| Southern California Edison Company<br><br>**INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN)** | CALC NO. C-259-1.01.11 | ICCN NO./ PRELIM. CCN NO. N-3 | PAGE 1 | TOTAL NO. OF PAGES 44 |
|---|---|---|---|---|
| | BASE CALC. REV. 2 | UNIT 2 & 3 | CCN CONVERSION: CCN NO. CCN 4 | CALC. REV. 2 |
| | CALCULATION SUBJECT: Evaluation of Spent Fuel Pool for Westinghouse High Density Racks | | | |
| CALCULATION CROSS-INDEX<br>☒ New/Updated Index Included<br>☐ Existing Index is Complete | ENGINEERING SYSTEM NUMBER/PRIMARY STATION SYSTEM DESIGNATOR 2202 / XE1 | | Q-CLASS II | |
| **1.** BRIEF DESCRIPTION OF ICCN/CCN: | CONTROLLED PROGRAM OR DATABASE IN ACCORDANCE WITH NES&L 41-5-1<br>☐ PROGRAM ☐ DATABASE | PROGRAM/DATABASE NAME(S)<br>☐ ALSO, LISTED BELOW<br>N/A | VERSION/RELEASE NO.(S) | |

During the refueling outage for cycle 8, the Control Element Assemblies (CEAs) will be removed from the reactor and replaced with new CEAs. The old CEAs will remain within the spent fuel pool for storage. The top of the CEA will be closer to the top of the storage rack than the fuel. This CCN re-evaluates load drop accident scenarios (e.g., fuel assembly, test equipment and bulkhead gate) above the fuel storage racks while considering storage of CEAs. Additional limitations for CEA storage are imposed within this calculation. Recent changes in the radiological evaluations [35] also require modifications to the reconstitution procedure limitations.

This calculation shows that fuel damage consequences subsequent to all postulated accidents will remain within the boundaries discussed within the UFSAR, provided that the limitations setforth within this calculation are implemented as procedural controls.

This CCN is being performed in parallel with CCN N-2, which considers the drop of a consolidated canister onto cells containing CEAs.

Sheets 6A, 8, 292G, 292I, and 292L are revised.
Sheet 292M has been renumbered to 292Q.
Sheet 292N has been revised and renumbered to 292R.
Sheet 325 is voided and replaced by a new Sheet 325.
Sheets 6B, 8A, 8B, 292M thru 292P, and 325A through 325X (SHP 1/25/95) are added.

Note: This calculation does not contain any computations performed directly as part of a word processor. All calculations are performed using a hand held calculator and are manually typed.

REGISTERED PROFESSIONAL ENGINEER RAIMUND F. OSBORNE #C038574 Exp 3/31/97 CIVIL STATE OF CALIFORNIA

INITIATING DOCUMENT (DCP/MMP, FCN, OTHER SCE Calculation N-4072-001 Rev. 4

**2.** OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

☒ YES ☐ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

**3.** APPROVAL: DISCIPLINE/ESC: CIVIL

Scott H. Pellet SHP 51656 — ORIGINATOR (Print name/initial) PAX
[signature] 1/25/95 — GS (Signature)
OTHER (Signature)

JOEL T. REGALADO /JTR 86312 — IRE (Print name/initial) PAX
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**4.** ASSIGNED SUPPLEMENT ALPHA DESIGNATOR:

CONVERSION TO CCN DATE 3/6/95 — Tanya Castello — SCE CDM-SONGS

9610280176 961023
PDR ADOCK 05000361
P PDR

| REV | ORIGINATOR | DATE | IRE | DATE | REV | ORIGINATOR | DATE | IRE | DATE |
|---|---|---|---|---|---|---|---|---|---|
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| | S. Pellet | 1/13/95 | JTR | 1/17/95 | | | | | |

Gate Weight:

The gate is made from stainless steel plates with a rubber seal. The major components are summarized below:

| ITEM | SIZE | QTY | UNIT | WT lbs. |
|---|---|---|---|---|
| SS Plate | 3/4 x 28'-1" x 3'-5" | 1 | ~~32.123~~ 30.6 psf | ~~3082~~ 2936 |
| SS Plate | 3/4 x 4" x ~~22'-0"~~ 27'-6 | 2 | 10.21 p/f | ~~449~~ 561 |
| SS Plate | 3/4 x 4" x 2'-8.5" | 8 | 10.21 p/f | 221 |
| SS Plate | 7/8 x 8 x 3'-5" | 1 | 23.82 p/f | 81 |
| SS Clip Plates | 3/16 x 2" x 2" | 254 | 0.2127 # | 54 |
| Rubber Seals | 3/16" x 3" x 58'-6" | 2 | 1.25 p/f | 146 |
| Misc. Items | Bolts/Guide Rollers | Lot | | 150 |
| Rigging and load block | | Lot | | 465 |
| TOTAL | | | | ~~4648~~ 4614 |

