



Neutron Generator Production Facility (NGPF), Building 870

Structural Fire Protection Analysis and Basis of Design Report

Sandia National Laboratories, Albuquerque, New Mexico

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FPE524 - Structural Fire Protection Project Report

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1. Executive Summary

This report was prepared to provide an explanation of the prescriptive-based code approach for the Neutron Generator Production Facility's (NGPF) structural fire protection and construction classification determinations based upon the original code-of-record (1991-UBC) and current International Building Code (2012-IBC) requirements.

The code approach presented in this report included a determination of the required construction type in accordance with the 2012-IBC. Through the evaluation of the record design drawings and subsequent site surveys, a determination was made of the existing types of materials used to construct the columns, beams, floor assemblies, roof assembly, and exterior and interior walls and partitions.

A summary is provided for the fire resistance requirements of the different elements of the building. In addition, a determination was made in regards to the fire resistance hourly ratings of the columns, beams, floor assemblies, roof assembly, exterior walls, interiors walls and partitions, door openings, joints and penetrations. Through design evaluation, site survey, code verification, and review of record documents, the actual construction classification (Type II-B) was confirmed to be compliant with the 2012-IBC.

2. Building Overview

The Neutron Generator Production Facility (NGPF) is an existing structure located at Sandia National Laboratories (SNL) in Albuquerque, New Mexico (SNL/NM). Lockheed Martin operates SNL for the U.S. Department of Energy (DOE) and all the buildings at SNL are designed to adhere to DOE Order requirements in addition to complying with nationally adopted codes and standards. Figure 1 shows 3-D views of the facility.



Figure 1 – 3D Views of the Neutron Generator Production Facility

The NGPF is the principal production facility for neutron generators at SNL. In simplest and unclassified terms, neutron generators are used as a neutron source in nuclear weapons systems. In order to support this laboratory mission, the facility utilizes the North and East Wings for the production and development related operations, while the West Wing contains offices and meeting rooms.

This facility has three distinct wings (North, West, and East). The North Wing is two stories in height with a basement, while the East and West Wings are one story each and they do not have basements. The NGPF was originally constructed in 1959, however in 1995, two (North and West Wings) of the three wings were razed and rebuilt; the East Wing of the facility was left standing, however it was completely gutted and remodeled. Figure 2 shows illustrative interior views of all the three levels of the NGPF (from left to right is the Basement, 1st floor, and 2nd floor). Refer to Appendix A for SNL Location Maps.



Figure 2 – Illustrative Interior Views of the 3 Levels of the NGPF

This structure's building construction consists of a concrete slab-on-grade foundation, gypsum board on metal studs cementitious stucco covered exterior walls, and a non-protected steel frame superstructure. The roof assembly is an insulated metal deck supported by unprotected steel beams and trusses.

The design of the building itself has been arranged to provide a two-hour cut-off barrier between each of the wings as a means of reducing potential common mode failures as directed by the user group. This arrangement, along with further interior subdivision with one-hour rated fire walls for processes in the North and East Wings and automatic sprinkler protection throughout, make the probability of a total conflagration fire event extremely low. Therefore, a fire event in one wing should not affect operations in adjoining wings.

In addition to the automatic wet-pipe sprinkler system, the building is provided with a wet standpipe system and an addressable fire alarm system. Lastly, there are a compliant number of fire hydrants located around the perimeter of the facility.

3. Applicable Codes and Standards

The following codes and standards are applicable to this project:

- International Building Code (IBC), 2012 Edition.
- International Existing Building Code (IEBC), 2012 Edition.
- International Fire Code (IFC), 2012 Edition.
- Uniform Building Code (UBC), 1991 Edition (Code-of-Record)
- NFPA 45, "*Standard on Fire Protection for Laboratories Using Chemicals*," 2015 Edition.
- NFPA 101, "*Life Safety Code*," 2015 Edition.
- NFPA 318, "*Standard for the Protection of Semiconductor Fabrication Facilities*," 2015 Edition.

4. Occupancy Classification

The NGPF contains offices, equipment rooms, mechanical/electrical rooms, meeting rooms, labs, and clean rooms. Table 1 provides the classification of the occupancies within the building based upon Chapter 3 of the 2012-IBC:

Table 1. Building Occupancies

Description of Use	Occupancy Classification
Conference Room	Assembly (Use Group A-3)
Office	Business (Use Group B)
* Incidental Use Room/Area	Business (Use Group B)
** Lab and Clean Room	Business (Use Group B)

*Incidental use rooms/areas for this facility consist of storage and equipment rooms in accordance with Table 509 of the 2012-IBC.

