**PHILADELPHIA ELECTRIC COMPANY**
2301 MARKET STREET
P.O. BOX 8699
PHILADELPHIA, PA 19101
(215) 841-4502

JOHN S. KEMPER
VICE-PRESIDENT
ENGINEERING AND RESEARCH

June 4, 1984

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Limerick Generating Station, Units 1&2 Demister in the Standby Gas Treatment System

References:
1) PECO and NRC Conference Call dated April 13, 1984.
2) J. S. Kemper to A. Schwencer letter dated April 13, 1984.

File: GOVT 1-1 (NRC)

Dear Mr. Schwencer:

This letter responds to a request made by the Effluent Treatment Branch Reviewer in the reference 1) conference call.

The attached calculation summaries provide the technical justification for why water droplets will not reach the SGTS filters. They also provide information on the size of water droplets which would be evaporated by the SGTS heaters.

The response to RAI 460.23 transmitted in reference letter 2) has been revised to incorporate the technical conclusions reached and documented in the calculation summaries. The attached revised draft response to RAI 460.23 will be incorporated into the FSAR, exactly as it appears on the attachment, in the revision scheduled for July 1984. The calculation summaries will not be incorporated into the FSAR.

Sincerely,

JW Gallagher
for
JS Kemper

8406080112 840604
PDR ADOCK 05000352
A PDR

RJS/gra/052984435

cc: See Attached Service List

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1/1

cc: Judge Lawrence Brenner (w/enclosure)
Judge Richard F. Cole (w/enclosure)
Troy B. Conner, Jr., Esq. (w/enclosure)
Ann P. Hodgdon, Esq. (w/enclosure)
Mr. Frank R. Romano (w/enclosure)
Mr. Robert L. Anthony (w/enclosure)
Charles W. Elliot, Esq. (w/enclosure)
Zori G. Ferkin, Esq. (w/enclosure)
Mr. Thomas Gerusky (w/enclosure)
Director, Penna. Emergency Management Agency (w/enclosure)
Angus R. Love, Esq. (w/enclosure)
David Wersan, Esq. (w/enclosure)
Robert J. Sugarman, Esq. (w/enclosure)
Spence W. Perry, Esq. (w/enclosure)
Jay M. Gutierrez, Esq. (w/enclosure)
Atomic Safety & Licensing Appeal Board (w/enclosure)
Atomic Safety & Licensing Board Panel (w/enclosure)
Docket & Service Section (w/enclosure)
Martha W. Bush, Esq. (w/enclosure)
Mr. James Wiggins (w/enclosure)
Mr. Timothy R. S. Campbell (w/enclosure)
Ms. Phyllis Zitzer (w/enclosure)
Judge Peter A. Morris (w/enclosure)

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## Response 460.23

A demister is not required for the SGTS filters. The absence of water droplets in the air stream entering the SGTS filters during post-LOCA isolation, refueling area isolation and primary containment purging is assured based on the following:

- The SGTS intake is downstream of the RERS filters so that entrained water droplets cannot exist in the air stream entering the SGTS filters during post-LOCA reactor enclosure isolation and drawdown. The absence of water droplets in the RERS air stream during reactor enclosure isolation was demonstrated in the response to NRC Question 460.4.

- There are no sources of water droplets in the refueling area which could enter the duct connection to SGTS. As discussed below, water droplets from condensation will not reach the SGTS filters during refueling area isolation because of the tortuous flow path and low velocities through the ducts, and low point drains in the ducts. The duct from the refueling area to the SGTS filters passes through the Unit 1 reactor enclosure for approximately 260 feet and includes at least 20 bends and turns. If condensation does occur, the amount of condensation would be minor, based upon the potential amount of water vapor in the air stream. One inch diameter low point drains are provided for the portion of ductwork in the reactor enclosure to ensure that any condensation will be drained from the duct. When refueling area drawdown begins, the flowrate could reach 3000 cfm for a short period of time. As water vapor accumulates in the refueling area, the flowrate will be decreasing. During the period when any significant condensation could occur in the ducts, the flowrate in the duct will be no more than 800 cfm. The air velocity during this period varies from approximately 162 to 325 feet per minute (1.8-3.7 mph) for the majority of the ductwork.

