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SANDIA NATIONAL LABORATORIES

Building 1090
Boil-Off Exhaust Modifications
90% Basis of Design

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I. EXECUTIVE SUMMARY

This document provides analysis and proposed modifications to correct current issues at Building 1090. Electrical modifications will add additional emergency lighting in Labs 170, 174, 178, 182, 184, 186, and 190, and back-up power for the exhaust systems, fume hood lighting and exhaust system controls during a power outage. Mechanical modifications will address building pressurization between the lab and office areas, and replacement of corroded exhaust ductwork and fume hoods related to boil-off operations of corrosive chemicals.

Mechanical modifications include the installation of a dedicated, chemical boil-off exhaust fan and ductwork to support corrosive boil-off operations in Lab 184. It should be noted that the proposed solution increases the overall building exhaust demand, also increasing the supply air needed.

Electrical modifications include the installation of an uninterruptible power supply (UPS) to provide power to the exhaust fan, controls, and fume hoods to allow safe exit from Laboratory 186 during a power outage. The existing lighting inverter will also be replaced with a larger model to support additional emergency lighting within the labs.

Architectural modifications include exterior doors on the east wall of the IDR room. An additional door in the corridor west of Lab 184 will provide direct access to Lab 186 without entering a common building corridor. Lab casework will be modified as-required to accommodate the new layout.

Construction Phasing

Phase I will require a system outage, and will shut down Lab 170 and Lab 172.

- A room will be built out in the southwest corner of Lab 170 to move the particulate lab function from Lab 178 to the new Lab 170A.
- Lab 172 will be modified to serve as office.
- The fume hoods, exhaust, and process gas will be removed from Lab 170
- A terminal unit will provide supply air to Lab 170A, and the supply air in Lab 170 will be reduced.
- Some equipment will be removed and stored for relocation into Lab 186 during Phase II.
- An inverter in the electrical room will be replace and will support emergency lighting being installed in Labs 174, 178, 182, 184, 186, and 190.

Phase II will require a system outage, and will shut down Lab 186 and Lab 178.

- The doors between Labs 182 and 186 will be modified.
- Equipment that was removed during Phase I will be relocated to Lab 186 and reconnected.
- A furnace will be removed and stored for reinstallation in Lab 184 during Phase III.
- Some equipment relocation will require electrical modifications.
- N2 and Argon piping will be extended to Lab 186 to support equipment operation.

- Process gas and vacuum piping in the ceiling above Lab 178 will be rerouted in order to create space adequate for a HEPA filter module to be reinstalled above the ceiling in Phase III.
- Vacuum piping and drops from Lab 186 will be removed complete. The vacuum piping serving this area will be capped over Lab 178.
- Two (2) 6 foot fume hoods will be removed from the southeast corner of Lab 186, and one (1) will be retained for reinstallation in Lab 178 during Phase III.
- A 12 foot fume hood that is currently in storage will be installed in the southeast corner of Lab 186. The existing fume hood will be installed on new chemical storage cabinetry.
- Emergency lighting will be installed and connected to the invertor installed during Phase I.

Phase II must be completed, and Lab 186 fully operable prior to advancing to Phase III.

Phase III will require a system outage, and will shut down Labs 184 178, and 194.

- The door between Labs 182 and 184 will be infilled, and a new door to the vestibule to the west of Lab 184 will be installed.
- The vestibule will be modified to support movement between Labs 184 and 186.
- All existing fume hoods in Lab 184 will be removed. The HEPA filter module will be retained and reinstalled in Lab 178, connected to the six foot fume hood removed from Lab 186 in Phase II, and recertified.
- All existing exhaust supporting boil-off operation will be removed.
- A backflow preventer will be installed in the mechanical room, and racked above existing. NPW piping will extend from the dedicated backflow preventer to Lab 184. Three drops will be provided for three new PVC acid digester hoods' washdown capability.
- A coated mixed flow induction exhaust fan will be installed on the roof and connected to PTFE coated ductwork for boil off operations in Lab 184.
- A terminal unit will be installed to support the increased supply air flow in Lab 184.
- During the system outage, a terminal unit with a hot water reheat coil will be installed in Lab 178 and a Nederman exhaust arm will be installed in Lab 194.
- Emergency lighting will be installed in Lab 184 and connected to the invertor installed during Phase I.
- Electrical conduit will be extended to the roof to power the new exhaust fan.
- A UPS will be installed in the IDR room to provide emergency power to the new exhaust fan.

II. ABBREVIATIONS

ACRONYM	DEFINITION
AFF	Above Finished Floor
AHU	Air Handling Unit
Btu/h	British Thermal Units per Hour
CFM	Cubic Feet per Minute
CRAC	Computer Room Air Conditioner
°F	Degrees Fahrenheit
DX	Direct Expansion
DHW	Domestic Hot Water
DB	Dry Bulb
ESP	External Static Pressure
FCS	Facilities Control System
GPM	Gallons per Minute
HEPA	High-Efficiency Particulate Air
IN W.C.	Inches of Water Column
MAQ	Maximum Allowable Quantity
MBH	Mega British Thermal Units per Hour
RTU	Roof Top Air Handling Unit
SF	Square Feet
SNL	Sandia National Laboratories
VAV	Variable Air Volume
VFD	Variable Frequency Drive

III. CODES ANALYSIS

The project has been designed in accordance with the following, SNL adopted codes. Specific references to applicable codes and standards can be found within the body of the calculations, located in Appendix D of this document.

- 2009 International Building Code
- 2009 International Plumbing Code
- 2009 International Mechanical Code
- 2009 International Fire Code
- 2009 International Energy Conservation Code
- 2009 International Existing Building Code
- NFPA 70, National Electrical Code (2011)
- NFPA 91, Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
- NFPA 510, Hazardous Exhaust Systems (2013)
- NFPA 400, Hazardous Materials Code
- NFPA 704, Identification of Hazards of Materials for Emergency Response
- NFPA 220 Standard on types of building construction 2009 edition
- NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals, 2011 edition
- ADA and ABA Accessibility Guidelines 2004 Edition as amended through 2014
- ICC A117.1 Accessible and Useable Buildings and Facilities 2009 Edition
- Code under which the building was constructed: IBC 2003 edition

General

Selected interior spaces will be modified in configuration.
Interior modifications are classified IEBC: alteration level 2

- The occupancy classification of the building will not change due to the work of this project, however, the Building Hazardous Material MAQ Evaluation dated March 22, 2012 indicates quantities of H4 liquids (highly toxic liquids) and O liquids (oxidizing liquid, class 3) exceed the maximum allowable for Occupancy Classification Group B. For the purposes of this study, it is assumed that quantities of hazardous materials will be administratively controlled and brought into compliance with the maximum allowable. The Building Hazardous Material MAQ Evaluation dated March 22, 2012 does not consider radioactive materials. Presence and or quantities of radioactive materials are not considered in this study.
- The building construction type, allowable area and allowable height will not change and are compliant with the use and occupancy classification.
- The building fire rated elements will not change and are compliant with the proposed use and occupancy classification.
- Where interior spaces will be modified in configuration or use, the changes will be compliant with the required means of egress, required fire ratings, and accessibility requirements.

Construction type

- IBC 2009: Type IIB non-combustible
- NFPA 220: Type II 000 non-combustible

Occupancy

IBC

- 304.1: The building occupancy classification is group B – Office and Laboratories

NFPA 101

- 6.1.12.1: Industrial Occupancy (Lab)
- 40.1.2.1.1: the lab area is sub-classified as General Industrial Occupancy
- 6.2.2.3: Contents are classified as Ordinary Hazard

Separation of occupancy

IBC

- Group B Office and Laboratories – No separation required

NFPA 101

- Table 6.1.14.4.1(b): two hour separation between business occupancy and industrial occupancy. The separation may be reduced to one hour with credit for the automatic sprinkler system.
- 6.1.14.3: the building currently has no separation between business and industrial occupancies and shall be classified as mixed occupancy eliminating the requirement for a one hour separation. As mixed occupancy the most restrictive requirements for the occupancies involved shall apply to the entire building.

Egress

This project will eliminate a door between Lab 184 and Lab 182 and add a door between Lab 182 and Lab 178. Egress from Labs 184 and 182 will not be affected. Laboratory 182 is approximately 1,140 square feet and is assumed to be a Class D laboratory unit per the original building construction documents dated 3/06. Two exits are required per NFPA 4 part 5.4.1(3).

This project will add a vestibule space in Hallway 188 south of door 186. Egress from Laboratory 186 through door 186 will be required to pass through the vestibule. A new door and path of egress will be added at the north end of the west wall of laboratory 184. This door will open into the new vestibule.

IBC

- Table 1018.1: occupancy group B with sprinkler – fire rated corridors are not required.
- Table 1016.1: maximum travel distance to an exit = 300ft
  - Existing travel distances will not be impacted by this project.
- 1014.3 exception 1: maximum common path of travel = 100ft
  - Existing travel distances will not be impacted by this project.
- 1018.4: maximum dead end corridor = 50ft
  - Dead end corridors will not be added by this project.

NFPA 101

- 40.3.6: industrial occupancy – the provisions of 7.1.3.1 shall not apply – fire rated corridors are not required.
- Table 40.2.5 (general industrial occupancy): maximum dead end corridor = 50ft; maximum common path of travel = 100ft
  - Dead end corridors will not be added by this project.
  - Existing travel distances will not be impacted by this project.
- Table 40.2.6 (general industrial occupancy): maximum travel distance to an exit = 250ft
  - Existing travel distances will not be impacted by this project.

As indicated in Appendices B, the current chemical quantity of nitric acid exceeds the Maximum Allowable Quantity (MAQ) per table 5.2.1.1.3 in NFPA 400 (See Appendix D). Once the MAQ is exceeded, the building is subject to additional requirements, including but not limited to providing standby or emergency power to maintain constant exhaust fan operation during a power outage (Appendix D – section 6.2.1.8 in NFPA 400.

The addition of an emergency generator would be a significant cost to the building users. The building users indicated that administrative controls would be applied to reduce the current chemical quantities within the MAQ level, thus eliminating the requirement for emergency power. The design approach described within this report are contingent on all chemical quantities within the building staying within MAQ levels.

IV. EXISTING SYSTEMS

Mechanical

Heating Water Plant

Two (2) 87% efficient hot water boilers (Symbols B-1 and B-2) provide heating water to the building. Each boiler is sized for an input of 1,000 MBH. The boilers are connected in a primary secondary configuration utilizing constant volume primary pumps and variable volume secondary pumps to circulate heating water to the connect devices. The boilers currently meet the needs of the building.

Chilled Water Plant

Building chilled water is provided by a 101 Ton air-cooled chiller (Symbol CU-1) mounted at grade on the north side of the building. The chilled water pumps operate in a variable primary configuration, modulating to meet the instantaneous demand of the loop. Connected loads currently include the lab and office air handling units (AHU-1 and 2) as well as the electrical and IDR room rooftop units (RTU-1 and 2). Per the record drawings, the total connected load is approximately 95 Tons.

Laboratory HVAC Systems

AHU-1 is a rooftop variable-volume, once-through (100% outside air) system capable of providing up to 21,000 CFM of conditioned air to the lab spaces. The unit includes chilled and heating water coils.

VAV terminal units with reheat coils provide zone level tempering within each of the zones served. The supply airflows within each zone are tracked along with exhaust airflows in order to maintain negative space pressures within the zones, however SNL has observed that the lab section pressurization of the building has been positive with respect to the office section – leading to air transfer from the lab space to the entry corridor through the transaction counter.

Chemical Exhaust Systems

Lab exhaust is provided by two (2) exhaust fans, EF-1 and EF-2. EF-1 is scheduled for 21,160 CFM of exhaust at 5" in w.c., serving fume hoods and other general building exhaust. EF-2 is scheduled for 4,000 CFM at 6.5" in. w.c., serving four (4) localized fume hoods with HEPA filtration requirements.

Current user processes require boiling off chemical samples within several fume hoods throughout the building. The current sample load is 15 – 20 samples per month, however it is expected that the load will increase to 20 – 60 samples per month. The boiling of chemicals has been exhibited in three (3) fume hoods:

- Lab 170
  - Hood Number K3165
  - 12 Foot Kewaunee Supreme Air Model
- Lab 184
  - Hood number K3180
  - 6 Foot Fisher Scientific Safety-Flow Model
- Lab 186
  - Hood number K3172
  - 6 Foot Kewaunee Supreme Air Model

Per the users, the chemicals heated in fume hoods include mixtures of Hydrofluoric, Nitric, Hydrochloric, Hydroiodic and Hydrogen Peroxide. Per Chad Hjorth with SNL IH, the increased chemical usage is within EPA regulations for the site and will not require the addition of scrubbers to the exhaust system.

The above-mentioned chemicals are highly-corrosive and current chemical concentrations have led to damage both to the fume hoods and the connected ductwork. Within Lab 170, the chemical vapors have condensed within the ductwork, causing corrosion and dripping at the connection to the exhaust valves. Dripping chemicals have not been observed in Labs 184 and 186. All three (3) fume hoods have noticeable deterioration in the interior of the hoods and fogging of the sash glass.

Existing ductwork is welded stainless steel without any chemical resistant coating. Face velocities are controlled to a constant 100 feet-per-minute (FPM) across the fume hood sashes. In coordination with SNL facilities, the design team determined the following operating procedures for the boil-off operations.

1. During boil-off operations, users are directed to close fume hood sashes to a minimum.
2. Closing the sashes reduces the required airflow to maintain the minimum face velocity, causing the exhaust valves to reduce airflow to the hood.
3. Minimum duct velocity through the exhaust valve is typically set to 400 FPM.

Electrical

Building Distribution System

Building 1090 has a single electrical service. The service consists of a 12470V-480Y/277V, 500kVA transformer (TF-1090-1) that is served from a PMH-19 (SW-1090-1). The transformer serves a 480Y/277V, 800A power distribution panel (MDP) located in the electrical room (Room 192). Panel "MDP" serves the following equipment:

- A 480Y/277V, 225A panel (Panel BH1). Panel BH1 serves:
    - House lighting
    - Emergency lighting via a 1500VA lighting inverter.
    - Hot Water and chilled water pumps
    - Roof top units RTU-1, and RTU-2.
- Exhaust fan #1 (EF-1).
- Exhaust fan #2 (EF-2).
- Chiller (CU-1).
- AHU-1
- AHU-2 (Supply & Return)
- House Compressor (CP-1)
- 480V-208Y/120V, 112.5kVA dry type transformers ("T1", "T2", "T3", and "T4").
    - Transformer "T1" serves via a double tap the following panels:
        - A 208Y/120V, 225A, 10kAIC Panel labeled PL1.
        - A 208Y/120V, 225A, 10kAIC Panel labeled PL2.
    - Transformer "T2" serves via a double tap the following panels:
        - A 208Y/120V, 225A, 10kAIC Panel labeled PL3.
        - A 208Y/120V, 225A, 10kAIC Panel labeled PL4.
    - Transformer "T3" serves via a double tap the following panels:
        - A 208Y/120V, 225A, 10kAIC Panel labeled BL2.
        - A 208Y/120V, 225A, 10kAIC Panel labeled IDR.
    - Transformer "T4" serves a 208Y/120V, 100A, 10KAIC panel labeled BL1.

Lighting

The building lighting system consists mainly of 2x4 fluorescent lay-in fixtures in the lab spaces, and offices, and 1x4 fluorescent lay-in fixtures in the corridors. Select fixtures in the corridor spaces are connected to the 1500VA lighting inverter located in the electrical room (Room 192). Currently the lab spaces do not have emergency lighting fixtures, and SNL has indicated that the pathway out of Labs 174, 178, 182, 184, 186, and 190 to the egress corridor is difficult to navigate during a power outage. SNL has requested that additional emergency lighting be provided in these seven labs.

Grounding

The building grounding system consists of bare copper ground conductors that route from the ground bar in panel "MDP" and bond to the building steel, cold water piping, the counterpoise, and a concrete encased electrode. There is one existing ground bar in the IDR room that is bonded to the manhole system in the communication manhole system and it is also bonded to the ground bar in panel "MDP". The ground bar is located at the southeast corner of the IDR. The ground bar in the IDR is bonded to the equipment racks in the IDR, as well as the FDH, technical security fiber termination cabinet, and ACU.

Fire Alarm System

The building has an addressable fire alarm system compliant with SNL Specification 13852. The fire alarm system consists of a fire alarm control panel at the lobby as well as horn strobes, pull stations, tamper and flow switches at the fire riser and smoke duct detectors at air handling unit supply ducts.

Lightning Protection

The building has a lightning protection system consisting of rooftop mounted air terminals, lightning protection conductors, downleads, and test wells. The lightning protection system connects to a counterpoise system which consists of a #4/0 bare copper conductor buried 30" below finished grade and is routed around the building.

Communications

The building communication system is served via a 48 OSP black fiber optic cable that originates from Building 960 MDR cabinet 960BUCN. The 48 fiber optic cable enters the 1090 IDR at the southeast corner and terminates at one of the black racks. A patch cable then serves a 144 Fiber Distribution Hub (FDH) which is located in the IDR. The FDH serves 4 GPON ONT's directly as well as five Rapid Distribution Terminals (RDT's). These RDT's in turn serve the remaining GPON ONT's located throughout the facility.

The building does not have non-black service or non-black data outlets.

Security

The building security system is served via a 12 OSP black fiber optic cable that originates from Building 821 MDR cabinet 821ESM1D. The 12 fiber optic cable enters the 1090 IDR at the southeast corner and terminates at a technical security fiber termination cabinet labeled "1090TST1" located at the northeast end of the IDR. The fiber termination cabinet serves an ACU also located in the IDR. The ACU serves a MUX cabinet in the electrical room. The ACU and MUX cabinet serve card readers and alarms for the building.

V. PROPOSED MODIFICATIONS

Overview

The following discussion describes a solution that centralizes boil off operations to Laboratory 184 – utilizing a dedicated exhaust fan and PTFE coated stainless steel ductwork for the boil off hoods. The proposed electrical and mechanical modifications provide backup power to operate the dedicated exhaust fan and boil-off exhaust for up to 15 minutes, providing a safer exit condition for the laboratory occupants. In addition, emergency lighting additions both in the ceiling and in the fume hoods are proposed in order to address current user concerns.

Phasing

A concurrent project, SNL Project 183242, is proposing the removal of fume hoods in Labs 170 and 172. These modifications will reduce the existing maximum overall building exhaust to levels allowing the addition of the dedicated exhaust fan in Lab 184. Therefore, Project 183242 will be completed prior to this project. Project 183242 will be considered Phase I.

Furthermore, the user requirements do not allow for significant Lab downtime during construction. Therefore, this project will be split into two phases to minimize Lab downtime in Building 1090. Each Phase will include a system outage to be scheduled over the weekend in order to minimize impact. Phase II will include all work in Lab 186, which will continue operation as modifications are made to Lab 184. The exhaust modifications in Lab 184, 178, and 194 will constitute the final phase, Phase III.

Phase I will require a system outage, and will shut down Lab 170 and Lab 172.

- A room will be built out in the southwest corner of Lab 170 to move the particulate lab function from Lab 178 to the new Lab 170A.
- Lab 172 will be modified to serve as office.
- The fume hoods, exhaust, and process gas will be removed from Lab 170. The process gas drops will be removed, and the associated gas regulators will be removed and stored during Phase I.
- A terminal unit will be installed to provide supply air to Lab 170A, and the supply air in Lab 170 will be reduced.
- The Profile Plus Spectrometer and the Atomic Absorber will be removed and stored for relocation into Lab 186 during Phase II. Both pieces of equipment will be stored with their associated canopy hoods, including slide dampers, for reinstallation. The Profile Plus Spectrometer has associated process gas and three phase wiring.
- An inverter in the electrical room will be replace and will support emergency lighting being installed in Labs 174, 178, 182, 184, 186, and 190.

Phase II will require a system outage, and will shut down Lab 186 and Lab 178.

- The doors between Labs 182 and 186 will be modified.
- The Profile Plus Spectrometer and the Atomic Absorber from Lab 170 (with associated hoods and regulators) that were removed during Phase I will be relocated to Lab 186 and reconnected.
- The ashing furnace and associated LEV canopy hood will be removed and stored for reinstallation in Lab 184 during Phase III.
- The furnace and spectrometer equipment relocation will require electrical modifications.
- N2 piping will be extended from above the ceiling in Lab 178 to Lab 186, and dropped to the center bench. Regulators that were removed from Lab 170 in Phase I will be reinstalled.
- Process gas and vacuum piping in the ceiling above Lab 178 will be rerouted and racked on the wall above the ceiling in order to create space adequate for a HEPA filter module to be reinstalled above the ceiling in Phase III.
- Argon Piping will be extended from existing piping above the ceiling in Lab 186, and dropped to the center bench. Regulators that were removed from Lab 170 in Phase I will be reinstalled.
- Vacuum piping and drops from Lab 186 will be removed complete. The vacuum piping serving this area will be capped over Lab 178.
- Two (2) 6 foot fume hoods will be removed from the southeast corner of Lab 186, and one (1) will be retained for reinstallation in Lab 178 during Phase III.

- A 12 foot fume hood that is currently in storage will be installed in the southeast corner of Lab 186. The existing fume hood will be installed on new chemical storage cabinetry.
- Emergency lighting will be installed and connected to the invertor installed during Phase I.

Phase II must be completed, and Lab 186 fully operable prior to advancing to Phase III.

Phase III will require a system outage, and will shut down Labs 184 178, and 194.

- The door between Labs 182 and 184 will be infilled, and a new door to the vestibule to the west of Lab 184 will be installed.
- The vestibule will be modified to support movement between Labs 184 and 186.
- All existing fume hoods in Lab 184 will be removed. The HEPA filter module will be retained and reinstalled in Lab 178, connected to the six foot fume hood removed from Lab 186 in Phase II, and recertified.
- All existing exhaust supporting boil-off operation will be removed.
- A backflow preventer will be installed in the mechanical room, and racked above existing. NPW piping will extend from the dedicated backflow preventer to Lab 184. Three drops will be provided for three new PVC acid digester hoods' washdown capability.
- A coated mixed flow induction exhaust fan will be installed on the roof and connected to PTFE coated ductwork for boil off operations in Lab 184.
- A terminal unit with a hot water reheat coil will be installed to support the increased supply air flow in Lab 184.
- During the system outage, a terminal unit with a hot water reheat coil will be installed in Lab 178 and a Nederman exhaust arm will be installed in Lab 194.
- Emergency lighting will be installed in Lab 184 and connected to the invertor installed during Phase I.
- Electrical conduit will be extended to the roof to power the new exhaust fan.
- A UPS will be installed in the IDR room to provide emergency power to the new exhaust fan.

Structural

Structurally the project consists of supporting one new 1500 lb exhaust fan on the existing roof structure at the Northwest end of the building. The existing single story building has a roof structure consisting of steel K-series joists that span to steel wide flange beams, which are supported by steel HSS columns. The steel HSS columns are supported on shallow spread footings that bear approximately 18-inches below the surrounding exterior finished grade elevation on three feet of structural fill material.

A structural analysis has been performed to verify the adequacy of the existing steel roof joists, wide flange beams and columns for supporting the weight of the new exhaust fan. The design loads for this analysis were obtained from the as-built construction drawings and the exhaust fan cut sheet information provided by the manufacturer.

Load factors for the preliminary structural analysis were in accordance with the applicable material codes. Roof live loads and snow loads were not reduced below the Sandia National Laboratories required minimum of 20 psf. Based on this structural analysis it has been determined that the existing roof structure has enough residual capacity without any structural modifications to support the weight of the new exhaust fan.

Architectural

Laboratory 170

Movement of materials and equipment to Lab 170 is available through exterior door 170A which is a 3' wide door located on the north exterior wall. A larger door has been requested. A 3'-8" wide door will be installed in the current location. The new exterior door will be access controlled with a badge reader. Because the door is located in an alcove, the new 3'-8" wide door will not meet ADA clearance requirements from the exterior. The new door will meet ADA clearances from the interior side for emergency egress. Lab 170 is accessible by a second door from the building interior which meets the ADA clearance requirements.

Laboratory 178

A new door will be added to the west wall of Lab 178 connecting to Lab 182. A 6'-0" fume hood will be relocated from Lab 186 and a HEPA filter module relocated from Lab 184 will be installed.

Laboratory 184

Lab 184 process requires direct access to Lab 186 for transport of samples. The Current space layout requires occupants to pass through Hallway 188 prior to entering Lab 186. For this reason, a new vestibule space will be added to the north of Hallway 188. A new door will be added between Lab 184 and the vestibule to allow passage between Labs 184 and 186 without passing through a common corridor.

The project will remove an existing door between Labs 184 and 182. The laboratory process does not require this adjacency. The opening will be filled with metal studs and gypsum board.

Two (2) 6'-0" fume hoods will be removed from Lab 184, including a HEPA filter module that will be relocated to Lab 178. Architectural scope of work includes removal and replacement of ceiling tiles as required for fume hood work.

A new exhaust fan will be added to the roof above Lab 184 to accommodate added exhaust volume from two (2) 8'-0" PVC fume hoods and one (1) 6'-0" PVC fume hood. The architectural scope of work includes cutting, patching and flashing the existing roof membrane. An existing eye wash & shower will be relocated to accommodate the new PVC fume hoods.

Laboratory 186

Two (2) 6'-0" fume hoods will be removed from Lab 186 and replaced with one (1) 12'-0" fume hood to be relocated from Lab 170. Architectural scope of work includes removal and replacement of ceiling tiles as required for fume hood work.

Electrical Room 192 and IDR 191

Electrical Room 192 will be enlarged to accommodate a new 80 KVA UPS system including battery cabinet, maintenance bypass cabinet, 15kVA transformer, lighting inverter, and VFC's for new mechanical equipment. The existing door to IDR 191 will be removed and a fire rated wall assembly will be installed to separate the electrical room expansion and the decreased IDR room spaces. A new door opening will be cut into the east exterior wall of IDR 191 for access. A badge reader will be provided at the new exterior door into the IDR room.