Total Gate Wt = 4.6~~5~~1 Kips SAY 4.65K

Buoyant Gate Weight:

Consider the minimum allowable low water elevation for maximum impact weight.

Low water elevation $H_w$ = 57'-6"
Bottom elevation of gate before drop $H_G$ = 36'-4"

Top of gate is: Gate Length - ( Water Elev. - Drop Elev.)

[28'-7½"] - ( [57'-6"] - [36'-4"] ) = 7'-5½" out of the water

Gate is approximately 75% submerged before the postulated drop.

NOTE: Gate will not be totally submerged at the time of impact.

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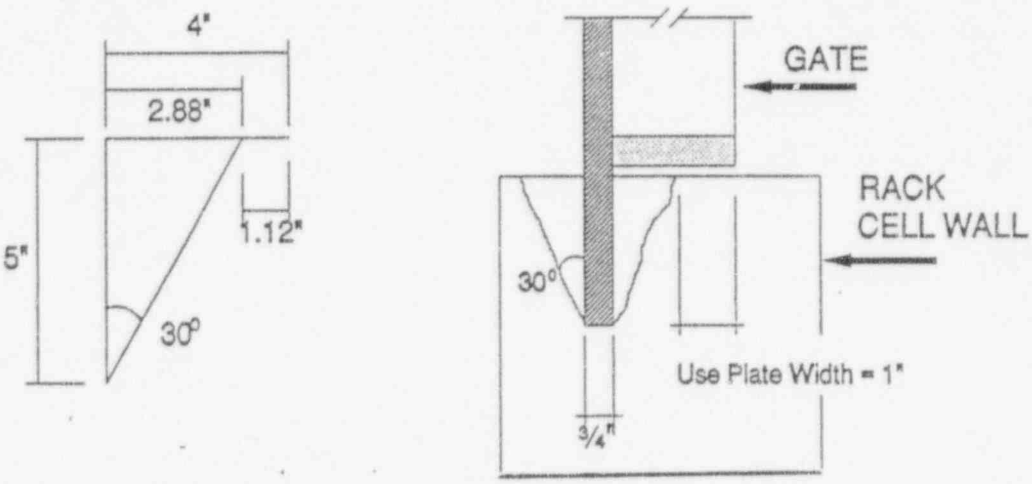
The load, $P_1$ ~~per inch depth~~, to cause plastic flow for 3/4" Plate:

$$P_1 = \frac{0.57\,F_y\,t\,w}{0.318} = \frac{0.57 \times 27{,}500\,psi \times 0.110\,in \times 0.75\,in}{0.318}$$

$$P_1 = 4067\ lbs.$$

The 3/4 inch plate has already penetrated the rack and continues to penetrate 5 inches below the 4" reinforcing plate. When the 4" wide reinforcing plate hits the top of the cell, the wall will already be damaged from the initial impact from the vertical plate. The damaged area will make approximately a 20 to 30 degree angle with the bottom of the vertical plate as it penetrates the wall. As such, only a fraction of the wall remains available for further energy absorption. Take an angle of 30° from the bottom of the vertical angle.




△

The load, $P_2$ ~~per inch depth~~, for 3/4 inch plate plus 1" of reinforcing plate: where w = 1.75 in.

$$P_2 = \frac{0.57\,F_y\,t\,w}{0.318} = \frac{0.57 \times 27{,}500\,psi \times 0.110\,in \times 1.75\,in}{0.318}$$

$$P_2 = 9489\ lbs.$$

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# CALCULATION SHEET

| ICCN NO./ PRELIM. CCN NO. N-3 | PAGE 10 OF 18 |
|---|---|
| | CCN CONVERSION CCN NO. CCN - 4 |

Project or DCP/MMP SONGS 2 & 3 Calc No. C-259-1.01.11

Subject Evaluation of Spent Fuel Pool for West. High Density Racks Sheet No. 292 L

| REV | ORIGINATOR | DATE | IRE | DATE | REV | ORIGINATOR | DATE | IRE | DATE |
|---|---|---|---|---|---|---|---|---|---|
| | D. M. SCHAFER | 4/22/94 | R. C. BLASCHKE | 4/22/94 | | | | | |
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Case 3: Secondary Impact

As the gate strikes the rack with the center of gravity over a bottom corner, there is a 50/50 chance of it falling over on its side toward the center of the spent fuel pool. The new drop height becomes the difference between the center of gravity from a standing position to that on its side.

