October 7, 1996

LICENSEE: Niagara Mohawk Power Corporation

FACILITY: Nine Mile Point Nuclear Station Unit No. 1

SUBJECT: TRIP REPORT REGARDING AUGUST 20, 1996, AUDIT OF REACTOR AND TURBINE BUILDING BLOWOUT PANEL CALCULATIONS (TAC NO. M94858)

On August 20, 1996, three members of the NRC staff from the Office of Nuclear Reactor Regulation visited Nine Mile Point Nuclear Station Unit No. 1, to review the licensee's calculations for blowout panels in the Reactor and Turbine Buildings. Participants for the NRC staff were Messrs. M. Hartzman, D. Jeng, and D. Hood. Participants for the licensee are listed in Enclosure 1.

This technical audit is associated with NRC Special Inspection Report No. 50-220/96; 50-410/96-05 and Licensee Event Report 96-05 which addressed deficiencies in the construction of the panels and in the licensee's earlier engineering calculations for the resolution of these deficiencies. The Inspection Report contained a number of technical questions regarding the deficiencies and calculations. Following discussions with NRC technical staff, the licensee revised the previous calculations and summarized the results in a letter dated July 3, 1996. Of particular interest during the audit were the revised calculations to establish maximum blowout pressures for the currently installed panel configurations and the minimum capability of the buildings to withstand the results of high energy line breaks outside containment.

Enclosure 2 is a summary of this audit, including a list of action items identified during the audit to be completed by the licensee.

Sincerely,

(Original Signed By)

Darl Hood, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-220

Enclosures: 1. Licensee participants
2. Audit summary

cc w/encls: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 7, 1996

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Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-220

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cc w/encls: See next page

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Nine Mile Point Nuclear Station
Unit No. 1

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August 20, 1996

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A. Zallnick

M. Alvi

M. Amin (Sargent & Lundy)

C. Stroup

Enclosure 1

SUMMARY OF AUDIT OF BLOWOUT PANEL CALCULATIONS

AT NINE MILE POINT NUCLEAR STATION UNIT NO. 1

On August 20, 1996, Messrs D. Jeng, M. Hartzman and D. Hood of the NRC's Office of Nuclear Reactor Regulation visited Nine Mile Point Nuclear Station Unit No. 1, to audit calculations performed by Niagara Mohawk Power Corporation (the licensee) regarding the relief (blowout) panels in the Reactor and Turbine Buildings. Of particular interest were the licensee's calculations to determine the highest blowout pressures of the panel bays as currently installed, and the lowest failure pressure capacities of the buildings.

In the Reactor Building, the blowout panel bays measure 19 feet in width and 44 feet in height. Each bay consists of 24 inch horizontal panels of metal decking, bolted horizontally to vertical building columns and interlocked vertically by crimped side joints. The bays in the Reactor Building are also bolted at the top and bottom.

In the Turbine Building, the bays measure 20 feet by 20 feet, and consist of panels that are otherwise similar to those of the Reactor Building. However, the bays in the Turbine Building are not bolted at the top.

Since the bays in the Reactor Building are bolted on all four sides, they essentially act as two-way orthotropic plates. In the analysis of these bays, the licensee assumed that these bays act essentially in one direction. The licensee based this assumption upon the premise that the crimped joints between the panels cannot transmit in-plane forces, bending, and shear loads except at very low values of transverse pressure. Therefore, the licensee considers that the panels cannot be considered as two-way plates. The NRC staff reviewed the licensee's calculations supporting this assumption, and concluded, based upon a comparison with its own independent calculations, that this assumption is valid. The pressure at which the crimped joints open was determined by the NRC staff to be greater than that calculated by the licensee, but both values are much lower than the blowout pressure of the panel. This issue did not need to be considered for the Turbine Building bays, since these are not bolted at the top.

The NRC staff reviewed the calculation of the largest blowout pressure of the panels for both buildings. These calculations were performed considering the panels as simply supported beams. The licensee used an elliptic interaction equation for the bolts. Based upon its own independent calculations, the NRC staff concluded that these blowout calculations are acceptable and, therefore, that the licensee had calculated acceptable blowout pressures for the bays in both buildings.

Enclosure 2

To analyze the minimum failure capacities of the Reactor and Turbine Building super-structures, the licensee used detailed COSMOS models to represent the structures and applied dead load and a reference internal pressure load of 93 pounds per square foot (psf). In the COSMOS model, the FKX steel siding is considered to provide continuous lateral-torsional support to column flanges of the structures. The licensee used yielding strength based upon minimum values from available mill certifications in evaluating the lower bound structural capacities. The analysis indicated that the pressure capacities for the structures were controlled by a roof bracing and a critical vertical column. The AISC Steel Construction Manual was used to determine the lower bound capacities of 143 psf and 135 psf for the Reactor Building and Turbine Building, respectively. These capacities are shown to be greater than twice the maximum computed blowout panel capacities of 65 psf (Reactor Building) and 62 psf (Turbine Building), and are, therefore, acceptable to the NRC staff.

During the audit, the NRC staff found that the linear scaling method that the licensee used to obtain the pressure capacities of the structures from the COSMOS computer analysis results needs minor adjustment in order to provide correct results. The structural dead load should not have been scaled. However, the NRC staff believes that the adjustment should not appreciably affect the computed structural capacities and change the conclusion drawn above. The licensee agreed with the NRC staff's view and committed to promptly implement the needed adjustment identified by the NRC staff and submit the revised results upon completion.

