Subject Code 004	**SOUTH CAROLINA ELECTRIC AND GAS COMPANY CALCULATION RECORD**			Page 1 of 38
Calculation Title: Post LOCA Sump pH Effect From Miscellaneous Sources	Calculation Number: DC00040-110		Revision: 0	Status
Parent Document: ECR 71072	System: NA	Safety Class: ☐ NN ☐ QR ☒ SR	☐Partial Calc. Revision ☒Complete Calc. Revision	
Originator: M. Waselus	Discipline: AE	Organization: WorleyParsons	Date: 10/22/2009	XREF Number: NA

CALCULATION INFORMATION

Content Description: The purpose of this calculation is to evaluate the effects of the sources listed in NUREG/CR-5950 on the post LOCA sump pH to assure the sump pH is maintained above a value of 7. Maintaining the sump pH greater than 7.0 post-LOCA precludes the need to consider iodine reevolution from the sump during the LOCA in calculating the potential offsite and control room radiological consequences.

Affected Components/Calculations/Documents:
NA

Piping Reconciliation Completed per QA-CAR-0089-18: ☐This Revision ☐ Previous Revision ☒ N/A

Contains Preliminary Data/Assumptions: ☒ No ☐ Yes, Affected Pages: ________________

Computer Program Used: ☒ No
- ☐ Yes, Validated per ______________________ computer program validation process (others)
  vendors name
- ☐ Yes, Validated in accordance with SAP-1040/ES-413 (ref. 3.4 & 3.5)
- ☐ Yes, Validated [ES-0412]
- ☐ Computer Program Validation Calculation

VERIFICATION ☐ Continued, Attachment

Scope: The scope of this review/verification is to confirm that the calculation is complete and accurate and in accordance with ES-412 requirements.

Verifier: P. Bunker
Assigned by: E. Toll [signature] for Ed Toll

[signature] 10-22-2009
Engineering Personnel /Date

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Owner's Acceptance Review
[signature] 11-25-2009
Responsible Engineer/Date
Required for all engineering work performed by contractor personnel not enrolled in the VCSNS Engineering Training Program

A

[signature] 11/25/09
Approval/Date

RECORDS

To Records Mgmt: ________________
Initials/Date

Distribution: Calc File (Original))

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Revision Number.	Summary Description
0	Initial Issue

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1.0 PURPOSE

The purpose of this calculation is to evaluate the effects of the sources listed below on the post LOCA sump pH to assure the sump pH is maintained above a value of 7 (Reference 1). Maintaining the sump pH greater than 7.0 post-LOCA precludes the need to consider iodine reevolution from the sump during the LOCA in calculating the potential offsite and control room radiological consequences. This calculation is based on the methodology provided in NUREG/CR-5950 (Reference 2), NUREG-1081 (Reference 3) and NUREG/CR-5732 (Reference 4). This calculation supplements calculation DC00040-066 (Reference 5) which determines a conservative (with respect to reevolution of iodine) post LOCA pH exclusive of the additional sources addressed herein. Per NUREG/CR-5950 there are a variety of acids and bases produced in containment during a LOCA. These include the following:

- Boric acid is a weak acid and will enter containment from accumulators, refueling water storage tanks, sprays, and the reactor coolant system (RCS).
- Hydriodic Acid (HI) is a strong acid introduced into containment with the release of iodine.
- Carbon Dioxide (CO_2) which depresses the pH of water by being absorbed in water from air to form carbonic acid. Carbonic acid is a weak acid the effects of which are insignificant relative to the other acids produced during the LOCA.
- Nitric acid (HNO_3) is a strong acid produced by the irradiation of water and air.
- Hydrochloric acid (HCl) is a strong acid produced by the radiolysis or pyrolysis of chlorine bearing materials during the accident. Per section 2.2.5.3 of NUREG/CR-5950, pyrolysis occurs at temperatures around 752 ^oF which is well above the post LOCA temperatures (maximum containment temperature < 330 ^oF). Therefore, only radiolysis is considered in this analysis.
- Sodium Hydroxide (NaOH) is a strong base introduced as the primary buffer into containment via the reactor building sprays.
- Cesium Hydroxide (CsOH) is a strong base introduced into containment with the release of cesium during the accident.
- Core-Concrete Aerosols are basic materials released from the interaction of the molten core materials with concrete. Consistent with the course of the postulated accident, core damage is assumed to be terminated after the in-vessel release phase and these chemicals are not considered any further herein.

2.0 COMPUTER CODE

No software other than Microsoft EXCEL was used in this calculation. EXCEL was used for numerical manipulation.

3.0 ASSUMPTIONS

The following assumptions are used in this analysis:

- The beta dose to cables is reduced by a factor of 2 due to localized shielding effects.
- The gaseous HCl produced by cable radiolysis will be conservatively assumed to be instantly dissolved in the sump.
- The sump is taken as well mixed by action of the ECCS systems such that a single pH value can be applied to the entire sump.

4.0 DESIGN INPUT

The following design input data is used in this analysis:

1. Minimum sump pH per DC00040-066 = 7.5. Section 4.0 [page 20] DC00040-066 provides a brief description of the operating conditions for the 4 cases. In all cases, the pH is ≥ 7.5. The pH ranges from a low of 7.5 in the sump at the end of the injection phase to a high of 8.8 during the injection phase, and is 8.0 at sump equilibrium after the SHST is empty.
2. Weight percent of chlorine for the various cable insulations (Attachment 1).
3. Post LOCA Gamma and Beta dose rate profiles and integrated doses in the reactor building atmosphere and sump are taken from the Equipment Qualification database. In accordance with USNRC RG 1.183, section 1.3.5 and SECY-98-154, the TID-14844 Equipment Qualification dose rates previously calculated in the containment air and sump (beta and gamma) bound those generated by AST. The reactor building EQ zones are shown on Reference 9. The 30 day reactor building doses are taken References 9 and 10.

RB Doses @ T = 30 days	Dose (Rad)	Dose (Mrad)
Airborne gamma	2.2+07	22
Airborne beta	1.4+08	140

4. Conservative values for the core inventory of cesium and core inventory of iodine in gram moles. These inventories include the stable Cs-133 and I-127 species. The values are provided via References 8 and 13 and reproduced below.

Nuclide	Inventory (grams)	Inventory (gram atoms)	Nuclide	Inventory (grams)	Inventory (gram atoms)
I-127	3.71E+03	2.92E+01	Cs-133	8.39E+04	6.31E+02
I-128	2.52E-02	1.97E-04	Cs-134	1.87E+04	1.40E+02
I-129	1.53E+04	1.19E+02	Cs-134m	8.52E-01	6.35E-03
I-130	1.27E+00	9.77E-03	Cs-135	3.19E+04	2.36E+02
I-130m	1.10E-02	8.45E-05	Cs-135m	2.18E-03	1.61E-05
I-131	6.63E+02	5.06E+00	Cs-136	9.08E+01	6.68E-01
I-132	1.15E+01	8.71E-02	Cs-137	1.08E+05	7.89E+02
I-133	1.47E+02	1.11E+00	Cs-138	3.33E+00	2.42E-02
I-133m	6.19E-04	4.65E-06	Cs-138m	1.70E-02	1.23E-04
I-134	6.70E+00	5.00E-02	Cs-139	9.61E-01	6.91E-03
I-134m	4.99E-02	3.72E-04	Cs-140	1.01E-01	7.19E-04
I-135	4.37E+01	3.24E-01	Cs-141	2.88E-02	2.04E-04
I-136	6.81E-02	5.01E-04	Cs-142	1.14E-03	8.02E-06
I-136m	2.44E-02	1.79E-04	Cs-143	5.63E-04	3.96E-06
I-137	1.99E-02	1.45E-04	Cs-144	9.54E-05	6.65E-07
I-138	2.58E-03	1.87E-05	Cs-145	1.43E-05	9.83E-08
I-139	4.45E-04	3.20E-06	Cs-146	7.29E-07	4.99E-09
I-140	4.63E-05	3.31E-07	Cs-147	4.71E-07	3.20E-09
I-141	3.74E-06	2.65E-08	Cs-148	1.15E-08	7.80E-11
I-142	3.10E-07	2.19E-09	Cs-149	0.00E+00	0.00E+00
I-143	3.70E-08	2.59E-10	Cs-150	7.14E-12	4.76E-14
I-144	1.33E-09	9.23E-12			
I-145	0.00E+00	0.00E+00			
Total	1.99E+04	1.55E+02		2.43E+05	1.80E+03

5. Minimum post-LOCA sump volume (55730 ft^3 or 1.578E+6 liters) per Reference 11.

5.0 METHOD

5.1 Boric Acid

Per Reference 5, page 77, for the minimum pH design case mass boric acid = 58245 lbm

Boric acid does not dissociate in aqueous solution, but is acidic due to its interaction with water molecules to form the tetrahydroxyborate ion:

$B(OH)_3 + H_2O \longrightarrow B(OH)_4 + H^+$ ($K_a = 5.8 \times 10^{-10}$ mol/l; $pK_a = 9.24$)

Converting to gm-moles results :

58245 lbm $B(OH)_3$ * 453.59 gm/lbm / 1 mole / 61.82 gm / 1.578E06 liters = 2.708E-01 moles/liter

or a total of 427320 moles [2.708E-01moles/liter * 1.578E6 liters].

based on minimum sump LOCA volume per Section 4, Item 5.