Drop height = 343.5/2 - 41/2 = 151.25 inches

The gate will impact: 343.5 / 8.85 = 38 cell walls

The Resistive forces remain approximately the same as in Case 1, except that the reinforcing plate strikes at 3.5 inches (free edge on side) instead of 5 inches (Ref. [illegible]).

$$4295\ lbs \times (151.25 + d)\ in = 38 \times [406\ lbs \times 3.5\ in + 9489\ lbs \times (d - 3.5)\ in]$$

$d = 3.8\ in. < 13.2"$

OK

In this case up to 76 cells could be damaged. Again, no fuel assemblies would be impacted.

As the gate rotates, it will penetrate deeper into the first cell. For conservatism, let the gate rest flat at a depth of 9.5 inches from the angled drop in Case 2. As it rotates to 45 degrees, the corner will go deeper into the cell by 1/2 the cell width.

d = 9.5 + 8.85/2 = 13.9 inches > 13.2 inches

Hence, 1 fuel assembly may be directly impacted during the secondary impact. The cell walls will cause the corner of the gate to remain centered within the cell. It is therefore, not credible for this impact to occur between any cells such that a second fuel assembly could be damaged.

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Case 3: Spent Fuel Pool Gate Drop Secondary Impact

As the gate strikes the rack with the center of gravity over a bottom corner, there is a 50/50 chance of it falling over on its side toward the center of the spent fuel pool.

Subsequent to the initial impact, the gate could topple over onto the racks for a secondary impact. As the gate rotates, it will penetrate deeper into the first cell. For conservatism, let the gate rest flat at a depth of 9.5 inches from the angled drop in Case 2. As it rotates to 45 degrees, the corner will go deeper into the cell by 1/2 the cell width.

$$d = 9.5 + 8.85/2 = 13.9 \text{ inches} > 13.2 \text{ inches}$$

Hence, one fuel assembly may be damaged subsequent to the primary impact. The cell walls will cause the corner of the gate to remain centered within the cell. It is therefore, not credible for this impact to occur between any cells such that a second fuel assembly could be damaged. It is conservatively assumed that the impacted fuel assembly is damaged and releases all of its contained gases into the spent fuel pool.

There are many paths which the gate can topple through prior to the secondary impact. The secondary drop will conservatively be analyzed as a knife edge impact onto the top of the racks similar to the primary impact. A knife edge impact may be considered as worst case, since considering the gate to topple in its own plane and cut through the water to strike the top of the racks on edge will produce the least water friction and the greatest impact velocity.