The licensee included a strain rate factor in the calculations to determine the pressure capacity of the Reactor and Turbine Buildings. The NRC staff found that use of a strain rate factor is inappropriate in that strain rate is valid only for rapidly-applied loads such as those associated with high explosives. However, the NRC staff also observed from the calculation that the contribution due to strain rate is small and not needed to meet the licensee's criteria.

NRC schedular constraints precluded completion of the staff's audit of calculations by the licensee and its contractor, Sargent & Lundy, regarding the consequences of a blowout panel striking the Turbine Building roof above the condensate storage tank after a high energy line break inside the Reactor Building. The licensee provided copies of these calculations (see attachment) to the NRC for subsequent completion of the audit. The NRC staff will advise the licensee of the results of this audit by separate correspondence upon review completion.

<u>Summary of Licensee Action Items From Exit Meeting</u>

A exit meeting was held at the conclusion of the audit. Licensee management, Mr. C. Terry, noted agreement with the NRC staff observations during the audit. However, with respect to the discussion of strain rate, Mr. Terry stated that this influence will be retained in the calculations but will not be included in the results to be presented in the next Updated Safety Analysis Report.

During the exit meeting, the licensee stated its intent to take the following actions:

- Adjust the linear scaling method used to obtain pressure capacities of both the Reactor and Turbine Buildings and submit the revised analysis results

- Eliminate the use of strain rate effect in establishing the Fy value used in capacity evaluation for the upcoming USAR

- Provide a paragraph justifying why it is conservative to use the mean minus one standard deviation for the value of Fy

- Further explain the basis for using 0.62 tension allowable as the shear allowable, and further discuss the available test data

- Provide a written rationale for selecting the number of bolts tested

- Explain why the type of stitch welds used justifies the rigid assumption for the angle to column joint connection

- Provide a written discussion of the code reconciliation effort previously implemented in the area of AISC design and acceptance criteria

Attachment:
Calculation S4 RX340 Misc. 01, Rev. 0, "RB Blowout Panel Impact on TB Roof" with attached Sargent & Lundy letter of June 4, 1996, regarding independent review of this calculation

NIAGARA MOHAWK NUCLEAR ENGINEERING

CALCULATION COVER SHEET

Page 1 (Next 2)
Total 15
Last A4 OF ATT.A

Project: NINE MILE POINT NUCLEAR STATION   Unit (1,2 or 0=Both): 1   Discipline: STRUCTURAL

Title	Calculation No.			
RB BLOW OUT PANEL IMPACT ONTB ROOF	S4 RX340 MISC 01			
	(Sub)system(s)	Building	Floor Elev.	Index No.
	N/A	RB	340	S4

Originator(s)
C.R. ACOSTA

Checker(s)/Approver(s)
CE Stroup / MOHAMMED ALVI

Rev	Description	Design Change No.	Prepared By	Date	Chk	Date	App	Date
00	INITIAL ISSUE	N/A	CA	5/12/96	CES	5-20-96	M.A	5/20/96

Computer Output/Microfilm separately filed? (Yes/No/N/A) NO   Safety Class: (SR/NSR/Qxx): SR

Superseded Document(s): NONE

Document Cross Reference(s) - For additional references see page(s) NONE

Ref No.	Document No.	Type	Index	Sheet	Rev	Ref No.	Document No.	Type	Index	Sheet	Rev

General References:
SEE PAGES 2 & 3

Remarks:
NONE

Confirmation Required (Yes/No): NO
See Page(s):

Final Issue Status (APP/FIO/VOI): APP

File Location (Calculation/Hold): CALC

Operations Acceptance Req'd (Yes/No): N

Safety Evaluation Number(s)/Revision:
Copy of Applicability Review Attached? Yes ___ N/R ✓

Component ID(s)/EPN(s)/Line Numbers:
N/A

Key Words: STRUCTURAL, BLOW OUT PANELS IMPACT LOADS

Attachment

(NEP-DES-08-F01-00)

NIAGARA MOHAWK
NUCLEAR ENGINEERING

CALCULATION CONTINUATION SHEET

Project: NINE MILE POINT NUCLEAR STATION Unit: 1

Originator/Date	Calc. No.	Rev
A 5/12/96	S4RX340 MISC 01	00

Checked	Date	Disposition
CGS	5-17-96	

Ref.

PURPOSE: DETERMINE IF THE REACTOR BUILDING (RB) BLOW-OUT PANEL WILL PENETRATE THE TURBINE BUILDING (TB) AUX. EXTENSION ROOF STRUCTURE. (PANELS WILL GET BLOWN OFF DUE TO PRESSURIZATION LOAD BECAUSE OF A HIGH ENERGY LINE BREAK IN RB).

ASSUMPTIONS:

1. IMPACT CRITERIA HAS MAINLY BEEN DEVELOPED ON AN EMPIRICAL BASIS FROM CORRELATING AVIALABLE TEST DATA.

2. THE SIZE OF A BLOW-OUT PANEL SECTION IS 19'-2" X 20'-0". THIS SECTION HAS A 3X2X1/4 ANGLE ATTACHED TO THE 20' SIDES. THE FOUR BOLTS, TWO IN THE ANGLE SPLICE SECTION AND TWO ATTACHING TO THE Q DECK, WILL FAIL. TYP.

