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Energy Systems

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AW-94-647

June 10, 1994

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. R. W. BORCHARDT

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: AP600 PASSIVE CONTAINMENT COOLING SYSTEM LETTER REPORTS

Dear Mr. Borchardt:

The application for withholding is submitted by Westinghouse Electric Corporation ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10CFR Section 2.790, Affidavit AW-94-647 accompanies this application for withholding setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-94-647 and should be addressed to the undersigned.

Very truly yours,

N. J. Liparulo, Manager
Nuclear Safety Regulatory And Licensing Activities

/nja

cc: Kevin Bohrer NRC 12H5

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Corporation ("Westinghouse") and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

Henry A. Sepp

Henry A. Sepp, Manager
Regulatory and Licensing Initiatives

Sworn to and subscribed
before me this 15 day
of June, 1994

Rose Marie Payne

Notary Public

Notarial Seal
Rose Marie Payne, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Nov. 4, 1996
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory and Licensing Initiatives, in the Nuclear Technology Division, of the Westinghouse Electric Corporation and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Energy Systems Business Unit.

(2) I am making this Affidavit in conformance with the provisions of 10CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Energy Systems Business Unit in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) Enclosed is Letter NTD-NRC-94-4166, June 10, 1994, being transmitted by Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, N. J. Liparulo (W), to Mr. R. W. Borchardt, Office of NRR. The proprietary information as submitted for use by Westinghouse Electric Corporation is in response to questions concerning the AP600 plant and the associated design certification application and is expected to be applicable in other licensee submittals in response to certain NRC requirements for justification of licensing advanced nuclear power plant designs.

This information is part of that which will enable Westinghouse to:

(a) Demonstrate the design and safety of the AP600 Passive Safety Systems.

(b) Establish applicable verification testing methods.

(c) Design Advanced Nuclear Power Plants that meet NRC requirements.

(d) Establish technical and licensing approaches for the AP600 that will ultimately result in a certified design.

(e) Assist customers in obtaining NRC approval for future plants.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for advanced plant licenses.

(b) Westinghouse can sell support and defense of the technology to its customers in the licensing process.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar advanced nuclear power designs and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing analytical methods and receiving NRC approval for those methods.

Further the deponent sayeth not.

Enclosure 2 to Westinghouse Letter NTD-NRC-94-4166

AP600 CONTAINMENT COOLING PLUME INVESTIGATION

Introduction

The purpose of this investigation is to assess meteorological conditions which could be postulated to degrade the performance of the AP600 containment passive cooling design, by causing recirculation of part of the effluent plume back into the shield building air inlets. The effects which need to be considered are temperature inversions and strong winds. The goal of this investigation is to identify existing studies which can be used to quantify recirculation for the AP600 design.

