EXECUTIVE SUMMARY

The following proposal is intended to provide an overview of the four analytical phases of IPD/BIM Team 2 senior thesis project for the New York Times Building. Overall, the group chose to follow a strategy emphasizing the reduction of dependency on grid-based energy sources and more efficient systems design as determined by performance, initial cost, life cycle cost, and constructability.

Each of the four phases were chosen for the fact that they require the analysis of more than one team member and allow the team members to further experiment with the Integrated Project Delivery portion of the IPD/ BIM thesis. However, some team members have certain requirements that are required by their department- these goals are outlined in the section labeled Individual Team Member Goals.

PHASE I: FAÇADE REDESIGN

The current configuration of the façade will be compared with a new shading system to determine the most optimal configuration for both daylight utilization and solar shading. A series of passive, active, and glazing reduction strategies will be investigated in which the goal of the redesign will be to optimize thermal loads on the building, while maintaining the architectural vision and owner requirements. This phase requires the participation of all team members.

PHASE II: COGENERATION PLANT REDESIGN

As currently designed, the cogeneration plant is capable of offsetting a small portion of the required demand load. Gas turbine, internal combustion, microturbine, and fuel cell systems will be investigated with respect to total production of energy versus life cycle cost, initial cost, and utility consumption. This phase requires the participation of all team members.

PHASE III: STRUCTURAL ALTERNATIVES

An alternative steel braced-frame lateral system with one outrigger level is proposed after the research performed by the structural team member during Technical Report 3, thus creating a penthouse level for high-end tenants. The structural team member will also concentrate on a redesign of the system that will effectively eliminate the need for the exposed X-braces as a method of controlling drift. The construction management team member will investigate the schedule and cost changes resulting from eliminating this element, and the mechanical team member will investigate the implications of relocating one of the main mechanical floors.

The progressive collapse resistance of the structure will also be analyzed, paying special attention to the twenty-foot cantilevers. Changes in member sizes and connections will be recommended based on findings.

PHASE IV: ALTERNATIVE DISTRIBUTION SYSTEMS

This analysis will target the specifics of the electrical and air distribution systems in the New York Times spaces and whether or not alternative systems are more or as effective with respect to energy efficiency, constructability, and first and lifecycle costs.

TABLE OF CONTENTS

TEAM VISION

The overall intent of the Team II analysis is to optimize building performance while preserving owner requirements and architectural vision. The Team II Redesign Analyses will focus on four key areas of study: facade, cogeneration, distribution systems, and the possible creation of a rentable penthouse for high-end tenants via new structural systems.
The optimization of building performance will be evaluated by comparing the alternative's first cost, life-cycle cost, maintenance considerations, and occupant flexibility individually within each of the four key areas of analysis.

PROJECT INTRODUCTION

The New York Times Building is a 52-story glass and steel structure designed to reinforce the values of the Times Company and its culture of transparency. Located at 620 Eighth Ave. between 40th and 41st streets in Times Square, the building utilizes water-white windows from floor to ceiling, exposed steel columns, and accents of red and gold making it a fitting home for a 21st-century media company. Architect Renzo Piano working with FXFOWLE Architects incorporate many themes into the architecture. The themes included are volume, views, light, respect for context, and relationship to the street to provide a design that is open and inviting. This also presents occupants with a sense of the city around them.

The New York Times Building is co-owned by The New York Times Company and developer Forest City Ratner Companies. It houses the New York Times Company on floors 2-27, and many private companies on floors 1, 29-50, and 52. Floors 28 and 51 are co-owned mechanical spaces, and the first floor is co-owned retail space.

FAÇADE REDESIGN

Following the completion of the technical assignments, it was determined that redesigning the façade could improve the performance of the New York Times Building in a manner which is aligned with our team goals. The façade redesign will focus on strategies for efficient daylighting and optimizing the dynamic thermal skin loads. The team decided to focus on three main areas: passive analysis with respect to shading and thermal mitigation strategies, active shading systems analysis, and an analysis focusing on reducing overall glazing surface area.

LIGHTING AND ELECTRICAL

With respect to the façade redesign analysis, lighting and electrical analysis will be¬ focused on three prime areas: Passive analysis, Active Analysis, and Glazing Reduction Analysis

Passive Analysis

A daylighting analysis on a typical office floor will be performed, which will assess the possibility of replacing the existing glazing with several proposed arrangements of fritted glass. This will be accomplished using the analytical programs AGI and Daysim. Using this information, establishing the resulting daylighting factors (increased from existing conditions, ideally) in conjunction with the mechanical team member will be necessary to ensure a positive change in energy savings.

Active Analysis

The feasibility of replacing the existing rod-based passive design system for daylighting control with an active louver system to better control daylight and heat gain will be analyzed. The study will look at different sizes, angles, and shapes of blades that will increase daylight penetration, reduce direct daylight and glare, and increase the view out of and into the building while still maintaining the core principles of transparency put in place by the architect and owner. This redesign will be considered successful if the daylighting factor of the office is increased, direct glare is able to be decreased, as well as obtaining positive effects on energy savings while working with the mechanical engineering team member.

Reduction in Glazing

The mechanical and lighting and electrical team members will work together to ensure that there is no loss in daylight penetration into the space or loss of visibility out of the building while a balance of clear glazing and non glazing area is determined. Ideally, this will increase energy savings, not diminish from the daylight penetration into the space, and at the same time not reduce the views out of and into the building.

MECHANICAL

The mechanical team member will work closely with other team members during the Façade Analysis phase, particularly the lighting and electrical and CM team members. The façade redesign phase was chosen by the group to be first because of the impact any changes to the building envelope may have on energy consumption and structural loads.

Passive and Active Analysis

An energy modeling program can be used for the analysis of shading effectiveness. A comparison between the ceramic rod baseline and the newly proposed system will be investigated with respect to monthly solar gain savings. The façade redesign will be evaluated based on the cost effectiveness and payback period compared to that of the baseline facade.

Reduction in Glazing

An energy modeling program will be used to find an optimal window to wall ratio with respect to: heat loss, solar gain, daylighting and architectural vision. Reducing the glazing will have dramatic impacts on the building's energy profile, but no redesign can be implemented if it does not meet all other project goals.

STRUCTURAL

The structural team member will primarily ensure that any possible changes to loads are properly addressed by the building structure. Changes to the facade weight will have to be investigated for possible increases of wall loads; this, in turn, might necessitate a change in the support system for the facade. The impact the new shading device has on the wind loads will also be considered, since the shape of the device and the amount of wind deflected to the facade will change. In addition, the structural team member will have to consider out-of-plane forces and in-plane story drifts in the façade redesign.

A reduction in glazing will lead to a change in the facade dead load. This dead load will have to be applied to the supporting beams and columns for strength and serviceability analysis.

CONSTRUCTION MANAGEMENT

Any changes to the façade will need to be examined with respect to initial cost, life cycle cost, potential maintenance issues, and construction time/ methodology. It is important to note that if one system does in fact cost more initially, it may still be economically viable if the payback period falls within a certain amount of time. Given the occupancy duration of the previous building, a payback period of under 100 years is seen as a positive.

It is also important to maintain the initial vision of transparency from both the architect and building owner. While it is quite possible to redesign a façade to perform better with respect to energy and daylighting, it will certainly be more of a challenge to achieve those ends while still maintaining an aspect of transparency.

COGENERATION PLANT REDESIGN

The cogeneration plant existed for the purpose of providing an uninterrupted power supply to the data center if the power grid were to go down. If the cogeneration plant were to run at full output continuously, it would only provide a portion of the total electricity consumed by the New York Times Building. In addition, a utility investigation revealed that purchased steam and electricity was very expensive. The team would like to upgrade the cogeneration plant to at least provide all of the New York Times Building's heating requirements by evaluating the feasibility of alternative systems sucha s Fuel Cells, Microturbines, Internal Combustion, and Gas Turbine systems. Not only will the cogeneration plant save the New York Times Building on operating costs, it will also consume less primary energy compared to a seperate heat and power arrangement.

LIGHTING AND ELECTRICAL

The lighting and electrical analysis of the cogeneration plant will revolve around investigations of Prime Mover Systems and total system energy outputs.

Prime Mover

A comparison of the different electrical load outputs provided by different generator systems will be performed. Opportunities to find a chance for energy savings in implementing load shedding during peak hours will be investigated-overall success will be measured by savings in total energy usage and cost with the combination of savings in steam purchasing that the mechanical tea member will be investigating.

System Outputs

For the study of the systems outputs, the key focus will be on computing both the maximum and minimum loads of the building. Attempts will be made to compare the resulting costs and savings by comparing multiple generators. Working with the construction management team member, success for this study will be measured with respect to their initial and lifecycle costs.

MECHANICAL

Using the seasonal energy profiles, an optimal prime mover can be found based on thermal efficiency and operational characteristics. Case studies and manufacturer's data can be used to select the best prime mover and configuration (centralized vs. decentralized) with respect to primary energy use and owner requirements.

An energy modeling program can be used to compare the two cases of sizing the CHP plant for heating only and heating and electric demand. The alternatives must be evaluated over the lifetime of the building and with respect to each related building system.

STRUCTURAL

The primary role of the structural engineering team member during this phase is to support the other team members in ensuring that the additional loads created by equipment changes are properly mitigated by the structural system, specifically concentrating on the podium roof and mechanical floor framing.

CONSTRUCTION MANAGEMENT

The primary focus of the construction management team member (as well as the prime CM MAE investigation) will be with respect to the production of on-site steam.

Heat is a byproduct of the cogeneration plant equipment and is used to create steam to heat the building. However, the amount of steam produced is far less than the amount of steam required to heat the building. Based on a presentation by the New York Times design team and owner, a significant amount of steam is purchased from local utility Consolidated Edison to account for this difference.

By producing more steam on site, it is possible to reduce the dependency on purchased steam. This could have two very important consequences- a significant reduction in annual utility expenses, and a further reduction in dependence on the local utility grid.

Based on the types of cogeneration plant equipment chosen by the design engineering team members, an analysis on different manufacturers of similar equipment type will be conducted. Most MEP equipment is very long lead-time, and larger equipment can take a long time to transport from the manufacturing facility to the job site. The manufacturer that provides the best combination of lowest first cost and highest equipment efficiency, shortest lead-time and ease of installation, and the closest distance to the jobsite and its ease of transportation. These will provide the highest benefit to life cycle cost, schedule reduction or maintenance, and lowest carbon footprint, respectively.

STRUCTURAL SYSTEM ALTERNATIVES

An alternative steel braced-frame lateral system with one outrigger level is proposed after the research performed by the structural team member during Technical Report 3. Due to the high cost of the architecturally exposed X-braces and their connections, the structural team member will concentrate on a redesign of the system that will effectively eliminate the need for these braces as a method of controlling drift. The construction management team member will investigate the schedule and cost changes resulting from eliminating this element.

LIGHTING AND ELECTRICAL

The lighting and electrical team member will utilize the time during this phase to refine analysis from the previous two phases and begin work on the fourth phase while continuing work on individual lighting thesis requirements.

MECHANICAL

This phase will be primarily driven by structural and construction management team members. Two major problems present themselves in this phase. First, based on the decisions made by the structural engineering team member, it will be necessary to evaluate the relocation of the mechanical room. Second, should the structural engineer be able to change any floor to floor heights, this would dictate the exact sizing of the alternative distribution system outlined in Analysis IV.

STRUCTURAL

Please refer to the Structural Engineering portion of the Individual Team Member Goals portion of the report for a more complete analysis proposal for this portion.

CONSTRUCTION MANAGEMENT

Based on the lateral system analysis completed by structural team members, it is known that eliminating the exterior cross bracing is potentially feasible with a redesign of the system. The prestressed cross bracing members of the lateral system are connected to the rest of the structure through a knuckle connection. In order to successfully analyze and ultimately make a value engineering suggestion, several important points must be considered. Foremost, the knuckle connections and cross bracing were partially chosen based on architectural appearance. It will be important to consider the architectural impact of removing these members.

Second, these cross bracing members originally served to control building drift due to wind as a serviceability concern. Since multiple changes are being made to the structural system by other team members, it is important to ensure that these changes eliminate the need for this cross bracing system to be in place and serve a structural purpose. In other words, it is imperative that building drifts are controlled by different structural elements in place with respect to the lateral system so that the original aesthetic scheme envisioned by the client and architect remains consistent.

After selecting an alternative structural connection based on the criteria mentioned above, it will be necessary to document what the new construction procedure is in comparison to the old knuckle connection, noting any increase in cost or schedule time due to changes in construction methods, local labor requirements, or material lead times.

ALTERNATIVE DISTRIBUTION SYSTEMS

Bus ducts provide electrical service distribution for the upper rentable floors, while copper conductors in conduit are used for the New York Times spaces. The usage of copper conductors in conduit can have many challenges with respect to constructability, particularly when it is spanning over twenty-five floors.

By switching to a bus duct system for electrical risers, it is quite possible to significantly reduce the amount of labor involved in constructing the electrical distribution system. It is possible that this could lead to schedule savings, overall project cost savings, and reduce conductor material consumption.

With respect to the mechanical system distribution, underfloor air distribution (UFAD) systems provide energy savings in almost every category except fan energy and are praised for the flexibility it provides for the owner. However, these marginal benefits do not outweigh the leading arguments against UFAD systems. These systems inefficiently use plenum space and in some cases, are harder to control than a more common variable air volume (VAV) system. This inefficiency could be translated into an increase in rentable space to the owner. The most significant pitfall of UFAD systems is the long-term depreciation of indoor air quality. The New York Times Building and similar high-rise office buildings could be in use for over a century. Dust and other pollutants will inevitably migrate into the underfloor plenum. This issue will be compounded when the building experiences moisture control problems due to inevitable equipment failure or occupant activity.

With these considerations, our design team will remove the UFAD system and use a uniform overhead ducted system throughout the building. Our team will explore two alternatives: traditional variable air volume and dedicated outdoor air systems with decoupled heating and cooling. These alternatives will be evaluated based on first cost, life-cycle cost, maintenance considerations and occupant flexibility. The analysis must focus on each system's performance with respect to the building as a whole. The system will be chosen based on energy modeling and a thorough cost and owner requirement investigation with the entire design team.

LIGHTING AND ELECTRICAL

The Electrical team member will assist the construction team member’s economic and constructability analysis by providing engineering calculations to ensure that the proposed distribution systems are capable of handling the building electrical loads.

The primary investigation will consist of performing calculations (including short ciruit analysis) allowing an evaluation between different electrical distribution systems such as bus duct verses conduit based distribution systems and, aluminum verses copper conductors..

MECHANICAL

Considering the background information on the UFAD system, VAV versus a dedicated outdoor air system (DOAS) will be evaluated. The success of each of these systems will be evaluated through a comparison in first cost, life-cycle cost, maintenance considerations and occupant comfort and flexibility with respect to the existing system configuration.

STRUCTURAL

Structural engineering team member work in this phase will primarily consist of ensuring that loads imposed by different systems are properly mitigated by the structural system. The impact these distribution systems will have on dead loads to floors and transferred to foundations and the possible creation of floors or structural space will also be considered.

CONSTRUCTION MANAGEMENT

The New York Times Company was initially skeptical over the concept of a bus duct, and felt that after consulting with their facility management group that the more traditional wire in conduit method was more reliable than a bus duct system. If it is determined that a bus duct system is more economical and less of a burden on the schedule, further research will be conducted investigating the lifespan and ease of replacement on the two distribution methods to provide the owner with a more complete set of information.

In order for a successful analysis to take place, the approximate cost of the existing electrical system needs to be compared to that of a proposed bus-duct based riser system. Pricing on bus duct riser equipment will also need to be obtained from manufacturers as well as any relevant construction costs and issues prevalent with this type of system.

INDIVIDUAL TEAM MEMBER GOALS

In addition to basic IPD/BIM requirements, each team member will also be bound to complete a certain series of tasks related to their specific option as required by their advisor.

LIGHTING AND ELECTRICAL STUDIES

The lighting and electrical thesis will consist of several additional aspects not covered under the group based IPD/ BIM Thesis. Several key spaces will be analyzed for lighting design as well as electrical implications of from cogeneration and distributions system changes.

Lighting Analysis

1. Lobby:

   Taking into account the comments provided by the professionals at Lutron, electrical team member will complete the redesign of the lobby to successfully create a design that will meet initial design consideration while meeting code lighting level and other requirements of the Lighting Hand book.

2. Offices:

   The main office floor lighting will be redesigned as initially proposed in technical report 3. Meeting personal design considerations, professionals' comments, as well as IES suggested lighting levels will measure success in this space. A major focus will be on the facade redesign with the rest of my design group. A large portion of time will be put towards the integrated design of the facade for this space.

Industry Feedback from Lutron Presentation

Sandra Stashik (GWA Lighting, Philadelphia, PA)

1. General:
   a. How was BIM different?
   b. Use of photos / graphics
   c. Overall very nice
2. Lobby:
   a. Good breakup of the space
   b. Good Schemes – overwhelming in section – try RCP view
3. Café:
   a. Good Model
   b. Careful with sketches – non uniform appeared uniform
   c. Good concepts

4. Office:
    a. Good introduction and explanation of thought process
    b. Good to come to a conclusion and choose one of the designs
    c. Good Daylighting analysis, issues, and graphics

5. Façade:
    a. Confusion as of location of fixtures add plan view to help

Helen Diemer (The Lighting Practice, Philadelphia, PA)

1. General:
    b. Careful with colors on slide, contrast and such
    c. Good descriptions of design criteria
2. Lobby:
    a. Cones of light hard to understand; show what light does more than where it comes from. Emphasize the surfaces it lights

3. Façade:
    a. Articulate purpose for minimizing skyglow
    b. Sustainable focus, where you will get the best impression
    c. Could use a bit further explanation
    d. Bottom of the building would be blocked in by other buildings so find a place to make the best impression at that level.

Electrical Analysis

1. Cogeneration System Analysis:

   Coordinating with the mechanical team member will be a main focus of the electrical study. The resulting changes will require new equipment and possible layout changes, as well as sizing or feeders and comparing results to NEC2009 and IBC regulations.

2. Electrical Distribution System:

   Short circuit analysis will take place from the main distribution board 3 to the series of panels located on floors 7, 8, and 9. This will also be the run where considerations of replacing the current conductors and conduit with bus duct will be taken into account. This will be done in coordination with the CM team member to ensure cost savings in time, initial cost, and constructability. A secondary study investigating the feasibility of replacing the same set of conductors with aluminum will also be conducted, also in coordination. A comparison between all 3 systems will then be performed, taking into account meeting any and all NEC requirements first and then savings in initial cost and installation.

MECHANICAL

In the façade redesign phase, the interoperability between Revit and various energy modeling programs such as Trane Trace and IES will be investigated and documented. The façade design alternatives will be modeled in Revit and should provide a suitable platform for compatible energy modeling programs. In previous experiences, there have been several barriers to accomplishing a successful workflow in this area. Furthermore, the "out of the box" compatibility of a Revit file exported into an energy modeling program will be evaluated for time spend resolving errors and the accuracy of the energy results.

In the alternative distribution systems phase, a thorough reproduction of a typical floor's mechanical systems will be created in Revit MEP to evaluate the program's usability. Several comments in industry have been that Revit Architecture is well developed and is a significant tool in the BIM and IPD process, but Revit MEP is severely lacking with respect to its library and ability to perform engineering calculations.

Both of these individual goals are based upon the overbearing project goals and schedule of Team II. However, the four phases do not contain equal amounts of work for each discipline. The individual goals of the mechanical team member will be fluid and they may work ahead or go back to revisit certain tasks as they see fit throughout the semester.

STRUCTURAL

Background

The New York Times Building structure is comprised of a composite steel and metal deck gravity system with a braced-frame core lateral system. Two-story outriggers located on both the 28th and 51st floors supplement the lateral stiffness of the frames. These floors house the mechanical equipment that supplies the tower. To further control drift and display the structural transparency of the building, pre-tensioned rods were added to the exterior of the building.

Existing Structure

The *foundation* of the New York Times Headquarters combines typical spread footings with caissons to achieve its maximum axial capacity. The tower and podium mostly bear on 20 tons per square foot rock; in this area, 6,000-psi spread footings were used under each column. At the southeast corner of the tower, 24-inch diameter concrete-filled caissons were used since the rock only has 8 tons per square foot capacity. The structural engineers did not disclose the depth of the caissons; it is only known that they extend until they reach rock with a bearing capacity of 20 tons per square foot or greater.

The New York City Subway passes below Eighth Avenue to the west and 41st Street to the north of the New York Times Building. However, this is not a major site restriction since the transit system is not directly beneath the structure.

The *floor system* is a steel composite system with a typical bay size of 30'-0"x 40'-0", with 2½" normal weight concrete on 3" metal deck. Typical beam sizes are W18x35 with a 10'-0" typical spacing, bearing on W18x40 girders. The girders frame into the various built-up columns, box columns along the exterior and built-up non-box columns in the core. Framing of the core consists of W12 and HSS shapes framing into W14 and W16 shapes, which bear on W33 girders. Framing layouts for each floor of the tower are typical as shown in Fig. 1.

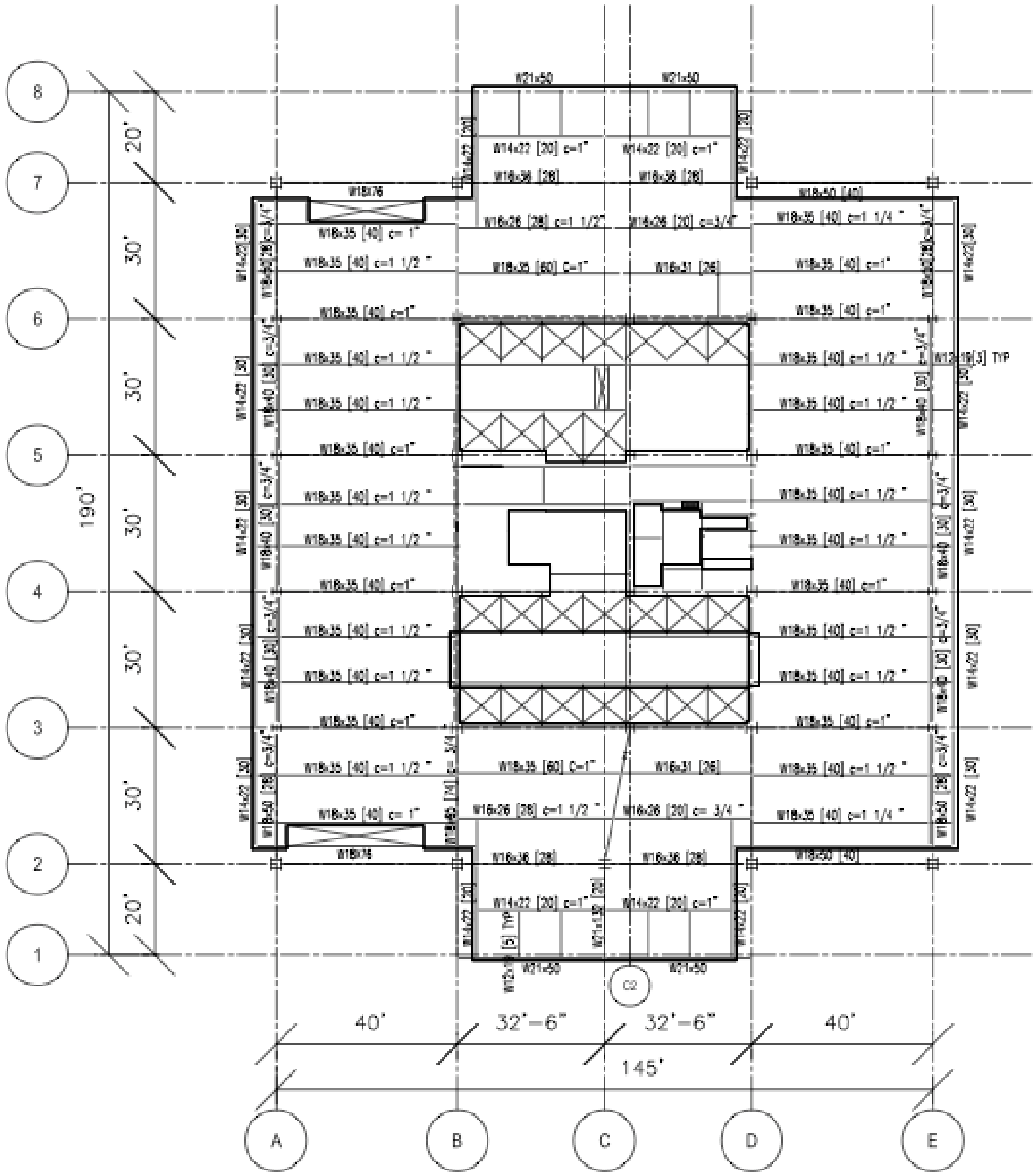


Figure 1: Typical Framing Layouts

The 30” by 30” box *columns*, exposed at the exterior corners of the tower, consist of two 30-inch long flange plates and two web plates inset three inches from the exterior of the column on either side. Each web and flange plate decreases in thickness up the building to adjust to the loads at each level. The yield strength of the plates also varies with tower height, from 50 ksi on the lower floors to 42 ksi on the upper floors. Interior columns are a combination of built-up sections and rolled shapes. Column locations stay consistent throughout the height of the building, spaced with the grid at 30 feet in one direction and 40 feet in the other. Every column is engaged in the lateral system via connections to bracing and outriggers.

The main *lateral force resisting system* for the tower of the New York Times Building consists of a centralized steel braced frame core with single-diagonal outriggers on the two mechanical floors (Levels 28 and 51) to engage the exterior columns. The structural core consists of single diagonal bracing in the North-South direction between grids 4 and 5, concentric chevron bracing in both the North-South and East-West directions, and eccentric chevron bracing in the North-South direction between grids 5 and 6. These braced frames surround the elevator shafts, MEP shafts, and stairwells. At this time, the member sizes of the braces have not been disclosed. The core configuration remains consistent from the ground level to the 27th floor, but one line of North-South bracing drops out above this level for the remaining height of the building. The structural engineers also utilized pre-tensioned steel rod X-braces to control drift while preventing the need for larger members. Typical bracing layouts for the tower are shown in Figures 2 through 4.

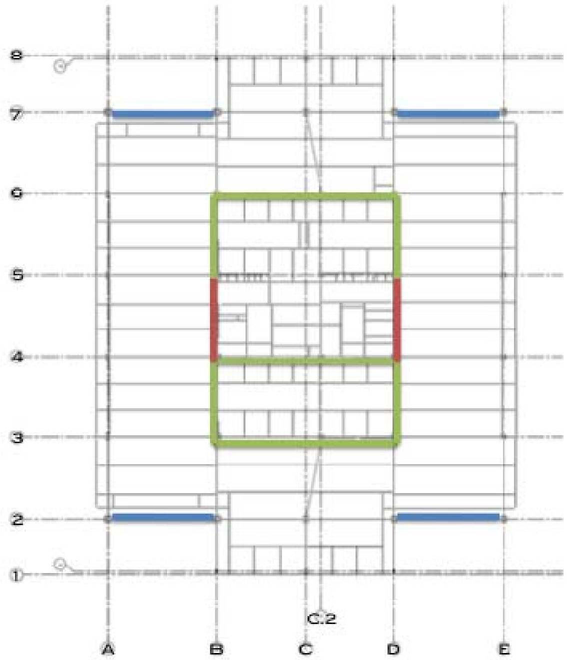


Figure 2: Lateral Layout, Floors 1-27

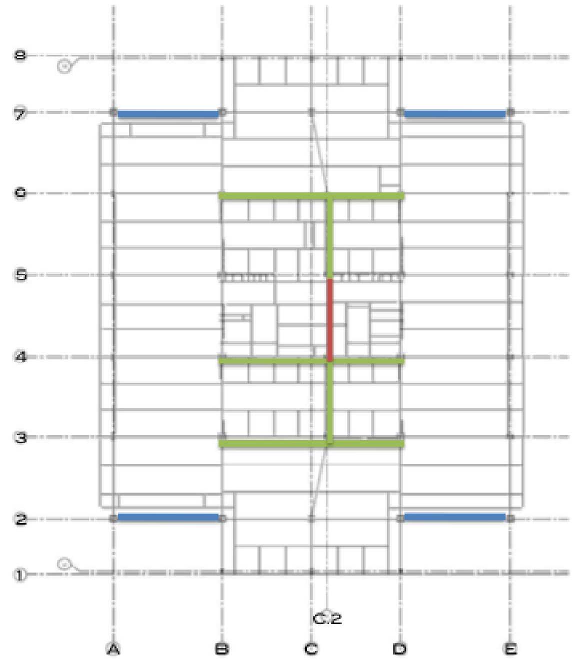


Figure 3: Lateral Layout, Floors 29-50

KEY:

- EXTERIOR X-BRACES
- CONCENTRIC & ECCENTRIC CHEVRONS
- SINGLE DIAGONAL BRACES
- OUTRIGGER

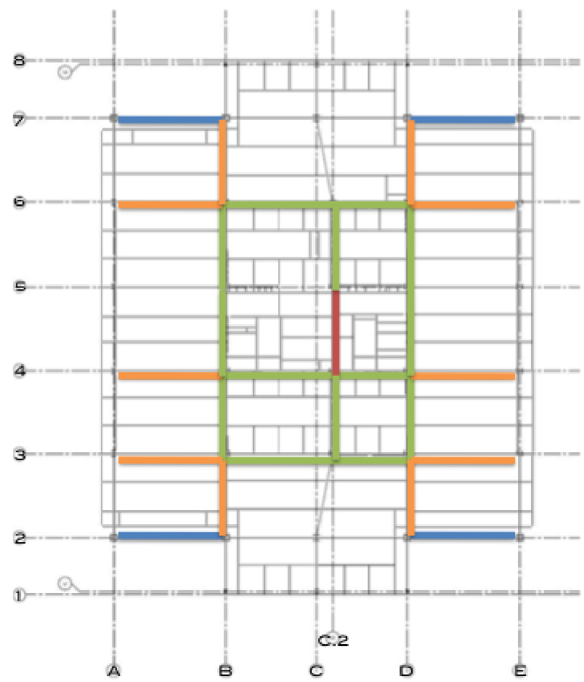


Figure 4: Lateral Layout, Mechanical Floors 28 & 51

Problem Statement

In the existing structure, the two-story outriggers on the 51st floor share space with the mechanical equipment. This space has the potential to bring in more revenue to the owner as a rentable penthouse floor. In addition, the exposed pre-tensioned X-braces on the exterior add extra cost to the system with their detailed connections. After investigating an alternate lateral system that eliminates the top floor outriggers and the exterior braces, I found that this system is a feasible alternative and is worth further consideration.

The New York Times Building structure was also designed with some attention paid to the effects of a blast, but it was not analyzed according to code regulations that took effect after September 11th. I would like to analyze the structure's compliance with up-to-date progressive collapse guidelines.

Proposed Solution

The alternate steel braced-frame system analyzed in Tech 3 will be used as a basis for an optimized and reconfigured lateral system. A single outrigger and mechanical floor will be investigated, and the location of this level will be optimized according to which location provides the lowest drift and period. In addition, a belt truss will be considered, if necessary, to enhance the performance of this system. ETABS will be used as part of the MAE requirements to analyze the lateral system and optimize the layout and configuration of frames in the core, in accordance with 13th Edition AISC Steel Construction Manual and using IBC 2009 and ASCE 7-05 loads. Rigid diaphragms will be used to model floors, and column and beam members will be modeled in three dimensions to include the effects of flexure, shear, axial, and panel-zone deformations in all directions, as learned in the Computer Modeling of Building Structures masters class. Inherent and accidental torsion and P-Delta effects will be also included in the analysis. Plans will be reviewed frequently to ensure the new bracing layout does not conflict with any openings. In the later stages of the analysis, a Revit model of the building will ideally be used to double-check these layouts.

To evaluate the new, optimized location of the outriggers, it will also be necessary to look at the viability of moving the mechanical equipment to the roof and outrigger floor. The existing mechanical floors in the tower are not necessarily organized according to the floors they service; this will make it easier to rearrange the lateral system and possibly allow for a more consolidated mechanical layout. The members on the roof will also be analyzed for an increase in loads.

Progressive collapse resistance will be analyzed according to the 2009 Department of Defense Unified Facility Criteria Alternate Path Method, using the 2003 GSA Progressive Collapse Analysis and Design Guidelines, ASCE 7-05, and the New York Building Code regulations. Key members will be designed to comply with these regulations and provide redundancy to the structure. In addition, special attention will be paid to the twenty-foot cantilevers on either side of the building. These are potential weak points, as they are not supported by gravity columns at the ground level. Beam and connection alternatives will be recommended for better progressive collapse resistance if the existing system is not sufficient.

Finally, foundations will have to be analyzed for changes in loading according to the combined IPD/BIM proposal. Changes in dead loads will affect individual floor framing, as well as have an impact on seismic calculations. These factors will all be accounted for in the final report.

Structural Solution Method

The general IPD/BIM Timeline will be followed as a basis for the semester schedule. A more specific task sequence is outlined below for Phase III, the bulk of the structural proposal.

1. Reconfiguration & Optimization of Lateral System
    a. Model braced-frames in ETABS and determine most efficient layout
    b. Check layout for compatibility with floor plans and stacking diagrams
    c. Optimize sizes of frame members
    d. Evaluate impact on other systems using BIM

2. Analysis of Structure for Progressive Collapse Resistance
    a. Research code requirements and Alternate Path Method
    b. Apply method to structure, looking at key members
    c. Analyze cantilever for tie forces
    d. Update sizes of members to reflect analysis
    e. Design connections for updated loads
3. Impact of IPD Developments on Structure
    a. Phase I: Façade gravity and lateral load updates
    b. Phase II: Cogeneration gravity load updates and vibrational check
    c. Phase IV: Distribution coordination with lateral system

CONSTRUCTION MANAGEMENT

From interactions with team members to date, it is becoming more apparent that the construction management team member will play more of a construction agent/ project architect role in addition to providing constructability, cost, and scheduling advice. An organized management plan and workflow will be required once the interdisciplinary teams formally begin to work together on a daily basis.

Several interdisciplinary team management strategies are currently coming to prominence in the industry. Two schools of thought will need to be evaluated and compared prior to the beginning of next semester: The *BIM Project Execution Planning Guide* created by the CIC research group at Penn State, and the *Integrative Design Guide to Green Building* by the consultancy 7group.

One school of thought with respect to the integrative design process is to work independently by discipline and then collaborate with other disciplines at predetermined points in the project timeline. Given the. An alternative phase-based approach to analyzing the NYT building will be a taken with respect to group workflow.

Several theories regarding the management and structure of the decision making/ analysis process of integrated design teams using BIM have come into prominence. Both the *BIM Project Execution Planning Guide* and portions of the *Integrative Design Guide to Green Building* suggest that the various design and construction disciplines work together semi-independently on the building as a whole and gradually begin to work more cohesively as the project progresses, coordinating each of their individual work with one another at established collaboration points. Due to the scale of many projects, the fact that in many cases the design and construction disciplines can be located very far away from one another, and that many individual (discipline specific) firms are highly dependent on the design/ performance of their system, the gradual cohesion of teams over time is a logical approach.

However, the configuration of the BIM Thesis teams is remarkably different. All of the design and construction team members are in one location- this allows for a slightly different approach to the integrated design process. Due to the background of architectural engineering students, it is quite possible that any student in an interdisciplinary team is capable of engaging in an informed design or construction discussion regarding an area of specialty outside of their own.
Based on this, it is possible that an integrated, sequential task-based problem solving method can be used. In this problem solving method, all interdisciplinary team members work on the same problem at the same time and strive to reach a common goal identified by the group. Ideally, the varied specialties and backgrounds of the team members will lead to different perspectives in solving the problem as a team, and this will ultimately lead to a solution that benefits all parties. For example: The team agrees as a whole that the cogeneration plant in a current design is not as optimized as it could be and evaluates changes to the system, receiving input from all team members in the initial design process.

In contrast, the traditional approach would be for each team member to have their own personal, discipline driven goals and merely interact with other team members as their own goals required the input of someone with a different specialization. For example, a mechanical student realizing that the cogeneration plant is undersized, increases the size of the equipment and then notifies the structural student that the loads have increased and the structural system should be changed accordingly.

TEAM TIMETABLE

WEIGHT MATRIX

The following are targets for the total amount of work time that each team member will put into each phase. Also included is an approximate breakdown of how much time will be spent on each phase.

PHASE SUMMARY

The redesign for the facade had a major focus on controlling and possibly eliminating direct sunlight penetration for as much of the year as possible, while increasing the ability of the occupants to see out and downward. Exterior blades provide the best results based on these criteria. The redesign was able to fully block sun penetration on the south and east facades during the hours of 11:00 A.M. to 1:00 P.M. all year, which helps reduce the cooling load for the building. With this new blade system, their spacing increases the view out to the horizon by about 50% and the view downward toward the street by about 75%. This is possible because of precisely angled blades at the base of the glazing arranged so that the blade length does not obstruct the view. This facade not only increases the transparency of the building from the inside out, it also allows for clearer views into the building from across the New York City skyline and also looking up from street level.

In order to reduce the life-cycle costs of the building, an effective redesign of the facade needed to include improved thermal and moisture control characteristics. A facade study was conducted which focused on the effects of changing the wall assembly. The building enclosure analysis tool Heat Air and Moisture Toolbox (HAM) was used to evaluate U-values and moisture penetration of the baseline facade and the redesigned facade. This was followed by a comprehensive energy simulation in Trane TRACE and a secondary analysis in Integrated Environmental Solutions (IES). These analyses provided critical information for all subsequent phases. An evaluation of the interoperability of these energy modeling programs with Revit will be included in this Phase. This evaluation will be conducted for the purpose of finding the limitations of BIM technologies in an integrated project delivery workflow. This interoperability analysis can be found in Appendix I.C.

For the structural aspect of Phase I, the new façade system weights and sizes were analyzed for compliance with the existing supports. The new bladed shading system had a lower weight than the ceramic rods, allowing the existing connection and support system to be used. Mullions between glazing panels were designed to account for the new IGU selection, taking into consideration the components and cladding wind load and the existing mullion and panel dimensions.

The assembly process for the redesigned and existing curtain wall system was kept as similar as possible to the original system excepting an investigation into the change in panel size; panels were proposed to be doubled in width to reduce the total number of panels by approximately half. The total cost of the existing system is approximately $83.5 million. The redesigned system came to a cost of approximately $120 million, likely due to the selection of high energy performance glazing materials and spandrel panels. The life cycle cost of the redesigned façade will be examined in conjunction with Phase II: Cogeneration Plant redesign

EXISTING DOUBLE-SKIN FAÇADE SYSTEM

EXISTING DAYLIGHTING SYSTEM

While it provides an interesting architectural aesthetic to the façade, the existing ceramic rod system is also used to control direct daylight penetration into the space. Figure 1 shows a cross section of the façade and Figure 1.1 shows a photo from the interior of the New York Times Building. Along with controlling penetration, it provides an interesting dynamic lighting effect over the course of the day as the rods cast striped shadows on the interior blinds used to complement the rod system (Figure 2). However, the presence of these stripes could potentially cause an uncomfortable lighting situation for the occupants of desks along the windows (Figure 3). Based on models created and calculations performed, it was discovered that the rod system was able to optimally block direct sun penetration only on the southern facing façade, from April to August between 11 A.M. and 1 P.M. According to FXFOWLE, this existing design results in a reduction of the cooling load which only accounts for a 1% reduction in the total annual energy consumption.

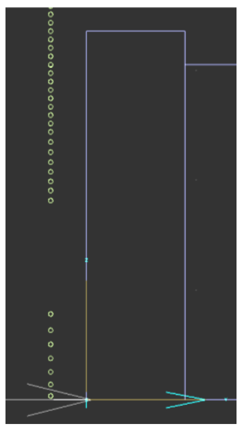


Figure 1

Figure 1.1

Figure 2

Figure 3

EXISTING ELECTRIC LIGHTING

The existing electrical lighting design uses T5 linear fluorescent luminaires to provide 50 footcandles at desk level, three feet above the floor. The Lutron Quantum lighting control system utilizes DALI control to individually dim fixtures to compensate for varying daylight levels in the office (Figure 4). The existing lighting uses 624 luminaires, custom Zumtobel's TechZone fixtures with a recessed louver and light chamber containing two 33 watt T5 lamps. The system uses a 277 volt electrical system, creating a total floor load of 20,592 watts, not including any task or cove lighting. The fixture is made up of two 2' sections with a 4" space between them for either a sprinkler head or daylighting sensor (Figure 5) and a 2" space at each end to allow for return air through the plenum. Each luminaire has the ability to dim to ten percent of its original output, allowing for increased energy savings during daytime hours. This same fixture is used throughout the floor plan to maintain consistency (Figure 6) in addition to a cove fixture around the perimeter of the building used to emphasize the transparency of the building at night. The cove lighting consists of seventy eight 40 watt T5 lamps, which are custom cove fixtures. Using Daylight autonomy analysis from Daysim, an estimated daylight savings with dimming was performed with a designed illuminance target of 450 lux with dimming ballasts. The rod system was determined to save 62.53% on lighting energy (See Chart 1).