5.2 Hydriodic Acid

Per section 2.2.2 of Reference 2, hydriodic Acid (HI) is a strong acid introduced into containment with the release of iodine, but small amounts are likely in containment.

Table 2 of USNRC Regulatory Guide 1.183 (Reference 1) indicates that 5% of the halogen inventory is released during the gap release phase and an additional 35% is released during the early in-vessel phase. In accordance with Section 3.5 of Reference 5, 95% of the iodine released should be assumed to be cesium iodide (CsI) 4.85% elemental and 0.15% organic iodine. The basis for this release was NUREG-1465, section 3.5 (Reference 7) wherein it states iodine entering containment is at least 95% CsI with the remaining 5% as I plus HI, with not less than 1% of each as I and HI. This analysis will conservatively assume that all 5% of the release is in the form of HI in order to maximize the acid generation. This release process is assumed to occur at a constant rate over the release period identified in Table 4 of Reference 1.

LOCA Release Phases PWRs Reference 1

Phase	Onset	Duration
Gap Release	30 sec	0.5 hr
Early In-Vessel Release	0.5 hr	1.3 hr

The core iodine inventory used in this evaluation includes stable I127 to maximize the amount of acid produced. Per Reference 13 the total core inventory of iodine is 155 gram atoms at the end of cycle. Note: For a monotonic element gram mole equals gram atom. The following equations are used to describe this release.

During the Gap Release Phase:

$d/dt[HI] = [0.05 * 0.05\ mi] / [Vs * 0.5\ hr]$

During the Early In-Vessel Release Phase:

$d/dt[HI] = [0.05 * 0.35\ mi] / [Vs * 1.3\ hr]$

where:

mi = gram mole iodine = 155

Vs Sump volume = 1.578E+06 liters (minimum sump LOCA volume per Section 4, Item 5.)

Integrating the above yields:

During the Gap Release Phase:

[HI](t) = [mi] / [.5 / (.05*.05)]Vs * [t – tgrp]
[HI](t) = [mi] / [200Vs] * [t – tgrp]

where tgrp = onset of the gap release phase = 0.008333 hr [0.5 minutes or 30 seconds]

During the Early In-Vessel Release Phase:

[HI](t) = [mi] / [1.3 / (.05*.35)] Vs] * [t –(0.5 + tgrp)] + [0.5 mi] / [(200Vs]
[HI](t) = [mi] / [74 Vs] * [t –(0.5 + tgrp)] + [mi] / [400 Vs]

The final HI concentration at t = 1.808 hr [1.3 hr+0.5hr+30 seconds], the end of the iodine release from the core is given as:

[HI](1.808 hr) = [(155) / (74*1.578E+06)] * [1.808 –(0.5 + 0.008333)]
+ [155] / [400*1.578+06]
[HI](1.808 hr) = [1.3274-06] *[1.3] + 2.4556-07 = 1.9712-06moles/liter

or a total of 3.1 moles [1.9712-06 moles/liter * 1.578+06 liters].

5.3 Nitric Acid

Radiolytic production of nitric acid is discussed in section 2.2.4 of Reference 2 and section 3.3.1.1 of Reference 4. The nitric acid (HNO_3) is produced by the irradiation of water and air. Both references provide the following constant for nitric acid production based on experimental data: g(HNO_3) = 0.007 molecules/100ev where the relationship is based on radiation absorption in the aqueous phase. This value is based on a water temperature of 86 °F, which is conservative for use following a LOCA since the solubility of nitrogen reduces with increasing temperatures. Per Reference 2 section 2.2.4, this equates to a radiation G value of 7.3-06 moles HNO_3/ L Megarad which means H^+ and NO_3 increase by 7.3-06 moles/L for each Megarad of dose delivered to the sump water. This is expressed as:

d/dt[HNO_3] = 7.3-06 moles HNO_3/ L Megarad * DR(t)

where: DR(t) = dose rate as a function of time in the sump (Megarads/hr).

For the purposes of determining the quantity of nitric acid formed, a 30 day sump integrated dose of 40 Mrad is applied based on Table 5-8, "Integrated Gamma Ray and Beta Source Strengths at Various Times Following a Maximum Credible Accident (TID-14844 release fractions)" of Reference 12.

T 5-8 RADM 30 day Conservative Integrated γ/β MEV/Watt				
Energy Group MeV/gamma	Source Strength at Time After Release MeV/Watt	Power (2958 MWt) Watt	MEV	Mrad (1)
0.20 - 0.40	2.30E+14	2.96E+09	6.80E+23	
0.40 - 0.90	2.70E+14	2.96E+09	7.99E+23	
0.90 - 1.35	5.40E+13	2.96E+09	1.60E+23	
1.35 - 1.80	7.20E+13	2.96E+09	2.13E+23	
1.80 - 2.20	1.60E+13	2.96E+09	4.73E+22	
2.20 - 2.60	1.70E+13	2.96E+09	5.03E+22	
2.60 - 3.00	1.50E+12	2.96E+09	4.44E+21	
3.00 - 4.00	8.50E+11	2.96E+09	2.51E+21	
4.00 - 5.00	2.10E+11	2.96E+09	6.21E+20	
5.00 - 6.00	1.10E+10	2.96E+09	3.25E+19	

Total γ	6.62E+14	2.96E+09	1.96E+24	19.84
Beta	6.60E+14	2.96E+09	1.95E+24	19.79

$$\gamma = \frac{[1.96E+24 \text{ Mev}] * 1 \text{ erg}/6.25E5 \text{ Mev} * 1\text{Rad-gm}/100 \text{ ergs} * 1 \text{ Mrad}/10^6 \text{ Rad} * 1 \text{ cc/gm}}{1.578E09 \text{ cc}} = 19.84 \text{ Mrad}$$

$$\text{Beta} = \frac{[1.95E+24 \text{ Mev}] * 1 \text{ erg}/6.25E5 \text{ Mev} * 1\text{Rad-gm}/100 \text{ ergs} * 1 \text{ Mrad}/10^6 \text{ Rad} * 1 \text{ cc/gm}}{1.578E09 \text{ cc}} = 19.79 \text{ Mrad}$$

These dose rates were determined using TID-14844 source terms. In accordance with USNRC RG 1.183, section 1.3.5 and SECY-98-154, the TID-14844 Equipment Qualification dose rates previously calculated in the containment air and sump (beta and gamma) bound those generated by AST. Therefore, it can be concluded that the dose rates calculated with TID-14844 are conservative and acceptable for use in determining the HNO_3 production herein.

$[HNO_3](t) = 7.3E\text{-}06 \int^t DR(t)\, dt$ where t = time into accident (hrs)

or the nitric acid produced at any point in time is given as

$[HNO_3](t) = 7.3E\text{-}06$ * Integrated Dose at Time t.

$[HNO_3]$(30 days-sump dose) = 7.3E-06 * 40 = 2.92E-04 moles/liter.

or a total of 460.8 moles [2.92E-04 moles/liter * 1.578E6 liters].

5.4 Hydrochloric Acid

The radiolysis of chloride-bearing cable jacketing will result in the production of HCl vapor as documented in Section 2.2.5.2 of NUREG/CR-5950 (Reference 2). It should be noted that a significant portion of the HCl vapor produced from cable radiolysis would react with the metal components within the primary containment (e.g., cable trays, gratings, etc.) and never enter the sump. However, for this analysis it is conservatively assumed that all of the gaseous HCl produced is immediately dissolved in the sump water. A model for the production of HCl from cable jacketing is developed below based on the approach given in Appendix B of NUREG/CR-5950.

The absorption of a radiation flux at a radius, r, can be described from basic principles as:

$$\varphi(r) = \varphi(Ro)e^{-\mu(Ro-r)}$$

μ = Linear Absorption Coefficient (cm^{-1}) from Table below.
Ro = Outside cable radius (cm)

Cable and Air Material Properties Reference 3			
	Density	Linear Absorption Coefficient (cm^{-1})	
Material	(gm/cm^3)	Beta Radiation	Gamma Radiation
Hypalon	1.55	52.08	0.099
EPR	1.27	42.67	0.081
Air		0.0198	0.0000374

Similar to the approach in Reference 2, Appendix B, the production of HCl from radiolysis is given by:

$$R = G\,(SA)\,\varphi\,A$$

where:

R = HCl production rate (gm moles/sec)

G = Radiation G value for Hypalon (molecules HCl/100 ev)

SA = Cable surface area (cm^2)

φ = Incident radiation energy flux (Mev/cm^2-sec)

A = Absorption fraction of energy flux in Hypalon jacket.

Radiation G value for Hypalon

Note: The radiation G value for Hypalon adopted in Reference 2, Section 2.2.5.2 is 2.115 molecules HCl per 100 eV. This G value is based on the energy absorbed by the polymer consistent with the footnote to Table 3 of NUREG-1081 (Reference 3). As described in Reference 3, this value represents a balance between the increased HCl production at elevated temperatures expected during accidents and the neutralization potential of fillers in the cable. The resulting value is 3.512E-20 moles/Mev (Reference 2, page B.3). This term can also be expressed in terms of moles/Mrad (absorbed dose)-gm (exposed material).