3. THE BLOW-OUT PANEL SECTION IS CONSIDERED A LARGE DEFORMABLE BODY.

4. HEIGHT OF FALL IS 46' ($\underbrace{360}_{\text{20' ABOVE 340' EL.}} - \underbrace{314}_{\text{ROOF EL.}} = 46'$)

REFERENCES:

1. BECHTEL POWER CORP. DESIGN GUIDE C-2.45, REV. O, DESIGN OF STRUCTURES FOR TORNADO MISSLE IMPACT (FORMULAE NOT USED)
2. MANUAL OF STEEL CONSTRUCTION, AISC 8TH ED.
3. H. H. ROBERTSON Q-FLOOR SYSTEMS, Q-LOCK FLOOR, Q-AIR FLOOR 1964
4. MANUAL OF STEEL CONSTRUCTION, AISC 6TH ED.

NIAGARA MOHAWK NUCLEAR ENGINEERING	CALCULATION CONTINUATION SHEET	Page 3

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CA 5/9/96	S4RX340MISC01	00

Checked	Date	Disposition
CSS	5-17-96	

Ref. REFERENCES (CONT.)

5. H. H. ROBERTSON CO. DRAWING EP-1, REV 9
" " " " EP-14, REV. 1
" " " " EP-40, REV. 1
" " " " EP-44, REV. 0
" " " " EP-45, REV. 0
" " " " EP-32, REV. 1

(NEP-DES-340-F2-00)
FORM #NEP-DES-340-2-042492

812-062 R01-92
SYMBOL NO. 55-10-135

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NUCLEAR ENGINEERING

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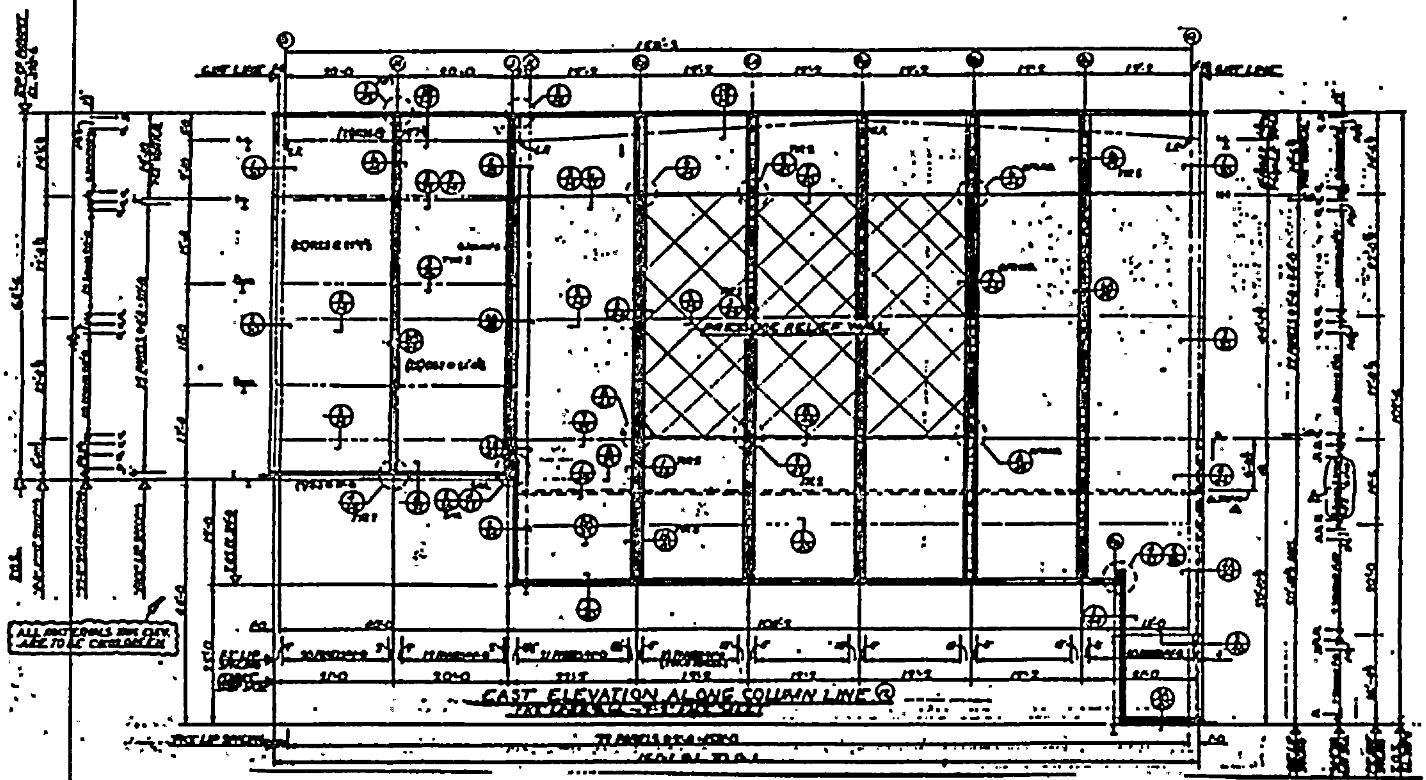

#5

REF. DWG. EP-32
(INFORMATION ONLY)

BLOW-OUT PANEL DIMENSIONS: 19.17' x 44.13': 2-20' SECTION & 1-4' SECTION

PANEL DEAD WEIGHT

THIS PANEL IS CONSTRUCTED OF A 3x2-1/4 STRUCTURAL ANGLE, EACH 20' SIDE, WITH 2'-0" WIDE FKX 16/16 H.H. ROBERTSON Q-DECK. THE OPEN Qs ARE FILLED WITH LOOSE INSULATION. THE EXTERIOR PANEL IS A 16GA. ALUMINUM F-2 PANEL.