Figure 4

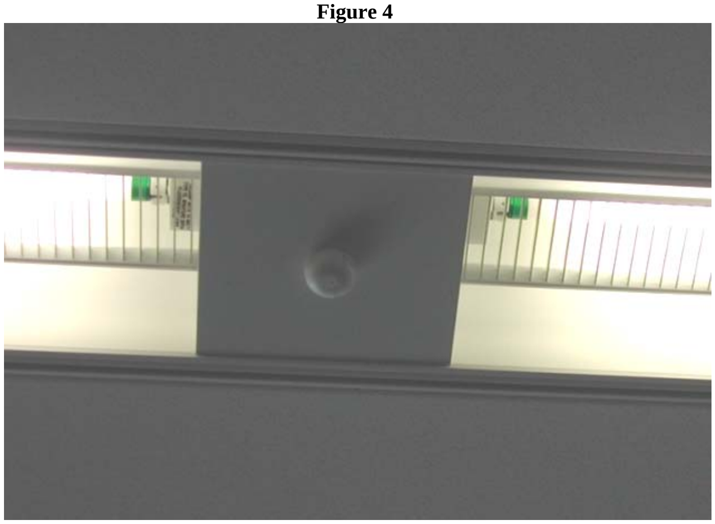


Figure 5

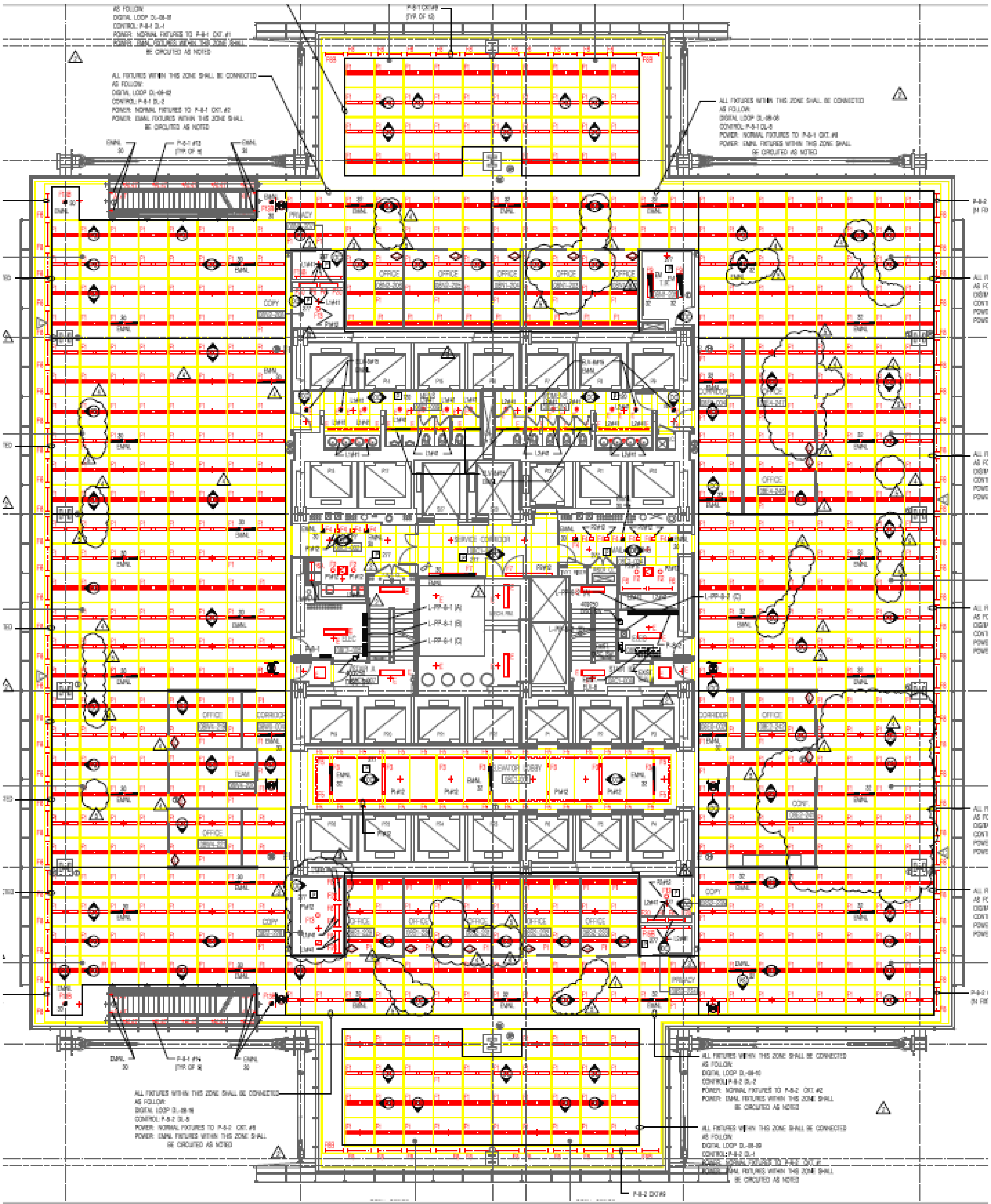


Figure 6

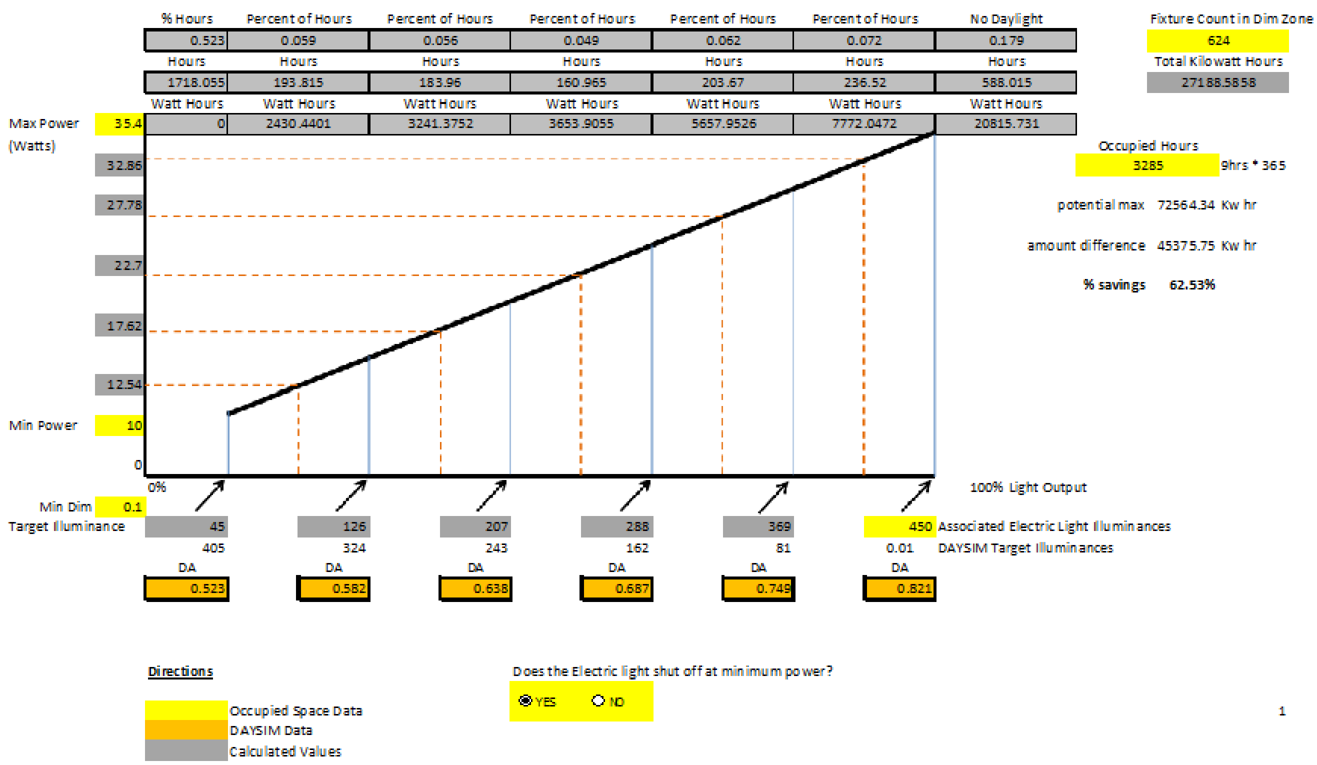


Chart 1

DAYLIGHTING STUDY

A daylighting study was performed to assess the building and site orientation with regard to solar positioning. The New York Times Building sits between West 40th and West 41st streets at 8th Avenue in New York City. The city grid is at a 20 degree angle rotated clockwise off of magnetic north. The declination of magnetic north to polar north is an additional 16 degrees, making the building's total rotation negative 36 degrees. Using the building modeling tool Ecotect to overlay the solar path of the sun on the building (Figure 7), it was found that solar shading will be needed on all four sides of the building. The northern and western facing facades will have sun penetration at the early and late hours in the day for almost the entire year. For this report, the southern facing façade refers to the façade facing in the south western direction and such that it relates to Figure 7. The use of an external blade system along with internal shades could be used to help with morning and late afternoon hours where sun angles are at their lowest and can cause direct and disabling glare within the building.

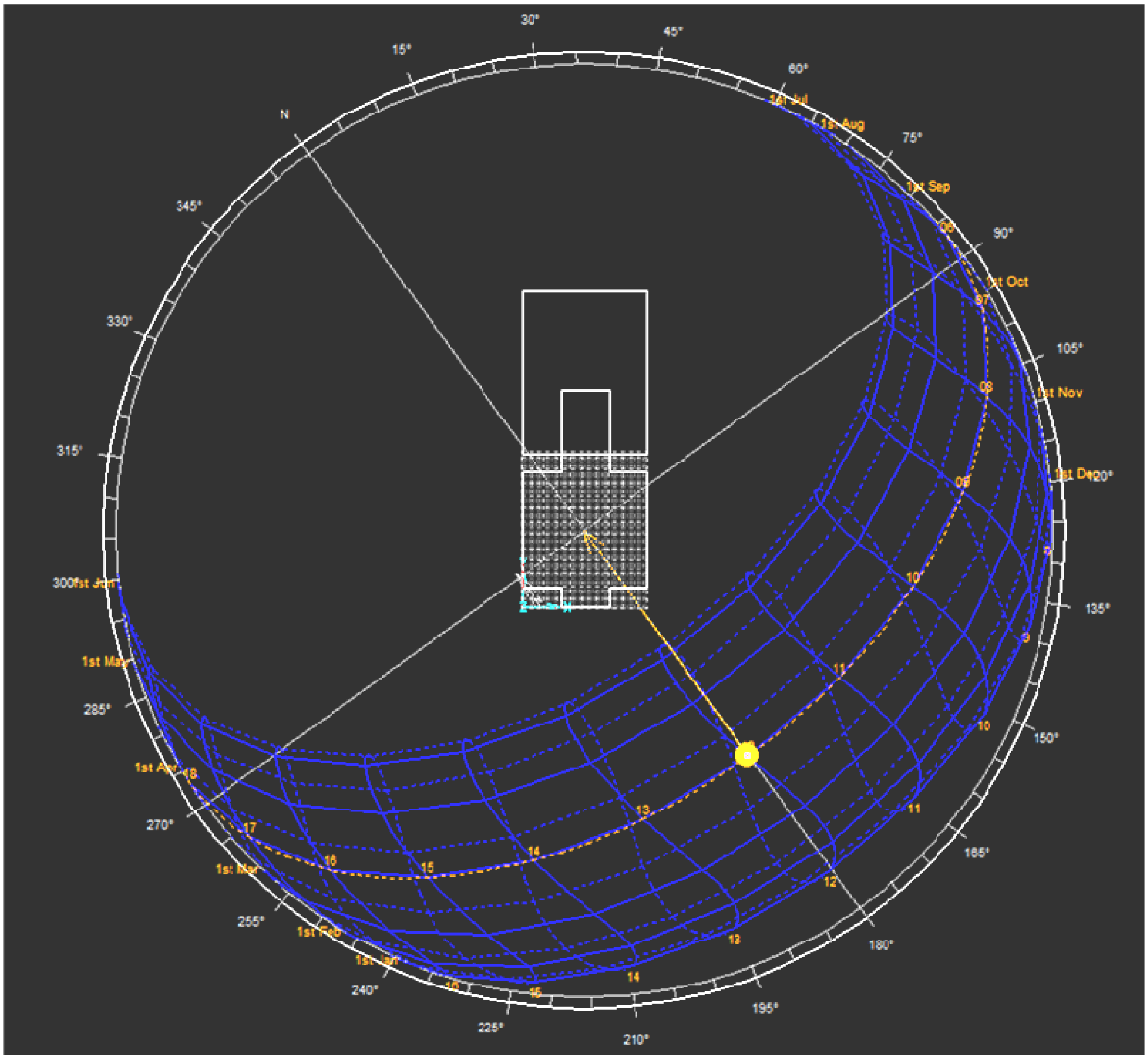

30°
45°
15°
60°
N
1st Jul
1st Aug
75°
1st Sep
345°
90°
1st Oct
330°
105°
1st Nov
315°
1st Dec
135°
1st May
285°
150°
1st Apr
270°
1st Mar
165°
255°
1st Feb
180°
1st Jan
240°
195°
225°
210°

Figure 7

BASELINE FAÇADE ENERGY ANALYSIS

GLAZING PROPERTIES

As previously stated, the vision of the architect was to create a highly transparent façade. To achieve this, the existing glazing consists of ultra clear, low-iron glass from the glazing manufacturer Saint-Gobain Glass. According to the manufacturer, two different lites of glass were combined to achieve the transparency that the New York Times Building required. The outermost pane was a monolithic lite of "Diamant" ultra-clear, low-iron glass coated with an anti-reflective metallic oxide. The innermost pane was a laminated lite to improve the thermal properties of the glazing unit. It consists of the Planitherm substrate sandwiched between two lites of "Diamant" glass. The resulting glazing unit has a very high overall visible light transmittance of 96%, with a visible light reflectance of about 1%. The overall U-value of the glazing assembly is 0.625 [Btu/ft^2-F].

SPANDREL PROPERTIES

The spandrel portion of the façade uses cavity wall construction. The outermost layer is a 3/16" thickness aluminum panel followed by an air space of approximately 1/2". On the inner side of the air gap, a vapor barrier is affixed to 2 1/2" rigid insulation. There is no "finish" on the inner layer because it is exposed to only the plenum. The resulting cavity wall has an overall U-value of 0.0874 [Btu/ft^2-F] and a peak condensation rate of 37 [grains H_2O/ft^2 per day]. The spandrel U-value and condensation rate was calculated using the Heat, Air, and Moisture Toolbox (HAM) program. See Appendix I.A for the complete wall analysis in HAM.

SHADING AND WALL DIMENSIONS

The existing façade uses 1 5/8" horizontal ceramic rods as external shading devices. On a typical floor, there are 20 rods which shade the floor-to-floor glazing. This corresponds to an effective shaded glazing area of 32.5" of the 10'-6" total glazing height. The under-floor air distribution in the original design requires a large plenum in the interstitial space. The total height of the raised floor, structure, and lighting cove clearance is 3'-3". For a complete wall section, see Appendix I.B.

ENERGY ANALYSIS

The baseline façade for the New York Times Building was evaluated for a number of criteria. The energy analysis was performed using two separate energy modeling programs: Trane TRACE and Integrated Environmental Solutions (IES) Virtual Environment (VE). Generally, TRACE uses the Total Equivalent Temperature Difference Time Averaged (TETD-TA1) method for cooling calculations and Fourier's Law of conduction (UATD) for heating calculations. IES uses the ASHRAE Heat Balance method for both cooling and heating calculations. The table below summarizes the results of the modeling. For detailed reports, see Appendix I.C.

	Trane TRACE Results	**IES VE Results**
Peak Cooling Load [Btu/h]	843,642	824,700
Peak Heating Load [Btu/h]	460,150	536,200
Cooling Energy Density [Btu/hr-ft^2]	39.7	34.0
Heating Energy Density [Btu/hr-ft^2]	63.0	26.0
Total Source Energy [kBtu/yr]	3,750,464	Not Calculated

METHODOLOGY AND ASSUMPTIONS

The analysis performed in TRACE is the primary energy modeling study. The energy modeling in IES is a secondary study and was primarily performed for the evaluation of the software interoperability in the IPD/BIM environment. This primary/secondary scheme was chosen because energy modeling in subsequent project phases would be done in TRACE.

Below is a list of the general assumptions made for both energy models:

- Only the 8th floor of the building was modeled. This was considered a typical floor for the rest of the building.
- Construction:
    - All U-values are modeled in accordance with the selected material unless otherwise noted.
    - The roof and floor were modeled with extremely low U-values so that conduction through these surfaces would be negligible.
    - Passive solar shading devices of the correct type could not be modeled in TRACE. As a result, the height of the glazing had to be adjusted to reflect the effective shading of the rods/blades on the glass. Also, the U-value for the spandrel was weighted so that this reduction of sunlit glass was accounted for in the conduction calculations.
    - The shading devices were more accurately modeled in IES because the program allowed the user to describe the shade's transparency in 15 degree increments along the vertical direction.
- Internal loads:
    - Lighting: 1.1 [W/SF]
    - Plug loads: 0.5 [W/SF] for majority of spaces.
    - Electrical/Telecom loads: Estimated 500 [W] per room.
    - Mechanical loads: Estimated 1000 [W] per room.
    - Occupant density approximate to those prescribed by ASHRAE Std. 62.1 – 2007.
        - Sensible load: 250 [Btu/h per occupant]
        - Latent load: 200 [Btu/h per occupant]
- Mechanical systems:
    - Schedule: The mechanical system was scheduled to run between the hours of 6AM and 12AM (100% utilization).
    - Distribution system:
        - Ceiling supply and return.
        - The core was modeled as a VAV system with reheat.
        - The perimeter was modeled as a VAV system with reheat and perimeter heating.
    - Plants (for TRACE only):
        - Water-cooled electric chiller (Default)
        - Natural gas fired boiler (Default)
    - Setpoints:
        - Cooling: 75 [deg F]
        - Heating: 70 [deg F]
        - Max relative humidity: 50%
        - Min relative humidity: 20%

EXISTING FAÇADE CONNECTION

The existing façade system, including the ceramic tube shading system and glazing, was estimated to weigh 25 pounds per square foot by the structural design team. The support for the shading system consists of C-shaped members bolted through each flange to vertical elements in two places per unitized panel, as shown in Figure 8. This arrangement allows for tolerances during assembly while still maintaining the vertical support during installation. These C-shaped members connect to a built-up beam that runs horizontally along the exterior at each floor level, in front of the spandrel panel. Members connected to the girders at each bay pass through the façade to carry the built-up beam on the exterior.

Figure 8

ASSEMBLY OF EXISTING FACADE

OVERVIEW

The existing double-skin façade system for the tower portion of the New York Times Building is comprised of a series of unitized panels. Each panel contains both parts of the double-skin façade: an inner panel consisting of glazing, mullions, and mounting hardware for both the shading system and the entire panel itself, and the outer shading system consisting of ceramic rods and their mounting hardware.

Benson Industries, LLC was the prime curtain wall consultant and contractor for the double skin façade of the New York Times Building. Benson's New York City office was responsible for all of the design consulting and contracting for the New York Times office, while their assembly facility in Oregon was responsible for assembling all of the unitized panels.

The New York Times Company opted to use Benson Industries, LLC after having a competition between four large curtain wall consultants/contractors to see which could create the most efficient solution for the proposed system. While Benson Industries' assembly facility is located in Oregon, the New York Times Company felt that Benson Industries' controlled-environment facility offered the best opportunity for a high level of quality control that justified the additional shipping costs compared to a local consultant or contractor.

OFF-SITE ASSEMBLY PROCESS

Each unitized double-skin façade panel consists of many individual parts: glazing panels, spandrel panels, mullions, ceramic rods, and mounting hardware for both the shading system and the entire unitized panel. All of these parts were integrated into a unitized panel of dimensions 5' x 13'- 4".

Using both the RS Means Labor Output Values and the original project schedule dates, the following information was determined for the off-site assembly of the existing facade:

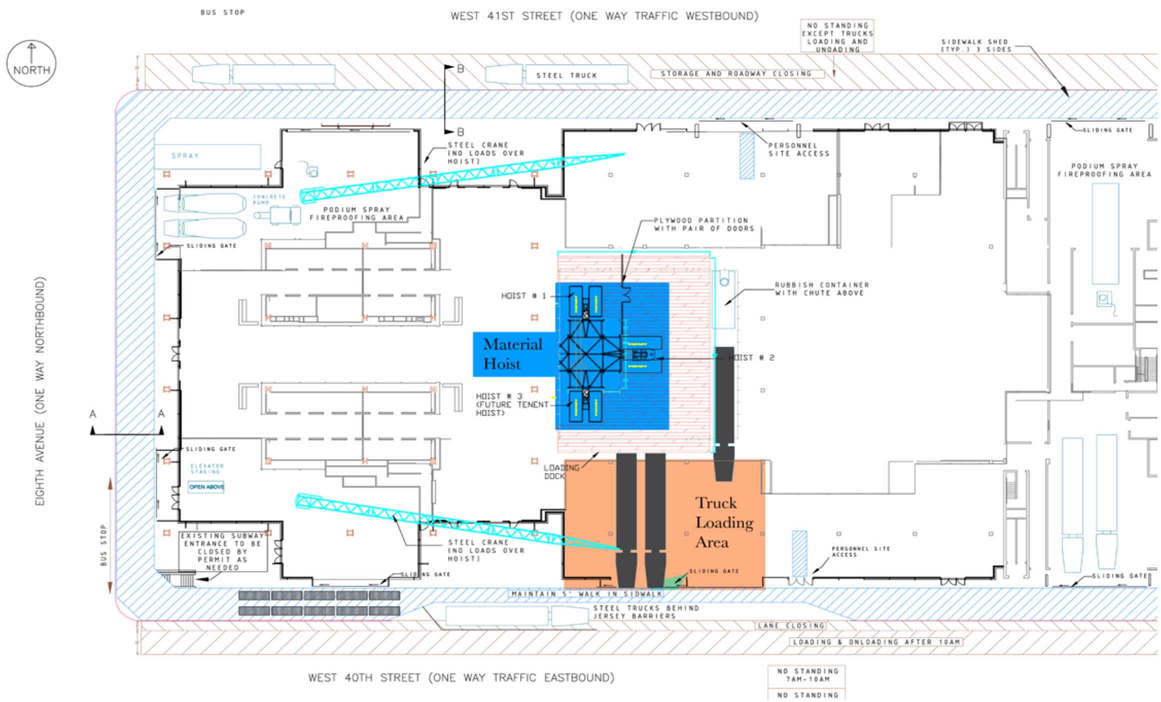
	Unitized Panels	**Workdays to Complete**
Typical Tower Floor	76	6.5
Entire Building	3952	356

Off-site assembly began on the panels 287 calendar days prior to the installation of the first curtain wall panel, and according to the actual project schedule was not on the critical path. The panels were shipped from Oregon to New York City over a period of 322 calendar days that were staggered with on-site construction.

ON-SITE ASSEMBLY PROCESS

Based on conversations with Jim Faust, an industry consultant and project superintendant from Turner Construction in the New York City area for 35 years, curtain panels of this size were not likely to have been put into place with a tower crane. Since only two tower cranes were located on site, scheduling anywhere from 1000-2000 additional picks with the crane operator would have been a source of catastrophic project delays.

For this reason, it is assumed that the core and shell CM (Amec) placed several stores of curtain wall panels on every floor that were subsequently installed by use of a swing-stage scaffolding system. Based on site planning drawings, it is assumed that these panels were unloaded into the central courtyard through an opening in the south face of the building and delivered to their proper floor via a material hoist.



By knowing the total number of panels per floor and the total amount of workdays allotted to install them, it is possible to determine the approximate work rates of the crews installing the panels on-site. All values below are with respect to the tower portion only.

Hourly Work Output	**Daily Work Output** (panels/day)	**Days per floor completion**	**Total curtain wall erection time** (Days)
1.9 Panels/ Hour	15.2	5	260

Each double-skin façade panel is lifted into place and secured by tradesmen inside the building and on the swing-stage scaffolding (the exact number is dictated by local union regulations and is unknown at this time). Each panel is then secured into place with a system of bolts to secure the panel to the floor slab.

COST OF EXISTING SYSTEM

METHODOLOGY

The cost of the existing façade system was obtained using a combination of Revit and typical Excel calculations using cost information obtained from contractor interviews. Benson Industries provided a base cost of $144 per square foot of façade area plus $20 per ceramic rod (includes mounting hardware for each rod). A brief summary of the full takeoff is included in the table below. The cost for a typical floor is the total building curtain wall cost divided by the total amount of floors in the building- it is very likely that the cost per floor is slightly higher than it was in actuality due to the inclusion of podium curtain wall area, but the cost for the building as a whole is accurate according to Revit takeoffs.

	Façade area (SF)	**Average Façade Unit Cost** ($/ SF)	**Rods** (ea.)	**Rod Unit Cost** ($/ rod)	**Total Cost** ($)
Typical Tower Floor	10,678	$144	14510	20	1,606,293
Entire Building	555,236	$144	754,510	20	83,527,260

The prices given by Benson are all inclusive- materials, labor, shipping to New York City from Oregon, and installation are all included in the cost. Equipment rental and crew costs are not included in this estimate, but they are accounted for in the general conditions estimate provided in CM Technical Assignment Two.

This general assembly-level estimate was as accurate as could be calculated from the information given by New York Times project team members- this baseline cost will be used for comparison with the redesigned double-skin façade system.

REDESIGNED DOUBLE-SKIN FAÇADE SYSTEM AND OFFICE LIGHTING

REDESIGNED DAYLIGHTING SYSTEM

The south-facing façade and office area was used to create an initial design. Multiple designs were analyzed at different angles and blade spacing, based on the design criteria of no direct light penetration during high noon hours, which is when the most heat gain would occur. Using Ecotect, which has a sunray tracing program, an angle of 17 degree tilt for the blades was found to be optimal to meet the criteria for a passive blade system. However, these results would only be optimal for the southern- and eastern-facing facades. For the northern and western sides, the blades would need to be rotated at a 30 degree angle, which reduces the view out of the building for occupants. Thus, the façade designed for the south side would be used in addition to an interior shading device. Shading devices that are controlled by the Lutron Quantum control system will be used to minimize direct glare from early and late hours when the sun is low in the sky.

A major goal of the façade redesign was to decrease the amount of direct sunlight penetration into the space while increasing the view from the inside out, all while increasing the building's overall transparency. A bladed system was proposed as an alternative to increase the projected area in order to block lower-angled sun rays. NACO 25E blades, 10" long by 1.57" high, were selected for the analysis (See Appendix I.D). The blades were spaced at 9" apart to allow for half the number of blades as ceramic rods (Figure 1). This spacing allows for a less obstructed view of the city outside and an increased area to block the direct rays of the sun (Figures 2 and 3). To increase the view downwards towards the city and streets below, the bottom section of blades are tilted at angles so that a six foot occupant standing at the window is able to look down at a 70 degree angle with a 5.25" viewing window (Figure 5) increasing viewing area out by about 50%. With the rod system, the same occupant can only see down at a 50 degree angle with only about ½" of viewing area (Figure 4). Increasing the ability of the occupant to see out increases the interior transparency as well as giving people outside the ability to see into the building when looking up.

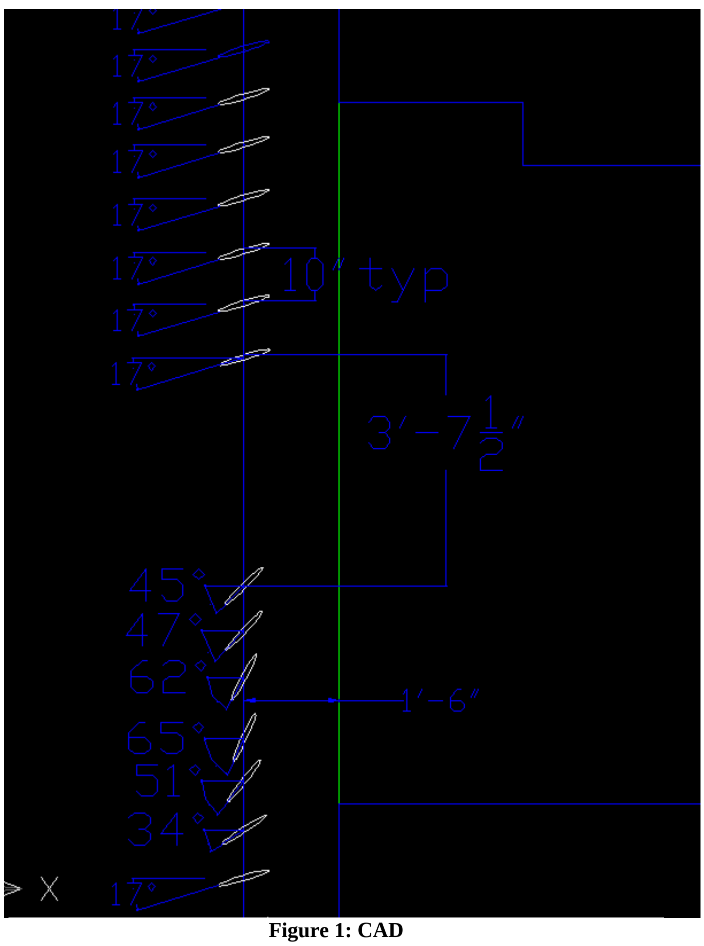


Figure 1: CAD

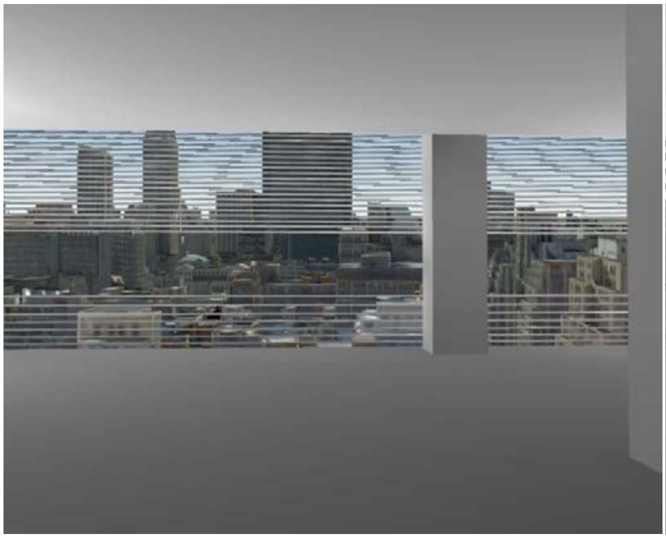


Figure 2: Rods

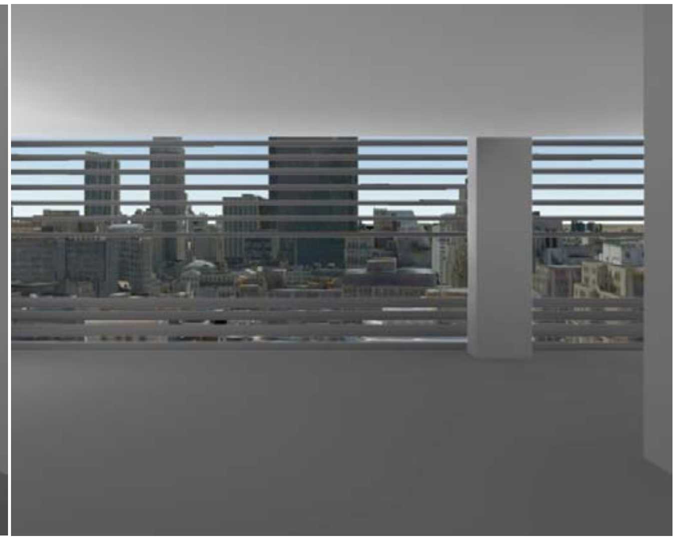


Figure 3: Blades

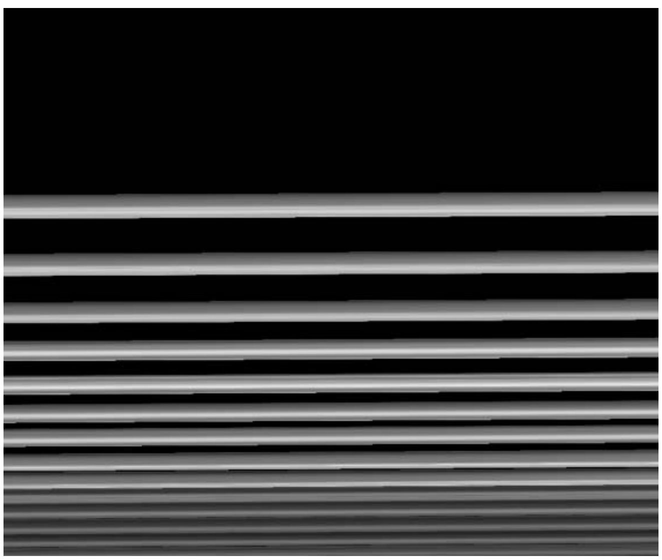


Figure 4: Rods

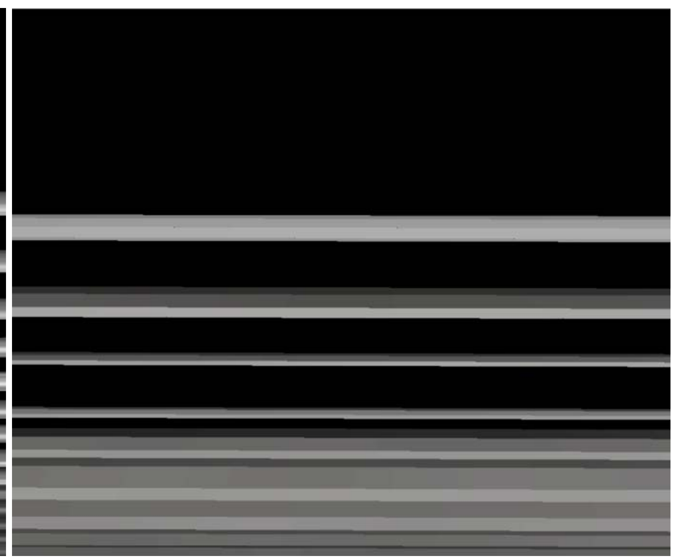
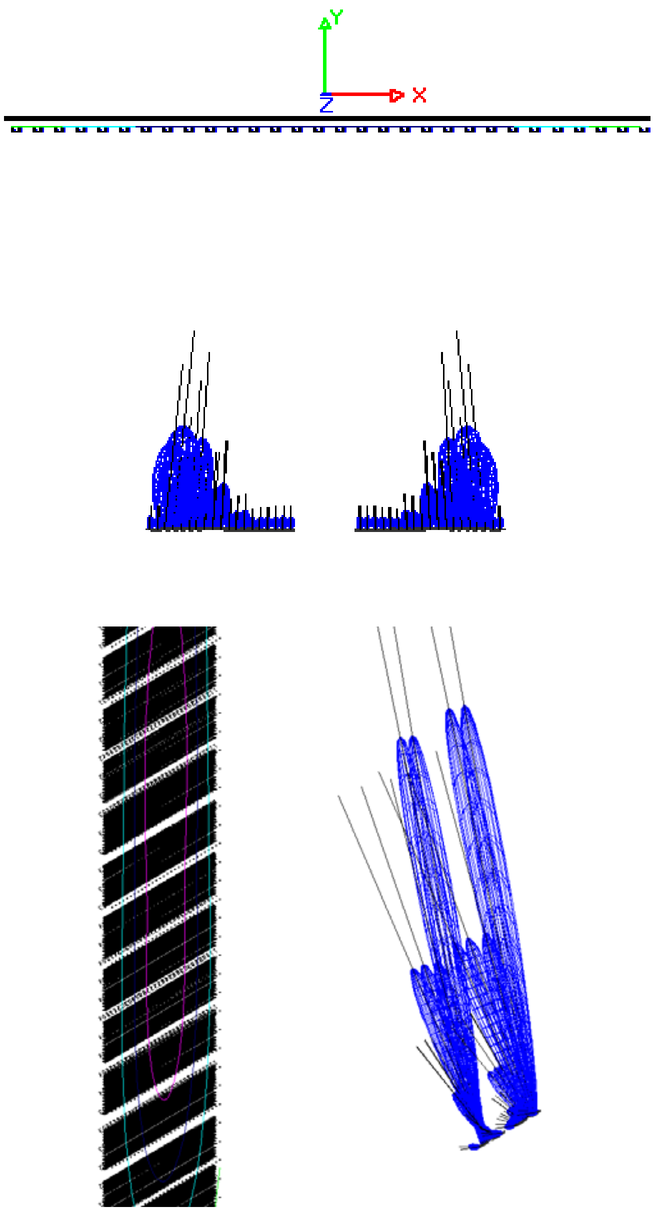


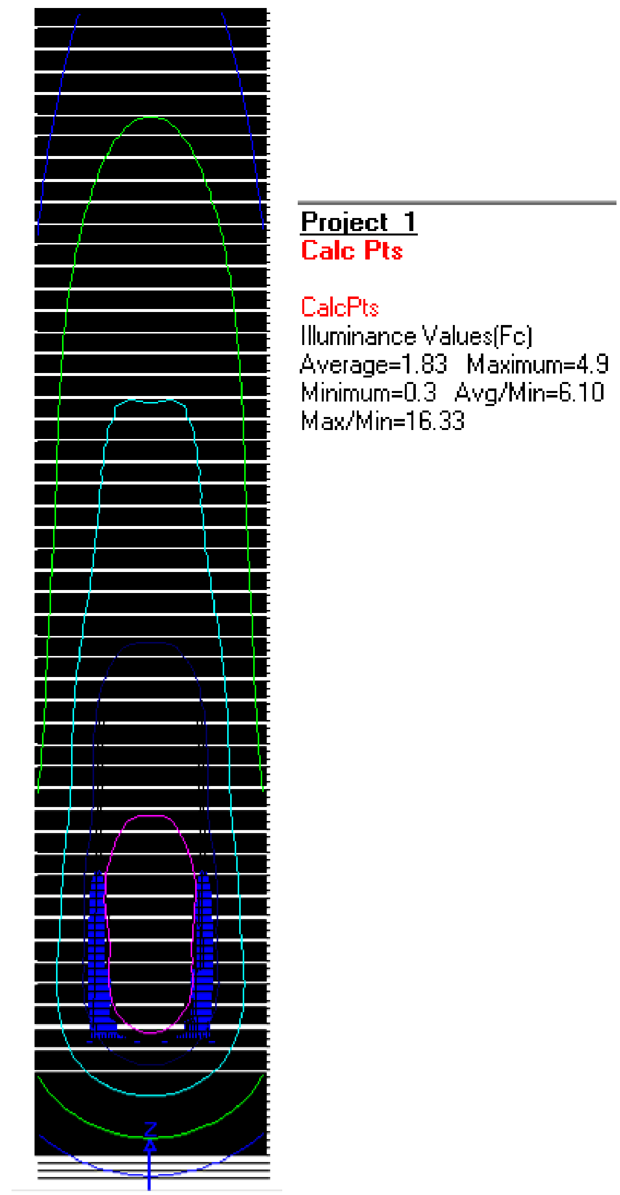
Figure 5: Blades

After comparing the resulting daylight autonomies of the existing and new design using the Daysim computer program, a simple comparison of overall daylight autonomy of the floor plan (see Figures 6 and 7) was done. This comparison involves a difference in daylight performance of the existing rod system versus that of the redesigned bladed system. The information will be used later in designing the office lighting to help find potential energy savings using daylighting controls with switching or dimming.

Overall, the new system provides the occupants with a space that is more transparent to the outside while reducing cooling loads for a savings in the cooling load for the building. The values represented in this report are based on a passive system, which means the blades do not move to adjust for the sun's change in altitude. However, the active blade system would allow the blades to rotate in order to block lower sun angles and lessen direct glare from early and late hour sun penetration. While also decreasing the direct sun, the blades can help reflect daylight deeper into the space, providing a balance of reduced heating load and increased daylighting. The blade system would work with the lighting system and the HVAC system to maximize energy savings as well as provide the occupants with optimal working conditions of increased natural lighting and decreased direct sun penetration.

The change of the façade provided the building with a new look. The lighting redesign for the façade had two key design criteria in mind: to minimize skyglow and light trespass and to help emphasize the architecture and highlight the blade system. To achieve this, a variety of optically controlled LED fixtures were used. The Philip's Color Kinetics iW Reach Powercore was found to provide the options the design required. The fixture angles range from 8 to 63 degrees; fixtures were arranged in a way such that the further reaching luminaries are pointing towards the center of the façade, minimizing the trespass of the light off the façade. This design achieved 5 lux (0.5 footcandles) at the top of the building, similar to the existing design, while at the bottom kept the maximum below 50 lux (5 footcandles).





The unique facade provided the building with a changing look based on the standpoint of a pedestrian at the building base to an observer across the Hudson looking at the New York Skyline. From the ground, the pedestrian is treated to a towering building reaching high into the sky while the blades reflect the light back to the ground allowing for even the highest point of the building to be seen (Figure 7). From across the Hudson River, the observer would view a building that appears to be disappearing into the skyline, with a wavy pattern of the blades providing an interesting effect of the façade (Figure 8). The façade lighting design utilizes the following fixtures.

Façade Lighting

	Number (Halfs)	Label	Manufactuer	Product Name	Angle	wattage	LLF	Lumens	Lamp	Ballast
	4	A1	Philips color Kinetics	IW Reach Powercore	5	125	0.75	4902.1	LED	iW Data Enabler
	6	A2	Philips color Kinetics	IW Reach Powercore	10	125	0.75	4872.6	LED	iW Data Enabler
	6	A3	Philips color Kinetics	IW Reach Powercore	20	125	0.75	4766.2	LED	iW Data Enabler
	6	A4	Philips color Kinetics	IW Reach Powercore	40	125	0.75	4691.6	LED	iW Data Enabler
	16	A5	Philips color Kinetics	IW Reach Powercore	60	125	0.75	4626.1	LED	iW Data Enabler

The advantage of the iW Reach Power Core is that it can utilize two different focused sets of LED boards in one fixture, thus reducing the number of fixtures required and decreasing installation time and material cost. The resulting electrical load is 4,750 watts per side. See Appendix I.E for cut sheets of Luminares and required accessories.

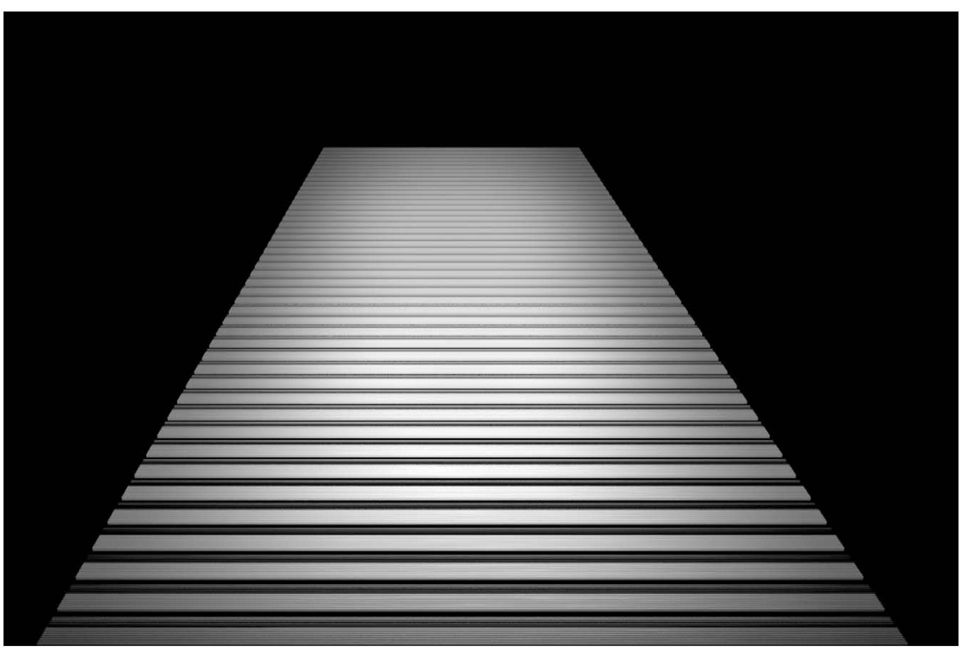


Figure 7: Pedestrian View

Figure 8 – Distant View

REDESIGNED OFFICE LIGHTING

GOALS AND CRITERIA

For the redesign of the open office lighting, design considerations were based on suggestions in the 9th Edition IESNA Lighting Handbook. Assuming the open office will have intermittent to intensive computer use and should allow for flexibility in the floor layout, the suggested horizontal illuminance in the IES handbook is 300 lux for intensive computer use and 500 for intermittent use. Also, as part of any open office, there are walkways used for circulation space within the area. The IES suggested illuminance of 50 lux for circulation will be met if the open office meets its level of 300 lux. However, in this instance, 300 lux will also be applied to the circulation area so that the employees of the New York Times will be able to walk around while reading. Thus, a design that will be able to meet the 500 lux level but be flexible enough to provide 300 lux will require controls that implement switching or dimming. The private offices on the floor plan will use the same fixtures as the open office to keep consistency throughout the space. The suggested levels for private offices in the IES handbook are 500 lux. Task lighting will also be provided at each desk in the open and private offices, allowing for additional light in that area if needed.

Keeping a linear, open feel within the space was an important goal of the architect, and a linear fluorescent fixture that can be run continuously throughout the space would help maintain openness while at the same time providing even illumination across the work plane. It is also suggested in Chapter 11-8 of the IES handbook that contrast ratios should be no greater then 4:1, with 2:1 being more desirable. For this same reason, it is necessary to attempt to light interior walls at higher levels to help create a balance between the interior spaces and the outside sunlight during the daytime, since the floor to ceiling glazing encompasses the entire office. Also, meeting a power density of less than 1.1 watts per square foot to meet ASHRAE 90.1 will be an important design consideration, also resulting in linear fluorescent leading to the most likely candidate for the lighting system. AGI will be used to run the analysis of the office to meet these requirements.

Other goals included using fewer fixtures to decrease installation time, minimizing the number of lamps for easier maintenance, and also reduce the duration of the commissioning process for the Lutron Quantom Lighting control system, which requires that each luminare is individually set up with the system for system-wide control.

MODEL SETUP AND ANALYSIS

Reflectances of 90%, 50%, and 30% for the ceiling, walls, and floor, respectively, will be used. The glazing that was chosen as a result of the mechanical systems analysis will be used; it has a transmittance value of 74%. AutoCAD 2010 was used with a floor plan exported from Revit as an underlay to create the office in a 3D environment. Stairs and partitioned rooms were removed from half of the AGI model and the entire Daysim model to decrease calculation times and to provide base design results that could be applied to any floor prior to adding partitions, desks, and other extras on that floor. To help create a better idea of scale within the office model used in AGI, desks, people, and book shelves were entered in half of the building, while the other half contained calculation grids. Since the floor plan is 100% symmetrical, calculations are only needed on one side while the other can be used for higher quality renderings for visualization of the space. Once the office was imported into the model, a visual inspection of the floor plan and the location of the private offices and long linear walls gave interesting existing linear feel to the floor plan. It was decided that rotation of the luminares 90 degrees to run parallel to the walls would help emphasize the lines of the space, while at the same time provide the possibility to provide adequate lighting onto the walls where contrast balance with the outside will take place.

