

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
REACTOR AND TURBINE BUILDING BLOWOUT PANELS
NIAGARA MOHAWK POWER CORPORATION
NINE MILE POINT, UNIT 1
DOCKET NO. 50-220

1.0 BACKGROUND

The external walls of the reactor building (RB) and the turbine building (TB) at Nine Mile Point, Unit 1 (NMP1), contain panels designed to provide pressure relief caused by a postulated high energy line break (HELB) within these buildings.

On November 1, 1995, NMPC submitted Licensee Event Report (LER) 95-005, "Building Blowout Panels Outside Design Basis Because of Construction Error." (Reference 1). NMPC stated that the relief panel blowout pressures shown in the FSAR were underestimated and outside the licensing basis, as a result of an initial construction deficiency and subsequent technical deficiencies in design calculations performed in 1993 to correct this deficiency. On the basis of this LER, NRC Region I conducted a special inspection at NMP1 from February 17 through March 11, 1996, in which several violations of NRC reporting and design control requirements were identified. These were detailed in a special inspection report dated March 29, 1996 (Reference 2). A predecisional enforcement conference was held on April 12, 1996, to discuss these violations. In support of this conference, Region I requested on March 13, 1996, assistance from NRR in evaluating the technical adequacy of the NMPC calculations.

2.0 EVALUATION

The RB panels are approximately 44' by 19'. The TB panels are approximately 20' by 20'. Each panel consists of 2'-wide by 19' or 20' long horizontal fluted floor decking panel segments, joined and crimped to form the complete panel. Each panel in both buildings was assumed to be attached to the building frame at the top and bottom by bolts in shear, and to the building columns at the sides by bolts under combined tension and shear.

2.1 1993 CALCULATIONS

Two sets of calculations were performed by NMPC in 1993. The purpose of the first set, dated 8/23/93, was to determine the blowout pressure capacity of the panels, based on the number and size (3/16" diameter) of the bolts shown on the design drawings, and the minimum ultimate tensile strength for the bolt material.

The first set of 1993 calculations were based on the following assumptions:

- Bolt minimum ultimate tensile strength;
- Linear bolt tension-shear interaction curve;

Attachment

- Panels represented as "two way" simply supported isotropic plates without in-plane membrane action. The in-plane panel edge loads acting on the top and bottom bolts were taken equal to the edge transverse reactions.

The failure mode was determined to be by shear-tension interaction of the side bolts, and the blowout pressures were determined as 39 psf for the RB and 43 psf for the TB.

The second set, dated 11/5/93, revised the calculations of the first set. These calculations were based on the same assumptions, except that the as-installed size of the bolts (1/4" diameter) and bolt ultimate strength values obtained from tests, were used. However, because of the changed bolt size, the governing failure mode was determined to be shear/tear of the panel sheet metal bolted to the top and bottom bolts. The blowout pressures were determined as 53 psf for the RB and 60 for the TB.

These pressures were lower than the building structural design pressure stated in the FSAR (80 psf). The blowout panels were declared operational eventhough the licensing basis blowout pressures were exceeded, on the basis that the pressurization due to a HELB was not a design basis for NMP1.

2.2 1995 CALCULATIONS

NMPC reevaluated the 1993 calculations and operability determination in 1995, and identified a number of technical deficiencies in the assumptions and the calculations. The blowout pressures were calculated as 91 psf for the RB and 89 psf for the TB. To bring the blowout pressures into conformance with the FSAR values, every other bolt in the side connections was removed, which halved these values.

The 1995 blowout calculations were based on the actual bolt size and ultimate strength, and the following assumptions:

- Linear bolt tension-shear interaction curve;
- Panel segments represented as "one way" simply supported beams, each considered to act separately from adjacent segments.

2.3 EVALUATION OF ASSUMPTIONS

The staff reviewed the assumptions on which the analyses were based, and concluded that they did not account for realistic deformation behavior of the bolts and the panels, and that the actual blowout pressures of the panels were therefore underestimated and not an upper bound.

- The representation of the panels as simply supported "two way" isotropic plates is technically deficient since it does not correspond to the as-built type shear connection at the top and bottom of the panels and the difference in horizontal and vertical stiffness. The panels develop longitudinal membrane action which exists as long as the horizontal panel segments remain joined and crimped. In addition, the panels are considerably stiffer in the horizontal direction than in the vertical

direction. The panels should therefore have been analyzed as simply supported "two way" orthotropic plates reflecting finite membrane action in the vertical direction.