3.512E-20 moles/Mev * 6.25E+5 Mev/erg * 100 ergs/gm-Rad * 1E+6 Rad/Mrad = 2.195E-6 moles/Mrad-gm or 9.97E-4 moles/Mrad-lb. This value is conservative compared to the value of 4.6E-4 moles of HCl per lb of insulation per Megarad listed in Section 2.2.5.2 of Reference 2 since it produces about 2.2 times more HCl per lb of exposed material.

Absorption fraction of energy flux in Hypalon jacket

The absorption fraction is the fraction of incident radiation energy flux absorbed by the Hypalon. As provided in Section 4.2 of NUREG-1081 (Reference 3), the factor is calculated with the following equation (Reference 3, Equation 4-5 – gamma and Equation 4-9 - beta):

$A_{\gamma,H} = 1 - \exp[-\mu\gamma^{H} * tH]$

where:

$A_{\gamma,H}$ = Absorption of incident gamma radiation

$\mu\gamma^{H}$ = Linear adsorption coefficient – gamma Hypalon (0.099/cm)

tH = Hypalon thickness (cm)

$A_{\beta,H} = 1 - \exp[-\mu\beta^{H} * tH]$

where:

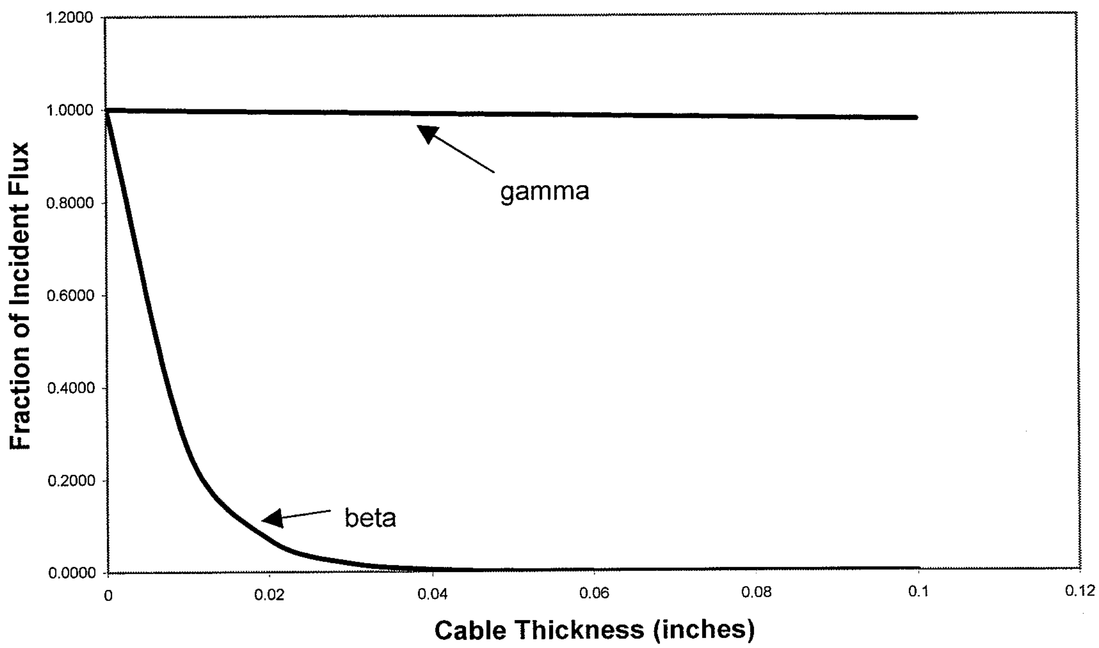
$A_{\beta,H}$ = Absorption of incident beta radiation

$\mu\beta^{H}$ = Linear adsorption coefficient – beta Hypalon (52.08/cm)

tH = Hypalon thickness (cm)

Using the above equations and values the following figure plots the radiation fluxes through Hypalon jacketing. As seen essentially all of the beta energy is completely absorbed even by relatively thin

Hypalon cable jacketing while very little of the gamma energy is absorbed. In the subsequent analysis all of the beta energy will be assumed completely absorbed in the jacket.



HCl Generation

The HCl generation can be calculated with the above equations as (See Reference 3, Equations 5-7 and 5-8 for gamma and Equations 5-10 and 5-11 for beta).

Gamma: $R = G\,(SA)\,\varphi\,A = G * SA * E_\gamma/V * [(1-\exp(-\mu\gamma air * r))/\mu\gamma^{air}] * [1-\exp(-\mu\gamma^{H} * tH)]$

Beta: $R = G\,(SA)\,\varphi\,A = G * SA * E_\beta/V * 1/\mu\beta^{air}$

where:

R	HCl production rate (gram moles/hr)
E_γ/V	Energy release rate / unit volume (Mev/hr-cc) gamma
E_β/V	Energy release rate / unit volume (Mev/hr-cc) beta
$\mu\gamma^{H}$	Linear adsorption coefficient – gamma Hypalon
$\mu\gamma^{air}$	Linear adsorption coefficient – gamma air
r	Distance of air to cable (cm) (252 cm).
$\mu\beta^{air}$	Linear adsorption coefficient – beta air

SA	Cable surface area (cm^2)
tH	Hypalon thickness (cm)
G	3.512E-20 gram moles/Mev (Reference 1, Appendix B)

Using the form for G in terms of absorbed dose [9.97E-4 moles/Mrad-lb (exposed material)], the total HCl generation from an integrated energy release is given as follows:

Gamma: $M_{HCl} = G * W* * [1- \exp(-\mu\gamma^{-H}*tH)]\int_0^t DR\, dt$

Beta: $M_{HCl} = G * W* \int_0^t DR\, dt$

where:

M_{HCl}	HCl production (gram moles)
W	Weight of cable jacket material (lbs)
t	Time (hrs)
$[1- \exp(-\mu\gamma^{-H}*tH)]$	Fraction of gamma energy absorbed
$\int_0^t DR\, dt$	Integrated dose (Mrad)
G	moles/Mrad-lb

Using G in terms of absorbed dose (Mrad) replaces G (E_γ/V) $[(1-\exp(-\mu\gamma^{air}*r)/ \mu\gamma^{air}]$ where the values were in terms of an incident flux and absorbed energy.

Due to the different attenuation properties of beta and gamma radiation they are addressed separately.

Beta:

From Attachment 1, the total weight of cable jacket (17083 lb) and insulation (36540 lb) (assumed to be Hypalon properties) is taken as 63812 lbs [(17083 + 36540) * 1.19]. Also as seen on above figure and on Attachment 1, the jacket thickness in almost all cases is equal to or greater than the thickness required for the entire beta energy to be absorbed, therefore, use of the total jacket + insulation is conservative.

The HCl concentration in the sump is M_{HCl} / Sump Volume (1.578E+6 liters) or

[HCl] = G * W* Integrated Beta Dose

[HCl] = 9.97E-4 moles/Mrad-lb * 63812lbs * ½[140 Mrad] / 1.578E+6 liters

[HCl] = 2.8222E-03 moles/l due to beta

or a total of 4453.4 moles [2.695E-03 moles/liter * 1.578E6 liters].

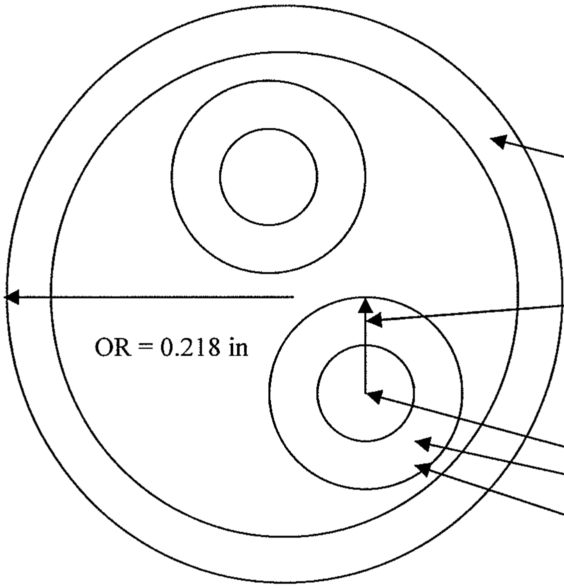
where a factor of 2 reduction is taken for the beta dose due to self shielding effects.

Gamma:

Unlike beta radiation, the gamma radiation can penetrate the cable interior and HCl may be generated by interior jackets on individual conductors in multi conductor cables.

Based on a review of the various cable types listed in Attachment 1, a bounding cable type is developed to conservatively determine the potential HCl production. A review of Attachment 1 indicates that type EK-B1G and EK-C1A cables comprise about 13.14% and 27.95% of the total cable length and 14.05% and 14.84% of the total outside jacket mass, respectively. Based on this type EK-C1A is used as the base for the subsequent evaluation. Per Reference 14 for type EK-C1A cable the OD = 0.436 in. where the properties for Hypalon are conservatively applied to the EPDM insulation material. The resulting EK-C1A insulation-jacket mass/ft is conservatively applied to the total length for all cable types from Attachment 1.

Approximate Representation of Cable



There are two 16 gage conductors with 30 mils EPDM and 15 mils Hypalon each.

Per Marks (Reference 6), diameter of 16 AWG conductor equals 51 mils or 0.051 inches (radius = 0.0255 inches. Therefore, the area of insulation-jacket/conductor is:

$\pi[R_2^2 - R_1^2] = \pi[(0.0705\text{in}/12\text{in/ft})^2 - (0.0255\text{in}/12\text{in/ft})^2]$
$= \pi[0.0000345 - .0000045] = 9.425\text{E-}5\ \text{ft}^2/\text{conductor}$

The total mass of insulation-jacket is conservatively estimated as:

2 conductors * 9.425E-5ft^2/conductor * 96.7 lb/ft^3 * 289,914 ft = 5285 lbs.