  The ductwork in the control enclosure that leads to the SGTS filters is completely insulated and rises immediately more than 15 feet through one vertical upward 90 degree turn, one additional 90 degree turn and three bends. The refueling area exhaust air velocity is 162 fpm (1.8 mph) in this portion of the duct. This velocity is not sufficient to overcome the force of gravity to impart a vertical upward velocity to any water droplets. Condensation of water vapor in the insulated ductwork will be negligible.

  The safety-related SGTS heaters are capable of reducing the relative humidity (RH) of the air, (3000 cfm maximum for this mode), from 100 percent RH to less than 70 percent RH.

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- Water droplets will not reach the SGTS filters during primary containment purging because of the reasons discussed below.

It is highly unlikely that water droplets will enter the purge lines during primary containment purging. As discussed in the response to question 460.5, the PECo preventative maintenance program will maintain normal plant leaks to low flow dripping type leakages. Any leakage with spraying water droplets, (such as those due to failed seals in pumps and valves), will be identified and corrected as part of the maintenance program. As discussed in the response to question 460.5, it can be shown that any droplets formed travel less than 20 feet. There are no potential sources of water droplets within 20 feet of the suppression chamber purge exhaust opening. There are no pumps, and only a few valves, within 20 feet of the drywell purge exhaust opening. The closest valve is 8 feet away from the opening. Because the purge system is used only a limited period of power operation (typically less than 90 hours per year), it is highly unlikely that a valve seal would fail and spray water into the drywell purge exhaust opening during purge system operation.

If water droplets are hypothetically assumed to enter the purge exhaust ducts, or if condensation within the ductwork occurs, the water droplets would not reach the SGTS filters because of the tortuous flow path, the insulated ductwork in the control structure, and the SGTS heaters. Purge air exhausted from the drywell flows approximately 215 feet in the reactor enclosure through three valves, two vertical upward turns and four additional bends and turns with a flow rate of 11,000 cfm at a velocity of 2240 fpm (25.5 mph) in the duct, and 3731 fpm in the pipe. The purge air from the suppression chamber flows more than 160 feet in the reactor enclosure through valves and six bends and turns with a flow rate of 9750 cfm and a velocity of 1986 fpm (22.6 mph) in the duct, and 6008 fpm in the pipe. At these velocities, if condensation occurs within the ductwork, it is possible for some water droplets to be entrained in the air stream. Condensation within the reactor enclosure ductwork could occur while purging the suppression chamber, but no significant condensation would occur while purging the drywell because the drywell is maintained at a low relative humidity by the drywell coolers. No significant condensation would occur in the control enclosure ductwork for either purge mode because it is insulated.

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The environmental conditions within the reactor enclosure ductwork will be such that only surface type condensation could occur. Droplets will coalesce on the inside surface of the duct creating larger doplets, forming condensate flow on the bottom of the duct. Much of this flow will drain to low points in the ductwork and be removed via drains, and therefore never enters the air stream. Much of the condensate which does become entrained in the airstream is subsequently removed from the airstream due to the many bends and turns in the duct. Water droplets greater than 20 microns in size are removed by the bends and turns, including a square elbow with turning vanes, which act like course moisture separators. (See page 64 of the "Nuclear Air Cleaning Handbook," ERDA 76-21). Water droplets less than 20 microns in size may reach the SGTS heaters. However, analyses have been performed which demonstrate that the SGTS heaters can evaporate all water droplets less than 25 microns in size. Thus, no water droplets will reach the SGTS filters.