- The representation of the panel by "one way" simply supported horizontal beams is valid only if the crimped joints between panel segments of the "two way" panels open up at a lower pressure than that determined based on the "one way" assumption. This pressure was not determined in these calculations.
- The use of a linear tension/shear interaction curve to represent bolt behavior is not conservative in this case, since the actual bolt strengths are underestimated. The bolt behavior in the calculations should have been represented by an elliptic tension/shear interaction curve.

A number of other technical deficiencies were identified, and NMPC was requested to provide a more realistic estimate of the blowout pressures.

2.4 ENFORCEMENT CONFERENCE

A predecisional enforcement conference was held on April 12, 1996, at Region I, at which the technical deficiencies were discussed with NMPC. The staff expressed its concerns regarding the assumptions on which the calculations were based, and NMPC was requested to provide a revised assessment of the blowout pressures for both buildings, based on realistic assumptions.

At this conference, the Region I staff also expressed a concern regarding the safety of the storage condensate tanks housed in the auxiliary turbine building. This building is located at a lower elevation than that of the blowout panels, and could potentially be subject to impact and piercing of the roof by the blowout panels. NMPC committed to perform a safety evaluation of this event.

2.5 AUDIT AT NINE MILE POINT, UNIT ONE

On August 26, 1996, the NRR staff performed an audit at NMP1 of the revised NMPC calculations. The staff reviewed the calculation of the blowout pressure of the panels for both buildings. These calculations were performed based on the following assumptions:

- The bolt behavior is governed by an elliptic tension/shear interaction equation.
- The bolt ultimate strength was taken as the highest determined from the 1993 tests.
- The panel segments are considered as "one way" simply supported beams.

The staff reviewed the justification for the last assumption. NMPC performed calculations showing that the pressure at which the ultimate load capacity of

the crimped joints between the panel segments is exceeded, is lower than the pressure determined to fail the bolts on the side connections based on the "one way" assumption. The staff found this acceptable, based on its own assessment of the ultimate load capacity of the crimped joints.

On this basis, the panel upper bound blowout pressure for the RB was determined as 65 psf, and for the TB as 62 psf. Based on the initial number of bolts, the panel blowout pressure of the RB was also calculated as 128 psf and for the TB as 122 psf. The staff found these values in accordance with its own assessment of the pressures under similar assumptions as those invoked by NMPC.

NMPC also recalculated the ultimate lower bound capacities of the buildings as 117 psf for the RB and 135 psf for the TB. This shows that there is ample safety margin for pressure relief of the buildings, based on the current number and size of the bolts.

2.6 IMPACT ON THE TURBINE BUILDING ROOF

The staff also reviewed the response by NMPC to the concern regarding impact of a blowout panel on the TB roof over the condensate storage tanks. The initial response was unacceptable, due to a technical error in the analysis. NMPC corrected this error and provided a revised response, based on a proper analytical evaluation. The results show that the safety of the condensate storage tanks is not compromised by this event since the roof is capable of absorbing the impact energy of a panel without rupturing or experiencing large plastic deformation. The staff reviewed the revised response and the results, and found them acceptable. *

3.0 CONCLUSION

The staff finds that the initial NMPC approach for calculating the blowout panel pressures was based on technically deficient simplifying assumptions which did not reflect the as-built panel construction and boundary conditions, the mode of load transmittal from the panels to the bolts, and the real behavior under combined loading of the bolts.

NMPC has provided revised calculations of the upper bound blowout panel pressures. NMPC has also provided an evaluation of panel impact on the roof of the turbine building. The staff has evaluated the bases of these calculations and finds them reasonable and in accord with current engineering practice.

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415-2755

REFERENCES

1. Letter of November 30, 1995, from N. L. Rademacher, Niagara Mohawk Power Corporation (NMPC), to the USNRC Document Control Desk, with enclosed Licensee Event Report (LER) 95-05 "Nine Mile Point, Unit 1, Building Blowout Panels Outside the Design Basis Because of Construction Error."
2. Letter of March 29, 1996, from R. W. Cooper, II, DRP, Region I, to B. R. Sylvia, NMPC, with enclosed NRC Special Inspection Report No. 50-220/96; 50-410/96-05.
3. Calculations of the Pressure Capacity of Pressure Relief Panels in the Reactor and Turbine Buildings at Nine Mile Point Nuclear Station, Unit 1 (NMP1), dated August 23, 1993, and March 29, 1995.