Mechanical

Exhaust Modifications

Laboratory 170

The existing 12'-0" fume hood in the northeast corner will be relocated to Lab 186.

The existing VAV terminal unit and general exhaust air terminal will be rebalanced to meet the revised air requirements for the space.

Laboratory 178

An existing 6'-0" fume hood will be relocated from Lab 186 and installed within Lab 178. This fume hood will be retrofit with a HEPA filter module relocated from Lab 184 and connected into Exhaust Fan EF-2.

The existing VAV terminal unit will be removed and replaced to meet the revised make-up air requirements for the space.

Laboratory 184

Two (2) existing 6'-0" fume hoods located in the northeast corner of the lab will be removed, the HEPA filter module will be relocated to Lab 178.

A new strobic rooftop exhaust fan will be installed to support boil-off chemical operations centralized in Lab 184. Three (3) proposed PVC acid fume hoods will be connected with PTFE coated stainless steel ductwork and heresite-coated exhaust valves for chemical resistance. Addition of perchloric exhaust capabilities to the system has been identified as a possible future requirement that would require additional safety measures and modifications beyond the scope of the current project. Refer to Appendix E for a cutsheet indicating typical features.

A backflow preventor will be installed in the mechanical room and non-potable water (NPW) piping will be extended to Lab 184 and connected to each of the three (3) new PVC fume hoods' integral internal washdown systems, including nozzles and drainage troughs. The washdown capabilities of the current system will be limited to general cleaning of the current boil-off processes and liquid waste would be contained within the fume hood by a carboy for manual disposal by the users.

The recommended exhaust ductwork system is factory-coated with Polytetrafluoroethylene (PTFE); with flanged sections joined together with PTFE gaskets to maintain the chemical resistance of the complete duct path and all installed components. PTFE coatings are available that meet current SNL flame spread and smoke developed criteria as specified in ASTM E84. Refer to Appendix E for information related to duct construction and chemical resistance information (reference PermaShield in the provided tables).

The recommended replacement for exhaust valves includes a Heresite epoxy coating that greatly improves the chemical resistance of the assembly consistent with the rest of the duct system and resistance to hydrofluoric, nitric, hydrochloric, hydroiodic acids and hydrogen peroxide.

The deterioration of the existing fume hoods is likely related to conducting the corrosive boiling processes within fume hoods with standard polyresin liners and glass sashes. The recommended fume hoods for this type of process are provided with PVC lined surfaces and Lexan sashes which have an improved resistance to corrosive chemicals. The fume hoods can also be specified with under-cabinet venting to provide the users with chemical storage under the hoods.

A dedicated 15 HP, 5,000 CFM variable-volume exhaust fan will be provided for the new hoods. The proposed exhaust fan is manufactured by Strobic-Air, similar to the two (2) existing exhaust fans. The exhaust fan will be factory coated with epoxy to limit damage to the fan from the caustic airstream. Deficit dampers located at the fan provide flexibility to modulate system airflow while maintaining a safe discharge velocity (3000 feet-per-minute) at the fan. The proposed fan also includes a stackless discharge that induces additional fresh air at the discharge to further dilute the airstream. Based on the preliminary unit selection, a 15 HP exhaust fan with 217% dilution rate provides an effective stack height or 43 FT at 15 MPH wind and 60 FT at 10 MPH wind.

Per NPFA 91, recommended duct velocity in order to achieve chemical entrainment in the airstream is between 1000 - 2000 FPM. To meet this specification, the recommended hoods are constant-volume type hoods with full-bypass capability. With full bypass, the duct velocity will be maintained during boil-off operations – even with the sash fully-closed.

However during design, SNL facilities personnel requested that the fume hoods be VAV controlled to allow the room supply and exhaust airflows to modulate according to the current usage of the space. The design team contacted Monica Perez, a representative of the design basis fume hood Labconco, who had the following comments regarding VAV operation of the boil-off fume hoods:

> *We do not recommend PVC acid digestion hoods to be operated on a VAV system since what is typically being done is harsher than a typical operation in a chemical fume hood - hence the specialty applications brochure. That's not to*

say it hasn't been done - it just may lead to faster corrosion of the fume hood since the air isn't being diluted as much.

Per ANSI Z9.5, the recommended minimum air changes per hour (ACH) inside the hood ranges from 150-375 ACH. This is also covered by the caveat that a review of the fume hood process and surroundings is required. For example, if there is a cross draft in the room, that can affect containment so operating at the 150 ACH rate is not recommended.

So for a 6' PVC Acid digestion hood, the range is 128-319 CFM (150-375 ACH respectively) and for the 8' wide hood it would be 177-442 CFM.

In accordance with the SNL request for VAV operation, the design incorporates VAV exhaust valves associated with each of the fume hoods; however, the proposed controls strategy modulates the exhaust valves in a two-position configuration. In this configuration, the exhaust valves will operate at a minimum only when the sashes are closed. The valves will modulate to 100% of the fume hood airflow only when the sashes are moved or when the boil-off mode is engaged by the users administratively pushing the manual override button—which forces all exhaust valves into the full bypass condition. Failure to press the override button during boil-off mode could create an unsafe condition by not providing adequate dilution air, which could also lead to premature wear on the fume hood(s).

During a power outage, the UPS will maintain operation of exhaust fan in order to maintain a safe egress condition. During this mode of operation, operation of the boil-off exhaust fan will ensure that fume hoods and other exhaust devices will remain under negative pressure to provide a level of safety to the occupants while ensuring that the users are still able to open the doors to exit the labs (Per IBC 1008.1.3, the doors need to be set in motion when subjected to a 30 lb force and swing to an open position when subjected to a 15 pound force).

During this condition, the design 100 FPM face velocity will not be maintained and alarms will likely be present. It is expected that the lab users close the sashes prior to exiting the room. Under this operating condition, the total room exhaust is 750 CFM—250 CFM through each of the three (3) fume hoods.

In order to maintain safe room pressurization within these limits, the design includes a transfer air opening with a motorized damper designed to open on a power outage. Given the air handling unit fan will be non-operational, the building will be drawn negative and air will transfer in through cracks at doorways and other openings throughout the building. Additionally, two (2) room pressure sensors with integrated alarm in the case of a positive pressure condition will be placed outside of Lab 184, next to each entrance.

The existing VAV terminal unit and supply distribution will be removed complete. The terminal unit size will be increased and low-velocity supply air diffuser will be installed in order to limit air disturbance along the fume hood sashes.

Laboratory 186

The existing slot exhaust hood above the sink in the northwest corner of the lab will be removed, and the exhaust air terminal will be rebalanced.

Two (2) existing 6'-0" fume hoods located in the southeast corner of the lab will be removed, and one (1) of these fume hoods will be relocated to Lab 178 and connected to the HEPA filter module relocated from Lab 184.

Relocate the existing 12'-0" fume hood from Lab 170 and install in the southeast corner where the 6'-0" fume hoods were previously located. Stainless steel ductwork will be extended to connect to EF-1 exhaust distribution ductwork. A carboy will be installed under the fume hood to collect any flow from sink use inside the hood. Sink use will be limited by the volume of the carboy for manual disposal by the users.

No boil off operations will be conducted within Lab 186.

Electrical Room 192 and IDR 191

Additional cooling requirements to the electrical room will be limited to heat rejection associated with the exhaust fan VFC, UPS and lighting inverter. Ductwork and distribution is extended from the existing electrical room rooftop coil unit to serve the UPS room.

Laboratory 194

The existing exhaust distribution will be removed and an exhaust arm installed to provide localized exhaust capture capability within the room. The overall supply and exhaust airflows for the room will remain unchanged and therefore the VAV terminal unit will not require replacement.

Control Modifications

Since the supply and exhaust air valves are maintained as a tracking offset type system, we recommend rebalancing of the zones to maintain the desired pressure differential between the office and lab sections of the buildings. Control modifications will support the relocation of the aforementioned fume hoods.

Electrical

Exhaust Modifications

Laboratory 178

Lighting

Add new switch in room 178 next to new door and re-configure lighting in for 3-way lighting control.

Power

Receptacle in room 182 on the east wall where the door is slated will be removed. The associated branch conduit and conductors will be removed and reinstalled as required to maintain circuit continuity to the remaining receptacles. 120V Power will be provided from Panel PL1 to the new fume hood being installed in room 178.

Communications

Remove voice outlet on east wall of room 182 where new door is slated to go. Remove voice cable and conduit back to IDR room.

Laboratory 184

Power

Remove power to the two 6' fume hoods in Laboratory 184 that are slated for removal. Provide power for 4 new terminal units from the new 208Y/120V, 60A, UPS panel and provide power to lighting in two 8' fume hoods and one 6' fume hood via the UPS panel. Power for the receptacles in all three fume hoods will be derived from panel PL4 so that boil off operations will stop in the event of a power outage. A furnace will be relocated from lab 186 to the west wall of lab 184. Power to the furnace will be removed and relocated to coordinate with the new location.

Laboratory 186

Power

Remove power to the receptacles serving the two 6' fume hoods in Laboratory 186 that are slated for removal. The power for the receptacles serving the fume hoods will be derived from panel PL3. Power for the 12' fume hood in storage, previously in lab 170, will be restored after reinstalling it in lab 186. The 12' fume hood will be powered by panel PL3 in its new location.

Power will be provided to 2 new terminal units in lab 186. These devices will utilize circuits panel BL1. An existing L6-15R receptacle will be replaced with a new L6-30R receptacle to power a relocated ICP. Lastly, the junction box serving the existing furnace in lab 186 will be removed and the furnace will be relocated and repowered in lab 184.

Backup Power

A new Uninterruptible Power Supply (UPS) is required per SNL customer request for a 15 minute electrical backup source for the exhaust system, control system supporting the exhaust fan, and lighting for fume hoods in Laboratory 184. The basis for this request is that in the event of an electrical outage, the occupants have sufficient time and lighting available to turn off their experiments, close the sashes to all fume hoods and safely exit the labs. SNL should consider the potential hazards during a power outage longer than 10 minutes. With the exhaust systems nonoperational, chemical hazards could be introduced to the labs. Upon re-establishing power to the facility, additional consideration may be required to verify that the facility is safe for the users.

The proposed Eaton 93PM UPS 50kVA, 480V input, 480V output UPS with internal battery strings and a compact external side mount bypass cabinet will be provided and installed in the new UPS room. The UPS will be served via a new 3P/60A breaker in panel "MDP".

The external wraparound bypass cabinet will have 2 breakers that will serve the following:

- 15HP, 480V exhaust fan via a new VFC which will be located in the new UPS room and a disconnect switch located on the roof near the exhaust fan.
- 480V-208Y/120V, 15kVA dry-type transformer which will serve a 208Y/120V, 60A panel. This panel in turn will serve the lighting for the three fume hoods in Laboratory 184, and the FID panel that provides controls for the exhaust fan. The receptacles within the fume hoods will remain on normal power – allowing any boil off operators to stop during a power outage.

In order to facilitate the space for this new UPS and associated equipment, a new wall and door will be installed in the IDR (Room 191) segmenting the room into two spaces; one space (labeled UPS Room) will be sized to support the UPS, maintenance bypass cabinet, transformer, lighting inverter, ACU, and UPS panel. The remaining space will satisfy the current space needs for the IDR equipment, IDR panel and security cabinet. The proposed dimensions of the UPS room are 8'-3" x 10'-5" (87 sq. ft). The remaining IDR space in Room 191 would be 12'-3" x 10'-5" (129 sq. ft). The SNL communication group was consulted during a site visit that occurred with Troy Holley on July 31st, 2013. During the site visit Troy approved the reduction to the IDR space to accommodate the UPS equipment.

An air terminal as well as lightning protection bonds will be provided for the new exhaust fan. The bonds will connect via two paths to ground to the existing rooftop lightning protection system.

The modifications for the IDR to facilitate the new UPS room are discussed below.

Emergency Lighting Modifications

The lighting inverter within the electrical room is currently at capacity and will need to be replaced in order to support adding additional electrical load on the inverter. Thus the inverter will be replaced with an SNL standard 4500VA rated inverter. The new lighting inverter will be installed in the new UPS room. Select fixtures within Labs 174, 178, 182, 184, 186, and 190 will be placed on emergency power by re-circuiting one of the two ballasts to the new lighting inverter. One ballast will be connected to two lamps within the fixture and to the normal lighting circuit and the other ballast will be connected to the remaining lamp within the fixture and to the "normally off" circuit in the new lighting inverter via new conduit and conductors. The new lighting inverter will have the capacity to serve an additional 16, 2 lamp 32W fluorescent fixtures if required in the future.

Construction Phasing

Since the building will be occupied during construction, the contractor will be required to coordinate all construction activities with the building occupants. Since the majority of the work occurs in Laboratory 184, it is anticipated that the space will need to be vacated by the building users for the entire duration of construction. The space will not be usable until construction is complete and the new exhaust systems are in service. See the UCP for additional phasing requirements.

APPENDIX A – MECHANICAL CALCULATIONS

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Form IWP –EC3.2 2F
Calculation Summary Sheet

Calculation Title: 1090 Exhaust Modifications–Exhaust Static Pressure Calculation		Project #: 179374	Date: 2/02/2015
Calculation No.: MCAL.001		QA Level: 60%	Revision:
Calculation Approval:	Rev Date:		Rev Date:
Originator Name: M. Mentillo	By:		By:
Checker Name: A.Beck	By:		By:

Purpose:	To determine the duct static pressure losses associated with the exhaust air for the bypass exhaust fan.
Scope:	Calculate exhaust fan external static pressure, serving Lab 184.
DESIGN BASIS	
Design Input:	Duct routing aspects (straight sections, fittings, etc)
Criteria:	To provide adequate pressure required to exhaust Lab 184 and the three PVC fume hoods.
Assumptions:	None
References	ASHRAE 2013 Fundamentals, design airflows, and duct layout
Method	Each section of duct was entered into an excel spreadsheet. The spreadsheet calculates the pressure losses for straight duct. Trane's VariTrane Duct Designer was utilized to find the loss coefficient associated with each duct fitting. Manufacturer's data was used for pressure losses associated with equipment. The spreadsheet was used to total all of the pressure losses associated with the most restricitive supply air path, which is shown in diagrams below as a red dashed line.
Results	See calculation output.
Conclusions	The total external static pressure for the bypass exhuast fan is 2.4 in WG.

IF COMPUTER PROGRAM IS USED IN CALCULATION:	
1. Identify software program used with version number.	VariTrane Duct Designer
2. If required by contract, validation/verification info on file.	☐Y OR ☐N OR ☐N/A
3. Note ID of computer used to run calculation	N36

AFFECTED DOCUMENTS:

ATTACHMENTS

System Pressure Drops, Duct Take Offs, Fitting Loss Coefficients

REASON FOR REVISION

BRIDGERS & PAXTON

Form IWP –EC3.2 2F
Calculation Summary Sheet

TOTAL PAGES IN CALCULATION PACKAGE:

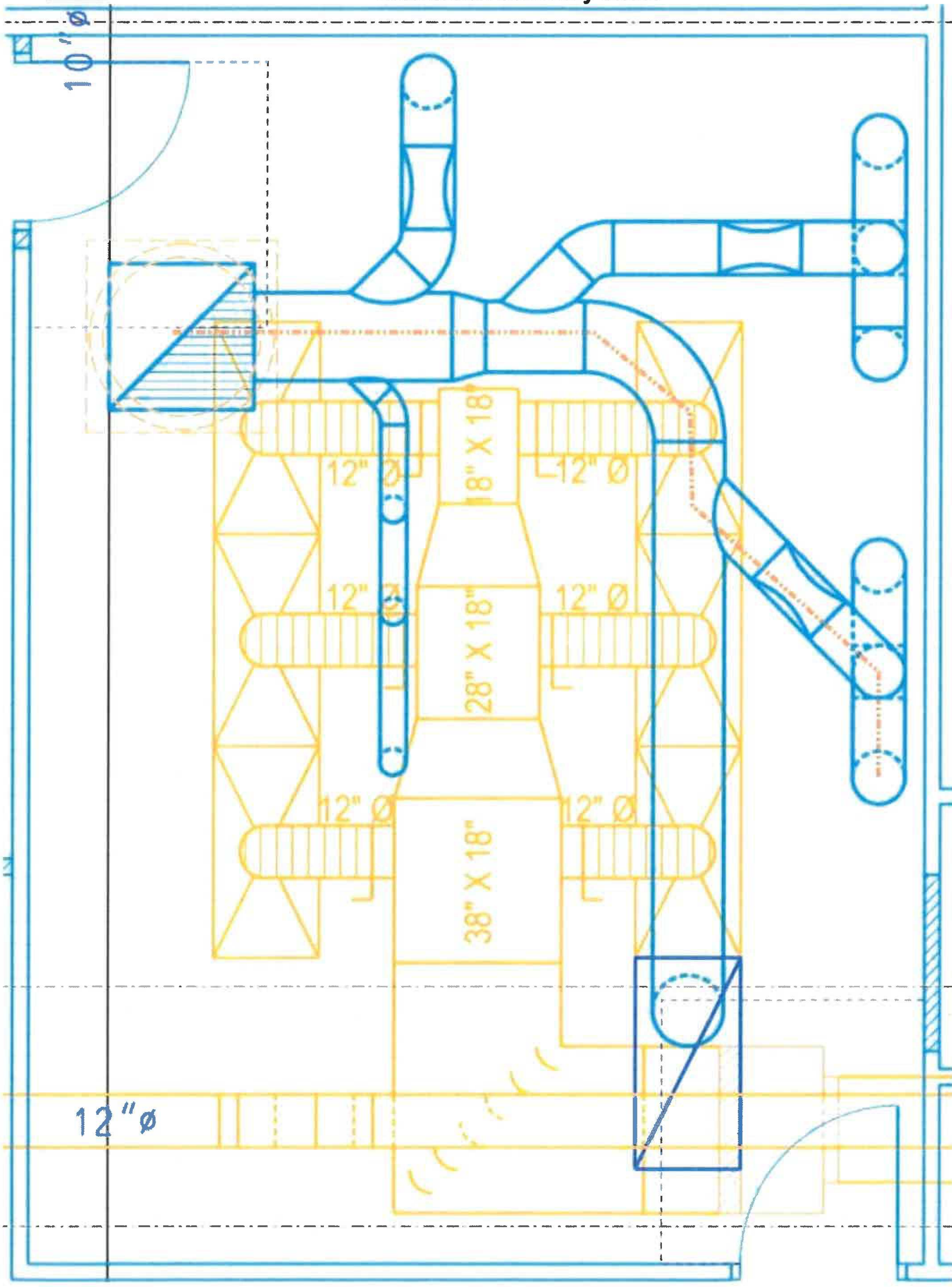
Calculation Inputs

Item Number	Item Description	Airflow Volume CFM	Rectangular Duct Height in.	Rectangular Duct Width in.	Round Duct Diameter in.	Duct Length ft	Fitting Loss Coefficent	Equipment Loss in w.g.	Equiv. Diameter D_e in
1	Fume Hood	1660			12	0	0	0.5	12.00
2	Trans to Duct	1660			12	0	0	0.1	12.00
3	Straight Duct	1660			12	1.5	0	0.0	12.00
4	90 Elbow	1660			12	0	0.11	0.0	12.00
5	Straight Duct	1660			12	3	0	0.0	12.00
6	VAV Exhaust Valve	1660			12	0	0	0.5	12.00
7	45 Elbow	1660			12	0	0.07	0.0	12.00
8	Straight Duct	1660			12	1	0	0.0	12.00
9	Junction	1660			12	0	0.49	0.0	12.00
10	Straight Duct	1660			16	1	0	0.0	16.00
11	90 Elbow	1660			16	0	0.11	0.0	16.00
12	Straight Duct	3320			16	4.5	0	0.0	16.00
13	Reducer	3320			16	0	1	0.0	16.00
14	Straight Duct	4980			20	4.5	0	0.0	20.00
15	90 Elbow	4980			20	0	0.11	0.0	20.00
16	Straight Duct	4980			20	1.5	0	0.0	20.00
17	Transition	4980			20	0	0.06	0.0	20.00
18	Junction	1660			12	0	2.02	0.0	12.00

Calculation Outputs

Item Number	Item Description	Duct Velocity FPM	Reynolds Number Re	Duct Roughness Factor	Friction Factor f	Air Density lb_m/ft^3	Item Total Pressure Loss in. w.g.	Cumulative Total Pressure Loss in. w.g.
1	Fume Hood	2113.6	217107	0.0005	0.01858	0.061	0.500	0.500
2	Trans to Duct	2113.6	217107	0.0005	0.01858	0.061	0.100	0.600
3	Straight Duct	2113.6	217107	0.0005	0.01858	0.061	0.006	0.606
4	90 Elbow	2113.6	217107	0.0005	0.01858	0.061	0.025	0.631
5	Straight Duct	2113.6	217107	0.0005	0.01858	0.061	0.013	0.644
6	VAV Exhaust Valve	2113.6	217107	0.0005	0.01858	0.061	0.500	1.144
7	45 Elbow	2113.6	217107	0.0005	0.01858	0.061	0.016	1.160
8	Straight Duct	2113.6	217107	0.0005	0.01858	0.061	0.004	1.164
9	Junction	2113.6	217107	0.0005	0.01858	0.061	0.111	1.275
10	Straight Duct	1188.9	162830	0.0005	0.01846	0.061	0.001	1.276
11	90 Elbow	1188.9	162830	0.0005	0.01846	0.061	0.008	1.284
12	Straight Duct	2377.8	325660	0.0005	0.01733	0.061	0.017	1.300
13	Reducer	2377.8	325660	0.0005	0.01733	0.061	0.287	1.587
14	Straight Duct	2282.7	390792	0.0005	0.01660	0.061	0.012	1.599
15	90 Elbow	2282.7	390792	0.0005	0.01660	0.061	0.029	1.628
16	Straight Duct	2282.7	390792	0.0005	0.01660	0.061	0.004	1.632
17	Transition	2282.7	390792	0.0005	0.01660	0.061	0.016	1.648
18	Junction	2113.6	217107	0.0005	0.01858	0.061	0.457	2.105
							Sub-Total =	**2.105**
							10% Safety Factor =	**0.211**
							Total =	**2.316**
							Total ≈	**2.40**

Form IWP –EC3.2 2F
Calculation Summary Sheet



Form IWP –EC3.2 2F
Calculation Summary Sheet

Fitting Loss Calculator

VariTrane™ Duct Designer

Fitting Number	Fitting Type	Description	Angle Length in. Dia in		Width in.	Height in	Diameter in.	Airflow cfm	Velocity fpm	Velocity Pressure in. wg	Loss Coefficient	Total Pressure Loss in wg
0001	Elbow	CD3-1 90 deg , die-stamped. r/D=1.5		Inlet			12	1,660	2 114	0.2859		
				Outlet			12	1,660	2 114	0.2859	0 11	0.0315
				Branch 1								
				Branch 2								
0002	Elbow	CD3-3 45 deg , die-stamped r/D=1 5		Inlet			12	1,660	2 114	0 2859		
				Outlet			12	1 660	2 114	0 2859	0 07	0 0200
				Branch 1								
				Branch 2								
0003	Elbow	CD3-1 90 deg die-stamped. r/D=1 5		Inlet			16	1.660	1 189	0.0905		
				Outlet			16	1.660	1.189	0.0905	0.11	0.0100
				Branch 1								
				Branch 2								
0004	Junction	SD5-1 div 45 deg wye		Inlet			16	3.320	2 378	0 3619		
				Outlet			16	1 660	1.189	0 0905	0.19	0.0172
				Branch 1			12	1 660	2 114	0 2859	0 49	0 1408
				Branch 2								
0005	Transition	SD4-1 round to round	90 00	Inlet			12	3,320	4 227	1.1436		
				Outlet			16	3 320	2 378	0.3619	1 00	0 3602
				Branch 1								
				Branch 2								
0006	Transition	SD4-2 rectangular to round		Inlet	33	20		4 980	1 087	0 0758		
			33 00	Outlet			20	4 980	2 283	0 3335	0 06	0 0213
				Branch 1								
				Branch 2								
0007	Elbow	CD3-1 90 deg die-stamped r/D=1 5		Inlet			20	4 980	2 283	0 3335		
				Outlet			20	4,980	2 283	0 3335	0 11	0 0367
				Branch 1								
				Branch 2								
0008	Junction	ED5-5 conv , symm tee w/vanes 90 deg		Inlet			12	830	1 057	0 0715	2.02	0.1444
				Outlet			12	1,660	2,114	0.2859		
				Branch 1			12	830	1 057	0 0715	2 02	0 1444
				Branch 2								

Number Of Fittings Specified For This System: 8

File.