**The labs and clean rooms were re-classified as Group B occupancies (per 304.1 of the 2012-IBC) rather than their original H-4 (H-7 per the 1991-UBC code-of-record) classification due to their inadequate separation with other areas, specifically at the floor/ceiling assemblies and also due to the maximum allowable quantities of hazardous materials being used were found to be below the allowable limits stated in Section 307 of the 2012-IBC.

The Group A-3 Assembly occupancy listed in Table 1 above, only constitutes approximately 2,790-sq ft of the 1st floor of the NGPF. Since the total 1st floor area is 49,829-sq ft, the aggregate areas of the A-3 occupancies do not occupy more than 10-percent ($.10 \times 49,829 = 4,983\text{-sq ft} > 2,790\text{-sq ft}$) of the story as stated in Section 508.2.1 of the 2012-IBC and they are thereby considered “accessory” to the main occupancy.

5. Building Characteristics

5.1. Description

This NGPF has three distinct wings (North, West, and East). The North Wing is two stories in height with a basement, while the East and West Wings are one story each. The facility has a gross area of 96,841 sq ft, it is 45-feet tall at its highest peak. The roof height of the single-story East and West Wings is approximately 16-feet. The roof portion of the two-story portion of the North Wing of the building has a height of approximately 35-feet, with the peak of the Clerestory having a height of approximately 45-feet. Architectural and Elevation drawings are provided in Appendix B of this report.

5.2. Construction Type

The allowable construction type(s) for the NGPF was determined by using Table 503 of the 2012-IBC. The tallest wing is 2 stories with a basement and the overall facility has a gross area of 96,841 square-feet (18,691 for the basement, 49,829 for the first floor, and 28,321-sq ft for the second floor). The basement is located approximately 19-feet below the 1st floor grade. The overall building height of the NGPF is 45-feet above the level of fire department vehicle access, with the highest occupied floor being at approximately 25-foot above that level. Since the highest occupied floor level is less than 75-feet, the building is not considered a high-rise per Section 403 of the 2012-IBC.

The NGPF is situated on a level lot with all the sides of the building fronting on a public way or open space having 20-foot minimum width. At SNL, multiple buildings are typically located on the same lot (aka, Technical Areas) and therefore, the entire distance between buildings or the public way width is permitted to be used according to Section 506.2.1 of the 2012-IBC. The weighted average of the widths of the public way or open space exceed 30-feet, therefore a value of 30-feet is used as required by Section 506.2.1 of the 2012-IBC. The frontage increase was calculated to be 75-percent as shown below:

$$I_f = \left(\frac{1445}{1445} - 0.25 \right) \left(\frac{30}{30} \right) = 0.75 \text{ OR } 75\%$$

It's worth mentioning that Unlimited (UL) Area buildings are permitted where the minimum yard distance on all sides is 60-feet, and occupancy, sprinklers, and number of stories (max. of 2) meet the criteria in Section 507 of the 2012-IBC. A frontage increase factor of 1.5 is allowed to be used for buildings that meet the aforementioned criteria. Due to construction at an adjacent facility to the NGPF, not all of the public way measurements could be confirmed for this facility, therefore this frontage increase factor was not used.

Since the NGPF is fully sprinklered in accordance with NFPA 13, then according to 504.2 of the 2012-IBC, the values specified in Table 503 for maximum building height can be increased by 20-ft and the maximum number of stories can be increased by one (1). These increases are shown in Table 2.

The North Wing has a basement and in accordance with 506.4 of the 2012-IBC, the Exception states in part that "a single basement need not be included in the total allowable building area, provided such basement does not exceed the area permitted for a building with no more than one story above grade plane." The area of a single basement is not required to be counted as part of the total building area when evaluating total allowable area in accordance with Section 506.4.1 of the 2012-IBC.

Table 2 below shows the types of construction that would be allowed with the aforementioned automatic sprinkler and frontage increases; this table uses values from Table 503 of the 2012-IBC. The NGPF basement area (18,691-sq ft) is excluded from the total allowable building area since it is less than any of the maximum area/story values calculated in Table 2. As shown, only the Type V-B construction would not be allowed since the total allowable building area in Table 2 (67,500-sq ft) is less than the aggregate gross square footage of the 1st and 2nd floors (49,829 + 28,321 = 78,150-sq ft) of the NGPF.