MEMORANDUM TO: Charles W. Hehl, Director
Division of Reactor Projects, Region I

FROM: Alexander W. Dromerick, Acting Director
Project Directorate I-1
Division of Reactor Projects - 1/II
Office of Nuclear Reactor Regulation

SUBJECT: TECHNICAL ASSISTANCE REQUEST REGARDING REACTOR AND TURBINE
BUILDING RELIEF PANEL DEFICIENCY, NINE MILE POINT NUCLEAR STATION,
UNIT NO. 1 (NMP1) (TAC NO. M94858)

By memorandum dated March 13, 1996, Division of Reactor Projects (DRP) requested NRR technical assistance to determine the adequacy of Niagara Mohawk Power Corporation's (NMPC) revised design calculations for the Reactor Building and Turbine Building pressure relief (or "blowout") panels. The calculations are related to an event (LER 50-220/95-05, dated November 30, 1995) regarding the licensee's discovery, in October 1993, that the panels would not blow out at the design pressure of 45 pounds per square foot (psf) because the bolt fasteners for the panels were larger, and had a higher ultimate strength, than designed. The licensee's initial 1993 engineering calculation of this condition erroneously determined that the Turbine Building panels and Reactor Building panels would blow out at 60 and 53 psf, respectively, to relieve internal building pressure prior to structural failure of the buildings, and the panels were declared operable. However, during a refueling outage in March 1995, the licensee discovered that an error had been made in 1993 regarding the design assumption for load distribution. The licensee's revised 1995 calculations determined that the relief panels would not blow out until the internal building pressure exceeded the minimum documented building structural design of 80 psf. Based on these calculations and before restarting Unit 1 in 1996, the licensee reported the condition to the NRC and removed every other bolt from the panels to reduce their blowout point to a value below the documented building structural capability.

By memorandum dated May 1, 1996, Region I supplemented the request for technical assistance to include two items arising from the related violations of EA 96-079. One item asked whether NMPC was correct in its 10 CFR 50.59 interpretation (apparently based on NSAC-125) that safety margins were not reduced because the actual blowout value (if not in error, which it was) was still under 80 psf. The second item asked whether a 10 CFR 50.59 safety evaluation (SE) is needed before making changes to restore a commitment or safety condition consistent with the original intent of a design. In addition, with respect to a public meeting with the licensee on January 6, 1997, Region I requested NRR support regarding the reportability of the panels being outside of their design basis.

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Adequacy of Licensee's Calculations

The licensee's 1993 and 1995 engineering calculations involving the Reactor Building blowout panels and Turbine Building blowout panels have been reviewed by NRR's Mechanical Engineering Branch (EMEB) and Civil Engineering and Geosciences Branch (ECGB). NRR's Containment Systems and Severe Accident Branch (SCSB) provided technical support to EMEB and ECGB for this review. The principal reviewers were David Jeng (ECGB), Mark Hartzman (EMEB), and William Long (SCSB).

Attachments 1 and 2 are the SEs by ECGB and EMEB, respectively. In these SEs, the staff verified that the licensee's 1993 calculations were technically inadequate. The staff also found that the subsequent 1995 calculations, that were intended to correct the deficiencies in the 1993 calculations, were also technically inadequate. After several discussions with the licensee and revised submittals by the licensee to correct technical deficiencies, the ECGB and EMEB reviewers conducted a site audit of the calculations and performed a walk down of the panels. After additional submittals by the licensee resolved issues raised by the NRC during the audit, the NRC staff concluded that the revised calculations were technically adequate.

Using the accepted methodology, the upper bound blowout pressure was determined to be 65 psf for the Reactor Building panels with every other bolt removed (or 128 psf before the bolts were removed), and 62 psf for the Turbine Building panels after every other bolt was removed (or 122 psf before the bolts were removed). The revised ultimate lower bound capacity of the Reactor Building was 117 psf, while the corresponding capacity for the Turbine Building was 135 psf. The staff concludes in the SEs that there is ample safety margin for pressure relief of the buildings, based on the current number and size of the bolts.