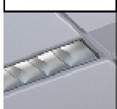
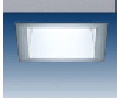
Other Assumptions:

Luminare	BF[1]	LLD[2]	LDD[3]	RSDD[4]	Total LLF
Recessed Bivergence	1.00	1.00	.94	.96	.90
Recessed BASYS	1.00	1.00	.94	.96	.90

[1] From Lutron Ecosystem ballast cut sheet
[2] Mean Lamp Lumens used for calculations
[3] Category IV – Very Clean
[4] RCR = 1.51, Direct, Very Clean, 20% DD

Using the lines of the private offices as a basis for spacing luminaries, a feeling of linearity is maintained in the space while still meeting the design criteria. Separate calculation areas were used for the private office area as well as the area surrounding the office cubicles as to check for numbers to meet both open office criteria as well as circulation area criteria. The linear fluorescent fixture used is a Zumtobel Bivergence louvered fixture. The fixture will utilize a 35 watt T5 lamp and Lutron Ecosystem Electronic, DALI utilizing ballast consuming a total of 41.6 watts each. For use in distinguishing the circulation areas a separate down light, a Zumtobel BASYS 4" down light, with 13 watt triple tube CFL dimmed using a similar Ecosystem DALI ballast, will be used. See Appendix I.F for cut sheets.

Office Lighting

	Number	Label	Manufactuer	Product Name	wattage	LLF	Lumens	Lamp	Ballast	Cat Number
	372	B1	Zumtobel	Bivergence	35	0.9	3650	Sylvania F35_835	Ecosystem DALI Dimming 277v	RBU-DX-65-1355-DD-WN
	44	B2	Zumtobel	BASYS Rec Non-IC Hsg. 4"	13	0.9	900	(1) 13w Triple Tube CFL	Ecosystem DALI CFL Dimming 277v	BRS4N1D-1H13GX24Q1-U-MS-CB-C-DCA

RESULTS

Using AGI32 software, the final layout provides the office with the following numbers and layout:

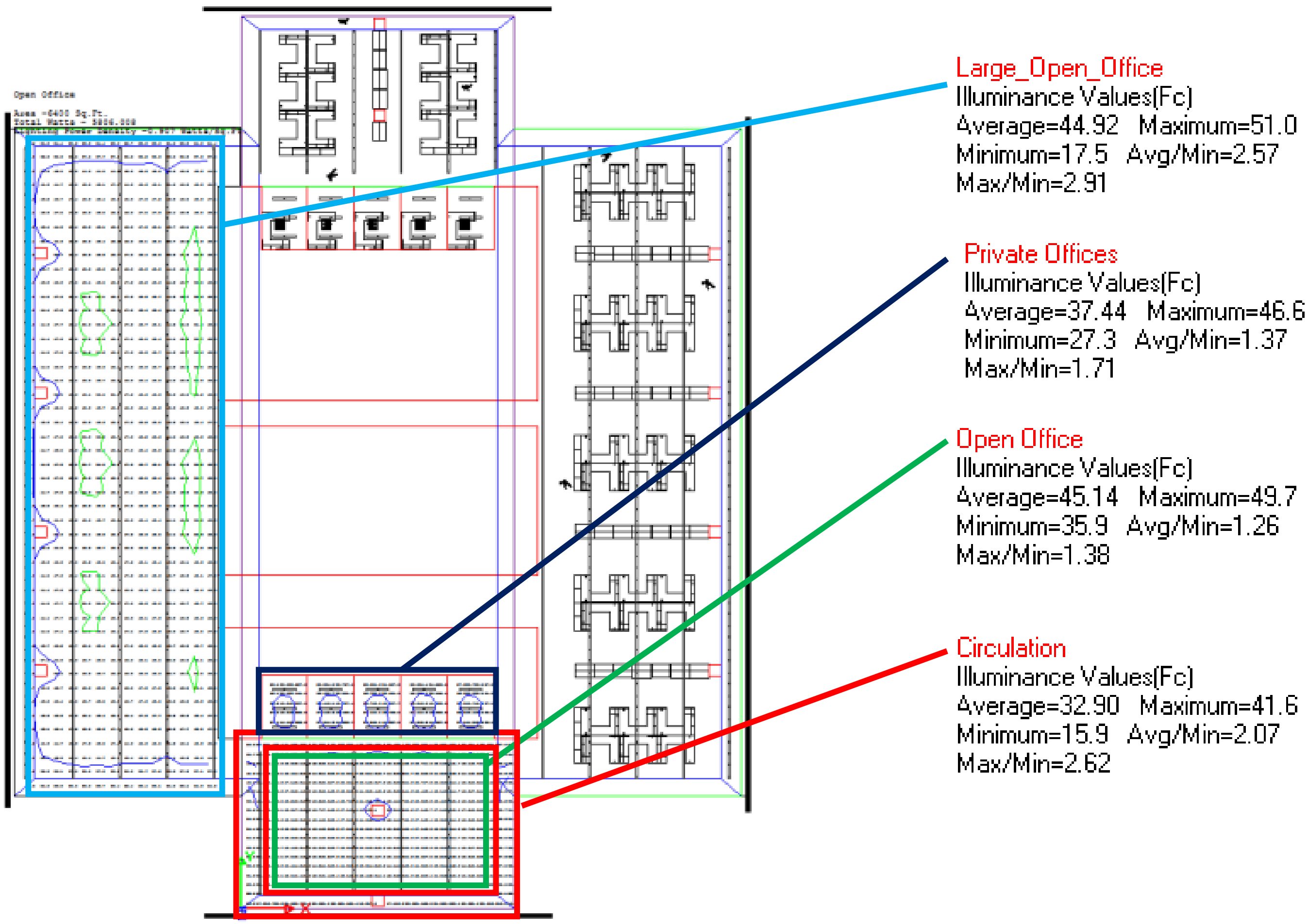


Figure 9 – AGI32 Analysis

These results show that the redesigned lighting performs to the desired suggested criteria. (Note: the conversion from FC to lux is roughly a 10x multiplier.) Though the 500 lux suggested criteria was not fully met, it has been suggested in an interview with the designers of the existing lighting design that upon post-installation interviews with the occupants, it was found that 500 lux is not needed for most day to day activity in the office, thus a 450 lux average will suffice and the added use of task lighting will make up for any individuals who require the additional lighting. The reduction of the number of fixtures by 68% will help lead to a reduction in the installation and commissioning time. The placement of the line of fixtures within the cove is placed in such a way that the mechanical returns along the cove wall are not illuminated thus drawing the eye of an occupant or an observer from the outside towards the return grills rather to the fixture its self or the room below. To see a wiring diagram for the design, please refer to Appendix I.G.

Going back to the previous section and using the values of daylight autonomy, we can now find an estimated energy savings based on switching or dimming. Daylight autonomy is able to represent potential energy saving. Placing the critical point at the lowest daylight autonomy point (in this case it will be located on the eastern side) provides the worst case scenario for potential energy savings from dimming will provide data to which system will save the most energy with respect to lighting controls (See Figures 10 and 11).

To make the decision between switching and dimming, an energy study was performed. First, a comparison was done for the possibility of switching controls and the resulting energy savings was found. For the design, 500 lux will be used at the target illuminance, but others were found to show what would happen as the desired target illuminance was changed.

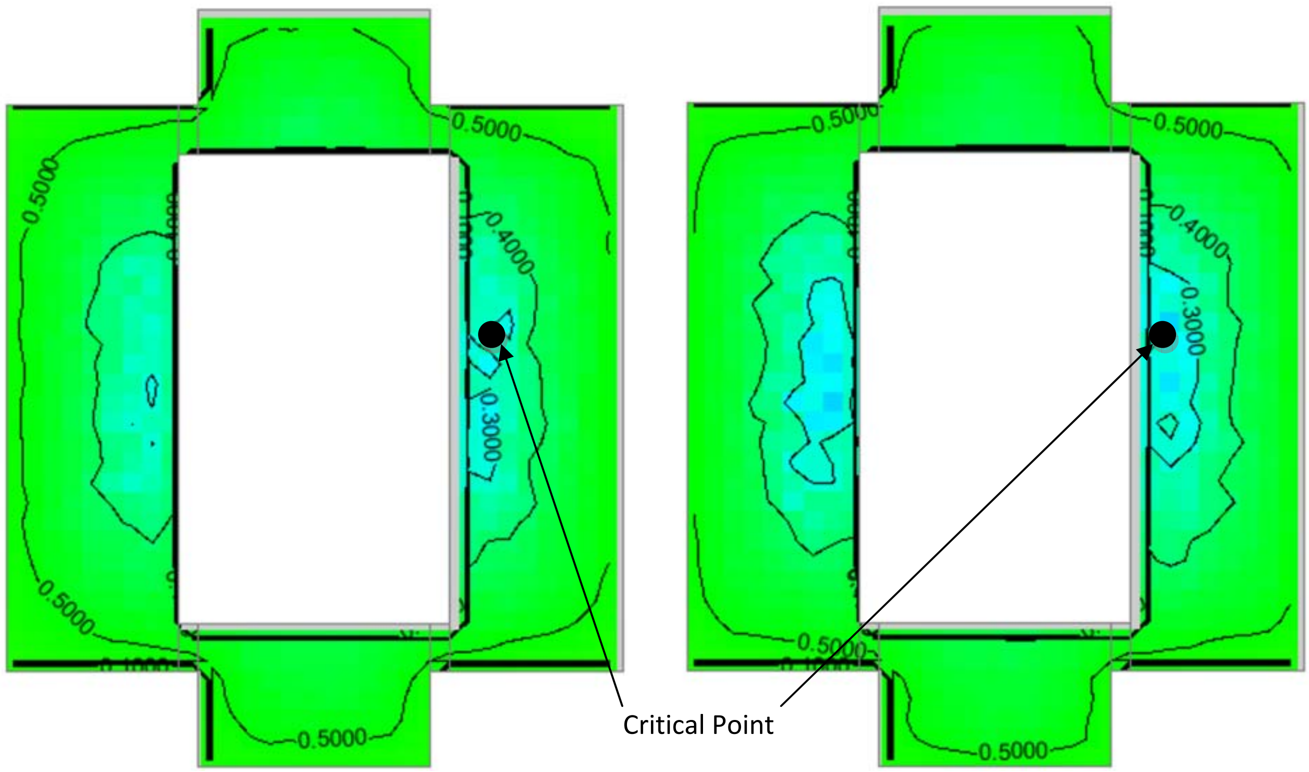


Figure 10 - With Rods

Figure 11 - With Blades

Looking at the results in Chart 1, it can be assumed that if switching was used as an energy savings tactic, with the implementation of the blade system, there is a possibility for a 50% savings in energy use for the typical floor plan versus that of the 45% savings with the rod system at the same illuminance level. Looking at the results of using a dimming control system in Chart 2, the new blade system and lighting design would have an estimated savings of 76.14% on lighting energy versus the previously found savings of 62.53% (See "Existing Daylighting Design" Chart 1). This result reinforces the previous decision to use dimming ballasts in the design.

Looking at the combination of a new façade and changing the lighting system, the design has led to a better daylighting design, which has decreased the lighting load by an additional 13.61%* and the overall mechanical load by 23.25% (see "Baseline Façade Energy Analysis" and "Redesign Façade Energy Analysis" sections) while still providing a comfortable working environment for its occupants (See Figures 12 and 13). For the sake of time and regulations to AGI32, space detail (i.e. less detailed desks, mullions, people) was minimized to allow for smaller mesh sizes to get more accurate and slightly better quality renders of the space.

*The analysis for the daylight autonomies did not use any type of alternative shading device, strictly relying on the façade rod or blade shading abilities. If shading devices were to be implemented, it was realized that there would be a decrease in daylight autonomies for each scenario, therefore only a percentage difference will be used to compare the results. With the shading system implemented with each scenario and the better control of direct glare by the bladed system, there is a potential that an even higher savings percentage could be achieved. Also, the application of an active shading system on the exterior would lead to much more control of daylight and direct glare situations; however, this type of iterative analysis is outside the time allotment and scope of this report.

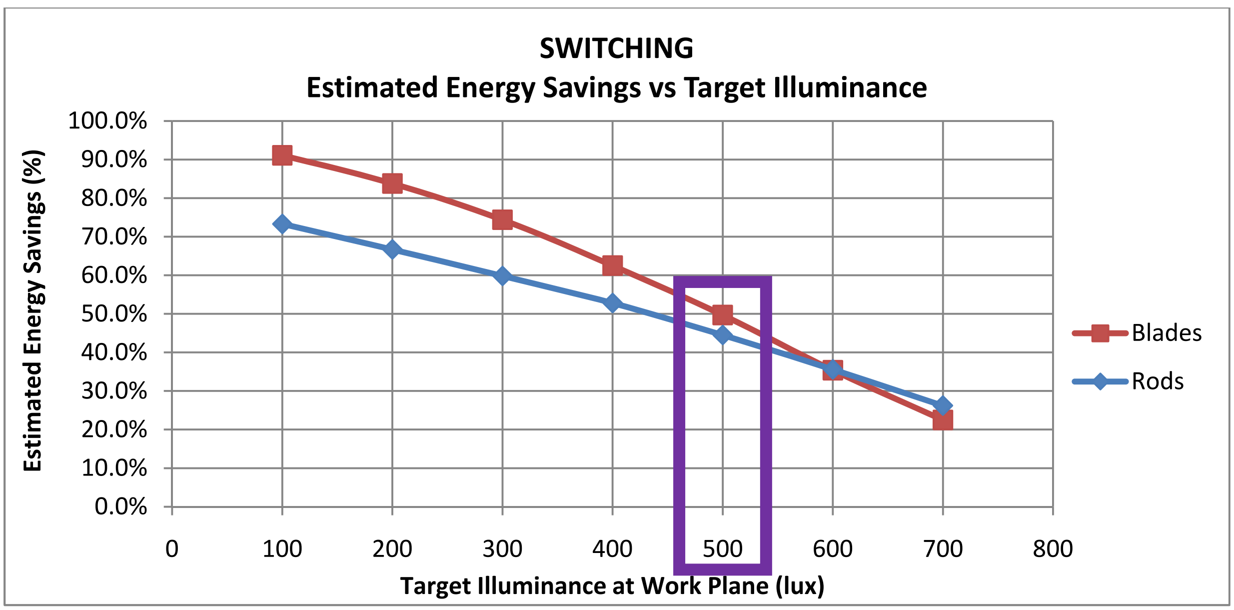


Chart 1 - Switching

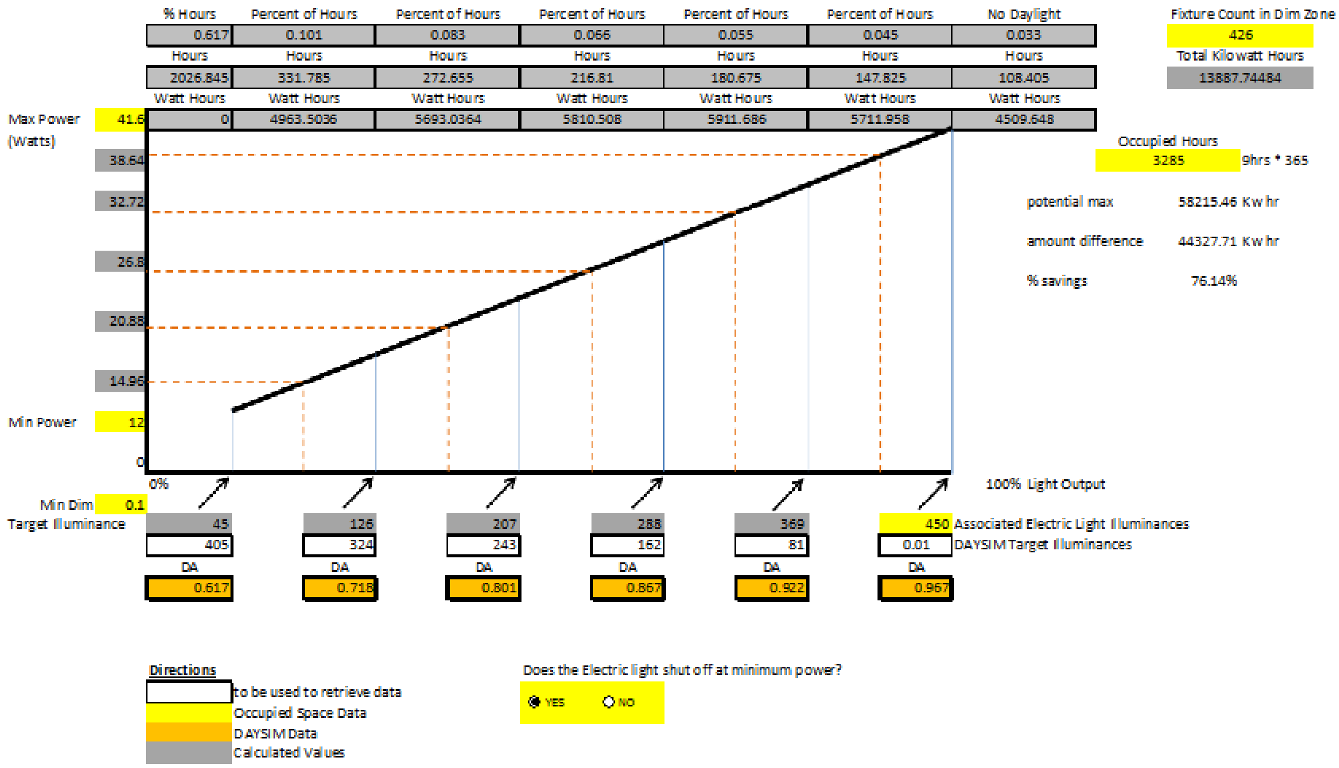


Chart 2 - Dimming

Figure 12

Figure 13

REDESIGNED FAÇADE ENERGY ANALYSIS

GLAZING PROPERTIES

An important goal of the façade redesign was to preserve Renzo Piano's architectural vision of transparency. As per the daylighting study, it was found that the thermal performance of the façade could be enhanced without significantly affecting the architectural vision. Alternative glazing manufacturers were found that were comparable to the original design. The new glazing was very similar to the original glazing in that it consisted of one outer lite, an air gap, and a dual lite laminate layer. The new glazing type has a low-E coating, increased thermal properties, and a reduced visible light transparency. The resulting glazing unit has an overall visible light transmittance of 74%. The overall U-value of the glazing assembly is 0.28 [Btu/ft^2-F].

SPANDREL PROPERTIES

The spandrel portion of the façade was redesigned for enhanced thermal and moisture characteristics. Instead of using a cavity wall system, the redesign uses a barrier wall. The primary component of the barrier wall system is the insulated metal wall panel. The appearance of the wall is the same compared to the baseline wall, but the insulation is bonded to the back of the metal panel. The outermost layer is a 22 gauge aluminum panel backed with 3.5" rigid insulation. Affixed to the backside of the rigid insulation is a vapor barrier. Similar to the baseline wall, there is no "finish" on the inner layer because it is exposed to only the plenum. The redesigned barrier wall improved the overall U-value to 0.067 [Btu/ft^2-F] and the peak condensation rate to < 2 [grains H_2O/ft^2 per day]. The spandrel U-value and condensation rate was calculated using the program "Heat, Air, and Moisture Toolbox (HAM)". See Appendix I.A for the complete wall analysis in HAM. The redesign of the façade to a barrier wall system will improve the constructability of the wall because there are fewer pieces to assemble.

SHADING AND WALL DIMENSIONS

The redesigned shading scheme can be found in detail in the "Redesigned Daylighting System" section. The effect of the new bladed shading system is an increased effective shading area compared to the baseline ceramic rods. The exact amount of shading depends on the time of day and season, but the intent was to reduce the overall solar load. The blades were positioned so that on the south façade, the effective un-shaded glazing area is 8" for the summer solstice and 2'-8" for the winter solstice. The floor to ceiling height was increased to 9'-11" and the total glazing height was increased to 10'-10". The total height of the raised floor, structure, and lighting cove clearance is 2'-9". For a complete wall section, see Appendix I.B.

ENERGY ANALYSIS

The redesigned façade for the New York Times Building was evaluated for a number of criteria. The energy analysis was performed using two separate energy modeling programs; Trane TRACE and Integrated Environmental Solutions (IES) Virtual Environment (VE). Generally, TRACE uses the Total Equivalent Temperature Difference Time Averaged (TETD-TA1) method for cooling calculations and Fourier's Law of conduction (UATD) for heating calculations. IES uses the ASHRAE Heat Balance method for both cooling and heating calculations. The table below summarizes the results of the modeling. Detailed energy modeling reports can be found in Appendix C. The modeling assumptions are fundamentally the same as the existing facade.

	Trane TRACE Results	IES VE Results
Peak Cooling Load [Btu/h]	544,623	479,900
Peak Heating Load [Btu/h]	364,238	454,100
Cooling Energy Density [Btu/hr-ft^2]	25.7	20.0
Heating Energy Density [Btu/hr-ft^2]	30.6	19.0
Total Source Energy [kBtu/yr]	2,878,147	Not Calculated

COMPARISON OF EXISTING AND REDESIGN

The results generated by the two energy modeling programs showed that a correlation could be made between the changes to the façade and significant annual energy savings. A surprising outcome was the large amount of energy reduction from the envelope loads alone. Another interesting finding that is not directly apparent from the output reports was the large amount of heat required to humidify the building. The original energy model created by the mechanical team did not include humidification. This particular model included humidification because it was originally required by the owner. The heating load on the coil due to humidification was approximately half of the total coil load.

Select reports from the TRACE and IES output files are included in Appendix I.C. There are a few points to note when comparing the reports generated by both TRACE and IES. First, the TRACE reports were better organized and more comprehensive than the IES reports. Also, one report's values were not consistently higher or lower than the other's report. This indicates that there is no correlation to determine if one calculation method is under or over-sizing the system.

ENERGY MODELING INTEROPERABILITY ANALYSIS

OVERVIEW

In the construction industry, there has always been the need to streamline the process of building a building. In recent history, tools have been created which assist design professionals with complex and time consuming calculations or designs. However, each discipline has their own set of independent programs which rarely operate in conjunction with other programs. Recent advances in software and the persistent need to streamline the construction process have lead to the development of Building Information Modeling (BIM). Furthermore, the industry is slowly recognizing the benefits of and adopting an integrated design process to more efficiently deliver a high quality building to the client. These two factors convey the need of all building design programs to have a certain degree of interoperability. This evaluation will focus on the experience and interoperability of energy modeling programs and Revit.

At the heart of this exchange of information between these two types of programs is the GBXML file. These files allow basic information such as building geometry, site location, room names and sizes, etc. to be exported from a building information model (in this case Revit) into a universal file type. This information is often very tedious and time consuming to manually enter into the energy modeling program. If this transaction is successful, the energy modeling program will be automatically updated with crucial and building-specific information. This GBXML import has the potential to cut the work of the operator in half (depending on the size of the project).

TRANE TRACE

TRACE and other similar manufacturer based energy modeling programs have been the choice energy simulation tool for thousands of HVAC specialists for many years. It is a powerful tool for selecting and sizing mechanical equipment for buildings of any type. For any one building, there are seemingly endless combinations of equipment and calculation methods to work with. In an attempt to reduce the amount of manual inputs the operator must perform, TRACE has adopted the use of GBXML files.

Despite the group's best efforts to make the GBXML file work with TRACE, the import was not possible. Even after simplifying the geometry in Revit and removing the passive shading devices, TRACE would not run the simulation with the imported GBXML file. During the creation of the GBXML file in Revit, there were no detectable errors. The TRACE model failed because when the analysis was run, the program encountered an error and had to be shut down. This of course did not allow the user to pin-point an error to correct it. In the interest of time, the decision was made to manually input everything into TRACE.

INTEGRATED ENVIRONMENTAL SOLUTIONS (IES) VIRTUAL ENVIRONMENT

IES is a software package which assists designers with building performance modeling. Unlike TRACE, the program does not just perform energy modeling, it can perform many other functions such as sustainability compliance, lighting analysis and airflow CFD analysis to name a few. For the purpose of this report, the energy modeling aspect is the only part of the program which was evaluated.

To begin, the user has a tremendous advantage over programs such as TRACE because the IES interface includes a 3-D model viewer to verify geometries and other important dependencies. Within Revit, IES provides a plug-in version of Virtual Environment so that the GBXML file can be error-checked and room properties can be added which are used for later energy analysis. Once the GBXML file was created, it worked almost flawlessly with IES and an energy simulation could be performed. The only piece of the Revit model which would not import properly was the passive shading devices. The IES interface also has a library of built-in materials and mechanical systems which rival the selection found in TRACE.

CONCLUSIONS AND RECOMMENDATIONS

The account described above reflects the opinion of one design team's experience with software used for a particular project. It is very possible that another team can have a very different experience using the same method under different circumstances.

Furthermore, it is believed that TRACE has inherent problems with large GBXML files. If Trane made their product more conducive to BIM and the integrated design process, it would be more accessible to a wider range of designers in industry.

It was found that IES is a great product for integration with BIM. The energy modeling component may be less technical than programs dedicated to energy modeling, but it will save the designer a lot of time from a process which has a lot of operator error. Furthermore, a design team which truly seeks an integrated design process should consider using IES as a design standard. Once the GBXML file is created from Revit or a similar program, it can be used within IES for dozens of analyses all the way from conceptual design to construction documents.

REDESIGNED INTERIOR CURTAIN WALL

OPTICAL AND THERMAL ANALYSIS OF SELECTED GLAZING

The glazing selection process found that "Oldcastle Glass" was the preferred manufacturer for the type of glazing required. An insulated glazing unit was selected which was similar to that of the original design. The outboard lite is a ¼" ply of low-E glass followed by a ½" air gap. The inner layer is a 9/16" laminate with two ¼" lites mounted to a substrate. The visible light transmission has reduced from the original 96% to 74%. This reduction in transparency is unlikely to adversely affect Renzo Piano's architectural vision. The selected glazing is on the high-end of typical transparencies for this building type and it still uses clear glass. The overall U-value for the glazing is 0.28 [Btu/ft^2-F]. The shading coefficient for the redesigned glazing has improved dramatically. The baseline shading coefficient was 0.73 compared to 0.46 for the redesigned glazing.

STRUCTURAL ANALYSIS OF SELECTED GLAZING

After considering the thermal and optical implications of the glazing selection, the glazing was then analyzed structurally for wind and seismic induced pressures. Information regarding the blast resistance of the current structural system was retained for security reasons by the New York Times Company and not available for comparison with the blast resistance of the glazing. However, the glazing should be sized to mitigate blast loadings of similar intensity to those that the structural system is designed to resist. For the purpose of this analysis, blast design was neglected but would typically be included in a thorough design and analysis of the glazing.

In the instance of lateral pressures and seismic induced pressures, the glazing was designed to resist breakage and fallout as dictated by ASTM1300-04, *Design of Window Glass for Lateral Pressures (Minor & Norville),* and *Design of Architectural Glazing to Resist Earthquakes (Behr).* If the blast resistance of the structural system was disclosed, *Blast-Resistant Glazing Design (Norville & Conrath)* would have been used to select an appropriate glazing system based on ordnance size and standoff distance.

In order to minimize changes to construction methods, schedule, and cost, overall dimensions of glazing panels were kept consistent with that of the existing system (3048mm x 1524mm). The redesigned glazing unit is an insulating glass unit with one 6mm thick fully-tempered monolithic outboard lite, a 12mm air space, and one 6mm thick two-ply laminated heat strengthened glass inboard lite (two 3mm thick plys and one UVB interlayer). This configuration allowed the glazing to significantly exceed the components and cladding load obtained from ASCE 7 when following the glazing design process specified in ASTM 1300-04 (shown in Figure 14 below).

Floor(s)

Lateral Pressures

Manufacturer Provided							ASTM E 1300-04 Provided					
Lite	Glazing Type	Glazing Height (mm)	Glazing Width (mm)	Area (mm^2)	AR	Thickness (mm)	GTF	LS Short	LS Long	NFL (kPa)	LR Short (kPa)	LR Long (kPa)
1 MO	FT	3048	1524	4645152	2	6.00	4	2	1.2	1.05	8.4	5.04
2 LG	HS	3048	1524	4645152	2	6.00	2	2	5.96	1.05	4.2	12.516

		ASCE 7	Manufacturer				Load Sharing			
Wind Load	Controlling LR (kPa)	Comp./ Cladding Load (kPa)	Lite 1 DL (kPa)	Lite 2 DL (kPa)	Least Dim. (mm)	LS Check	Lite 1 Short	Lite 1 Long	Lite 2 Short	Lite 2 Long
	4.2	2.459	0.14	0.22	1524	LS Necessary	8.22	4.7403352	4.02	12.4556648

Check:		Short	Long
	Lite 1	Pass	Pass
	Lite 2	Pass	Pass

For Lateral Pressures

Figure 14- Lateral pressure calculations on glazing units

When calculating seismic pressures, an interstory drift of 2.0% was used along with 13mm edge clearances as shown in Fig. 5 below. The glass manufacturer (PPG) was not able to immediately provide the results of the AAMA 501.6-01 test to obtain $\Delta_{fallout}$. In the meantime, value of $\Delta_{fallout}$ = 77mm was used as a minimum condition for allowing the glazing unit to pass. If the actual tested number is below this, the glazing unit will fail based on its geometric configuration and allowable story drift.

Seismic Induced Pressures

Story Height (mm)	Story Drift (%)	V. Edge Clearance (mm)	H. Edge Clearance (mm)	Importance	Dp	$\Delta_{fallout}$	1.25*I*Dp	D_{clear}	1.25*Dp
3048	2.00%	13	13	1	60.96	77	76.2	78	76.2

	$\Delta_{fallout} \geq 1.25*I*Dp$	Pass
or	$\Delta_{fallout} \geq .5"$	Pass
	$D_{clear} \geq 1.25*Dp$	Pass

For Seismic-Induced Pressures

Figure 15- Seismic pressure calculations on glazing units.

SELECTION OF SPANDREL PANELS

The original design of the spandrel consisted of a curtain wall system. The group decided that a barrier wall system would be appropriate to accomplish the goals of the redesign. The original spandrel protected the building from thermal and moisture considerations, but to improve the life-cycle costs of the building, the façade needed to be enhanced. The amount of rigid insulation was increased to improve the thermal performance of the spandrel. To improve the constructability of the spandrel panel, the rigid insulation was formed onto the metal panel to create a single component. The combination of an increased layer of insulation and tighter fitting joints also minimizes the moisture penetration.

MULLION SIZING

Mullions were sized based on the maximum components and cladding wind pressure calculated per Method 2, Section 6.5.12.4.2 of ASCE 7-05. Calculations performed were taken from Chapter 3 of *An Introduction to the Design of Curtain Walls, Aluminum Windows, Glass Walls, Skylights and Canopies* by Dr. Wilson Zhou. The existing exterior mullion dimensions of 5-¼"x2-½" obtained from Revit were used as a basis for the mullion resizing; through calculation, it was determined that the new mullion thickness within unitized panels should be a maximum of 7/8" at the top of the building and ½" at the base of the building, with deflection the controlling factor. At the split mullion between unitized panels, the thickness will likely have to increase to a maximum of 1" to accommodate the moment based on each half's moment of inertia. A typical hand calculation of mullion size can be found in Appendix I.F along with the components and cladding wind pressures.

REDESIGNED FAÇADE CONNECTION

The redesigned double skin façade system was determined to have a total weight slightly lower than that of the existing system, at approximately 18 pounds per square foot. As a result, it was assumed that the supports of the existing system could be used for the redesigned system as well. The built-up beam is most likely oversized for this new load, but its exterior dimensions will not be changed in order to conform to the existing architectural aesthetic.

The vertical supporting elements on either side of the panels of the new shading system must change according to typical connection details in the shading manufacturer's brochure; the geometry of the blades requires a slight increase in the depth of the vertical elements to accommodate the blades and provide a uniform horizontal line between unitized panels. To ensure that large breaks would not be visible between these panels, the thermal expansion of the aluminum blades was calculated based on a 120 degree Fahrenheit temperature differential. For each panel, the blades were found to expand horizontally a maximum of ¼"; with construction tolerances being around 3/8", the ideal aesthetic can be achieved.

ASSEMBLY OF REDESIGNED DOUBLE-SKIN FACADE

OVERVIEW

The redesigned double-skin façade system was kept as similar as possible to the existing system with respect to the number of parts per panel to reduce potential delays in construction completion. There are no additional components required in each of the redesigned curtain wall panels, but the blade shading devices were substituted for the ceramic rods.

While the existing system was unitized into 5’ x 13’- 4” panels, the possibility of increasing the width of the panels to 10’ x 13’- 4” was initially investigated in order to achieve schedule savings. It was initially theorized that the increase in size would require an additional crew to set each panel, but the fact that each crew would be working for half of the time that they were originally scheduled for would create a break-even financial situation while reducing construction time by half.

After interviewing the design/build curtain wall contractor about the proposed redesign, it was determined that the increase in size would not require any additional crewmen to set each panel- this could potentially reduce labor costs by 50% in addition to the 50% reduction in schedule. However, the increased width of the panels would have made it impossible to hoist into position given the equipment and space limitations used in the New York Times Project. Given this information, the initial panel width of 5' was kept.

OFF-SITE ASSEMBLY PROCESS

The off-site assembly process is nearly identical to that of the existing system. The same amount of crews will be required to fabricate each unitized panel; the costs for each of these crew types and their overall work output were determined by using RS Means Costworks, a web-based version of the RS Means estimating series.

RS Means does not contain information on assembling a rod-based shading system or double-skin façade- for the purposes of this analysis it is assumed that it was similar to the redesigned blade-based system. The durations for off-site fabrication are shown below.

Material	**Area per Floor** (SF)	**Installation Rate** (Area/ day)	**No. of Crews**	**Time Per Floor** (Days)	**Total Building Fabrication** (Days)
Glazing + Mullions	10,540	180	9	6.5	338
Spandrel panels	4,215	120	6	5.85	304
Blades + Support	565	35	3	5.38	279

The total amount of time to complete a given floor is controlled by the crews fabricating the glazing and mullion system for the inner façade. In actuality, the spandrel panels and glazing are going to be installed simultaneously; however, RS means separates glazing and mullion systems from spandrel panels for the purpose of cost estimation. It is also very likely that the blades and accompanying support system would be fabricated separately and then joined to the completed glazing panel/

spandrel panel/ mullion system. For these two reasons, it can be assumed that the panels for each floor can be created in 6.5 working days each for a total of 338 working days for the entire building façade.

ON-SITE ASSEMBLY PROCESS

The original on-site assembly process is identical to that of the redesigned double-skin façade, outlined below:

Hourly Work Output	**Daily Work Output** (panels/day)	**Days per floor completion**	**Total curtain wall erection time** (Days)
1.9 Panels/ Hour	15.2	5	260

It is assumed that the assembly process for the redesigned system will not require additional or different equipment for proper installation of a unitized blade-based system in comparison to rod-based system.

COST OF REDESIGNED DOUBLE-SKIN FACADE

METHODOLOGY

The cost of the redesigned façade system was obtained by using a combination of RS Means Costworks cost data in conjunction with quantities obtained from a Revit material takeoff for a typical floor. Once the cost for a typical floor was obtained, it was multiplied by 56 to account (approximately) for the 52 typical tower floors, two double height mechanical spaces, and podium level.

The estimate of the original double-skin façade system was not broken down into material, off-site fabrication labor, shipping, and site installation costs because the initial cost data was obtained as a rough square foot and assembly. The following estimate takes material and off-site fabrication labor. Shipping information will not be able to be obtained for this report, and the site installation costs will be reflected in changes to the general conditions estimate.

MATERIAL COSTS

Using a RS Means Assembly estimate, it was possible to obtain a much higher degree of accuracy than the original estimate since costs could be broken up by system and the opportunity to account for special coatings and glazing configurations. All costs were adjusted for the year 2007 in order to account for economic changes- if the same material was bought in the year 2010, the costs would have been much higher.

Material Cost (including 10% O+P)

Material	Area	Unit	$/Unit	Cost
Glass	10540	SF	26.46	$278,869
Low E Coating	10540	SF	18	$189,707
Lamination	10540	SF	7.5	$79,044
Mullions	11805	SF	13.93	$164,443
Spandrel Panels	4220	SF	21.52	$90,722
Blades + Support	565	EA	13.5	$7,627
Material Total			**Floor**	$810,414
			Building	$45,383,218

OFF-SITE FABRICATION LABOR COSTS

Using a RS Means Assembly estimate, it was possible to obtain a much higher degree of accuracy than the original estimate since costs could be broken up by system and the opportunity to account for special coatings and glazing configurations. All costs were adjusted for the year 2007 in order to account for economic changes- if the same material was bought in the year 2010, the costs would have been much higher. RS Means Costworks offers labor and work rates for combined glazing and mullion systems and combined blade and support systems, and spandrel panels are considered separately.

Off-site Assembly Labor

Material	Area	Unit	$/Unit	Units Fabr./Day - Crew	Crews	Cost
Glazing + Mullions	10540	SF	11.53	180	9	$1,093,661
Spandrel Panels	4220	SF	8.16	120	6	$206,401
Blades + Support	565	EA	25.5	35	3	$43,222
			Floor	**Total**		$1,343,285
			Building	**Total**		$69,850,848

TOTAL MATERIAL AND FABRICATION COSTS

The following contains a summary of floor by floor and overall building material and labor costs for the redesigned double-skin façade of The New York Times Building

	Material ($)	**Labor** ($)	**Total Cost** ($)
Typical Tower Floor	810,414	1,343,285	2,153,700
Entire Building	45,383,218	75,223,990	120,607,208

PHASE SUMMARY

According to the mechanical designer Flack and Kurtz, the primary purpose of the existing combined heat and power (CHP) plant was to reduce the purchased electricity and carbon footprint for the New York Times Building. The CHP plant also acted as a stand-by power source for the data center. For this redesign, the purpose of the CHP plant has shifted from the original intent. The new purpose of the CHP plant is to eliminate the need for purchased steam while still providing electrical back up to critical areas of the building, with excess electricity going to other building loads.

A preliminary energy study was performed to find the feasibility of different chiller and CHP plant configurations within the newly redesigned façade system. Once an optimal system was chosen, equipment was selected to further refine the predicted operating characteristics. This more developed model was used to compare the performance of the redesigned façade and CHP plant with the existing New York Times Building. In addition, the redesigned CHP plant was also compared to a separate heat and power configuration within the context of the redesigned façade.

The redesigned CHP plant has roughly twice the generating capacity of the existing plant. This translates into a higher initial cost for the owner. This higher initial cost will be justified by developing a payback period through a life-cycle cost analysis. This study indicates that the savings incurred by the reduced thermal loads from the façade redesign and elimination of purchased steam will provide a reasonable payback period.

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GOALS OF CHP REDESIGN

Combined heat and power plants can be designed to meet a variety of criteria; these were established before beginning redesign. After a utility investigation, it was determined that purchased steam was an expensive commodity in New York City. First and foremost, the intent of the redesigned CHP plant was to eliminate the need for the New York Times Building to purchase steam from the utility under normal operating conditions and investigate options for electrical generation.

The redesigned CHP plant is roughly twice the size of the existing plant. This extra electrical generating capacity is desirable for a number of building operating strategies. When the prime movers (PM) are running, they are inherently generating electricity. This is an immediate reduction in electricity purchased from the utility. During hours when the PMs are operating at part load conditions to meet thermal requirements, the building operators have the option to run the PMs at full load to generate additional electricity. In addition to meeting thermal and power requirements in the most efficient manner possible, this strategy would be economically beneficial during periods of peak utility electrical demand. Furthermore, the New York Times Building can participate in electrical demand limiting programs in which utilities grant better rates to consumers who reduce their usage in times of peak demand.

The elimination of purchased steam and the reduction of purchased electricity both contribute to a very important characteristic of the redesigned CHP plant. The advantage that every CHP system has compared to a separate heating and power strategy is a reduction of primary energy usage. The redesigned plant will have a higher primary fuel utilization efficiency than that of the utility. This translates to fewer fossil fuels consumed and fewer emissions produced.

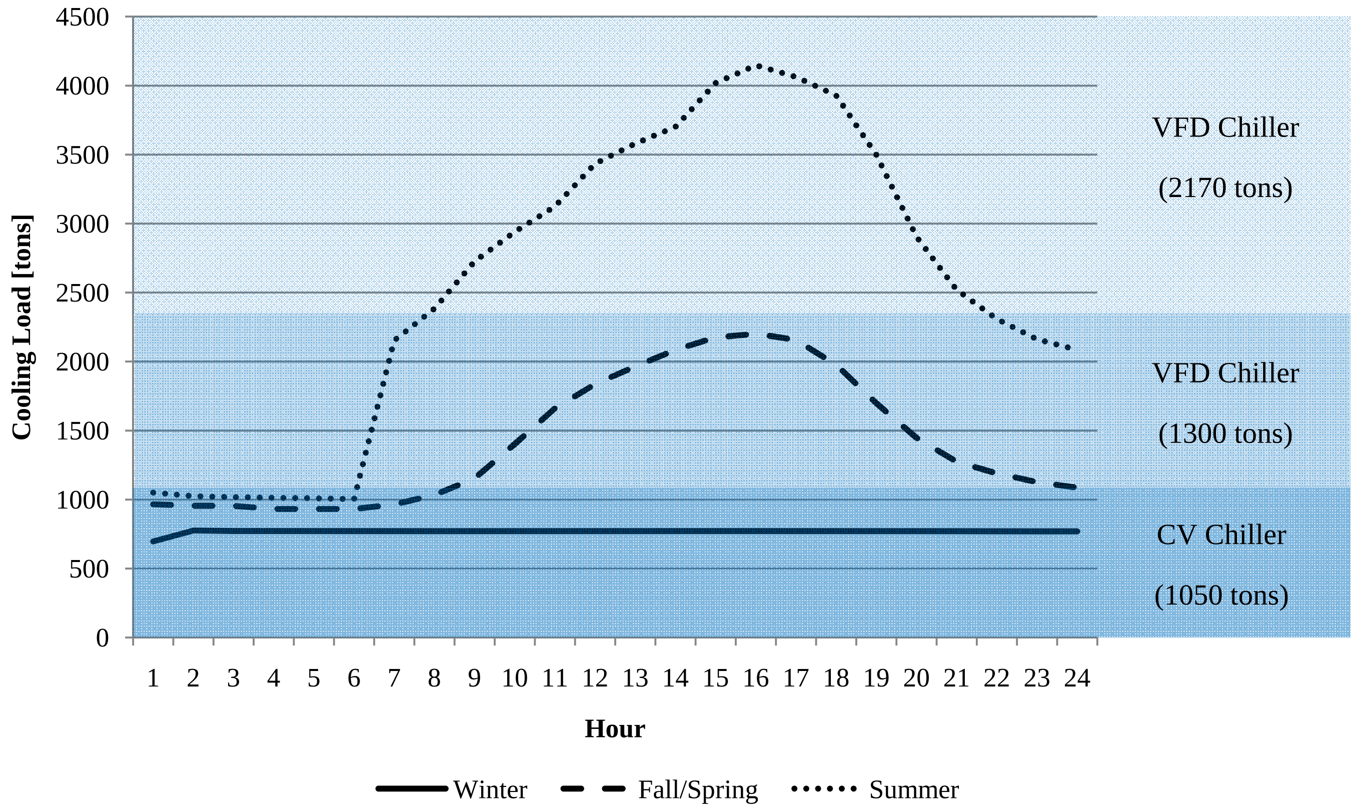
PRIME MOVER AND CHILLER PLANT STUDY

METHODOLOGY

In conjunction with the outputs of a whole building energy simulation (excluding the podium), a preliminary study was performed to explore potential PM and chiller plant configurations. The TRACE energy model from Phase I was adapted to more accurately display the energy requirements of the entire building. First, the typical floor was multiplied by 48 to represent the entire office tower. Additional spaces were included such as building mechanical rooms and the data center. The values used for the heating and cooling profiles where generated from typical meteorological data. For each month, TRACE finds the heating and cooling loads for every hour out of the typical meteorological day. This produces a wide variety of operating conditions so that the performance of each system can be fairly judged.