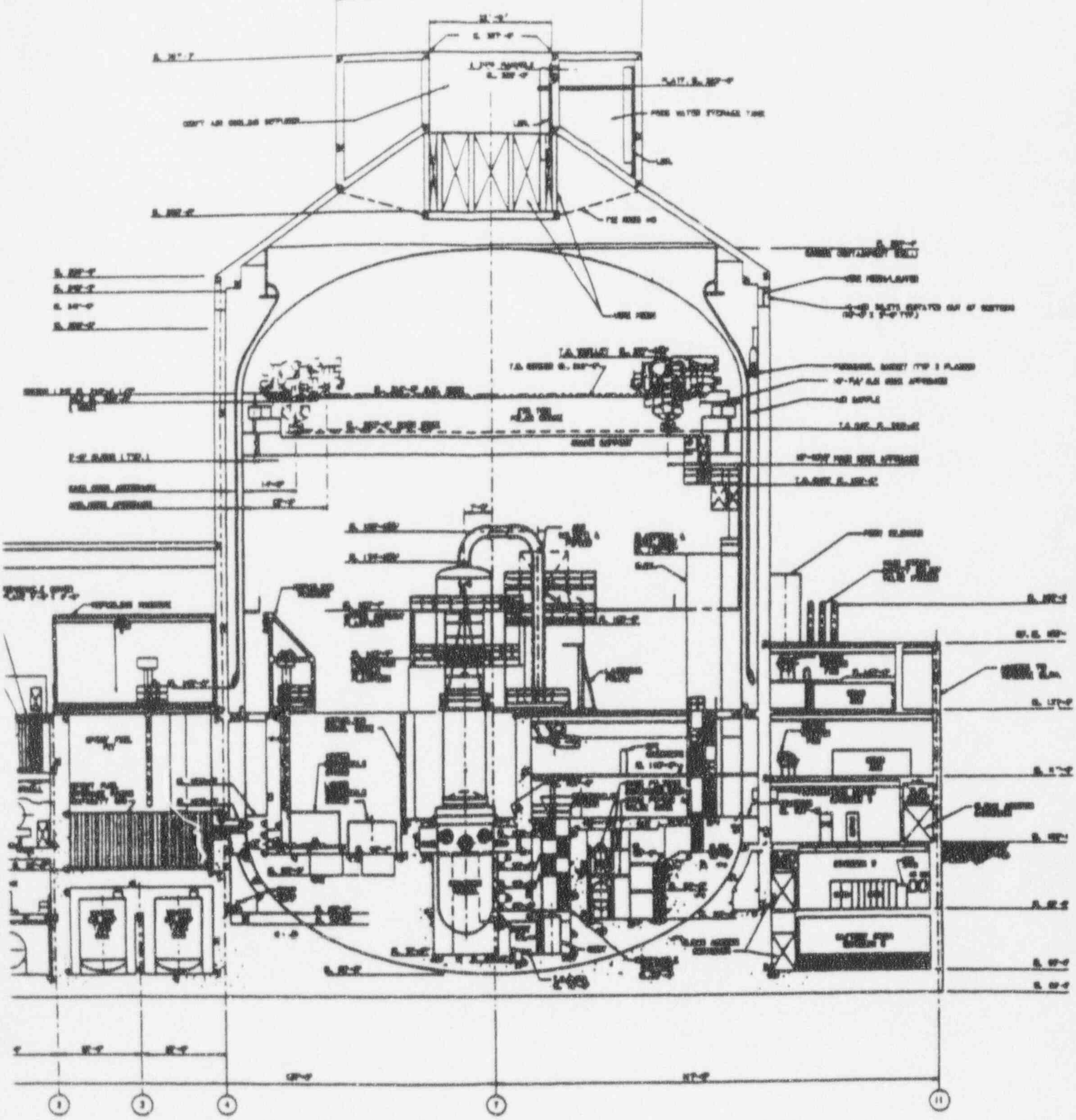
The passive containment cooling system uses the steel containment vessel as a heat transfer surface. The surrounding concrete shield building is used along with a baffle to direct air from the top-located air inlets down to the bottom of the containment and back up along the outside of the containment vessel. In addition, a water storage tank is supported by the shield building at an elevation sufficient to allow gravity drain of the water over the top of the steel containment vessel. The air and the evaporated water exhaust through an opening in the roof of the shield building and through a chimney-like structure. Figure 1 shows the containment structure.

Summary of Results

The literature reviewed examined many different mechanical and natural draft cooling tower and roof vent configurations, and discussed models for wind induced recirculation. Based on the investigation conducted, an upper limit for recirculation of the AP600 chimney effluent is [ ]^{a,c}. It is recommended that a more conservative value of [ ]^{a,c} be used for containment performance analyses to account for uncertainty. It was determined that inversions and/or stable atmospheric layers, in the absence of cross winds, do not induce the downward flow of effluent required for circulation. Consequently, the recirculation value determined for wind induced recirculation is sufficiently enveloping. These results are based on the assumption that the AP600 containment structure is not located in a downwind recirculation or wake area of another structure or land formation.