The above results also show that before every other bolt was removed in 1995, the Reactor Building panels might not have contributed to the overpressure protection of the Reactor Building (i.e., the panel's maximum blowout pressure exceeded the building's lower bound ultimate capacity), and that the margin of safety for the Turbine Building during this time was only 13 psf (135 psf minus 122 psf)--significantly less than the 35 psf or more (80 psf or more minus 45 psf) intended by the original design.

10 CFR 50.59 and Reportability Issues

The NRC's position regarding NMPC's contention that the design bases for internal building pressure is only to provide pressure relief at or below 80 psf is addressed in Mr. A. Thadani's letter to NMPC dated September 12, 1997. As stated in that letter, the NRC considers that the blowout panel pressure of 45 psf is part of the design bases, that 45 psf established the reference for

the acceptability of the facility's design, and exceeding 45 psf met the reporting requirements of both 10 CFR 50.72(b)(1)(ii)(B) and 10 CFR 50.73(a)(2)(ii)(B). ✓

Because the NRC's position on the NMP1 violations was not based upon the "margin of safety" test specified in 10 CFR 50.59, the NMP1 citations will not be affected by the resolution of existing differences between industry and NRC as to the proper definition of this term. By the NRC staff's definition, the margin of safety calculated in 1993 (i.e., 80 psf minus 60 or 53 psf) would be considered significantly less than the design basis margin (80 psf minus 45 psf).

Facility (or procedure) changes by licensees that merely restore a commitment or safety condition consistent with the intended design "as described in the safety analysis report" would not normally require a 10 CFR 50.59 SE or prior Commission approval. For example, NMPC's action in 1995 of removing every other bolt from the panels to restore the blowout pressure to the final safety analysis report (FSAR) specified value of 45 psf did not change the FSAR design description that the NRC staff found acceptable during the operating license review, and did not require a TS change; therefore, it did not require a 10 CFR 50.59 evaluation. The relevant requirements for such restorations are based upon the requirements for the intended design, including as applicable, the quality assurance criteria of 10 CFR Part 50, Appendix B.

Attachment 3 is a bibliography of the principal documents associated with this technical review.

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This completes our efforts under TAC NO. M94858 which is now closed.

Docket No. 50-220

Attachments: 1. ECGB SE
2. EMEB SE
3. Bibliography

This completes our efforts under TAC NO. M94858 which is now closed.

Docket No. 50-220

- Attachments: 1. ECGB SE
- 2. EMEB SE
- 3. Bibliography

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ORIGINATOR: D. Hood

SECRETARY: R. Laskin

SUBJECT: TECHNICAL ASSISTANCE REQUEST REGARDING REACTOR AND
TURBINE BUILDING RELIEF PANEL DEFICIENCY, NINE MILE
NUCLEAR STATION, UNIT NO. 1 (TAC NC. M94858)

POINT

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	<u>NAME</u>	<u>DATE</u>
1.	<u>D. Hood</u>	<u> / /97</u>
2.	<u>S. Little</u>	<u> / /97</u>
3.	<u>A. Dromerick</u>	<u> / /97</u>
4.	<u>J. Zwolinski</u>	<u> / /97</u>
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8.	Secretary - Dispatch	

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BIBLIOGRAPHY

1. Final Safety Analysis Report, Nine Mile Point Nuclear Station [Unit 1], dated June 1967, including Section III.A.1.2, "Turbine Building - Design Bases - Pressure Relief Design," and Section VI.B.1.2, "Reactor Building - Design Basis - Pressure Relief Design."
2. Nuclear Safety Analysis Center report NSAC-125, "Guidelines for 10 CFR 50.59 Safety Evaluations," dated June 1989.
3. NRC Generic Letter 91-18, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Non-Conforming Conditions and on Operability," dated November 7, 1991, including two enclosures from NRC Inspection Manual Chapter 9900, "Technical Guidance." Enclosure 1 is titled "Resolution of Degraded and Nonconforming Conditions," and Enclosure 2 is titled "Operable/Operability: Ensuring the Functional Capability of a System or Component."
4. NUREG-1022, Revision 1 Second Draft, "Event Reporting Guidelines 10 CFR 50.72 and 50.73," dated February 1994.
5. Updated Final Safety Analysis Report, Nine Mile Point Nuclear Station, Unit 1, dated June 1996, including Section III.A.1.2, "Turbine Building - Design Bases - Pressure Relief Design," and Section VI.C.1.2, "Reactor Building - Design Bases - Pressure Relief Design."
6. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1007), dated November 30, 1995, forwarding Unit 1 Licensee Event Report 95-005, "Building Blowout Panels Outside the Design Basis Because of Construction Error."
7. Memorandum from Region 1 to NRR dated March 13, 1996, "Request for Technical Assistance on Nine Mile Point 1 Reactor and Turbine Building Blowout Panels."
8. Letter from U.S. NRC to Niagara Mohawk Power Corporation, dated March 29, 1996, forwarding (1) NRC Special Inspection Report No. 50-220/96-05; 50-410/96-05, (2) NRC staff questions, and (3) Section V of Enforcement Policy.
9. Memorandum from Region 1 dated April 2, 1996, "Notice of Significant Meeting," announcing enforcement conference with Niagara Mohawk Power Corporation scheduled for April 12, 1996, in King of Prussia, Philadelphia.
10. Memorandum from Region 1 to NRR dated May 1, 1996, "Request for Technical Assistance on Nine Mile Point 1 Reactor and Turbine Building Blowout Panels - Supplement 1."