Table 2. Types of Construction with Area, Height, Frontage and Sprinkler Area Increases

Added Fire Protection Features	Max Height w/ Sprinklers	Max Stories w/ Sprinklers	Max Story Area w/ Sprinklers & Frontage Area	Total Allowable Bldg Area	Acceptable
<i>Const. Type</i>	<i>Equals Max Height +20'</i>	<i>Equals +1 story</i>	$Aa=\{At+[At*I_f]+[At*I_s]\}$	$Aa*2$	
IA	UL	UL	UL	UL	Yes
IB	180	12	UL	UL	Yes
IIA	85	6	140625	281250	Yes
IIB	75	4	86250	172500	Yes
IIIA	85	6	106875	213750	Yes
IIIB	75	4	71250	142500	Yes
IV	85	6	135000	270000	Yes
V-A	70	4	67500	135000	Yes
V-B	60	3	33750	67500	No

As shown in Table 2 above, the minimum construction permitted for the building is Type V-A, however design documents show that the NGPF was built as a Construction Type II-B building. Record design documents show that the building was constructed as a Type II-B construction (Type II-N per 1991 UBC code-of-record). Table 3 summarizes the height and area calculations for a fully sprinklered Type II-B Group B occupancy:

Table 3. Height and Area Calculations

Requirements/Details	Values
Floor Area	Use Group B
Tabular Area per Story (Table 503)	23,000 square feet
Frontage Increase (Section 506.2)	17,250 square feet
Sprinkler Increase (Section 506.3)	46,000 square feet
Maximum Allowable Floor Area	86,250 square feet
Total Allowable Building Area	172,500 square feet
Building Height	
Tabular Building Height (Table 503)	55 feet
Automatic Sprinkler System Increase (Section 504.2)	20 feet
Total Building Height Allowed	75 feet
Actual Building Height	45 feet
Number of Stories	

Requirements/Details	Values
Tabular Building Height (Table 503)	3 stories
Automatic Sprinkler System Increase (Section 504.2)	1 stories
Total Building Height Allowed	4 stories
Actual Building Height	2 stories plus a basement

As shown in Tables 2 and 3 above, the NGPF is compliant with the maximum allowable building area, building height and number of stories per 2012-IBC requirements for a Type II-B construction building.

5.3. Structural Fire Protection

The primary steel structure for the NGPF consists of steel wide-flange columns supporting steel wide-flange girders, beams, and joists. Only a small percentage of the primary steel structure is protected by spray applied fire-resistive material (SFRM); the SFRM is not a requirement since this building is classified as a Type II-B noncombustible construction. Structural drawings are provided in Appendix C of this report.

Building construction elements for the NGPF consist of a concrete slab on grade foundation and non-protected steel frame superstructure. Exterior walls at the East and West Wings are coated with 4-in. thick isocyanate form exterior mounted insulation covered by 1/4-in. thick cementitious stucco covering.

The roof assemblies of the facility are constructed of a single-ply membrane system over rigid insulation supported by a metal deck with an FM Type I-90 wind uplift rating and a 20-psf design live load. Additional design loads are shown in Figure 3. Roof framing members are sloped to provide positive drainage. The roof assembly is Class II insulated metal deck supported by unprotected steel beams and trusses. The SNL Structural Specification is provided in Appendix D of this report.

DESIGN CRITERIA:
LOADS PER DOE ORDER 6430.1A AND UCRL-15910.
GENERAL DESIGN CRITERIA AS FOLLOWS:
FACILITY USE CATEGORY: LOW HAZARD
FIRST AND SECOND FLOOR DEAD LOADS:
5" SLAB: 56 PSF
PARTITIONS: 20 PSF
SUSPENDED MECH. ELECT. AND ARCH.: 20 PSF
ROOF LIVE LOAD: 20 PSF
ROOF JOIST CONCENTRATED LOADS:
AT ANY PANEL POINT: 1,000 LBS
BETWEEN PANEL POINTS: 100 LBS
SECOND FLOOR LIVE LOAD: 125 PSF
FIRST FLOOR LIVE LOAD: 125 PSF
BASEMENT FLOOR LIVE LOAD: 200 PSF
FLOOR JOIST CONCENTRATED LOADS:
AT ANY PANEL POINT: 2,000 LBS
BETWEEN PANEL POINTS: 200 LBS
WIND LOAD (REF. ASCE 7-88):
BASIC WIND SPEED: 78 MPH
IMPORTANCE FACTOR: 1.07
EXPOSURE FACTOR: C
SEISMIC LOAD (REF. 1991 UBC):
IMPORTANCE FACTOR: 1.25
Z: 0.22
C: 3.0
RW:
NORTH/SOUTH BRACED FRAMES: 6
EAST/WEST MOMENT FRAMES: 6
SEISMIC ZONE: 2B
VEHICLE LOAD (SHIPPING/RECEIVING AREA ONLY):
5,000 POUND CAPACITY FORK LIFT
WITH 13,000 POUND LOADED AXLE LOAD