Once the heating and cooling loads were assembled, the demand profiles could be analyzed to determine appropriate chiller configurations. To efficiently handle the cooling load year-round, the chiller plant was split into three parts. Figure 1 shows the cooling load profile for the New York Times Building. The data center and core office areas require a fairly consistent cooling load throughout the year. For this reason, the chiller plant uses a constant volume (CV) chiller to handle the year-round base cooling load. During the fall and spring seasons, the load begins to form a peak in the afternoon. To accommodate this peaking, the CV chiller is used in conjunction with another chiller which is sized to meet the cooling demand for most of the months out of the year. This mid-range chiller has a variable frequency drive (VFD) so it can load-follow without running excessively. In the summer months, the cooling load peaks fairly high in the afternoon. The final chiller has a VFD and is sized for the cooling design day. Once the chiller plant was conceptually planned, types of chillers could then be selected for each operating range. Table 1 gives a summary of all tested alternatives.

Figure 1: Building Cooling Load [tons]



The selection of the PMs was similar to that of the chiller plant. The one important difference was that the heating profile for the building was dependent on the type of chiller selected. For example, the selection of an absorption chiller would increase the heat demand when cooling was required. For this reason, the selection of the PMs was not as straightforward as the selection of the chiller plants. Figure 2 shows the heating demand for an alternative with one CV absorption chiller and two VFD steam-driven compressor chillers.

In most cases, each alternative's heating profile includes features which are well matched to the operating characteristics of a certain type of PM. For example, the area on the figure marked "Region 1" has a fairly consistent base heating load throughout the entire year. A gas turbine (GT) would be well suited in this area because this type of equipment should not be operated at part-load conditions. "Region 2" has a highly variable profile throughout the year, but the heating demand would be in this region for the majority of the time. An internal combustion (IC) engine would be appropriate for this region because of its good performance at part-load conditions. "Region 3" represents the area of the highest heating demand, but it is also the least likely region in which the heating demand will fall. This area would be best suited for an auxiliary boiler, steam generator, or another IC engine which can efficiently load-follow. It is a good strategy to assign a variable speed PM to follow the highest loads because these high loads do not occur often enough to justify using a larger, more efficient constant volume PM such as a GT. Not every load profile looked like Figure 2, but a similar PM selection process was performed for each chiller plant alternative. Table 1 gives a summary of all tested alternatives.

Figure 2: Total Heating Demand [Btu/h]

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Chiller Plant	**Low range CV**	Electric	Absorption (1-stage)	Absorption (2-stage)	Absorption (2-stage)	Absorption (2-stage)
	Mid range VFD	Electric	Absorption (1-stage)	Absorption (2-stage)	Steam Comp. (2-stage)	Electric
	High range VFD	Electric	Electric	Electric	Steam Comp. (2-stage)	Electric
Prime Movers	**Low range**	IC Engine (VFD)	Gas Turbine (CV)	Gas Turbine (CV)	Gas Turbine (CV)	IC Engine (VFD)
	Mid range	Gas Turbine (CV)	Steam Generator (VFD)	IC Engine (VFD)	Gas Turbine (CV)	Gas Turbine (CV)
	High range	IC Engine (VFD)		Steam Gen. (VFD)	Steam Gen. (VFD)	IC Engine (VFD)

Table 1: Chiller and CHP Plant Alternatives

PLANT STUDY MODELING ASSUMPTIONS

The assumptions for the whole building energy model are the same for that of the typical floor unless otherwise noted. The modeling assumptions for the typical floor can be found in the Phase I report.

- The base energy model which was adapted for the whole building was developed from the redesigned façade model.
- Total building area (without podium): 1,091,648 [SF]
- Electrical loads:
  - Lighting: 1.1 [W/SF]
  - Plug loads: 0.5 [W/SF]
  - Mechanical and misc. loads (except chiller): 1.0 [W/SF]
  - Electrical profile was weighted throughout a 24 hour day, with its peak usage from 8 AM to 6 PM.
- Data center
  - Electrical loads: 150 [W/SF] x 8000 [SF] = 1,200,000 [W].
  - Cooling loads: Approx. 400 tons.
  - Mechanical system: VAV computer room unit.
  - Data center is operating at full load continuously.
- Chiller plant
  - Established full-load and part-load COP for each piece of equipment from TRACE equipment libraries.
  - Modeled part-load total chiller plant COP by weighting the COPs of all active chillers for that hour.
- Prime movers
  - Established full-load and part-load heat rates and electrical efficiency for each piece of equipment from Department of Energy PM guidelines.
  - Modeled part-load prime mover heat rate and electrical efficiency by weighting the values of all active PM's for that hour.
- Energy calculations
  - Natural gas has a 100% fuel utilization on-site (not thermal efficiency in equipment).
  - Electric purchased from the grid has a total efficiency of 35%.
  - Pollution rates for prime movers and purchased electricity are taken from EIA guidelines.

PLANT STUDY RESULTS

The overall efficiency of each plant alternative is best represented by the primary fuel utilization efficiency (PFUE). This number represents the ratio between the useful energy output and the total primary energy usage. A higher PFUE indicates a more efficient usage of primary energy. A summary of the results from the preliminary plant alternative study are shown in Table 2. A more detailed annual primary energy use profile is shown for each plant alternative in Appendix II.C. This study indicates that Alternative 3 has the highest overall efficiency while Alternative 1 is the least efficient. Furthermore, Alternative 4 has the lowest operating cost, while Alternative 1 has the highest.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Annual Primary Energy Used [MMBtu/yr]	444,224	546,834	446,416	516,813	424,050
Primary Fuel Utilization Efficiency	0.362	0.455	0.458	0.395	0.442
Emissions [lbs CO2e/yr]	74,126,978	72,880,358	62,906,626	68,864,354	62,767,763
Annual Operating Costs [$/yr]	10,133,170	8,155,927	7,459,702	7,704,658	7,794,157

Table 2: Chiller and CHP Plant Simulation Results

REDESIGNED CHP PLANT STUDY

EQUIPMENT SELECTION METHODOLOGY

The preliminary chiller and CHP plant study was performed to select the desired operating characteristics of the redesigned mechanical and electrical systems. Ultimately, Alternative 5 was chosen as the final chiller and CHP plant configuration for its overall efficiency and low operating cost. Eliminating the need for purchased steam was the primary goal, but this could have been easily achieved by steam generators alone. Prime movers with electric generation were selected for the final system because they involved a more integrated solution. These prime movers allow the New York Times Building to implement load shedding strategies for lower purchased electricity rates. The final reason for choosing Alternative 5 was the selection of more common equipment. The steam driven compressor chillers in Alternative 4 were only found to be made by one manufacturer (York). Common equipment was selected in order to make building operation as easy as possible for the owner. Tables 3 through 5 show general information about the major equipment selected for the redesigned chiller and CHP plant. Select manufacturer catalogs are included in Appendix II.B.

Table 3: Absorption Chiller Schedule

Model	Quantity	Size [Tons]	Full-load COP	Chilled Water		Condenser Water		Generator Steam	
				°F (In/Out)	Flow [gpm]	°F (In/Out)	Flow [gpm]	[psig]	Flow [lbs/h]
Trane ABTF-1050	1	1,058	1.21	54/44	2,106	85/93	3,780	120	10,294

Table 4: Electric Chiller Schedule

Model	Quantity	Size [Tons]	Full-load COP	Chilled Water		Condenser Water	
				°F (In/Out)	Flow [gpm]	°F (In/Out)	Flow [gpm]
Trane CVHF-1300	1	1,300	~6.1	54/44	2,026	85/100	2,600
Trane CDHF-2170	2 (Stand-by)	2,170	~6.1	54/44	3,382	85/100	4,340

Table 5: Prime Mover Schedule

Model	Quantity	Heat Rate [Btu/kWh]	Power Output [kW]	Electrical Efficiency [%]	Recoverable Heat Rate [Btu/kWh]
Solar Saturn 20	1	13,906	1,185	25	8,975
Caterpillar G3516	2	10,593	1,040	32	5,234

SYSTEM OPERATION

The following description is for the operation of the building as it was modeled in the detailed energy model. When the distribution systems are specified in Phase IV, the system operation may change slightly. Figure 3 highlights the operation of the redesigned chiller plant for the New York Times Building. Conforming with the preliminary plant study, the building has a consistent base load year-round due to data center and core office cooling requirements. In addition, for five months out of the typical year, the cooling load is rarely greater than 1,000 tons. For this reason, the absorption chiller was sized for 1,058 tons so that it could run close to full-load consistently throughout the entire year. The electrical portion of the chiller plant is sized with a 1/3 – 2/3 configuration. The 1/3 chiller (1,300 tons) will operate more often than the 2/3 chiller (2,170 tons) so that the overall chiller plant efficiency will be higher when considering a yearly average. There will be (2) 2,170 ton chillers installed for stand-by considerations. The chilled water plant serves the cooling coils in each floor-by-floor air handler (AHU) and well as the outdoor air units (OAU) on the 28th floor and tower roof.

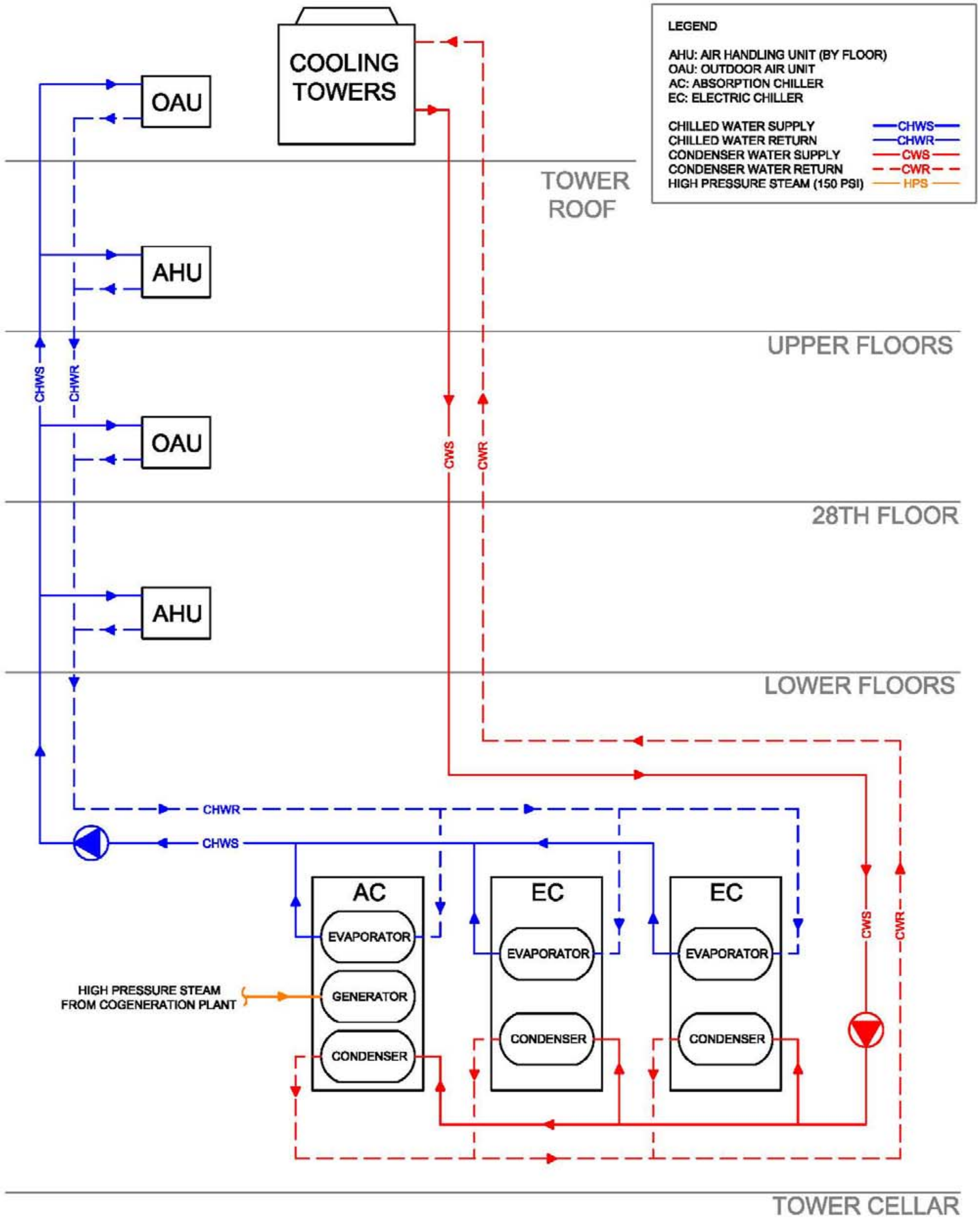


Figure 3: Chilled Water and Condenser Water Flow Diagram

Refer to Figure 4 for a flow schematic of the proposed CHP plant. Under normal operating conditions, the CHP plant operates to meet the heating requirements of the New York Times Building. The GT was sized so that when the absorption chiller is running (nearly the entire year), the full heat requirements are satisfied by the turbine's recoverable heat output. When the demand for heat increases above the GT's output, the two IC engines are staged to meet the remaining heating load. In the rare case that the heating load cannot be matched with the three PMs, a back-up steam generator has the ability to meet the remaining load.

Through the use of a heat recovery steam generator (HRSG), the GT exclusively produces high pressure steam (HPS) at 150 [psig]. The IC engines have a lower recoverable heat rate, so they only produce heating hot water (HW) through both water jacket and exhaust heat recovery systems. In the case when the IC engines are not running and there is a demand for HW, the HPS system can produce HW through the use of a heat exchanger. When the building has an abundance of HW and a shortage of steam, a heat exchanger is used for preheat of steam condensate for the HRSG.

The only two loads within the HPS system are the absorption chiller and hot water production via the heat exchanger. To serve the rest of the building's heating loads, the steam's pressure must be reduced for safe distribution. To accomplish this, a study was performed to determine whether a steam turbine could be used instead of using a pressure reducing valve. The study concluded that the potential electrical generation for the amount of steam converted was not adequate to justify a reasonable payback period for the owner. The pressure reducing valve makes 20 [psig] low pressure steam (LPS) which is required for the heating loads within the rest of the building.

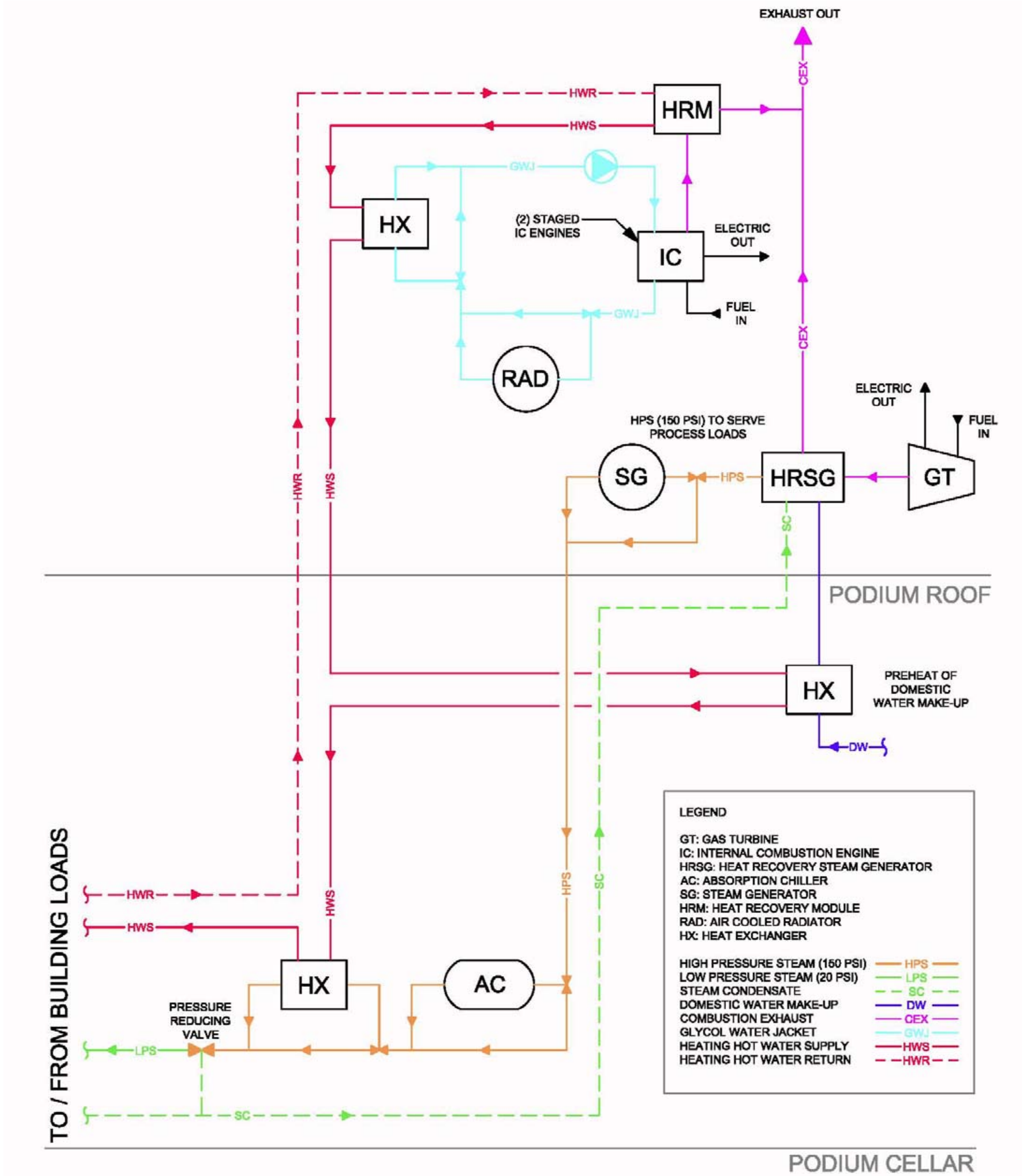


Figure 4: CHP Plant Flow Diagram

A continuation of the heating system from the CHP plant can be found in Figure 5. The LPS system only serves the preheat and humidification loads in the OUAs on the 28^{th} floor and tower roof. The HW system similarly only has two heating loads (other than steam condensate preheat). HW is required for domestic hot water heating and the zone-by-zone VAV reheat coils.

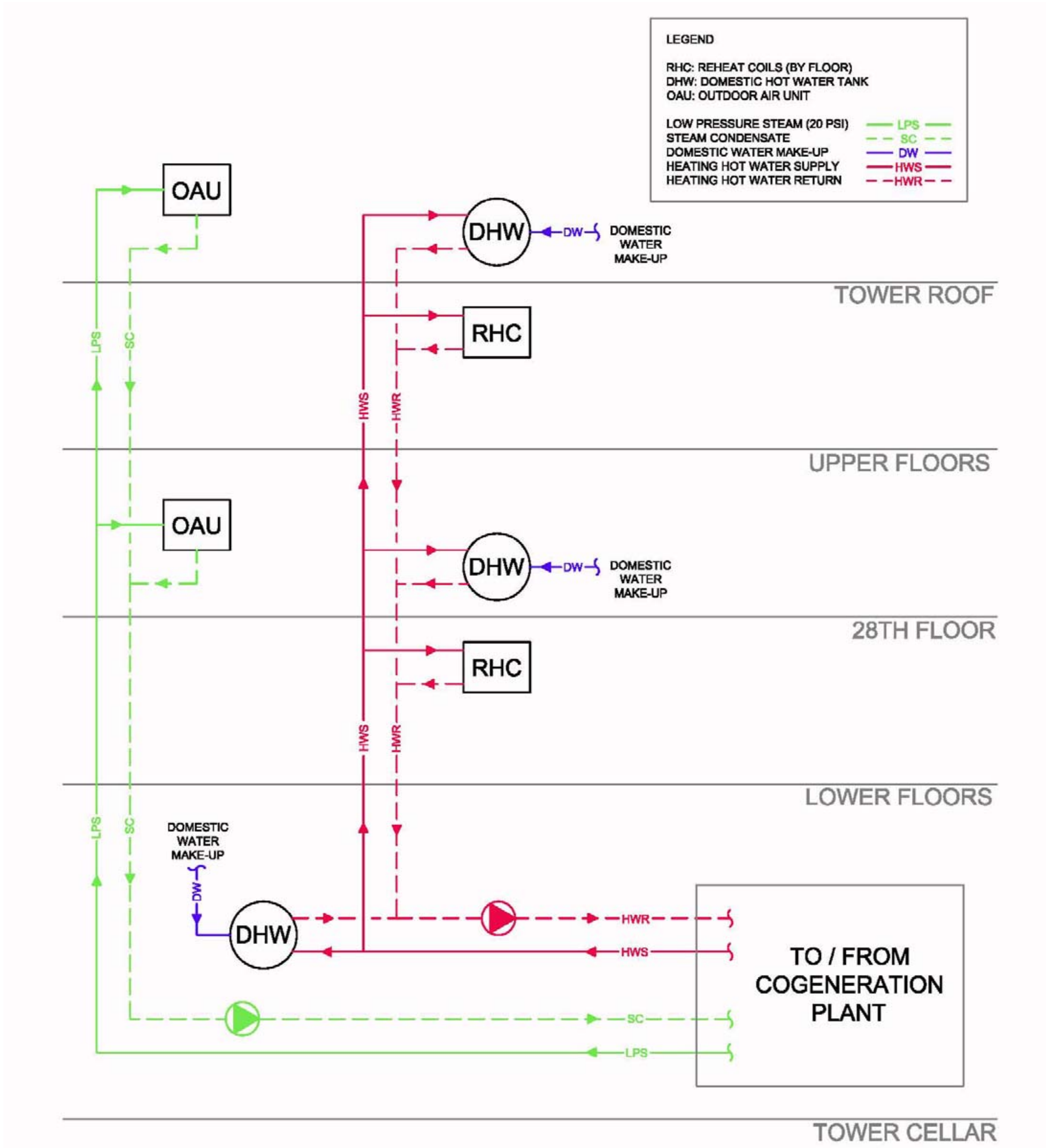


Figure 5: Steam and Heating Hot Water Flow Diagram

DETAILED MODELING ASSUMPTIONS

A more detailed energy study was conducted to compare the proposed redesign to the performance of the existing building as well as the redesigned façade utilizing separate heat and power (SHP). The redesigned CHP and SHP cases apply the same heating and cooling load profiles that were used in the preliminary plant study. The whole building load profiles for the existing building were generated from TRACE with the same method used to create the whole building load profiles for the redesigned façade.

- Chiller plants
  - Modeled part-load total chiller plant COP by weighting the COPs of all active chillers for that hour.
  - CHP and SHP
    - In both cases, the actual performance characteristics of the selected chillers were used.
  - Existing
    - Established full-load and part-load COP for each piece of equipment from TRACE equipment libraries.
- Prime movers
  - Modeled part-load prime mover heat rate and electrical efficiency by weighting the values of all active PM's for that hour.
  - CHP
    - The actual performance characteristics of the selected PMs were used.
  - SHP
    - No PMs were used in this analysis.
  - Existing
    - The actual performance characteristics of the existing PMs were used (according to manufacturer).
- Energy utilization
  - All heating loads for the SHP option were met by the use of purchased steam.
  - Any heating loads not met by the PMs in the existing option were made-up by purchased steam.
  - Natural gas has a 100% fuel utilization on-site (not thermal efficiency in equipment).
  - Electric purchased from the grid has a total efficiency of 35%.
  - Domestic hot water load of 1.0 [gal/person per day].
- Emissions and Economics
  - Pollution rates for prime movers and purchased electricity are taken from EIA guidelines.
  - There are negligible emissions due to the use of purchased steam because the utility is a cogeneration facility. Any steam purchased is considered a by-product of the purchased electricity.
  - Energy rates come from the utility investigation in the mechanical Technical Report 1 and are given below.

Utility	Yearly [$/Unit]	Reference
Natural Gas	1.392 [$/100 ft^3]	New York State Public Service Commission
Electric	0.249 [$/kWh]	New York State Public Service Commission
Purchased Steam	18.36 [$/1000 lbs]	Consolidated Edison

DETAILED ENERGY SIMULATION RESULTS

The redesigned CHP plant outperformed the existing CHP plant and the SHP system in many categories. Table 6 shows that the CHP redesign has a significantly reduced operating cost compared to the other systems. The redesigned CHP plant saves an estimated $2,157,548 in energy costs compared to the existing New York Times Building. The savings compared to the SHP configuration were even greater with an annual energy cost reduction of $3,289,930.

Table 6: Average Daily Operating Costs [$]

	CHP Existing	SHP Redesign	CHP Redesign
January	31,850	33,646	21,130
February	33,944	34,343	20,528
March	30,380	32,706	21,510
April	26,699	31,173	23,143
May	27,950	32,028	24,918
June	30,648	33,861	26,623
July	34,073	35,981	28,747
August	31,923	34,687	27,424
September	29,744	33,396	26,122
October	26,357	31,337	23,939
November	26,155	31,165	23,259
December	30,417	32,908	21,444
Annual Total	10,949,147	12,081,529	8,791,599

According to Table 7, the least efficient system according to the annual primary fuel utilization efficiency (PFUE) was the existing CHP system. The fact that the PFUE for the SHP configuration is higher than the existing CHP system indicates that the façade redesign had a larger impact on overall energy use than the CHP plant redesign. The combination of the façade and CHP redesign did, however, produce the highest PFUE of all three options.

Table 7: Average Monthly and Annual PFUE

	CHP Existing	SHP Redesign	CHP Redesign
January	0.533	0.493	0.508
February	0.557	0.513	0.522
March	0.524	0.483	0.499
April	0.468	0.455	0.479
May	0.386	0.439	0.463
June	0.377	0.431	0.461
July	0.375	0.425	0.455
August	0.376	0.432	0.461
September	0.379	0.434	0.463
October	0.414	0.449	0.473
November	0.453	0.454	0.477
December	0.523	0.486	0.501
Annual Total	0.447	0.458	0.480

The emissions data contained in Table 8 indicate that both CHP options had lower carbon dioxide production rates. Interestingly, there was a tradeoff in NOx and SOx emissions between the CHP and SHP configurations. This difference is due to the type of fuel used, specifically natural gas for CHP and mostly coal for SHP. The PMs in the CHP options produce more NOx per unit of natural gas burned because these engines operate at high flame temperatures. The coal used to generate electricity in the SHP option is less pure and less energy-dense than natural gas. For this reason, more SOx is produced per unit of fuel burned. More detailed results of this study are included in Appendix II.C.

Table 8: Annual Emissions Data

	CHP Existing	SHP Redesign	CHP Redesign
[lbs CO2/yr]	67,562,895	84,787,465	63,443,589
[lbs NOx/yr]	497,038	135,807	292,978
[lbs SOx/yr]	285,510	333,528	210,681

INTERDISCIPLINARY COORDINATION

PODIUM FRAMING REDESIGN

With an increase in size of the cogeneration plant on the podium roof, it was necessary to recalculate the loads applied to the roof members. For the analysis, the overall size, positioning, and total weight of each piece of mechanical equipment was considered in relation to the planning of the roof. The existing location of this equipment is at the end of the podium farthest away from the tower, as shown in Figure 6. This prevents unnecessary noise and vibrations from impacting the structure and occupants of the tower.

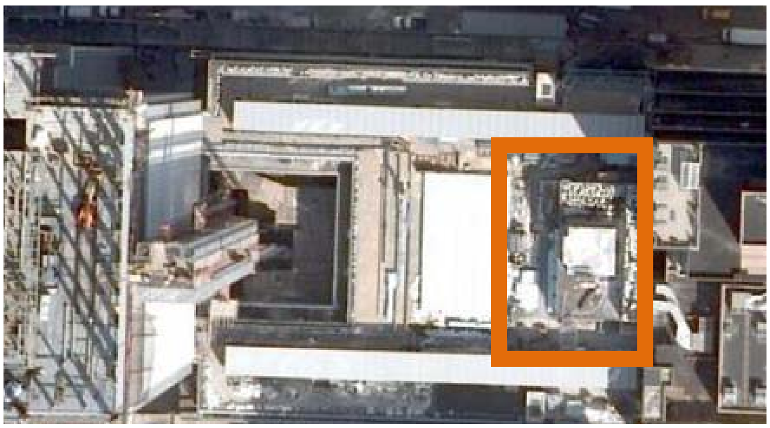


Figure 6: Aerial view of podium showing mechanical equipment location

The gravity members were analyzed in RAM Structural System to ensure the mechanical equipment could still be effectively supported. Not surprisingly, it was determined that the existing W21x44 beams (31 studs and 1" camber) framing into W30x132 girders (45 studs) were no longer effective to support the new dead loads applied to the structure, as shown in Figure 7; the white highlighted beams all failed AISC LRFD criteria for bending and/or deflection. A new area of 1140 square feet was required to support the equipment, as opposed to the old area of approximately 800 square feet, because of the increase in equipment size. The old and new systems were both assumed to be supported on housekeeping pads that distribute an area load from the equipment to the structure.

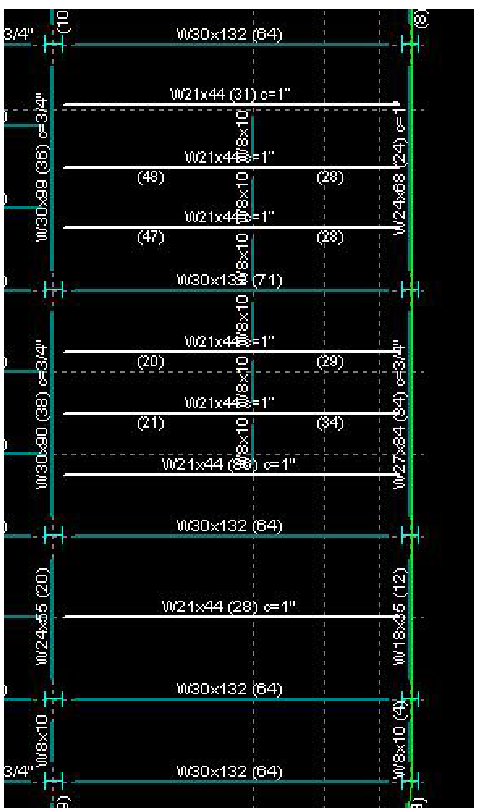


Figure 7: RAM Output for existing framing check

The affected gravity framing members were redesigned using RAM Structural System according to the new mechanical area. Dead, live, snow, and mechanical loads applied to the roof can be seen in Table 9; mechanical loads were applied specifically to the areas of relocated cogeneration equipment. After analyzing the structure for the new loads, it was determined that the average beam needed to be increased to W24x62 with a camber of 1.5" and approximately 40 studs, and that the girders could remain as W30x132. These new beam sizes can be seen in Figure 8. Although the load on the columns increases due to the new framing and mechanical equipment, columns were not checked at these locations because their sizes are unknown. In addition, foundation loads would also be affected. The total weight increase from the existing system is approximately 70 kilopounds, which is a significant value and should be considered further if the system were to be implemented.

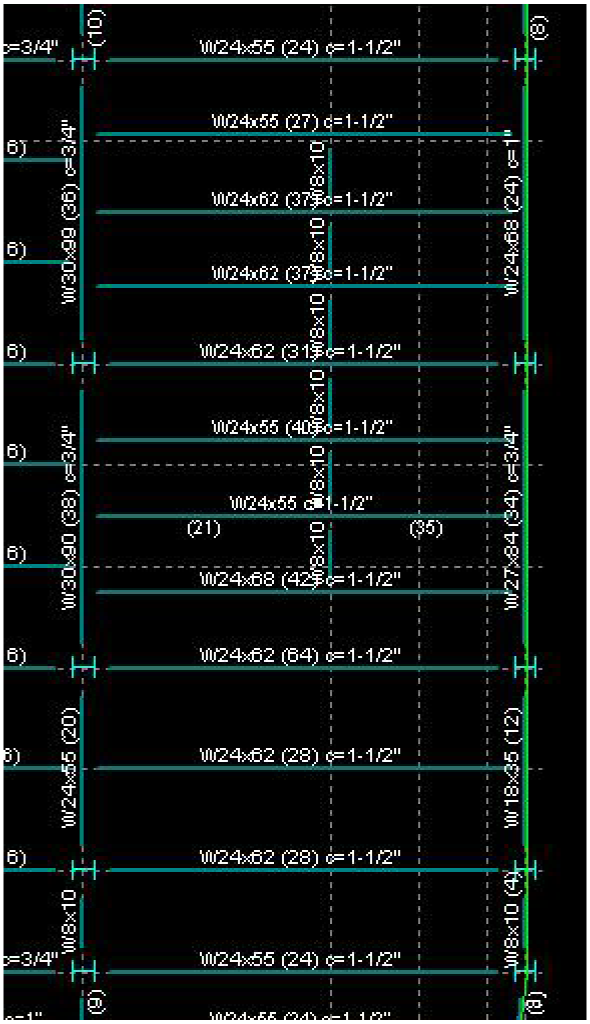


Figure 8: RAM Output for new podium framing

Roof dead load - mech. spaces	**160 psf**
12" composite slab	130 psf
Roofing	10 psf
Framing	15 psf
MEP general area	15 psf
Roof live load	**20 psf**
Snow load	**35 psf**
Mechanical wt.	**325 psf**
4 x chillers	322 psf
3 x cogen	294 psf

Table 9: New loads for podium roof

CONSTRUCTABILITY

Several key constructability challenges arose due to the reconfiguration of the cogeneration plant and chiller systems, largely revolving around their final placement in the building. A significant amount of site logistics information was not known, so several assumptions were made in order to perform an analysis; most notably, based on preliminary analysis of the construction schedule provided by Amec, it can be assumed that no portions of the tower will have been constructed at the time of cogeneration/ chiller placement. Second, it is assumed that the crawler cranes used in this portion of construction would have been in use for the erection of the podium structure before and after the placement of the cogeneration and chiller plant equipment.

The cogeneration plant equipment is located on the roof of the podium and farthest away from the tower portion of the site. The chiller equipment is located in the central green atria portion of the New York Times building. Both of these locations are shown above in Figure 6.

At the time of podium and cogeneration plant construction in the original project schedule, tower cranes have not yet been erected. It is very unlikely that two tower cranes would have been erected near the five-story podium for its construction, broken down, and then re-erected for the construction of the tower. Despite lacking detailed information on the site logistics of the project, it was possible to determine one solution to lifting the heavy mechanical equipment into place as detailed in Table 10.

Item	Shipping Weight (lb)	Elevation (ft)	Horizontal Distance from Crane (ft)
Absorption Chiller	59,800	-16	40
Electric Chiller (Single Compressor)	37,701	-16	40
Electric Chiller (Dual Compressor)	78,890	-16	40
Internal Combustion Engine	20,560	80	180
Gas Turbine Engine	23,215	80	180

Table 10: Weights and Locations of Mechanical Equipment

Based on these factors, a Manitowoc Crawler Crane (Model 16000) with a heavy lift main boom with luffing jib in conjunction with a 1,320,000 pound Carbody Counterweight would be sufficient for equipment placement purposes. The controlling condition in selecting this crawler crane was lifting the 23,215 pound gas turbine engine into place at a distance of 180 feet and elevation of 80 feet. According to the load tables shown in Appendix II.D, this crane is capable of meeting these conditions if a 137 foot heavy lifting boom angled at 87 degrees with a 196 foot luffing jib is used. The cogeneration equipment (internal combustion engine and gas turbine engine) would be lifted into place using both the main boom and luffing jib, while the chillers being lowered into the basement would only require the use of the main boom. For more information regarding the actual site logistics used on the project, please refer to Appendix II.E.

SCHEDULE

The amount of time required to install the cogeneration and chiller plant equipment will be purely a function of how many pieces of equipment there are. Had there been tower cranes on the site, weekend work would have been required to keep the plants' construction on track. Since the tower portion is not yet erected, weekend work is not required as originally anticipated.

Based on conversations with industry experts, it takes much more time to lift equipment of this size into place; approximately two pieces of equipment per day can be placed on average with a standard crew (steamfitter foreman, steamfitter, steamfitter apprentice, crane operator, crane oiler, and a skilled worker). It is assumed that after placing the equipment, a different crew will continue to set up the equipment and install the necessary connections.

There were a total of eight pieces of equipment in the original design, while there are only seven in the redesigned version. This accounts for a savings of one half day of working time, but would likely not account for much cost savings for several reasons. First, crane equipment of this size is rented on a daily basis and the saved half of a workday would be used for positioning it for future lifts for podium construction. In the case of the installation crews themselves, the steamfitting crew would likely assist other steamfitting crews in the setup of the equipment.

Based on an analysis of load capacity tables for smaller cranes, the same size crane would have been required to lift the existing cogeneration plant equipment as in the redesign. No significant schedule savings come from this redesign, but the same schedule can be maintained without any increase in general conditions cost.

RS Means Crew	Personnel	Quantity	Daily Rate ($/ day)	Work Rate (Equip/ day)	Days Worked	Total Cost
Q-7	Steamfitter Foreman	1	$550.00	2	4	$2,200.00
	Steamfitter	2	$1,088.00	2	4	$4,352.00
	Steamfitter Apprentice	1	$434.80	2	4	$1,739.20
B-21C	Crane Operator	1	$318.40	2	4	$1,273.60
	Crane Oiler	1	$408.80	2	4	$1,635.20
	Skilled Worker	1	$473.20	2	4	$1,892.80
	Total	**7**	**$3,273.20**		**4**	**$13,092.80**

ECONOMIC ANALYSIS

UTILITY COST ANALYSIS

When obtaining utility rates for the State of New York, the process is slightly different than that of other states. The New York energy market was deregulated in March of 1996 and subsequently created two important components for the industry- energy distributors and energy suppliers. Energy distributors are responsible for the construction and maintenance of energy distribution systems, whereas energy suppliers are responsible for providing the energy source itself.

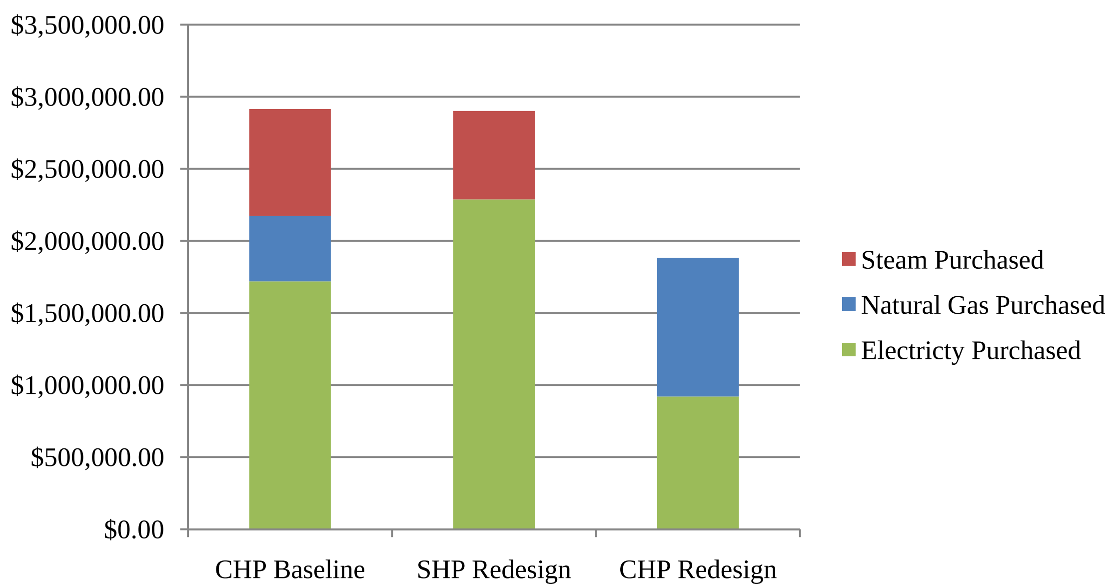
Consolidated Edison (ConEd) is responsible for distributing utilities to the New York Times Building, but the exact energy supplier is unknown. It is very likely that the New York Times' facility management team were able to negotiate special rates for energy distribution system usage while at the same time optimizing their selection of an energy supplier. For the life cycle cost analysis of this phase, the utility rates obtained from previous mechanical analysis were used and are shown below. It should be noted that the real cost of electricity depends on many factors involving rate structures and time of day. Due to a lack of information provided from both the New York Times Company and ConEd, the electricity rate is considered to be constant.

Utility	Annual [$/Unit]	Source
Natural Gas	1.392 [$/100 ft^3]	NY State Public Service Commission
Electric	0.249 [$/kWh]	NY State Public Service Commission
Steam	18.36 [$/1,000 lbs]	Consolidated Edison
Water	2.31 [$/748 gallons]	New York City Water Board

NORMAL OPERATING COSTS

The redesigned CHP plant operates to meet the prescribed heating requirements under normal operating conditions. Any electricity produced helps the New York Times Building to reduce the amount of purchased electricity, which in turn reduces operating costs. Electricity generated by the existing CHP plant costs an average of 0.15 [$/kWh], while the redesigned CHP plant requires about 0.19 [$/kWh]. Figures 9-12 show the seasonal energy costs for all three cases. (Note: Winter = December, January, February; Spring = March, April, May; Summer = June, July, August; Fall = September, October, November.)