11. Memorandum by D. Hood, U.S. NRC, dated May 8, 1996, "Summary of Telephone Conversation of May 2, 1996, on Reactor and Turbine Building Blowout Panels."

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12. Memorandum by D. Hood, U.S. NRC, dated June 7, 1996, "Summary of Telephone Conversation of May 22, 1996, on Reactor and Turbine Building Blowout Panels."
13. Letter from U.S. NPC to Niagara Mohawk Power Corporation, dated June 18, 1996, "Notice of Violation and Proposed Imposition of Civil Penalty - \$50,000." (EA 96-079).
14. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1089), dated June 26, 1996, forwarding Supplement 1 to LER 95-05, "Building Blowout Panels Outside Design Basis Because of Construction Error."
15. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1096), dated July 3, 1996, "Response to Questions in Enclosure 2 of Inspection Report 50-220/96-05."
16. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1100), dated July 16, 1996, replying to June 18, 1996 Notice of Violation.
17. Memorandum by D. Hood, U.S. NRC, dated October 7, 1996, "Trip Report Regarding August 20, 1996, Audit of Reactor and Turbine Building Blowout Panel Calculations."
18. Memorandum by D. Hood, U.S. NRC, dated November 13, 1996, "Summary of Telephone Conversation of October 23, 1996, on Reactor and Turbine Building Blowout Panels."
19. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1155), dated November 15, 1996, "Response to Trip Report for August 20, 1996 Audit of Reactor and Turbine Building Blowout Panels."
20. Letter from U.S. NRC to Niagara Mohawk Power Corporation, dated December 3, 1996, "Order Imposing a Civil Monetary Penalty - \$50,000." (EA 96-079).
21. Memorandum by D. Hood, U.S. NRC, dated January 6, 1997, "Summary of Telephone Conversation of December 18, 1996, on Reactor and Turbine

Building Blowout Panels."

22. Letter from Niagara Mohawk Power Corporation to U.S. NRC (NMP1L 1177), dated January 23, 1997. "Remittance of Civil Penalty EA 96-079."
23. Letter from U.S. NRC to Niagara Mohawk Power Corporation, dated February 13, 1997, forwarding a transcript and slides on the January 6, 1997, public meeting to discuss issues associated with NRC enforcement action EA 96-079.
24. Letter from N. Reynolds of Winston and Strawn (Counsel for Niagara Mohawk Power Corporation) to U.S. NRC, dated February 19, 1997, requesting clarification of reporting requirements.

25. NUREG-1606, "Proposed Regulatory Guidance Related to Implementation of 10 CFR 50.59 (Changes, Tests, or Experiments)," published as a draft report for comments April 1997. See e.g., Section III.S, "Definition of Reduction in Margin of Safety."
26. Letter from Niagara Mohawk Power Corporation to U.S. NRC endorsing comments of July 7, 1997, by Nuclear Energy Institute and Winston & Strawn on NUREG-1606.
27. Memorandum from R. Zimmerman, U.S. NRC, to ADPR Project Managers and ADPR Project Directors, dated July 22, 1997, "Interim Expectations Related to Oversight of 10 CFR 50.59 Process and FSAR Updates."
28. Letter from A. Thadani, U.S. NRC, to Niagara Mohawk Power Corporation, dated September 12, 1997, responding to request for clarification of reporting requirements.