Figure 3 – Structural Design Loads from Record Drawings

The building floor for the East and West Wings is a reinforced 5-in. concrete slab on grade. The floor of the North Wing is a reinforced 5-in. concrete floor slab. Record drawings show that the floor/ceiling assemblies in the basement area were intended to be constructed to UL Design No. D501 (using layers of gypsum to protect the steel) and/or P701 (using spray applied fire-resistive material - SFRM) to provide one-hour fire resistive ceilings for the exit corridor. However, the UL Designs were not followed properly (i.e. – SFRM location, thickness, etc.) so the floor/ceiling assemblies can't be credited as providing the required occupancy separation or exit corridor protection. This was another reason the original Group H areas were re-classified as Group B occupancies. Miscellaneous applicable UL Fire Resistance Rating Design Sheets and DOE Orders are provided in Appendix E of this report.

Unprotected steel column and beam construction was observed in many areas during a recent site visit confirming the Type II-B construction. In addition, record documents for this building indicates it's constructed entirely of Type II-B noncombustible materials in accordance with the 2012-IBC. Figure 4 shows unprotected steel beams and beams with SFRM applied.

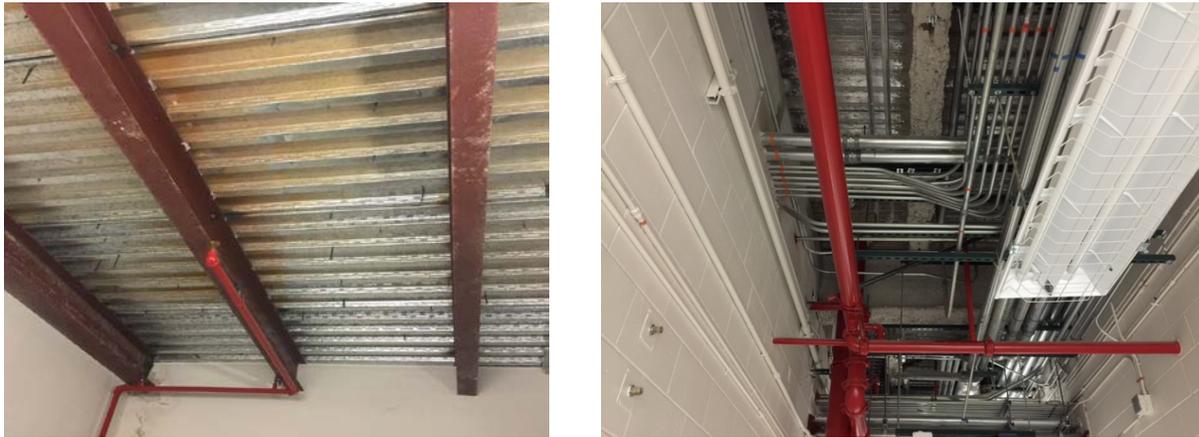


Figure 4 – Unprotected and Protected Steel Beams

5.4. Building Use

The NGPF is used for research and light production that utilizes chemical, physics and electronic laboratories and office support areas in order to support the laboratory mission. On average, there are approximately 140-people occupying the building; these occupants are trained to be familiar with their work hazards and are capable of self-preservation in the event of an emergency.

5.5. Occupancy Separations

The NGPF does not require fire-resistive protection for building elements except for those that are part of a fire barrier. The North, East and West Wings are separated by 2-hour fire-resistive construction barrier designed as area separation walls for the phased renovation work that took place back in 1995; this was done in order to continue manufacturing operations and was a user group mandated requirement. Door

opening protectives in these 2-hour walls were designed with a 90-minute fire-resistance rating which is in compliance with Table 716.5 of the 2012-IBC.

The exit stair enclosures, elevator shafts and utility shafts are constructed as one-hour fire-resistive shafts as required for exit stair enclosures and shafts connecting less than four (4) stories. Door assemblies in the required 1-hour-rated shafts, exit stair enclosures and exit passageways have a fire-resistance rating of 60-minutes per the code of record (i.e. – Section 3309 of the 1991 UBC) as well as the current code requirements of the 2012-IBC. Door assemblies in other 1-hour fire barriers (e.g. – control areas, electrical rooms) have a fire-resistance rating of 45 minutes which is in compliance with Table 716.5 of the 2012-IBC.