VariTrane™ Duct Designer fill calculated at 1 40 05PM on 2/3/2015
Project Summary Report Page 1 of 1

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Form IWP –EC3.2 2F
Calculation Summary Sheet

Calculation Title: Building 1090- Electric Room Cooling Load Calculation	**Project #: 179374**	**Date: 02/05/2015**
Calculation No.: MCAL.002	**QA Level: 60%**	**Revision:**
Calculation Approval:	**Rev 1 Date:**	**Rev Date:**
Originator Name: M. Mentillo	**By:**	**By:**
Checker Name: A. Beck	**By:**	**By:**

Purpose:	**Provide supply air for modified electrical room.**
Scope:	**Electrical Room 190, IDR Room 192.**
DESIGN BASIS	
Design Input:	**Quantities of user equipment for each room, rated wattage for equipment, load diversity based on ASHRAE heat gain values.**
Criteria:	**Cooling Temperature Setpoint of 75 Deg F. 55 Deg F cooling supply air temperature. UPS Manufacturer heat load data. ASHRAE transformer heat load data.**
Assumptions:	**R19 walls entered at 16'0" with R30 flat roof. Lighting entered as 1 w/sq ft. No regular occupants.**
References	**2013 ASHRAE Fundamentals**
Method	**Computer Calculation**
Results	**Cooling Load required**
Conclusions	**The cooling load calculations were used to generate system minimum sizes to meet the load. It was determined that the existing roof top unit cooling only system, RTU-1, is sufficient to meet the increased load.**

IF COMPUTER PROGRAM IS USED IN CALCULATION:	
4. Identify software program used with version number.	**Trane Trace 700**
5. If required by contract, validation/verification info on file.	**☐Y OR ☐N OR ☐N/A**
6. Note ID of computer used to run calculation	**N36**

AFFECTED DOCUMENTS:

ATTACHMENTS

2013 ASHRAE Design Conditions for Albuquerque, NM, Design Inputs for UPS, Trane Trace 700 System Checksums

REASON FOR REVISION

Design Modifications

Form IWP –EC3.2 2F
Calculation Summary Sheet

TOTAL PAGES IN CALCULATION PACKAGE:

Form IWP –EC3.2 2F
Calculation Summary Sheet

Table 1. General Purpose Dry-Type Units Having an 80°C Temperature Rise

Temperature Rise (°C)	Rated Voltage (V)	Kilo-Volt-Amps	Average No Load Losses (W)	Average Full Load Losses (W)	100% Margin Total Losses (W)	80% Margin Total Losses (W)	50% Margin Total Losses (W)
80	480D-208Y	15	330	277	607	507	399
80	480D-208Y	25	530	502	1032	851	656
80	480D-208Y	30	415	616.5	1032	810	569
80	480D-208Y	37.5	530	671	1201	959	698
80	480D-208Y	45	487.5	963.5	1451	1104	728
80	480D-208Y	50	700	1371	2071	1577	1043
80	480D-208Y	75	725	1969.5	2695	1985	1217
80	480D-208Y	112.5	700	2230	2930	2127	1258
80	480D-208Y	150	1075	2136	3211	2442	1609
80	480D-208Y	225	1450	2820.5	4271	3255	2155
80	480D-208Y	300	1650	3279	4929	3749	2470
80	480D-208Y	500	2900	4857	7757	6008	4114
80	480D-208Y	750	3640	8572	12212	9126	5783
80	15kD-480Y	500	2400	5000	7400	5600	3650
80	15kD-480Y	750	2800	9000	11800	8560	5050
80	15kD-480Y	1000	3500	9600	13100	9644	5900
80	15kD-480Y	1500	5000	11600	16600	12424	7900
80	15kD-480Y	2000	6500	15500	22000	16420	10375
80	15kD-480Y	2500	7200	18500	25700	19040	11825

RESULTS

Transformers

There are a variety of different transformer types. A small sample of the available data is presented here. Table 1 presents information concerning general purpose dry-type units, with an 80°C temperature rise. Other units could have different temperature rises. Table 2 contains data concerning general purpose liquid-filled units. The full-load loss figures in Tables 1 and 2 correspond to rated current. The losses at any fractional load can be determined by

$$\text{Total losses} = \text{no load losses} + \text{load losses} \times (LF)^2, \quad (1)$$

where

LF = the load fraction, i.e., the fraction of full-load current (between zero and one).

Transformer losses are not a strong function of environmental temperature; thus, the full-load and no-load losses can be considered as constant regardless of the ambient tenperature.

Those power and lighting transformers (and larger units) built and tested in accordance with the NEMA TP1 Standard (NEMA 1996) have maximum efficiencies that either exceed or meet those efficiencies shown in Table 3 at a given percentage of load. For low-voltage units (600, 208, 120 volts), the given load percentage for peak efficiency is 35%, while for medium-voltage units, the load value for peak efficiency is 50%. The efficiencies of these dry-type units are referred to an average winding rise temperature of 75°C, while the liquid immersed efficiencies are referred to an average winding temperature rise of 85°C. Losses vary linearly with winding temperature. Referring the efficiencies to a particular winding temperature allows comparison between units. The temperature to which the losses are referred is listed at the top of Table 3.

Given the full capability of the unit in kVA, the full-load losses for the NEMA TP1 units are approximately

$$\text{Full load losses} = \frac{pf \times kVA \times 1000\left(1 - \frac{\eta}{100}\right)}{2(LF)\frac{\eta}{100}} \text{ watts}, \quad (2)$$

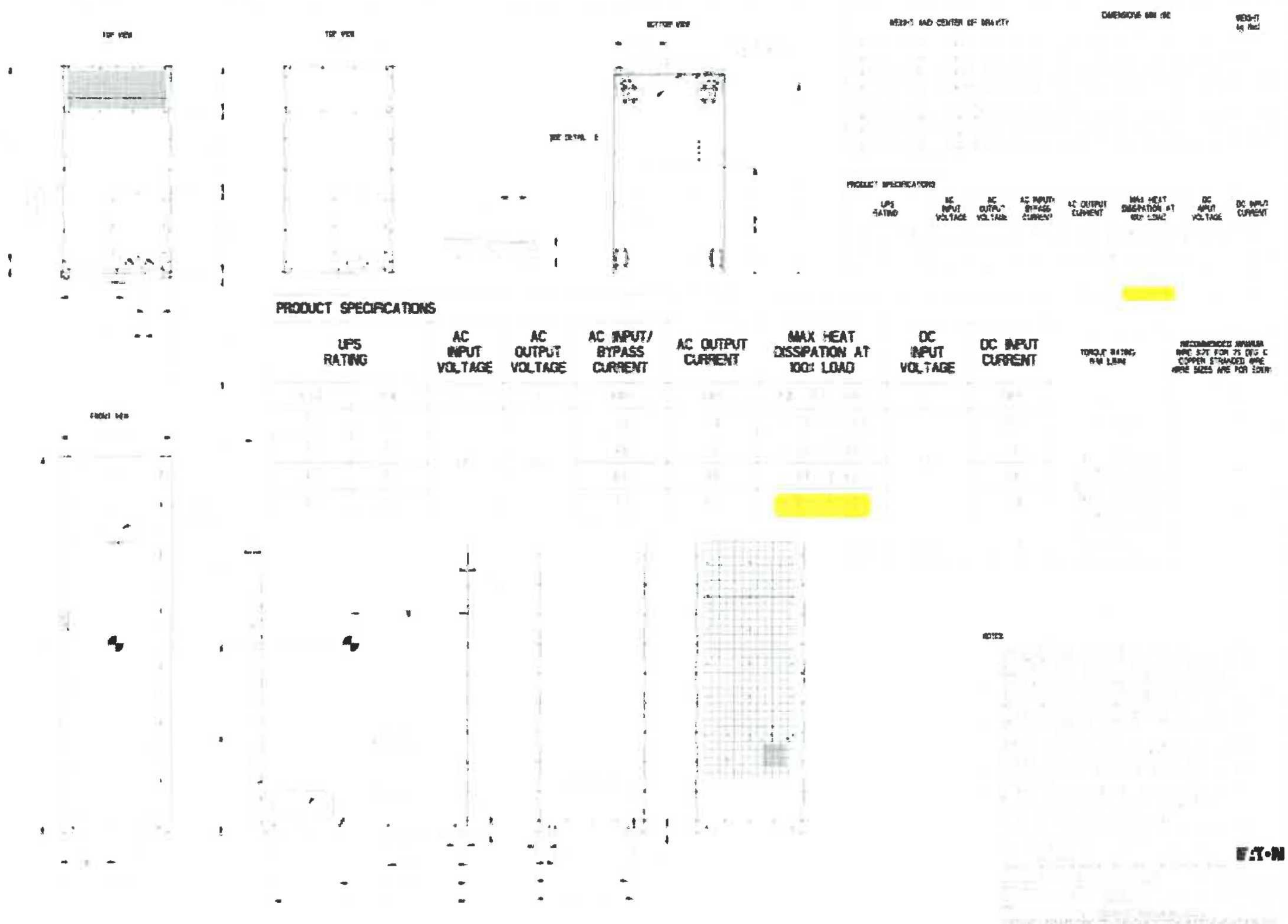
where

pf = power factor,

LF = load fraction for peak efficiency (0.35 or 0.5), and

η = efficiency from Table 3 corresponding to kVA and unit type.

Form IWP –EC3.2 2F
Calculation Summary Sheet



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Form IWP –EC3.2 2F

Calculation Summary Sheet

System Checksums

By Bridgers & Paxton ABQ

System - 001 — **Single Zone**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 13; Outside Air: OADB/WB/HR: 91 / 60 / 48

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	112	0	112	0	112	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	59	0	59	0	59	0
Wall Cond	1,140	0	1,140	3	1,140	3
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	1,311	0	1,311	3	1,311	3
Internal Loads						
Lights	812	203	1,015	3	812	2
People	0	0	0	0	0	0
Misc	35,633	0	35,633	94	35,633	94
Sub Total ==>	36,445	203	36,848	97	36,445	97
Ceiling Load	0	0	0	0	0	0
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		0	0	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	37,756	203	37,959	100.00	37,756	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 16

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	-339	-339	26.64
Glass Solar	0	0	0.00
Glass/Door Cond	-143	-143	11.28
Wall Cond	-789	-789	62.07
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	0	0	0.00
Sub Total ==>	-1,271	-1,271	100.00
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	0	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-1,271	-1,271	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	50.7
Ra Plenum	75.0	50.0
Return	75.1	50.0
Ret/OA	75.1	50.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	2,081	2,081
Terminal	2,081	2,081
Main Fan	2,081	2,081
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	0	0
MinStop/Rh	0	0
Return	2,081	2,081
Exhaust	0	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	7.00	7.00
cfm/ton	657.80	
ft²/ton	84.00	
Btu/hr·ft²	127.65	0.00
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	3.2	38.0	38.0	2,081	75.1	58.4	63.2	55.0	51.3	63.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.2	38.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	297		
Part	0		
Int Door	0		
ExFlr	0		
Roof	297	0	0
Wall	440	0	0
Ext Door	21	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	2,081	50.0	50.7
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	2,081	50.0	55.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	0.0			

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Room Checksums

By Bridgers & Paxton ABQ

ELEC 192

COOLING COIL PEAK		CLG SPACE PEAK	HEATING COIL PEAK	TEMPERATURES		
Peaked at Time: Mo/Hr: 7 / 13	Outside Air: OADB/WB/HR: 91 / 60 / 48	Mo/Hr: 7 / 13; OADB: 91	Mo/Hr: Heating Design; OADB: 16		Cooling	Heating
				SADB	55.0	50.4

BRIDGERS & PAXTON

Form IWP –EC3.2 2F

Calculation Summary Sheet

Room Checksums

By Bridgers & Paxton ABQ

ELEC/IDR 191

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 13; Outside Air: OADB/WB/HR: 91 / 60 / 48

CLG Space Peak — Mo/Hr: 7 / 13; OADB: 91

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	29	0	29	1	29	1
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	675	0	675	22	675	22
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	704	0	704	23	704	23
Internal Loads						
Lights	239	60	298	10	239	8
People	0	0	0	0	0	0
Misc	2,111	0	2,111	68	2,111	69
Sub Total ==>	2,349	60	2,409	77	2,349	77
Ceiling Load	0	0	0	0	0	0
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		0	0	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	3,053	60	3,113	100.00	3,053	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 18

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	-100	-100	15.57
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	-540	-540	84.43
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	-639	-639	100.00
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	0	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
System Plenum Heat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-639	-639	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	54.2
Ra Plenum	75.0	50.0
Return	75.4	50.0
Ret/OA	75.4	50.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	168	168
Terminal	168	168
Main Fan	168	168
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	0	0
MinStop/Rh	0	0
Return	168	168
Exhaust	0	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.93	1.93
cfm/ton	648.77	
ft²/ton	336.78	
Btu/hr·ft²	35.63	0.00
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	0.3	3.1	3.1	168	75.4	58.5	63.2	55.0	51.3	63.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	3.1								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	87		
Part	0		
Int Door	0		
ExFlr	0		
Roof	87	0	0
Wall	301	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	168	50.0	54.2
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	168	50.0	55.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	0.0			

Project Name:

Dataset Name: BLDG 1090.TRC

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APPENDIX B – ELECTRICAL CALCULATIONS

BRIDGERS & PAXTON

Form IWP-EC 3.2 2F
Calculation Summary Sheet

Page 1 of 2

Calculation Title (include Project Name): UPS Load Calculation for Bldg. 1090 Exhaust Modifications		Project #: 5940.509		Date: 02/18/15
Calculation No.:ECAL001		QA Level: 60%		Revision: 0
Calculation Approval:	Rev Date:		Rev Date:	
Originator Name: J. Slater	Sig:		Sig:	
Checker Name: W. Herbst	Sig:		Sig:	

Purpose:	To determine the required size of a UPS based on selected loads.
Scope:	This calculation is for sizing the UPS based on the load of a new exhaust fan and fume hoods for building 1090.
DESIGN BASIS	
Design Input:	Loads from exhaust fan and fume hoods.
Criteria:	Load on UPS must not exceed its rating.
Assumptions:	Devices are running at full load.
References	Exhaust Fan Cutsheet
Method	Spreadsheet
Results	See attached page for results
Conclusions	The UPS is required to have a rating of at least 40kVA.

IF COMPUTER PROGRAM IS USED IN CALCULATION:	
1. Identify software program used include version number.	
2. If required by contract, validation/verification info on file.	☐Y OR ☐N OR ☐N/A
3. Note ID of computer used to run calculation	

AFFECTED DOCUMENTS:

ATTACHMENTS

Building 1090 Exhaust Modifications UPS Load Calculation

REASON FOR REVISION

TOTAL PAGES IN CALCULATION PACKAGE: 2

Original: Project Specific File
Copies: Project Manger
PDF in Project QA File

BRIDGERS & PAXTON

Form IWP –EC3.2 2F
Calculation Summary Sheet

50kVA UPS — **60A**

Descriptio	SQ FT	Watts/SF	MECH ID	VFD?	HP	kVA	Multiplier	kVA	Amps	Breaker Size	# Poles	Notes
Exhaust Fan				Yes	15	17.5	1 25	21.9	26.3	30	3	1
Panel 1BL1						0.9	1.00	0.9	1.1	30		
Total kVA Demand (UPS)								22.8				
Total Amps Demand (UPS)									27.4			

208V Panel 1BL1 — **60A**

Descriptio	SQ FT	Watts/SF	MECH ID	VFD?	HP	kVA	Multiplier	kVA	Amps	Breaker Size	# Poles	Notes
FID Panel						0 5	1 25	0 6	2	20	1	
Lighting in Fume Hood						0 2	1.25	0 3	1	20	1	
Total kVA Demand (1BL1)								0 9			0	
Total Amps Demand (1BL1)									2			

Notes
1 Based on mechanical nameplate or load information
2. The new 50kVA UPS will be adequate for the new load.
3. Not in scope

APPENDIX C – CHEMICAL MAXIMUM ALLOWABLE QUANTITY (MAQ) ANALYSIS

Sandia National Laboratories
Operated for the U.S. Department of Energy by
Sandia Corporation

Building Hazardous Material MAQ Evaluation

BUILDING:	1090	**FULLY SPRINKLERED?**	☒ YES ☐ NO
		CONTROL AREAS?	☐ YES ☒ NO (Control area bounded by exterior walls)
DATE:	3/22/2012	**DATE OF PREVIOUS EVALUATION:**	
EVALUATOR:	Laura Draelos	**BUILDING OCCUPANCY**	IBC - Group B, NFPA 101 - General Purpose Industrial
FPA OWNER	Paul R. Smith		

GENERAL INFORMATION

This evaluation is based on the latest information available in the Chemical Information System (CIS). Some of the information contained in CIS may not be accurate, but this evaluation will indicate the overall hazardous material MAQ situation in the building. Use this information to author findings in the Building's Fire Protection Assessment.

This evaluation should be performed prior to the FPA field visit to alert the assessor to hazardous material MAQ problems for inspection

The MAQ for storage will be used for the evaluation, since the aggregate quantity for use and storage shall not exceed the quantity listed for storage

Total amounts in blue indicate that the quantity of hazardous materials do not exceed MAQs. Total amounts in red indicate a problem with the amounts of hazardous materials

This analysis assumes the control area is bounded by the building's exterior walls.

CIS and EIS do not list radioactive materials, and neither the ICC codes nor NFPA 1 regulate radioactive materials

FIRE FIGHTER WARNING PLACARD DESIGNATIONS BASED ON HAZARD CLASSIFICATION CATEGORIES (IFC)

TABLE F101.2
FIRE FIGHTER WARNING PLACARD DESIGNATIONS BASED ON HAZARD CLASSIFICATION CATEGORIES

HAZARD CATEGORY	DESIGNATION
Combustible liquid II	F2
Combustible liquid IIIA	F2
Combustible liquid IIIB	F1
Combustible dust	F2
Combustible fiber	F3
Cryogenic flammable	F4, H3
Cryogenic oxidizing	OX, H3
Explosive	R4
Flammable solid	F2
Flammable gas (gaseous)	F4
Flammable gas (liquefied)	F4
Flammable liquid IA	F4
Flammable liquid IB	F3
Flammable liquid IC	F3
Organic peroxide, UD	R4
Organic peroxide, I	F4, R3
Organic peroxide II	F3, R3
Organic peroxide III	F2, R2
Organic peroxide IV	F1, R1
Organic peroxide V	Nonhazard
Oxidizing gas (gaseous)	OX
Oxidizing gas (liquefied)	OX
Oxidizer 4	OX
Oxidizer 3	OX
Oxidizer 2	OX
Pyrophoric gases	F4
Pyrophoric solids, liquids	F3
Unstable reactive 4D	R4
Unstable reactive 3D	R4
Unstable reactive 3N	R3
Unstable reactive 2	R2
Water reactive 3	W, R3
Water reactive 2	W, R2
Corrosive	H3, COR
Toxic	H3
Highly toxic	H4

F—Flammable category.
R—Reactive category.
H—Health category.
W—Special hazard: water reactive.
OX—Special hazard: oxidizing properties.
COR—Corrosive.
UD—Unclassified detonable material.
4D—Class 4 detonable material.
3D—Class 3 detonable material.
3N—Class 3 nondetonable material.

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Control Area #1 (bounded by building's exterior walls)
Flammable and Combustible Liquids (F4, F3, F2, and F1)

Total quantity from CIS:
Class IA: F4 = 1 gallon

Class IB: F3 = 4 gallons

Class IC: F3 = 2 gallons

Class II: F2 = 1 gallon

Class IIIA: F2 = 1 gallon

Class IIIB: F1 = 55 gallons

Total of Class IA, IB, and IC = 7 gallons

IFC MAQ (Combination of IA, IB, and IC)* Storage not in cabinets = 240 gallons
(Combination of IA, IB, and IC)* Storage in cabinets = 480 gallons
*Containing not more than the maximum allowable quantity per control area of Class IA, IB, or IC flammable liquids, individually.

Class IA Storage not in cabinets = 60 gallons
Class IA Storage in cabinets = 120 gallons
Class IB and IC Storage not in cabinets = 240 gallons
Class IB and IC Storage in cabinets = 480 gallons

Class II Storage not in cabinets = 240 gallons
Class II Storage in cabinets = 480 gallons

Class IIIA Storage not in cabinets = 660 gallons
Class IIIA Storage in cabinets = 1,320 gallons
Class IIIB - NOT LIMITED

NFPA 30 MAQ's are identical to the IFC.

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Pyrophoric Liquids (F4 and F3)
Total quantity from CIS = 0 gallons IFC and NFPA 1 MAQ Pyrophoric Liquids Storage not in cabinets = 0.4 gallons Pyrophoric Liquids Storage in cabinets = 0.8 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Flammable and Pyrophoric Solids (F4 and F3)
Total quantity from CIS: Flammable Solids = 8 pounds Pyrophoric Solids = 0.7 pound IFC and NFPA 1 MAQ Flammable Solids Storage not in cabinets = 250 pounds Flammable Solids Storage in cabinets = 500 pounds IFC and NFPA 1 MAQ Pyrophoric Solids Storage not in cabinets = 4 pounds Pyrophoric Solids Storage in cabinets = 8 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Flammable and Pyrophoric Gases (F4)
Total quantity from CIS (these have been classified per IFC): Liquefied Flammable Gas = 0 pounds = 0 ft^3 = 0 gallons Gaseous Flammable Gas (inside building) = 0 ft^3 Gaseous Flammable Gas (Gas Storage outside) = 0 ft^3 Pyrophoric Gas = 0 ft^3 IFC MAQ Liquefied Flammable Gas Storage not in cabinets = 300 pounds Liquefied Flammable Gas Storage in cabinets = 600 pounds NFPA 1 MAQ Liquefied Flammable Gas Storage not in cabinets = 60 gallons Liquefied Flammable Gas Storage in cabinets = 120 gallons Liquefied Petroleum Flammable Gas = 300 gallons IFC and NFPA 1 MAQ Gaseous Flammable Gas Storage (inside) not in cabinets = 2,000 ft^3 Gaseous Flammable Gas Storage (inside) not in cabinets = 4,000 ft^3 Gaseous Flammable Gas Storage (outside) = 3,000 ft^3 IFC MAQ Pyrophoric Gas Storage not in cabinets = 50 ft^3 Pyrophoric Gas Storage in cabinets = 100 ft^3 Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Page 5 of 17

H4 Liquids (Highly Toxic Liquids)
Total quantity from CIS = 4.62 gallons IFC and NFPA 1 MAQ Highly Toxic Liquids Storage not in cabinets = 2 gallons Storage in cabinets = 4 gallons Does the CIS total exceed the most conservative MAQ above? ☒ YES* ☐ NO *MAQ for Highly Toxic Liquid is exceeded.

H4 Solids (Highly Toxic Solids)
Total quantity from CIS = 0 pound IFC and NFPA 1 MAQ for each classification Storage not in cabinets = 20 pounds Storage in cabinets = 40 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

H4 Gas (Highly Toxic Gas)
Total quantity from CIS = 0 ft^3 IFC and NFPA 1 MAQ for each classification Storage must be in cabinets = 40 ft^3 Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Page 6 of 17

H3 Liquids (Corrosive or Toxic Liquids)

Total quantity from CIS:

Corrosive Liquids H3 = 40 gallons

Toxic Liquids H3 = 2 gallons

IFC and NFPA 1 MAQ for each classification
Storage not in cabinets (Corrosive Liquids) = 1,000 gallons
Storage in cabinets (Corrosive Liquids) = 2,000 gallons

Storage not in cabinets (Toxic Liquids) = 100 gallons
Storage in cabinets (Toxic Liquids) = 200 gallons

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

H3 Solids (Corrosive or Toxic Solids)

Total quantity from CIS:

Corrosive Solids H3 = 88 pounds

Toxic Solids H3 = 10 pounds

IFC and NFPA 1 MAQ for each classification
Storage not in cabinets (Corrosive Solids) = 10,000 pounds
Storage in cabinets (Corrosive Solids) = 20,000 pounds

Storage not in cabinets (Toxic Solids) = 1,000 pounds
Storage in cabinets (Toxic Solids) = 2,000 pounds

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

H3 Gas (Corrosive or Toxic Gas)	
Total quantity from CIS: Corrosive Gas = 0 ft³ Toxic Gas = 0 ft³	
IFC and NFPA 1 MAQ for each classification	Storage Corrosive Gas = 1,620 ft³ Storage in cabinets (Toxic Gas) = 3,240 ft³ Storage not in cabinets (Toxic Gas) = 1,620 ft³ Storage in cabinets (Toxic Gas) = 3,240 ft³
Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO	

Page 8 of 17

R4 Liquids (Unstable Reactive Liquids, Class 4)
Total quantity from CIS = 0 gallon IFC and NFPA 1 MAQ for Storage not in cabinets = 0.1 gallon Storage in cabinets = 0.2 gallon Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
R4 Solids (Unstable Reactive Solids, Class 4)
Total quantity from CIS = 0 pound IFC and NFPA 1 MAQ for Storage not in cabinets = 1 pound Storage in cabinets = 2 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
R3 Liquids (Unstable Reactive Liquids, Class 3)
Total quantity from CIS = 0.01 gallon IFC and NFPA 1 MAQ for Storage not in cabinets = 1 gallon Storage in cabinets = 2 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

R3 Solids (Unstable Reactive Solids, Class 3)
Total quantity from CIS = 1 pound IFC and NFPA 1 MAQ for Storage not in cabinets = 10 pounds Storage in cabinets = 20 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
R3 Gas (Unstable Reactive Gas, Class 3)
Total quantity from CIS = 0 ft^3 IFC and NFPA 1 MAQ for Storage not in cabinets = 100 ft^3 Storage in cabinets = 200 ft^3 Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
R2 Liquids (Unstable Reactive Liquids, Class 2)
Total quantity from CIS = 0 gallon IFC and NFPA 1 MAQ for Storage not in cabinets = 10 gallons Storage in cabinets = 20 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

R2 Solids (Unstable Reactive Solids, Class 2)
Total quantity from CIS = 0 pound IFC and NFPA 1 MAQ for Storage not in cabinets = 100 pounds Storage in cabinets = 200 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

R2 Gas (Unstable Reactive Gas, Class 2)
Total quantity from CIS = 0 ft³ IFC and NFPA 1 MAQ for Storage not in cabinets = 500 ft³ Storage in cabinets = 1,000 ft³ Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Organic Peroxides Classes 1, 2, and 3 Liquids
Total quantity from CIS (all located in remainder): Class 1 OP Liquids = 0 gallon IFC and NFPA 1 MAQ Class 1 OP for Storage not in cabinets = 1 gallon Storage in cabinets = 2 gallons Class 2 OP Liquids = 0 gallon IFC and NFPA 1 MAQ Class 1 OP for Storage not in cabinets = 10 gallons Storage in cabinets = 20 gallons Class 3 OP Liquids = 0 gallon IFC and NFPA 1 MAQ Class 3 OP for Storage not in cabinets = 25 gallons Storage in cabinets = 50 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Organic Peroxides Classes 1, 2, and 3 Solids

Total quantity from CIS:

Class 1 OP Solids = 0 pound
IFC and NFPA 1 MAQ Class 1 OP for Storage not in cabinets = 10 pounds
Storage in cabinets = 20 pounds

Class 2 OP Solids = 0 pound
IFC and NFPA 1 MAQ Class 1 OP for Storage not in cabinets = 100 pounds
Storage in cabinets = 200 pounds

Class 3 OP Solids = 0 pound
IFC and NFPA 1 MAQ Class 3 OP for Storage not in cabinets = 250 pounds
Storage in cabinets = 500 pounds

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Water Reactive Liquid, Class 3

Total quantity from CIS = 0 gallon

IFC and NFPA 1 MAQ for Storage not in cabinets = 1 gallon
Storage in cabinets = 2 gallons

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

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Water Reactive Liquid, Class 2
Total quantity from CIS = 2 gallon IFC and NFPA 1 MAQ for Storage not in cabinets = 10 gallons Storage in cabinets = 20 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Water Reactive Solid, Class 3
Total quantity from CIS = 0 pound IFC and NFPA 1 MAQ for Storage not in cabinets = 10 pounds Storage in cabinets = 20 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Water Reactive Solid, Class 2
Total quantity from CIS = 1 pound IFC and NFPA 1 MAQ for Storage not in cabinets = 100 pounds Storage in cabinets = 200 pounds Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

O Liquid, (Oxidizing Liquid, Class 4)
Total quantity from CIS = 0 gallon IFC and NFPA 1 MAQ for Storage not in cabinets = 0.1 gallons Storage in cabinets = 0.2 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
O Liquid (Oxidizing Liquid, Class 3)
Total quantity from CIS = 5 gallons IFC and NFPA 1 MAQ for Storage not in cabinets = 2 gallons Storage in cabinets = 4 gallons Does the CIS total exceed the most conservative MAQ above? ☒ YES* ☐ NO *MAQ for Class 3 Oxidizing Liquid is exceeded
O Liquid (Oxidizing Liquid, Class 2)
Total quantity from CIS = 12 gallons IFC and NFPA 1 MAQ for Storage not in cabinets = 50 gallons Storage in cabinets = 100 gallons Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO
O Liquid (Oxidizing Liquid, Class 1)
Total quantity from CIS = 2 gallons IFC and NFPA 1 MAQ for Storage NOT LIMITED Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Page 14 of 17

O Solid (Oxidizing Solid, Class 4)

Total quantity from CIS = 0.01 pound

IFC and NFPA 1 MAQ for Storage not in cabinets = 1 pounds
Storage in cabinets = 2 pounds

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

O Solid (Oxidizing Solid, Class 3)

Total quantity from CIS = 0 pound

IFC and NFPA 1 MAQ for Storage not in cabinets = 20 pounds
Storage in cabinets = 40 pounds

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

O Solid (Oxidizing Solid, Class 2)

Total quantity from CIS = 2 pounds

IFC and NFPA 1 MAQ for Storage not in cabinets = 500 pounds
Storage in cabinets = 1000 pounds

Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

O Solid (Oxidizing Solid, Class 1)
Total quantity from CIS = 6 pounds IFC and NFPA 1 MAQ for Storage NOT LIMITED Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

O Gas (Oxidizing Gas)
Total quantity from CIS: Storage inside = 0 ft³ Storage outside (Gas Storage) = 0 ft³ IFC and NFPA 1 MAQ for Storage (inside) not in cabinets = 3,000 ft³ Storage (inside) in cabinets = 6,000 ft³ Storage (outside) = 6,000 ft³ Does the CIS total exceed the most conservative MAQ above? ☐ YES ☒ NO

Explosives
Building 1090 is not licensed for any MAX NEW.