FIGURE 1

AP600 NUCLEAR ISLAND SECTION - CONTAINMENT



Reference: AP600 Standard Safety Analysis Report, Figure 1.2-12

Investigation

Many of the references discuss the formation of a recirculation cavity on the leeward side of a building or cooling tower during windy conditions. It is evident from the literature that certain wind speeds can cause some amount of plume recirculation, and this effect should be addressed.

For plume recirculation due to strong winds, the ratio of exit velocity to wind speed (or the inverse of this ratio) are commonly calculated to determine if tower downwash (the lowering of the plume due to tower effects) is expected and should be taken into account. These ratios are used primarily to identify the need to model downwash, and are not used in a way which can be directly correlated to plume recirculation. The following references indicate, in the parentheses, the tower exit velocity to wind speed ratio below which downwash has an effect; Reference 7 (1.30), Reference 8 (1.5), Reference 16 (1.3), Reference 2 (1.5), Reference 5 (1.5). References 11, 13, and 14 examined field data from cooling towers. Those references note that the outline of the plume and/or its centerline drop below the tower exit plane, but not necessarily right at the tower, when the wind speed exceeds the exit velocity by a factor of 1.5. For an exit velocity of 5 ft/sec (see discussion of exit conditions on page 6) this would correspond to a wind speed of 7.5 ft/sec, or approximately 5 mph. This confirms that plume recirculation due to strong winds needs to be addressed.

Two separate areas in the literature were examined for plume recirculation due to strong winds. One area was the analytical and experimental research to determine the extent of the recirculation cavity behind a natural draft cooling tower, and its effect on the plume. The second area was the literature which investigated recirculation problems for mechanical draft cooling towers. Reference 1 states that recirculation problems are typical for mechanical draft cooling towers, but almost non-existent for hyperbolic cooling towers because of the height of vapor discharge. The AP600 chimney outlet is about 60 feet above the air inlets, which is a much shorter distance than that of a large natural draft cooling tower (hundreds of feet), but it is greater than the distance for a typical mechanical draft cooling tower (10 to 20 feet).

<u>Natural draft cooling towers:</u> Reference 14 (Volume 2, section 4) presents isoconcentration figures from experiments modeling the characteristics of natural draft cooling towers. The figures represent a wide range of wind speeds. The figures indicate that plume concentrations near the tower may be diluted to 1 to 5%, however, the study focussed on the overall effects on the plume, not on a recirculation fraction. These same figures are also presented in Reference 13.

Reference 12 presents a series of isotherm curves from calculational results and experimental data. These curves are based on a normalized temperature difference which indicates the increase in the ambient air inlet temperature due to mixing with the plume. The normalized curves suggest a maximum normalized temperature increase of 10% for the recirculation area.

<u>Mechanical draft cooling towers:</u> Reference 6 discusses the results of investigations performed for mechanical draft cooling towers. It presents experimental results which show that recirculation can approach a maximum of 15%. Reference 6 defines recirculation as a ratio of temperature differences which measure the increase in the inlet temperature due to recirculation of the cooling tower exhaust. The literature typically defines recirculation as:

$R = (T_{in}-T_{\infty})/(T_{out}-T_{\infty})$,
where T_{in} is the mass average temperature of the inlet air,
T_{out} is the mass average temperature of the outlet air,
and T_{∞} is the ambient air temperature.

Reference 9 states that the cooling capacity for mechanical draft cooling towers can be reduced significantly due to recirculation. It also states that this problem is greater for mechanical draft cooling towers because of their relatively low-profile structure. Reference 4 uses a model of a typical power plant mechanical draft cooling tower for the purposes of defining a better testing technique for tower performance. In defining various conditions, Reference 4 examines a 12% recirculation which is described as "a worst case condition within normal test limits." Reference 1 presents a simple formula to estimate the amount of recirculation. The formula is for mechanical draft towers and is:

$R_c = (0.073 \times \text{tower length})/(1 + 0.004 \times \text{tower length})$,
where the tower length is the horizontal length of the tower,
and R_c is expressed as a percentage (Reference 1, Eq. 6.8)

The length of the tower is important because, in a strong wind, more of the plume is bent downward further from the tower exit. Applying this to the AP600 design, the tower length is assumed to be the diameter of the shield building at the inlet louvers, which is approximately 142 feet. Using 142 feet, R_c = 7%.