The typical fire-resistive wall construction was determined to be 5/8-inch Type “X” gypsum board on metal studs in office and light laboratory areas. These walls were provided for several reasons including NFPA 318, Section 708 of the 1991 UBC requirements for separation of mechanical rooms. The clean rooms were constructed with one-hour fire-resistive separation in accordance with the requirements in NFPA 318.

Ceilings are suspended mineral tiles in the office areas. Gypsum board ceilings were provided for the humidity room and main computer rooms. All light laboratories and cleaning areas have non-shedding, noncombustible ceiling tiles.

Section 707.5 of the 2012-IBC requires fire barriers to extend from the top of the foundation to the underside of the floor or roof sheathing. Section 707.6 limits the size of an opening in the fire barrier, however the NGPF is fully sprinklered and that allows the openings to not be limited to 156-sq ft per Exception 1. Openings in the fire barrier shall be protected in accordance with Section 716 and penetrations shall be protected in accordance with Section 714. Joints in the fire barrier shall comply with Section 715. Section 603 of the 2012-IBC describes combustible materials that are permitted to be used for caulking and sealing around joints, penetrations, and openings in rated assemblies.

Recent site surveys confirmed that sampled fire barriers and their associated penetrations, were installed/protected in accordance with the aforementioned 2012-IBC requirements.

5.6. Communicating Space

The NGPF building contains a 2-story communicating space (aka, atrium) connecting the 1st and 2nd Floor levels. In accordance with the 2012-IBC, an “atrium” is defined as an opening connecting two or more stories other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning or other equipment, which is closed at the top and not defined as a mall. Section 404.5 of the 2012-IBC Exception states that smoke control is not required for atriums that connect only two-stories. In accordance with Section 404.6 of the IBC (2012 Ed.) and Section 8.6.7 of NFPA 101 (2015 Ed.), atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier. Figure 5 shows an interior view of the communicating space looking up from the 1st floor level.



Figure 5 – Interior View of the Communicating Space

Previous editions of the building code, including the 1991 UBC (code-of-record), defined an atrium as an opening connecting *three* or more stories, therefore the building did not have to meet atrium requirements at the time of construction; this type of area was referred to as a communicating space between floors. In accordance with Section 1706 and Table 17-A of the 1991 UBC, the communicating space was designed as an area for evacuation assistance with a one-hour fire-resistance rating. Therefore, the one-hour fire-resistive corridors that are part of this atrium space, as well as the continuation of these corridors to the building exits, will be maintained. This passive fire protection feature has been retained to comply with the communicating space provisions of the 1991 UBC (code-of-record) and the current atrium provisions of the 2012-IBC.

6. Fire Resistance Ratings

Table 4 is a summary of the required fire resistance ratings and opening protection requirements for the NGPF's Type II-B construction in accordance with IBC-2012 Tables 601 and 602, unless otherwise noted.

Table 4. Building Elements

Building Element	Required Fire Resistance Rating	Provided/Actual Fire Resistance Rating
Structural Frame (beams and columns)	0 Hours	0 Hours
Bearing Walls (exterior)	0 Hours	0 Hours
Bearing Walls (interior)	0 Hours	0 Hours
* Nonbearing Walls (exterior)	0 Hours	0 Hours
*Unprotected Openings (IBC Section 705.8)	Not required	Not required
Nonbearing Walls and Partitions (interior)	0 Hours	0 Hours
Floor Construction	0 Hours	0 Hours
Roof Construction	0 Hours	0 Hours

* The NGPF is fully sprinklered and has a fire separation distance of greater than 30-feet on all sides, therefore the exterior nonbearing walls do not require a rating in accordance with Section 705.8 and Table 705.8 of the 2012-IBC.

7. Interior Finish

Table 5 outlines the required interior wall and ceiling finish requirements in accordance with 2012-IBC Table 803.9 for a sprinklered Group B occupancy.

The NGPF record documents state that all interior finish materials are UL-listed for a flame spread index rating of 25 or less and a smoke developed index rating of less than 50.

Table 5. Wall and Ceiling Finish

Component	Minimum Required Classification	*Provided Classification	Flame Spread Index	Smoke Development Index
Exit Enclosures/Passageways	B	I	0-25	0-450
Corridors	C	II	26-75	0-450
Rooms/Enclosed Spaces	C	III	76-200	0-450

*The provided classification designations are based off Tables 42-A and 42-B of the 1991-UBC (code-of-record) for a Group B occupancy.