SUMMARY for Control Area #1 (bounded by building's exterior walls)
The following MAQs of hazardous materials are exceeded at this time: H4 Liquids (Highly Toxic Liquids) O Liquid (Oxidizing Liquid, Class 3) Both of the above exceedances are due to nitric acid owned by Joseph Zigmond.

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APPENDIX D – CODE REFERENCE MATERIAL

(4) Class 3 solid or liquid oxidizers that are used or stored in normally closed containers or systems at gauge pressures of less than 15 psi (103.4 kPa)
(5) Class 2 unstable (reactive) materials
(6) Class 2 water-reactive solids, liquids or gases
(7) Oxidizing gases
(8) Oxidizing cryogenic fluids

4.2.1.2.4 High Hazard Level 4 Contents. High hazard Level 4 contents shall include materials that are acute health hazards limited to the following hazard categories:

(1) Corrosive solids, liquids, or gases
(2) Highly toxic solids, liquids, or gases
(3) Toxic solids, liquids, or gases

4.3 Mixtures. Mixtures shall be classified in accordance with the hazards of the mixture as a whole by an approved, qualified organization, individual, or testing laboratory.

4.4* Multiple Hazards. Hazardous materials that have multiple hazards shall conform to the code requirements for each applicable hazard category.

4.5* Classification of Waste. Waste comprised of or containing hazardous materials shall be classified in accordance with Sections 4.1 through 4.4 as applicable.

4.5.1* Waste classified in accordance with Sections 4.1 through 4.4 shall comply with the requirements of Chapters 1 through 9 and the material-specific requirements of Chapters 11 through 21 as applicable.

Chapter 5 Permissible Storage and Use Locations

5.1* General.

5.1.1 Control Areas or Special Protection Required. Hazardous materials shall be stored and used in any of the following:

(1) In control areas complying with Section 5.2
(2) In occupancies complying with requirements for protection level 1, protection level 2, protection level 3, or protection level 4 in accordance with Section 5.3
(3) In outdoor areas complying with Section 5.4

5.1.2 Weather Protection Structures. Weather protection, when provided, shall comply with 6.2.7.2.

5.1.3 High Hazard Contents. Occupancies in which high hazard contents are stored, used, or handled shall also comply with Chapter 6.

5.2 Control Areas.

5.2.1 Hazardous materials shall be permitted to be stored and used in control areas in accordance with 5.2.1 and 5.2.2.

5.2.1.1 General.

5.2.1.1.1 All occupancies shall be permitted to have one or more control areas in accordance with Section 5.2.

5.2.1.1.2 The quantity of hazardous materials in an individual control area shall not exceed the MAQ for the applicable occupancy set forth in 5.2.1.2 through 5.2.1.13, except as modified by Table 5.2.1.1.3.

5.2.1.1.3 For all occupancies not covered by 5.2.1.2 through 5.2.1.13, the MAQ of hazardous materials per control area shall be as specified in Table 5.2.1.1.3.

5.2.1.2 Assembly Occupancies. The MAQ of hazardous materials per control area in assembly occupancies shall be as specified in Table 5.2.1.2.

5.2.1.3 Educational Occupancies. The MAQ of hazardous materials per control area in educational occupancies shall be as specified in Table 5.2.1.3.

5.2.1.4 Day-Care Occupancies. The MAQ of hazardous materials per control area in day-care occupancies shall be as specified in Table 5.2.1.4.

5.2.1.5 Health Care Occupancies. The MAQ of hazardous materials per control area in health care occupancies shall be as specified in Table 5.2.1.5.

5.2.1.6 Ambulatory Health Care Occupancies. The MAQ of hazardous materials per control area in ambulatory health care occupancies shall be as specified in Table 5.2.1.6.

5.2.1.7 Detention and Correctional Occupancies. The MAQ of hazardous materials per control area in detention and correctional occupancies shall be as specified in Table 5.2.1.7.

5.2.1.8 Residential Occupancies. The MAQ of hazardous materials per control area in residential occupancies, including lodging and rooming houses, hotels, dormitories, apartments, and residential board and care facilities, shall be as specified in Table 5.2.1.8.

5.2.1.9 Mercantile Occupancies. The MAQ of hazardous materials per control area in mercantile occupancies shall be as specified in Table 5.2.1.1.3, with increased quantities permitted where storage or display areas comply with 5.2.1.13.

5.2.1.10 Business Occupancies.

5.2.1.10.1 The MAQ of hazardous materials per control area in business occupancies, other than laboratories, shall be as specified in Table 5.2.1.10.1.

5.2.1.10.2 The MAQ of hazardous materials per control area in laboratories classified as business occupancies shall be as specified in Table 5.2.1.1.3.

5.2.1.11 Industrial Occupancies. The MAQ of hazardous materials per control area in industrial occupancies shall be as specified in Table 5.2.1.1.3, with increased quantities permitted where storage areas comply with 5.2.1.13.

5.2.1.12 Storage Occupancies. The MAQ of hazardous materials per control area in storage occupancies shall be as specified in Table 5.2.1.1.3, with increased quantities permitted where storage areas comply with 5.2.1.13.

Table 5.2.1.1.3 Maximum Allowable Quantity (MAQ) of Hazardous Materials per Control Area[a]

			Storage			Use — Closed Systems			Use — Open Systems	
Material	Class	High Hazard Protection Level	Solid Pounds	Liquid Gallons (lb)	Gas[b] scf (lb)	Solid Pounds	Liquid Gallons (lb)	Gas[b] scf (lb)	Solid Pounds	Liquid Gallons (lb)
Physical Hazard Materials										
Combustible liquid	See note	See note	See note	See note	See note	See note	See note	See note	See note	See note
Consumer fireworks	See note	See note	See note	See note	See note	See note	See note	See note	See note	See note
Combustible metals	See note	See note	See note	See note	See note	See note	See note	See note	See note	See note
Cryogenic fluid [55: Table 6.3.1]	Flammable	2	N/A	45[j,k]	N/A	N/A	45[j,k]	N/A	N/A	45[j,k]
	Oxidizing	3	N/A	45[c,d]	N/A	N/A	45[c,d]	N/A	N/A	45[c,d]
	Inert	N/A	N/A	NL	N/A	N/A	NL	N/A	N/A	NL
Explosives	See note	See note	See note	See note	See note	See note	See note	See note	See note	See note
Flammable gas[l] [55: Table 6.3.1]	Gaseous	2	N/A	N/A	1000[c,d]	N/A	N/A	1000[c,d]	N/A	N/A
	Liquefied	2	N/A	N/A	(150)[c,d]	N/A	N/A	(150)[c,d]	N/A	N/A
	Liquefied Petroleum (LP)	See note	See note	See note	See note	See note	See note	See note	See note	See note
Flammable liquid	IA	See note	See note	See note	See note	See note	See note	See note	See note	See note
	IB and IC	See note	See note	See note	See note	See note	See note	See note	See note	See note
	Combination (IA, IB, IC)	See note	See note	See note	See note	See note	See note	See note	See note	See note
Flammable solid	N/A	3	125[c,d]	N/A	N/A	125[c,d]	N/A	N/A	25[c,d]	N/A
Inert Gas	Gaseous	N/A	N/A	N/A	NL	N/A	N/A	NL	N/A	N/A
	Liquefied	N/A	N/A	N/A	NL	N/A	N/A	NL	N/A	N/A
Organic peroxide	UD	1	1[c,j]	(1)[c,j]	N/A	1/4[j]	(1/4)[j]	N/A	1/4[j]	(1/4)[j]
	I	1	5[c,d]	(5)[c,d]	N/A	1[c,d]	(1)[c,d]	N/A	1[c,d]	(1)[c,d]
	II	2	50[c,d]	(50)[c,d]	N/A	50[d]	(50)[d]	N/A	10[c,d]	(10)[c,d]
	III	3	125[c,d]	(125)[c,d]	N/A	125[d]	(125)[d]	N/A	25[c,d]	(25)[c,d]
	IV	N/A	NL	NL	N/A	NL	NL	N/A	NL	NL
	V	N/A	NL	NL	N/A	NL	NL	N/A	NL	NL
Oxidizer	4	1	1[c,j]	(1)[c,j]	N/A	1/4[j]	(1/4)[j]	N/A	1/4[j]	(1/4)[j]
	3[f]	2 or 3	10[c,d]	(10)[c,d]	N/A	2[d]	(2)[d]	N/A	2[d]	(2)[d]
	2	3	250[c,d]	(250)[c,d]	N/A	250[d]	(250)[d]	N/A	50[d]	(50)[d]
	1	N/A	4000[c,e]	(4000)[c,e]	N/A	4000[e]	(4000)[e]	N/A	1000[e]	(1000)[e]
Oxidizing gas [55: Table 6.3.1]	Gaseous	3	N/A	N/A	1500[c,d]	N/A	N/A	1500[c,d]	N/A	N/A
	Liquefied	3	N/A	N/A	(150)[c,d]	N/A	N/A	(150)[c,d]	N/A	N/A
Pyrophoric	N/A	2	4[c,j]	(4)[c,j]	N/A	1[j]	(1)[j]	N/A	NP	NP
Pyrophoric Gas [55: Table 6.3.1]	Gaseous	2	N/A	N/A	50[c,j]	N/A	N/A	50[c,j]	N/A	N/A
	Liquefied	2	N/A	N/A	(4)[c,j]	N/A	N/A	(4)[c,j]	N/A	N/A
Unstable (reactive) Gas [55: Table 6.3.1]	4	1	1[c,j]	(1)[c,j]	N/A	1/4[j]	(1/4)[j]	N/A	1/4[j]	(1/4)[j]
	3	1 or 2	5[c,d]	(5)[c,d]	N/A	1[d]	(1)[d]	N/A	1[d]	(1)[d]
	2	2	50[c,d]	(50)[c,d]	N/A	50[d]	(50)[d]	N/A	10[d]	(10)[d]
	1	N/A	NL	NL	N/A	NL	NL	NL	NL	NL
Unstable (reactive) Gas	Liquefied 4 or 3 detonable	1	N/A	N/A	(1)[c,j]	N/A	N/A	(1)[c,j]	N/A	N/A
	3 non-detonable	2	N/A	N/A	(2)[c,d]	N/A	N/A	(2)[c,d]	N/A	N/A
	2	3	N/A	N/A	(150)[c,d]	N/A	N/A	(150)[c,d]	N/A	N/A
	1	N/A	N/A	N/A	NL	N/A	N/A	NL	N/A	N/A
Water-reactive	3	2	5[c,d]	(5)[c,d]	N/A	5[d]	(5)[d]	N/A	1[d]	(1)[d]
	2	3	50[c,d]	(50)[c,d]	N/A	50[d]	(50)[d]	N/A	10[d]	(10)[d]
	1	N/A	NL	NL	N/A	NL	NL	N/A	NL	NL

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Table 5.2.1.1.3 ***Continued***

Material	Class	High Hazard Protection Level	Storage			Use — Closed Systems			Use — Open Systems	
			Solid Pounds	Liquid Gallons (lb)	Gas[b] scf (lb)	Solid Pounds	Liquid Gallons (lb)	Gas[b] scf (lb)	Solid Pounds	Liquid Gallons (lb)
Health Hazard Materials										
Corrosive	N/A	4	5000[c,d]	500[c,d]	N/A	5000[d]	500[d]	N/A	1000[d]	100[d]
Corrosive Gas [55: Table 6.3.1]	Gaseous	4	N/A	N/A	810[c,d,g]	N/A	N/A	810[c,d,g]	N/A	N/A
	Liquefied	4	N/A	N/A	(150)[c,d]	N/A	N/A	(150)[c,d]	N/A	N/A
Highly toxic	N/A	4	10[c,d]	(10)[c,d]	N/A	(10)[d]	(10)[d]	N/A	3[d]	(3)[d]
Highly toxic gas [55: Table 6.3.1]	Gaseous	4	N/A	N/A	20[d,g]	N/A	N/A	20[d,g]	N/A	N/A
	Liquefied	4	N/A	N/A	(5)[d,g]	N/A	N/A	(5)[d,g]	N/A	N/A
Toxic	N/A	4	500[c,d]	(500)[c,d]	N/A	500[d]	(500)[d]	N/A	125[d]	(125)[d]
Toxic gas	Gaseous	4	N/A	N/A	810[c,d]	N/A	N/A	810[c,d]	N/A	N/A
	Liquefied	4	N/A	N/A	(150)[c,d]	N/A	N/A	(150)[c,d]	N/A	N/A

UD: Unclassified detonable For SI units, 1 lb = 0.454 kg; 1 gal = 3.785 L; 1 scf = 0.0283 Nm^3.

N/A: Not applicable. NL: Not limited. NP: Not permitted.

Note: The hazardous material categories and MAQs that are shaded in this table are not regulated by NFPA 400 but are provided here for informational purposes. See Chapter 2 for the reference code or standard governing these materials and establishing the MAQs. In accordance with 1.1.1.2, materials having multiple hazards that fall within the scope of NFPA 400 shall comply with NFPA 400.

[a] Table values in parentheses correspond to the unit name in parentheses at the top of the column. The aggregate quantity in use and storage is not permitted to exceed the quantity listed for storage.

[b] Measured at NTP or 70°F (21°C) and 14.7 psia (101.3 kPa).

[c] Quantities are permitted to be increased 100 percent where stored or used in approved cabinets, gas cabinets, exhausted enclosures, gas rooms explosives magazines, or safety cans, as appropriate for the material stored, in accordance with this code. Where footnote d also applies, the increase for both footnote c and footnote d is permitted to be applied accumulatively.

[d] Maximum quantities are permitted to be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.* Where footnote c also applies, the increase for both footnote c and footnote d is permitted to be applied accumulatively.

[e] The permitted quantities are not limited in a building equipped throughout with an automatic sprinkler system in accordance with NFPA 13.

[f] A maximum quantity of 200 lb (91 kg) of solid or 20 gal (76 L) of liquid Class 3 oxidizer is permitted where such materials are necessary for maintenance purposes, operation, or sanitation of equipment. Storage containers and the manner of storage are required to be approved.

[g] Allowed only where stored or used in gas rooms or approved cabinets, exhausted gas cabinets or exhausted enclosures, as specified in this Code. [5000: Table 34.1.3.1]

[h] Conversion. Where quantities are indicated in pounds and when the weight per gallon of the liquid is not provided to the AHJ, a conversion factor of 10 lb/gal (1.2 kg/L) shall be used.

[i] Permitted only in buildings equipped throughout with an automatic sprinkler system in accordance with NFPA 13.

[j] None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this Code.

[k] With pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood. [55: Table 6.3.1.1]

[l] Flammable gases in the fuel tanks of mobile equipment or vehicles are permitted to exceed the MAQ where the equipment is stored and operated in accordance with the fire code.

Table 5.2.1.13.3(b) Maximum Allowable Quantity (MAQ) per Indoor and Outdoor Control Area for Selected Hazard Categories in Mercantile and Storage Occupancies

	Maximum Allowable Quantity[a,b,c]			
	Solids		Liquids	
Hazard Category	lb	kg	gal	L
Physical Hazard Materials: Nonflammable and Noncombustible Solids and Liquids				
Unstable (reactive)				
Class 3	550	250	55	208
Class 2	1,150	522	115	435
Water-reactive				
Class 3	550	250	55	208
Class 2	1,150	522	115	435
Health Hazard Materials: Nonflammable and Noncombustible Solids and Liquids				
Corrosive	10,000	4536	1,000	3785
Highly toxic[d]	20	9	2	8
Toxic[d]	1,000	454	100	378

[a]Maximum quantities for hazard categories not shown are required to be in accordance with Table 5.2.1.1.3.
[b]Maximum quantities are permitted to be increased 100 percent in buildings that are sprinklered in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. Where footnote b also applies, the increase for both footnotes can be applied.
[c]Maximum quantities are permitted to be increased 100 percent where stored in approved storage cabinets in accordance with NFPA 1, *Fire Code*. Where footnote (a) also applies, the increase for both footnotes is permitted to be applied. [5000:Table 34.1.3.3.1(b)]
[d]Toxic or highly toxic solids or liquids displayed in original packaging in mercantile or storage occupancies and intended for maintenance, operation of equipment, or sanitation when contained in individual packaging not exceeding 100 lb (45.4 kg) shall be limited to an aggregate of 1200 lb (544.3 kg) or 220 gal (832.8 L). The increases allowed by footnotes a, b, and c shall not apply to highly toxic solids and liquids.

5.3.5.2 High hazard level 3 contents shall include materials that readily support combustion or present a physical hazard as defined in 4.2.1.2.3.

5.3.6 Protection Level 4.

5.3.6.1 Buildings, and portions thereof, containing quantities of hazardous materials exceeding the MAQ of high hazard level 4 contents permitted in control areas shall comply with applicable regulations for protection level 4, as set forth in the applicable sections of Chapter 6, Chapters 11 through 21, and the building code.

5.3.6.2 High hazard level 4 contents shall include materials that are acute health hazards as defined in 4.2.1.2.4.

5.3.7 Detached Building Required for High Hazard Level 2 and High Hazard Level 3 Materials. Buildings required to comply with protection level 2 or 3 and containing quantities of high hazard contents exceeding the quantity limits set forth ~~in Table 5.3.7 shall be in accordance with 6.2.3.4 or 6.2.4.4, as~~ applicable.

Table 5.2.2.1 Design and Number of Control Areas

Floor Level	Maximum Allowable Quantity per Control Area (%)*	Number of Control Areas per Floor	Fire Resistance Rating for Fire Barriers† (hr)
Above grade			
>9	5.0	1	2
7–9	5.0	2	2
4–6	12.5	2	2
3	50.0	2	1
2	75.0	3	1
1	100.0	4	1
Below grade			
1	75.0	3	1
2	50.0	2	1
Lower than 2	NP	NP	N/A

NP: Not permitted. N/A: Not applicable.
*Percentages represent the MAQ per control area shown in Table 5.2.1.1.3, with all the increases permitted in the footnotes of that table.
†Fire barriers are required to include floors and walls, as necessary, to provide a complete separation from other control areas.

Table 5.3.7 High Hazard Level 2 and High Hazard Level 3 Materials — Detached Building Required

		Maximum Quantity Without a Detached Building	
Material	Class	Solids and Liquids (tons)	Gases scf (Nm³) [m³]*
Individual bulk compressed gas systems	N/A	N/A	15,000 (425)
Oxidizers	3	1,200	N/A
	2	2,000	N/A
Organic peroxides	II	25	N/A
	III	50	N/A
Unstable (reactive) materials	3, nondetonable	1	2,000 (57)
	2	25	10,000 (283)
Water-reactive materials	3	1	N/A
	2, deflagrating	25	N/A
Pyrophoric gases		N/A	2,000 (57)

For SI units, 1 ton = 0.9 met ton.
N/A: Not applicable.
~~[55: Table 6.5]~~
*See Table 21.2.5.

6.2.1.5 Ventilation. Buildings, or portions thereof, in which explosive, flammable, combustible, corrosive, or highly toxic dusts, mists, fumes, vapors, or gases are, or might be, emitted shall be provided with mechanical exhaust ventilation or natural ventilation where natural ventilation can be shown to be acceptable for the materials as stored. [5000:34.3.2.5.1]

6.2.1.5.1 Solids and liquids stored in closed containers shall not be required to comply with 6.2.1.5. [5000:*34.3.2.5.1.2*]

6.2.1.5.2 Mechanical exhaust systems shall comply with the mechanical code. [5000:34.3.2.5.2]

6.2.1.5.3 Mechanical ventilation shall be at a rate of not less than 1 $ft^3/min/ft^2$ (5.1 $L/s/m^2$) of floor area over areas required to comply with protection level 1 through protection level 4. [5000:34.3.2.5.3]

6.2.1.5.4 Ventilation requirements shall be determined by calculations based on anticipated fugitive emissions or by sampling of the actual vapor concentration levels under normal operating conditions. [5000:34.3.2.5.5]

6.2.1.5.5 Make-up air shall be provided, and provision shall be made for locating make-up air openings to avoid short-circuiting the ventilation. [5000:34.3.2.5.6]

6.2.1.5.6 Ducts conveying explosives or flammable vapors, fumes, or dusts shall extend directly to the exterior of the building without entering other spaces. [5000:34.3.2.5.7]

6.2.1.5.6.1 Exhaust ducts shall not extend into or through ducts and plenums. [5000:34.3.2.5.7.1]

6.2.1.5.6.2 Ducts conveying vapor or fumes having flammable constituents less than 25 percent of their lower flammability limit shall be permitted to pass through other spaces. [5000:34.3.2.5.7.2]

6.2.1.5.7 Emissions generated by workstations shall be removed from the areas in which they are generated by means of local exhaust installed in accordance with the mechanical code.

6.2.1.5.8 The location of supply and exhaust openings shall be in accordance with the mechanical code. [5000:34.3.2.5.9]

6.2.1.5.9 Systems shall operate continuously unless alternate designs are approved. [5000:34.3.2.5.11]

6.2.1.5.10 A manual shutoff control for ventilation equipment required by 6.2.1.5 shall be provided outside the room adjacent to the principal access door to the room. [5000:34.3.2.5.12]

6.2.1.5.11 The shutoff control described in 6.2.1.5.10 shall be of the break-glass type and shall be labeled as follows:

VENTILATION SYSTEM EMERGENCY SHUTOFF

[5000:34.3.2.5.13]

6.2.1.5.12 Exhaust ventilation shall be arranged to consider the density of the potential fumes or vapors released. [5000:34.3.2.5.14]

6.2.1.5.12.1 For fumes or vapors that are lighter than air, exhaust shall be taken from a point within 12 in. (305 mm) of the high point of the room or area in which they are generated.