The effects of water droplets on the SGTS HEPA filters were evaluated, even though there is no credible way for water droplets to reach the HEPA filters. (Effects on the charcoal filters were not evaluated because the HEPA filters are upstream of the charcoal filters, and would collect any water droplets postulated to be in the airstream). When HEPA filters are exposed to high concentrations of liquid, plugging could occur which would decrease airflow through them. Decreased efficiency in collecting particulate matter would not occur unless plugging is severe enough to rupture the HEPA filter. Based on page 65 of the "Nuclear Air Cleaning Handbook" by ERDA, (ERDA 76-21), if the maximum water delivery rate is kept below 0.18 gpm per 1000 cfm of airflow, plugging will not occur. Analyses have been performed which demonstrate that even if all of the condensation that forms in the duct during the worst case condition of suppression pool purging is hypothetically assumed to reach the HEPA filters in the form of water droplets, the condensate loading is only $8.33 \times 10^{-3}$ gpm/1000 cfm, which is well below 0.18 gpm/1000 cfm. Thus, plugging of the filters would not occur.

Analyses were performed to demonstrate that the SGTS heaters are capable of reducing the relative humidity of the air during suppression pool purging (9750 CFM for this mode) from 100 percent RH, with entrained droplets, to less than 70 percent RH, with no entrained droplets. The SGTS heaters are also capable of reducing the relative humidity of the air during drywell purging (11,000 CFM for this mode), from 100 percent RH to less than 70 percent RH.

# CONDITIONS OF AIR ENTERING SGTS FILTERS

## - CALCULATION SUMMARY-

Purpose:

The purpose of this calculation is to determine air conditions entering the SGTS filters during suppression-pool purge, and the effect on SGTS filter performance from any entrained water droplets.

Method of Calculation:

The calculation consists of the following two parts.

1. Determination of the relative humidity of the air entering the SGTS filters.
2. Determination of the quantity of condensation in the form of water droplets that could reach the filters.

## Part 1 - Relative Humidity

This part of the calculation is based on the heat balance for the moist air stream, i.e. that "the heat transferred through the duct is equal to the heat-loss of moist air".

Heat transferred through duct = $A_D U_D \left[\frac{t_i+t_o}{2} - t_a\right]$

Heat loss of air = $M\,(h_i-h_o)$

also $h = .24t + w\,(1061+ .444t)$ where,

$A_D$ = Surface Area of Duct, $ft^2$

$U_D$ = Overall heat transmission coefficient, Btu/h, °F, $ft^2$

$t_i$ = Temperature of entering air, °F (saturated)

$t_o$ = Temperature of air leaving the duct, °F (also saturated)

$t_a$ = Ambient air temperature, °F

$M$ = Weight of saturated air in duct, lbs/hr

$h_i$ = Enthalpy of entering air, Btu/lb

$h_o$ = Enthalpy of leaving air, Btu/lb

h = Enthalpy of air at dry bulb temperature t
and humidity ratio W

The heat balance equation is solved by trial and error. First, a leaving air temperature t is assumed. Next, humidity ratio W at this temperature and 100% saturation is calculated. Then enthalpy h is calculated and values of temperature t and enthalpy h are substituted in the heat balance equation and evaluated. This process is repeated until a reasonable balance is obtained. With the known heater capacity, the conditions of air leaving the heater and entering the filters are calculated.

## Part 2 - Quantity of Condensation

The total quantity of condensation formed in the SGTS duct is calculated by the difference of the humidity ratios of entering and leaving conditions times the flow rate.

In order to determine how much of the total condensation could be entrained in the airstream and travel to the SGTS filters, the type of condensation is evaluated.

Moist air exhausted from the suppression pool is conservatively assumed to be 100°F DB and have a relative humidity of 100%. The inside surface temperature of the uninsulated duct is approximately equal to the ambient temperature, which is conservatively assumed to be at 65°F. To form fog type condensation, a supersaturated condition must exist. This condition is determined by computing the ratio of the vapor pressure of moist air to the vapor pressure at the duct surface temperature. If this ratio is equal to or larger than 3.5 a supersaturated condition will exist and fog type condensation will be formed. Otherwise, only surface condensation will take place. Refer to the "Theory of Fog Condensation" by A.G. AMIELIN, translated to English by the ISRAELI PROGRAM FOR SCIENTIFIC TRANSLATIONS, JERUSALEM 1967.