The floor finishes for the NGPF include carpet tile in the office areas, vinyl tile in corridors, and sealed concrete in light laboratories and storage areas. As shown in Table 5 above, the NGPF has code compliant wall and ceiling finishes.

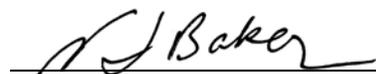
8. Prescriptive-Based Analysis Conclusion

Based upon site surveys, code verification, and review of record documents, the NGPF meets the prescriptive construction requirements of the 2012-IBC. Based upon the review of the aforementioned documents and site surveys, the actual construction classification (Type II-B) was confirmed to be compliant with the 2012-IBC.

9. Summary

The Neutron Generator Production Facility (NGPF) was designed as a partial 2-story Type II-B building comprising just slightly under 97,000 gross sq ft that consists of various types of Group B occupancies. It was shown through code analysis, site surveys, calculations, and review of record documents, that the NGPF Type II-B construction type exceeds the minimum requirements for the design occupancy in regards maximum allowable building area, building height and number of stories per 2012-IBC requirements. Any design excess (i.e., 2-hour rated walls separating the Wings) was prescribed by the user group.

It has been demonstrated in this report that the design and construction of the NGPH meets or exceeds the requirements found in the 2012-IBC for this building classification type.

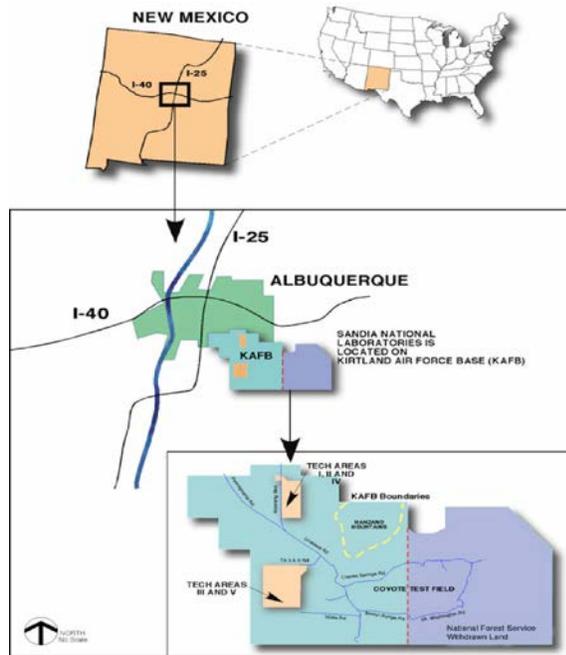


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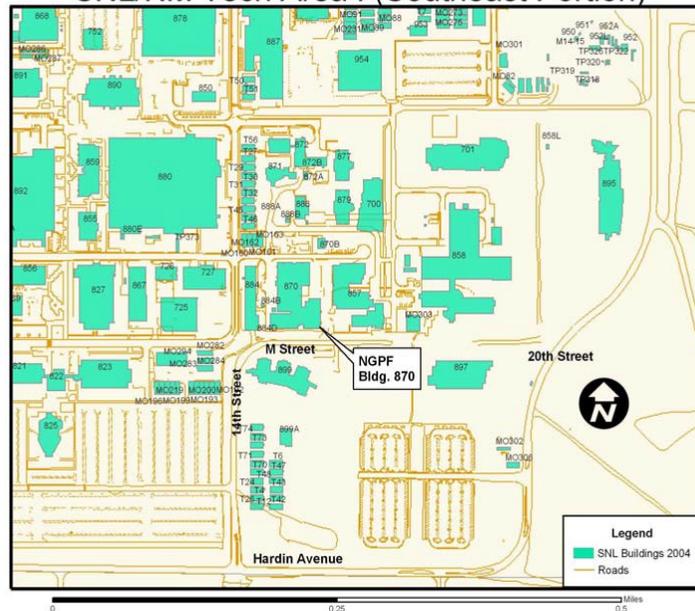


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Appendix A – Sandia National Labs Location Maps



SNL/NM Tech Area I (Southeast Portion)



Appendix B – NGPF Architectural & Elevation Drawings

Appendix C – NGPF Structural Drawings

Appendix D – SNL Structural Specification

Appendix E – Miscellaneous UL Sheets and DOE Orders