Figure 9: Winter Energy Costs



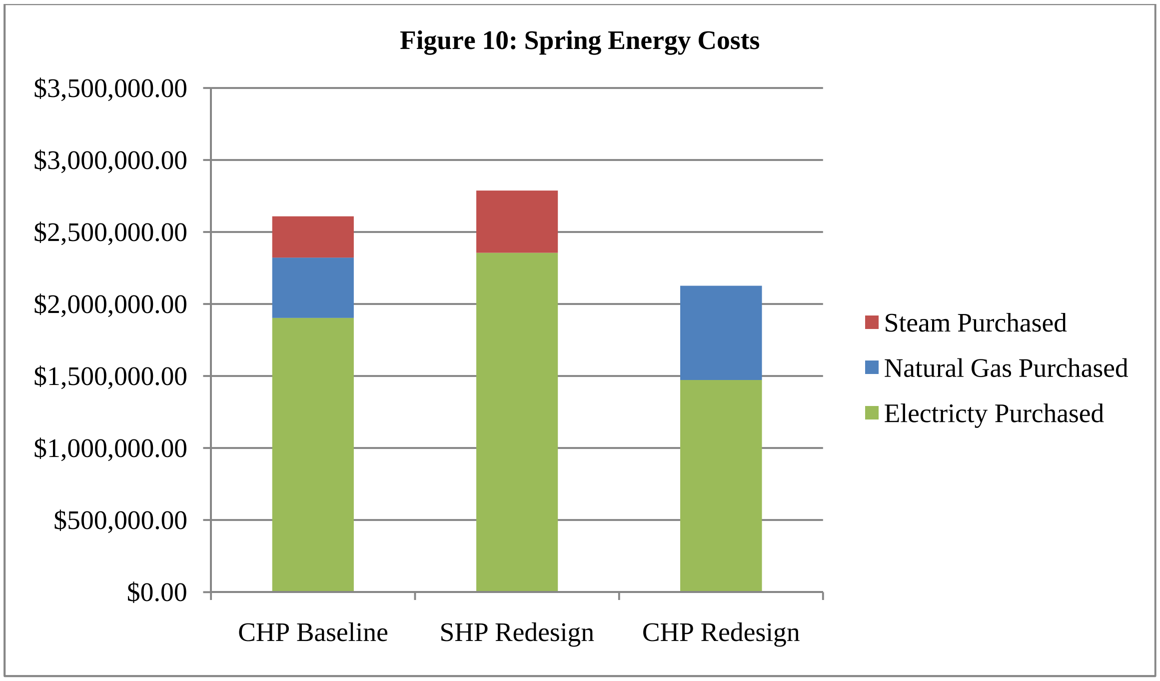


Figure 10: Spring Energy Costs
$3,500,000.00
$3,000,000.00
$2,500,000.00
$2,000,000.00
$1,500,000.00
$1,000,000.00
$500,000.00
$0.00
CHP Baseline
SHP Redesign
CHP Redesign
Steam Purchased
Natural Gas Purchased
Electricty Purchased

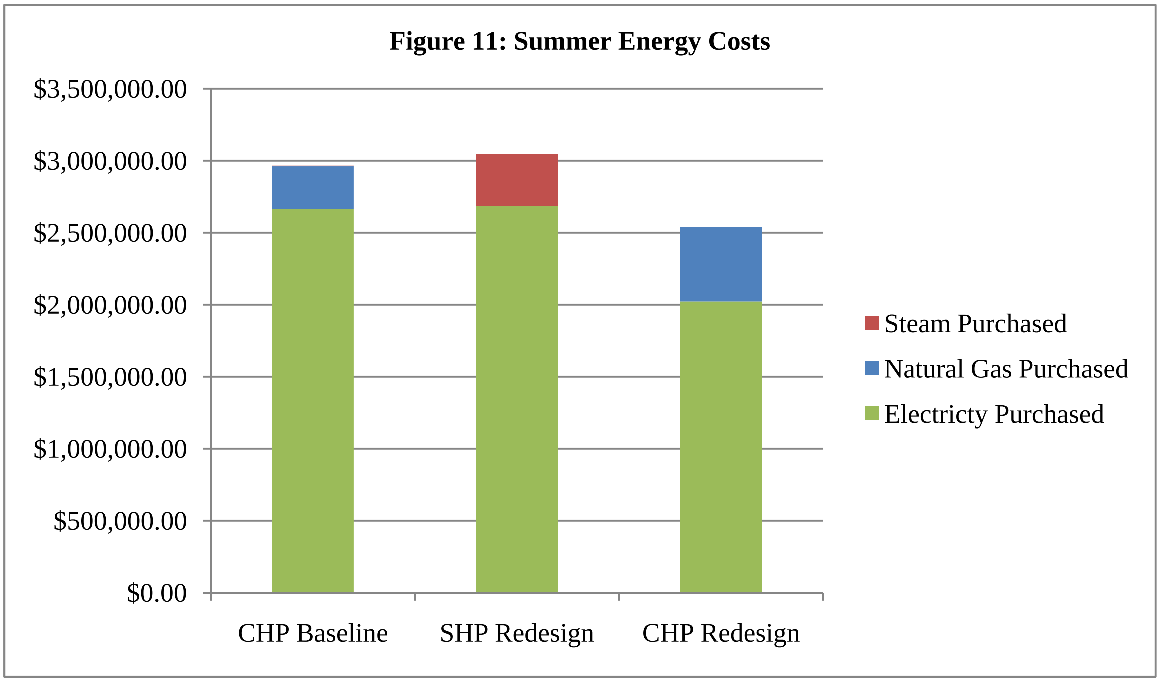


Figure 11: Summer Energy Costs
$3,500,000.00
$3,000,000.00
$2,500,000.00
$2,000,000.00
$1,500,000.00
$1,000,000.00
$500,000.00
$0.00
CHP Baseline
SHP Redesign
CHP Redesign
Steam Purchased
Natural Gas Purchased
Electricty Purchased

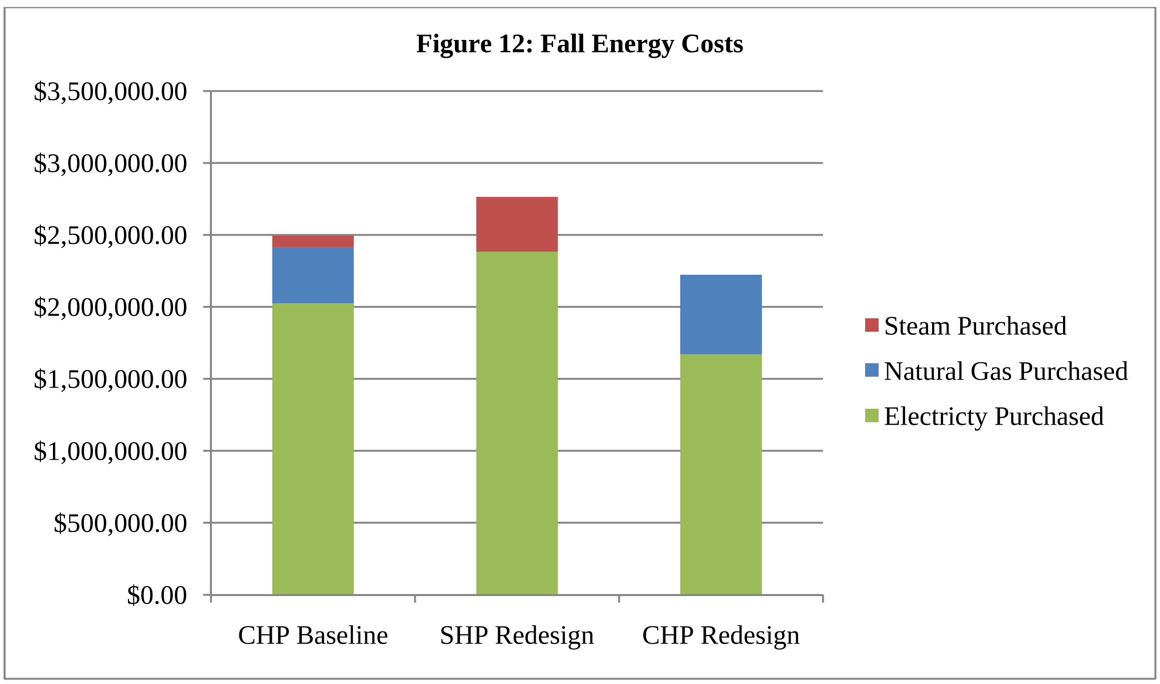


Figure 12: Fall Energy Costs
$3,500,000.00
$3,000,000.00
$2,500,000.00
$2,000,000.00
$1,500,000.00
$1,000,000.00
$500,000.00
$0.00
CHP Baseline
SHP Redesign
CHP Redesign
Steam Purchased
Natural Gas Purchased
Electricty Purchased

ELECTRICAL LOAD CONTROL STRATEGIES

As a secondary function, the CHP plant could be operated in conjunction with an electrical load shedding strategy. The total installed generation capacity of all the PMs is 3,265 [kW]. The New York Times Building's calculated peak electrical demand for the redesign, calculated in the "Detailed Energy Simulation Results," is around 7,394 [kW]. A recommended strategy for a demand limiting program would be to sequence the PMs in a manner that would cap the allowable electricity purchased from the utility. This strategy is shown in Figure 13 which shows the goal of Maximum peak demand limiting. Figure 14 shows the application of this system for the NTY building and its results. The purchased electricity is capped at 4,129 [kW], which is simply the peak load minus the installed generation capacity. The building operators have the capability to cut the peak power demand approximately in half, which would drastically reduce the electrical demand charges billed by the utility. Synchronization equipment is used to ensure that all 3 generators are on phase with each other as well as the utility. The equipment that will be used is the Zenith Energy Commander by GE (See Appendix XX for more information). The system would be connected similar to that in Figure 15, where generators are hooked into the synchronization gear as well as the utility, then when peak demand is near, the synchronizing gear disconnects certain loads from utility power and puts them on generated power, this is known as paralleling with utility.

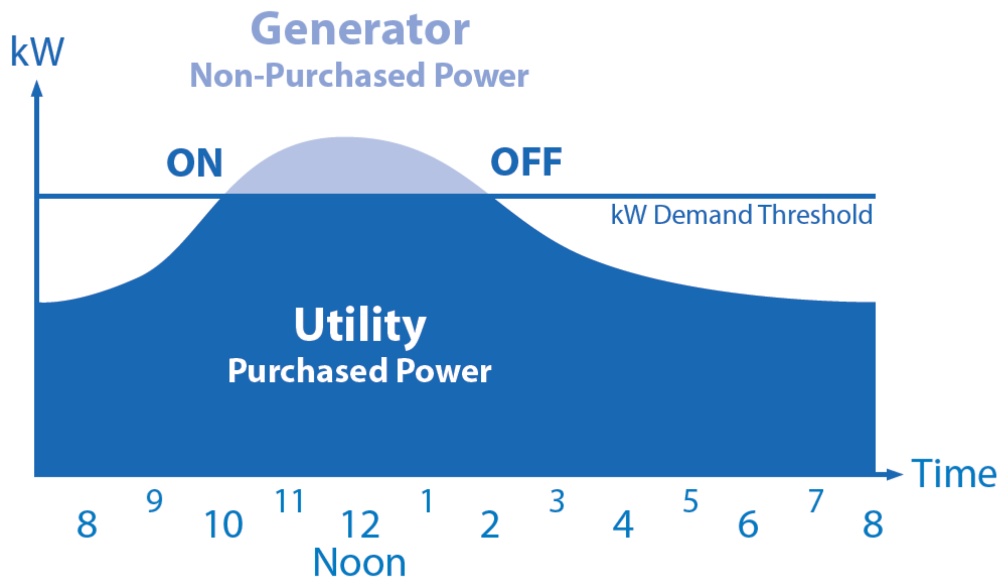


Figure 13

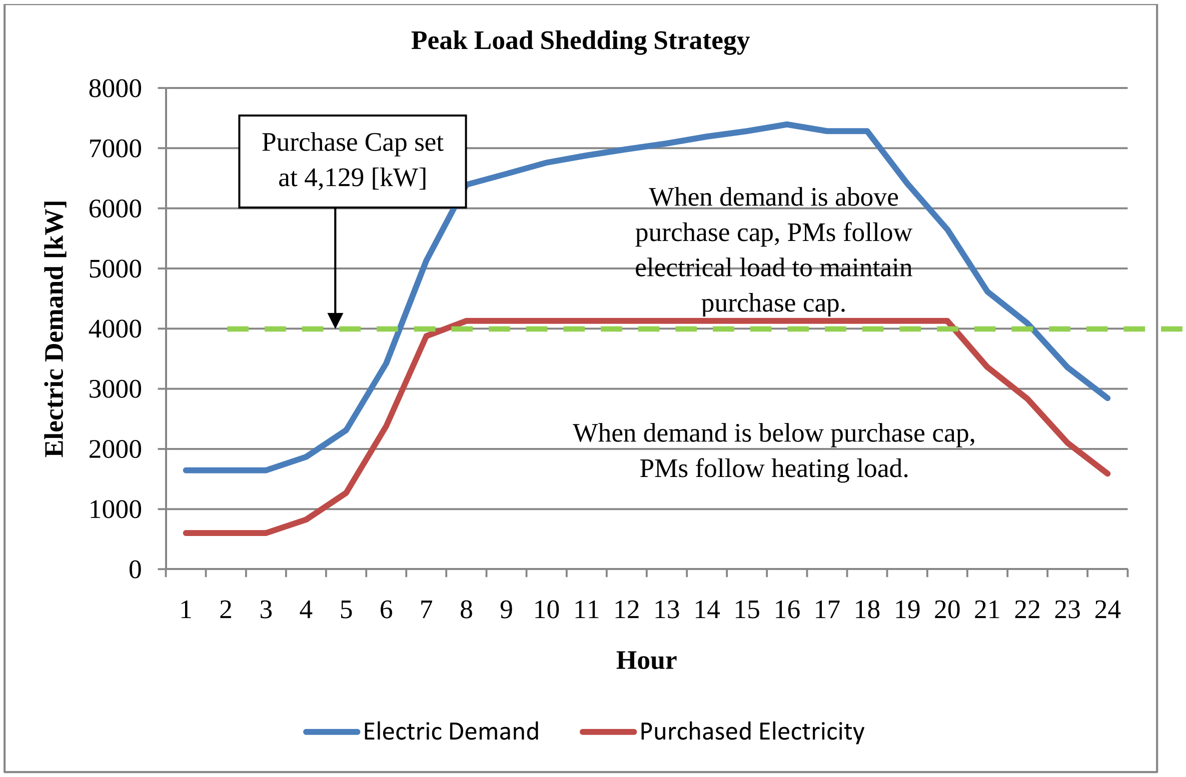


Figure 14

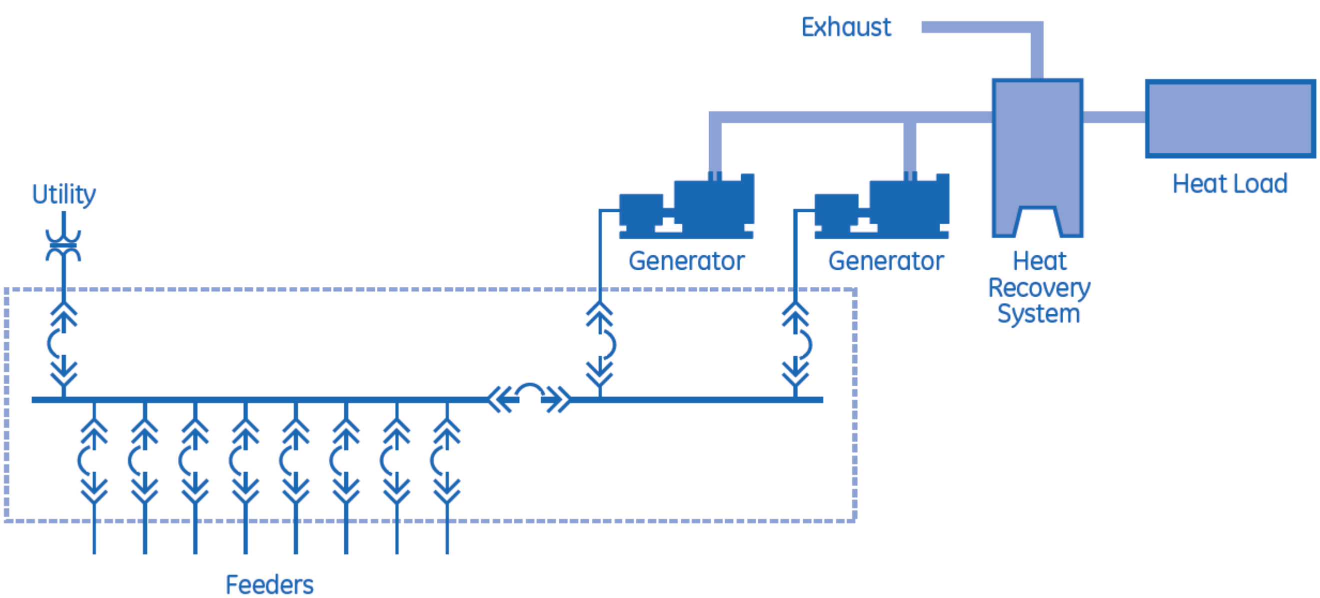


Figure 15

Although the CHP plant is not sized to meet the full electrical load, there are periods of the day and parts of the year when the plant has more generating capacity than is required by the building load. Some utilities have programs which allow customers with excess generating capacity to sell electricity back to the grid in times of peak utility demand. ConEd has a similar program which is called the "Critical Peak Rebate Program." This program qualifies customers with lean burning generating equipment to act as an emergency back-up for the utility to prevent brownouts and blackouts. The redesigned CHP plant is qualified to meet a portion of the load for a localized area in what the program calls a "non-peak emergency event." ConEd will pay the New York Times Building for every kilowatt provided in the two highest hours in which emergency load relief is provided. The rate the utility agrees to pay the customer is $1.50 per kW during the load relief period. This program only pays the customer in the rare case that emergency load relief is required and the CHP plant has extra generating capacity.

LIFE CYCLE COST ANALYSIS

Determining the overall life cycle cost of the improvements suggested in Phase II is much more complex than it would seem at first glance. The owners of the building are expected to occupy it in excess of 100 years; in this time, many fluctuations in the energy market are likely to occur that make determining the life cycle cost of the equipment extremely difficult.

For these reasons, calculating the payback period of the equipment was deemed much more practical.

	Equipment Cost	Labor Cost	Annual Operating Cost
CHP Baseline	$3,673,500.00	$114,750.00	$10,983,700.00
CHP Redesign	$6,708,800.00	$255,000.00	$8,773,200.00

Annual Savings	$2,210,500.00	
Payback of Redesign	3.15	Years

After 3.15 years, any cost savings generated by the CHP equipment can be fully realized by the owners of the New York Times Building.

CHP OPERATION SAVINGS AND IMPLICATIONS ON BANK LOAN RATES

Moneylenders working in the real estate market are beginning to recognize the value of regular energy savings. In many cases, if a proposed design will consistently save on operating costs and is viewed as a sustainable feature, the lender will offer a reduction in the total number of payments or additional funds to the borrower.

The following table outlines several different outcomes of increased initial loan value or reduction in total number of payments based on interest rate. A loan value (at present value) of $1.041 billion repaid over 25 years was assumed; this amount will cover the increased first cost of the redesigned façade and CHP plant equipment in addition to the rest of the existing-design building features. Since cost savings due to utility consumption vary from month to month, for ease of comparison it is also assumed that loan payments are made annually since annual energy savings values are known. Lastly, it is assumed that the New York Times Company and Forest City Ratner Companies are taking out a single loan that they will each repay according to their own financial agreements.

Interest Rate	Number of Annual Payments	Present Value of Loan	Current Annual Payment	Future Value of Loan at End of Loan Period	Annual Savings Applied to Payments	Potential PV w/ savings applied to payment	Potential NP w/ savings applied to payment
0.015	25	$1,041,000,000.00	($50,242,255.52)	($1,256,056,387.88)	($2,210,500.00)	$1,086,800,700.55	23.74
0.02	25	$1,041,000,000.00	($53,320,476.39)	($1,333,011,909.81)	($2,210,500.00)	$1,084,156,600.53	23.73
0.025	25	$1,041,000,000.00	($56,501,233.81)	($1,412,530,845.22)	($2,210,500.00)	$1,081,727,084.08	23.72
0.03	25	$1,041,000,000.00	($59,782,413.75)	($1,494,560,343.79)	($2,210,500.00)	$1,079,491,762.97	23.71
0.035	25	$1,041,000,000.00	($63,161,670.86)	($1,579,041,771.57)	($2,210,500.00)	$1,077,432,388.01	23.69
0.04	25	$1,041,000,000.00	($66,636,453.26)	($1,665,911,331.52)	($2,210,500.00)	$1,075,532,607.72	23.67
0.045	25	$1,041,000,000.00	($70,204,028.19)	($1,755,100,704.71)	($2,210,500.00)	$1,073,777,755.91	23.65
0.05	25	$1,041,000,000.00	($73,861,508.05)	($1,846,537,701.21)	($2,210,500.00)	$1,072,154,664.46	23.63

When the annual savings of approximately $2,210,500.00 from improved CHP performance are applied towards loan repayments, it could either allow the borrower to obtain an extra $38.5 million at the beginning of the project for initial investment, or reduce the total loan payback period by approximately 1.3 years.

CONCLUSIONS

The results of the preliminary chiller and CHP plant study concluded that the optimal configuration of the chiller plant was a constant volume absorption chiller with two larger variable speed electric chillers. The study also concluded that a gas turbine and two staged internal combustion engines would be an effective method for meeting the entire heating demand. Equipment was selected to model the actual operating characteristics of the major mechanical and electric systems. A detailed energy simulation compared the redesigned CHP plant with two other building cases. The results of this analysis showed that the redesigned CHP plant reduced the operating costs from the existing CHP plant by 20% and from the SHP option in the redesigned façade by 27%. These reduced operating costs allow the system to have a very appealing pay-back period for the owner. The results of this project phase will be addressed in greater detail in the structural redesign (Phase III) and the specific heating and cooling loads and their influence on the distribution systems in Phase IV.

A study of the gravity framing on the podium roof was performed to ensure the equipment could be carried by the existing structural system. It was found that several beam members in the general area of the equipment needed to be increased in size to accommodate the added gravity loads, from W21x44 to W24x68.

PHASE SUMMARY

The structural redesign phase began with a few interdisciplinary goals. Since the cogeneration plant was upsized to create more energy on-site, the up-front project cost was increased significantly. A lateral redesign was proposed in order to create two additional rentable levels, including a penthouse for high-end tenants, by eliminating the 51st story outrigger system. This would effectively bring in more revenue for the New York Times. However, eliminating this outrigger raised a few issues, including the thermal movement of the exposed box columns and the relocation of the mechanical units contained within the 51st floor. The best solution to control this thermal movement was found to be relocating the belt truss to the roof of the structure, where it will be covered by the façade shading system.

To create more symmetry in the structure, the layout of the concentric chevron braced frames in the North-South and East-West directions was reconfigured in order to create more symmetry in the structure. Moment frames were added to two bays adjacent to the core to replace an East-West braced frame, allowing for a savings of 3.5% of the total structural steel weight. Due to the high cost of the architecturally exposed X-braces and their connections, the system was also redesigned to eliminate the need for these braces as a method of controlling drift. An ETABS model was used to analyze the lateral system and meet specified drift requirements of H/450 and period requirements of 6.75 seconds in the North-South and 6.25 seconds in the East-West. All requirements were met with the redesigned system, and the goals of the proposal were met.

The progressive collapse resistance of the structure was also analyzed according to the 2003 General Services Administration Progressive Collapse Analysis and Design Guidelines. A base assumption of the removal of a reentrant corner column was made for simplification after a blast threat study was performed to determine the locations with the most threat potential, assuming the New York Times Building is classified as a “high profile” structure. The linear-static and nonlinear-static finite element procedures were both performed to compare their results; required member sizes were then found for each of the procedures. Surprisingly, the linear-static procedure yielded much smaller required member sizes than the nonlinear-static procedure. For the nonlinear-static procedure, the required plastic moments of the beams below the 37th floor were so large that there are no available rolled shapes with enough capacity. However, this could be due to the virtual work method employed for the nonlinear analysis, which only considered the bay with the removed column. An ETABS model was utilized for the linear-elastic analysis, which took into account the adjacent frames.

The GSA guidelines were then compared to the 2009 Department of Defense Unified Facilities Criteria. It was determined that the Department of Defense standards are a bit more in-depth since they consider factors dependent on individual members. In addition, the load combination employed by the DoD method gives a slightly higher force value, which is expected to yield somewhat larger members.

Although a redesign of the system to mitigate the risk of progressive collapse was originally proposed, it was determined that a redesign based on analysis results would not be a viable option in terms of cost. The increase in required steel and new moment connections prove that this analysis is not effective for tall buildings. For a real structure, a nonlinear dynamic procedure should be employed to create efficiency and take into account all contributing members in the structural system.

Since the existing 51st mechanical and outrigger level is now occupied by two floors including a penthouse space, the mechanical equipment on this level was relocated to the roof. Since the mechanical areas in the New York Times Building are under-utilized, moving the equipment to the roof did not pose too many challenges.

INTRODUCTION

The 52-story New York Times Headquarters Building is located on Eighth Avenue between 41st and 42nd Streets. Home to the New York Times newsroom, 26 floors of Times administrative offices, and several law firms, it was intended to be a flagship building promoting sustainability, lightness, and transparency. The architectural façade reflects the ever-changing environment surrounding the building, an appropriate acknowledgement of the heart of New York City. Thornton Tomasetti worked closely with architect Renzo Piano to create a building that displayed not only transparency in the media, but also structural transparency. For this reason, exterior columns, X-bracing, and beams were shifted outside of the façade, and the visual appearance of these elements and connections was given special attention.

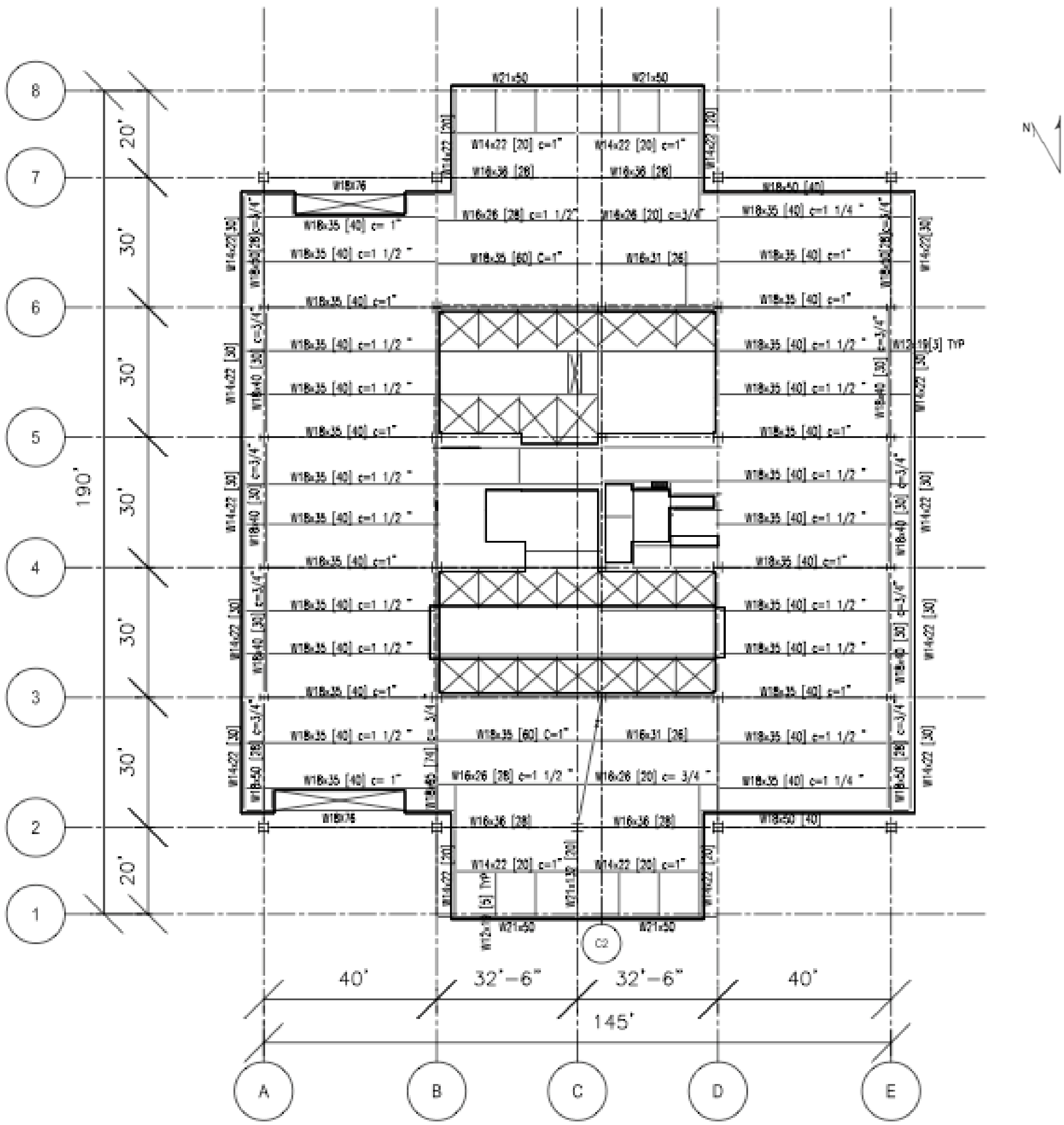


Figure 1: Typical tower framing plan

The office floors are intended to be open plans, with minimal disturbance from columns and other structural elements. For this reason, two-story outriggers were used at mechanical levels (floors 28 and 51) to engage exterior columns in the lateral system and increase stiffness. Story heights average approximately 13'-9", and floor-to-ceiling heights are approximately 10'-9" due to the 16" allowance for an under-floor air distribution system and 20" structural depth. A typical structural floor plan can be seen in Figure 1.

For the Integrated Project Delivery and Building Information Modeling thesis project, a few changes were made to the existing layout. The under-floor mechanical system was replaced by a ducted system, reducing the total plenum depth and allowing for deeper structural members. Because of this, the lateral force resisting system in the building was able to incorporate moment frames for added stiffness. In addition, the mechanical and outrigger space on the 51st floor was replaced with two more rentable floors. This created a penthouse level for high-end tenants, and could potentially bring in more revenue to the New York Times. The exterior X-braces on the structure were also eliminated to save money for use elsewhere.

CODES AND REFERENCES

ORIGINAL DESIGN CODES

National Model Code:
- 1968 Building Code of the City of New York

Structural Standards:
- ASCE 7-98, Minimum Design Loads for Buildings and other Structures

Structural Design Codes:
- AISC – LRFD, Steel Construction Manual, 2nd Edition, American Institute of Steel Construction, 1998
- National Building Code of Canada, 1995
- Uniform Building Code, 1997
- ACI 318-95, Manual of Concrete Practice, American Concrete Institute

DESIGN DEFLECTION CRITERIA

Lateral Deflections:
- Total building sway deflection for 10-year wind loading is limited to H/450.
- Seismic deflection as per ASCE 7-05.

Thermal Deflections:
- The shortening and elongating effects due to temperature changes are designed to L/300.
- At this point in time additional gravity and lateral deflections were not disclosed.

THESIS DESIGN CODES

National Model Code:
- 2006 International Building Code

Structural Standards:
- ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
- ASCE 41-06, Seismic Rehabilitation of Existing Buildings

Structural Design Codes:
- AISC, Steel Construction Manual 13th Edition
- 2009 Department of Defense Unified Facilities Criteria 4-023-03, Design of Buildings to Resist Progressive Collapse
- 2003 General Services Administration Progressive Collapse Analysis and Design Guidelines

OTHER REFERENCES

- Fintel, Mark and Khan, Fazlur. “Thermal effects of column exposure in high-rise structures.” Building Research. September-October 1967. Pages 6-12.
- Seigel, L.G. “Water-filled tubular steel columns- fire protection without a coating.” Civil Engineering. September 1967. Pages 65-67.
- “U.S. Steel headquarters building.” Civil Engineering- ASCE. April 1970. Pages 58-63.

MATERIAL STRENGTHS

Structural Steel:
Wide Flange Shapes..ASTM A572 or A992, Grade 50
Built-Up Sections..ASTM A572, Grade 50 & Grade 42
HSS Shapes..ASTM A500 Grade B
Diagonal & X-Braced Rod..ASTM A572, Grade 65
Connection Plates..ASTM A36

Concrete:
Caissons..f'_c = 6000 psi
Spread Footings..f'_c = 6000 psi
Slabs on Deck NWC ……..f'_c = 4000 psi

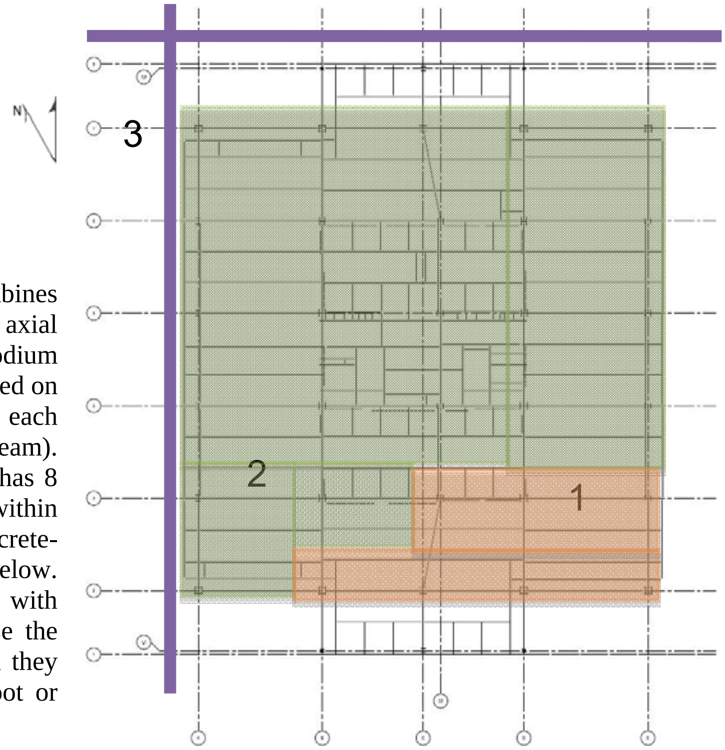
Metal Decking:
3” Composite Deck..F_y = 40 ksi

The designer did not disclose shear stud, weld, bolt, and reinforcement strengths.

BACKGROUND

EXISTING STRUCTURAL SYSTEM

Foundation



Key:
1. Assumed Caisson Location
2. Assumed Spread Footing Location
3. Subway

Figure 2: Foundation layout

The foundation of the New York Times Headquarters combines typical spread footings with caissons to achieve its maximum axial capacity. Below the building's 16-foot cellar, the tower and podium mostly bear on 20 tons per square foot rock; in this area, indicated on Figure 2 in green, 6,000-psi spread footings were used under each column (dimensions of footings not disclosed by the design team). However, at the southeast corner of the tower, the rock only has 8 tons per square foot capacity. At the seven columns that fall within this area, indicated in orange on Figure 2, 24-inch diameter concrete-filled steel caissons were used to transfer loads to the rock below. Each caisson was designed to support a load of 2,400 kips with 6,000 psi concrete. The structural engineers did not disclose the depth of the caissons; it is only known that they extend until they reach rock with a bearing capacity of 20 tons per square foot or greater.

The New York City Subway passes below Eighth Avenue to the west and 41st Street to the north of the New York Times Building. However, this is not a major site restriction since the transit system is not directly beneath the structure.

Floor System

The floor system is a steel composite system with a typical bay size of 30’-0”x 40’-0”, with 2 ½” normal weight concrete on 3” metal deck. Typical beam sizes are W18x35 with a 10’-0” typical spacing, bearing on W18x40 girders. The girders frame into the various built-up columns, box columns along the exterior and built-up non-box columns in the core. Framing of the core consists of W14 and W16 shapes for beams, which bear on W33 girders.

In the New York Times spaces, the structural steel is 16 inches below the finished floor to accommodate the under-floor air distribution plenum. Because the façade is transparent and office spaces are visible from the exterior, the architect wanted members passing through to the outside to line up with the perceived floors. To align the girder with the office floor level and not the level of the structure, engineers created a “dog leg” at the end of the girders on these floors. Figure 3 depicts the dog leg during construction; an aluminum spandrel was used to mask the location of the girder, as shown in Figure 4. The top of steel of the girder is at the bottom of the spandrel in the figure, and the spandrel covers up the plenum.

Figure 3: 'Dog-leg' beam connection

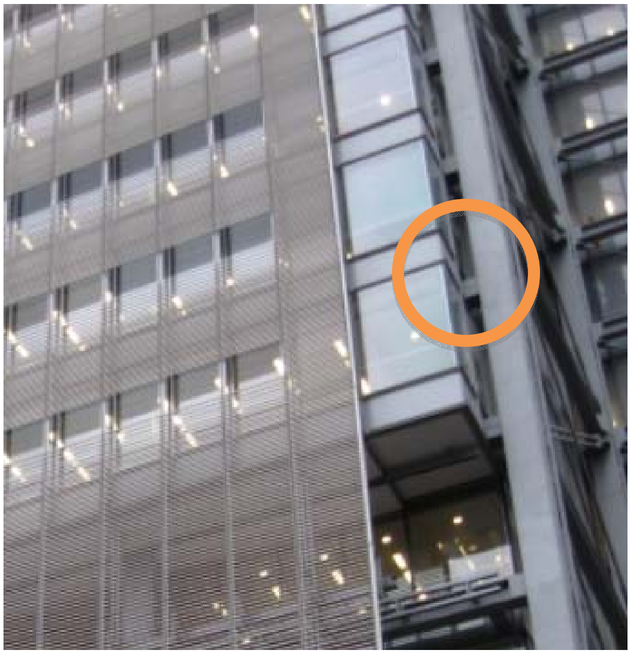


Figure 5: 'Dog-leg' beam connection

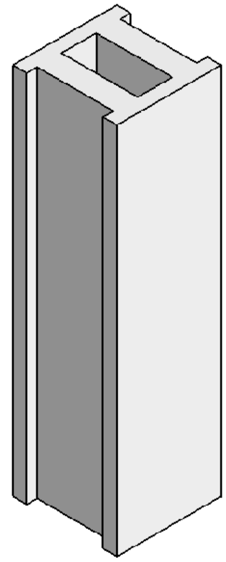


Figure 4: Box Column

Columns

The 30" by 30" box columns (Figure 5), exposed at the exterior corners of the tower, as seen in Figure 4, consist of two 30-inch wide flange plates and two web plates inset three inches from the exterior of the column on either side. Each web plate decreases in thickness from 7 inches at the bottom of the building to adjust to the loads at each level. The flange plates decrease thickness from 4 inches to conform to the "lightness" of the architecture with an increase in elevation. Although the yield strength of the plates also varies with tower height, the strength was assumed to be a uniform 50 ksi for calculations. Interior columns are a combination of built-up sections and rolled shapes. Column locations stay consistent throughout the height of the building, spaced with the grid at 30 feet in one direction and 40 feet in the other. Most of the columns are engaged in the lateral system via connections to bracing and outriggers; this system is described in more detail in the lateral system section.

Existing Lateral System

The main lateral load resisting system for the tower of the New York Times Building consists of a centralized steel braced frame core with outriggers without belt trusses on the two mechanical floors (Levels 28 and 51) to engage the exterior columns. The structural core consists of single diagonal bracing in the North-South direction between grids 4 and 5, concentric chevron bracing in both the North-South and East-West directions, and eccentric chevron bracing in the North-South direction between grids 5 and 6 (Figure 6 & 7). These braced frames surround the elevator shafts, MEP shafts, and stairwells. At this time, the member sizes of the braces have not been disclosed. The core configuration remains consistent from the ground level to the 27th floor as shown in Figure 7 on the next page. But above the 28th floor, some elevators were no longer required due to capacity. In order to optimize the rentable space on the upper levels of the tower, the number of bracing lines in the North-South direction was reduced from two to one (Figure 7). Please refer to Figures 10 and 11 to view the typical core bracing elevations.

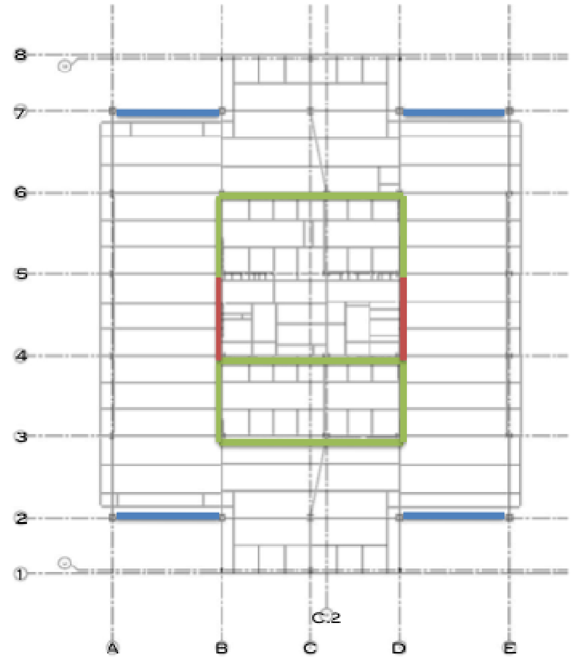


Figure 6: Typical Lateral System (Floors 1-27)

The outriggers on the mechanical floors consist of single diagonal braces extending from the core bracing to the exterior columns at grids 3, 4, 5, and 6 on either side of the core (seen in Figure 9). The outrigger system was designed to increase the efficiency and redundancy of the tower by engaging the perimeter columns in the lateral system.

During the design of the tower, the engineers at Thornton Tomasetti sized the members of the main lateral force resisting system merely for strength. In order to increase stiffness and meet drift and deflection criteria, the structural engineers utilized the double story steel rod X-braces instead of increasing the member sizes of the main lateral force resisting system. These X-brace locations can be seen in Figures 6-9. The high strength steel rods transition from 2.5" to 4" in diameter and were prestressed to 210 kips, according to Thornton Tomasetti. This induced tensile load prevents the need for large compression members that would not conform to the architectural vision of the exterior.

Although the X-braces reduced the need for an overall member size increase, the lateral system still did not completely conform to the deflection criterion. Therefore, some of the 30” by 30” base columns were designed as built-up solid sections that reduced the building drift caused by the building overturning moment. After combining these solid base columns and the X-braces with the main lateral force resisting system, the calculated deflection of the tower due to wind was H/450 with a 10 year return period and a building acceleration of less than 0.025g for non-hurricane winds.

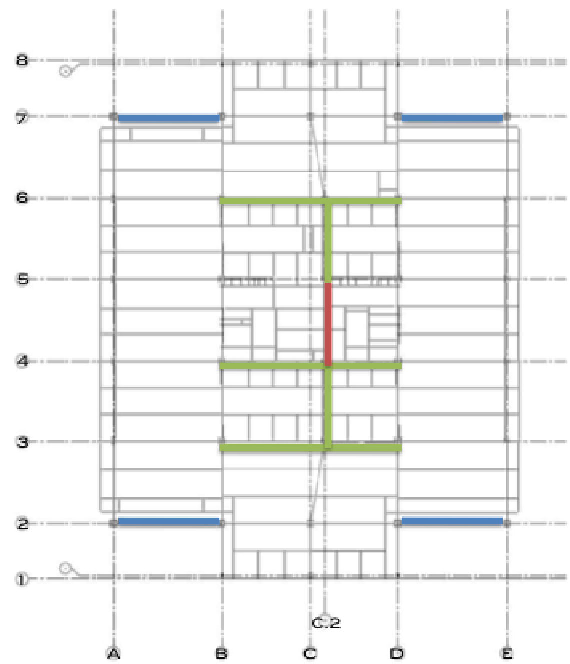
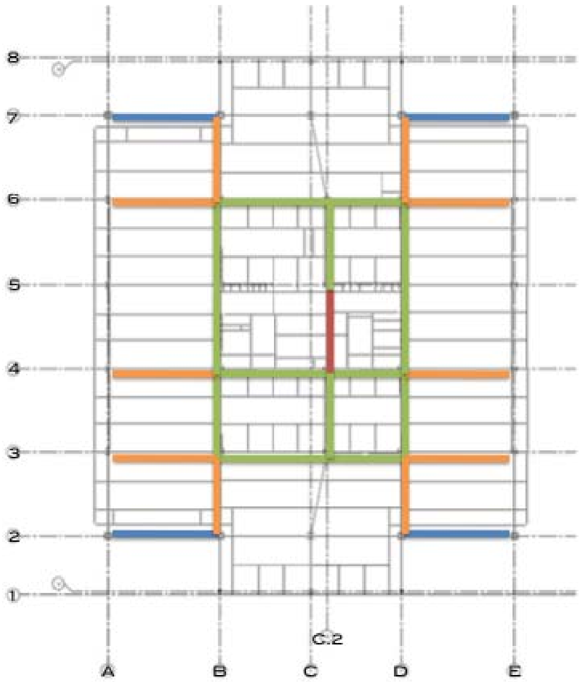


Figure 7: Typical Lateral System (Floors 29-50)

According to information obtained from the structural engineer, the podium of the New York Times Building was designed with a separate lateral system. Though the owner did not disclose information about the podium, it is known that the lateral system is comprised of concrete shear walls. The podium was not considered in this analysis.