6.2.1.5.12.2 For fumes or vapors that are heavier than air, exhaust shall be taken from a point within 12 in. (305 mm) of the floor. [5000:34.3.2.5.14.1]

6.2.1.5.12.3 The location of both the exhaust and inlet air openings shall be arranged to provide air movement across all portions of the floor or room to prevent the accumulation of vapors. [5000:34.3.2.5.14.2]

6.2.1.5.12.4 Exhaust ventilation shall not be recirculated within the room or building if the materials stored are capable of emitting hazardous vapors. [5000:34.3.2.5.14.3]

6.2.1.5.12.5 Recirculation shall be permitted where it is monitored continuously using a fail-safe system that is designed to automatically sound an alarm, stop recirculation, and provide full exhaust to the outside in the event that vapor–air mixtures in concentrations over one-fourth of the lower flammable limit are detected. [5000:34.3.2.5.14.4]

6.2.1.5.12.6 Air contaminated with explosive or flammable vapors, fumes, or dusts, or with radioactive materials, shall not be recirculated.

6.2.1.6* Explosion Control. Buildings, or portions thereof, required to comply with protection level 1 through protection level 3 and containing materials shown in Table 6.2.1.6 shall be provided with a means of explosion control. [5000:34.3.2.6]

Table 6.2.1.6 Explosion Control Requirements

Hazard Category	Class	Protection Method
Combustible dust presenting an explosion hazard	NA	Explosion control*
Organic peroxides	Unclassified	Barricade†
	Class I	Barricade†
Oxidizer liquids and solids	Class 4	Barricade†
Unstable (reactive)	Class 4	Barricade†
	Class 3, detonating	Barricade†
	Class 3, deflagrating	Explosion control*
Water-reactive liquids and solids	Class 3	Explosion control*
	Class 2, deflagrating	Explosion control*

NA: Not applicable.
*Explosion control is required to be a deflagration prevention method, such as combustible concentration reduction or oxidant concentration reduction, or a deflagration control method complying with NFPA 69, *Standard on Explosion Prevention Systems*, or an approved, engineered deflagration-venting method.
†Barricades are required to comply with NFPA 495, *Explosive Materials Code*.
[5000: Table 34.3.2.6]

6.2.1.7 Limit Controls. Limit controls shall be provided in accordance with 6.2.1.7.1 and 6.2.1.7.2.

6.2.1.7.1 Temperature Control. Materials that must be kept at temperatures other than normal ambient temperatures to prevent a hazardous reaction shall be provided with an approved means to maintain the temperature within a safe range.

6.2.1.7.1.1 Redundant temperature control equipment that will operate on failure of the primary temperature control system shall be provided.

6.2.1.7.1.2 The use of alternative means that prevent a hazardous reaction shall be permitted subject to the approval of the AHJ.

6.2.1.7.2 Pressure Control.

6.2.1.7.2.1 Stationary tanks and equipment containing hazardous material liquids that can generate pressures exceeding design limits due to exposure fires or internal reaction shall have some form of construction or other approved means that will relieve excessive internal pressure.

6.2.1.7.2.2 The termination point for piped vent systems used for the purpose of operational or emergency venting shall be located to prevent impingement exposure on the system served and to minimize the effects of high-temperature thermal radiation or the effects of contact with the material being vented from the escaping plume on the supply system, personnel, adjacent structures, and ignition sources.

6.2.1.8 Standby and Emergency Power.

6.2.1.8.1 Where mechanical ventilation, treatment systems, temperature control, alarm, detection, or other electrically operated safety systems are required by this code or the building code, such systems shall be provided with standby power or emergency power as required by 6.2.1.8. [5000:34.3.2.7.1]

6.2.1.8.2 Standby power for mechanical ventilation, exhaust treatment, and temperature control systems shall not be required where such systems are engineered and approved as fail-safe. [5000:34.3.2.7.2]

6.2.1.8.3 The secondary source of power shall be an approved means of legally required standby power in accordance with *NFPA 70, National Electrical Code.*

6.2.1.9 Spill Control and Secondary Containment for Hazardous Materials Liquids and Solids.

6.2.1.9.1 General. Buildings, or portions thereof, required to comply with Protection Level 1 through Protection Level 4 shall be provided with spill control and secondary containment in accordance with 6.2.1.9.2 and 6.2.1.9.3, except for outdoor storage on containment pallets complying with 6.2.7.3.3.

6.2.1.9.2 Spill Control.

6.2.1.9.2.1 Buildings, or portions thereof, used for storage of hazardous materials liquids in individual containers having a capacity of more than 55 gal (208.2 L) shall be provided with spill control to prevent the flow of liquids to adjoining areas.

6.2.1.9.2.2 Where spill control is required, floors in indoor locations and similar surfaces in outdoor locations shall be constructed to contain a spill from the largest single vessel by one of the following methods:

(1) Liquidtight sloped or recessed floors in indoor locations or similar areas in outdoor locations
(2) Liquidtight floors in indoor locations or similar areas in outdoor locations provided with liquidtight raised or recessed sills or dikes
(3) Sumps and collection systems

6.2.1.9.2.3 Except for surfacing, the floors, sills, dikes, sumps, and collection systems shall be constructed of noncombustible material, and the liquidtight seal shall be compatible with the material stored.

6.2.1.9.2.4 Where liquidtight sills or dikes are provided, they shall not be required at perimeter openings that are provided with an open-grate trench across the opening that connects to an approved collection system.

6.2.1.9.3 Secondary Containment.

6.2.1.9.3.1 Buildings, or portions thereof, used for any of the following shall be provided with secondary containment:

(1) Storage of liquids where the capacity of an individual vessel exceeds 55 gal (208.2 L) or the aggregate capacity of multiple vessels exceeds 1000 gal (3785 L)
(2) Storage of solids where the capacity of an individual vessel exceeds 550 lb (248.8 kg) or the aggregate capacity of multiple vessels exceeds 10,000 lb (4524.8 kg)

6.2.1.9.3.2 Buildings, or portions thereof, containing only hazardous materials in listed secondary containment tanks or systems shall not be required to comply with 6.2.1.9.3.1.

6.2.1.9.3.3 Buildings, or portions thereof, containing only ammonium nitrate solids, organic peroxide solids, flammable solids, pyrophoric solids, or corrosive solids shall not be required to comply with 6.2.1.9.3.1.

6.2.1.9.3.4 The building, room, or area shall contain or drain the hazardous materials and fire protection water through the use of one of the following methods:

(1) Liquidtight sloped or recessed floors in indoor locations or similar areas in outdoor locations
(2) Liquidtight floors in indoor locations or similar areas in outdoor locations provided with liquidtight raised or recessed sills or dikes
(3) Sumps and collection systems
(4) Drainage systems leading to an approved location

6.2.1.9.3.5 Where incompatible materials are present in open containers or systems, such materials shall be separated from each other in the secondary containment system.

6.2.1.9.3.6 Secondary containment for indoor storage areas shall be designed to contain a spill from the largest vessel plus the design flow volume of fire protection water calculated to discharge from the fire-extinguishing system over the minimum required system design area, or area of the room or area in which the storage is located, whichever is smaller, for a period of 20 minutes.

6.2.1.9.3.7 A monitoring method shall be provided to detect hazardous materials in the secondary containment system.

6.2.1.9.3.8 The monitoring method specified in 6.2.1.9.3.7 shall be permitted to be visual inspection of the primary or secondary containment or other approved means.

6.2.1.9.3.9 Where secondary containment is subject to the intrusion of water, a monitoring method for detecting water shall be provided.

6.2.1.9.3.10 Where monitoring devices are provided, they shall be connected to distinct visual or audible alarms.

6.2.1.9.3.11 Where remote containment systems are provided, drainage systems shall be in accordance with the plumbing code, as referenced in Chapter 2, and the following provisions also shall be met:

(1) The slope of floors in indoor locations to drains or similar areas in outdoor locations shall be not less than 1 percent.
(2) Drains from indoor storage areas shall be sized to carry the volume of the fire protection water, as determined by the design density discharged from the automatic fire-extinguishing system over the minimum required system design area, or area of the room or area in which the storage is located, whichever is smaller.

6.2.5 Protection Level 4.

6.2.5.1 Buildings, or portions thereof, required to comply with protection level 4 shall comply with 6.2.1 and 6.2.5.2. [5000:34.3.6]

6.2.5.2 Highly Toxic Solids and Liquids. Highly toxic solids and liquids not stored in approved hazardous materials storage cabinets shall be isolated from other hazardous materials storage by a 1-hour fire barrier. [5000:34.3.6.2]

6.2.6 Protection Level 5. In addition to the requirements set forth elsewhere in *NFPA 5000, Building Construction and Safety Code,* buildings, and portions thereof, required to comply with protection level 5 shall comply with NFPA 1, *Fire Code,* and NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities.* [5000:34.3.7.1]

6.2.7 Outdoor Storage. Outdoor storage areas shall be in accordance with the requirements of Chapters 11 through 21, as applicable.

6.2.7.1 Clearance from Combustibles. Clearance from combustibles shall comply with 6.1.15(2).

6.2.7.2 Weather Protection. Where weather protection is provided for sheltering outside hazardous material storage areas, such storage areas shall be considered outside storage areas, provided that all of the following conditions are met: [5000:34.2.6]

(1) The overhead structure shall be approved noncombustible construction with a maximum area of 1500 ft² (140 m²) except that area increases based on location or fire protection systems under the requirements of the building code shall be allowed.
(2) Supports and walls shall not obstruct more than one side or more than 25 percent of the perimeter of the storage area.
(3) The distance from the structure and the structural supports to buildings, lot lines, or public egress to a public way shall not be less than the distance required by Chapters 11 through 21 for an outside hazardous material storage area without weather protection.
(4) Weather protection structures containing storage of explosive or detonable materials shall be considered indoor storage.

6.2.7.3 Secondary Containment.

6.2.7.3.1 General. Where secondary containment is required, it shall be in accordance with 6.2.1.9.3.

6.2.7.3.2 Where Required. Where required by Table 6.2.7.3.2, outdoor storage areas used for hazardous materials solids or liquids shall be provided with secondary containment in accordance with 6.2.1.9.3.

6.2.7.3.3 Containment Pallets. Where used as a substitute for spill control and secondary containment for outdoor storage in accordance with 6.2.1.9.1, containment pallets shall comply with the following:

(1) A liquidtight sump accessible for visual inspection shall be provided.
(2) The sump shall be designed to contain not less than 66 gal (249.8 L).
(3) Exposed surfaces shall be compatible with the material stored.
(4) Containment pallets shall be protected to prevent collection of rainwater within the sump.

6.3 Requirements for Use, Dispensing, and Handling of Hazardous Materials in Amounts Exceeding Maximum Allowable Quantities.

6.3.1* General. The following shall apply to aggregate quantities of hazardous materials used, dispensed, or handled:

(1) Where the aggregate quantity of hazardous materials used, dispensed, or handled exceeds the MAQ, the requirements set forth in Section 6.3 shall apply, except as specified in 6.3.1.1.
(2) Where the aggregate quantity of hazardous materials used, dispensed, or handled does not exceed the MAQ, Section 6.3 shall not apply.

6.3.1.1 Uses Not Required to Comply. The following use conditions shall not be required to comply with Section 6.3:

(1) Corrosives used in stationary lead–acid battery systems used for standby power, emergency power, or uninterrupted power supply complying with Chapter 52 of NFPA 1, *Fire Code*
(2) Application and release of pesticide products and materials intended for use in weed abatement, erosion control, soil amendment or similar applications, where applied in accordance with the manufacturer's instructions and label directions

6.3.1.2 Limit Controls.

6.3.1.2.1 General. Limit controls shall be provided in accordance with 6.3.1.2.1 through 6.3.1.2.4.2.

6.3.1.2.2 Temperature Control. Process tanks and equipment, which involve temperature control of the material to prevent a hazardous reaction, shall be provided with limit controls to maintain the temperature within a safe range. [1:60.4.4]

6.3.1.2.3 Pressure Control.

6.3.1.2.3.1 Stationary tanks and equipment containing hazardous materials liquids that can generate pressures exceeding design limits due to exposure fires or internal reaction shall have a form of construction or other approved means that relieves excessive internal pressure. [1:60.4.4]

6.3.1.2.3.2 The means of pressure relief shall vent to an approved location.

6.3.1.2.3.3 Where required by Chapter 21, the means of pressure relief shall vent to an exhaust scrubber or treatment system.

6.3.1.2.4 Liquid Level.

6.3.1.2.4.1 High Level. Open tanks in which hazardous materials are used shall be equipped with a liquid level limit control or other means to prevent overfilling of the tank. [1:60.4.4]

6.3.1.2.4.2 Low Level. Open tanks and containers in which hazardous materials are heated shall be equipped with approved automatic shutoff controls, which will sense low liquid levels and shut off the source of heat. [1:60.4.4]

6.3.1.3 Standby and Emergency Power. Standby or emergency power shall be provided in accordance with 6.3.1.3.1 and 6.3.1.3.2 for required mechanical ventilation, treatment systems, temperature control, alarm, detection, or other electrically operated safety systems. [5000:34.3.2.7.1]

6.3.1.3.1 Standby power for mechanical ventilation, exhaust treatment, and temperature control systems shall not be required where such systems are engineered and approved as fail-safe. [5000:34.3.2.7.2]

APPENDIX E – CUTSHEETS

Single Duct Terminal Units
SPV, SDV Series
Single Duct – Controller Type

Product Information

General Information

Price has, as a primary component of its terminal unit line, the SPV (pneumatic controls), SDV (digital controls) single duct VAV assemblies. These units are designed to control the air flow rate of conditioned air into an occupied space in response to a control signal, usually a thermostat. The clean and efficient design of these single duct terminal units result in a system component which has minimal pressure drop reducing fan horsepower requirements, and low noise generation for quiet operation. A compact configuration makes this unit easier to use in today's crowded mechanical spaces or in retrofitting existing systems.

Control options for this product line are wide and varied with pneumatic, analog electronic and state of the art direct digital control available to suit most any application. Most of the control options utilize the exclusive Price SP300 multipoint sensor for accurate duct air velocity pressure measurement. This allows the terminals to monitor the desired flow rate, as dictated by the thermostat, and compensate instantly for any changes in supply air pressure that might tend to alter the supply volume. In other words, the net result is a pressure independent variable air volume system.

In addition to the basic volume control assembly, a complete line of accessories is offered to meet specific job requirements. Sound attenuators, multi-outlet adaptors and heating coils are all available. These are factory assembled to the basic assembly for shipment as an integrated unit.

Model SDV

SXV X000

Controller Type
- P — Pneumatic
- D — Digital
- M — Manual

Controls
- 5 — Supplied by others (Digital Only)
- 6 — Pressure Dependent
- 8 — Pressure Independent by Price

✓ Product Selection Checklist

1] Select Unit Inlet Size based on control and acoustic parameters.
2] Select Control type (Pneumatic, Digital) based on system design.
3] Select Accessories (Multi-Outlet Adaptor, Attenuator) as required.
4] Select Reheat Coil, if required.
5] Select Control Sequence based on system design.

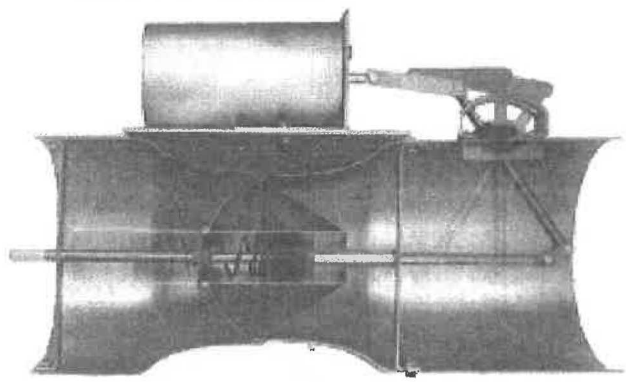
Features:

- Capacities ranging from 50 – 8000 cfm in 11 sizes.
- Pressure independent operation.
- Can be used for VAV or constant volume applications.
- Available with pneumatic, or direct digital controls.
- Factory calibrated to job requirements.
- Individually adjustable minimum and maximum air volumes – easily field adjusted.
- SP300 multipoint flow sensor designed to maintain control accuracy independent of field installation conditions.
- Gauge taps for flow measurement and balancing supplied with factory mounted pneumatic controls (optional for digital controls by others).
- Conveniently accessible externally mounted controls.
- Inlet connection bead offers a means for secure flex duct connections.
- A full 2 in. inlet connection to secure flex and hard duct connections.
- Full range of accessories available (i.e. coils, attenuators, etc.).
- NEMA1 Protective metal shrouds for digital (by Price) controls. Protective metal cover optional for pneumatic controls.
- Compact, lightweight design for ease of installation.
- 22 gauge zinc-coated steel housing (optional 20 gauge available).
- 1/2 in. [13] thick, min. 1.5 lb density fiberglass internal insulation – meets requirements for NFPA90A and UL181. 3/4 in. [19] and 1 in. [25] insulation also available as an option.
- Special liners and insulations available see page F52.
- Damper blade constructed of two layers of heavy gauge galvanized steel with a sandwiched peripheral gasket of cross linked polyurethane foam to ensure tight seal and no damper deflection.
- Plated damper shaft with position indicator is mounted in self-lubricating bearings.
- Optional insulated access door 4 x 6 3/4" (102x171) attached with 4 screws or optional latches.
- Discharge complete with slip and drive cleat duct connections.
- Performance certified in accordance with the AHRI 880 certification program.
- Units with factory-mounted high voltage components like transformers or disconnect switches are ETL certified to UL 873.
- Selected product configurations are OSHPD seismic pre-approved, in compliance with CBC 2013 and IBC 2012.

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

SELECTION

FIGURE 4



MA-VVS

TABLE 1

MA-CV AND VV VOLUME RANGE

VALVE NO.	CFM MINIMUM / MAXIMUM			*DIMENSIONS	
	LOW	MED.	HIGH	O.D.	L.
	ΔP 0.3" - 3.0"	ΔP 0.6" - 3.0"	ΔP 1.0" - 6.0"	In.	In.
5	20 - 150	30 - 175	45 - 275	4 15/16	14 1/4
6	35 - 250	50 - 300	55 - 400	5 15/16	16 5/8
8	50 - 400	60 - 500	85 - 700	7 7/8	19 1/2
10	40 - 700	60 - 900	90 - 1200	9 7/8	21 1/2
12	190 - 1200	200 - 1400	230 - 1750	11 7/8	24
210	80 - 1400	120 - 1800	180 - 2400	24 x 12	21 3/4
212	380 - 2400	400 - 2800	460 - 3500	28 x 14	24 1/4
312	570 - 3600	600 - 4200	690 - 5250	42 x 14	24 1/4
412	760 - 4800	800 - 5600	920 - 7000	56 x 14	24 1/4

* Actual dimensions are per current drawings. Future changes may be shown on approval drawings only. See page 8 for recomended selection ranges.

CV AND VV SELECTION

Determine system pressure after the fan and select valves according to capacity requirements in low, medium or high pressure columns. Low pressure valves are for systems where the ΔP across the valve is between 0.3" and 3.0" water gauge. Medium pressure valves are for system pressure between 0.6" and 3.0" water gauge. High pressure valves are for systems with ΔP across the valve of 1.0" to 6.0" water gauge. In order to allow for flexibility in cases of future changes, avoid selecting valves at either their maximum or their minimum limits. Duct diameter should match valve size to elinminate transitions.

TABLE 2

MA-VVS VOLUME RANGE

VALVE NO.	CFM MINIMUM / MAXIMUM			*DIMENSIONS	
	LOW	MED.	HIGH	O.D.	L.
	ΔP 0.4" - 3.0"	ΔP 0.6" - 3.0"	ΔP 1.25" - 6.0"	In.	In.
6	0 - 250	0 - 300	0 - 400	5 15/16	16 5/8
8	0 - 400	0 - 500	0 - 700	7 7/8	19 1/2
10	0 - 700	0 - 850	0 - 1200	9 7/8	21 1/2
12	0 - 1000	0 - 1200	0 - 1500	11 7/8	24
210	0 - 1400	0 - 1700	0 - 2400	24 x 12	21 3/4
212	0 - 2000	0 - 2400	0 - 3000	28 x 14	24 1/4
312	0 - 3000	0 - 3600	0 - 4500	42 x 14	24 1/4
412	0 - 4000	0 - 4800	0 - 6000	56 x 14	24 1/4

* Actual dimensions are per current drawings. Future changes may be shown on approval drawings only. See page 9 for recomended selection ranges.

VVS SELECTION

Determine system pressure after the fan and select valves according to capacity requirements. Low pressure valves are for systems where the static pressure drop across the valve can range between 0.4" and 3.0" water gauge. Medium pressure valves are for systems between 0.6" and 3.0" water gauge. High pressure valves are for systems where the static pressure is between 1.25" and 6.0" water gauge across the valve.

Flush Face Radial Flow Diffuser
FRFDA/AFRFDA/FRFDSSA Series

price

Product Information

Price FRFDA Series diffusers are designed to produce an adjustable, low velocity, multi-directional air pattern.

The diffuser design achieves precise, repeatable air patterns using pattern adjustment controllers mounted in predetermined locations above the equalization baffle. The following patterns can be ordered preset from the factory: 2 way radial, 1 way radial, 2 way horizontal, and 1 way vertical. Patterns may be re-adjusted in the field by simply relocating the pattern controllers. Once adjusted, the pattern controllers are firmly fixed in place, preventing inadvertent movement during cleaning.

An internal air baffle equalizes air flow across the face of the diffuser. The entire face of the diffuser, including the pattern control blades, is flush with the ceiling line for blending in well with most ceiling systems. The face panel is removable from the room side via quarter-turn fasteners, providing access for damper adjustment or cleaning.

The high capacity and low noise level of the FRFDA series diffuser makes it suitable for critical applications such as laboratories, cleanrooms, medical facilities, and kitchens. The ability to modify air pattern settings makes this model an ideal choice for areas where design conditions or equipment location is variable. Field relocation of pattern controllers provides additional system flexibility.

Features

- Adjustable pattern: 2 way radial, 1 way radial, 2 way horizontal, and 1 way vertical patterns can be preset or field adjusted.
- Common appearance with FRFD allows for integration of both products on the same site with uniform architectural appeal.
- Optional neck-mounted volume control damper is fabricated of coated steel with nickel-plated operators and finished in B12 white powder coat paint. Optional stainless steel damper also available.
- Suitable for use in either T-bar or surface mount applications.

Construction/Finish

FRFDA

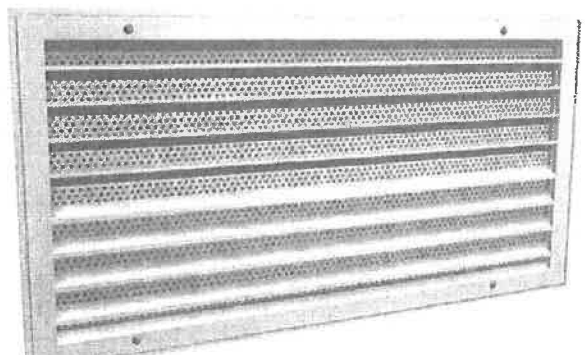
- Diffuser frame and control blades - aluminum
- Plenum and Equalization Baffle - steel
- Finish: B12 - white powder coat

AFRFDA

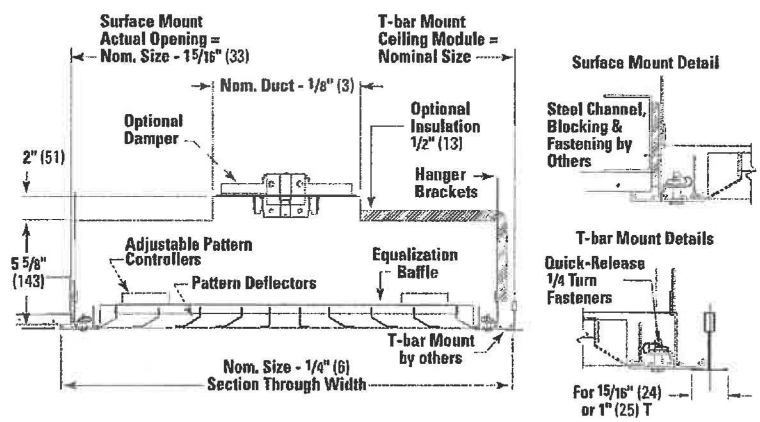
- Diffuser frame, control blades equalization baffle and plenum - aluminum
- Finish: B12 - white powder coat

FRFDSSA

- All-stainless steel construction - #4 Finish on exposed surface



FRFDA



Dimensional Data - Imperial (in.) / Metric (mm)

Nominal Duct	Nominal Size L x W Imperial
8 (204)	24 x 24 (610 x 610)
10 (254)	24 x 24 (610 x 610)
10 (254)	48 x 24 (1219 x 610)
12 (305)	48 x 24 (1219 x 610)

✓ Product Selection Checklist

1) Select Diffuser Type by model number (FRFDA, AFRFDA, FRFDSSA).
2) Select Inlet Diameter.
3) Select Factory Preset Blow Pattern (2R, 1R, H, V).
4) Select Damper Construction if required. **Example: FRFDA / 10" / 1R / 24" x 48"**

All Metric dimensions ( ) are soft conversion.
Imperial dimensions are converted to metric and rounded to the nearest millimeter.