The conditions stated above produce a ratio of 3.1. Therefore, only surface type condensation is expected. Droplets will coalesce on the inside surface of the duct creating larger droplets, forming condensate flow on the bottom of the duct. Much of this flow will drain to low points in the ductwork and be removed via drains. About 50 percent of the condensate is estimated to be removed from the ducts in this manner, and therefore never enters the air stream. Much of the condensate which does become entrained in the airstream is subsequently removed from the airstream due to the many bends and turns in the duct. Water droplets greater than 20 microns in size are removed by the bends and turns, including a square elbow with turning vanes, which act like coarse moisture separators. (See page 64 of the "Nuclear Air Cleaning Handbook," ERDA 76-21). Water droplets less than 20 microns in size may reach the SGTS heaters.

A separate calculation was performed to determine what size of droplets would be evaporated by the SGTS heaters. See the "Calculation Summary of Water Droplet Size Evaporated by the SGTS Heaters". It was conservatively calculated that the SGTS heaters would evaporate water droplets which are less than 25 microns in size. Thus, no water droplets will reach the SGTS filters.

The effects of water droplets on the SGTS HEPA filters were evaluated, even though there is no credible way for water droplets to reach the HEPA filters. (Effects on the charcoal filters were not evaluated because the HEPA filters are upstream of the charcoal filters, and would collect any water droplets postulated to be in the airstream).

When HEPA filters are exposed to high concentrations of liquid, plugging could occur which would decrease airflow through them. Decreased efficiency in collecting particulate matter would not occur unless plugging is severe enough to rupture the HEPA filter. Based on page 65 of the "Nuclear Air Cleaning Handbook" by ERDA, (ERDA 76-21), if the maximum water delivery rate is kept below 0.18 gpm per 1000 cfm of airflow, plugging will not occur.

Results/Conclusion:

1. Starting with 100°F, 100% saturated air and a 55 KW electric heater, the relative humidity of air entering the SGTS filters has been calculated to be 65%.

2. Because of the bends and turns in the SGTS duct, and the SGTS heaters, no water droplets will reach the SGTS filters. However, even if all of the condensation that forms in the duct is hypothetically assumed to reach the HEPA filters in the form of water droplets, plugging of the filters would not occur. The basis for this conclusion is that the condensate loading for this hypothetical case is 8.33x10-3 gpm/1000 cfm, which is well below 0.18 gpm/1000 cfm.

# WATER DROPLET SIZE EVAPORATED BY THE SGTS HEATERS

## - CALCULATION SUMMARY-

Purpose:

The purpose of this calculation is to determine what size of water droplets in the SGTS duct air-stream would be evaporated by the SGTS heaters.

Method of Calculation:

The method of calculation is based on the heat balance of a water droplet. That is, the heat of evaporation of the water droplet is equal to the heat transferred to it.

Radiative, convective, and conductive heat transfer is accounted for in the calculation. Heat transfer occurs in three sections; first, in the upstream duct where droplets can see the heating element; second, the heater; third, in the down-stream duct. At three feet downstream of the heater, the duct size starts increasing up to a size equal to the SGTS HEPA filter size. The velocity of the air decreases in this expansion section of duct, which is accounted for in the calculation.

The following equations are used in the calculation:

<u>Heat Balance on Droplet</u>

$\dot{E}_D = \dot{Q}_{rad} + \dot{Q}_{cc} - \dot{M}h_g$

$E_D = M_D C_v (T_D - 32)$

$T_D = E_D / M_o C_v + 32$

$E_D(0) = M_o U_f (T_D(0))$

$A_D = A_D(t) = \pi D^2(t)$

$M_o = \rho_f (T_D(0)) \pi D_o^3/6$

$E_D = E_o + \dot{E} \Delta t$

$\dot{Q}_{rad} = f_s A_D(t) \sigma (T_{H_{abs}}^4 - T_{D_{abs}}^4)$ radiative heat transfer

$$\left.\begin{aligned} f_s &= D_H^{\,2}/(4(X_1-X)^2+D_H^{\,2}), && 0\leq X<X_1 \\ &= 1 &&, X_1\leq X\leq X_2 \\ &= D_H/(4(X-X_2)^2+D_H^2), && X>X_2 \end{aligned}\right\}\ \text{Shape Factor}$$