KEY:

- EXTERIOR X-BRACES
- CONCENTRIC & ECCENTRIC CHEVRONS
- SINGLE DIAGONAL BRACES
- OUTRIGGER

Figure 8: Mechanical Levels 28 & 51

Figure 9: Exposed X-braced rods

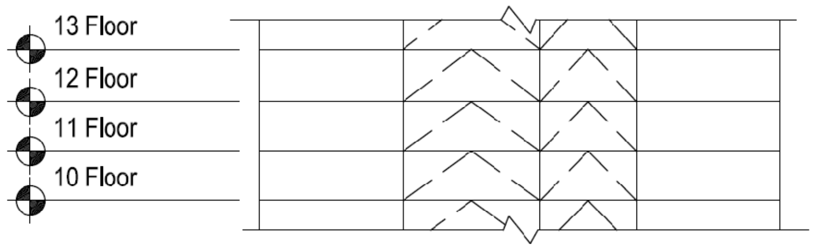


Figure 13: Typical Core E-W Bracing Elevation

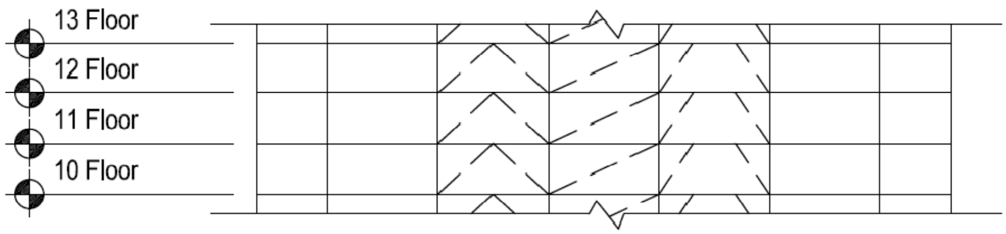


Figure 12: Typical Core N-S Bracing Elevation

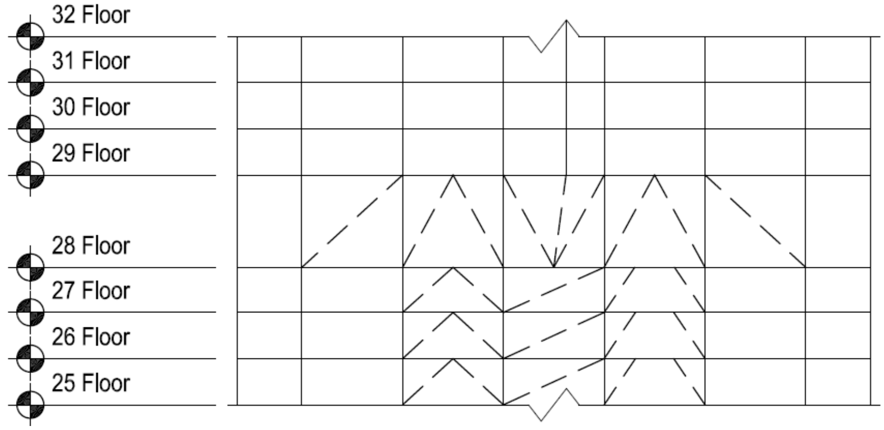


Figure 11: Typical N-S Outrigger Elevation

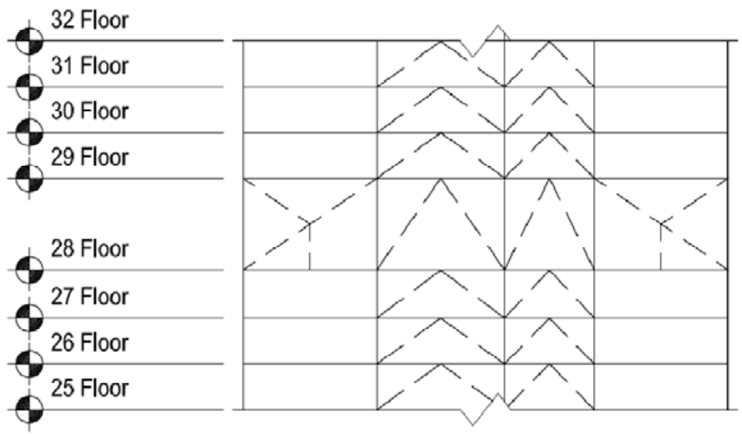


Figure 10: Typical E-W Outrigger Elevation

GOALS OF STRUCTURAL REDESIGN

STRUCTURAL PROBLEM STATEMENT

After investigating the lateral system of the New York Times Building in previous technical assignments, it was found that there was potential to eliminate the outrigger on the top level of the building in favor of a rentable penthouse suite. The structural aspect of this final report will simulate that the owner would like to add a penthouse floor, and will study the option of redesigning the lateral system to accommodate a single outrigger floor on the 28th level. This option will eliminate the use of the exterior cross-braced rods in the lateral system and will require a complete redesign of the lateral system.

In addition, the progressive collapse resistance of the structure will be analyzed for compliance with current Department of Defense and General Services Administration guidelines. Since the New York Times Building is a high profile structure and located in New York City, there is the potential for a security threat in the form of a blast that could severely affect its structural integrity. It is known that blast resistance and progressive collapse had been taken into consideration in the existing design; however, new codes have been developed since the initial design of the structure that could have an impact on the code compliance of its threat resistance.

SOLUTION

To accommodate a single outrigger level to supplement the lateral force resisting system, the chevron braced frame members will likely have to increase in size to meet lateral drift requirements. To add stiffness to the lateral system, moment frames will possibly be added in bays adjacent to the existing braced frames, and the number of frames in each direction may be increased as necessary. It is also necessary to investigate the thermal effects on the columns of removing the top-level outrigger, and a solution to this potential movement will be developed. A lateral model will be created in ETABS to analyze the structure, using rigid and semi-rigid diaphragms for the floor plates. Column and beam members will be modeled in three dimensions to include the effects of flexure, shear, axial, and panel-zone deformations in all directions, as learned in the Computer Modeling of Building Structures masters class. Inherent and accidental torsion as well as P-Delta effects will be included in the analysis.

To analyze the structure for progressive collapse, a study will first be done to determine which column location within the structure was most susceptible to a threat large enough to cause column removal. Due to the wide range of blast loading possibilities, a base assumption of a removed column due to any blast will be made. This at-risk column location will then be analyzed according to the GSA Guidelines for Progressive Collapse, using the Linear- and Nonlinear-Static Methods. The linear method sets maximum ratios for demand to ultimate shear and flexural resistance, while the nonlinear method utilizes a plastic hinge analysis of frames adjacent to a removed column. In addition, a finite-element model will be created in ETABS to determine the linear-elastic response of the structure due to a removed column, following the guidelines in the GSA document for the linear-static procedure. The GSA and Department of Defense Unified Facilities Criteria: Design of Buildings to Resist Progressive Collapse standards will be used as a basis for the model, in addition to following modeling recommendations from Chapter 5 of ASCE 41. These methods will then be compared and discussed.

LATERAL SYSTEM ANALYSIS

LOADS

Gravity loads were based off of those determined in the first technical report; however, the seismic weight was updated to include the change in weight of the braces with an increase in height of the building. Weights were determined by taking an average value at each of eight vertical building segments, roughly 6 stories each, and assigned to each story accordingly. These gravity loads can be found in Table 1 and as the seismic weights in Table 6 of Appendix 3.A.

Gravity Loads for Analysis	
Dead Loads	*93-100 psf*
2.5" slab on 3" metal deck	53 psf
Ceiling	5 psf
MEP systems	20 psf
Structure	15-22 psf
Façade load	*25 psf*
Live Loads	*70 psf*
Open office	50 psf
Partitions	20 psf

Table 1: Gravity Loads

The lateral loads applied to the structure at each level are resisted by moment frames and steel braced frames connected to a rigid diaphragm that distributes the loads to each bay. The columns then carry these vertically down to the foundations, where the loads are dissipated by the soil or carried by the rock below.

Wind loads as determined in the first technical report were not utilized for this analysis in light of new base shears from a wind tunnel study provided by Thornton Tomasetti. The ASCE 7-05 wind loads and updated wind loads are shown in Table 2; wind tunnel testing loads were lower than those determined by the code, and were multiplied by an importance factor of 1.15. Cases 1, 2, 3 and 4 from ASCE were considered in this analysis. The Case 1 wind condition yielded the highest drifts and load effects in both directions; these are explained in more detail under the analysis results below.

Seismic calculations were updated after the first technical report based on the actual periods of 6.75 and 6.25 seconds and the difference in floor self-weight. These updates led to a slight decrease in the lateral seismic forces applied to the structure at the center of mass; these forces are tabulated below in Table 3. When analyzed, the combination 1.2D + 1.0E + 1.0L was used, since it would likely have the greatest combined impact on the structure in terms of seismic lateral forces and gravity loads. However, the forces due to wind were much greater than the seismic forces, so seismic forces will not control the size of the members.

LATERAL WIND FORCE COMPARISON

	ASCE 7-05 lateral forces (k)		wind tunnel lateral forces (k)	
level	*E/W*	*N/S*	*E/W*	*N/S*
Roof	676	674	159	164
51	284	224	134	138
50	193	152	123	100
49	188	148	84	68
48	187	147	81	66
47	187	147	81	66
46	186	146	81	66
45	185	146	81	66
44	185	145	80	65
43	184	145	80	65
42	183	144	80	65
41	182	143	79	65
40	182	143	79	64
39	181	142	79	64
38	180	142	78	64
37	179	141	78	63
36	179	140	78	63
35	178	140	77	63
34	177	139	77	63
33	176	138	77	62
32	175	138	76	62
31	174	137	76	62
30	173	136	76	61
29	259	203	75	61
28	262	205	112	91
27	175	137	114	92
26	169	132	76	61
25	168	131	73	59
24	167	130	73	59
23	165	129	72	58
22	164	129	72	58
21	163	128	71	58
20	162	127	71	57
19	161	126	70	57
18	159	124	70	56
17	158	123	69	56
16	157	122	68	55
15	149	116	68	55
14	154	120	64	52
13	159	124	67	54
12	150	117	69	55
11	149	116	65	52
10	147	114	64	52
9	145	112	64	51
8	142	111	63	50
7	140	109	62	50
6	137	106	61	49
5	137	106	60	48
4	142	110	59	48
3	143	110	62	49
2	181	125	62	49
base shear	9336	7438	3968	3278

Table 2: Lateral wind force comparison

SEISMIC LATERAL FORCES

level	*force (k)*
Roof	89.36
52	79.32
51	80.16
50	68.92
49	66.99
48	64.40
47	61.86
46	59.37
45	56.93
44	54.55
43	53.05
42	50.73
41	48.46
40	46.24
39	44.07
38	41.96
37	40.53
36	38.49
35	36.50
34	34.56
33	32.68
32	30.85
31	29.52
30	27.77
29	26.07
28	26.53
27	21.40
26	19.72
25	18.58
24	17.18
23	15.84
22	14.55
21	13.32
20	12.15
19	11.19
18	10.11
17	9.08
16	8.10
15	7.18
14	6.28
13	5.70
12	4.83
11	4.12
10	3.47
9	2.87
8	2.33
7	1.85
6	1.44
5	1.07
4	0.75
3	0.48
2	0.25
base shear	1504 k

Table 3: Seismic forces

LATERAL SYSTEM LAYOUT STUDY

The lateral force resisting system was redesigned to accommodate a single outrigger level to replace an outrigger level at both the 28th and 51st floors and to eliminate the exterior X-braces that control drift in the existing lateral system. Eliminating the top outrigger presented some challenges, including removing the members that controlled differential movement of the exposed columns due to thermal effects, reducing the overall stiffness of the lateral system, and causing the mechanical equipment to be relocated. However, removing this mechanical and outrigger level creates two penthouse floors for high-end tenants, increasing the amount of revenue brought in by the owner. Criteria for comparing the new system with the original system included drift limits of H/450 due to wind (obtained from Thornton Tomasetti), $0.025h_{sx}$ due to seismic, and a target period of 6.75 seconds in the North-South direction and of 6.25 seconds in the East-West direction. These targets were obtained from those values representative of the existing system.

First, an optimization study was done to determine whether moving the outrigger system from the 28th floor would provide any advantages in terms of stiffness. Separate lateral models of the existing system were created in ETABS, placing the outrigger at various levels, including the 25th, 28th, 32nd, and 36th floors, to evaluate these preliminary locations' impacts on the period and drift of the structure. It was found that relocating the outriggers to a higher floor slightly increased the period and drift of the building, since the attached columns effectively become longer and more slender. In addition, relocating the outriggers to a significantly lower floor also slightly increased the period and drift, since the outriggers only benefit the levels below by reducing drift. Since moving the system one or two floors did not yield results much different from those at the 28th level, relocation was ruled out as a more efficient option.

Instead, to add stiffness to the lateral system, several bracing layouts with moment frames in adjacent bays were investigated. Figures 14 and 15 depict the first option, with moment frames in purple, except at the 28th floor, where outriggers replace moment frames. Bracing is in red, with three lines in the East-West direction, and two in the North-South below the 28th floor and one above. This option was ruled out based on the interaction between this system and the new ducted mechanical system; adding moment frames in both directions would limit

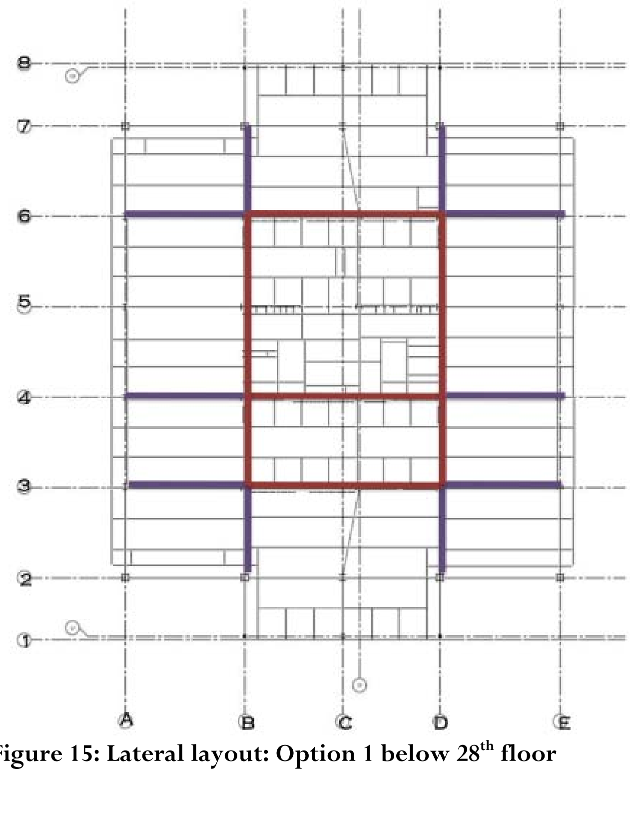


Figure 15: Lateral layout: Option 1 below 28th floor

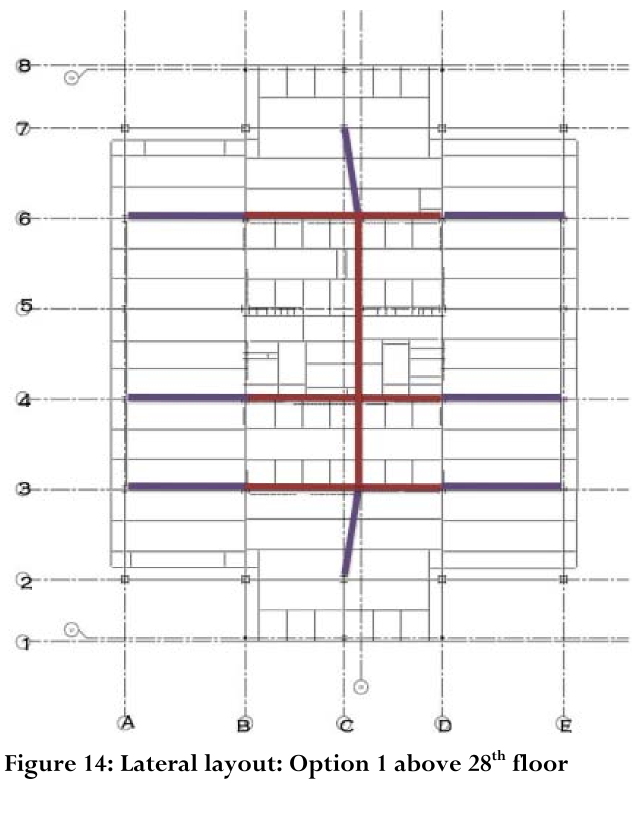


Figure 14: Lateral layout: Option 1 above 28th floor

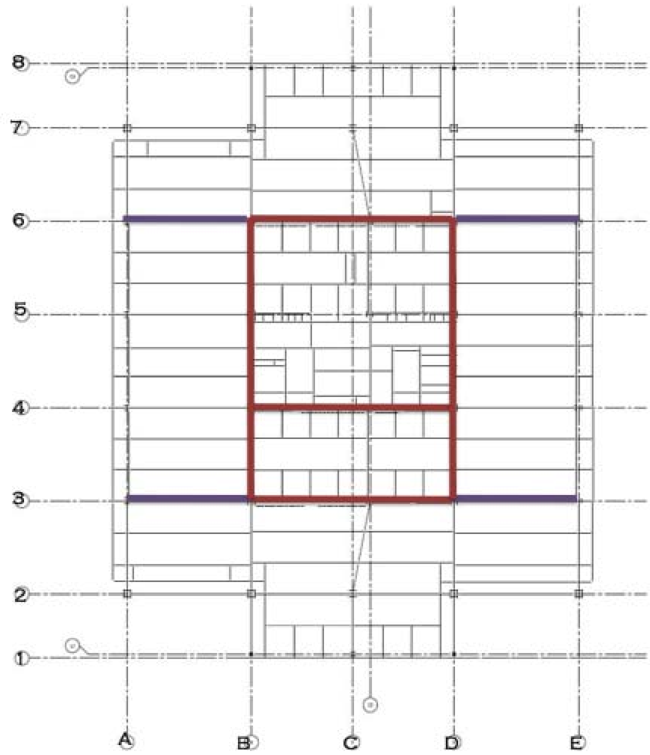


Figure 16: Lateral layout: Option 2

the locations of large duct runs and excessive material would have to be used to work around the system. The alternative, punching through the beams of the moment frames, is also far from ideal. In addition, the moment frames at grids B and D are not able to continue up past the outrigger level, and would have to be moved out of plane from the North-South system to connect to a column, decreasing the stiffness of the system.

Figure 16 depicts the second option, with moment frames and outriggers (purple) kept only in the East-West direction. Both lines of North-South bracing continue the whole way up the structure, unlike in the existing system. The extra bracing adds stiffness to the system in this direction, since moment frames did not prove to be a viable option. However, more steel is being added to the lateral system without any members being eliminated, which would result in a higher overall cost with an increase in structural weight. Therefore, this option does not seem viable for future study.

The third option, shown in Figures 17 and 18, eliminates one line of East-West bracing and adds moment frames (purple) only to the floors above the outrigger in the East-West direction. The two lines of North-South bracing are continued above the outrigger level instead of adding moment frames in this direction. This option eliminates some steel, but adds it back in other places, and would likely yield total steel closest to that of the existing system. Since the moment frames had a greater impact on the stiffness at higher floors, they were eliminated from lower floors to save steel. It also makes the lateral system completely symmetrical in both directions, effectively removing any inherent torsional forces from the system. This option seems like the most ideal of the three that were investigated, and will be analyzed further as an alternate to the existing system

For the final solution, moment frames were added on either side of the braced frames above the outrigger level in the East-West direction, as shown in purple in Figures 17 and 18. The number of frames in the North-South direction was increased from one to two to create symmetry, reduce inherent torsional forces, and eliminate the large bracing members. Figures 19 and 20 show the elevations of a typical bracing line in the North-South and East-West directions, respectively.

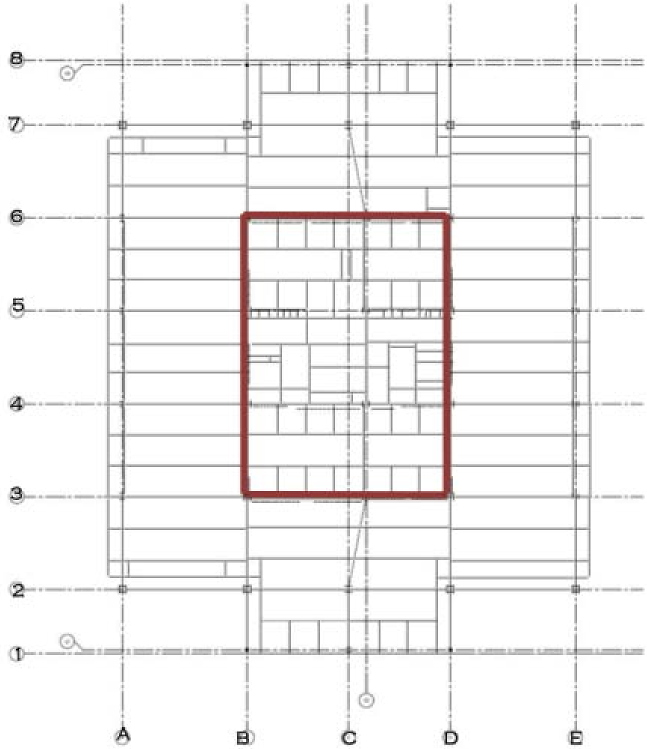


Figure 18: Lateral layout: Option 3 below 28th floor

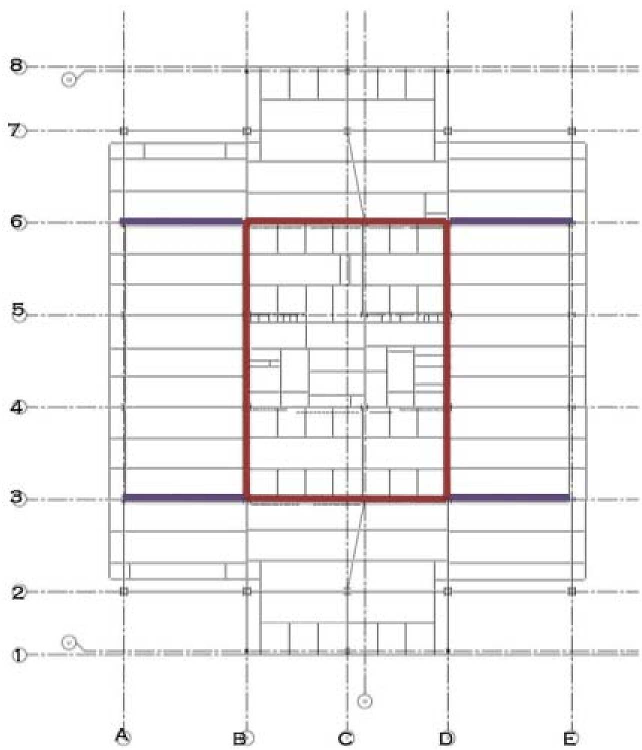


Figure 17: Lateral layout: Option 3 above 28th floor

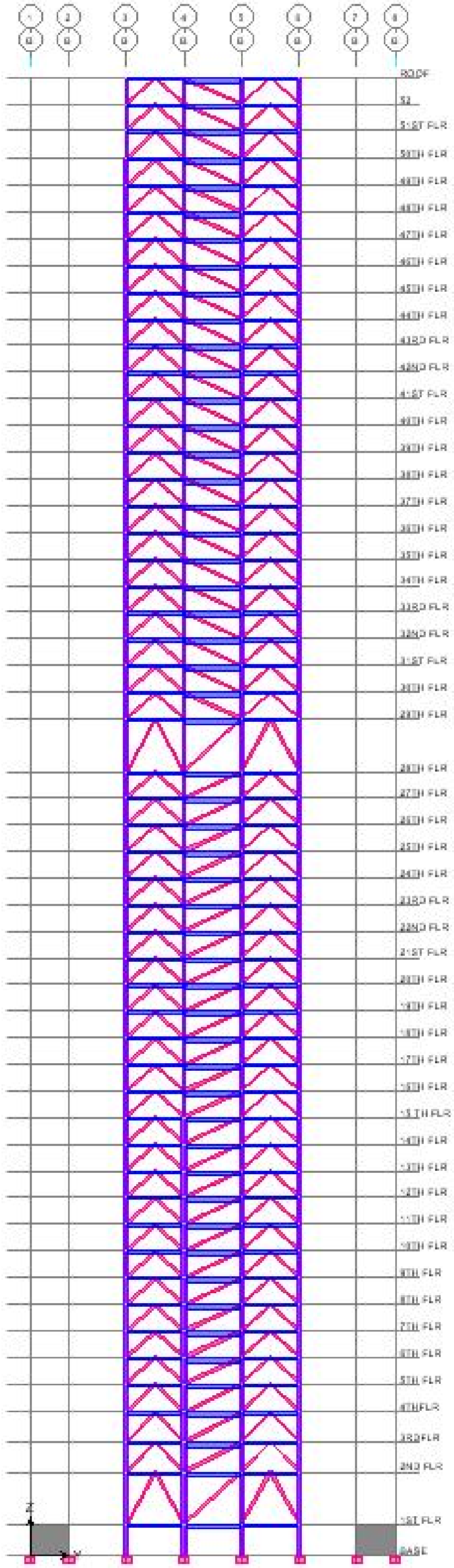


Figure 20: North-South bracing

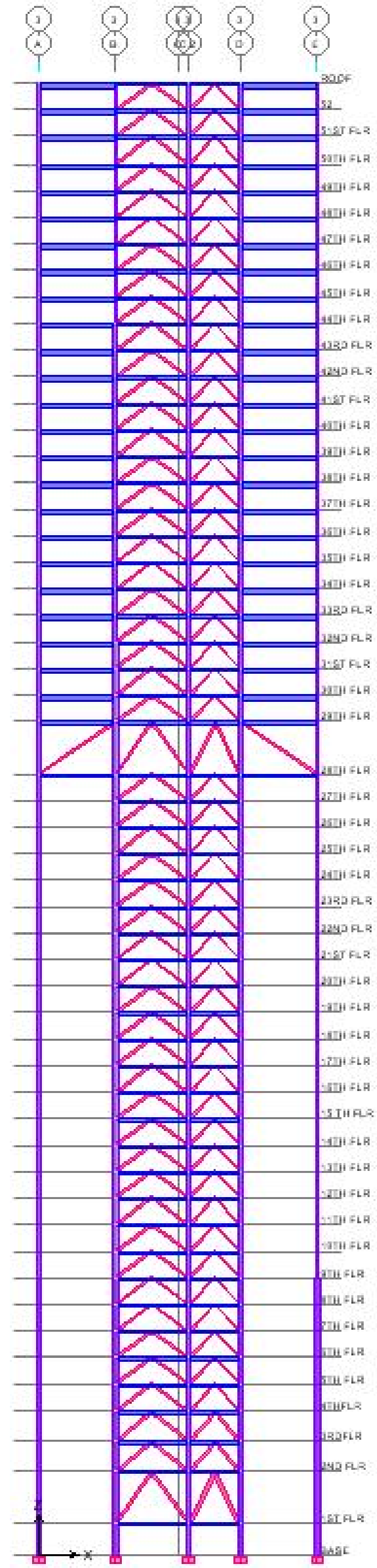


Figure 19: East-West bracing

LATERAL FORCE RESISTING SYSTEM ANALYSIS

A lateral model was created in ETABS (Figure 21) to analyze the structure, with rigid diaphragms used to model all floor plates except at the outrigger levels, where semi-rigid diaphragms were used to represent the actual floor stiffness based on its elements instead of an axially-rigid diaphragm. This way, the model can simulate much more accurately the effect of the outriggers. Column and beam members were modeled in three dimensions to include the effects of flexure, shear, axial, and panel-zone deformations in all directions. Panel zone modifiers were applied at the moment frame locations, and P-Delta effects were included in the analysis. Accidental torsion was included in the analysis through the 5% multiplier in ETABS; since the lateral system is symmetrical in both directions, the center of rigidity, center of pressure, and center of mass are in the same position, and inherent torsion did not apply.

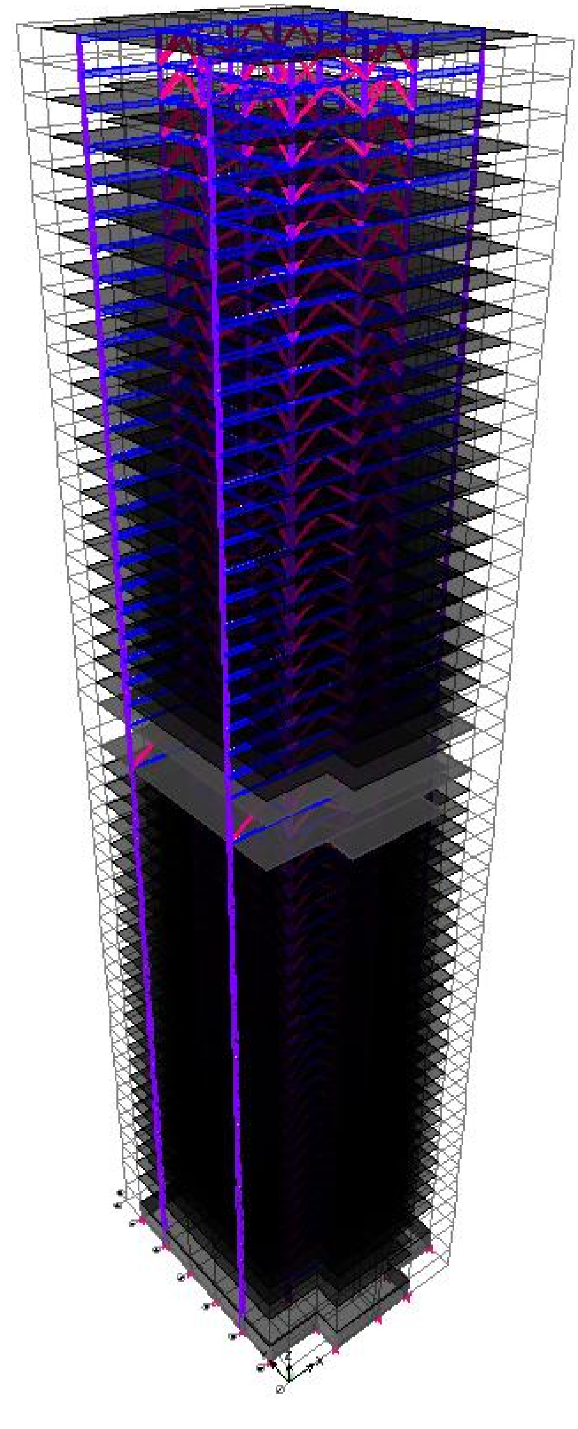


Figure 21: ETABS finite element lateral model

Existing column sizes were kept the same throughout this analysis; although the weight of the structure decreased slightly, it was not a large enough change to require a redesign of the members. These sizes can be viewed in Table 10 of Appendix 3.B. A column interaction check was performed in Excel for a member in each direction; this can be found in Table 8 of Appendix 3.A. All columns were okay for the LRFD combination of $1.2D + 1.6W + 1.0L + 0.5L_r$. In addition, beams not contributing to the moment frames were modeled with the same member size as in the existing system to allow for as close a performance comparison as possible.

Wind was found to be the controlling lateral force over seismic, with larger lateral loads at each level induced by the Case 1 loading condition in both the North-South and East-West directions; these values can be seen in Table 2. An Excel spreadsheet was developed, as shown in Table 9 of Appendix 3.A, to estimate the size of the bracing members based on strength to resist calculated wind loads; an LRFD combination of $1.2D + 1.6W + 1.0L + 0.5L_r$ and importance factor of 1.15 were applied to the base shear in each direction. Base shear values were obtained from Thornton Tomasetti and distributed by factors along the height of the building. After the brace member sizes based on strength were found, they were modeled in ETABS to determine whether the sizes were also acceptable for the drift and period requirements specified above. From there, members were further optimized to meet these requirements; by comparing the sizes in Tables 9 and 11 in Appendix 3.A and 3.B, it can be seen that all members needed to be increased in size from their strength values.

Table 11 of Appendix 3.B shows the lateral sizes of the existing and new systems; existing bracing members range from W14x68 to W14x455. The new system's braces range from W14x53 to W14x176; they can be smaller because of the stiffness contribution of the moment frames. Brace sizes were determined through ETABS iterations and comparisons to the initial design criteria. Each moment frame beam was designed as W30x132 in order to successfully control wind drifts and lower the periods to their required levels; iterations were performed after an initial estimate was made based on member flexural strength to reach this final section. A similar design approach was taken for the outrigger members that attach to the exterior columns; they were sized initially based on an estimate of their existing section depth of about 2 feet (as built-up members). However, a slightly smaller section of W14x342 was required based on strength checks in the redesigned system. The total structural weight of each system was calculated, and the new system was found to be 3.5% lighter than the existing, at 21.2 pounds per square foot versus 21.9 pounds per square foot existing.

The final lateral design had a period of 6.69 seconds in the East-West direction and 6.26 seconds in the North-South direction with the torsional period of 4.39 seconds. Drifts due to wind were slightly under a maximum of 19.9 inches (H/450) required by Thornton Tomasetti; in the East-West direction, drift due to wind was17.9 inches, and in the North-South direction, drift was 13.4 inches. ASCE 7-05 commentary permits the wind forces to be reduced using the combination 1.0D + 0.5L + 0.7W. Drifts due to seismic forces were tabulated in Excel and checked against $\Delta_a = 0.015*h_{sx}$; the story drifts from ETABS were adjusted for the actual periods as well as for the response modification factor of 3.25 and the importance factor of 1.25. Every story drift was below the maximum, and the total building drifts in both directions, 12.9 in the East-West and 11.9 in the North-South, were also well under the overall drift limit of H/450 =19.9 inches, as shown in Table 7 of Appendix 3.A.

Overturning calculations were performed for both directions of the building, as shown in Figure 27 of Appendix 3.B, since the total weight of the structural system decreased slightly. The weight of the building still proved to be more than sufficient to prevent overturning of the structure; the overturning force was approximately 1/3 less than that of the resisting building weight. The reduced weight of the structure also potentially has an effect on the size of the foundations; however, the owner has not disclosed detailed information on foundation sizes, capacities, or geotechnical data, so a redesign for comparison could not be performed.

The architectural impact of the extra line of North-South bracing on the upper floors was also considered; although it creates a wall where there previously could have been open space, the layout is no different than the lower New York Times floors. In addition, a wall in the East-West direction was eliminated, allowing for more flexibility in that direction to make up for the constraints in the North-South. The cost differences of these systems can be found in the construction section of this report.

THERMAL MOVEMENT STUDY

The thermal effects on the exposed columns of removing the top-level outrigger were investigated, since this outrigger and truss system controlled thermal shortening and lengthening of the columns. By eliminating this system at the 51st story, length changes due to thermal fluctuations are no longer controlled and can cause serious problems with the structure. According to Mark Fintel and Fazlur Khan, these length changes are cumulative, building up to a large change at the top of a structure (1967). With an assumed temperature change of 120 degrees Fahrenheit between the inside and outside, based on assumptions made by the design team, the columns can shorten or lengthen

Δ = 0.00000645 in/in-°F * (12in * 357.5’) * 120°F = 3.32 inches

over half the height of the building. This assumes that the outriggers at the 28th floor control the movement of the lower half. If the columns lengthened or shortened 3.32 inches between the 28th floor and the roof, this could cause substantial “racking of floor slabs and consequently a distortion of partitions” (Fintel & Khan 1967). This distortion due to thermal movement can be seen in Figure 22; there is a subsequent rotation at the corner of the partition, causing separation from the wall and ceiling, which could be damaging to interiors.

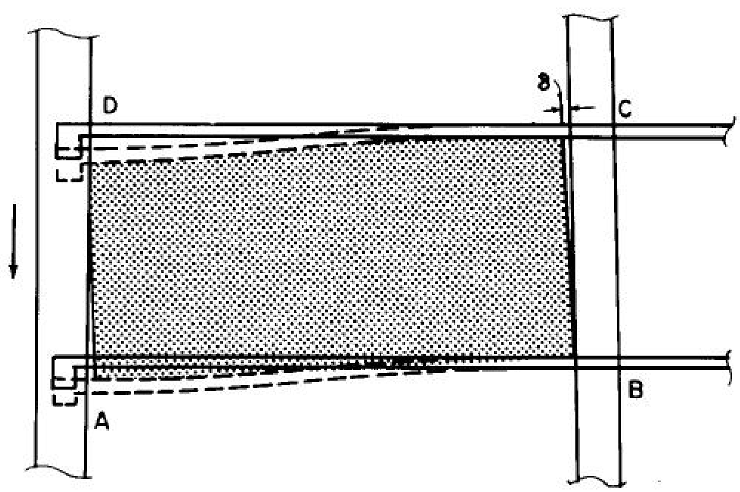


Figure 22: Partition displacement due to thermal movement of columns

In addition to thermal shortening and lengthening, another issue caused by weather-exposed columns is the effect of the temperature gradient through their width (Fintel & Kahn 1967). This can cause bowing of the members, as one side may shorten or lengthen more than the other due to the temperature change. However, Fintel and Kahn claim that bowing is typically controlled by the column's connections to the rest of the structural frame. They also state that a relative movement of approximately ¾ inches over 36 feet of height should not cause stress issues "requiring special structural details" (1967).

One option for controlling differential movement is to heat or cool the columns based on the exterior temperature, similar to the system implemented in the United States Steel Building in Pittsburgh, Pennsylvania (Seigel 1967). Water is pumped through the hollow columns in the US Steel Building, but the water serves a different purpose: fire protection. The water was intended to regulate the temperature of the columns under extreme heat, since the column steel was exposed to the environment, but this system could also be used in general to control temperature differentials (Seigel 1967). Since the exposed columns of the New York Times Building are built-up box columns, there is space for pipes to be installed within the steel plates to control temperature change of the exterior structural members. However, this would require constant monitoring to heat and cool a large amount of water depending on the ambient temperature, and would lead to additional energy consumption.

A second option is to place a truss on the roof of the building, connecting the exposed columns between grid 1 and grid 8. The outrigger system of the existing structure includes a belt truss connected to the exterior columns to restrain potential movement; the United States Steel Building in Pittsburgh has a similar "hat" framing structure to control movements, shown in Figure 23 (Civil Engineering 1970). This truss could be covered by the exterior shading system, invisible from below, and could be very similar in size as the removed belt truss system at the top floor of the existing structure. This system seems like a more viable solution, and since the steel would only serve the purpose of serviceability, it would not need to be fireproofed.

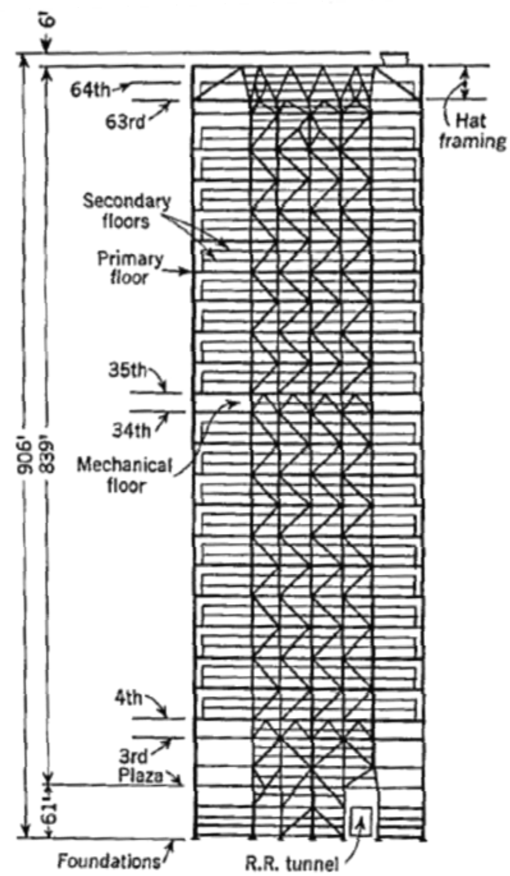


Figure 23: Hat truss on US Steel Building

PROGRESSIVE COLLAPSE ANALYSIS

PROGRESSIVE COLLAPSE MITIGATION THEORY

Progressive collapse has long been a concern in engineering, but is less common today due to the inherent redundancy of modern structural systems. However, large sections of some buildings are still susceptible to collapse, as demonstrated by the 1995 Alfred P. Murrah building failure in Oklahoma City. Although blast loads initiated the failure, "the majority of the 168 fatalities were due to the partial collapse of the structure" (DoD 2009). Now, due to a heightened awareness for attacks in the United States, guidelines are being followed in designing prevention systems for new government buildings, and these methods can also be applied to other high-occupancy or high-risk structures.

The General Services Administration Progressive Collapse Analysis Design Guidelines take a "threat independent" approach to limit the potential for progressive collapse; this means that they do not consider different types of blasts and other threats that could lead to the removal of a column or wall section. It also does not assume that the result of any type of threat is column or wall removal; this simulation is only used as a "load initiator." The correct way to execute this removal for the analysis is to remove the clear span between floors, as seen in Figure 24 below (GSA Figure 5.7 2003).

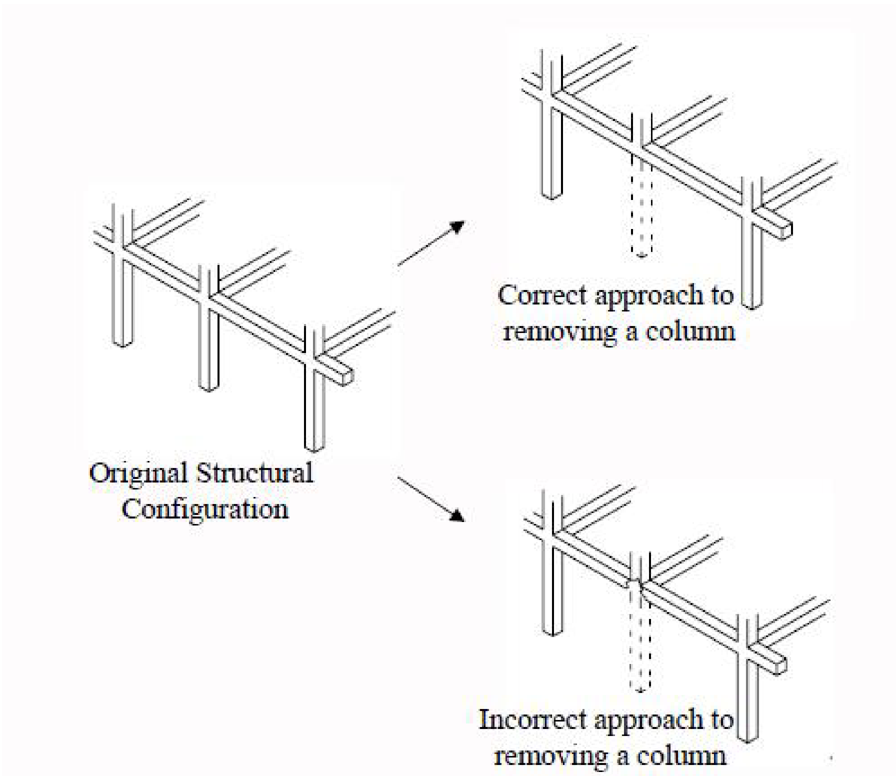


Figure 24: Proper column removal per GSA 2003 Progressive Collapse Guidelines

Typically, the linear procedures for analysis of structures are confined to buildings less than 10 stories, rendering this procedure less than ideal for the 52-story New York Times Building. However, an iteration of this linear-static finite element analysis was performed anyway as a basis of comparison for the progressive collapse study, even though potential non-linear effects of the high-rise structure were ignored. The linear-static procedure entails creating a finite-element model and applying a load equivalent to 2(DL + 0.25LL), cumulatively, at each floor above the removed column.

The shear and moment effects in the beams are then compared to their plastic moment capacity, making sure the ratio of demand to ultimate force (Demand-Capacity Ratio) is less than the prescribed limits contained within the document. The procedure for this analysis can be seen below in Figure 25, from GSA 2003. If no DCR values are exceeded, the structure has a low potential for progressive collapse. However, if the DCR values continue to be exceeded outside of the adjacent bays, the structure has a high potential for progressive collapse.

The step-by-step procedure for conducting the linear elastic, static analysis follows.

Step 1. Remove a vertical support from the location being considered and conduct a linear-static analysis of the structure as indicated in Section 5.1.2.2. Load the model with 2(DL + 0.25LL).

Step 2. Determine which members and connections have DCR values that exceed the acceptance criteria provided in Table 5.1. If the DCR for any member end or connection is exceeded based upon shear force, the member is to be considered a failed member. In addition, if the flexural DCR values for both ends of a member or its connections, as well as the span itself, are exceeded (creating a three hinged failure mechanism – Figure 2.2), the member is to be considered a failed member. Failed members should be removed from the model, and all dead and live loads associated with failed members should be redistributed to other members in adjacent bays.

Step 3. For a member or connection whose Q_{UD}/Q_{CE} ratio exceeds the applicable flexural DCR values, place a hinge at the member end or connection to release the moment. This hinge should be located at the center of flexural yielding for the member or connection. Use rigid offsets and/or stub members from the connecting member as needed to model the hinge in the proper location. For yielding at the end of a member the center of flexural yielding should not be taken to be more than ½ the depth of the member from the face of the intersecting member, which is usually a column (Figure 5.6).

Step 4. At each inserted hinge, apply equal-but-opposite moments to the stub/offset and member end to each side of the hinge. The magnitude of the moments should equal the expected flexural strength of the moment or connection, and the direction of the moments should be consistent with direction of the moments in the analysis performed in Step 1.