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DEAD WEIGHT (DW)

	WEIGHT (lbs)
3x2-1/4 ANGLE: 40' x 4.1 lb/ft =	164
FKX16/16 PANELS: 19.17' x 20' x 8.4 lb/ft² =	3221
LOOSE INSULATION: 1½" t	100
EXTERIOR PANEL: 19.17' x 20' (0.0635"/12"/1 x 165 lb/ft³) THICKNESS-16GA, DENSITY OF AL	335
MISC (SCREWS, etc)	25
	3845 SAY 3900

$\boxed{DW = 3.9^K}$

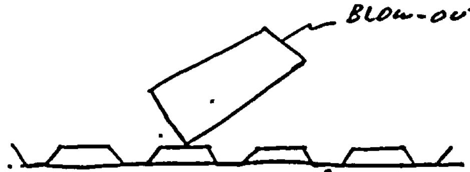
DETERMINE STRIKING FORCE (F_S)

ASSUME A DYNAMIC LOAD FACTOR (LF) = 3 BASED ON USING A LF = 2 AT NO APPRECIABLE DROP IN HEIGHT (BLODGETT)

$F_S = 3 \times 3900 = 11700 \text{ lbs} = 11.7^K$

ROOF STRUCTURE

Q DECK NKX 18/16



ASSUMPTIONS:

1. THE BLOW-OUT PANEL STRIKES THE NKX DECKING ON ONE EDGE
2. THE PANEL IS RIGID; IN ACTUALLITY, THE PANEL WILL DEFORM.
3. THE ROOF FELTS & RIGID INSULATION WILL ABSORB NO LOAD; IN ACTUALLITY, THESE ELEMENTS WILL ABSORB SOME LOAD. TYPO

NIAGARA MOHAWK
NUCLEAR ENGINEERING

CALCULATION CONTINUATION SHEET

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4. THE IMPACT AREA IS A 3X2" (THE WIDTH OF THE OUTSIDE ANGLE) $= 6\ IN^2$

NKX 18/16

TOTAL THICKNESS $(t) = 0.0478 + 0.0598 = 0.1076''$ (18GA, 16GA)

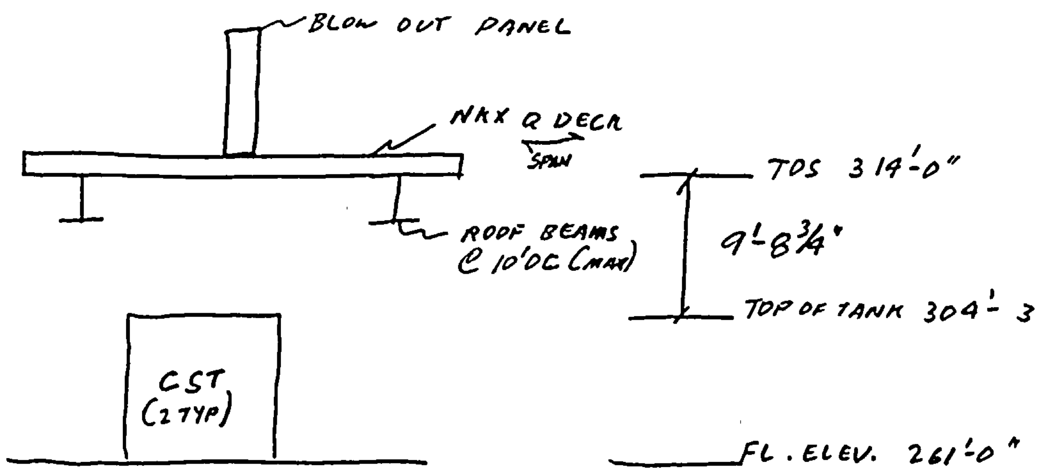
$F_Y = 33\ KSI$ (REF ASTM A 446, GRADE A-ASSUMED)

$F_{U_{ALL}} = 1.6 \times F_Y = 1.6 \times .4 \times 33 = 21.1 KSI$ WHERE 1.6 IS FROM NRC SRP & AISC SAFETY FACTOR TO AN ALLOWABLE STRESS

PUNCHING SHEAR (V_c)

$$V_c = t\,A_I\,F_U = 0.1076'' \times 6 in^2 \times 21.1 ksi = 13.6\,K > 11.7^K \therefore$$

THE BLOWOUT PANEL WILL PENETRATE A SMALL LOCAL AREA BUT WHEN THIS AREA IS EXPANDED TO 3", THE Q DECK WILL DEFORM AND WILL SUFFER DAMAGE. HOWEVER THE CONDENSATE STORAGE TANKS WILL NOT BE DAMAGED AS THE BLOW-OUT PANEL WILL NEVER STRIKE THESE TANKS. (SEE ILLUSTRATION BELOW)



