 by commercial organisation.

The few sections provide recommended debris characteristics for use in the NUREG/CR-6224 head loss correlation.

Debris characteristics

In a homogeneous debris bed, the densities and size characteristics of the individual constituents are necessary to determine the porosity of the debris bed. In general, the lower bound values for the characteristic sizes of the debris were adopted. This is conservative for head loss calculations because the specific surface is inversely proportional to the characteristic size of the debris particle. The smaller the characteristic size of the debris bed constituents the higher the pressure drop across the debris bed. The following tables provide a listing of the characteristics necessary for the head loss computations for debris originating from thermal insulation material, coatings, and miscellaneous debris.

Thermal insulation characteristics

Table 1 has characteristic values for thermal insulation materials which have been identified in American nuclear containments. Some are listed by trade names and others by generic names; some are listed as a system and some as simply an insulation material. The different types of mass insulation could be subdivided generically into fibrous, granular, and cellular insulation.

2. Approach velocity is defined is the total flow divided by the total screen area.

Fibrous insulation materials include fibrous glass wool such as Performance Contracting, Inc.'s NUKON®, Transco Products, Inc.'s Thermal Wrap®, preformed fiberglass pipe (made by Owens Corning, Knauf, and Johns Manville), and fiberglass pipe and tank wrap (from the same three manufacturers). The NRC refers to the insulation fillers in NUKON and Thermal Wrap as "Low Density Fiber Glass" (LDFG). There are also some glass fiber felt mat insulation materials and these include Temp-Mat® and Insulbatte® insulations, both made by JPS Corp., as well as some by other trade names such as Alpha Inc.'s AlphaMat®. Other fibrous materials include ceramic felt mat insulation, two of which are Thermal Ceramics Inc.'s Kaowool® and Cerawool®. Finally, there are mineral wool insulation products with a number of different trade names, forms, and densities. Major North American manufacturers are Rock Wool Manufacturing, Roxul, Fibrex, IIG, and Thermafiber. While mineral wool has been widely used in Europe in some nuclear containments and fibrous glass and glass fiber felt have not been widely used, mineral wool has limited use in North American nuclear containments. Mineral wool was the original drywell piping insulation, at the Barsebäck Plant, that was blown off by a lifted steam relief valve and which subsequently blocked a couple of ECCS strainers. In general, mineral wool in available in densities that are at least twice those of comparable fibrous glass wool insulations.

Granular insulation materials include calcium silicate and microporous. All the calcium silicate insulation in North America has been manufactured without the use of asbestos since about 1972. While it has been made by various manufacturers over the years, today all calcium silicate is manufactured by IIG, a joint venture between Calsilite Corp. and Johns-Manville Corp., at three factories. The only microporous insulation manufactured in North America is MinK®, manufactured by Thermal Ceramics, Inc. today but by Johns Manville for many years. Microtherm manufactured in the UK, is also available in North America.

The only cellular insulation on the above list is cellular glass. Most of what has been installed in US nuclear plants has been manufactured by Pittsburgh Corning Corporation and is known by its trade name, Foamglas®. This is an inorganic, rigid, and brittle cellular insulation typically used in containments on chilled water lines. However, for reference, there are numerous other types of cellular insulations available which are organic compounds; these include melamine, polystyrene, polyisocyanurate, phenolic, polyimide, polyolefin, flexible elastomeric, and polyurethane foams. There are numerous trade names by which these are known. The best known is Dow Chemical's Styrofoam, which is polystyrene foam insulation.

Failed coatings characteristics

Debris from failed coatings has been recognised as an important contributor to the particulate debris loading. Some of the earlier work in characterising coating debris can be found in [10]. The following types of coatings are commonly found within American PWR containments: inorganic zinc (IOZ), epoxy, epoxy phenolic and alkyd. Their characteristics for use in the NUREG/CR-6224 head loss correlation are shown in Table 2.