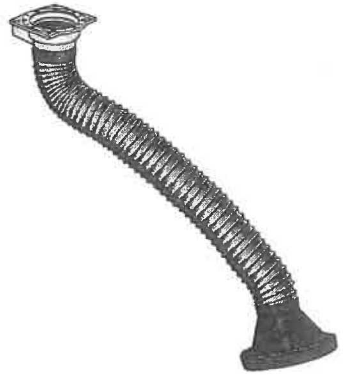
Technical leaflet	Date
150033 0	2010-12-27

90

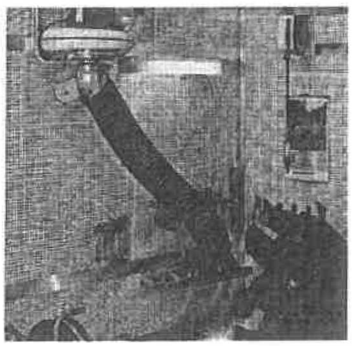
Nederman

IMPROVING YOUR WORKSPACE

Extraction Arm Telescopic

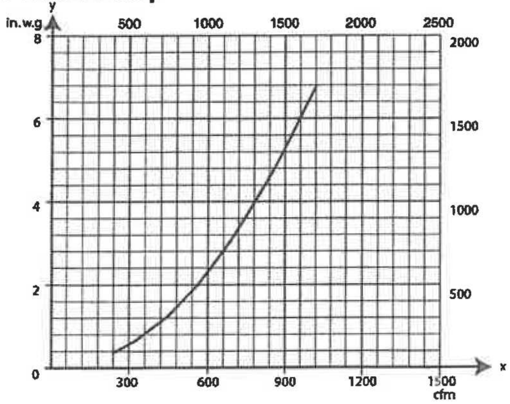


The Nederman Telescopic arm is specially designed for working environments with fumes, vapours or non explosive dust, where the space is limited. Typical workplaces can be welding schools or for production in small welding booths. The applications can be welding, grinding, or other industrial processes where a small, easily positioned arm is required. The reach of the arm is between 0.9 and 1.6 m (3 and 5 ft.).



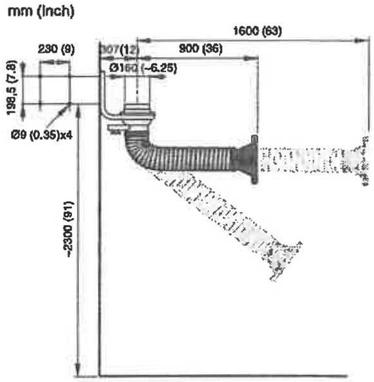
- The arm is flexible in all directions and simple to position and to extend
- The arm has a balanced telescopic action by an adjustable balance block
- The assembly is suspended by a swivel, which allows it to rotate 360 degrees
- The hood can be tilted in all directions

Pressure drop



X: airflow m³/h (cfm)
Y: static pressure Pa

mm (inch)



Description	Reach, m (ft.)	Airflow, m³/h (cfm)	Connection Ø, mm (in)	Max. fume temperature, °C (°F)	Noise level at hood, dB(A)	Weight, kg (lb.)	Part no.
Telescopic arm with metal hood with damper	0.9-1.6 (3 - 5)	600-1000 (350-600)	160 (6 ¼)	70 (160)	76	12 (26)	10502731
Telescopic arm with metal hood without damper	0.9-1.6 (3 - 5)	600-1000 (350-600)	160 (6 ¼)	70 (160)	76	12 (26)	10502531
Telescopic arm with Original hood	0.9-1.6 (3 - 5)	600-1000 (350-600)	160 (6 ¼)	70 (160)	76	12 (26)	10502331

Product availability may differ by country

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Strobic Air Corporation
A Subsidiary of CECO Corporation
700 Emlen Way
Telford, PA 18969
Phone: (215) 723-4700 | Fax: (215) 723-7401
www.choosetristack.com | www.strobicair.com

Project: SNL Boil-Off Exhaust REV1 - Fan Reference: EF-3
Fans: 1 (operating) / 0 (redundant)

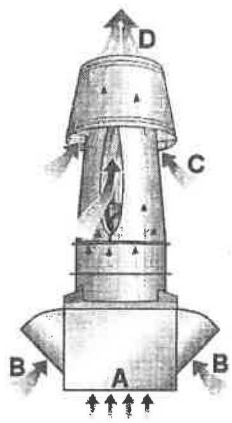
Tri-Stack™

A: Inlet Flow
5000 cfm

B: Bypass Flow
2272 cfm

C: Entrained Flow
3636 cfm

D: Total System Flow
10908 cfm



Operating Conditions

Inlet Static Pressure: **5** in w.g.
Inlet Air Temperature: **70 deg F**
Inlet Air Density: **0.0612 lb/cu ft**

Inlet Flow per Fan: **5000 cfm**
Ambient Air Temp.: **70 deg F**
Ambient Air Dens: **0.0612 lb/cu ft**

Inlet Flow Total: **5000 cfm**
Altitude at Site: **5400 ft**
Operating Frequency: **60 Hz**

Fan Performance Data - (single fan)

Fan Model: **TS1S150B18**

Fan Flow Rate: **7272 cfm**
Total Flow: **10908 cfm**
Operating Speed: **1800 rpm**
Dilution Ratio: **218 %**

Nozzle Velocity: **7991 fpm**
Min. Motor Hp: **15 hp**
Corrected BHP: **11.3 hp**

Effective Stack Height:
10 mph Wind: **60 ft**
15 mph Wind: **43 ft**

Altitude and Temperature Corrections

Mixed Air Density:	Mixed Air Temperature:	Corrected Static Pressure:
0.0612 lb/cu ft	**70 deg F**	**6.1 in w.g.**

Comments

1. Number of fans running does not include redundant fan.
2. Inlet static pressure had been derated for discharge nozzle, windband, airfoil isolation damper, and outlet silencer
3. Inlet static pressure had been derated for system effects through the mixing box, based on the factory-recommended duct configurations.
4. Consult factory for additional derations when duct configurations do not meet factory guidelines.
5. Add an additional 0.15 inches static pressure for gravity isolation dampers (usable on single fan mixing boxes only).
6. Effective stack height from roof line is given for fan without a mixing box, mounted on an 18 inch high curb.
7. Stack height calculated using Briggs equation, per ASHRAE Fundamentals (1997).

The Sherwin-Williams Company

Industrial & Marine Coatings

SeaGuard Marine & Specialty Coatings

COR-COTE® VEN GF

Strobic Air Corporation [Laboratory Exhaust Equipment Coating Specifications]

High Performance Interior Corrosion Resistant Coating System

A multi-functional epoxy novolac based vinyl ester reinforced with laminar graphite fillers for applications where exposure to hydrofluoric or hydrofluosilicic acids are encountered.

Surface Preparation & Comments

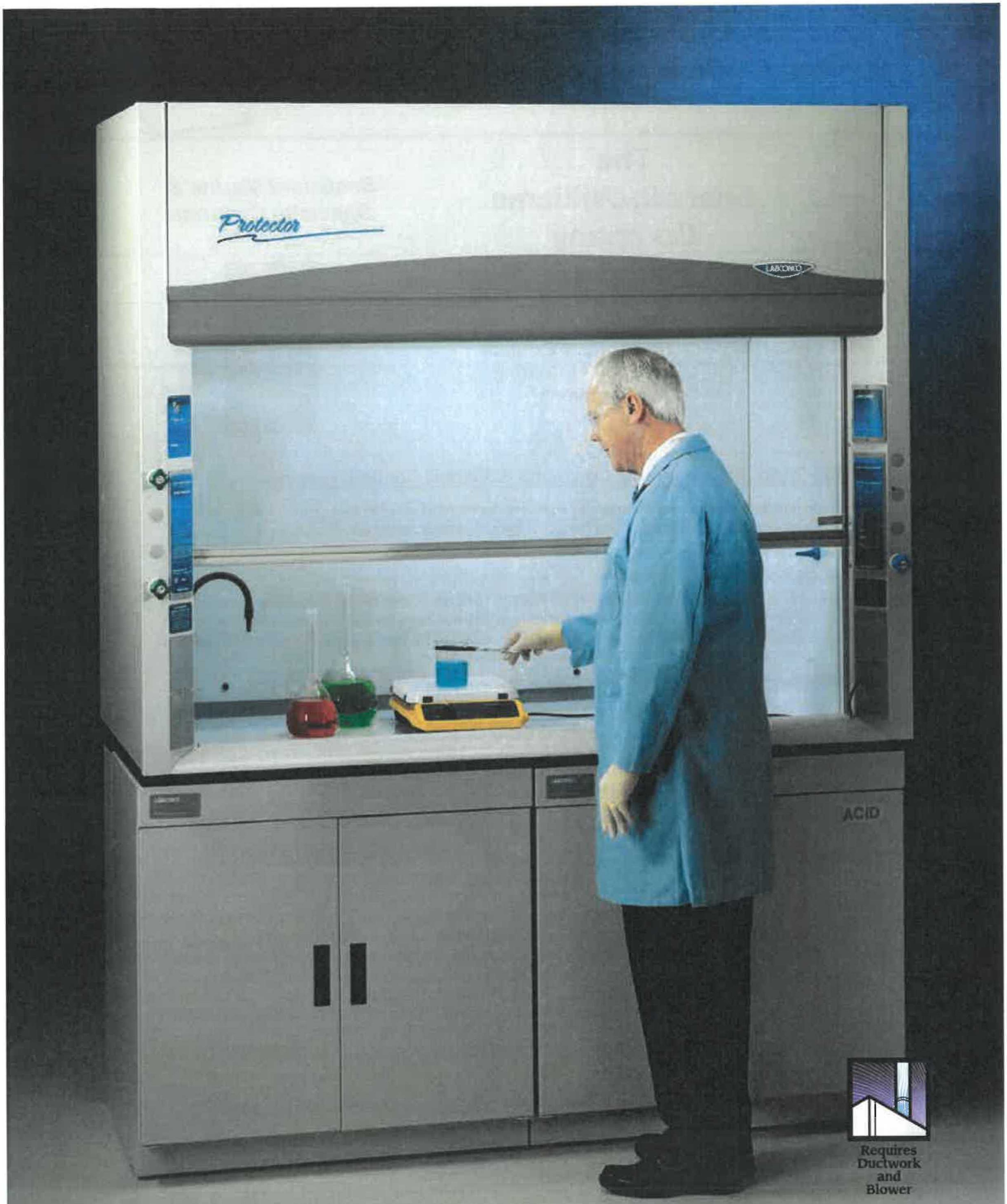
- Abrasive blast clean to Sa2.5 (ISO 8501-1:1988) or SSPC-SP10. If oxidation has occurred between blasting and application, the surface should be reblasted to the specified visual standard. Surface defects revealed by the blast cleaning process, should be ground, filled, or treated in the appropriate manner
- A sharp, angular surface profile of 2-3 mils (50-75 microns) is recommended.

Area Size: 1 ft²

#	Product Name	Coat Type	VS (%)	Application Method	DFT (mil)	Overcoating Interval€Min - Max (73°F)	Pot Life at 73°F (25°C) (73°F)	PSR (ft²/gal)
1	Cor-Cote VEN GF	Full Coat	100% Reactive	Airless Spray, Brush, Roller, Air Spray	16.0-24.0	3 Hr - 6 Day	30 - 60 Min	64 - 80

Sherwin-Williams Cor-Cote VEN GF graphite filled vinyl ester is a multi-functional epoxy novolac based vinyl ester. It provides resistance to many aromatic and aliphatic solvents, organic and mineral acids, and excellent resistance to thermal degradation. It employs laminar graphite fillers in place of silica based fillers for applications where exposure to hydrofluoric or hydrofluosilicic acids are encountered. This resistance makes Cor-Cote VEN GF the material of choice for protection of fume hoods, fan blades, condenser housing and other chemical process equipment with hydrofluoric or hydrofluosilicic acids applications.

For specific chemical resistance requirements please consult Strobic Air Corporation's technical department.



Protector PVC Perchloric Acid Laboratory Hood 140610002 is shown with Protector Standard Storage Cabinet 9901000 and Protector Acid Storage Cabinet 9901100.

Protector® PVC Perchloric Acid & Acid Digestion Laboratory Hoods

Features & Benefits

Protector PVC Perchloric Acid Laboratory Hoods feature an internal washdown system, integral work surface and drainage trough so that they may be thoroughly rinsed after each use to prevent the accumulation of potentially reactive perchloric salts. The liner of Type 1 unplasticized polyvinyl chloride is designed to withstand reaction from perchloric acid and other highly corrosive inorganic chemicals that do not involve high temperatures. Protector PVC Acid Digestion Laboratory Hoods feature a Lexan* sash, which is recommended for applications involving the use of acids including hydrofluoric acid but not perchloric acid.

Front and side panels may be easily removed for lamp replacement and access to electrical and plumbing connections.

Large unobstructed sightline provides visibility of 37.5" high from the work surface to the header panel, allowing taller users comfortable viewing while standing.

By-pass airflow design ensures stable face velocities. The by-pass block partially obstructs the by-pass opening above the sash to control and reduce the minimum air volume demanded.

Fluorescent lighting illuminates the interior. The high-efficiency, instant start, T8 fluorescent lights are located outside the hood interior for corrosion-resistance and easy replacement.

Durable and attractive exterior is glacier white powder-coated steel.

Vertical-rising tempered safety glass sash with cable pulley is anti- racking for smooth operation. Protector PVC Acid Digestion Hoods feature a Lexan* polycarbonate sash that resists fogging or etching when exposed to hydrofluoric acid fumes.

Service access panels allow accessibility to plumbing from the front of the hood.

Pre-wired electrical components. Fluorescent lights and switches are factory-wired to the hood's single point junction box. On some models, one electrical duplex receptacle is factory-wired on the right side; on some 8' models, one duplex receptacle is mounted on each side. Each hood is factory-prepared for up to four electrical duplexes and an airflow monitor.

Corrosion-resistant baffle and liner of Type 1 unplasticized PVC with integral work surface provides a crevice-free work area and withstands heat up to 140° F (60° C).

Hardboard surface to support integral work surface is included.

Optional color-coded service fixtures for gas, air, water, vacuum and other services have remote controls for use regardless of the sash position. On some models, two service fixtures are pre-plumbed, the left one a rigid gooseneck faucet, the right a serrated hose connector. Each corner post is factory-prepared for up to 4 service fixtures (8 fixtures total per hood). **Additional service fixtures require holes drilled in the liner at the factory or on site.**

Eco-Foil™ air foil with Clean-Sweep™ openings reduces energy consumption by 7-10% compared to flat air foils while its aerodynamic curve allows air to sweep the work surface for maximum containment. Air foil is powder-coated stainless steel for durability.

Built-in washdown system facilitates the removal of hazardous perchlorates from behind the baffle. The system consists of pre-plumbed internal piping, spray nozzles and upper left side-mounted remote control knob.

CE Mark. Hoods for 230 volt operation conform to the CE (European Community) requirements for electrical safety and electromagnetic compatibility.

Cord-Keeper™ slots on the left and right side of the air foil allow the sash to close completely when electrical cords from equipment inside the hood are plugged into receptacles located on the corner posts. Cords are kept out of the way of the operator.

Performance tested to ASHRAE 110-1995.

ETL-listed. Hoods carry the ETL mark signifying that they are certified to UL 61010-1, UL 1805 and CAN/CSA C22.2 No.61010.1.

Clean-Sweep™ sash handle and tracks. The powder-coated aluminum sash handle includes Clean-Sweep openings to bleed air into the hood chamber and away from the operator's breathing zone. Clean-Sweep slots on the powder-coated stainless steel sash tracks of the corner posts enhance airflow.

**Lexan is a registered trademark of SABIC Innovative Plastics*

Exclusive Feature

Protector® PVC Perchloric Acid & Acid Digestion Laboratory Hoods

6' x 37.7" deep Protector PVC Perchloric Acid Laboratory Hood 140610002 is shown with 3' Protector Standard Storage Cabinet 9900100 and 3' Protector Acid Storage Cabinet 9901100. ***Blower, ductwork and base must be ordered separately.***

All models feature:

- By-pass airflow design and by-pass block.
- Glacier white powder-coated steel exterior.
- Powder-coated stainless steel Eco-Foil™ air foil with Clean-Sweep™ airflow openings.*
- Cord-Keeper™ slots on left and right side of air foil.
- Heat-welded Type 1 unplasticized PVC liner with integral work sur face, drainage trough and pre-set baffle(s). PVC withstands maximum continuous operating temperature of 140° F (60° C) and has a flame spread less than 25 per ASTM E-84.
- Black enamel-coated hardboard supporting surface.
- Powder-coated aluminum sash handle with Clean-Sweep™ openings and Clean-Sweep™ slots on the powder-coated stainless steel sash tracks.*
- Removable front and side panels and front access panels for access to plumbing and electrical wiring.
- Pre-wired T8 fluorescent lighting with vapor-proof design and ADA-compliant light and blower switches.
- Built-in washdown system with internal piping and spray nozzles with maximum flow rate from 0.5 -1.0 GPM. Include upper left side-mounted remote control fixture with forged brass valve with maximum flow rate of 3 GPM and maximum working pressure ranging from 10 to 40 psi depending on number of hood's spray nozzles. Valve is capable of supplying water to hood's spray nozzles and, except for 8' models, one wash ring (wash rings not included).
- Washdown fitting located on top of hood to facilitate connection to external wash rings (wash rings not included).
- 12.75" OD PVC exhaust connection(s).

Exclusive Feature   ** U.S. Patent No. 6,461,233*

All models conform to the following standards:

- CFR 29, Part 1910 • SEFA 1-2010 • CE (230 volt models)
- SEFA 8-2010, Cabinet Surface Finish Tests • NFPA 45-2011
- ASTM E84-09C • ASHRAE 110-95 • ANSI Z9.5-2012
- CAN/CSA C22.2 No. 61010.1 • UL 61010-1 • UL 1805

Protector PVC Perchloric Acid Hoods feature:

- 3/16" thick tempered safety glass vertical-rising sash with cable pulley. Glass is suitable for perchloric acid use.

Protector PVC Acid Digestion Hoods feature:

- 1/4" thick Lexan polycarbonate vertical-rising sash with cable pulley. Lexan resists etching by hydrofluoric acid fumes.

Fixtured models may feature:

- Two pre-plumbed service fixtures with forged brass valves, lower right side with brass tubing and plastic serrated hose connector for gas and lower left side with copper tubing and gray PVC rigid gooseneck faucet for cold water. Components for converting the lower right fixture to air or vacuum are provided. **Inlet tubing is not provided.**
- One pre-wired GFCI electrical duplex receptacle on lower right side and, on 8' models, one additional pre-wired GFCI electrical duplex receptacle on the lower left side.

Required accessories not included:

- ***Dedicated remote PVC blower***
- ***Wash rings and other ductwork*** • ***Base cabinet or stand***

Optional accessories for on-site installation include:

- ***Service Fixture Kits*** • ***Electrical Duplex Kits***
- ***Guardian Airflow Monitor Kits*** • ***Sash Stop Kits***
- ***Ceiling Enclosure and Rear Finish Panel Kits***

Total Exhaust CFM and Static Pressure @ 28" Sash Opening (100% Open)

Face Velocity (fpm)	Airflow Volumetric Rate (CFM) @ Static Pressure (inches of water)							
Sash @ Full Open (28")	4' Hood		5' Hood		6' Hood		8' Hood	
	CFM	s.p.	CFM	s.p.	CFM	s.p.	CFM	s.p.
125	905	0.27	1195	0.44	1475	0.59	2050	0.35
100	725	0.17	955	0.28	1180	0.38	1640	0.22

Total Exhaust CFM and Static Pressure @ 18" Sash Opening (62.5% Open)

Face Velocity (fpm)	Airflow Volumetric Rate (CFM) @ Static Pressure (inches of water)							
Sash @ 62.5% Open (18")	4' Hood		5' Hood		6' Hood		8' Hood	
	CFM	s.p.	CFM	s.p.	CFM	s.p.	CFM	s.p.
125	565	0.11	745	0.17	920	0.23	1280	0.13
100	455	0.07	595	0.11	740	0.15	1025	0.09

Contact Labconco at ***800-821-5525*** *or* ***816-333-8811*** *for ordering information on accessories and options such as flush air foils and for blower sizing assistance.*

Ordering Information & Dimensional Data

Protector® PVC Perchloric Acid & Acid Digestion Laboratory Hoods

Use this key to configure the **nine digit catalog number** to order your Protector PVC Laboratory Hood. For example, a **140410002** is a 4' Protector PVC Perchloric Acid Laboratory Hood, 100-115 volt, 50/60 Hz electrical requirements, two service fixtures and one GFCI electrical duplex receptacle.

1 4 _ _ 1 0 0 _ _

STEP 1. Select the **application type** of your fume hood. This number is the third digit of your catalog number.

- **0** = Perchloric Acid (with safety glass sash)
- **1** = Acid Digestion (with Lexan sash)

STEP 2. Select the **width** of your fume hood. This number is the fourth digit of your catalog number. Add 10 lbs. (5 kg) for Fixtured Models.

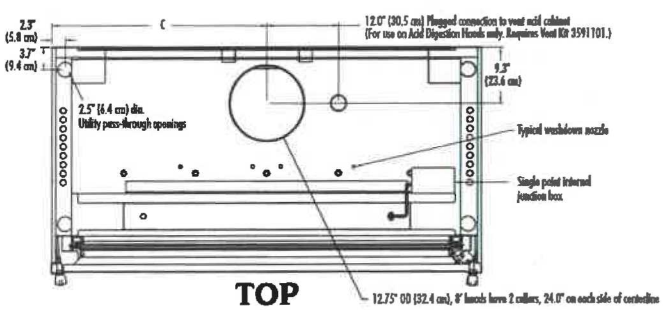
- **4** = 4' (122 cm)/735 lbs. (333 kg)
- **5** = 5' (152 cm)/790 lbs. (358 kg)
- **6** = 6' (183 cm)/850 lbs. (386 kg)
- **8** = 8' (244 cm)/970 lbs. (440 kg)

STEP 3. Select the **Electrical Requirements, Service Fixtures** and **GFCI Electrical Duplex Receptacle** combination you desire. These two numbers comprise the eighth and ninth digits of your catalog number.

Electrical Requirements	No Service Fixtures	Two Service Fixtures*	Two Service Fixtures* & GFCI Duplex**
100-115 volts, 50/60 Hz, 10 amps	00	01	02
208-230 volts, 50/60 Hz, 5 amps	20	21	—

**Left side service fixture is a Rigid Gooseneck Faucet. Right side service fixture is serrated hose connector.*

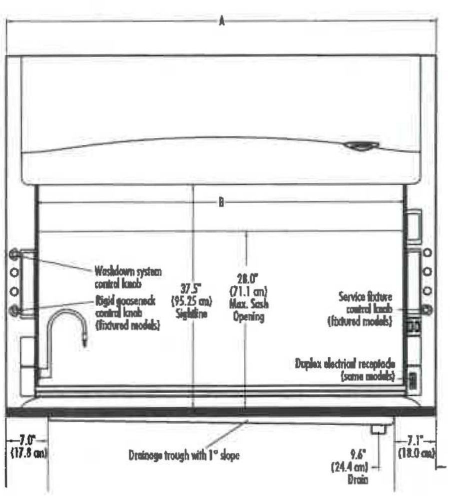
***Hoods with GFCI electrical duplex are rated at 20 amps. 8' hoods have two GFCI electrical duplex receptacles, one mounted on each side, rated at 20 amps each.*



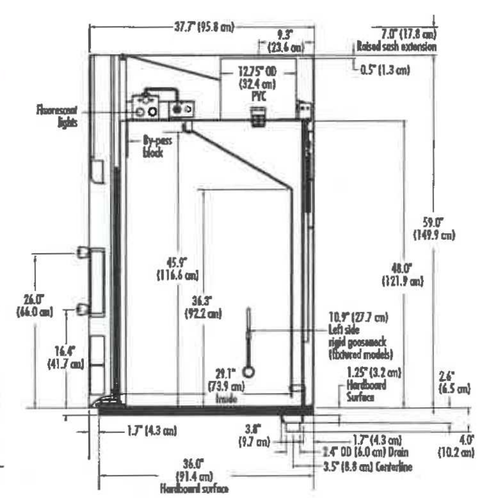
TOP

	A	B	C
4' Hood	48.0" (121.9 cm)	38.25" (97.2 cm)	24.0" (61.0 cm)
5' Hood	60.0" (150.0 cm)	50.25" (97.2 cm)	30.0" (61.0 cm)
6' Hood	72.0" (182.9 cm)	62.25" (158.1 cm)	36.0" (91.4 cm)
8' Hood	96.0" (243.8 cm)	86.25" (219.1 cm)	24.0"* (61.0 cm)

**8' model has two exhaust collars, 24.0" on each side of centerline*



FRONT



SIDE

Protecting your laboratory environment

LABCONCO.

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SEFA

ISO 9001: 2008 CERTIFIED

*Contact Labconco at **800-821-5525** or **816-333-8811** or visit **www.labconco.com** for detailed AutoCAD drawings.*

PermaShield Pipe

Chemical Compatibility

PermaShield Fluoropolymer Barrier Coating

PSP®
PermaShield Pipe

Research and testing

Over the course of several years, Fab-Tech conducted a comprehensive program of research and testing of available fluoropolymers to determine the attributes of compatible coatings on the market. This unique PermaShield barrier coating far outperformed all others.

Fab-Tech engineers worked closely with resin manufacturers to select a base product. The selected formula was then modified to enhance permeation resistance and tested under Fab-Tech's unique coating methodology. Exhaustive tests of virtually all duct coatings available confirmed that this new fluoropolymer formula has much better adhesion and permeation resistance than standard ETFE or ECTFE.

FM Approved

PermaShield Pipe with the PermaShield barrier coating is FM 4922 approved for use as a fume exhaust product without internal fire suppression systems. This covers the maximum approval range of 4" to 60" diameter and a coating thickness up to 12 mils.

Test Results

The PermaShield barrier coating has gone through extensive testing both internally and at independent laboratories. All test results met or exceeded benchmarks.