$$D_H = \sqrt{4A_H/\pi}$$

$$\dot{Q}_{cc} = h_{cc}\, A_D\, (T_A(x) - T_D(t))$$ convective & conductive heat transfer

$$A_D = \pi\, D^2(t)$$

$$D(t) = \sqrt[3]{\frac{M_D(t)\ 6}{\rho_f(T_D)\,\pi}}$$

$$h_{cc} = Nu\ k/D$$

$$Nu = 2.0 + 0.6\ Pr^{1/3}\ Gr^{1/4}$$ (Ranz and Marshall Correlation)

$$Pr = C_p\mu/k$$ Prandtl No. ($Pr = 0.89$) const.

$$Gr = D^3(t)\rho^2 g\beta\Delta T/\mu^2$$ Grashof No. $Gr$ = variable

Mass Transfer

$$\dot{m} = (\dot{Q}_{cc} + \dot{Q}_{rad})/h_{fg}(T_D(t))$$

Velocity in Expansion Section

$$VA = \text{const.} = V_1A_H$$

for $X>X_3$

$$V(X) = V_1A_H/A(X)$$

$$A(X) = A_H + (A_2-A_H)(X-X_3)/(X_{max}-X_3)$$

$$V(X) = V_1/[(1+(A_2/A_H-1)\ (X-X_3)/(X_{max}-X_3))]$$

The symbols used in the equations are defined as follows:

$\dot{E}_D$ = Energy Rate of Droplet
$\dot{Q}_{rad}$ = Radiative Heat Transfer
$\dot{Q}_{cc}$ = Convective and Conductive Heat Transfer
$\dot{m}$ = Evaporated Mass of Droplet
$M_D$ = Mass of Droplet
$h_g$ = Enthalpy of gas
$C_v$ = Specific Heat at Constant Volume
$T_D$ = Temperature of Droplet
$U_f$ = Internal Energy
$A_D$ = Area of Droplet
$t$ = Time
$D$ = Droplet Diameter
$\rho_f$ = Specific Weight of Water
$f_s$ = Shape Factor
$\sigma$ = Stefan - Boltzmann Constant
$T_H$ = Heater Element Temperature
$X$ = Distance of Droplet at time t
$X_1$ = Distance to Heater Inlet
$X_2$ = Distance to Heater Outlet
$X_3$ = Distance to Start of Transition
$X_{max}$ = Distance to HEPA Filter
$D_H$ = Equivalent Heater Diameter
$h_{cc}$ = Convective and Conductive Heat Transfer Coefficient
$T_A$ = Air Temperature
$K$ = Conductivity
$C_p$ = Specific Heat at Constant Pressure
$\mu$ = Viscosity
$\rho$ = Density of Air
$g$ = Acceleration of Gravity
$\beta$ = Coefficient of Expansion
$h_{fg}$ = Enthalpy of fluid and gas
$V$ = Air Velocity
$A_H$ = Cross Sectional Area of Heater
$A_2$ = HEPA Filter Face Area
$\dot{M}_A$ = Air Flowrate
$\Delta T_A$ = Change in Air Temperature Through Heater

The following input data was used.

$T_D(0)$ = 100°F
$T_A(0)$ = 100°F
$RH(0)$ = 100%
$\dot{M}_A$ = 9750 cfm
$\Delta T_A$ = 15°F
$T_H$ = 550°F
$A_H$ = 4.88 $ft^2$
$A_2$ = 78.08 $ft^2$
$X_1$ = 8 ft
$X_2$ = 9 ft
$X_3$ = 12 ft
$X_{max}$ = 20 ft

Conclusion:

With the above input data, a water droplet size of 25 microns in diameter has been conservatively calculated. Thus, all water droplets equal to or less than 25 microns in size will be evaporated by the SGTS heater.

The "Calculation Summary of Conditions of Air Entering SGTS Filters" concludes that no water droplets greater than 20 microns in size will reach the SGTS heaters. Therefore, no water droplets will reach the SGTS filters.