Step 5. Re-run the analysis and repeat Steps 1 through 4. Continue this process until no DCR values are exceeded. **If moments have been re-distributed throughout the entire building and DCR values are still exceeded in areas outside of the allowable collapse region, the structure will be considered to have a high potential for progressive collapse.**

Figure 25: GSA 2003 Progressive Collapse Linear Elastic Static Procedure

After this study is completed, a nonlinear-static analysis can be performed to assess plastic hinge formation. Virtual work can be used to do this by hand, or a nonlinear-static finite element model can be created. This model entails applying nonlinear moment hinges to all restrained connections in the model, and assigning to these hinges the plastic moment capacities and acceptable rotations for the member. This way, members can be increased in size to reach an acceptable level of plastic moment capacity.

BLAST THREAT STUDY

Different blast threat scenarios were studied to determine which case would lead to the greatest potential failure of the structure due to progressive collapse. Due to the wide range of blast loading possibilities, a base assumption of a removed column due to any blast was made; this assumption is in accordance with the GSA's 2003 Progressive Collapse Analysis Design Guide. According to the Department of Defense, there are a few main areas that are at the highest risk for a potential attack: attached or basement parking structures, sidewalks, and publicly accessible spaces in the building (2009). Since the New York Times Building has no public access to its basement level, and no parking structure, the most unrestricted location for a blast damage to originate was assumed to be near the public café area on the ground floor that sits along 8th Avenue in New York City. This café is adjacent to a large column at a re-entrant corner that supports an area of 2825 square feet per floor. The re-entrant corner was also selected because it had the greatest effective area framing into it, and the column is exposed on the exterior of the building. Of course, there is no way to predict whether or not this column is most susceptible, or that any other column would be more susceptible. However, for the sake of scope, this column will be analyzed as the origination of a progressive collapse mechanism.

STATIC ANALYSES

The column removal scenario was then analyzed according to the 2003 General Services Administration Progressive Collapse Analysis Design Guidelines using the Linear-Elastic and Nonlinear-Elastic Methods. The linear-elastic method utilizes a two-dimensional finite element model in ETABS to determine the response of the structure due to a removed column. All beam members were assumed to be rigidly connected to the columns, and member sizes were taken from a typical floor of the New York Times Building. The GSA factored load was applied as a point load at every floor above the removed column. The induced moments and shears in adjacent members were then tabulated in Excel, and Demand Capacity Ratios were calculated based on the plastic moment of each member and compared to the minimum acceptable values. Since members are required to be redesigned to meet the DCR values, the first time through the procedure was enough to prove that redesign was necessary; all members failed the flexural check and some failed the shear check, and redistribution of loads was not performed. For each failed member, the required plastic moments of the beams above the removed column were found, and members were upsized using the 13th Edition Steel Manual. These sizes and calculations are available in Table 12 of Appendix C.3. The member sizes in the frame were all increased significantly to the point where cost would lead designers to question upsizing as a viable option. This indicates that a linear-static analysis of the New York Times building is not the end-all solution; loads likely redistribute out to other frames as they move up the structure, but this method does not take that into account. Figure 26 shows the deformation of the structure due to the removal of the reentrant corner column.

The nonlinear-elastic method was performed by hand using a virtual work analysis (Figures 28 & 29 and Table 14, Appendix C.3). The resisting frame was analyzed for plastic hinge formation on the beams at their supports, and values were obtained for the maximum allowable downward force. At 154.1 kips per floor, this force was much less than the actual 397.8 kip force acting on the frame. Consequently, it was necessary to redesign the system based on calculated required plastic moments. A spreadsheet was developed to simplify the process, but below the 37th floor, the plastic moments required are larger than any rolled shape in the AISC manual, as

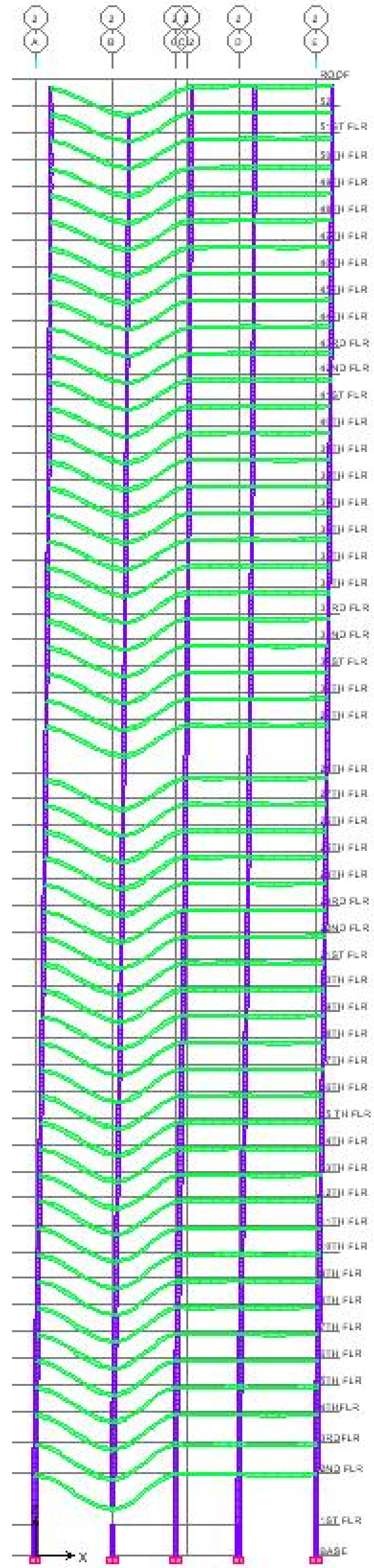


Figure 26: Deformation due to column removal at grid B

shown in Table 13 of Appendix C.3. Built-up members would have to be designed to provide this moment, but the cost and logistical implications of this redesign prove that it is not a viable option. The mass of the sections is exponentially greater than that required for the gravity system, and the increased cost of rigid connections to carry this type of load would be much larger than those of the existing system. This analysis also does not consider the contribution of any members other than those in this particular frame; in a real life situation, the load would likely be distributed to many more surrounding members. In addition, the virtual work method does not allow for a check of rotations, which is an essential part of the nonlinear dynamic procedure. A nonlinear-elastic model can also be developed in ETABS, applying nonlinear hinges to resisting beam members with defined rotational and moment constraints. However, this was not included in the scope of the structural thesis analysis.

It was somewhat surprising that the linear-elastic model yielded such small members compared with the nonlinear-elastic analysis; however, this could be due to the use of virtual work and the redistribution of loads provided by the adjacent bays in the ETABS model.

The third, nonlinear dynamic procedure utilizes a load combination of 1.0D + 0.5L, half of that required for the static procedures. This considers the in- and out-of-plane member characteristics and load redistributions as a function of time, and it should be considered in further detail in a complete analysis of the building structure. However, it is also not contained within the scope of this report.

The Department of Defense's Anti-Terrorism Standards for Progressive Collapse Resistant Structures Linear Static and Nonlinear Static Procedures were also considered as a comparison to the GSA procedures. For these analyses, a finite element model must be created following modeling criteria and procedures discussed in Chapter 5 of ASCE 41. There is no allowance for a two-dimensional or hand analysis to be performed, and the load combination required is $\Omega(1.2D + 0.5L)$, with the Ω increase factor depending on the element in question. This amounts to a slightly higher applied load, as Ω is typically very close to 2 (DoD 2009). In addition, these guidelines require that each primary member be labeled as either force- or deformation-controlled based on its failure mode. Then, a model containing all primary elements is developed and results are compared using an LRFD-like method, i.e. $\phi Q \geq Q_u$, based on either force or deformation, instead of to a Demand-Capacity Ratio. A time-dependent loading is also applied to the structure for the nonlinear procedure to simulate the loading condition during a progressive collapse scenario. Rotations from ASCE 41 are used to determine the adequacy of flexural members (DoD 2009). Overall, the guidelines seem similar, with a few more multipliers, which were assumed to produce more refined results.

MASTER OF ARCHITECTURAL ENGINEERING INTEGRATION

The Master of Architectural Engineering requirements for the structural senior thesis were met by integrating and further exploring knowledge obtained in many master's courses. Progressive collapse of building structures was discussed in the Failures and Forensics course as a problem affecting buildings with too little redundancy; it was demonstrated that this type of structural design could lead to disastrous results in the presence of an abnormal loading condition. This course facilitated an interest in this type of domino-effect collapse that was explored further within the structural thesis. In addition, knowledge of ETABS obtained in the Computer Modeling of Building Structures course was used extensively for all lateral and gravity models and analyses completed for the structural thesis. These methods are explained thoroughly within their respective sections. A thermal study was also completed as a mini-depth to cover all bases concerning the lateral system redesign. References used for each of these studies can be found in the reference section of the report.

MECHANICAL ROOM RELOCATION

To optimize the building's use of enclosed floor space, the existing mechanical room on the 51st floor will be moved to a penthouse on the tower's roof. In most cases, the mechanical floors in the existing New York Times Building were underutilized in terms of floor space. These low space requirements allowed for the 51st floor mechanical room to be easily relocated to the roof. The existing equipment space requirements according to the design drawings are given below. These areas include the clearance requirements for the equipment and also apply a 50% area allowance for connections to piping and ductwork.

EQUIPMENT SPACE REQUIREMENTS FOR THE EXISTING 51st MECHANICAL FLOOR		
Equipment	Quantity	Total Area (sf)
Domestic hot water pumps	3	14
Fire protection pump	1	7
Condensate pumps	2	48
Heating hot water pumps	2	24
Expansion tanks	2	20
Condensate cooler	1	16
Heat exchangers	2	32
Elevator shaft exhaust fan	2	24
General exhaust fan	1	12
Smoke purge fan	1	40
Outdoor air units	2	784
	Subtotal	1,021
	Total (including 50% distribution)	1,532

Table 4: Mechanical equipment area

The existing roof had a few large items which took up a large portion of the area. Four 10,000 gallon water tanks were used for domestic water and fire protection, 2,000 gallons and 7,500 gallons respectively. Six cooling towers and a platform for which façade maintenance is performed surrounded the mast in the center of the floor plate. In addition to these items, a five foot setback from the exterior walls was taken from the available open roof area for aesthetic purposes. T he relocated equipment fit well within the available space and the details are included below. In addition, the relocated equipment will be placed within an insulated penthouse and equipped with unit heaters for freeze protection.

Equipment	Quantity	Total Area (sf)
Total available roof area (with 5' setback)	-	18,060
10,000 gallon domestic water tanks	4	420
Cooling towers	6	1,456
Façade maintenance platform	1	2,408
Relocated equipment	-	1,532
Remaining roof area	-	12,224

Table 5: Relocated mechanical areas

CONCLUSIONS

The goals of the structural redesign phase included creating a penthouse level for high-end tenants to bring in revenue, and eliminating the need for the expensive architecturally-exposed X-braces. This required an overall increase in stiffness of the rest of the lateral system. In addition, one braced frame in the East-West direction was replaced with moment frames adjacent to the other two East-West braced frames on the floors above the 27th mechanical floor. To create complete symmetry within the system, the two North-South braced frames were continued up the entire height of the structure with smaller bracing members. Overall, 3.5% of the structural weight was saved through the redesign of the system. This new system also met the criteria set up in the beginning for drift and periods, with the maximum wind drift at 17.9 inches (under the required 19.9 inches) and a period of 6.70 seconds in the North-South and 6.26 seconds in the East-West direction.

Although the removal of the outrigger on the 51st floor also eliminated the possibility of a mechanical space at that level, the equipment was able to be relocated to the roof without a problem. A study was done to determine the amount of space currently occupied by the mechanical equipment at the 51st floor; this area was compared to the total area available on the roof, which came out to be more than enough to allow relocation. There are also no height restrictions on the roof, so the move did not create any other issues.

Thermal movement of the exterior exposed columns was also considered, since the primary form of restraint was removed to create a penthouse floor. It was determined that the optimal solution would be to add a truss to the roof, spanning between the exterior columns, in order to control the lengthening and shortening of these columns relative to the interior.

The progressive collapse resistance of the structure was also analyzed according to the 2003 General Services Administration Progressive Collapse Analysis and Design Guidelines. The New York Times Building was assumed to be a “high profile” structure, and a column at a reentrant corner was removed to initiate the progressive collapse loading condition. This column was selected because it has exterior accessibility and supports the greatest total area of the exterior columns, although it is recognized that no one can predict a blast threat. The GSA linear-static and nonlinear-static finite element procedures were both performed and proved that the building is not inherently progressive collapse resistant. Members were redesigned based on the ratio of the demand to capacities of the members. The linear-static procedure yielded much smaller required member sizes than the nonlinear-static procedure, but this is potentially due to the use of a virtual work analysis in replace of a nonlinear finite element model. It was determined that a redesign of the entire building to mitigate progressive collapse would not be a viable option, due to the large size of upsized members and moment connections required.

The 2009 Department of Defense Unified Facilities Criteria: Design of Buildings for Progressive Collapse was also studied thoroughly and compared to the GSA method. These standards consider more parameters based on the individual beam, column, and connection elements, which possibly makes this analysis more accurate. In addition, the load applied to the structure with this method has a larger dead load factor. Instead of the DCR ratios, the DoD method utilizes an LRFD-like comparison for each member.

PHASE SUMMARY

Phase IV: Distribution Systems and Coordination is the final phase of the analysis of the New York Times Building and consists of three distinct parts. First, several significant changes were made to mechanical and electrical systems in Phase II. In this phase, alternative means of distribution for these new mechanical and electrical systems were investigated with respect to both performance and cost.

Next, in this phase the results of the design decisions made in Phases I-III are brought together and coordinated with one another using BIM-related software such as Autodesk Navisworks. It is important to note that the analysis and design that took place in the first three phases were constantly coordinated across all disciplines due to the heavy focus on integrated project delivery methods. BIM software was merely used as a tool to either affirm or refute the design choices made in earlier phases.

After coordinating any design conflicts, the possibility of reducing critical path schedule time through the usage of 4D modeling and short interval production scheduling (SIPS) techniques will be analyzed for a typical floor. The results of the schedule changes will then be compared to the existing building with respect to a typical floor and with respect to the New York Times Building as a whole.

ELECTRICAL SYSTEMS DISTRIBUTION

While investigating different possibilities for electrical distribution, an analysis of the option to change the existing feeder system in the New York Times portion of the building to an aluminum conductor, copper bus duct, or aluminum bus duct was performed. The analysis is done from the existing distribution panels in the basement to the 38th floor as designed in the existing system. The existing copper installation uses nine runs of four sets of 500 mcm copper cables within 3-1/2" conduit. Assumptions were made for the equivalent load from all nine sets of feeders supplying the floors. The use of 500 mcm cable as the existing cable provides an idea of the load per set. With the allowable load of 320 amperes per cable, it was assumed that a 300 ampere breaker would be used. This 300 ampere load was multiplied by a 0.8 factor to allow for the overdesign of the conductors per NEC 2008 Section 215.2.A.1, and provided a 240A load potential for each set. This, multiplied by the nine sets of feeders, results in a full load of 2160 amperes per side of the building.

For estimating the lengths of each run, a basement height of 15 feet, basement horizontal run of 70 feet, basement ceiling to lobby height of 35 feet, floor to floor height of 13'-9" for the office floors, and an additional five feet per termination is added for installation. For cost analysis, the 2007 RS Means cost based on 10% overhead and 10% profit were used with materials and labor added together. This information yields the following results for each analysis.

Conductors:			Units	Mat + Lab	With O & P*
	Copper	500mcm [1]	L.F.	$17.07	**$19.99**
	Aluminum	750mcm [2]	L.F.	$8.01	**$10.18**
Conduit:					
	EMT	3-1/2" [3] for copper	L.F.	$22.30	**$28.06**
	EMT	4" [4] For Aluminum	L.F.	$24.98	**$31.61**
Bus Duct:					
	Copper	2500A	L.F.	$835.52	**$980.79**
		2500A - Elbow	Ea.	$3,434.67	**$4,054.37**
		2500A - Cable Tap Box	Ea.	$5,127.94	**$6,279.75**
	Aluminum	2500A	L.F.	$721.66	**$827.70**
		2500A - Elbow	Ea.	$3,462.02	**$4,081.72**
		2500A - Cable Tap Box	Ea.	$4,662.30	**$5,639.63**

[1] Comes from drawing IE.5100

[2] To find equivalent Aluminum size, table 310.169 in the 2008 National Electric Code (NEC) is used. 500 60oC cable can accommodate 320 amperes; the equivalent size in Aluminum is 750 mcm.

[3] Existing installation used 3-1/2" conduit; from drawing IE.5100

[4] Table C.1 in the NEC 2008 was used to find what size conduit for four (4) 750mcm cables.

500mcm - Copper Conductors - Existing Conditions

From DP to Floor __	Price	Length	Length + 5'per termination	Number	Total	3-1/2" - Conduit Price	Length	Total
4	$19.99	175	205	4	$16,421.79	$28.06	175	$4,921.02
7	$19.99	217	247	4	$19,750.12	$28.06	217	$6,089.02
10	$19.99	259	289	4	$23,078.46	$28.06	259	$7,257.02
13	$19.99	300	330	4	$26,406.79	$28.06	300	$8,425.02
16	$19.99	342	372	4	$29,735.13	$28.06	342	$9,593.01
19	$19.99	384	414	4	$33,063.46	$28.06	384	$10,761.01
22	$19.99	425	455	4	$36,391.80	$28.06	425	$11,929.01
25	$19.99	467	497	4	$39,720.13	$28.06	467	$13,097.01
28	$19.99	508	538	4	$43,048.47	$28.06	508	$14,265.00
				TOTALS:	**$267,616.13**			**$86,337.11**
	Price per side	**$353,953.24**						
	Price Both sides	**$707,906.48**						

750mcm - Aluminum Conductors

From DP to Floor __	Price	Length	Length + 5'per termination(6)	Number	Total	3-1/2" - Conduit Price	Length	Total
4	$10.18	175	205	4	$8,362.87	$28.06	175	$4,921.02
7	$10.18	217	247	4	$10,057.84	$28.06	217	$6,089.02
10	$10.18	259	289	4	$11,752.81	$28.06	259	$7,257.02
13	$10.18	300	330	4	$13,447.78	$28.06	300	$8,425.02
16	$10.18	342	372	4	$15,142.75	$28.06	342	$9,593.01
19	$10.18	384	414	4	$16,837.72	$28.06	384	$10,761.01
22	$10.18	425	455	4	$18,532.69	$28.06	425	$11,929.01
25	$10.18	467	497	4	$20,227.66	$28.06	467	$13,097.01
28	$10.18	508	538	4	$21,922.63	$28.06	508	$14,265.00
				TOTALS:	**$136,284.75**			**$86,337.11**
	Price per side	**$222,621.86**						
	Price Both sides	**$445,243.73**						

2500A - Copper Bus Duct						
From DP to Floor __		**Price**	**Units**	**Length**	**Number**	**Total**
28	Bus	$980.79	LF	508	1	**$498,609.12**
	Elbows / Up / Downs	$4,054.37	EA	-	5	**$20,271.85**
	Taps	$6,279.75	EA	-	28	**$175,833.00**
					Sub Total:	**$694,713.97**

Price per side	**$694,713.97**
Price Both sides	**$1,389,427.93**

2500A - Aluminum Bus Duct						
From DP to Floor __		**Price**	**Units**	**Length**	**Number**	**Total**
28	Bus	$827.70	LF	508	1	**$420,781.99**
	Elbows / Up / Downs	$4,081.72	EA	-	5	**$20,408.60**
	Taps	$5,639.63	EA	-	28	**$157,909.64**
					Sub Total:	**$599,100.23**

Price per side	**$599,100.23**
Price Both Sides	**$1,198,200.46**

Results:		
	Existing:	**$707,906.48**
	Aluminum Alternate:	**$445,243.73**
	Copper Bus:	**$1,389,427.93**
	Aluminum Bus:	**$1,198,200.46**

As shown by the results, changing the risers from conductor in conduit to bus duct almost doubles the cost of the existing system. However, the change from copper to aluminum conductors shows a savings of $262,662.75. Economically, aluminum would be a better alternate for the existing system. However, aluminum is vulnerable to expansion and contraction as it heats up when current begins to pass through the cable. This movement could have adverse effects on connections by potentially pulling the cable out from a termination, causing damage and loss of power. With this in mind, the existing system is a better overall choice.

For this same run, a short circuit analysis was performed. The importance of a short circuit analysis is to find the potential energy available at any point, should there be a major failure of any device at any point on the circuit. This energy value helps size and determine the type of breakers, panel boards, and other critical equipment. The higher the short circuit rating, the more potential energy available at the fault, thus the equipment must be designed to resist the massive energy release of the fault. This could cause equipment to break or fall if improperly sized resulting in even more damage. The energy flows from the distribution panel to the 28th floor into the lighting panel, and then goes into a 75kW transformer which ends in a 208Y/120 volt general electrical load panel. An Excel spreadsheet was created and used for this analysis. Please refer to Appendix IV.C for analysis and results.

A circuit breaker coordination study was also done for this run. The importance of this study is to ensure that if a fault occurs at any point along the branch circuit or anywhere along the load path, the nearest breaker reacts first in opening the circuit path. If not done properly circuits that are not on the affected circuit may be shut off. For this particular coordination, the following breakers were used: 1) 300A breaker in the distribution panel, 2) 150A breaker in the lighting panel LP-8-1 on the 28th floor, and 3) 20A breaker leading to a lighting circuit. For the results of this coordination and the timing curves, please refer to Appendix IV.A. The results indicate a potential issue if a large fault occurs, which may trip both the 20A and the 150A breakers depending on the amount of current drawn by the fault and also the duration of the fault. An alternate 20A breaker may be needed. For a specification sheet of the panel board that will be used in a standard electrical closet, please refer to Appendix IV.B. The LP-8-1 panel was redesigned after the lighting redesign for the 8th floor. The new loads applied to this panel are as follows:

PANELBOARD SIZING WORKSHEET										
Panel Tag-------------------------->					LP-8-1	Panel Location:			8th Floor Electrical (1)	
Nominal Phase to Neutral Voltage------->					277	Phase:			3	
Nominal Phase to Phase Voltage-------->					480	Wires:			4	
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	SW	2695	w	0.95	2695	2837	
2	A	Lighting	3	S	2268	w	0.95	2268	2387	
3	B	Lighting	3	SE	2895	w	0.95	2895	3047	
4	B	Lighting	3	NW	2895	w	0.95	2895	3047	
5	C	Lighting	3	N	2268	w	0.95	2268	2387	
6	C	Lighting	3	NE	2695	w	0.95	2695	2837	
7	A	SPARE	9		0	w	1.00	0	0	
8	A	SPARE	9		0	w	1.00	0	0	
9	B	SPARE	9		0	w	1.00	0	0	
10	B	SPARE	9		0	w	1.00	0	0	
11	C	SPARE	9		0	w		0	0	
12	C	SPARE	9		0	w		0	0	
13	A	SPACE			0	w		0	0	
14	A	Subfeed	9		40000	w	1.00	40000	40000	
15	B	SPACE				w		0	0	
16	B	Subfeed	9		40000	w	1.00	40000	40000	
17	C	SPACE				w		0	0	
18	C	Subfeed	9		40000	w	1.00	40000	40000	
PANEL TOTAL								135.7	136.5	Amps= 164.3

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL		A					45.0	45.2	33%	163.3
PHASE TOTAL		B					45.8	46.1	34%	166.4
PHASE TOTAL		C					45.0	45.2	33%	163.3
LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		15.7	16.5		15.7	16.5	0.95		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		120.0	120.0		120.0	120.0	1.00		
Total Demand Loads						135.7	136.5			
Spare Capacity			20%			27.1	27.3			
Total Design Loads						162.9	163.9	0.99	Amps=	197.2

These loads result in a panel board schedule as follows:

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: LP-8-1
PANEL LOCATION: 8th Floor Electrical (1)
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	SW	2695	20A/1P	1	*			2	20A/1P	2268	S	Lighting
Lighting	SE	2895	20A/1P	3		*		4	20A/1P	2895	NW	Lighting
Lighting	N	2268	20A/1P	5			*	6	20A/1P	2695	NE	Lighting
SPARE		0	20A/1P	7	*			8	20A/1P	0		SPARE
SPARE		0	20A/1P	9		*		10	20A/1P	0		SPARE
SPARE		0	20A/1P	11			*	12	20A/1P	0		SPARE
SPACE		0	20A/1P	13	*			14	100A/3P	40000	Transformer	Subfeed
SPACE		0	20A/1P	15		*		16	100A/3P	40000		Subfeed
SPACE		0	20A/1P	17			*	18	100A/3P	40000		Subfeed
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	44.96	TOTAL DESIGN LOAD (KW)	162.86
CONNECTED LOAD (KW) - B Ph.	45.79	POWER FACTOR	0.99
CONNECTED LOAD (KW) - C Ph.	44.96	TOTAL DESIGN LOAD (AMPS)	197

MECHANICAL DISTRIBUTION

GENERAL SELECTION

The conclusion of the air distribution study performed by the mechanical team was that although underfloor air distribution (UFAD) systems are appealing to owners, they have significant life-cycle performance issues which must not be overlooked. Further research by the design team has led to the conclusion that the UFAD system will be removed in favor of another means of air distribution. Citing an article published by the Testing Adjusting and Balancing Bureau, UFAD is a system with much potential, but more work needs to be done to perfect the actual implementation. Common pitfalls in UFAD systems include indoor air quality issues, water collection causing structural failure when sprinklers are activated, and most commonly thermal comfort issues stemming from under- or over-pressurization. UFAD may be an attractive system in the design stages, but experience proves that there are many conflicts which need to be resolved.

Upon removal of the existing UFAD system as the primary means of air distribution, it was determined that a raised floor system would be an economical solution to meet the owner's requirements of having a flexible floor plan. The new proposed raised floor would be 6 inches in height and provide convenient access to electrical, telecom and other utilities. The original proposal for the mechanical distribution system redesign was to compare an overhead ducted variable air volume (VAV) system with a dedicated outdoor air system (DOAS) utilizing active chilled beams (ACB). However, it was found that it would not be practical to implement the all-air VAV option due to new space requirements for the structural redesign established in Phase III. The issue was that the main corridor through which all ductwork needed to pass was surrounded by stairwells and elevator shafts. The floor layout required two large ducts (approximately 24" by 80" each) to pass through a 30' beam. The team was not satisfied with this amount of structural penetration to be required on each floor. Figure 1 below depicts a recreation of the circumstance which caused the elimination of the VAV option.

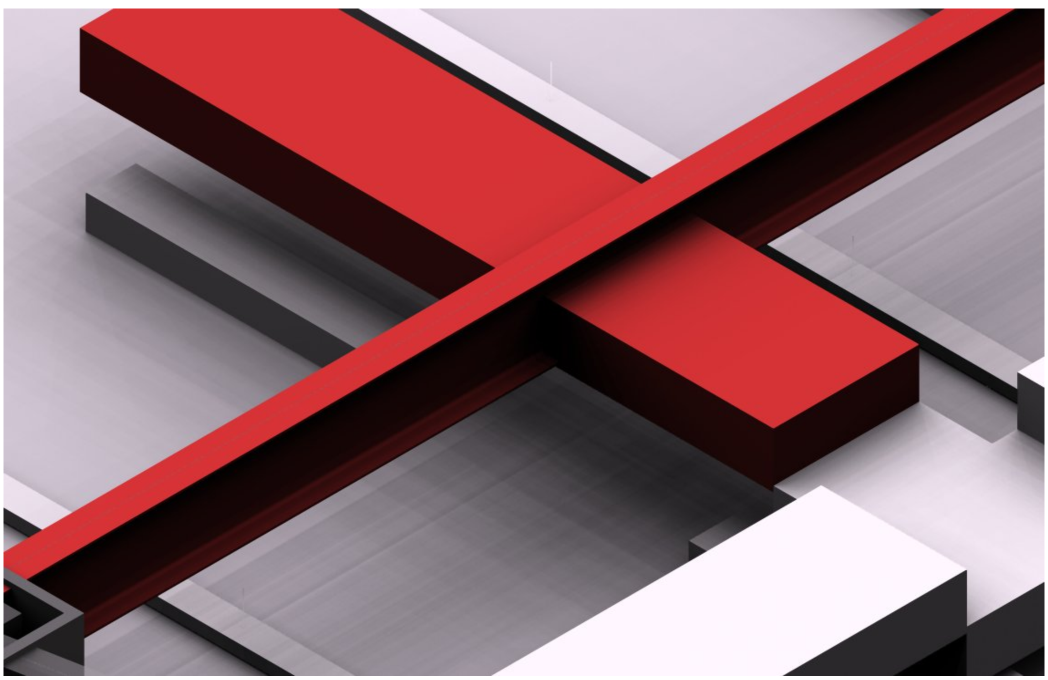


Figure 1: Beam and duct clash in core corridor

NEW SCOPE FOR REDESIGN

The proposal for redesigning the New York Times Building indicated that both alternative systems would be evaluated based on first cost, life-cycle cost, maintenance considerations and occupant flexibility. Since only one system could actually be implemented, no comparison between the two systems was performed. Instead, the DOAS with ACBs option was researched concerning all of the above criteria. An energy model in TRACE was created for the typical floor, but it was only used for the purpose of sizing the floor-by-floor components and does not reflect the performance of the system in the building as a whole.

CRITERIA FOR DOAS WITH ACBS REDESIGN

Other than the obvious plenum space restrictions, DOAS was implemented with ACBs for two other reasons; demand controlled ventilation (DCV) was assumed to be necessary in the redesign because this technology was included in the existing HVAC system. DCV pairs very well with DOAS, because both systems seek to only use as much ventilation air as the real-time building conditions dictate. More on the implementation of DCV in the redesigned system is included later in this report. Secondly, DOAS with ACBs was chosen because the additional mechanical room space requirements were not an issue; the existing mechanical rooms were underutilized.

Research suggests that DOAS in an office building is best implemented when the ventilation and heating/cooling requirements are decoupled. ASHRAE Std. 62.1 provides criteria for ventilation air requirements of typical occupancy types. Oftentimes, the amount of ventilation air alone is not enough to meet the thermal requirements of the space. Traditional all-air HVAC systems have an outdoor air percentage of around 20% to 40% of total air volume, which is more than enough air to effectively manage the temperature of the space.

The goal of a DOAS system with decoupled heating and cooling is to remove all latent loads by the use of an outdoor air unit, and then deliver the dry ventilation air into the space for further sensible load removal. A major design consideration is to ensure that the dew point is low enough so that condensation will never occur on the terminal units (in the case of this design, the terminal units are the ACBs). If the dew point is reached, water damage and long-term indoor air quality issues may arise. For this reason, latent loads must be precisely managed by reducing infiltration and monitoring humidity within the space. Research conducted by Dr. Stanley Mumma indicates that a dew point of 45ºF is the recommended benchmark to maintain year-round humidity control. In addition, compliance with ASHRAE Std. 55 can be achieved under summer conditions with a supply air temperature of no higher than 55ºF. As long as the system and building operators are proactive about moisture control, this system should cause no significant long-term maintenance issues that are out of the ordinary for all mechanical systems.

Some additional considerations for ACBs add a new layer of complexity to the mechanical system. The reduced quantity of air being delivered to the space requires better air mixing properties of the terminal unit. An active chilled beam design guide published in the ASHRAE Journal suggests that mixing ratios (discharge air to primary air) of up to 6:1 can be achieved. The redesign specifies a lower value of 5:1 for acoustic reasons. To ensure the proper mixing ratio is met, the static pressure at the terminal unit must be fairly high. For proper air induction, a value of 0.8 in. wg will be maintained at the terminal unit. According to ASHRAE Std. 55, occupants can tolerate higher air velocities is the discharge air temperature is closer to the space condition. For this reason, a discharge air temperature for the cooling mode of 64-66ºF at 30 [fpm] should be maintained. To ensure that the dew point is never met within the space, the temperature of the chilled water running through the ACB must be lowered. The design guide suggests raising the chilled water supply temperature to 57-61ºF. Instead of raising the chiller plant setpoints, a tempered chilled water loop for each floor will maintain the proper coil temperature.

SYSTEM SELECTION

Figure 2 below depicts the general zoning scheme for a typical office floor. The redesigned mechanical system will mostly be comprised of chilled beams, using TROX as the basis of design (included in Appendix IV.D). Perimeter zones will be heated by finned tube radiators concealed within the raised floor. Perimeter finned tube was chosen so that when a floor has a heating request in the unoccupied mode, the OAU serving half the building does not need to turn on. The perimeter finned tube also modulates to meet heating demand under normal operation conditions. Any miscellaneous zones that have high heating loads, such as telecommunications and electric rooms, are served by fan coil units. The typical floor plan was divided into quadrants, the purpose of which will be discussed in the next section.

SYSTEM COST ESTIMATE

The following table represents a general cost estimate for the total cost of installing the DOAS/ ACB mechanical system. All cost data was obtained from RS Means Costworks (Online Database)

Material	Quantity	Unit	Unit Cost	Cost Per Floor	Cost for NYT Spaces
Ductwork and Connections	11,400	lb	$0.76	$8,664.00	$242,592.00
Chilled Beams	161	EA	$800.00	$128,800.00	$3,606,400.00
VAV Box and Connections	44	EA	$18.00	$792.00	$22,176.00
Outdoor Air Units	2	EA	$26,100.00	-	$52,200.00

Labor	Quantity	Unit	Unit Cost	Cost Per Floor	Cost for NYT Spaces
Ductwork and Connections	11,400	lb	$8.86	$101,004.00	$2,828,112.00
Chilled Beams	161	EA	$217.00	$34,937.00	$978,236.00
VAV Box and Connections	44	EA	$57.33	$2,522.52	$70,630.56
Outdoor Air Units	2	EA	8778	-	$17,556.00
			Total:	$276,719.52	$7,800,346.56

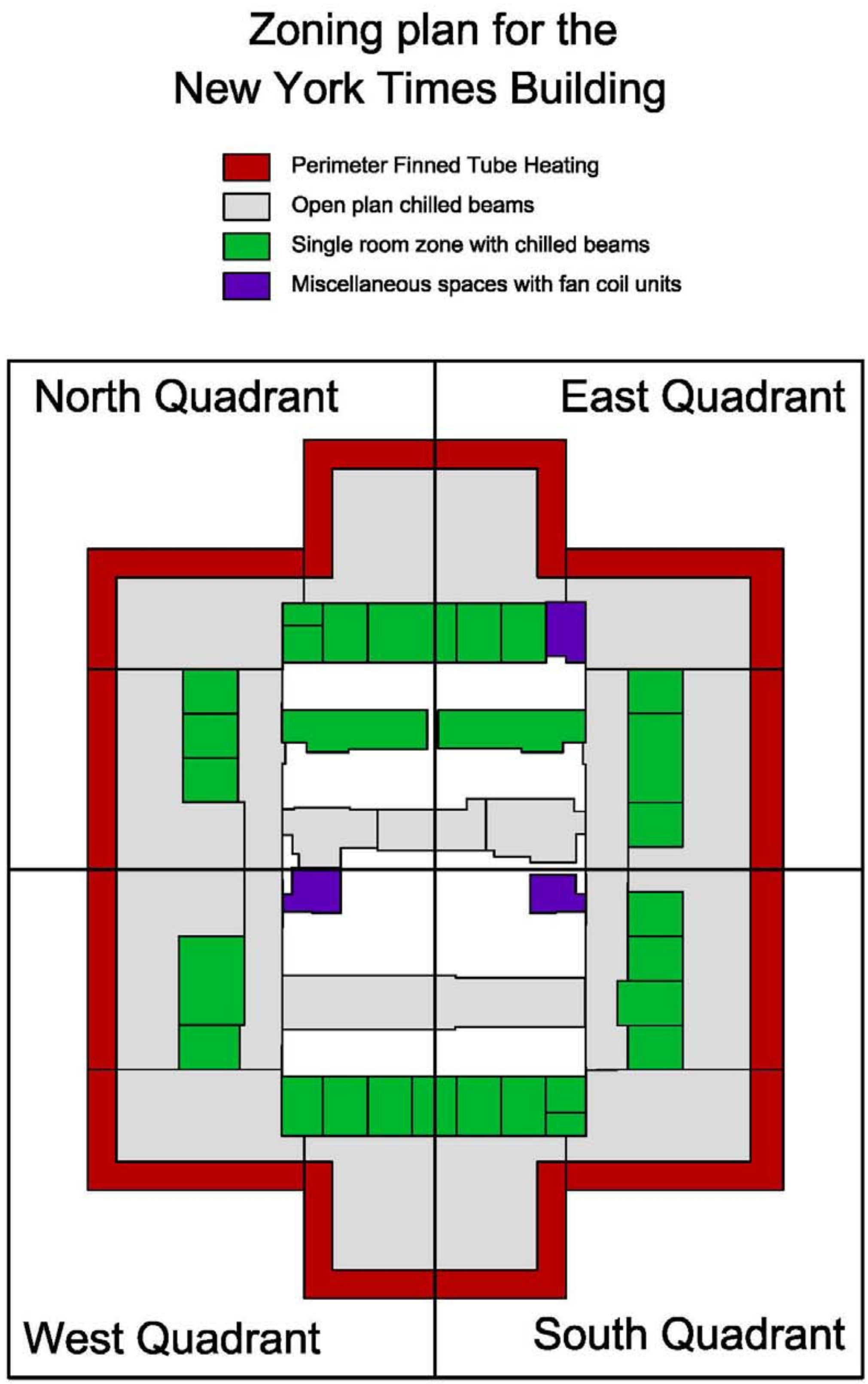
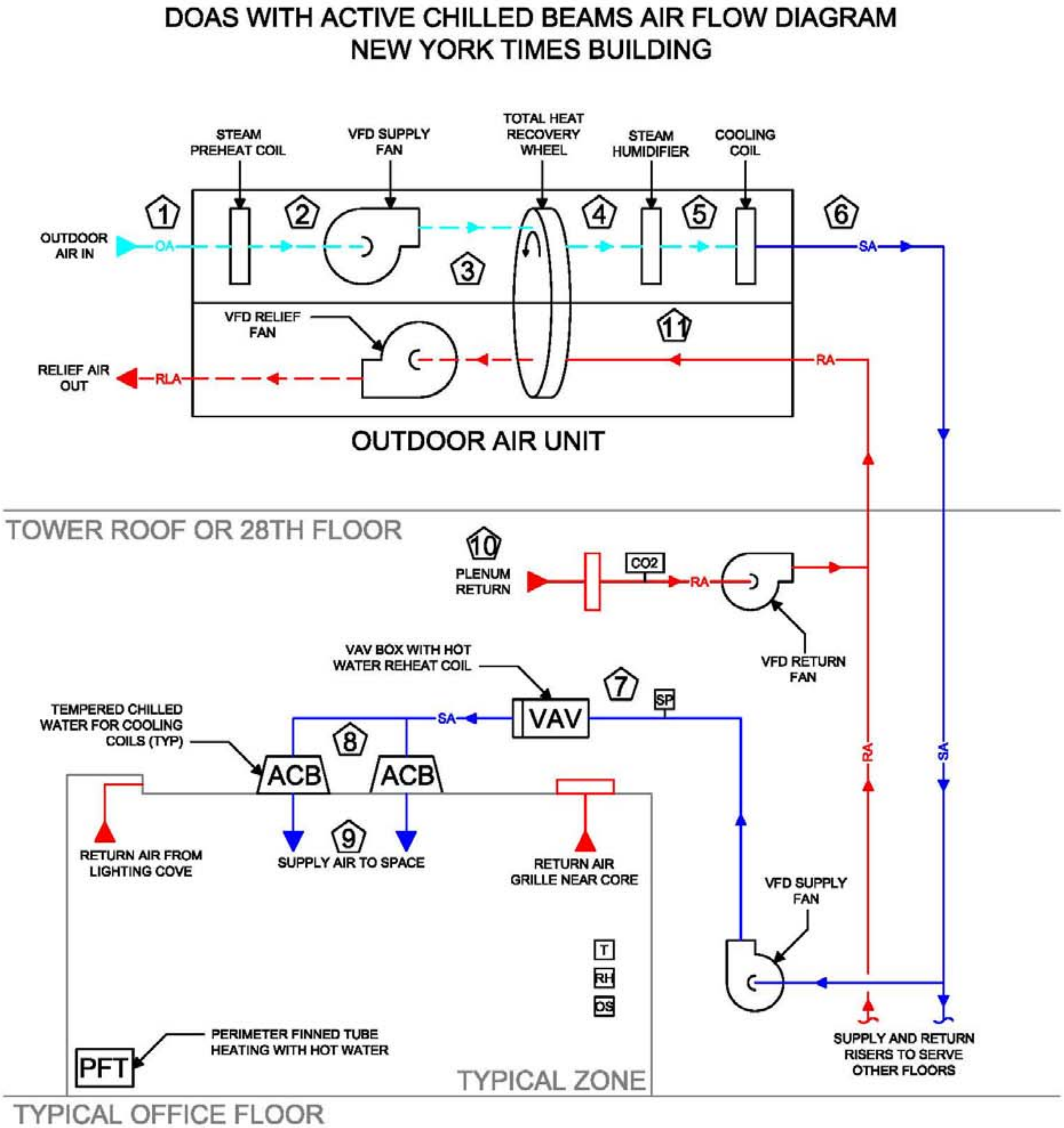


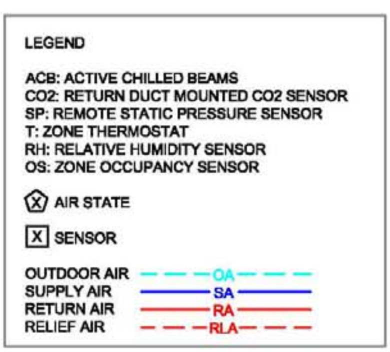
Figure 2: Mechanical zoning plan

SYSTEM OPERATION

The airflow diagram below depicts a general schematic for the operation of the redesigned mechanical system. The hydronic and CHP diagrams from Phase II have been revised to reflect the new requirements of the DOAS with ACB system and are included in Appendix IV.E. The air states were based on design guidelines obtained from research and psychometric calculations. These calculations can be found in Appendix IV.F. The general operating characteristics for the system are as follows:

- Outdoor Air Unit
  - The purpose of the steam preheat coil is for freeze protection of the energy wheel.
  - The OAU supply fan is sized according to ASHRAE Std. 62.1 OA requirements for a total of 25 floors using a diversity factor of 0.8.
    - Supply fan size: 55,000 [CFM]
  - The energy wheel rotates between the two airstreams with an effectiveness of 0.64.
    - This effectiveness was calculated based on uneven flow due to building pressurization.
  - The steam humidifier operates in the winter when space humidity ratio is below 0.006 [lb H2O/lb DA].
  - The cooling coil modulates to meet the required supply air dew point temperature.
- Floor-by-floor
  - The supply fan for each floor is sized to meet the ASHRAE Std. 62.1 minimum ventilation requirements plus an additional 30%. This amounts to a 2,500 [CFM] supply fan.
  - A TRACE model of a typical floor was created to size the peak terminal unit cooling load. The zone-by-zone chilled beams were sized using this criteria.
  - The tempered chilled water loop consists of a constant volume pump and a heat exchanger connected to the building chilled water loop. A three-way valve regulates the flow through the heat exchanger to meet the tempered chilled water setpoint.
  - The zone thermostat controls the amount of tempered chilled water flowing through the chilled beams. The thermostat can also reset the supply air temperature if all zones are not requiring terminal cooling.
  - The occupancy sensor is to be installed in all single-zone rooms. The occupancy sensor will allow the VAV box to reset back to the ASHRAE Std. 62.1 specified room area ventilation requirement instead of the total ventilation requirement.
  - A CO2 sensor is installed in the return duct of every floor quadrant to reset the floor-by-floor supply fan if the minimum CO2 concentration is met.
  - A relative humidity sensor is installed within the breathing zone of each floor quadrant. If the space condition is reaching the dew point on the coils, the temperature of the tempered chilled water is reset.