Where:
96.7 lb/ft^3 = density of Hypalon
289,914 ft = total length of all cable from Attachment 1. By inspection of Attachment 1, type Q11 cable bounds most types of cable used and provides a conservative estimate of the material used to generate HCl.

HCl concentration in the sump is M_{HCl} / Sump Volume

[HCl] = G * W* * [1- exp(-$\mu\gamma^{-H}$*tH)] * Integrated Gamma Dose
[HCl] = 9.97E-4 moles/Mrad-lb * [63812 + 5285]lbs * [(1 – exp- (.099 * 0.436)] * [22 Mrad] / 1.5788E+6 liters
[HCl] = 9.97E-4 * 69097 lbs * 0.0422 * 22 /1.578E+6
[HCl] = 4.053E-5 moles/liter due to gamma

or a total of 64 moles [4.053E-5 moles/liter * 1.578E6 liters].

Therefore, the total gamma + beta HCl equals 64 moles + 4453.4 moles = 4517.4 moles.

5.5 Sodium Hydroxide

In order to maintain the post LOCA sump pH greater than 7 a buffering agent is required to offset the various acid production post LOCA. NaOH solution is used (NaOH). The molecular weight is:

Component	No. of Atoms	Atomic Weight
Na	1	22.9898
H	1	1.00794
O	1	15.99994
Total		40 gm/mole

Per Reference 5, page 77, for the minimum pH design case mass NaOH = 3829.046 lbm

Converting to gm-moles results :

3829.046 lbm NaOH* 453.59 gm/lbm / 1 mole / 40 gm / 1.578E06 liters = 2.7516E-02 moles/liter

or a total of 43420 moles [2.7516E-02 moles/liter * 1.578E6 liters].

Sodium hydroxide (NaOH), also known as lye and caustic soda, is a caustic metallic base. Sodium hydroxide forms a strong alkaline solution when dissolved in a solvent such as water. However, only the hydroxide ion is basic.

Sodium hydroxide dissociates in water as follows:

$$NaOH + H_2O \longrightarrow Na + OH + H_2O$$

Therefore, the injection of 3829.046 lbm NaOH or 43420 gm-moles NaOH results in 43420 gm-moles basic OH.

Base will buffer the sump water at a pH corresponding to the following:

$pH = pK_a + \log [anion]/[acid]$ (Henderson-Hasselbalch equation per page 754 of Reference 15)

where:

pK_a = negative of the log of the acid dissociation constant = $-\log[K_a]$

Per Reference 2, section 2.3.3, a borate buffer that controls pH at values near 9.2 has a dissociation constant of 5.8E-10 and a phosphate buffer that controls pH at values near 7 has a dissociation constant of 6.3E-08. Sodium hydroxide is a strong base that controls pH at values near 11. The value of 5.8E-10 from Reference 2, section 2.3.3 is conservatively assumed in this analysis for NaOH buffering.

K_a	5.8E-10	= for borate buffer (Reference 2)
[anion]		= borate concentration
[acid]		= acid concentration

where:

$pH = pK_a + \log [anion]/[acid]$

5.6 Cesium Hydroxide

Per section 2.3.1 of Reference 2, cesium may be introduced into containment in various forms following an accident. The cesium will form cesium hydroxide and cesium borates which are basic materials

Table 2 of USNRC Regulatory Guide 1.183 (Reference 1) indicates that 5% of the alkali metal inventory (including cesium) is released during the gap release phase and an additional 25% is released during the early in-vessel phase. Table 2 Reference 1 also indicates that 5% of the halogen inventory is released during the gap release phase and an additional 35% is released during the early in-vessel phase. In accordance with Section 3.5 of Reference 1, 95% of the iodine released should be assumed to be cesium iodide (CsI). This release process is assumed to occur at a constant rate over the release period identified in Table 4 of Reference 1.

LOCA Release Phases PWRs Reference 1

Phase	Onset	Duration
Gap Release	30 sec	0.5 hr
Early In-Vessel Release	0.5 hr	1.3 hr

The core cesium and iodine inventories used in this evaluation include stable Cs-133 and stable I-127. Per References 8 and 13, the total core inventory of iodine is 155 gram atoms at the end of cycle (EOC) and the total core inventory of cesium is 1800 gram atoms at EOC.

Note: For a monotonic element gram mole equals gram atom. The following equations are used to describe this release.

During the Gap Release Phase:

$d/dt[CsOH] = [0.05mcs - (0.95 * 0.05mi)] / [Vs * 0.5\ hr]$

During the Early In-Vessel Release Phase:

$d/dt[CsOH] = [0.25mcs - (0.95 * 0.35mi)] / [Vs * 1.3\ hr]$

where

mi = gram mole iodine = 155

mcs = gram mole cesium = 1800

Vs = Sump volume (liters) = 1.578E+06 liters [55730 ft^3]

Integrating the above yields:

During the Gap Release Phase:

[CsOH](t) = {[(.05/.5)mcs – (.05*.95/.5)mi] / [Vs]} * [t – tgrp]

[CsOH](t) = {[0.1mcs – 0.095mi] / [Vs]} * [t – tgrp]

where tgrp = onset of the gap release phase = 0.008 hr [0.5 minutes or 30 seconds]

During the Early In-Vessel Release Phase:

[CsOH](t) = {[(0.25/1.3)mcs – (.35*.95/1.3)mi] / [Vs]} * [t –(0.5 + tgrp)] + [(0.1*.5)mcs – (0.095*.5)mi] / [Vs]

[CsOH](t) = {[0.19mcs – 0.256mi] / [Vs] * [t –(0.5 + tgrp)]} + [0.05mcs – 0.0475mi] / [Vs]

The final CsOH concentration at t = 1.808 hr [1.3 hr+0.5 hr+0.008 hr] is given as:

[CsOH](1.808 hr) = {[0.19 * 1800 – 0.256 * 155] / [1.578E+06]} * [1.808 –(0.5 + 0.008)] + [0.05 * 1800 – 0.0475 * 155] / [1.578E+06]

[CsOH](1.808 hr) = [[342 – 39.7]/[1.578E+06]] * [1.3] + [90 – 7.4]/ [1.578E+06]

[CsOH](1.808 hr) = [2.49E-04] + [5.23E-05] moles/liter

[CsOH](1.808 hr) = 3.013E-04 moles/liter

or a total of 475.5 moles [3.013E-04 moles/liter * 1.578E6 liters].

5.7 Summary of Acid and Base Production

The following provides a summary of the production of acids and bases in the sump for 2958 MWt.

Material	Concentration in Sump generated by Beta radiation moles/liter	Concentration in Sump generated by gamma radiation moles/liter	Concentration in Sump moles/liter	Reference Section
Boric Acid			2.71E-01	5.1
Hydriodic Acid	NA	NA	1.97E-06	5.2
Nitric Acid	NC	NC	2.92E-04	5.3
Hydrochloric Acid	2.82E-3	4.05E-5	2.86E-03	5.4
Sodium Hydroxide	NA	NA	2.75E-02	5.5
Cesium Hydroxide	NA	NA	3.01E-4	5.6

NA: Not Applicable
NC: Not Calculated

Material	Sump gm-moles	Reference Section
Boric Acid	427320	5.1
Hydriodic Acid	3.1	5.2
Nitric Acid	460.8	5.3
Hydrochloric Acid	4517.4	5.4
Total acid	432301.3	
Sodium Hydroxide	43420	5.5
Cesium Hydroxide	475.5	5.6
Total Base	43895.5	

Base Case pH considering only boric acid and sodium hydroxide = 8.244 (No credit for CsOH production):

Hydriodic Acid	0.000E+00		
Nitric Acid	0.000E+00		
Hydrochloric Acid	0.000E+00		
Boric Acid	2.708E-01		
Total Acid	2.708E-01		
Cesium Hydroxide	0.000E+00		
Sodium Hydroxide	2.752E-02		
Total Base	2.752E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.244E+00

where pKa = -log[Ka]

Base Case pH considering only boric acid and sodium hydroxide = 8.248 (With credit for CsOH production):

Hydriodic Acid	0.000E+00		
Nitric Acid	0.000E+00		
Hydrochloric Acid	0.000E+00		
Boric Acid	2.708E-01		
Total Acid	2.708E-01		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.248E+00

Additional Cases with no credit for CsOH production:

Hydriodic Acid	**0.000E+00**				Hydriodic Acid	1.971E-06		
Nitric Acid	2.920E-04				**Nitric Acid**	**0.000E+00**		
Hydrochloric Acid	2.860E-03				Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01				Boric Acid	2.708E-01		
Total Acid	2.740E-01				Total Acid	2.737E-01		
Cesium Hydroxide	0.000E+00				Cesium Hydroxide	0.000E+00		
Sodium Hydroxide	2.752E-02				Sodium Hydroxide	2.752E-02		
Total Base	2.752E-02				Total Base	2.752E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH		pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.239E+00			5.800E-10	9.237E+00	8.239E+00
Hydriodic Acid	1.971E-06				Hydriodic Acid	1.971E-06		
Nitric Acid	2.920E-04				Nitric Acid	2.920E-04		
Hydrochloric Acid	**0.000E+00**				Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01				Boric Acid	2.708E-01		
Total Acid	2.711E-01				Total Acid	2.740E-01		
Cesium Hydroxide	0.000E+00				Cesium Hydroxide	0.000E+00		
Sodium Hydroxide	2.752E-02				Sodium Hydroxide	2.752E-02		
Total Base	2.752E-02				Total Base	2.752E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH		pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.243E+00			5.800E-10	9.237E+00	8.239E+00
Hydriodic Acid	0.000E+00				Hydriodic Acid	0.000E+00		
Nitric Acid	0.000E+00				Nitric Acid	0.000E+00		
Hydrochloric Acid	0.000E+00				Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01				Boric Acid	2.708E-01		
Total Acid	2.708E-01				Total Acid	2.737E-01		
Cesium Hydroxide	0.000E+00				Cesium Hydroxide	0.000E+00		
Sodium Hydroxide	2.752E-02				Sodium Hydroxide	2.752E-02		
Total Base	2.752E-02				Total Base	2.752E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH		pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.244E+00			5.800E-10	9.237E+00	8.239E+00

Additional Cases with credit for CsOH production:

Hydriodic Acid	**0.000E+00**		
Nitric Acid	2.920E-04		
Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01		
Total Acid	2.740E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.243E+00

Hydriodic Acid	1.971E-06		
Nitric Acid	2.920E-04		
Hydrochloric Acid	**0.000E+00**		
Boric Acid	2.708E-01		
Total Acid	2.711E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.248E+00

Hydriodic Acid	0.000E+00		
Nitric Acid	0.000E+00		
Hydrochloric Acid	0.000E+00		
Boric Acid	2.708E-01		
Total Acid	2.708E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.248E+00

Hydriodic Acid	1.971E-06		
Nitric Acid	**0.000E+00**		
Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01		
Total Acid	2.737E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.244E+00

Hydriodic Acid	1.971E-06		
Nitric Acid	2.920E-04		
Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01		
Total Acid	2.740E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.243E+00

Hydriodic Acid	0.000E+00		
Nitric Acid	0.000E+00		
Hydrochloric Acid	2.860E-03		
Boric Acid	2.708E-01		
Total Acid	2.737E-01		
OH- for pH = 7.5	3.160E-07		
Cesium Hydroxide	3.010E-04		
Sodium Hydroxide	2.752E-02		
Total Base	2.782E-02		
pH=pKa+log[total base/total acid]	Ka	pKa	pH
	5.800E-10	9.237E+00	8.244E+00

6.0 RESULTS

The results of the evaluation based on the above data are summarized as follows:

Case	pH No CsOH	pH with CsOH
Base Case Boric Acid & NaOH only	8.244	8.248
All	8.238	8.243
All - Nitric Acid	8.239	8.244
All - HI	8.238	8.243
All - HCl	8.243	8.248
HCl only	8.239	8.244

The results herein indicate that the prior pH prediction provided in Reference 5 are conservative from a minimum pH perspective i.e. 8.2 versus 7.5. Nevertheless, as demonstrated in this calculation the effects of the additional acids: Hydriodic Acid (HI), Nitric acid (HNO_3)and Hydrochloric acid (HCl) have a negligible effect of the post LOCA sump pH (<0.1). Therefore, the conclusion that the post LOCA sump pH remains above 7, thereby precluding iodine re-evolution pH as previously identified in Reference 5 remains valid.

7.0 REFERENCES

1. USNRC Regulatory Guide 1.183, Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors, July 2000.
2. NUREG/CR-5950, Iodine Evolution and pH Control, Revision 3 (12/92).
3. NUREG-1081, Post-Accident Gas Generation from Radiolysis of Organic Materials, September, 1984.
4. NUREG/CR-5732, Iodine Chemical Forms in LWR Severe Accidents, April, 1992.
5. Calculation DC00040-066, Spray and Sump pH With Delta-75 SGs, Revision 1.
6. Marks Standard Handbook for Mechanical Engineers, 7th edition.
7. NUREG-1465, Accident Source Terms for Light-Water Nuclear Power Plants- Final Report, February, 1995.
8. Westinghouse Letter to Wayne Stuart (SCE&G) Core Inventories of Iodine and Cesium Isotopes at End-of-Cycle for V. C. Summer, CGE-09-27 dated July 23, 2009.
9. VCS Drawing SS-021-009, Revision 1.
10. VCS Drawing S-021-018, Sheets 3-185 and 3-192.
11. Calculation DC01380-002, Sump Volume, Revision 3.
12. Westinghouse Radiation Analysis Manual, Revision 1 for VCSNS Uprating updated 12/98 (attachment to letter CGE-98-036).
13. Westinghouse memo, Core Inventories of Iodine and Cesium Isotopes at End-of-Cycle for V. C. Summer, LTR-REA-09-116 dated July 23, 2009.
14. TWR Serial 66006, Determination of Chlorine Containing Cables within Reactor Building, 7/26/2009 (Attachment 1).
15. Ebbing and Gammon, General Chemistry, 7th edition, Houghton Mifflin Company (2002)

Attachment 1 Cable Data per TWR Serial 66006 (attached)

ENGINEERS TECHNICAL WORK RECORD		Serial:	66006
		Engineer:	I. Budo
		Date:	July 26th, 2009
Project Title	Determination of Chlorine containing Cables within Reactor Building.	Tab	Page 1 of 6

Objective:

This TWR relates to EIR-81550. The purpose of this TWR is to describe and discuss the methods used to determine cables located within the RB and the Chloride presence in the insulation of these cables.

Step 1 Objective:

The objective of Step 1, designed and executed by Donn Kelly, was to determine the types, quantities, and overall insulation weights of Cables found within the RB. This information was finalized in the Excel output of "qry - LIST Step B - Cable by BOM Known to be in RB". A second list of Cables, named "qry - LIST Step D - Cable by BOM in unknown locations", was generated in order to identify the cables with unknown locations.

A series of PCCKS Access output tables were used as source data tables in order to identify the locations of cables and further determine those being within the RB. These tables, which are shown below, were grouped in a single Access database named "Tables on PCCKS-VCS_Tables 2009-07-21".

A second Access database, named 'CablesInRB Rev 04' was created to analyze the input data obtained from PCCKS. The process of identifying and sorting cables within the RB, in order to determine their types and total lengths for use in Step 2, is shown as a list of consecutive queries below. The function of each query is explained below.

Step 1 was reviewed by Ilir Budo. The logic described below ensures that, based on data available, all known cables located within the RB are captured and considered.

Tables on PCCKS-VCS_Tables 2009-07-21

BOM01A00, CIR01A00, CON01B00, CON02A00, CON03A00, SSA01A00, TRA01A00, TRA01B00, TRA01C00, TRA02A00, TRA02B00

Queries

1) "qry - step 101 - Append valid circuits" appends true values from Fields CIR_NAME, CIR_TYPE, CIR_BOM, and CIR_CLENGTH from table CIR01A00 (direct product of PCCKS) to table 'Cables in RB'

2) "qry - Step 103 - Mark Cables in Tray in RB" updates Fields CktInRB and CktInTrayRB of table 'Cables in RB' with true values when join conditions are met.

3) "qry - Step 104 - Mark Cables in Tray Outside" updates Fields CktOut RB and CktInTrayOut when join conditions are met.

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4)"qry - Step105 – Mark Cables in RB in Conduit" updates Fields CktInRB and CkInCondInRB with true values when Join conditions are met.

5)"qry - Step 106 - Mark Cables in Conduit Outside" updates Fields CktOutRB and CktInCondOut of table 'Cables in RB' when join conditions are met.

6)"qry - Step 207 - Mark Cables in RB based on FT tag" updates Field CktInRB and FromOrToInRB of table 'Cables in RB' when join conditions are met.

7)"qry - Step 208 - Mark Cables based on FT tag Outside" updates Fields CktOutRB and FromOrToOut of table 'Cables in RB_1' and confirms that the circuits are out RB when join conditions are met.

8)"qry - Step 209 - Mark Cables in RB based on RBPen" updates Fields CktInRB and RBPenInRB of table 'Cables in RB_1' and confirms that circuits are in RB when join conditions are met.

9)"qry - Step 210 - Mark Cables based on RBPen Outside" updates Fields CktOutRB and RBPenOut of table 'Cables in RB_1' when join conditions are met.

10) "qry - Step 219 - Mark in RB from GenData" updates Fields CktInRB and FromOrTobyGenDataInRB of table 'Cables in RB' when all join conditions are met.

11) "qry - Step 220 - Mark Outside RB from GenData" updates Fields CktOutRB and FromOrtoByGenDataOut when all join conditions are met.

12) "qry - Step 301-List From and To Boxes" portrays data under Fields CIR_NAME, CktInRB and CktOutRB, from table 'Cables in RB' and data from Fields CIR_ESYST, CIR_F_DESC and CIR_T_DESC from table CIR01A00 and Fields FromBox and ToBox when the join conditions are met.

13) "qry - Step 302 - List From and To boxes clean format" updates new Fields FBox and TBox.

14) "qry - Step 305 - Match boxes to locations" looks into Tables TermBoxData and "qry-Step 302" and creates and shows data for three new fields CIR_NAME, FBox, and ToBox

15) "qry - Step 307 - Define box location table" defines box locations by looking into Step 305

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16) "qry - Step 309 - Mark Inside based on box locations" updates Fields CktInRB and BoxInRB from table 'Cables in RB' when join conditions are met.