| REV | ORIGINATOR | DATE | IRE | DATE | REV | ORIGINATOR | DATE | IRE | DATE |
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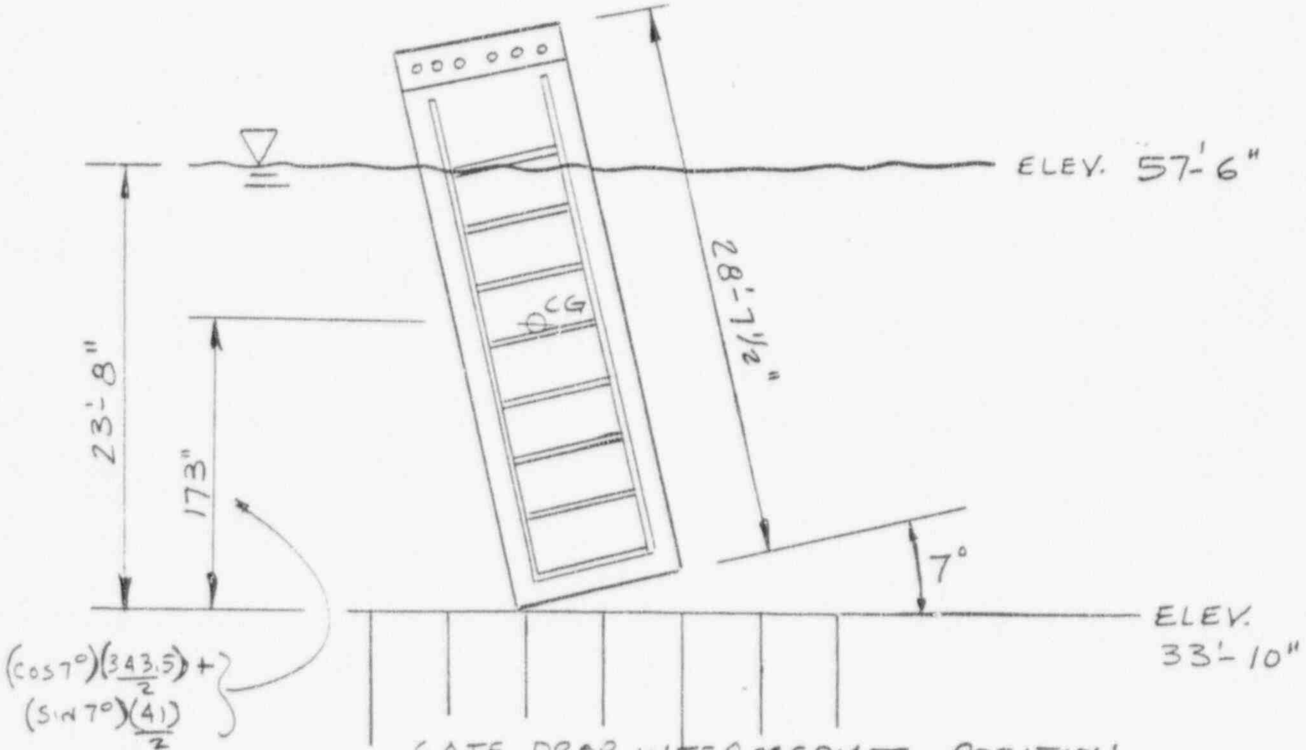
The sketch below provides the dimensions of concern to describe the secondary gate drop.

Note: The gate position shown below is subsequent to initial impact and prior to toppling. The initial penetration into the rack is neglected here providing a greater center of gravity height.




GATE DROP INTERMEDIATE POSITION

To simplify the analysis of this accident, the following conservative assumptions will be used as a basis for the model shown in the sketch below.

- The gate is in a horizontal position prior to its drop, and remains in this position throughout its entire drop duration.
- The gate is initially located with the top just below the surface of the water. This position is conservative, since it raises the gate's center of gravity much higher than the initial position subsequent to the initial impact previously postulated.
- The only drag to be considered will be for the front (leading) surface of the gate. The drag on the trailing lip (which would be nearly equal to the leading surface) and the skin friction will be neglected.

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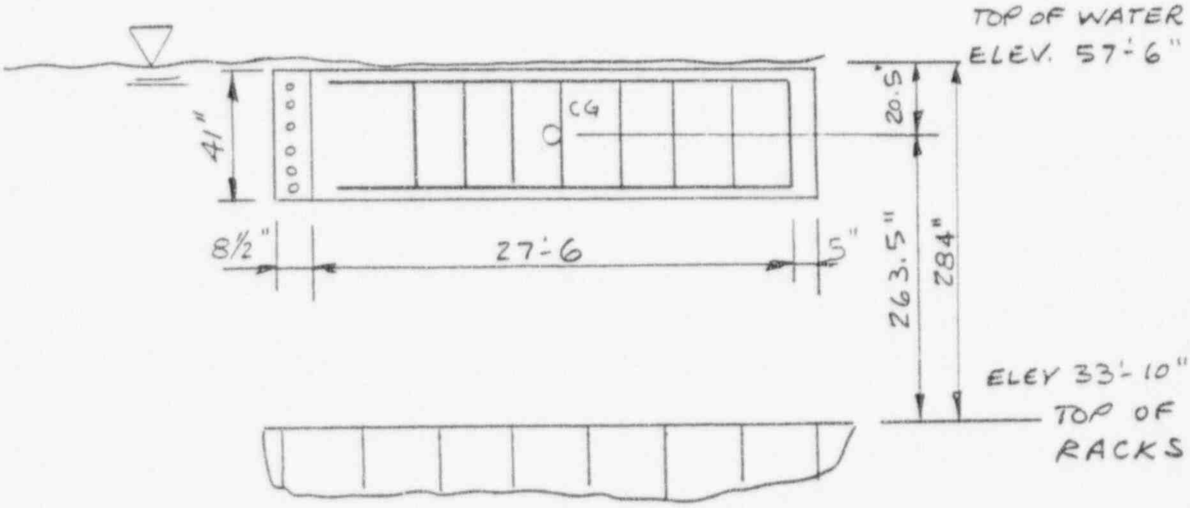
The sketch below shows the initial and final position of the gate as modeled and considering the assumptions stated above for the postulated secondary drop. This model will be conservative for the actual gate drop configuration. The elevation of the top of the racks will be taken to be 33'-10". This elevation is lower than the actual elevation, which is conservative, since the greater the drop distance is, the higher the kinetic energy will be.