TEST	TEST DESCRIPTION	TEST RESULTS
Chemical Immersion	Extended immersion in strong acids.	Samples exhibited no evidence of chemical attack or loss of adhesion, no blisters developed, some other coatings tested did blister.
EIS (Electrochemical Impedance Spectroscopy)	Following extended immersion in strong acids, impedance measurements taken to determine permeation resistance.	Results indicate excellent protection with end of test percentages of 97% or greater permeation resistance.
E-84 (Stiner Tunnel)	ASTM E 84 tests for Fire Spread and Smoke Developed, frequently used by code officials and regulatory agencies in the acceptance of interior finish materials.	PermaShield barrier falls in the Class 1 category with a Flame Spread Index of 10-15 and a Smoke Developed Index of 35-40.
Atlas Cell	Standard ASTM test involving test pieces subject to boiling water for defined periods of time then check the coating for delamination or blisters.	The new PermaShield barrier coating ran far longer than any other coating ever tested.
Boil and Peel	Standard test, prolonged boil of flat coated substrate samples with scored coating, samples then deformed in a defined way to see if coating will peel.	The adhesion of the PermaShield coating is the best ever seen.
Field Flange	Round duct samples are cut and reflanged to observe coating adhesion to the new flange.	No peel or delamination observed, adhesion to substrate remains consistent.
Field Patch / Repair	Coated samples are repair patched.	Patches found to be superior to patches of other coatings.
FM 4922	Standard Factory Mutual test, measures flame propagation in duct systems.	Test passed: temperatures well below 1,000°F at 23 feet.

Desirable attributes

Besides its high level of chemical resistance, this new fluoropolymer formula possesses the following desirable attributes:

- Mechanically tough with excellent cut through and abrasion resistance
- Low cold flow
- High tensile strength and good elongation properties
- Excellent impact resistance at room temperature and down into the cryogenic
- Dimensionally stable
- Continuous use to 300°F in most applications
- Excellent release properties
- Very smooth surface

Atlas cell test.

FM 4922 test.

Chemical Compatibility

Table 1 - Chemical Compatibility Comparison

Table 1 lists over 500 chemicals whose corrosive characteristics create problems that can often be solved by specifying PermaShield fluoropolymer barrier. The maximum use temperature for each chemical service is suggested as a guide only and are not necessarily upper limits of usability but are limits of data available. Little or no chemical attack is indicated at the temperature listed with <10% swelling or dimensional change and <15% loss of tensile strength at 100% concentration, concentrated, or saturated solution. It is recommended that tests be conducted under actual or simulated use conditions whenever possible to determine suitability of PermaShield barrier coating or any other material for a specific application. This guide is based on selective controlled tests of representative chemicals, field applications and experience, and engineering judgements with regard to the suitability of PermaShield barrier coating in these chemical environments.

Table 2 - PTFE Sealant Compatibility Data

Table 2 was assembled from known compatibility data for PTFE materials and should be used only as a general guide for determining the suitability of Gore-Tex® sealants for specific applications.

TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Acetaldehyde	100			120	NR
Acetamide	200	NR		73	
Acetic Acid Vapors	212	NR	73	180	140
Acetic Acid (10%)	212*	210		70	70
Acetic Acid (20%)	212*	210		70	70
Acetic Acid (50%)	212*	175		70	70
Acetic Acid (80%)	300	175		70	70
Acetic Acid (90%)	300	100		70	70
Acetic Acid (Glacial)	212*	NR	NR	120	73
Acetic Anhydride	200*	NR		75	NR
Acetone	212		NR	73	NR
Acetone Cyanohydrin	122				
Acetonitrile	300	NR		70	NR
Acetophenone	200	NR		120	NR
Acetyl Chloride	122*				
Acetylene	212*			73	140
Acrylonitrile	212*	NR	NR	120	NR
Acrylic Acid	212				
Adipic Acid	122*	70	185	140	140
Alcohols General	200	100	NR	170	NR
Alcohols, Amyl	300	200	185	170	140
Alcohol, Benzyl	300				
Alcohol, Butyl, Primary	300	120		70	70
Alcohol, Butyl, Secondary	300	120		70	70
Alcohol, Diacetone	122				
Alcohol, Ethyl (Ethanol)	300	100		140	70
Alcohol, Hexyl	70*				
Alcohol, Isopentyl	122				
Alcohol, Isopropyl	300				
Alcohol, Menthyl	300				
Alcohol, Propyl	300				
Allyl Alcohol	212	140		140	73
Allyl Chloride	300	80		80	NR
Alum	300				
Alum, Ammonium	300				
Alum, Chrome	212*				
Alum, Potassium	300				
Aluminum Chloride	300	210	185	180	140
Aluminum Fluoride	300	80 w/mat		225	73
Aluminum Hydroxide	300	180	185		140

ANNOTATIONS: * = No Data Available Above Temperature Listed, **NR** = Not Recommended by Manufacturer,
Blank = No Data Available or Other Relevant Data Prevails, **w/mat** = Synthetic Fiber Surfacing Mat Recommended by Manufacturer

Maximum use temperatures listed for PermaShield fluoropolymer barrier coating are based on tests of the resin with representative chemicals in valid laboratory or field tests. PermaShield Pipe products treated with such coating may exhibit different properties and therefore no guarantee is expressed or implied as to the results obtained by the user. .Coatings formulated from this resin, and finished products treated with such coatings may exhibit different properties. These data are intended for use by persons having technical skill and at their own discretion and risk. Fab-Tech Incorporated makes no warranties, expressed or implied, and assumes no liability in connection with the use of this information.

TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Aluminum Nitrate	300	160	185	180	140
Aluminum Oxychloride	300				140
Aluminum Sulfate	300	140		225	150
Ammonia, Gas	212*				
Ammonia (Anhydrous)	200				
Ammonia (Aqueous 30%)	200	NR		73	NR
Ammonium Acetate	122*				
Ammonium Bifluoride	300		185		140
Ammonium Bisulfide	300				
Ammonium Carbonate	300	150 w/mat		180	140
Ammonium Chloride	300	210	185	180	140
Ammonium Dichromate	250*				73
Ammonium Fluoride 10%	300	150 w/mat			
Ammonium Fluoride 25%	300	140		212	73
Ammonium Hydroxide (30%)	300	150 w/mat	185	180	140
Ammonium Metaphosphate	300				
Ammonium Nitrate	300	180	185	180	140
Ammonium Persulphate	122*	180	73	150	140
Ammonium Phosphate	300	210		225	140
Ammonium Sulfate	300	210	185	180	140
Ammonium Sulfide	300	120			
Amyl Acetate	122	NR		NR	NR
Amyl Chloride	300	120		NR	NR
Aniline	212*		NR	180	NR
Anisole	122				
Anthraquinone	122*				140
Anthraquinone Sulfonic Acid	122*				140
Antimony Trichloride	70*	220		180	140
Aqua Regia	212*		73		NR
Aqua Regia (Fumes)	212	150		70	100
Arsenic Acid	300	80	185	225	140
Barium Carbonate	300	210		225	140
Barium Chloride	300	210		212	140
Barium Hydroxide	300	160		212	140
Barium Nitrate	300			70	70
Barium Sulfate	300	210	185	70	140
Barium Sulfide	300	180		225	140
Beer	300				
Beet Sugar Liquors	300	180		140	150

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Benzaldehyde 10%	200			70	73
Benzaldehyde above 10%	122	NR		70	NR
Benzene	200	NR	NR	NR	NR
Benzene Sulfonic Acid	200	210		70	70
Benzene Sulfonic Acid 10%	200			180	40
Benzoic Acid	250*	210		73	140
Benzyl Alcohol	200	NR		150	NR
Benzyl Chloride	100	80		250	70
Benzonitrile	200				
Bismuth Carbonate	300				140
Black Liquor	300		185		140
Bleach 12.5% Active Cl_2	300		185	120	140
Bleach 5.5% Active Cl_2	300				
Borax	300	210		180	140
Boric Acid	300	210	185	180	140
Brine Acid	300				
Bromine, Liquid	122	NR			
Bromine, Vapor 25%	122	NR		NR	NR
Bromine, Water	212*			NR	
Bromobenzene	122				NR
Bromotoluene	122			NR	NR
Butadiene	250*		73	NR	140
Butane	250*			73	140
Butanol n	250				
Butyl Acetate	100	NR	73	NR	NR
Butyl Alcohol	300	120	73	180	140
Butylaldehyde	122				
Butyl Acrylate	122				
Butyl Amine	122	NR		70	NR
Butyl Cellosolve	70*				
Butyl Lactate	122				
Butylene	300				140
Butyl Phenol	212*				73
Butyl Phthalate	212*	190		180	NR
Butyl Stearate	212*				
Butyric Acid	250*	100		180	73
Cadmium Cyanide	122*				
Calcium Bisulfide	300	180			
Calcium Bisulfite	300	140		212	150

ANNOTATIONS: * = No Data Available Above Temperature Listed, **NR** = Not Recommended by Manufacturer,
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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Calcium Carbonate	300	180 w/mat	185	180	140
Calcium Chlorate	300	210			140
Calcium Chloride Saturated	300	210	185	180	140
Calcium Hydroxide Saturated	300	180	185	180	140
Calcium Hypochlorite	300	160 w/mat		140	140
Calcium Nitrate	300	300		180	140
Calcium Oxide	300				
Calcium Sulfate	300	210		225	140
Cane Sugar Liquors	212*				
Caprylic Acid	122*	180			
Carbolic Acid (Phenol)	212	NR		140	70
Carbon Dioxide (Dry)	300		185	150	140
Carbon Dioxide (Wet)	300		185	150	140
Carbon Dioxide (Gas)	300	210			
Carbon Disulfide	200*	NR		NR	NR
Carbon Monoxide	300	210	185	225	140
Carbon Tetrachloride (Liquid)	300	100		70	NR
Carbon Tetrachloride (Vapor)	300	175		70	NR
Carbonic Acid	300	210	185		140
Castor Oil	300		185		140
Caustic Potach (10% & 50%)	300	150	185	140	140
Caustic Soda (10% & 50%)	212	210	210	180	100
Cellosolve®	300	210		70	NR
Cellosolv Acetate	212				
Chloracetic Acid 50%	212*				
Chloral Hydrate	121*				140
Chloramine	70*				
Chlorine Dioxide	212*				
Chlorine Gas, Dry	212*	210		NR	73
Chlorine Gas, Wet	212*	210		NR	NR
Chlorine, Liquid	212*	NR			
Chlorine (Dry)	212	210		NR	73
Chlorinated Water Saturated	212	195		150	140
Chlorobenzene	122	NR		73	NR
Chlorobenzyl Chloride	70				
Chloroethanol	200	100		NR	NR
Chloroform	200*	NR	NR	NR	NR
Chlorosulfonic Acid 5%	200	NR		NR	73
Chlorotoluene	122				
Chromic Acid 10%	212*				

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Chromic Acid 30%	212*				
Chromic Acid 40%	212*				
Chromic Acid 50%	212*	NR	210	180	NR
Citric Acid	300	140		225	150
Coconut Oil	300				
Coke Oven Gas	212*				
Copper Carbonate	300				
Copper Chloride	300	210	185		140
Copper Cyanide	300	210 w/mat	185	225	140
Copper Fluoride	300	210 w/mat		225	150
Copper Nitrate	300	210		225	150
Copper Sulfate	300	210	185	120	140
Corn Syrup	300				
Cottonseed Oil	300			225	150
Creosote Hot (wood & coal tar)	212			NR	70
Cresol (crude)	212	140		73	NR
Cresylic Acid 50%	70	NR		NR	140
Croton Aldehyde	70				
Crude Oil	300	210	185	150	150
Cupric Chloride	300	140		140	150
Cupric Fluoride	300				
Cupric Sulfate	300				
Cuprous Chloride	300				
Cyclohexane	212	120	NR	NR	NR
Cyclohexanol	122		NR	120	NR
Cyclohexanone	200	85	NR	NR	NR
Cyclohexylamine	122				
Detergents General	300	140		200	140
Detergent Solution (Heavy Duty)	300				
Dexron (Trans Fluid)	300				
Dexron II (Auto Trans Fluid)	300				
Dextrin	300				140
Dextrose	300				
Diacetone Alcohol	122		NR	120	NR
Dibutyl Sebacate	212*				
Dibutyl Phthalate	122	180		120	NR
Dichlorobenzene	122	100		70	NR
Dichloropropane	70				
Dichlorotoluene	70				

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Dichlorodifluoro Methane (F-12)	70			80	80
Dichloroethane	70	80		70	NR
Dichloroethylene	100	NR		NR	NR
Dichloropropane	212				
Dichlorotoluene a, a	250				
Diesel Fuels	300	180		200	140
Diethyl Cellosolve	300				
Diethylene Glycol	70	140		225	70
Diethylamine	122	NR		120	NR
Diethylene Glycol Butyl Ether Acetate	122				
Diethylene Glycol Meno Butyl Ether	122				
Diethylene Triamine	122				
N, N Diethylethanolamine	122				
Diethyl Ether	200*	NR		NR	73
Diethyl Hydroxy Amine 85%	86				
Diethyl Phthalate	122				
Diglycolic Acid	70*				140
Diisobutyl Ketone	122*				
Diisopropyl Acetate	70				
Diisopropyl Ketone	212				
Dimethyl Acetamide N, N	212				
Dimethylamine	70			120	140
Dimethyl Aniline	200			NR	NR
Dimethyl Formamide	100	NR	NR	120	NR
Dimethyl Hydrazine	70				
Dimethyl Phthalate	212*	150		NR	NR
Dimethyl Sulfoxide	212*	NR		125	NR
Dioctyl Phthalate	200	180	NR	NR	NR
Dioxane 1,4-	122				
Dioxane 2,4	212				
p-Dioxane	200	NR		73	NR
Dipropylene Glycol Methyl Ether	122				
Disodium Phosphate	300				
Divinylbenzene	70				
Dow Therm	200	150		NR	NR
Epichlorhydrin Dry	200	NR		120	70
Epsom Salt	300				
Ethanol	284				
Ethers	212	180		NR	NR

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CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
2 Ethoxy-ethanol 99%	122				
Ethyl Acetate	200	NR		120	NR
Ethyl Acetoacetate	72*				
Ethyl Acrylate	212				
Ethyl Chloride	300	NR		73	NR
Ethyl Ether	200*	NR		73	NR
Ethyl Formate	212				
Ethylene Bromide	300	NR		NR	NR
Ethylene Chlorohydrin	72	200		NR	NR
Ethylene Diamine	72	100		120	NR
Ethylene Dichloride	200	NR	140	NR	NR
Ethylene Glycol	300	140	185	120	140
Ethylene Oxide	212*			NR	NR
Fatty Acids	300	210	73	120	140
Ferric Chloride	300	210	185	180	140
Ferric Nitrate	300	210	140	180	140
Ferric Sulfate	300	210		180	140
Ferrous Chloride	300	210	185	180	140
Ferrous Nitrate	300	210	140	140	73
Ferrous Sulfate	300	210	185	180	140
Fluorine Gas, Wet	72*		73	NR	73
Fluoroboric Acid	250*	180 w/mat	73	73	140
Fluorosilicic Acid	300		73		140
Formaldehyde (Formalin)	200*	150		140	70
Formic Acid	250	100	73	73	73
Freon Dry	200			NR	
Freon Wet	200			70	NR
Freon F-11	122*	75	73		140
Freon F-12	122*		73	73	140
Freon F-21	122*				
Freon F-22	122*			73	NR
Freon F-113	122*				
Freon F-114	122*				
Fruit Juices, Pulp	300				
Fuel Oils	300	70		80	150
Fuming Sulfuric Acid	122				
Furan	100				
Furfural (Furfuraldehyde)	212	NR		NR	NR

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Gallic Acid	122*		73	225	140
Gas-Natural	300	210		80	150
Gasoline, Leaded Refined	300	140		NR	140
Gasoline, Unleaded Refined	300	140		NR	140
Gasoline, Sour	300				
Gelatin	212*	120		225	150
Gin	300				
Glucose	300	220		225	150
Glycerine, Glycerol	300	220		225	125
Glycol (Ethylene Glycol)	200	140	185	225	140
Glycolic Acid (Hydroxy Acetic)	122*	100	73	225	140
Glycolis	300				
Heptane	300	140		NR	140
Hexane	250	100		70	70
Hydrochloric Acid (20%)	300	140		70	NR
Hydrobromic Acid (50%)	300	100		120	
Hydrochloric Acid (up to 37%)	300	180	210	150	140
Hydrochloric Acid (Conc.)	200				
Hydrochloric Acid (Gas)	200	210			
Hydrocyanic Acid	300	150		225	150
Hydrocyanic Acid, 10%	300	180		73	140
Hydrofluoric Acid (35%)	300	100 w/mat		125	70
Hydrofluoric Acid (50%)	300	NR	NR	73	73
Hydrofluosilicic Acid	300	180 w/mat		225	70
Hydrogen Gas	300	250	73	73	140
Hydrogen Cyanide	300			225	140
Hydrogen Peroxide (50%)	140*	100	185	150	140
Hydrogen Peroxide (90%)	140*	100		70	140
Hydrogen Phosphide	122*				140
Hydrogen Sulfide (Dry)	300	210	185	150	140
Hydrogen Sulfide (Wet)	200*	210			140
Hydroquinone	212*				140
4 Hydroxybenzene Sulfonic Acid	158				
Hypochlorous Acid	300	140	140	73	140
Iodine (Dry)	212*	150			
Iodine Solution 10%	212*	150		170	70
Isopropyl Ether	122*				
Isooctane	300				

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Isopentyl Alcohol	122*				
Isophorone	122				
Isopropyl Alcohol	230	100		225	70
Jet Fuel-JP4	300	120	73	70	140
Jet Fuel-JP5	300	120	73	70	140
Kerosene	300	150	73	150	140
Keytones	200	NR		70	NR
Lactic Acid	300	210		150	73
Laquers & Laquer Solvents	70			NR	NR
Lard Oil	300		185	73	140
Lauric Acid	212*				140
Lauryl Chloride	212*				
Lead Acetate	300	210	185	180	140
Lead Chloride	300				
Lead Nitrate	300	220		125	140
Lead Sulfate	300				
Lemon Oil	300				
Lime Sulfur	122*			225	150
Linoleic Acid	212*	210		80	140
Linoleic Oil	250*				
Linseed Oil	300	210		225	150
Linseed Oil, Blue	300				
Lithium Bromide	212*	210			
Lithium Hydroxide Saturated	300			70	140
LPG (Propane)	70	44		120	140
Lubricating Oil, ASTM #1	300	200		70	140
Lubricating Oil, ASTM #2	300	200		70	140
Lubricating Oil, ASTM #3	300	200		70	140
Lye					
Calcium Hydroxide 50%	200	180		140	70
Potassium Hydroxide 50%	200	180		140	70
Sodium Hydroxide 50%	200	180		140	70
Magnesium Carbonate	300	180			140
Magnesium Chloride	300	210	185	180	140
Magnesium Hydroxide	300	210	185	180	140
Magnesium Nitrate	300	210	185	180	140

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Magnesium Sulfate	300	210	185	180	140
Maleic Acid	250*	200	185	180	140
Malic Acid	250*	140	185	150	140
Mercuric Chloride	250*	210	140	180	140
Mercuric Cyanide	250*	140		225	140
Mercuric Sulfate	250*				
Mercurous Nitrate	250*	140			140
Mercury	300	210	185	150	140
Mesityloxide	122				
Methane	300			70	140
Methane Sulfuric Acid 50%	151				
Methyl Acetate	122			70	NR
Methyl Acrylate	122				
Methyl Alcohol (Methanol)	70	100		180	140
Methylamine	70	NR		70	NR
Methyl Bromide	300			NR	NR
Methyl Cellosolve	300	NR		70	NR
Methyl Chloride	300	NR		NR	NR
Methyl Chloroform	122		NR		
Methyl Ethyl Keytone	122	NR	NR	NR	NR
Methyl Formate	212				
5 Methyl 2 Hexanone	122				
Methyl Isobutyl Keytone	122		NR	NR	NR
Methyl Methacrylate	122				73
Methyl Sulfate	300				
Methyl Sulfuric Acid	122*				
1 Methyl 2 Pyrrolidinone	70				
Methylene Bromide	122				NR
Methylene Chloride	122	NR		70	NR
Methylene Iodine	70				NR
Milk	300	140		212	150
Mineral Oil	300	210	185	120	140
Molasses	300	140		225	150
Monochlorobenzene	100	NR	73		
Monochlorodifluoromethane (F-22)	70			70	NR
Monoethanolamine	150	75		175	NR
Morpholine	200	80		150	
Motor Oil	300	220		140	150
N, N Dimethyldodecylamine	167				

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CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Naphtha	300	200	73	120	140
Naphthalene	300	180			NR
Natural Gas	122				
Nickel Chloride	300	210	185	180	140
Nickel Nitrate	300	210			140
Nickel Sulfate	300	210	185	180	140
Nicotine	122*				140
Nicotinic Acid	212*				140
Nitric Acid 10%	250*				
Nitric Acid 30%	212*				
Nitric Acid 40%	212*				
Nitric Acid 50%	122*	NR	73	NR	100
Nitric Acid 70%	122				
Nitric Acid 90%	122				
Nitrobenzene	122	100		73	NR
Nitrogen Gas					70
Nitrous Acid 10%	212*	150		NR	73
Nitrous Oxide	122*			70	70
Nitromethane	200				
N Methylpyrrolidinone	70				
Nonyl Phenol	122				
2 Octanol	122				
Oils, Crude	200	210		70	150
Oils, Mineral	300	210		140	70
Oils, Vegetable	300	210		140	140
Oleic Acid	250*	210		170	150
Oleum 30%	72			NR	NR
Oleum 30% in Sulfuric Acid	72			NR	NR
Oxalic Acid	122	210		140	70
Oxalic Acid 50%	122		185	180	140
Oxygen, Gas	300				
Ozone	212*	220		NR	NR
Palmitic Acid, 10%	250	210	73	180	140
Paraffin	300	150		70	140
Pentanedione 2, 4	212				
Pentyl Acetate	122				
Perchloroethylene	200	100		NR	NR
Perchloric Acid (10%)	200*	150		NR	NR

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Perchloric Acid (72%)	200*			200*	200*
Perchloric Acid (up to 30%)	200	80		80	80
Petroleum Oils, Sour	212*	200		70	150
Petroleum Oils, Refined	212*	200		70	150
Phenol	122		NR	NR	NR
Phenylhydrazine	122*				NR
Phosphoric Acid 10%	300				
Phosphoric Acid 30%	300				
Phosphoric Acid 50%	300				
Phosphoric Acid 85%	300	210	73	180	140
Phosphorous Oxychloride	122				
Phosphorous Pentoxide	212*		73	73	73
Phosphorous Trichloride	212*	NR		NR	NR
Phosphorous Yellow	70*				
Photographic Solutions (Developers)	300	70		150	140
Picric Acid	70*	120		70	NR
Potash	300				
Potassium Alum	300				
Potassium Aluminum Sulfate	300	210		225	150
Potassium Acetate	70			70	150
Potassium Bichromate	250*	210		225	150
Potassium Bisulfate	250*				
Potassium Borate	250*				140
Potassium Bromide	250	210		180	140
Potassium Carbonate Saturated	300	150		225	150
Potassium Chlorate Aqueous	300				
Potassium Chloride	300	210	185	180	140
Potassium Chromate	300	140		225	140
Potassium Chlorate	300	140		180	140
Potassium Cyanide	300	140	185	225	140
Potassium Dichromate	300	210	185	225	140
Potassium Ferricyanide	300	210		225	140
Potassium Ferrocyanide	300	210		140	150
Potassium Hydroxide (50%)	300	150 w/mat	185	150	140
Potassium Iodide	250*	200		176	140
Potassium Nitrate	300	210		225	140
Potassium Perchlorate	122*				140
Potassium Permanganate 10%	300	210		150	140
Potassium Permanganate 25%	300	210		150	140
Potassium Persulfate	122*	210		140	

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Potassium Sulfate	300	210		225	150
Propane	300	44	73	70	70
Propyl Acetate	122				
Propyl Alcohol (Propanol)	122	100		225	
Pydravl	70				70
Pyridine	200	NR		140	NR
Pyrogallic Acid	122*			70	140
Pyroligneous Acid	100				
Pyroligneous Acid 10%	200	100		70	70
Salicyclic Acid	250*	160		70	140
Salicylaldehyde	122				NR
Salt Brine 10%	250	210		225	140
Sea Water	250	210		225	140
Silicic Acid	300				
Silicone Oil	300			150	70
Silver Nitrate	300	210		70	70
Silver Sulfate	300				
Soap Solutions	300	140		225	140
Skydrol 500 & 7000	70				70
Sodium Acetate	300	210	185	180	140
Sodium Alum	300				
Sodium Benzoate	300	180	140	170	140
Sodium Bicarbonate	300	210	185	180	140
Sodium Bichromate	212*	210		140	70
Sodium Bisulfate	300	210		180	140
Sodium Bisulfite	300	210	185	180	140
Sodium Borate (Borax)	300	210		140	150
Sodium Bromide	300	210	180	180	140
Sodium Carbonate Saturated	300	150	185	180	140
Sodium Chlorate	300	210		180	70
Sodium Chloride	300	200	210	225	150
Sodium Chlorite Saturated	250*				
Sodium Chromate 10%	100	210		140	
Sodium Cyanide	300	210 w/mat	185	180	140
Sodium Dichromate	212*	210		140	70
Sodium Fluoride	300	180	140	185	140
Sodium Hydrosulfide 50%	300				
Sodium Hydroxide 15%	300	150 w/mat			
Sodium Hydroxide 30%	250				

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CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Sodium Hydroxide (50%)(Caustic Soda)	250	180 w/mat	210	180	100
Sodium Hypochlorite 5%	250	150 w/mat	185	120	73
Sodium Iodide	300				
Sodium Metaphospate	300			70	150
Sodium Nitrate	300	210		225	150
Sodium Nitrite	300	210	185	180	140
Sodium Perchlorate	250*		170		140
Sodium Peroxide	300	80		212	120
Sodium Phosphate, Alkaline	300	210		225	70
Sodium Phosphate, Acid	300	210		180	70
Sodium Phosphate, Neutral	300	210		225	70
Sodium Silicate	300	210 w/mat		180	150
Sodium Sulfate	300	210	185	150	140
Sodium Sulfide	300	210	185	150	140
Sodium Sulfite	300	210	185	150	140
Sodium Tetraborate (Borax)	300	210		140	150
Sodium Thiosulfate (Hypo)	300	70		150	150
Sour Crude Oil	300	210			140
Stannic Chloride	300	180	185	225	150
Starch	300				
Stearic Acid	300	210	185	73	140
Stearoyl Chloride	250				
Steam	300	220	185		NR
Stoddard's Solvent	300	210		70	125
Succinic Acid	212*				
Sulfate Liquors	212*				
Sulfite Liquor	212*				
Sulfolane	200				
Sulfur	300	250		225	140
Sulfur Chloride	70*	NR		NR	70
Sulfur (Molten)	250			NR	NR
Sulfur Dioxide Gas Wet & Dry	300	210	NR	73	73
Sulfuric Acid 10%	300				
Sulfuric Acid 50%	300	180	210	150	140
Sulfuric Acid 90%	300	NR	210	73	140
Sulfuric Acid 93%	300				
Sulfuric Acid 96%	300				
Sulfuric Acid 98%	300				
Sulfuric Acid (Conc.)	300	NR		NR	NR
Sulfuric Acid (Fuming-Oleum)	300				

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TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Sulfurous Acid	212*	120		225	150
Tall Oil	300	150		175	140
Tannic Acid	300	210	185	180	140
Tanning Liquors	250*			225	150
Tar	300			70	70
Tartaric Acid	250*	210		150	140
Tetrachloroethylene	200	120		70	70
Tetraethyl Lead	300			150	140
Tetrahydrofuran	100		NR	NR	NR
Tetramethyl Ammonium Hydroxide	212				
Thionyl Chloride	122*	NR		120	70
Thread Cutting Oils	300				
Toluene (Tolvol)	200	140	NR	NR	NR
Toluenesulfonic Acid (sol. sat.)	158				
Tomato Juice	212*	210	185	180	70
Transformer Oil	212*	210		150	70
Tricresyl Phosphate	212*	140		150	70
Tributyl Phosphate	122				NR
Trichloroacetic Acid	122			150	140
Trichlorobenzene	122				
Trichloroethylene	100		NR	NR	NR
Trichloroethylene 1, 1, 1	70	140		125	70
Trichloroethylene and Nitric Acid	122				
Trichloroethylene in Methanol	122				
Trichlorotrifluoroethane (F-113)	70			70	73
Triethanolamine	75	120		170	140
Triethylamine	122				
Triethylene Tetramine	122				
Triethyl Phosphate	212*				
Triphenyl Phosphite	100				
Trisodium Phosphate	300	210	185	225	150
Turpentine	300	100	73	NR	125
Urea	212*	140	185	225	70
Vaseline	300				
Vinegar	212*	210		225	150
Vinyl Acetate	122	NR		NR	NR

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Maximum use temperatures listed for PermaShield fluoropolymer barrier coating are based on tests of the resin with representative chemicals in valid laboratory or field tests. PermaShield Pipe products treated with such coating may exhibit different properties and therefore no guarantee is expressed or implied as to the results obtained by the user. .Coatings formulated from this resin, and finished products treated with such coatings may exhibit different properties. These data are intended for use by persons having technical skill and at their own discretion and risk. Fab-Tech Incorporated makes no warranties, expressed or implied, and assumes no liability in connection with the use of this information.