NIAGARA MOHAWK NUCLEAR ENGINEERING — **CALCULATION CONTINUATION SHEET** — Page 7

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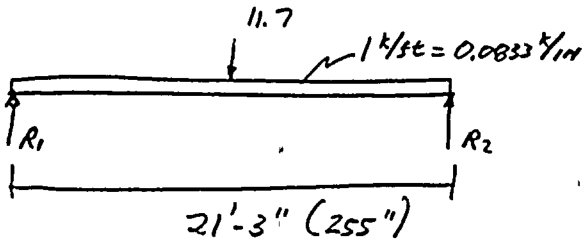
	CHECK ROOF STEEL

14 WF 30 (WORSE CASE)

LOADS DW = 25 psf (FKX 18/16, FELTS, etc)
LL = 75 psf (NMPC DWG. C18717C, R/20)
TOTAL 100 psf

$w = 10' \times 100\,psf = 1^k/ft$ (10 O.C., REF NMPC DWG C15328C SHT. 1 R/4)

$P = 11.7^k$ (STRIKING FORCE OF BLOW-OUT PANEL AT CENTER OF BEAM)



$R_1 = R_2 = \frac{11.7^k}{2} + \frac{1.03^k/ft \times 21.25'}{2} = 16.8^k$

$M = \frac{11.7^k \times 255''}{4} + \frac{0.0833\,k/in \times (255'')^2}{8} + \frac{0.030\,k/ft \times (255'')^2 \times 1/12}{8}$

$M = 745.9\,in\text{-}k + 677.1\,in\text{-}k + 20.3\,in\text{-}k = 1443\,in\text{-}k$

#4 1-15 $M_p = F_y Z = 36 \times 47.2\,in^3 = 1699$

$M_p > M$ THEREFORE, THE BEAM WILL DEFORM BUT NO CATASTROPHIC FAILURE WILL OCCUR.

END CONNECTION

3 - 7/8" ϕ ASTM A-325 BOLTS (REF. DWG C15326C SHT 2 c C15330C SHT. 1)

CAPACITY = 3 BOLTS × 18.04 k/BOLT = $54.1^k > 11.7^k + \frac{1.03 \times 21.25}{2} = 22.6^k$

- DBL. SHEAR, THDS IN SHEAR PLANE (CONSERVATIVE) AISC 6TH ED PG. 4-4

PANEL STRIKING CONNECTION

NIAGARA MOHAWK NUCLEAR ENGINEERING

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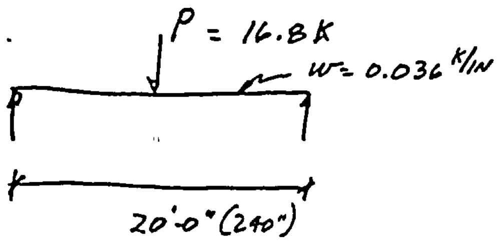
16 WF 36 GIRDER



$P = R_1 = R_2 = 16.8^K$

CONNECTION CAPACITY IS AT LEAST THE CAPACITY OF THE 14WF30 = 54.1^K > 16.8^K + 0.4 = 17.2^K

$$M = \frac{16.8^K \times 240''}{4} + \frac{0.036^{K/ft} \times (240'')^2 \times \frac{1}{12}}{8} = 1030 \text{ k-in}$$

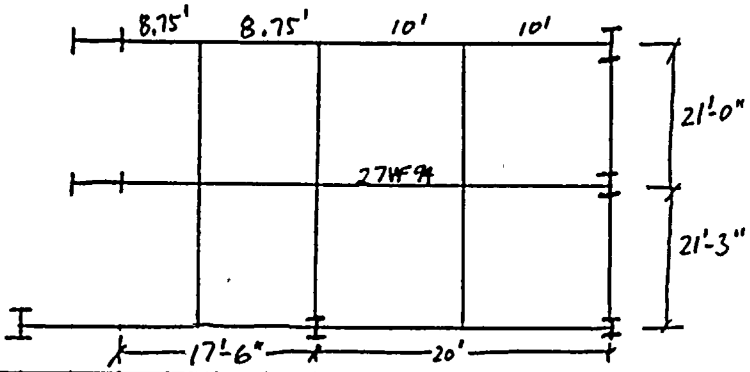
#4 11 $S = 56.3 \text{ in}^3$

LATERAL SUPPORT IS 5'O.C. w/ 3/8" STIFF. PL & A 12C20.7 SECTION WELDED TO TOP FLANGE (REF. DWG 45266C SECTION 3-3)

$$f_b = \frac{1030}{56.3} = 18.3 < 0.6 \times 36 = 21.6 \quad \therefore OK.$$

THEREFORE, THIS GIRDER WILL NOT YIELD NOR FAIL DUE TO THE LOADING CONDITIONS SPECIFIED.