GATE DROP MODEL

The methodology outlined in BC-TOP-9A [10], and previously used on sheets 288 through 292A, will be used to determine the impact velocity and kinetic energy of the gate. The weight of the gate will be taken as 4,650 lbs, as determined on sheet 292G, considering the rigging and load block.

The coefficient of drag ($C_D$) is 1.27, also given on sheet 288. This value is conservative due to the greater cross sectional area of the side of the gate compared to the bottom of the gate.

Since the gate is assumed to be completely submerged prior to dropping, the $V_1$ term is equal to zero. The remaining terms necessary to determine the velocity of impact with the racks are computed as follows:

$H = 284'' ; \quad L = 41''$

$$A_m = (27.5)\ ft\ \frac{(4.75)\ inches}{(12)\ inches/ft} = 10.89\ ft^2$$

$$a = \frac{\delta\ A_m\ C_D}{2W} = \frac{(0.0624)kips/ft^3\ (10.89)ft^2\ (1.27)}{2(4.65)\ kips.} = 0.0928\ /ft.$$

The terminal velocity is given by

$$V_2^2 = \frac{g}{a}\left(1 - \frac{\delta}{\delta_m}\right)$$

, where $\delta_m$ is given on page 288 as 0.49 k/ft.

$$V_2^2 = \frac{32.17}{0.0928}\left(1 - \frac{0.0624}{0.49}\right) = 302.5\ ft.^2/second^2$$

The impact velocity when the gate strikes the top of the racks is then given by the formula

$$V^2 = V_2^2\ (1 - e^{-2a(H - L)})$$

Plugging in values gives a velocity of

$$V = \sqrt{(302.5)\ \left(1 - e^{-2(0.0928)\frac{(284 - 41)}{12}}\right)}$$

$$= 17.2\ ft./second$$

The kinetic energy of the gate which must be dissipated by the rack during penetration will be

$$K.E. = \frac{1}{2}\ MV^2 = \frac{(4650)\ lbs.\ (17.2)^2\ ft.^2/second^2}{2(32.17)ft./second^2} = 21,400\ ft\text{-}lbs.$$

$$= 256,800\ inch\text{-}lbs.$$

The gate overall height is approximately 343.5". This dimension can be used to determine the number of storage rack cell walls which will be impacted by the secondary drop of the gate. Region II racks will control, since there is only one cell wall between assemblies. The number of cell walls which will be impacted is given by:

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# CALCULATION SHEET

| ICCN NO./ PRELIM. CCN NO. N-3 | PAGE 15 OF |
|---|---|
| CCN CONVERSION CCN NO. CCN - 4 | |

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Subject Evaluation of Spent Fuel Pool for West. High Density Racks Sheet No. 292P

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$$\frac{343.5}{8.85} = 38 \text{ cell walls}$$

, where 8.85" is the cell center to center spacing in a region II storage rack.

The depth of rack penetration will be determined using the methodology employed on sheet 292J as

$$d = \frac{256{,}800 \text{ inch-lbs.}}{(38) \text{ cell walls } (4{,}067) \text{ lbs/cell wall}} = 1.67 \text{ inches}$$

Since this calculated penetration value is conservative and is less than the 13.2" dimension from the top of the racks to the top of fuel, there will be no fuel impacted by the secondary drop. Therefore, storage of standard fuel is acceptable in the secondary impact of the gate drop.

See sheet 325P for a discussion of CEA storage provisions within the secondary impact zone of the gate.