TABLE 1 - Chemical Compatibility Comparison (Maximum Use Temperatures)

CHEMICAL	PermaShield[1] °F	FRP[2] °F	CPVC[3] °F	PP[4] °F	PVC[5] °F
Water	300	210	210	180	140
Water, Acid Mine	300	210		225	150
Water, Braskish	300				
Water, Deionized	300	210		225	150
Water, Demineralized	300	210		225	150
Water, Distilled or Fresh	300	210		225	150
Water, Salt	300	210		225	150
Water, Sea	300	210		225	150
Water, Sewage	300				
Whiskey	300	80		225	150
White Liquor	212*	180		140	150
Wines	212*	180		225	150
Xylene (Xylol Xylole)	200	70	NR	NR	NR
Zinc Chloride	300	210	185	225	140
Zinc Nitrate	300	210		225	140
Zinc Sulfate	300	210	185	225	140
Plating Solutions					
Plating Solutions, Brass	212*	180	185	180	140
Plating Solutions, Cadmium	212*	220	185	180	140
Plating Solutions, Chrome	212*	140	210	180	140
Plating Solutions, Copper	212*	120	210	180	120
Plating Solutions, Gold	212*	180	185	180	125
Plating Solutions, Lead	212*	160		225	140
Plating Solutions, Nickel	212*	180		225	140
Plating Solutions, Rhodium	212*				
Plating Solutions, Silver	212*	180		225	150
Plating Solutions, Tin	212*	210		225	150
Plating Solutions, Zinc	212*	180		225	150

ANNOTATIONS: * = No Data Available Above Temperature Listed, **NR** = Not Recommended by Manufacturer,
Blank = No Data Available or Other Relevant Data Prevails, **w/mat** = Synthetic Fiber Surfacing Mat Recommended by Manufacturer

1 Fluoropolymer barrier resin. From Fab-Tech, Inc. Colchester, VT.

2 Vinyl Ester. From Koppers Company, Inc. Pittsburgh, PA.

3 Chlorinated Polyvinyl Chloride. Class 23447-B.

4 Polypropylene. Type 1. Polyolefin.

5 Polyvinyl Chloride. Class 12454-B.

Maximum use temperatures listed for PermaShield fluoropolymer barrier coating are based on tests of the resin with representative chemicals in valid laboratory or field tests. PermaShield Pipe products treated with such coating may exhibit different properties and therefore no guarantee is expressed or implied as to the results obtained by the user. .Coatings formulated from this resin, and finished products treated with such coatings may exhibit different properties. These data are intended for use by persons having technical skill and at their own discretion and risk. Fab-Tech Incorporated makes no warranties, expressed or implied, and assumes no liability in connection with the use of this information.

TABLE 2 - Chemical Compatibility of 100% PTFE Gore-Tex® Sealants

CHEMICAL	CHEMICAL RESISTANCE RATING	CHEMICAL	CHEMICAL RESISTANCE RATING
Abietic Acid	1	Benzoyl Chloride	1
Acetic Acid, Crude	1	Benzyl Alcohol	1
Pure	1	Black Sulfate Liquor	1
Vapors	1	Bleach (Sodium Hypochlorite)	1
Acetic Anhydride	1	Borax	1
Acetone	1	Boric Acid	1
Acetophenone	1	Brine	1
Acetylene	1	Bromine	1
Acrylic Anhydride	1	Bromine Trifluoride	N
Allyl Acetate	1	Butadiene	1
Allyl Methacrylate	1	Butane	1
Aluminum Chloride	1	Butyl Acetate	1
Aluminum Fluoride	1	Butyl Alcohol, Butanol	1
Aluminum Hydroxide (Solid)	1	N-Butyl Amine	1
Aluminum Nitrate	1	Butyl Methacrylate	1
Aluminum Sulfate	1	Calcium Bisulphate	1
Alums	1	Calcium Chloride	1
Ammonia, Liquid	1	Calcium Hypochlorite	1
Ammonia, Gas, 150°F & Below	1	Capolactam	1
Above 150°F	1	Carbolic Acid, Phenol	1
Ammonium Chloride	1	Carbon Dioxide, Dry	1
Ammonium Hydroxide	1	Wet	1
Ammonium Nitrate	1	Carbon Disulfide	1
Ammonium Phosphate		Carbon Monoxide	1
Monobasic	1	Carbon Tetrachloride	1
Dibasic	1	Carbonic Acid	1
Tribasic	1	Cetane (Hexadecane)	1
Ammonium Sulfate	1	Chlorine, Dry	1
Amyl Acetate	1	Wet	1
Aniline, Aniline Oil	1	Chlorine Dioxide	1
Aniline Dyes	1	Chlorine Trifluoride	1
Aqua Regia	1	Chlorazotic Acid (Aqua Regia)	1
Barium Chloride	1	Chloronitrous Acid (Aqua Regia)	1
Barium Hydroxide	1	Chlorinated Solvents, Dry	1
Barium Sulfide	1	Wet	1
Benzaldehyde	1	Chloroacetic Acid	1
Benzene, Benzol	1	Chloroethylene	1
Benzonitrile	1	Chloroform	1

1 = Recommended (little or no effect) O = Insufficient Data N = Not Recommended

TABLE 2 - Chemical Compatibility of 100% PTFE Gore-Tex® Sealants

CHEMICAL	CHEMICAL RESISTANCE RATING
Chlorosulfonic Acid	1
Chromic Acid	1
Chromic Anhydride	1
Chromium Trioxide	1
Citric Acid	1
Copper Chloride	1
Copper Sulfate	1
Cresols, Cresylic Acid	1
Cyclohexane	1
Cycloheanone	1
Dibutyl Phthalate	1
Dibutyl Sebacate	1
Diethyl Carbonate	1
Dimethyl Ether	1
Dimethyl Hydrazine, Unsymmetrical	1
Dimethyl Formamide	1
Dioxide	1
Dow Therm A	1
Dow Therm E	1
Ethane	1
Ethers	1
Ethyl Acetate	1
Ethyl Alcohol	1
Ethyl Cellulose	1
Ethyl Chloride	1
Ethyl Ether	1
Ethyl Hexoate	1
Ethylene	1
Ethylene Bromide	1
Ethylene Glycol	1
Ethylene Oxide	1
Ferric Chloride	1
Ferric Phosphate	1
Ferric Sulfate	1
Fluorine, Gas	N
Liquid	1
Fluorine Dioxide	1
Formaldehyde	1
Formic Acid	1
Freon	1
Furfural	1
Glycerine, Glycerol	1
Glycol	1
Grain Alcohol	1
Green Sulfate Liquor	1
Heptane	1
Hexachloroethane	1
Hexane	1
Hydrazine	1
Hydrobromic Acid	1
Hydrofluoric Acid, less than 65%	1
150°F and Below	1
Above 150°F	1
65% To Anhydrous	1
Hydrofluoric Acid, Anhydrous	1
Hydrofluorosilicic Acid	1
Hydrofluosilicic Acid	1
Hydrogen Gas, +150°F To -350°F	1
Above 150°F	1
Hydrogen Fluoride	1
Hydrogen Peroxide 10-90%	1
Hydrogen Sulfide	1
Dry, 150°F and Below	1
Dry, Above 150°F	1
Wet, 150°F and Below	1
Wet, Above 150°F	1
Iodine Pentafluoride	1
Isobutane	1
Isopropyl Alcohol	1
Jet Fuels	1
Kerosene	1
Lactic Acid, 150°F and Below	1
Above 150°F	1
Lime Saltpeter (Calcium Nitrates)	1
Lubricating Oils, Sour	1
Refined	1

1 = Recommended (little or no effect) O = Insufficient Data N = Not Recommended

TABLE 2 - Chemical Compatibility of 100% PTFE Gore-Tex® Sealants

CHEMICAL	CHEMICAL RESISTANCE RATING	CHEMICAL	CHEMICAL RESISTANCE RATING
Lye	1	Oleic Acid	1
Magnesium Chloride	1	Oleum	1
Magnesium Hydroxide	1	Oxalic Acid	1
Magnesium Sulfate	1	Oxygen, Gas, 150°F and Below	1
Mercuric Chloride	1	Gas, Above 150°F	1
Mercury	1	Liquid, Down to -350°F	O
Methane	1	Liquid, Below -350°F	O
Methanol, Methyl Alcohol	1	Ozone	1
Methylacrylic Acid	1	Palmitic Acid	1
Methyl Chloride	1	Pentachlorophenol	1
Methyl Ethyl Keytone	1	Perchloric Acid	1
Methyl Methacrylate	1	Perchloroethylene	1
Mineral Oils	1	Petroleum Oils, Crude	1
Molten Alkali Metals	N	Refined	1
Muriatric Acid	1	Phenol	1
Naphthalene	1	Phosphoric Acid, Crude	1
Naphthas	1	Pure, Less Than 45%	1
Naphthols	1	Above 45%, 150°F and Below	1
Natural Gas	1	Above 45%, Above 150°F	1
Nickel Chloride	1	Phosphorus Pentachloride	1
Nickel Sulfate	1	Phthalic Acid	1
Nitric Acid, Crude	1	Picric Acid, Molten	O
Less Than 30%	1	Water Solution	1
Above 30%	1	Pinene	1
Red Fuming	1	Piperidene	1
Nitrobenzene	1	Polyacrylonitrile	1
2-Nitro-Butanol	1	Potash, Potassium Carbonate	1
Nitrocalcite (Calcium Nitrate)	1	Potassium Acetate	1
Nitrogen Tetroxide	1	Potassium Bichromate	1
Nitromethane	1	Potassium Chromate, Red	1
2-Nitro-2-Methal-Propanol	1	Potassium Cyanide	1
Nitromuriatic Acid (Aqua Regia)	1	Potassium Dichromate	1
Nitrohydrochloric Acid	1	Potassium Hydroxide	1
(Aqua Regia)	1	Potassium Permanganate	1
Norge Nitter (Calcium Nitrate)	1	Potassium Sulfate	1
Norwegian Saltpeter	1	Producer Gas	1
(Calcium Nitrate)	1	Propane	1
N-Octadecyl Alcohol	1	Propylene	1

1 = Recommended (little or no effect)   O = Insufficient Data   N = Not Recommended

TABLE 2 - Chemical Compatibility of 100% PTFE Gore-Tex® Sealants

CHEMICAL	CHEMICAL RESISTANCE RATING
Propyl Nitrate	1
Prussic Acid, Hydrocyanic Acid	1
Pyridine	1
Saltpeter, Potassium Nitrate	1
Silver Nitrate	1
Soda Ash, Sodium Carbonate	1
Sodium Bicarbonate, Baking Soda	1
Sodium Bisulfate	1
Sodium Chloride	1
Sodium Cyanide	1
Sodium Dioxide	1
Sodium Hydroxide	1
Sodium Hypochlorite	1
Sodium Metaphosphate	1
Sodium Metaborate Peroxhydrate	1
Sodium Nitrate	1
Sodium Perborate	1
Sodium Peroxide	1
Sodium Phosphate, Monobasic	1
Dibasic	1
Tribasic	1
Sodium Silicate	1
Sodium Sulfate	1
Sodium Sulfide	1
Sodium Thiosulfate, "Hypo"	1
Sodium Superoxide	1
Stannic Chloride	1
Steam	1
Stearic Acid	1
Styrene	1
Sulfur Chloride	1
Sulfur Trioxide, Dry	1
Sulfuric Acid	
10%, 150°F and Below	1
10%, Above 150°F	1
10-75%, 150°F & Below	1
75-95%, 150°F & Below	1
75-95%, Above 150°F	1
Fuming	1
Sulfurous Acid	1
Tannic Acid	1
Tartaric Acid	1
Tetrabromoethane	1
Toluene	1
Trichloroacetic Acid	1
Trichloroethylene	1
Tricresyl Phosphate	1
Triethanolamine	1
Turpentine	1
Varnish	1
Vinegar	1
Vinyl Chloride	1
Vinyl Methacrylate	1
Water, Mild Acid, With Oxidizing Salt	1
No Oxidizing Salts	1
Whiskey And Wines	1
Wood Alcohol	1
Ylenes	1
Zinc Chloride	1

1 = Recommended (little or no effect) O = Insufficient Data N = Not Recommended

This chemical compatibility guide was assembled from know compatibility data for PTFE materials and should be used only as a general guide for determining the suitability of Gore-Tex® sealants for specific applications. An independent study of the compatibility with your specific fluids is advised for confirmation of chemical compatibility. When immersion tests are performed with Gore-Tex® sealants, the test sample must be first precompressed at 250psi minimum. Immersion test samples are available for your use, free of charge from our Elkton, Maryland facility.

About Fab-Tech

The success of any company is dependent on its workforce. This has certainly been the case with Fab-Tech. From dedicated office personnel to skilled and motivated craftsmen, the work environment is one of exceptional teamwork. This business approach has earned Fab-Tech the distinction as one of the most responsive and innovative companies in the metal fabrication industry. Fab-Tech takes great pride in its workforce and boasts the finest forming, fabricating, welding and coating facilities in North America, totaling over 78,000 square feet.

Customer Service

Fab-Tech is fully dedicated to complete customer service. Since each exhaust fitting is essentially manufactured to order, communication is critical. We work very closely with contractors, engineers and end-users to assure the finished product is consistent with prints, shop drawings and cut sheets. In addition, our professional engineering staff is also available to evaluate and design your custom fabrication as well as provide installation supervision and training upon request. Constantly aware of valuable lead time and the need for minimal delays, Fab-Tech is capable of round-the-clock manufacturing and expedited turn around. Fab-Tech continues to strive for new and better ways to serve our customers, from initial order to final installation.

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Technical information contained in this document is subject to change without notice.

PSP® also manufactured under license in Taiwan, South Korea, and China.

APPENDIX F – STRUCTURAL CALCULATIONS

STRUCTURAL ANALYSIS OF THE EXISTING STEEL K-SERIES ROOF JOISTS TO SUPPORT A NEW 1500lb EXHAUST FAN AT SANDIA NATIONAL LABORATORES BUILDING 1090

PREPARED FOR:

BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.

APRIL 2015

DAVID G. GRABIEL
STATE OF
13829
NEW MEXICO
REGISTERED PROFESSIONAL ENGINEER

04/22/2015

CALCULATION SHEETS: 1 THROUGH 3

BY:

QUIROGA-PFEIFFER ENGINEERING CORPORATION

6621 GULTON COURT NE

ALBUQUERQUE, NM 87109

QPEC
QUIROGA ◆ PFEIFFER
ENGINEERING CORPORATION

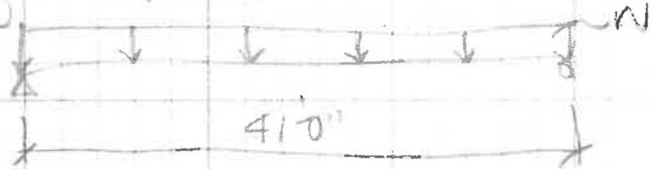
Project SNL BLDG 1090 ES&H
Job No. 6100.83
Subject EXISTING JOIST ANALYSIS

SHEET 1/3

By DGG Date 9/24/14 Ck ________ Date ________

EXISTING ROOF JOIST ANALYSIS FOR NEW EXHAUST FAN

TRIBUTARY WIDTH = 4'-6 5/8" & 4'-8"
DESIGN LIVE LOAD = 20 psf (PER CONST. DRAWINGS)
(NON-REDUCIBLE)



EXISTING JOISTS ARE 24K7 . . .

$W_{TL\,ALLOW} = 241\,plf$
$W_{LL\,ALLOW} = 137\,plf$

ALLOWABLE MOMENT = $wl^2/8 \Rightarrow 241(41)^2/8 = 50.64\,k\text{-}ft$

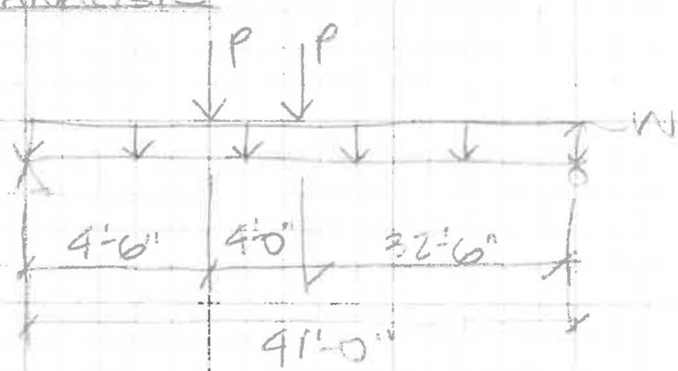
ALLOWABLE TL PSF LOADING = $\dfrac{241\,plf}{(4'6\tfrac{5}{8}/2 + 4'8/2)} = 52.3\,psf$

ALLOWABLE LL PSF LOADING FOR L/360 DEFLECTION = $\dfrac{137\,plf}{(4'6\tfrac{5}{8}/2 + 4'8/2)} = 29.7\,psf > 20\,psf$ ✓OK

ALLOWABLE SHEAR = $wl/2 \Rightarrow 241(41)/2 = 4.94\,kips$

** ASSUME ROOF DEAD LOAD = 20 psf **

NEW LOADING ANALYSIS



LOADING

$W = (20\,psf + 20\,psf)(4'6\tfrac{5}{8}/2 + 4'8/2) = 185\,plf$

Q P E C

QUIROGA ◆ PFEIFFER

ENGINEERING CORPORATION

Project: SAL BLDG 1090 ESH

Job No.: 6100.83

Subject: EXISTING JOIST ANALYSIS

SHEET 2/3

By: DGG Date: 9/24/14 Ck: ________ Date: ________

LOADING (CONT.)

$P = \frac{(1500\,lbs\ (\text{FAN}) + 300\,lbs\ (\text{CURB}))\,2/3}{2} = 600\,lbs$

$I_J = 26.767(W_{LL})(L^3)(10^{-6})$ PER SJI

$W_{LL} = 137\,plf$

$L = 41'0" - 0.33 = 40.67\,ft$

$I_J = 26.767(137)(40.67)^3(10^{-6}) = 246.7\,in^4$

PER ANALYSIS PROGRAM . . .

$M_{MAX} = 42.87\,k\text{-}ft < 50.64\,k\text{-}ft$ ✓OK

$V_{MAX} = 4.80\,kips < 4.94\,kips$ ✓OK

$\Delta_{TL} = 1.834"\ (L/269) > L/240$ ✓OK

EXISTING 24K7 STEEL ROOF JOISTS ARE ADEQUATE FOR SUPPORTING THE WEIGHT OF THE NEW EXHAUST FAN (1500 lbs)

SINGLE-SPAN BEAM ANALYSIS

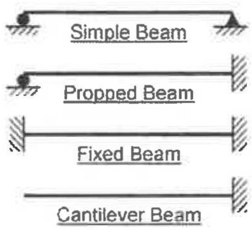
For Simple, Propped, Fixed, or Cantilever Beams

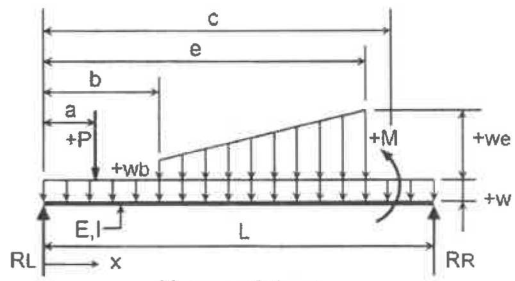
Job Name:	SNL Building 1090 ES&H PRD	Subject:	Exist. 24K7 Joist Analysis w/ New Fan		
Job Number:	6100.83	Originator:	DGG	Checker:	

Input Data:

Beam Data:

Span Type?	Simple	
Span, L =	41.0000	ft.
Modulus, E =	29000	ksi
Inertia, I =	246.70	in.^4





Nomenclature

Beam Loadings:

Full Uniform:

w = 0.1850 kips/ft.

Distributed:	Start		End	
	b (ft.)	Wb (kips/ft.)	e (ft.)	We (kips/ft.)
#1:				
#2:				
#3:				
#4:				
#5:				
#6:				
#7:				
#8:				

Results:

Reactions:

RL =	4.80 k	RR =	3.98 k
ML =	N.A.	MR =	N.A.

Maximum Moments:

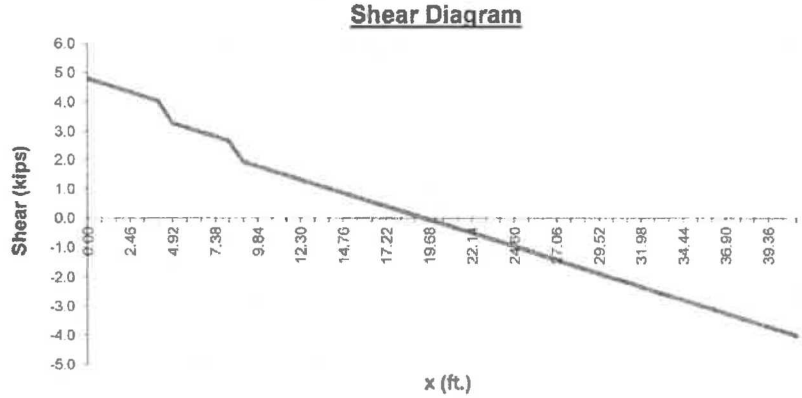
+M(max) =	42.87 ft-k	@ x =	19.47 ft.
-M(max) =	0.00 ft-k	@ x =	0.00 ft.

Maximum Deflections:

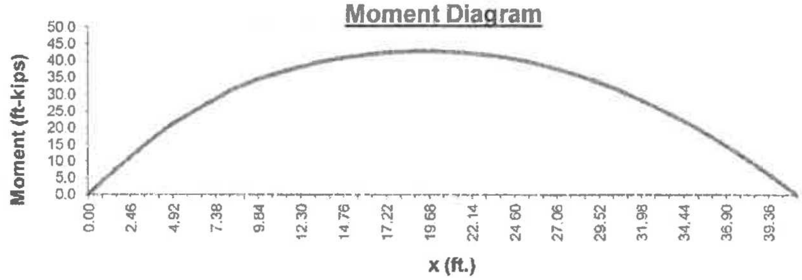
-Δ(max) =	-1.834 in.	@ x =	20.23 ft.
+Δ(max) =	0.000 in.	@ x =	0.00 ft.
Δ(ratio) =	L/268		

Point Loads:	a (ft.)	P (kips)
#1:	4.5000	0.60
#2:	8.5000	0.60
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		
#13:		
#14:		
#15:		

Shear Diagram



Moment Diagram



Moments:	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		