17) "qry - Step 310 - Mark Outside based on box locations" updates Fields CktOutRB and BoxOutside from table 'Cables in RB' when join conditions are met.

18) "qry - Step 351 - List From and To Paging" updates data for the new FromSpkr, ToSpkr, and FromHand Fields, by looking into Tables 'Cables in RB' and CIR01A00, when join conditions are met.

19) "qry - Step 352 - Valid Speaker circuits" shows valid speaker circuits from Step 351.

20) "qry - Step 353 - Find Speakers in RB" finds Speaker Circuits in RB by finding Speakers in RB, looking into step 352 and table 'ReactorBldg_HandSet-Speaker_Data'

21) "qry - Step 354 - Find Speakers Outside RB" created by showing Fields from Step 352

22) "qry - Step 355 - Mark speakers in RB " updates Fields CktInRB and PageInRB from Table 'Cables in RB' when join conditions between Step 353 and table 'Cables in RB' are met.

23) "qry - Step 356 - Mark speakers outside RB" updates Fields CktOutRB and PageOutside from table 'Cables in RB' when Join conditions between table List Speakers outside RB and table Cables in RB are met.

24) "qry - Step 372 - Valid Handset circuits" looks into Step 351 and shows valid Handset Circuits.

25) "qry - Step 373 - Find Handsets in RB" finds valid Handset circuits from Step 372 that are located within the RB.

26) "qry - Step 374 - Find Handsets Outside RB" shows Handset Circuits outside RB by looking into Step 372 and table ReactorBld_Handset-Speaker_Data.

27) "qry - Step 375 - Mark handsets in RB" updates Fields CKInRB and PageInRB from table 'Cables in RB' when join conditions between step 375 and table 'Cables in RB' are met.

28) "qry - Step 376 - Mark handsets outside RB" updates Fields CktOutRB and PageOutside from Cables in RB when join conditions between tables 'List handsets outside RB' and 'Cables in RB' are met.

29) "qry - Step 411 - Mark in RB by Area Field" updates Fields CktInRB and AreaInRB from table 'Cables in RB' when join conditions with table Cir01A00 are met.

30) "qry - Step 412 - Mark by Area Field Outside" updates Fields CktOutRB and AreaOutside from table 'Cables in RB' when join conditions with table Cir01A00 are met.

31) "qry - Step 514 - Mark Outside based on system" updates Fields CktOutRB and SysOutside from table 'Cables in RB' when join conditions are met.

32) The following VB code was developed in order to determine the location of those particular circuits with unclear locations.
The following Sql Strings select those particular circuits that have not been identified and flagged to this point as being Inside or Outside the RB:

```
SqlStr = "SELECT CIR01A00.CIR_NAME, CIR01A00.CIR_F_DESC, CIR01A00.CIR_T_DESC, [tbl - Cables in RB].CktOutRB, [tbl - Cables in RB].DescOutside "
SqlStr = SqlStr & "FROM [tbl - Cables in RB] INNER JOIN "
SqlStr = SqlStr & "CIR01A00 ON ([tbl - Cables in RB].CIR_TYPE = CIR01A00.CIR_TYPE) AND ([tbl - Cables in RB].CIR_NAME = CIR01A00.CIR_NAME)"
SqlStr = SqlStr & "WHERE ((([tbl - Cables in RB].CktOutRB)=No) AND (([tbl - Cables in RB].CktInRB)=No));"
```

And

```
SqlStr = "SELECT CIR01A00.CIR_NAME, CIR01A00.CIR_F_DESC, CIR01A00.CIR_T_DESC, [tbl - Cables in RB].CktInRB, [tbl - Cables in RB].DescInside "
SqlStr = SqlStr & "FROM [tbl - Cables in RB] INNER JOIN "
SqlStr = SqlStr & "CIR01A00 ON ([tbl - Cables in RB].CIR_TYPE = CIR01A00.CIR_TYPE) AND ([tbl - Cables in RB].CIR_NAME = CIR01A00.CIR_NAME)"
SqlStr = SqlStr & "WHERE ((([tbl - Cables in RB].CktOutRB)=No) AND (([tbl - Cables in RB].CktInRB)=No));"
```

Furthermore, the following 'If InStr' functions were used to determine the location of the records produced by the SqlStrs shown above by comparing string words and phrases known to be inside or outside the RB against the 'From' and 'To' description recordsets.

```
StInSt = RsInSt("InsideString")
        If InStr(1, StF_DESC, StInSt) > 0 Or InStr(1, StT_DESC, StInSt) > 0 Then
RsCkts.Edit

            RsCkts("CktInRB") = True
```

RsCkts("DescInside") = True

And

StOutSt = RsOutSt("OutsideString")

If InStr(1, StF_DESC, StOutSt) > 0 Or InStr(1, StT_DESC, StOutSt) > 0 Then

RsCkts.Edit

RsCkts("CktOutRB") = True
RsCkts("DescOutside") = True

The "*InsideString*" is *(CRDM INST PLUG; CRDM PLUG BOARD; CRDM PWR PLUG; LEG; NI DETECTOR; PRESSURIZER; PRZR; RCS; REACTOR BLDG & REACTOR BUILDING)*

The "*OutsideString*" is *(ATWS MITIGATION SYS ACT CAB; AUX BLDG; AUX BLR; AUX BOILER; CABLE STORAGE; CAMERA; CARDOX; CHARGING CABLES; CHILLER AREA; COMPRESSOR; COMPUTER RM; COMPUTER ROOM; CONDENSING UNIT; CONT BLDG; CONT RM; CONT. ROD LOGIC CAB; CONTROL BLDG; CONTROL ROOM; COOLING TOWER; CPTR RM; CPTR ROOM; DELUGE; DOMESTIC; DOOR A; DOOR C; DOOR F; DOOR I; DOOR S; E FIELD; E-FIELD; FILT WATER; FIRE PROT CONT; FIRE SERV; FIRE SERVICE; FOR CB; HALON; HYDRO PLANT; INDUSTRIAL; INTERMED BLDG; ISO PHASE; ISOPHASE; LAB; LAUNDRY ROOM; MAIN DISTRIBUTION FRAME; MANHOLE; MCB TERM PANEL; MCC; MICROWAVE; MOBILE LUBE; MONTICELLO; MUCLEAR OPS; OFFICE; OPERATIONS BLDG; OPERATIONS BUILDING; PARR HYDRO; POTABLE WATER; RAD MAINT BLDG; RECORDS ROOM; SECURITY BLDG; SECURITY ENGR BLDG; SERV BLDG; SERVICE BLDG; SHOP; STOR BLDG; TOOL ROOM; TRAINING; TURB BLDG; TURB. BLDB.; WAREHOUSE & ZONE)*

33) "qry - LIST Step B - Cable by BOM Known to be in RB" updates Fields BOM ID, Cable Desc, Total Length, and Total Insulation Weight obtained in "qry-LIST Step A-Qty Cable Known to be in RB" by looking into tables 'Cables in RB', CIR01A00, and BOM01A00.

34) "qry - LIST Step D - Cable by BOM in unknown locations" updates Fields BOM ID, Cable Desc, Total Length, and Total Insulation Weight obtained in "qry - LIST Step C - Qty Cable for unknown locations" by looking into tables Cables in RB, CIR01A00 and BOM01A00.

Step 2 Objective:

The data obtained from Step 1 was further analyzed by Ilir Budo. BOM records, PCCKS BOM Information report # CKSR0350 and archived EQDPs of various cable vendors were used to determine the Chlorine content of the insulation and jacketing of every type of cable identified as being within the RB or of unknown location.

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		Engineer:	I. Budo
	TECHNICAL WORK RECORD	Date:	July 26th, 2009
Project Title	Determination of Chlorine containing Cables within Reactor Building.	Tab	Page 6 of 6

Excel tables, exported from step one Access database 'CablesInRB Rev 04', 'LIST Step D - Cable by BOM in Unknown Locations', and 'LIST Step B - Cable by BOM Known to be in RB' were combined in one Excel file called 'List B+D Updated July 23rd FINAL .xls'. There were 5 new columns added to the 'Final B List' and 'Final D List': Vendor, GAI SPEC, Chlorine Content, Data found, and Data Source columns. All relevant data is stored under column 'Data Found'. Column 'Chlorine Content' identifies all BOM ID entries as 'Yes'-containing Chlorine, 'No'-not containing Chlorine, and '?' for all entries for which it was not possible to determine Chlorine content based on available vendor supplied historical data.

For cables located inside the RB the total weight of insulation of cables with unknown Chlorine content is 3.7% of the total weight of insulation of all cables located inside the RB. For cables with unknown location, the total weight of insulation of cables with unknown Chlorine content is 3.5% of the total weight of the insulation of all cables with unknown location. 'Notes and Observations' sheet of 'List B+D Updated July 23rd FINAL .xls' file shows a summary of data described above.

Furthermore, a new sheet named 'Calc' was created in order to systematically tabulate all the necessary data needed to calculate the Chloride weight against the individual BOMs.