CHECK GATE STIFFENER PLATE

It was assumed that the gate remains rigid when the 3/4 x 4" stiffener plate impacts the rack. The stiffener plate should resist the force applied by the rack cell.

$$P_1 = \frac{0.57\ F_y\ t\ w}{0.318} = \frac{0.57 \times 27{,}500\ psi \times 0.110\ in \times 1.00\ in}{0.318}$$

$P_1$ = 5422 *lbs.*

Check stiffener as a cantilever plate:

M = 5422 x 4" = 21.7 K-in

Cell spacing = 8.85 in.

$S = 8.85 \times (.75)^2 / 6 = 0.83\ in^3$

$f_b = M/S = 26.1$ Ksi < $.75\ F_y$ = 27 Ksi OK

Check Weld:

P = 5422 / 8.85" = 613 #/in.

Weld provided = 3/8" Fillet 2" Length every 6" both sides(Ref. 19)

Weld capacity (Ref. 21, AWS D412, E60XX)

$P_w$ = ( 2 x 2" / 6" ) x 4.77 k/in

= 3.18 K/in > 0.6 K/in

OK

Therefore, the stiffener plate is okay.

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# CALCULATION SHEET

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| ICCN NO./ PRELIM. CCN NO. ~~N-1~~ N-3 | PAGE ~~15~~ 17 OF 18 |
| | CCN CONVERSION CCN NO. CCN - ~~2~~ 4 |

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Subject Evaluation of Spent Fuel Pool for West. High Density Racks Sheet No. 292 N

| REV | ORIGINATOR | DATE | IRE | DATE | REV | ORIGINATOR | DATE | IRE | DATE |
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| △ | S. Pellet | 1/13/95 | JTR | 1/17/95 | | | | | |

Sheet 293 Follows

GATE DROP ON SPENT FUEL RACK CONCLUSIONS

The gate can strike and damage a single fuel assembly during a drop scenario. The rotation of the gate after an initial impact will cause the gate to touch a fuel assembly. Since the cell walls will keep the gate corner centered within the cell there is no chance that another assembly could be affected. The cell walls above the assemblies may be damaged in as many as 76 cells. This will make removal of fuel assemblies in those cells very difficult. Adjacent cells may also experience some deformations resulting in assemblies being stuck within the racks. This is considered acceptable since the fuel assemblies will remain intact.

This calculation is based on all fuel assemblies being at or below 13.2 inches from the top of the rack. Fuel assemblies should not be stored on spacers while the gate is being removed or installed to ensure only one assembly could be damaged. (That is, no fuel or reconstitution spacers.)

There will not be gross deformations in the body of the rack that would alter the center to center spacing of the fuel assemblies. As such, fuel criticality for the spent fuel assemblies in the vicinity of the damaged rack cells would not be adversely affected.

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# CALCULATION SHEET

| ~~ICCN NO.~~ PRELIM. CCN NO. N-3 | PAGE 18 OF |
|---|---|
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Subject Evaluation of Spent Fuel Pool for West. High Density Racks Sheet No. 292R

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| | D. M. SCHAFER | 4/22/94 | R. C. BLASCHKE | 4/ /94 | | | | | |
| △ | S. Pellet | 12/6/94 | JTR | 12/6/94 | | | | | |

Sheet 293 Follows

GATE DROP ON SPENT FUEL RACK CONCLUSIONS

The gate can strike and damage a single fuel assembly during a drop scenario. The rotation of the gate after an initial impact will cause the gate to touch a fuel assembly. It is conservatively assumed that the impacted fuel assembly is damaged and releases all of its contained gases into the spent fuel pool. △

Since the cell walls will keep the gate corner centered within the cell during toppling to a second impact there is no chance that another assembly could be affected. The cell walls above the assemblies may be damaged in as many as 76 cells. This will make removal of fuel assemblies in those cells very difficult. Adjacent cells may also experience some deformations resulting in assemblies being stuck within the racks. This is considered acceptable since the fuel assemblies will remain intact. △

There will not be gross deformations in the body of the rack that would alter the center to center spacing of the fuel assemblies. As such, fuel criticality for the spent fuel assemblies in the vicinity of the damaged rack cells would not be adversely affected. △

For a discussion of the gate drop evaluation with consideration of CEAs within the impact areas, see sheets 325~~D~~L through 325~~H~~P. △