Reference 10 developed a mathematical model for predicting recirculation for mechanical draft cooling towers. Reference 10 reports that the amount of recirculation increases as the wind speed increases, but reaches a peak, then decreases as wind speed increases. Reference 10 cites three other studies which support this finding. Reference 6 also shows this trend. Simply explained, as the wind speed increases, the plume is bent more towards the recirculation cavity, but it is also more diluted before it becomes entrained in the cavity. At high enough wind speeds, the dilution effect is greater than the additional entrainment, and the percentage of recirculation decreases. Although Reference 10 did not attempt to define a maximum recirculation, for the range of wind speeds between 4 and 12 m/sec, the recirculation calculated was less than 3%.

EPRI Roof Vent Study: This study (Reference 2) was performed at the Duane Arnold Energy Center (DAEC). In a review of previous studies, Reference 2, Section 1, contains a summary discussion of a study at EBR-II. The study involved the release of a tracer from the downwind side of the EBR-II building complex. The release concentration was found to be proportional to the -.6 power of the distance. Applying this to the AP600 containment structure, the horizontal distance from the chimney centerline to the air inlet is 71 ft; $71^{-.6} = .077$. However, this predicts the average concentration, it was based on samples collected between 30 and 600 meters from the release point, and the meteorological conditions and the physical layout of the test are not discussed.

The experiments performed at DAEC used a gas tracer released from roof vents at DAEC. For the experiments performed, Reference 2, Section 5 states that a downwash correction factor for the plume rise of elevated releases was not used because of the conditions which existed during the testing at DAEC. This correction factor would have been applied for exit velocities less than 1.5 times the horizontal wind velocity, in accordance with Reference 5. Reference 2 did note that when plant intake vents are downwind of the release, a considerable entrainment of roof vent effluent into the plant is to be expected. The data from the turbine building vent releases resulted in the greatest concentrations at the intake vent, however, the turbine building vent had a mushroom cap. Thus, the release exit velocity was near zero. In addition, the location of the intake vent could not be determined from the information presented. It is concluded that relevant information to apply to recirculation estimates could not easily be obtained from the concentration data provided in Reference 2.

Temperature Inversions: The literature cited some discussion of temperature inversions and the combination of wind and temperature inversion occurring at the same time. References 1, 15, and 16 discuss the potential adverse effects of a low level temperature inversion. References 1, 15, and 16 all refer to adverse inversion conditions as having calm or light wind. Reference 3 contains data from cooling tower sites during various conditions including inversions. The discussions in Reference 3 cite plume bending as a wind induced effect, and the limit of plume rise as an inversion or atmospheric stability effect. In all of the inversion cases noted in Reference 3, plume rise did occur.

An inversion, by itself, does not induce the downflow necessary to recirculate chimney effluent. Based on containment conditions for limiting accidents, the exit temperature from the chimney is expected to peak around 160°F and level off around 130°F. The chimney air flow peaks at approximately 5 ft/sec and levels off at approximately 3 ft/sec. Using simplified plume rise equations from Reference 8, the approximate effluent steady state conditions result in plume rise above the shield building chimney for stable atmospheric conditions (inversions). The plume rise is sufficient to raise the plume, in light wind, above the recirculation zone of structures the size of those associated with AP600 design. Consequently, the maximum expected recirculation is the value determined in the recirculation cavity of the containment structure in a strong cross wind.