File "Calc" per TWR Serial 66006 (Reference 14) Known Cables in the Reactor Building

								CALCULATED VALUES							
					NUMBER OF					Hypalon 1.55g/cc	mH	SA	SA	Total wt	% wt
Cable Code	Sum Of Length(ft)	Chlorine Content	Total Insulation Weight(lb)	Outside Diameter (inch)	CONDUCTORS	CONDSIZE	Outside Jacket Thickness	OR inch	OR-OJT	density	lb/ft	sq cm/ft	sq cm/lb	jacket lbs	
CFC- 13	2259	?	16	0.190	4	24	0.025	0.095	0.07	96.7	8.70E-03	46.2118	5310.242	19.66	0.07
CFC- 30	3161	?	506	0.863	10	16	0.065	0.4315	0.3665	96.7	1.09E-01	209.8990	1918.135	345.90	1.59
CFC- 48	5275	?	58	0.300	4	22	0.050	0.15	0.1	96.7	2.64E-02	72.9660	2766.916	139.11	0.37
CFC- 61	2625	?	407	0.667	8	16	0.065	0.3335	0.2685	96.7	8.26E-02	162.2278	1965.173	216.70	1.16
CFC- 71	250	Yes	49	0.585	COAX		0.065	0.2925	0.2275	96.7	7.13E-02	142.2838	1995.372	17.83	0.12
EK -A1A	358	Yes	1751	3.740	3	750	0.140	1.87	1.73	96.7	1.06E+00	909.6434	855.511	380.65	3.98
EK -A2G	797	Yes	1060	2.260	3	350	0.110	1.13	1.02	96.7	4.99E-01	549.6776	1101.697	397.65	2.72
EK -A2H	1470	Yes	1712	2.000	3	250	0.110	1	0.89	96.7	4.39E-01	486.4403	1109.073	644.74	4.39
EK -A2J	744	Yes	734	1.800	3	4/0	0.095	0.9	0.805	96.7	3.42E-01	437.7963	1281.177	254.24	1.84
EK -A2M	2014	Yes	1406	1.430	3	1/0	0.095	0.715	0.62	96.7	2.68E-01	347.8048	1299.918	538.86	3.63
EK -A2S	220	Yes	95	1.220	2	1/0	0.080	0.61	0.53	96.7	1.92E-01	296.7286	1542.232	42.33	0.26
EK -A3B	139	Yes	47	0.820	2	6	0.065	0.41	0.345	96.7	1.04E-01	199.4405	1926.364	14.39	0.11
EK -A3C	375	Yes	98	0.740	2	8	0.065	0.37	0.305	96.7	9.26E-02	179.9829	1944.461	34.71	0.25
EK -A3D	4326	Yes	908	0.610	2	10	0.065	0.305	0.24	96.7	7.47E-02	148.3643	1985.202	323.30	2.30
EK -A3E	2906	Yes	1212	1.610	3	2	0.080	0.805	0.725	96.7	2.58E-01	391.5845	1516.454	750.40	3.66
EK -A3F	1195	Yes	541	1.020	3	4	0.080	0.51	0.43	96.7	1.59E-01	248.0846	1563.749	189.58	1.36
EK -A3G	2283	Yes	895	0.870	3	6	0.065	0.435	0.37	96.7	1.10E-01	211.6015	1916.879	252.02	2.14
EK -A3H	122	Yes	46	0.790	3	8	0.065	0.395	0.33	96.7	9.94E-02	192.1439	1932.682	12.13	0.11
EK -A3J	8157	Yes	1175	0.640	3	10	0.065	0.32	0.255	96.7	7.88E-02	155.6609	1974.165	643.17	3.39
EK -A3K	136	Yes	88	1.270	4	2	0.085	0.635	0.55	96.7	2.12E-01	308.8896	1453.621	28.90	0.22
EK -A3P	2367	Yes	1053	1.210	3	1	0.080	0.605	0.525	96.7	1.91E-01	294.2964	1543.127	451.42	2.81
EK -B1F	120	Yes	8	0.380	1	12	0.050	0.19	0.14	96.7	3.48E-02	92.4237	2655.121	4.18	0.02
EK -B1G	32121	Yes	4850	0.610	2	12	0.065	0.305	0.24	96.7	7.47E-02	148.3643	1985.202	2400.57	13.52
EK -B1H	6146	Yes	1039	0.640	3	12	0.065	0.32	0.255	96.7	7.88E-02	155.6609	1974.165	484.61	2.84
EK -B1J	9207	Yes	1722	0.690	4	12	0.065	0.345	0.28	96.7	8.57E-02	167.8219	1958.125	789.09	4.68
EK -B1K	5971	Yes	1254	0.740	5	12	0.065	0.37	0.305	96.7	9.26E-02	179.9829	1944.461	552.69	3.37
EK -B1L	4285	Yes	1016	0.800	7	12	0.065	0.4	0.335	96.7	1.01E-01	194.5761	1930.519	431.88	2.70
EK -B1M	4011	Yes	1384	1.060	10	12	0.080	0.53	0.45	96.7	1.65E-01	257.8134	1558.743	663.41	3.82
EK -B1N	815	Yes	347	1.190	15	12	0.080	0.595	0.515	96.7	1.87E-01	289.4320	1544.965	152.68	0.93
EK -B1P	548	Yes	253	1.290	19	12	0.080	0.645	0.565	96.7	2.04E-01	313.7540	1536.381	111.91	0.68
EK -B6A	846	?	159	0.850	4	12	0.065	0.425	0.36	96.7	1.08E-01	206.7371	1920.528	91.07	0.47
EK -C10	520	Yes	33	0.360	4	12	0.045	0.18	0.135	96.7	2.99E-02	87.5593	2927.953	15.55	0.09
EK -C12B	459	Yes	21	0.420	1	.036" OD	0.040	0.21	0.17	96.7	3.21E-02	102.1525	3185.594	14.72	0.07
EK -C13A	1846	?	59	0.349	2	16	0.025	0.1745	0.1495	96.7	1.71E-02	84.8838	4967.354	31.55	0.17
EK -C1A	68294	Yes	3893	0.436	2	16	0.045	0.218	0.173	96.7	3.71E-02	106.0440	2856.814	2535.05	11.99
EK -C1B	21750	Yes	1501	0.462	3	16	0.045	0.231	0.186	96.7	3.96E-02	112.3677	2838.429	861.04	4.40
EK -C1C	25168	Yes	2366	0.552	4	16	0.045	0.276	0.231	96.7	4.81E-02	134.2575	2789.352	1211.39	6.67
EK -C1D	395	Yes	51	0.725	4	16	0.060	0.3625	0.3025	96.7	8.42E-02	176.3346	2094.835	33.25	0.16
EK -C1E	3525	Yes	649	0.837	8	16	0.060	0.4185	0.3585	96.7	9.84E-02	203.5753	2069.845	346.69	1.86
EK -C2B	531	Yes	74	0.460	1	18	0.040	0.23	0.19	96.7	3.54E-02	111.8813	3156.700	18.82	0.17
EK -C3B	417	Yes	123	0.960	12	18	0.060	0.48	0.42	96.7	1.14E-01	233.4914	2049.567	47.51	0.32
EK -C4A	206	Yes	54	0.930	22	16	0.080	0.465	0.385	96.7	1.43E-01	226.1947	1576.735	29.55	0.16
EK -C7	1485	Yes	68	0.205	22	19	0.025	0.1025	0.0775	96.7	9.49E-03	49.8601	5252.016	14.10	0.15
EK -F1A	3933	Yes	228	0.360	2	16	0.045	0.18	0.135	96.7	2.99E-02	87.5593	2927.953	117.61	0.64
EK -F3B	20	Yes	6	0.351	10	16	0.080	0.1755	0.0955	96.7	4.57E-02	85.3703	1866.520	0.91	0.01
EK -G1A	143	Yes	8	0.405	2	14	0.045	0.2025	0.1575	96.7	3.42E-02	98.5042	2882.204	4.89	0.02
EK -G1B	1082	Yes	49	0.351	2	18	0.045	0.1755	0.1305	96.7	2.91E-02	85.3703	2938.718	31.43	0.15
EK -G1C	3066	Yes	1021	0.351	10	18	0.080	0.1755	0.0955	96.7	4.57E-02	85.3703	1866.520	140.23	2.17
VFC- 11	120	?	3	0.500	1	14	0.045	0.25	0.205	96.7	4.32E-02	121.6101	2815.340	5.18	0.02
VFC- 12	80	?	1	0.400	1	14	0.045	0.2	0.155	96.7	3.37E-02	97.2881	2886.714	2.70	0.01

File "Calc" per TWR Serial 66006 (Reference 14) Known Cables in the Reactor Building