27 WF 94 GIRDER



(NEP-DES-340-F2-00)
FORM #NEP-DES-340-2-042492

812-062 R01-92
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NIAGARA MOHAWK
NUCLEAR ENGINEERING

CALCULATION CONTINUATION SHEET

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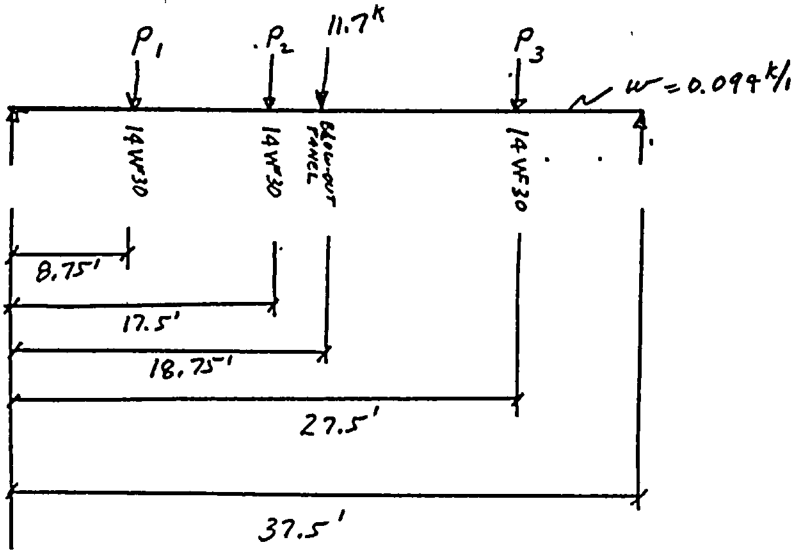

$P_1 = 8.75' \times 100\,psf = 875\ ^{lb}/_{ft}\,;\ 0.875\ ^{k}/_{ft}\left(\frac{21.25'}{2} + \frac{21'}{2}\right) + 0.030(21.13')$ (21.13')

$= 18.49^k + 0.634^k$

$P_1 = 19.1^k$

$P_2 = (4.375' + 5')\,100\,psf = 0.94\ ^{k}/_{ft} \times 21.13' + 0.634^k$

$P_2 = 19.862 + 0.634 = 20.5^k$

$P_3 = 10' \times 100\,psf = 1\ ^{k}/_{ft} \times 21.13' + .0634^k$

$P_3 = 21.13 + 0.634 = 21.8^k$

Project: *NINE MILE POINT NUCLEAR STATION* Unit: 1

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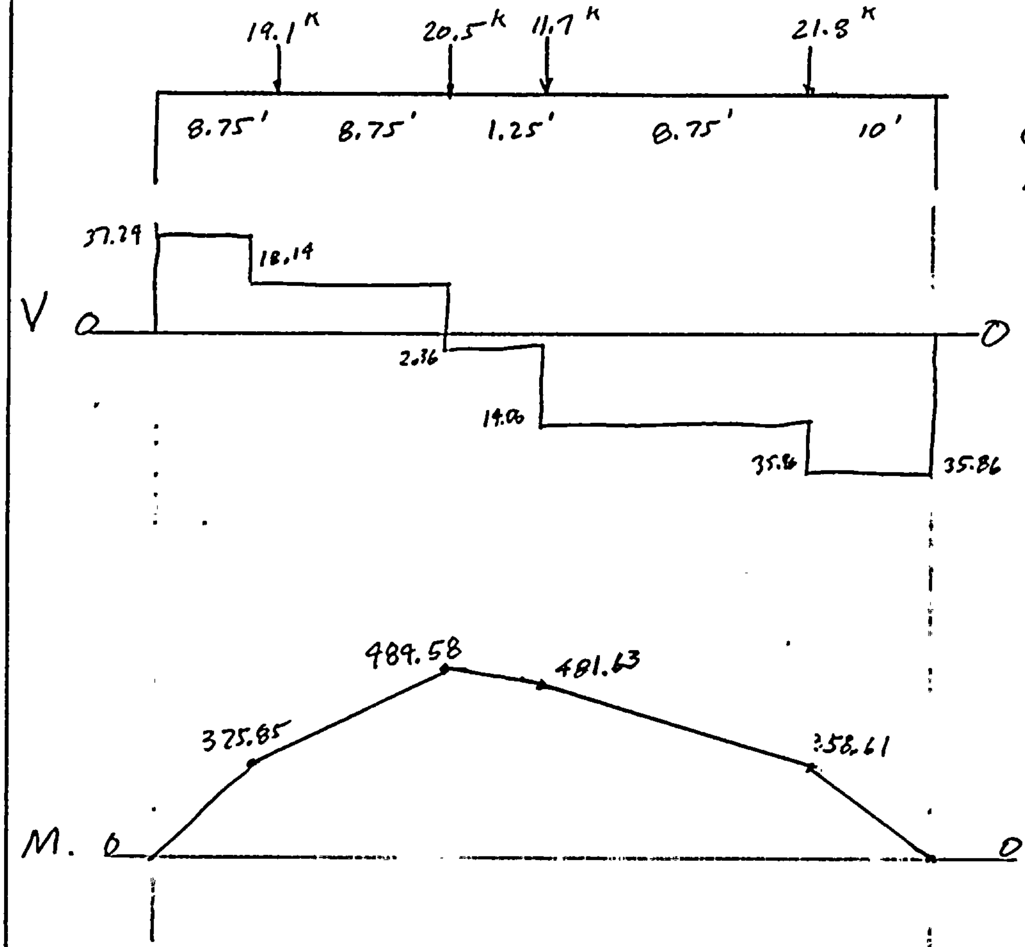