Conclusions

The literature reviewed examined many different mechanical and natural draft cooling tower and roof vent configurations, and discussed models for wind induced recirculation. The AP600 containment structure design had some similarities and many differences with all of them. Based on the investigation conducted, an upper limit for recirculation of the AP600 chimney effluent is [ ]^{a,c}. This value is [greater than that calculated using the simplified formula for mechanical draft cooling towers, it is in the range of that reported from experimental studies for mechanical draft towers, and it appears to be reasonable when compared to the isoconcentration/isotherm experimental and measured data presented in the literature for natural draft cooling towers]^{a,c}.

To account for the uncertainty in choosing a value for recirculation, it is recommended that a more conservative value of [ ]^{a,c} be used for containment performance analyses. As an example, using the equation $R = (T_{in}-T_{\infty})/(T_{out}-T_{\infty})$, with an ambient temperature of 115°F, an exit temperature of 160°F, and R = [ ]^{a,c}, the inlet temperature would be [ ]^{a,c}.

One approach to evaluate the recirculation is to use the above formula to determine the increase in inlet temperature relative to the AP600 SSAR bases. The humidity will also be greater and should be taken into account. Humidity increases were not discussed in the literature reviewed, the main focus was on the temperature increase. The new inlet conditions would be applied to all of the inlet vents because the literature defines the temperatures in the equations as mass average temperatures. If there is little circumferential flow around the inside of the shield building, then the realistic effect of the recirculation would be to increase the inlet conditions in one quadrant.

References:

1. Cooling Towers, N.P. Cheremisinoff, P.N. Cheremisinoff, 1983, Ann Arbor Science.

2. Building Effects on Effluent Dispersion from Roof Vents at Nuclear Power Plants, R. Thuillier, R. Mancuso, EPRI NP-1380, April 1980.

3. Evaluation of Mathematical Models for Characterizing Plume Behavior from Cooling Towers, A. Policastro et al, NUREG/CR-1581 (Vol. 1 & 3), Sept. 1980.

4. Accurate Performance Testing of Crossflow Cooling Towers, J. Reisman, J. Ovard, ASME publication 72-WA/PTC-5, 1972.

5. US NRC Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Revision 1, July 1977.

6. An Experimental Investigation of Recirculation and Interference on Modeled Forced-Draft Round Cooling Towers, G. Hitchman, P. Slawson, Journal of Eng. Gas Turbines, Power Trans. of the ASME, vol 109, n.1, Jan. 1987.

7. Fundamentals of Air Pollution, S. J. Williamson, Addison-Wesley, 1973.

8. Practical Guide to Atmospheric Dispersion Modeling (training manual), R.H. Shulze, Trinity Consultants Inc.

9. Investigation of Numerical Modeling Techniques for Recirculating Flows, Envirodyne Ltd (P. Slawson et al), EPRI Coal Combustion Sys. Div., EPRI CS n 1665, Feb., 1981.

10. Numerical Model of Cooling Tower Plume Recirculation, B. Becker et al, Mathematical and Computer Modelling, v. 12, n 7, 1989.

11. Prediction of Stack Plume Downwash, F. Tatom, Journal of Fluids Engineering, Trans. of the ASME v. 108 n. 3, p. 379, Sept. 1986.

12. Three-dimensional Numerical Calculations of Flow and Plume Spreading Past Cooling Towers, A. Demuren, W. Rodi, Journal of Heat Transfer, Trans. of the ASME, Series C, v. 109:1, Feb 1987.

13. An Improved Model for Natural and Mechanical-Draft Cooling Tower Plume Rise, R. Carhart et al, conference paper presented at International Assoc. of Hydraulic Research Cooling Tower Workshop, Sept 1980.

14. Studies on the Mathematical Models for Characterizing Plume and Drift Behavior From Cooling Towers, A. Policastro et al, EPRI-CS-1683 (exec. summary & Vol. 1- 5), April 1981.

15. Mapping Air Quality by Laser, R. Whitaker, EPRI Journal, July/August 1981.

16. Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, M. Smith, ASME Committee on Air Pollution Controls, 1968.

Enclosure 1 to Westinghouse Letter NTD-NRC-94-4166