								CALCULATED VALUES							
Cable Code	Sum Of Length(ft)	Chlorine Content	Total Insulation Weight(lb)	Outside Diameter (inch)	NUMBER OF CONDUCTORS	CONDSIZE	Outside Jacket Thickness	OR inch	OR-OJT	Hypalon 1.55g/cc density	mH lb/ft	SA sq cm/ft	SA sq cm/lb	Total wt jacket lbs	% wt
VFC- 14	100	?	3	0.620	1	14	0.065	0.31	0.245	96.7	7.61E-02	150.7965	1981.390	7.61	0.02
VFC- 18	240	Yes	36	0.575	15	18	0.065	0.2875	0.2225	96.7	6.99E-02	139.8516	1999.719	16.78	0.10
VFC- 19	210	Yes	54	0.665	16	16	0.040	0.3325	0.2925	96.7	5.27E-02	161.7414	3066.665	11.08	0.12
VFC- 20	180	Yes	75	0.805	26	16	0.040	0.4025	0.3625	96.7	6.46E-02	195.7922	3032.907	11.62	0.16
VFC- 21	250	Yes	16	0.122	4	16	0.040	0.061	0.021	96.7	6.92E-03	29.6729	4288.157	1.73	0.03
VFC- 22	600	?	10	0.122	1	16	0.040	0.061	0.021	96.7	6.92E-03	29.6729	4288.157	4.15	0.03
VFC- 23	145	Yes	37	0.939	16	16	0.080	0.4695	0.3895	96.7	1.45E-01	228.3837	1575.314	21.02	0.11
VFC- 24	632	?	17	0.138	1	14	0.040	0.069	0.029	96.7	8.27E-03	33.5644	4058.614	5.23	0.04
VFC- 25	190	?	6	0.330	2	16	0.050	0.165	0.115	96.7	2.95E-02	80.2627	2717.507	5.61	0.02
VFC- 26	145	?	19	0.138	3	14	0.040	0.069	0.029	96.7	8.27E-03	33.5644	4058.614	1.20	0.04
VFC- 44	215	Yes	5	0.242	COAX		0.018	0.121	0.103	96.7	8.51E-03	58.8593	6919.577	1.83	0.01
VFC- 51	95	Yes	7	1.014	12	20	0.065	0.507	0.442	96.7	1.30E-01	246.6252	1895.148	12.36	0.04
VFC- 57	160	?	38	0.765	24	18	0.065	0.3825	0.3175	96.7	9.60E-02	186.0634	1938.361	15.36	0.10
VFC- 59	60	?	13	0.678	4	12	0.065	0.339	0.274	96.7	8.41E-02	164.9033	1961.736	5.04	0.03
VFC- 72	380	Yes	16	0.242	COAX		0.018	0.121	0.103	96.7	8.51E-03	58.8593	6919.577	3.23	0.04
VFC-116	350	Yes	10	0.242	8-SPL		0.018	0.121	0.103	96.7	8.51E-03	58.8593	6919.577	2.98	0.02
VFC-117	100	Yes	4	0.242	10-SPL		0.018	0.121	0.103	96.7	8.51E-03	58.8593	6919.577	0.85	0.01
VFC-118	65	?	1	0.236	6	22	0.025	0.118	0.093	96.7	1.11E-02	57.4000	5157.916	0.72	0.00
VFC-119	274	Yes	12	0.242	COAX		0.018	0.121	0.103	96.7	8.51E-03	58.8593	6919.577	2.33	0.03
VFC-128	620	?	26	1.000	COAX		0.065	0.5	0.435	96.7	1.28E-01	243.2202	1896.967	79.49	0.20
VFC-133	135	?	2	0.166	2	22	0.025	0.083	0.058	96.7	7.44E-03	40.3745	5429.173	1.00	0.01
VFC-134	18	?	4	0.880	9	14	0.065	0.44	0.375	96.7	1.12E-01	214.0337	1915.122	2.01	0.01
VFC-135	324	?	29	0.450	4	14	0.045	0.225	0.18	96.7	3.84E-02	109.4491	2846.621	12.46	0.08
VFC-136	120	?	2	0.500	8	14	0.045	0.25	0.205	96.7	4.32E-02	121.6101	2815.340	5.18	0.01
VFC-138	380	?	0	0.230	TRIAX		0.018	0.115	0.097	96.7	8.05E-03	55.9406	6948.710	3.06	0.01
VFC-144	55	?	0	1.000	12	12	0.065	0.5	0.435	96.7	1.28E-01	243.2202	1896.967	7.05	0.01
VFC-155	48	?	1	0.200	1-COAX		0.018	0.1	0.082	96.7	6.91E-03	48.6440	7038.349	0.33	0.00
														17083.28	100.00
	244380		36540												

Total	cable+insulation	53623
	unknow	0.19
	19% increase	63812

Composite Cables: the largest conductor size has been shown

Cables with Unknown Locations

								CALCULATED VALUES							
Cable Code	Sum Of Length(ft)	Chlorine Content	Total Insulation Weight(lb)	Outside Diameter (inch)	NUMBER OF CONDUCTORS	CONDSIZE	Outside Jacket Thickness	OR inch	OR-OJT	Hypalon 1.55g/cc density	mH lb/ft	SA sq cm/ft	SA sq cm/lb	Total wt jacket lbs	% wt
CFC- 7	5	?	0	0.292	6	22									
CFC- 8	140	?	18	1.100	COAX										
CFC- 13	140	?	1	0.190	4	24									
CFC- 16	100	?	10	0.734	100	24									
CFC- 18	12	?	1	0.650	38	22									
CFC- 27	60	?	2	0.313	4	18									
CFC- 36	529	?	10	0.340	15	22									
CFC- 40	45	?	4	0.600	8	18									
CFC- 41	70	?	45	0.436	2	16									
CFC- 50	5	?	0	0.273	6	22									
CFC- 52	29	?	3	0.675	16	14									
CFC- 73	1230	?	19	0.188	8	24									
CFC- 76	410	?	0	1.245	100	22									
CFC- 82	240	?	2	0.195	8	24									
CFC- 86	15	?	0	0.660	16	14									
EK -A2E	15	Yes	12	1.680	2	4/0	0.090								
EK -A2H	36	Yes	42	2.000	3	250	0.110								
EK -A2K	185	Yes	158	1.660	3	3/0	2.000								
EK -A2M	25	Yes	17	1.430	3	1/0	0.095								
EK -A2S	48	Yes	21	1.220	2	1/0	0.080								
EK -A3B	13	Yes	4	0.820	2	6	0.065								
EK -A3C	3350	Yes	874	0.740	2	8	0.065								
EK -A3D	98	Yes	21	0.610	2	10	0.065								
EK -A3H	111	Yes	42	0.790	3	8	0.065								
EK -A3H	56	Yes	21	0.790	3	8	0.065								
EK -A3J	710	Yes	102	0.640	3	10	0.065								
EK -A3J	363	Yes	52	0.640	3	10	0.065								
EK -A3L	40	Yes	21	1.120	4	4	0.080								
EK -A3P	35	Yes	16	1.210	3	1	0.080								
EK -A3S	11	Yes	6	1.370	4	1	0.090								
EK -B1A	720	Yes	60	0.420	1	9	0.050								
EK -B1G	4588	Yes	693	0.610	2	12	0.065								
EK -B1G	1620	Yes	245	0.610	2	12	0.065								
EK -B1H	142	Yes	24	0.640	3	12	0.065								
EK -B1H	89	Yes	15	0.640	3	12	0.065								
EK -B1J	2204	Yes	412	0.690	4	12	0.065								
EK -B1J	55	Yes	10	0.690	4	12	0.065								
EK -B1K	171	Yes	36	0.740	5	12	0.065								
EK -B1K	50	Yes	10	0.740	5	12	0.065								
EK -B1L	893	Yes	212	0.800	7	12	0.065								
EK -B1M	540	Yes	186	1.060	10	12	0.080								
EK -B1N	76	Yes	32	1.190	15	12	0.080								
EK -B1P	138	Yes	64	1.290	19	12	0.080								
EK -B3B	105	?	9	0.440	3	12									
EK -C13A	755	?	24	0.349	2	16	0.000								
EK -C13A	88	?	3	0.349	2	16	0.000								

Cables with Unknown Locations

								CALCULATED VALUES							
Cable Code	Sum Of Length(ft)	Chlorine Content	Total Insulation Weight(lb)	Outside Diameter (inch)	NUMBER OF CONDUCTORS	CONDSIZE	Outside Jacket Thickness	OR inch	OR-OJT	Hypalon 1.55g/cc density	mH lb/ft	SA sq cm/ft	SA sq cm/lb	Total wt jacket lbs	% wt
EK -C1A	6961	Yes	397	0.436	2	16	0.045								
EK -C1A	847	Yes	48	0.436	2	16	0.045								
EK -C1B	13	Yes	1	0.462	3	16	0.045								
EK -C1C	402	Yes	38	0.552	4	16	0.045								
EK -C1E	316	Yes	58	0.837	8	16	0.060								
EK -C1G	86	Yes	26	1.014	12	16	0.080								
EK -C3B	110	Yes	32	0.960	12-SPL		0.060								
EK -C7	60	Yes	3	0.205	COAX		0.025								
EK -D1C	12985	Yes	429	0.246	1	10	0.015								
EK -D1D	660	Yes	20	0.246	1	10	0.015								
EK -F3B	20	Yes	6	0.351	10	16	0.080								
EK -G1A	372	Yes	21	0.405	2	14	0.045								
EK -G1A	246	Yes	14	0.405	2	14	0.045								
EK -G1B	688	Yes	31	0.351	2	18	0.045								
EK -G1B	12	Yes	1	0.351	2	18	0.045								
EK -G1C	410	Yes	137	0.351	10	14	0.080								
EK -G1C	18	Yes	6	0.351	10	14	0.080								
VFC- 4	15	Yes	8	0.690	8	8	0.065								
VFC- 36	572	?	25	1.000	19	22									
VFC- 48	180	?	6	0.450	2	16									
VFC- 73	135	Yes	7	0.351	2SPL		0.045								
VFC-130	60	?	9	0.080	1	22									
VFC-137	6	?	1	0.453	SPL										
														0.00	0.00

45534 ratio unknown to RB 19%