The specific gravity for IOZ is listed as 5.6. A specific gravity of 5.6 corresponds to a nominal density of 350 lbs/ft^3. This value is lower than the 437 lbs/ft^3 reported by carboline for the zinc dust used in the formulation of CarboZinc 11. As such, the nominal density value of 350 lbs/ft^3 is conservative since lower density values imply higher volumes and thus higher head losses.

Coatings within the ZOI will be ablated by the break jets. In the absence of specific experimental details about the debris particle size distribution for IOZ, alkyds, epoxy and epoxy phenolic coating debris generated by high pressure water/steam jets in the ZOI, a diameter of 10 µm has been selected as the characteristic size of coating debris generated within the ZOI. The 10 µm characteristic diameter is the nominal diameter of unbound zinc particles and also the alkyd pigment particles of failed coatings. Epoxy and epoxy phenolic coatings outside the ZOI will fail as chips. A typical lower bound for epoxy and epoxy phenolic coating chip thickness is 1 mil (25.4 µm). 10 µm diameters are shown as the characteristic size of IOZ and alkyd coating debris outside of the ZOI.

Table 1. Thermal insulation material characteristics

Debris name	Insulation material description	As-fabricated density (lbs/ft^3)	Material density (lbs/ft^3)	Characteristic size	
				µm	Inch
PCI's NUKON® blankets	Removable/reusable blankets with woven glass fiber cloth covering fibrous glass insulating board (referred to by the NRC as a "LDFG")	2.4	159	7.0 fiber diameter	28E-05
Fiberglass – preformed pipe	Knauf fibrous glass wool preformed into cylindrical shapes	4.0 +/- 10%	159	7.5 fiber diameter	30E-05
Fiberglass – preformed pipe	Owens Corning fibrous glass wool preformed into cylindrical shapes	3.5 to 5.5	159	8.25 fiber diameter	33E-03
Fiberglass – pipe and tank wrap	Fibrous glass wool wrap, using perpendicularly oriented fibers, adhered to an All Service Jacketing (ASJ) facing (made by Knauf, Owens Corning, & others)	3.0 +/- 10%	159	6.75 fiber diameter	27E-05
Transco's Thermal Wrap® Blankets	Removable/reusable blankets with woven glass fiber cloth covering fibrous glass insulant (Knauf ET Panel®) (referred to by the NRC as a "LDFG")	2.4	159	5.5 fiber diameter	22E-05
Temp-Mat® and Insulbatte®	Glass fibers needled into a felt mat; these are trade names of insulation products made by JPS Corp.	11.8	162	9.0 fiber diameter	36E-05 max.
Cellular Glass	Foamglas® is the trade name for this cellular glass product made by Pittsburgh Corning Corporation	6.1 to 9.8 (mean value of 7.5)	156	NA	0.05 to 0.08 pore size
Kaowool®	Needled insulation mat made from ceramic fibers; Kaowool is a trade name for a family of ceramic fiber products made by Thermal Ceramics, Inc.	3 to 12	160 to 161	2.7 to 3.0 fiber diameter	10.8 to 12.0E-05
Cerawool®	Needled insulation mat made from ceramic fibers; Cerawool is a trade name for a family of ceramic fiber products made by Thermal Ceramics, Inc.	3 to 12	156 to 158	3.2 to 3.5 fiber diameter	12.8 to 14.0E-05
Mineral Wool	Generic name for families of products made by Rock Wool Mfg., Roxul, Fibrex, IIG, and others	4, 6, 8, and 10 pcf are standard	90	5 to 7 fiber diameter	20 to 28 E-05
MinK®	Trade name of microporous insulation products made by Thermal Ceramics, Inc. from fumed silica, glass fibers, and quartz fibers	8 to 16 pcf	NA	< 0.1	< 4e-06
Calcium Silicate	Manufactured by IIG in three locations (2 use diatomaceous earth, 1 uses expanded perlite)	14.5	144	40 µm mean particle size (2 to 100 µm range)	1.60E-03