CONNECTION CAPACITY IS AT LEAST THE CAPACITY OF THE 14 WF30 = 54.1 k > 37.5 k

$37.5 R_2 = 8.75' \times 19.1^k + 17.5' \times 20.5^k + 18.75' \times 11.7^k + 27.5' \times 21.8^k$

$R_2 = \frac{1344.75}{37.5} = 35.86'$ $R_1 = 19.1 + 20.5 + 11.7 + 21.8 - 35.86 = 37.24^k$

$M_{MAX} = 484.58 \text{ ft-k} \times 12''/1 + \frac{0.094^k/1 \times (37.5')^2}{8} \times 12''/1 = 6013 \text{ K-IN}$

$M_p = 36 \times 278 = 10008 \text{ IN-k} > 6013$ ∴ THE GIRDER WILL DEFORM BUT NO CATASTROPHIC FAILURE WILL OCCUR.

NIAGARA MOHAWK NUCLEAR ENGINEERING	CALCULATION CONTINUATION SHEET	Page 11

Project: NINE MILE POINT NUCLEAR STATION Unit: 1

Originator/Date		Calc. No.	Rev
A 5/9/96		S4RX340MISC01	00
Checked CES	Date 5-20-96	Disposition	

Ref.

CONCLUSIONS

* WILL PENETRATE A SMALL LOCAL AREA BUT WILL NOT COLLAPSE.

THE ROBERTSON Q-DECK WILL FAIL* DUE TO THE BLOW-OUT PANEL IMPACT LOAD. HOWEVER, THE CONDENSATE STORAGE TANKS WILL NOT BE IMPACTED.

THE ROOF BEAM WILL YIELD BUT WILL NOT FAIL.

THE 16WF36 ACTUAL YIELD IS UNDER ALLOWABLE. THE 27WF94 GIRDER WILL YIELD BUT WILL NOT FAIL.
THEREFORE, THE BLOW-OUT PANELS IMPACTING THE TB AUX EXTENSION ROOF WILL NOT IMPACT THE CSTs.

ATTACHMENT A
CALC NO S4-RX340MISC01
REVISION 0
PAGE NO A-1

Sargent & Lundy LLC

Don K. Schopfer
Vice President
312-269-6078

June 4, 1996
Project No. 8934-34

Niagara Mohawk Power Corporation
Nine Mile Point - Unit 1

Independent Review of Calculations
Calc. #S4 TB300 Bldg. 01, Rev. 0
Calc. #S4 RX340 Misc. 01, Rev. 0

Mr. Mohammed Alvi
Supervisor, Civil and Structural, Unit 1
Niagara Mohawk Power Corporation
Lake Road, Engineering Services Building
Lycoming, New York 13093

Dear Mr. Alvi:

At your request, an independent review of the subject calculations was performed by Mr. Y. Singh at your office on 05/20/96 through 05/23/96. Preliminary analysis results were reviewed and discussed with your staff engineers Mr. C. Stroup and Mr. C. Agosta.

Final Calculation #S4 TB 300 Bldg. 01, Rev. 0 was received on 06/03/96. The subject calculations are found to be acceptable. A summary of our independent review is noted below:

1. Independent Review of Calc # S4 TB 300 Bldg 01, Rev. 0, "Evaluation of Turbine Building above EL. 300' for 125 PSF Internal Pressure".

   Turbine building super structure steel is modeled using beam and truss finite elements in COSMOS/M computer program.

The finite element model uses proper support boundary conditions. The column base is supported at the floor EL. 300' using fixed transnational degree of freedom. Rotational degree of freedom is released using member end release. This is appropriate to account for the base connection which is intended to be more of a pin connection than a fully moment resisting connection. Also, it is conservative to use pin connection at the column base to maximize the column moment for pressure load capacity evaluation. Dead weight of the structure, the element material properties, and applied pressure loading of 125 psf are properly included in the finite element model analysis.

During our independent review at your office, the preliminary computer analysis model and results were reviewed with Mr. C. Stroup. Upper portion of column properties and column axis orientation were incorrect in the initial computer runs. Also, Column Row 17 and Column Row 1 results (displacements) were reviewed for consistency. These minor inconsistencies were corrected and a final analysis was made on 05/25/96.

This computer run along with final calculations have been reviewed and found to be acceptable for a pressure capacity of 135 psf at failure. The calculated ultimate pressure capacity is conservative since it includes the capacity reduction factor. The use of plastic section modulus to estimate the ultimate failure load is acceptable in combination with the elastic analysis.

2. Independent Review of Calc. #S4 RX340 Misc 01, Rev. 0, "RB Blowout Panel Impact on TB Roof".

   This calculation concludes that the roof deck will fail (perforate) due to blowout panel impact and the roof beams will yield but will not fail and thus the Condensate Storage Tanks will not be impacted. As part of independent review, this conclusion is confirmed by an alternate approach using energy balance method as described in Attachment A.

If you have any questions regarding this independent review report, please feel free to contact me.