Table 2. Coating debris characteristics

Generic coating material	Material density (lbs/ft^3)	Characteristic size	
		µm	ft
Inorganic zinc (IOZ)	350	10[3]	3.28E-05
Epoxy and epoxy phenolic coating chip (outside ZOI)	94	25[4]	8.20E-05
Epoxy and epoxy phenolic coating particles (in ZOI)	94	10[2]	3.28E-05
Alkyd coating	98	10[2]	3.28E-05

Miscellaneous debris characteristics

Miscellaneous debris such as concrete debris, dust, dirt, other latent debris, rust, etc. all have to be considered if they are present inside the containment. Items such as equipment tags (paper or plastic) and things such as plastic sheeting or tarps also have to be evaluated. These latter ones are generally treated as a surface area reduction hence not included explicitly in the head loss calculations.

Rust flakes are considered as iron oxides with a microscopic density of 324 lb/ft^3. Rust flakes have the same similar appearance as thick paint chips. As such it is reasonable to adopt the same lower bound value of epoxy paint chip thickness for rust flakes thickness. Hence an equivalent thickness of 1 mil (25.4 µm) was adopted for the characteristic size of rust flakes in this calculation.

In the absence of specific information, a microscopic density of 156 lb/ft^3 is adopted for dirt/dust. Based on typical diameter of dust particles, a diameter of 10 µm was adopted.

Table 3. Miscellaneous debris characteristics

Debris material	Material density (lbs/ft^3)	Characteristic size	
		µm	ft
Rust	324[5]	25	8.2E-05
Dirt/Dust	156[6]	10	3.28E-05

3. Spherical Particle Diameter.
4. Flat Plate Thickness.
5. Flat Plate Thickness.
6. Spherical Particle Diameter.

REFERENCES

[1] Serkiz, A.W. "Containment Emergency Sump Performance", NUREG-0897, U.S. Nuclear Regulatory Commission, October 1985.

[2] NEA, (1996) "Knowledge Base for Emergency Core Cooling System Recirculation Reliability", NEA/CSNI/R(95)11, Prepared by the U.S. Nuclear Regulatory Commission for the Nuclear Energy Agency (NEA) of the OECD, February 1996.

[3] BWROG, "Utility Resolution Guidance for ECCS Suction Strainer Blockage", Boiling Water Owners' Group, NEDO-32686, Rev. 0, November 1996.

[4] Rao, D.V., *et al*. "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance", NUREG/CR-6808, Los Alamos National Laboratory, February 2003.

[5] Zigler, G., *et al.* "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris", US NRC Report NUREG/CR-6224, Science and Engineering Associates, October 1995.

[6] Rao, D.V., *et al*. "GSI-191 Technical Assessment: Parametric Evaluations for Pressurized Water Recirculation Sump Performance", NUREG/CR-6762, Vol. 1. Los Alamos National Laboratory, August 2002.

[7] Westinghouse Owner's Group/Nuclear Energy Institute, "PWR Containment Sump Evaluation Methodology", 30 October 2003.

[8] Mast, Peter K. and Francisco J. Souto "HLOSS 1.0: A Code for the Prediction of ECCS Strainer Head Loss", ITS/ITS-97-01, ITS Corporation, 16 May 1997.

[9] Zigler, G., *et al.* "Experimental Investigation of Head Loss and Sedimentation Characteristics of Reflective Metallic Insulation Debris", Science and Engineering Associates, Inc., Report No. SEA95-970-01-A:2, May 1996.

[10] Bostelman, Jan and Gil Zigler, "Failed Coating Debris Characterization", BWROG Containment Coating Committee, 10 July 1998.

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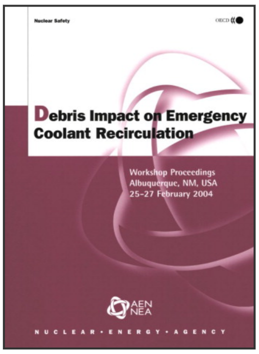

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