Yours very truly,

[signature] for D.K. Schopfer

D. K. Schopfer
Project Director

DKS:spr
Attachment
Copies:
D. M. Wright
Y. Singh

ENERGY BALANCE APPROACH

ATTACHMENT A
~~PAGE 1/1~~

Reference Calc. # 54RX340 MISC01, REV. 0

ATTACHMENT A
CALC NO ~~54RX340 MISCφ1~~
REVISION ~~0~~
PAGE NO ~~A-3~~

RB Blowout Roof Panel D.Wt. $= 3.9^K$

Height of fall $= 46'$

Velocity at impact $V = \sqrt{2gh} = \sqrt{2 \times 32.2 \times 46} = 54.43^{FT/SEC}$

Kinetic Energy $= \frac{1}{2} m v^2 = \frac{1}{2} \times \frac{3.9}{32.2} \times 54.43^2 = 179.4$ K.FT.

As stated in Ref. Calc. Page 2, the blowout panel section is considered a large deformable body. Assuming a large portion of the kinetic energy will be absorbed in the deformation of the blowout panel itself. In addition the air resistance will reduce the initial kinetic energy.

- Force due to air resistance $F = \frac{1}{2} \underbrace{\rho}_{\text{Air Mass Density}} \underbrace{A}_{\text{Ave. Area of Panel}} V^2 \times \text{Drag Coeff.}$

$$= \frac{1}{2} \times \frac{.08071}{1000 \times 32.2} \times \frac{20' \times 20'}{2} \times 54.43^2 \times 2$$

$$= 1.5^K$$

$\therefore$ NET PANEL WT. $= 3.9 - 1.5 = 2.4^K$

NET Kinetic Energy $= \frac{1}{2} \frac{2.4}{32.2} \times 54.43^2 = 110.4$ K.FT

- Equating Momentum, the energy absorbed in plastic deformation of the impacting masses is calculated as follows:

$$\underbrace{m_1}_{\text{Impacting mass}} V_1 = (m_1 + \underbrace{m_2}_{\text{Resisting mass}}) V_2 \quad \text{OR} \quad \frac{m_1}{m_1 + m_2} = \frac{V_2}{V_1}$$

$$\text{Ratio } R = \frac{K.E._{Final}}{K.E._{Initial}} = \frac{\frac{1}{2}(m_1 + m_2) V_2^2}{\frac{1}{2} m_1 V_1^2} = \frac{m_1 + m_2}{m_1} \times \left(\frac{V_2}{V_1}\right)^2 = \frac{V_1}{V_2} \times \left(\frac{V_2}{V_1}\right)^2 = \frac{V_2}{V_1}$$

OR $R = \frac{m_1}{m_1 + m_2}$

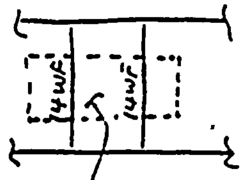
Net Panel wt. $m_1 = 2.4^K$

Resisting Element wt. m_2 is calculated as below

Roof Decking wt. = (25 PSF) × Area

$= .025 \times (20' \times 10') = 5^K$

└ contributory Area



wt. of 2 Beams 14 WF 30 $= 2 \times \frac{30}{1000} \times 10' = 0.6^K$
(Resisting Beams) └ contributory Length

$\therefore$ Total $m_2 = 5 + 0.6 = 5.6^K$

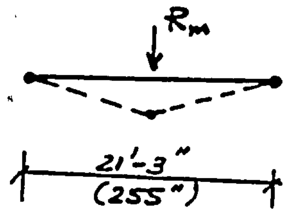
$$\therefore R = \frac{m_1}{m_1 + m_2} = \frac{2.4}{2.4 + 5.6} = 0.3$$

$K.E_{Final} = R \times K.E_{Initial} = 0.3 \times 110.4 = 33.1$ K.FT.

$$\therefore K.E/BEAM = \frac{33.2}{2} = \underline{16.6 \text{ K.FT}}$$

This K.E. of 16.6 K.FT will have to be absorbed in plastic deformation with acceptable ductility limit.

14 WF 30 : $Z_x = 47.3$ IN^3, $I_{xx} = 291$ IN^4

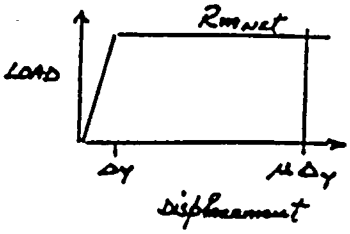


$$M_p = \frac{R_m L}{4} = F_y Z_x$$

$$\therefore R_m = \frac{4 F_y Z_x}{L} = \frac{4 \times 36 \times 47.3}{255} = 26.7^K$$

D.wt. of Roof Decking + Beam $= \frac{1}{2}\left((.025 \times 10 \times 21.25) + (.030 \times 21.25)\right)$
└ Effective wt.
$= 3^K$

$\therefore$ Net $R_m = 26.7 - 3 = 23.7^K$



Yield Displacement $\Delta_Y = \frac{PL^3}{48EI} = \frac{23.7 \times 255^3}{48 \times 29000 \times 291}$
$= 0.97$ IN

Maximum Ductility is calculated as

$(\mu - \frac{1}{2}) \Delta_Y \times R_{m_{Net}} = 16.6 \times 12$
└ KE.

$$(\mu - \tfrac{1}{2}) = \frac{16.6 \times 12}{0.97 \times 23.7} = 8.7$$

OR $\mu = \underline{9.2} < 10$ $\therefore$ ACCEPTABLE