AIR STATE / EQUIPMENT	SUMMER OPERATION			WINTER OPERATION		
	DRY BULB	WET BULB	EQUIP. STATUS	DRY BULB	WET BULB	EQUIP. STATUS
1 (OA)	88	72		15	15	
PREHEAT COIL			NOT RUNNING			FREEZE PROTECTION
2	88	72		35	28	
3	90	72		37	29	
ENERGY WHEEL			MAINTAIN MIN. DPT			MAINTAIN MIN. DPT
4	83	67		51	41	
HUMIDIFIER			NOT RUNNING			MAINTAIN MIN. RH
5	83	67		65	53	
COOLING COIL			MAINTAIN MIN. DPT			NOT RUNNING
6	45	45		65	53	
7	48	46		67	54	
REHEAT COIL			NOT RUNNING			NOT RUNNING
8	48	46		67	54	
9 (SA)	65	57		72	55	
10 (RA)	78	64		74	56	
11	80	64		76	57	

Figure 3: Air flow diagram

TEAM WORKFLOW FOR COORDINATION PHASE

OVERVIEW

It is extremely important to note one key point about Phase IV: Systems Coordination: this phase was not the first time any interdisciplinary coordination was performed. Due to the heavy focus on Integrated Project Delivery, large and medium scale coordination took place across all disciplines on a near-daily basis throughout each of the first three project phases. The purpose of Phase IV: Systems Coordination was to focus exclusively on smaller-scale details- more specifically, the precise placement of building technical systems and their relationship to each other and the architecture of the New York Times Building.

At the beginning of Phase IV: Systems coordination, every other phase had been completed in its entirety. Aside from architecture, the work of design disciplines had been completed in specialized design software tailored to each specific discipline. There are two negative aspects of this workflow. First, excepting ETABS and RAM Structural System, many of these specialized software suites do not readily export their proprietary file formats into one that is utilized by BIM software. Secondly, as in the case of Trane TRACE, three dimensional modeling is not always considered by discipline specific software packages- some are used purely for calculation purposes and require separate modeling software. Autodesk Revit was chosen to be the primary modeling software for coordination, and one key feature, called *Worksets*, greatly increased interdisciplinary productivity.

BACKGROUND INFORMATION: WORKSETS

The chief feature of Autodesk Revit that allowed for interdisciplinary collaboration was the use of worksets. In many design firms that house multiple disciplines, a file management system is often in place that allows a group or a single individual to access a central database and “check out" a drawing for their own personal use, preventing others from accessing it until it is returned to the database. In an interdisciplinary design firm utilizing standard CAD files, most utilize a system of external file references and layers that allow them to have access to constantly-updated work of other disciplines and select which information they want to see at any given time, respectively.

Worksets in Autodesk Revit give design team members the ability to incorporate the functions of file withdrawal, the ability to reference the work of others, the ability to selectively view only information that is relevant to them, and the ability to have real-time updates from the work of other project team members.

Worksets are able to be defined in any way the user chooses; for the purposes of this analysis, each workset was defined very similarly to how layers are defined for a typical CAD drawing in an interdisciplinary design firm. Workset groups were created on a discipline by discipline basis (through naming designation) and then further categorized in greater detail (e.g.- specific equipment or fixtures) through the use of individual worksets. Figure 4 shows an open workset window.

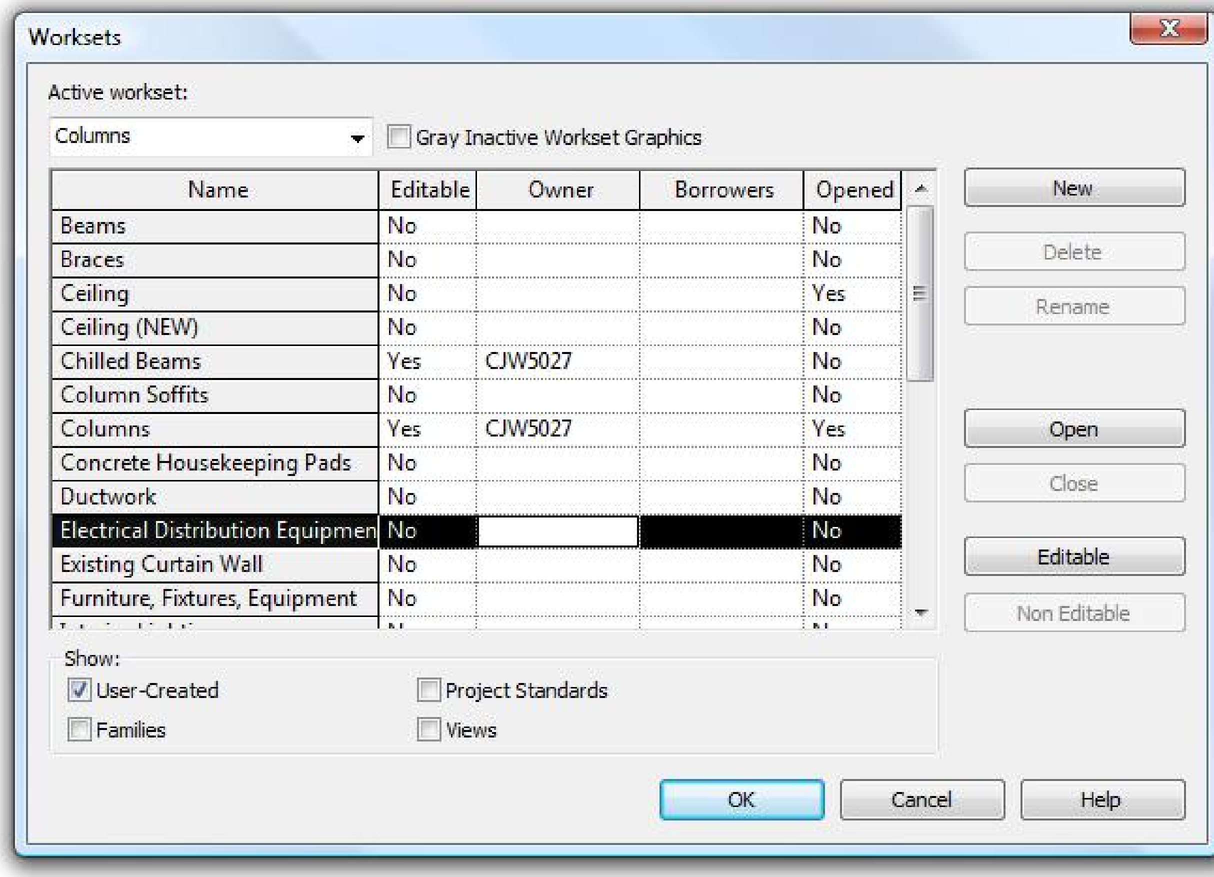


Figure 4: Shows a combination of worksets that are opened (viewable) and not editable (checked out), worksets that are editable by user CJW5027 but not opened, worksets that are opened but not editable, and worksets that are both checked out and editable.

The file structure of a project utilizing a workset method is vastly different than a project in a standard CAD format. When working on a project utilizing a standard CAD program, a large number of files are generated in order to communicate different aspects of the building. For instance, each floor is likely to be drafted architecturally, and then every other design discipline will reference this in their own system-specific drawings. When working with worksets, one central file exists and one local copy of the central file is created for each user.

In most cases, a user will only have access to their own local file. This local file essentially serves as a viewport into the central file; from the local file, a user can select which worksets from the central file they want to view, and which they want to have editing rights to by opening or setting the workset as editable, as shown in Figure 4 above. It is important to note that multiple project team members are able to open the same workset to view it for reference purposes, whereas only one user at a time can edit any given workset. Each workset that is being edited will display which user currently has editing rights (ownership) of the file, as indicated by the user "CJW5027" in Figure 4.

After opening the appropriate worksets from the central file for reference and selecting which worksets require editing permissions, a user then selects which editable workset they wish to work on. This is a direct analogy to choosing which specific layer to work on in a standard CAD file. Within an active workset, new elements can be added to that workset and existing elements can be modified.

TEAM COLLABORATION PROCESS

TASK FOCUSED VS. DISCIPLINE FOCUSED

In a typical design-bid-build delivery method, there are usually separate discipline-based firms (or departments within a firm) that work more or less independently from one another and coordinate at specific meeting times. Documents typically flow very linearly from one discipline to another, with each one adding to the design in succession and avoiding conflicts with the disciplines ahead of them.

Even if all of the disciplines are within the same firm, the integration between disciplines will not be as effective as if it had been a true integrated design project. Many systems have symbiotic relationships with one another and addressing them as a whole rather than how it impacts one particular discipline will be exponentially more effective for the building as a whole in comparison to standard design methods.

Information obtained from the book of the integrative design consultancy *7group*, titled The Integrative Design Guide to Green Building, was instrumental in designing the workflow and overall team collaboration process. In essence, the total project was divided into different successive phases (similar to bid packages on a fast-track design/build project) in which each discipline could offer design and construction feedback. In theory, if each phase is integrated across multiple disciplines, the entire project will be much more integrated upon completion.

This work pattern also has the inherent advantage of allowing for constant coordination across the design and construction periods of building construction. If one discipline intends to utilize a certain system, it is nearly guaranteed that other disciplines affected by this decision will be able to offer critical design feedback much earlier in the design phase and resolve any potential conflicts. In some cases, it is even possible for multiple designers to amplify the positive effects of another discipline by selecting systems that have more symbiotic relationships with one another.

In this configuration, leaders are more likely to emerge naturally based on experience in any given area, yet still allow for others to voice their opinions and expertise on any design phase. The fluid nature of leadership in a true integrated design project helps keep interpersonal tensions to a minimum and can increase overall team productivity.

COORDINATION RESULTS

OVERVIEW

The coordination process of the team was streamlined significantly due to the focus on integrated design from the outset of the project. Constant communication across multiple media allowed most coordination issues to be resolved well in advance of the systems coordination phase.

Due to difficulty in obtaining accurate information from the core and shell contractor (Amec), the coordination process focused entirely on the interior fit out phase (Turner portion) of the project. One typical New York Times floor was to be modeled and analyzed in BIM-related software to investigate interdisciplinary conflicts and potential resolutions. Choosing to model one floor allowed for all major changes to be represented, while still having an appropriate baseline to compare to in the existing design.

CLASH DETECTION

The results of the first Navisworks clash detection analysis for the proposed redesign are shown Figure 6. Above all else, it is important to note that there were zero clashes between a very large number of major system elements. This can be attributed to the heavy focus on Integrated Project Delivery from the early stages of the project- any potential coordination issues were known and solved well in advance of them becoming a major conflict, and well in advance of final design integration.

Every redesigned system was included in the clash detection model; however, several items were omitted from the analysis that would have been included in a model intended for construction. Most notably, sprinkler heads and lines, plumbing lines, and electrical conduit have been omitted. However, if these systems had been integrated into the coordination model, it is safe to assume that there would have been minimal coordination issues due to a large amount of open plenum space. In most cases there will be approximately 9" to 11" of open plenum space to run overhead plumbing and sprinkler lines. The electrical conduit is run through a raised access floor with 6" of plenum space- it is assumed that this is more than sufficient for the distribution purposes of any one floor.

Several important parameters used in the clash detection process are shown in Figure 6- T*ype, Tolerance, Found, and Left/ Right* were the most relevant factors to this analysis. A "Hard" clash type refers to the situation in which two objects physically occupy the same space. This can be changed to "Clearance" or "Duplicates" to signify when two objects do not intersect physically but do come within a specified radius or are identical geometry overlaid on top of one another, respectively. A tolerance of zero indicates that any physical infraction will be labeled as a clash by the analysis program. The *Found* number indicates how many clashes were found in the analysis. The *Left* and *Right* panes indicate which systems are being checked for clashes; the systems in the *Left* pane are being examined for clashes with systems in the *Right* pane. In this particular case, clashes between the structural system and itself were not analyzed because meeting points between structural elements currently register as hard clashes.

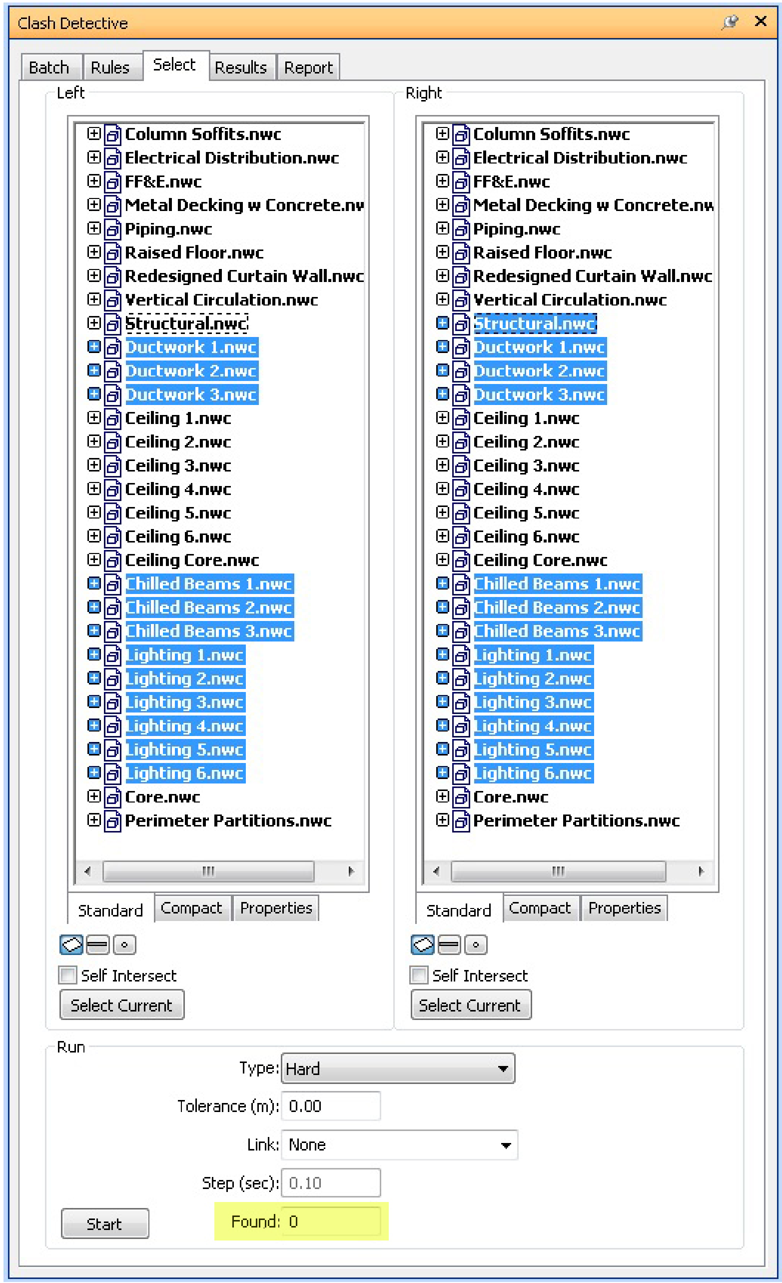


Figure 6: Navisworks clash detection

TRADE FLOW AND SCHEDULE ANALYSES

After finishing physical and sequential coordination processes, analysis of the 4D construction model allowed led to the creation of six distinct assembly zones as shown in Figure 7. These zones were intended to stagger the trades as closely as possible in a manner very similar to a Short Interval Production Schedule (SIPS) by dividing the work into equal portions. Each trade is intended to enter the next zone as the trade in front of them completes work.

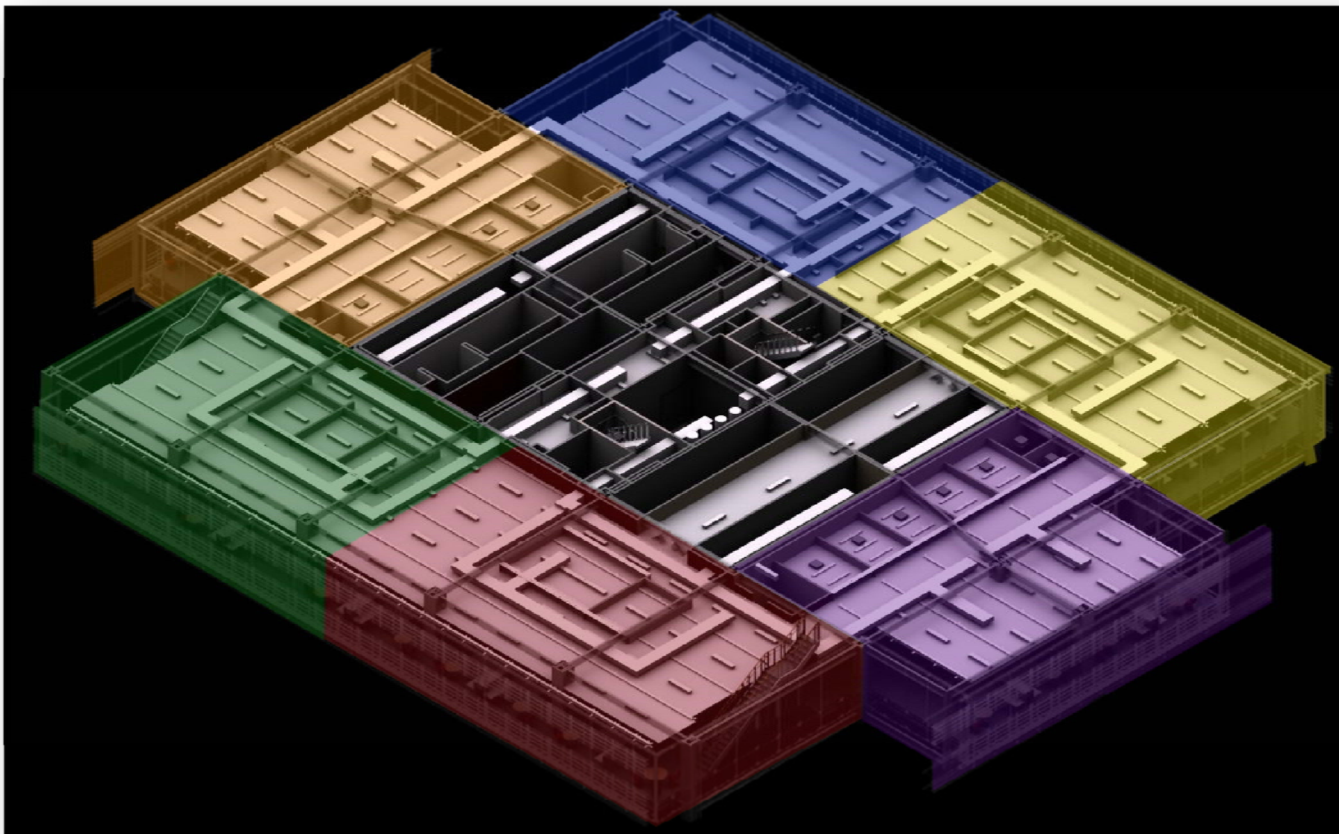


Figure 7: Six construction zones for the short interval production schedule

Excepting the crews installing ductwork and chilled beams, each trade was assumed to have the same daily output work rate as in the construction of the existing building. In the case of the sheet metal contractors, two crews were necessary in order to cut back on a very high schedule time (40 days based on RS Means daily output of 285 pounds of sheet metal installed/ day); two crews were also required for the installation of the chilled beams (160 units total at 6 units per day per crew, 13.3 days total).

SCHEDULE REDUCTIONS AS A RESULT OF ANALYSIS

In the case of the original interior fit out, the schedule was controlled by the placement of the UFAD mechanical components, as shown in Appendix IV.G. While this system may have streamlined the coordination process in the original design, the system was also a significant barrier to tightly coordinating trades in a short interval production style schedule.

In the redesigned dedicated outdoor air system with active chilled beams, the schedule was still controlled by the installation of the mechanical system. However, due to the simplicity of the overhead system, trades could be sequenced much closer together in a near SIPS-style pattern. This resulted in a savings of 6.33 days per floor on the interior fit out portion of construction- applied to all of the NYT spaces, this will reduce the total fit out time (and allow sooner owner occupancy) by 178 days total.

Total Interior Fit Out Time (Days)

	Typical Floor	Schedule Savings in NYT Spaces
Existing Building	77	0
Redesigned Building	70.67	177.27

For more detailed schedule information on the interior fit out spaces, please refer to Appendix IV.H.

CONCLUSIONS

Changing the risers from conductor in conduit to bus duct almost doubles the cost of the existing system. However, when considering aluminum conductors there is a potential savings of $262,662.75. Unfortunately, aluminum is vulnerable to expansion and contraction as it heats up when current begins to pass through the cable- this movement could have adverse effects on connections by potentially pulling the cable out from a termination, causing damage and loss of power. Based on these factors, the existing conductor in conduit design is a more economically and technically viable solution.

Due to space limitations, the only proposed system that would work within the redesigned building was the dedicated outdoor air system with active chilled beams. The redesigned system is more complex than the UFAD or ducted VAV systems, but it provides superior comfort throughout the year. Even though a whole building energy model was not created for the DOAS with ACBs option, a previous energy study conducted by the mechanical team indicated that this system has lower operating cost and energy use compared to the baseline system.

Based on the results of the 3D coordination analysis analyzed with BIM-related software, the integrated project delivery focus was very successful having preemptively eliminated clashes between any major building system. By using the integrated model for a typical floor, a SIPS technique was used to reduce the completion time per floor by almost 7 days, accounting for a reduction in 177 days of interior fit out time.

SUMMARY OF ANALYSES

PHASE I: FACADE REDESIGN

- Increased potential energy savings from dimming while decreasing overall energy load
- Reduced number of fixtures required per floor by approximately 50%
- Minimized direct solar glare
- Maintained architectural and owner vision of building transparency
- Reduced the annual energy consumption by 23%

PHASE II: COGENERATION PLANT REDESIGN

- Devised a method for building operators to implement a cap on purchased peak electrical demand
- Increased the installed electric generating capacity from 1,400 kW to 3,265 kW
- Reduced the annual building operating costs by 20% compared to the existing CHP system

PHASE III: LATERAL SYSTEM REDESIGN

- Redesigned moment and braced frame lateral system eliminates inherent torsion and reduces required steel by 3.5% while maintaining Thornton Tomasetti's performance requirements
- Removed outrigger at 51st floor to create two additional rentable floors (including a penthouse) to bring in additional revenue
- Analyzed building for progressive collapse resistance; analysis indicates it is not currently resistant according to GSA and DoD standards, but increasing sizes based on static methods does not seem to be a cost effective option

PHASE IV: DISTRIBUTION SYSTEM AND COORDINATION

- Concluded that bus ducts were not a cost effective replacement for wire in conduit
- Replaced existing UFAD system with a more simple raised floor for utility access
- Chose DOAS with ACBs because of reduced space requirements and superior thermal comfort
- Focused on team IPD to allow for constant coordination; zero system clashes were found on the first clash detection analysis
- Achieved a 177 day schedule reduction for the interior fit out portion of the project- 3D coordination model allowed for the creation of 4D models that ultimately aided in utilizing SIPS techniques

SUMMARY OF FINANCES

The costs shown below only reflect those of systems that have been suggested for implementation based on technical analysis. Negative numbers reflect an increased cost, whereas positive numbers represent a savings.

Phase I: Façade Redesign*

	Material	Labor	Typical Floor Cost	Total Building Cost
Existing Façade	$810,414	$45,383,218	$1,606,293	$83,527,260
Redesigned Façade	$1,343,285	$75,223,990	$2,153,700	$120,607,208
Difference	-$532,871	-$29,840,772	-$547,407	-$37,079,948

Phase II: Cogeneration Plant Redesign

	Equipment Cost	Labor	Annual Operating Costs	Payback Period
Existing CHP Plant	$3,673,500.00	$114,750.00	$10,983,700.00	-
Redesigned CHP Plant	$6,708,800.00	$255,000.00	$8,773,200.00	3.15 Years
Difference	-$3,035,300.00	-$140,250.00	$2,210,500.00	

* Additional first costs do have a significant impact on energy savings, which are reflected in the annual operating costs shown in Phase II.

The rise in first costs coupled with the large annual savings can have significant impacts on loan repayment, as shown below:

Interest Rate	Number of Annual Payments	Present Value of Loan	Current Annual Payment	Future Value of Loan at End of Loan Period	Annual Savings Applied to Payments	Potential PV of Loan w/ savings applied to payments	Potential NP w/ savings applied to payment
0.015	25	$1,041,000,000.00	($50,242,255.52)	($1,256,056,387.88)	($2,210,500.00)	$1,086,800,700.55	23.74
0.02	25	$1,041,000,000.00	($53,320,476.39)	($1,333,011,909.81)	($2,210,500.00)	$1,084,156,600.53	23.73
0.025	25	$1,041,000,000.00	($56,501,233.81)	($1,412,530,845.22)	($2,210,500.00)	$1,081,727,084.08	23.72
0.03	25	$1,041,000,000.00	($59,782,413.75)	($1,494,560,343.79)	($2,210,500.00)	$1,079,491,762.97	23.71
0.035	25	$1,041,000,000.00	($63,161,670.86)	($1,579,041,771.57)	($2,210,500.00)	$1,077,432,388.01	23.69
0.04	25	$1,041,000,000.00	($66,636,453.26)	($1,665,911,331.52)	($2,210,500.00)	$1,075,532,607.72	23.67
0.045	25	$1,041,000,000.00	($70,204,028.19)	($1,755,100,704.71)	($2,210,500.00)	$1,073,777,755.91	23.65
0.05	25	$1,041,000,000.00	($73,861,508.05)	($1,846,537,701.21)	($2,210,500.00)	$1,072,154,664.46	23.63

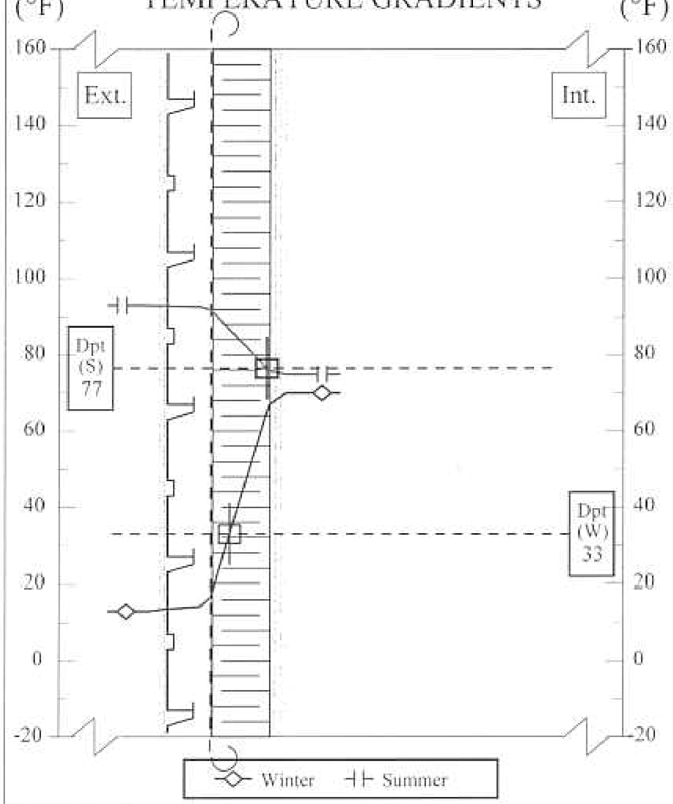
APPENDIX I.A: HEAT AIR AND MOISTURE (HAM) WALL REPORTS

Baseline Spandrel Wall for NYTB

R VALUE ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11)

WALL SECTION AND TEMPERATURE GRADIENTS



PROJECT

Name	New York Times Building
Number	1
City	New York, NY
Date	2/8/2010
Analysis by:	Peter Clarke
Wall Type	
Option	

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ext.
Temp (°F)	70	13	75	93
RH (%)	25	80	50	57
DPT (°F)	33	8	56	77

PENNSYLVANIA STATE UNIVERSITY

104 ENGINEERING, UNIT A
UNIVERSITY PARK, PA, USA, 16802

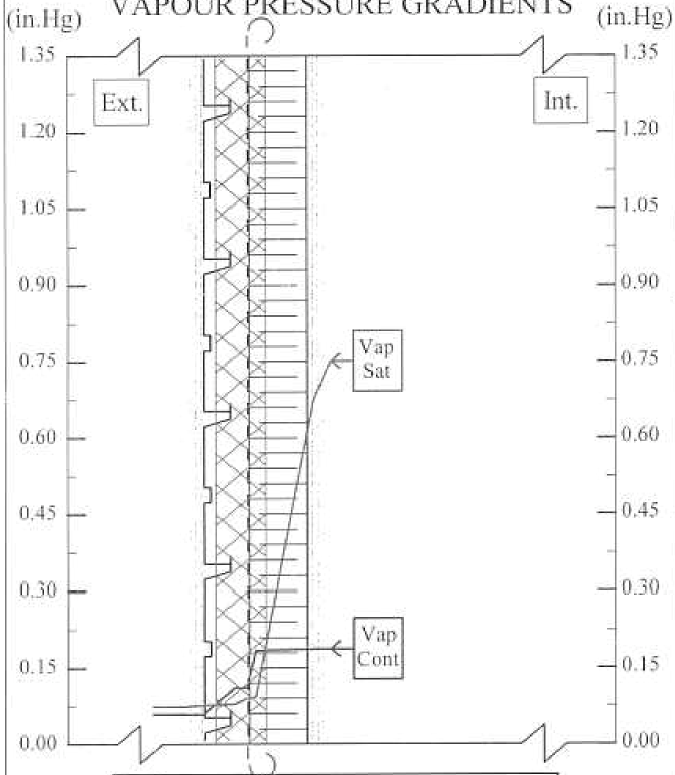
	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	13.6	92.9
2	aluminum clad.(unvntd), 1-1/2 in.	No Recor...	Generic...	1.50	0.12	14.2	92.7
3	cavity, 1/2 in.	No Recor...	Generic...	0.50	0.52	16.8	91.9
4	poly film, (6mil)	No Recor...	Generic...	0.01	0.12	17.4	91.7
5	rigid ins.,(expand.), 2-1/2 in.	No Recor...	Generic...	2.50	9.88	66.8	76.0
6	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0
	Total or (Layer 0)			4.50	11.44	(12.7)	(93.2)

Baseline Spandrel Wall for NYTB

CONDENSATION ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11a)

WALL SECTION AND VAPOUR PRESSURE GRADIENTS



Condensation 37 grains/(ft²-d)

PROJECT

Name	New York Times Building
Number	1
City	New York, NY
Date	2/8/2010
Analysis by:	Peter Clarke
Wall Type	
Option	

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ext.
Temp (°F)	70	13		
RH (%)	25	80		
DPT (°F)	33	8		

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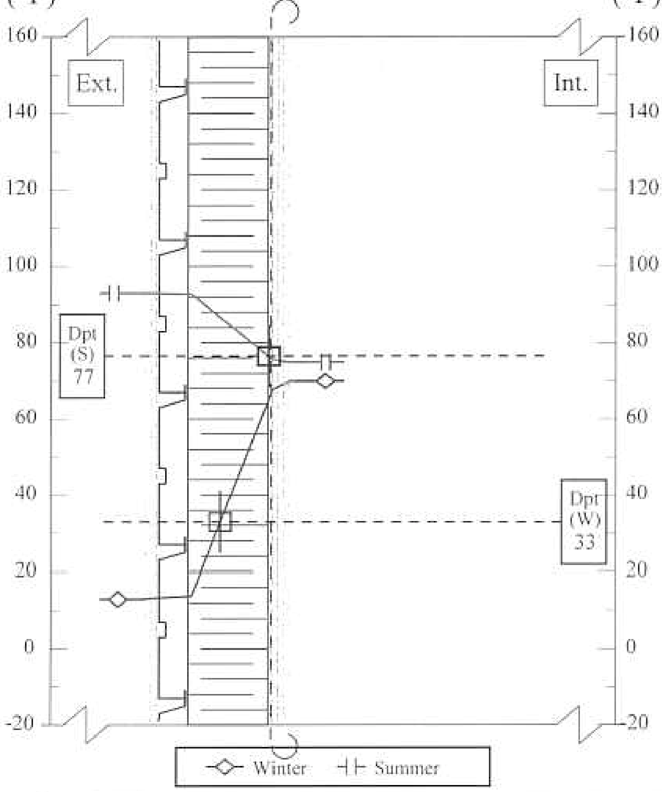
	Material	Manufacturer	Model No.	Rvap (1/M)	Temp (°F)	VapSat (in.Hg)	VapCont (in.Hg)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.001	13.9	0.076	0.058
2	aluminum clad.(unvntd), 1-1/2 in.	No Recor...	Generic...	11.443	14.4	0.078	0.109
3	cavity, 1/2 in.	No Recor...	Generic...	0.006	17.0	0.089	0.109
4	poly film, (6mil)	No Recor...	Generic...	16.827	17.6	0.092	0.182
5	rigid ins.,(expand.), 2-1/2 in.	No Recor...	Generic...	0.643	66.8	0.664	0.185
6	air film (int), 3/4 in.	No Recor...	Generic...	0.006	70.0	0.740	0.185
7							
8							
9							
10							
11							
12							
	TOTAL or (Layer 0)			29.046	(13.0)	(0.073)	(0.058)

Redesigned Spandrel Wall for NYTB

R VALUE ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11)

WALL SECTION AND TEMPERATURE GRADIENTS



PROJECT

Name	New York Times Building
Number	1
City	New York, NY
Date	2/8/2010
Analysis by:	Peter Clarke
Wall Type	
Option	

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ext.
Temp (°F)	70	13	75	93
RH (%)	25	80	50	57
DPT (°F)	33	8	56	77

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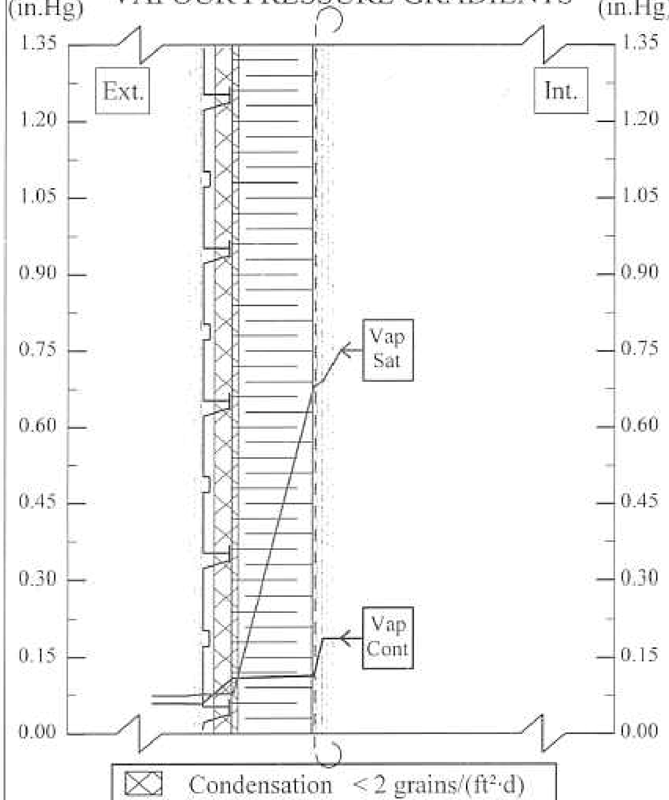
	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	13.4	93.0
2	aluminum clad.(unvntd), 1-1/2 in.	No Recor...	Generic...	1.50	0.12	13.9	92.8
3	rigid ins.,(expand.), 3-1/2 in.	No Recor...	Generic...	3.50	13.83	67.1	75.9
4	poly film, (6mil)	No Recor...	Generic...	0.01	0.12	67.6	75.8
5	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0
	Total or (Layer 0)			5.00	14.87	(12.7)	(93.2)

Redesigned Spandrel Wall for NYTB

CONDENSATION ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (11a)

WALL SECTION AND VAPOUR PRESSURE GRADIENTS



PROJECT

Name: New York Times Building
Number: 1
City: New York, NY
Date: 2/8/2010
Analysis by: Peter Clarke
Wall Type: Option:

CLIMATIC CONDITIONS

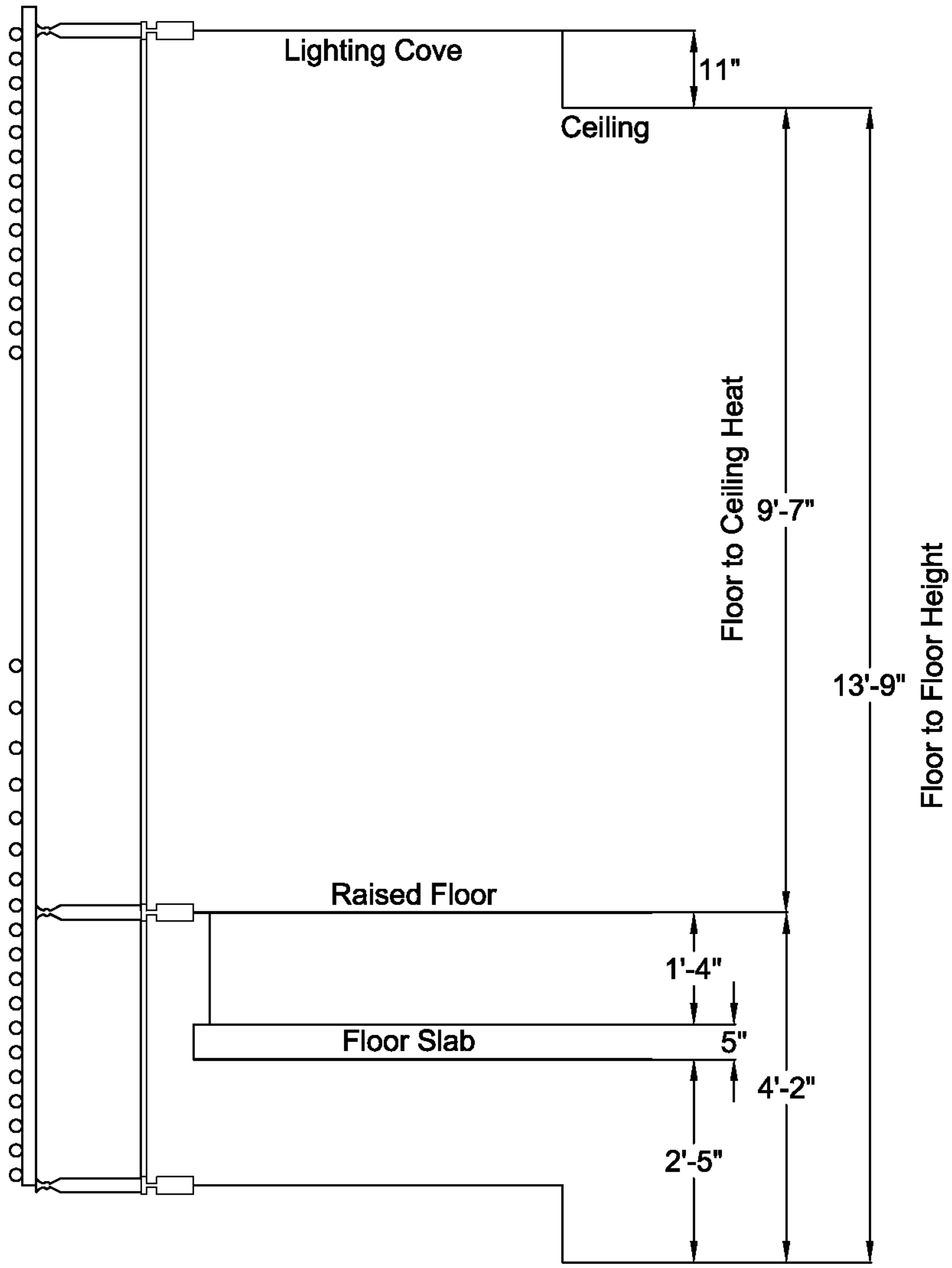
	Winter		Summer	
	Int.	Ext.	Int.	Ext.
Temp (°F)	70	13		
RH (%)	25	80		
DPT (°F)	33	8		

PENNSYLVANIA STATE UNIVERSITY

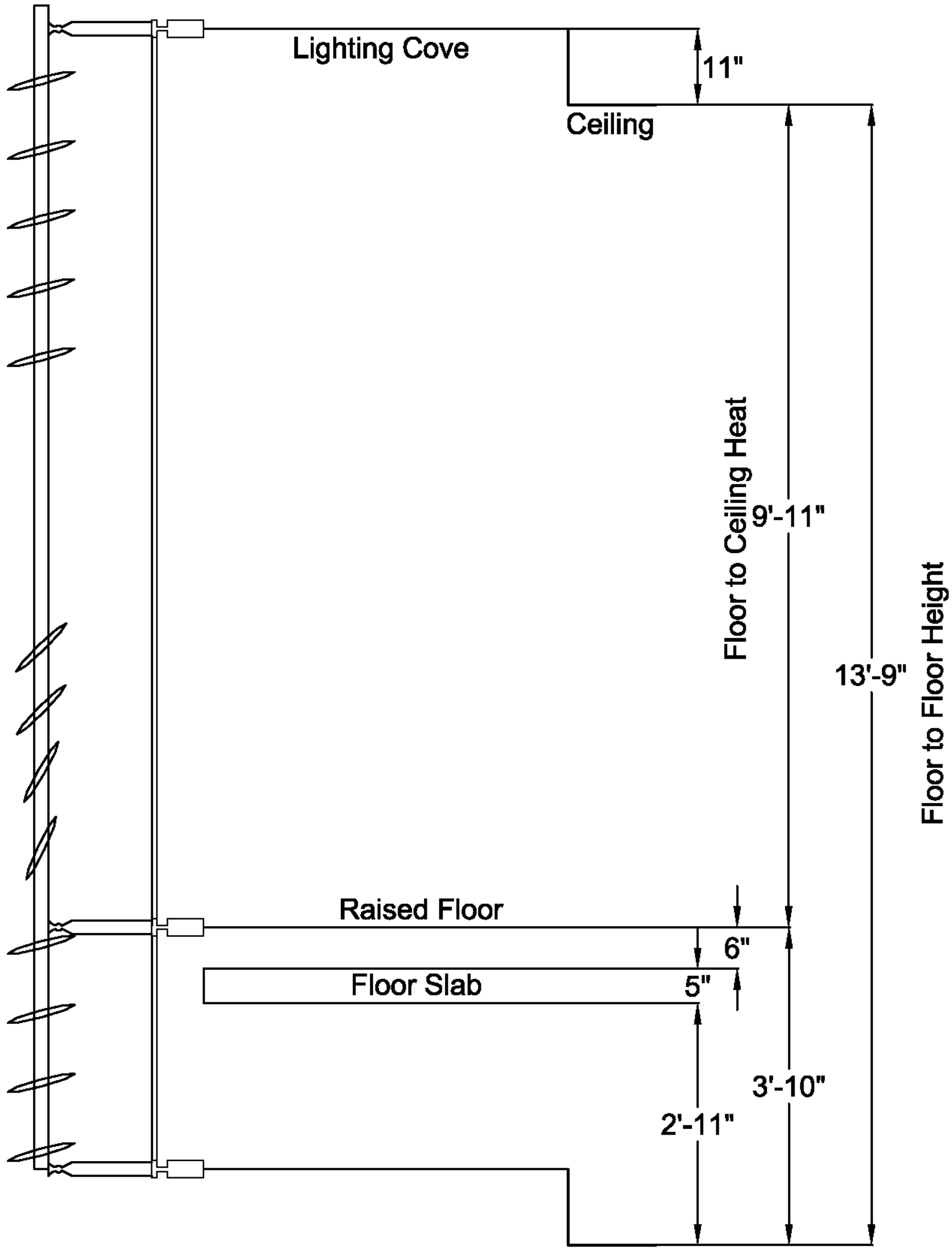
104 ENGINEERING, UNIT A
UNIVERSITY PARK, PA, USA, 16802

	Material	Manufacturer	Model No.	Rvap (1/M)	Temp (°F)	VapSat (in.Hg)	VapCont (in.Hg)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.001	13.7	0.076	0.058
2	aluminum clad.(unvntd), 1-1/2 in.	No Recor...	Generic...	11.443	14.1	0.077	0.108
3	rigid ins.,(expand.), 3-1/2 in.	No Recor...	Generic...	0.894	67.1	0.670	0.112
4	poly film, (6mil)	No Recor...	Generic...	16.827	67.6	0.681	0.185
5	air film (int), 3/4 in.	No Recor...	Generic...	0.006	70.0	0.740	0.185
6							
7							
8							
9							
10							
11							
12							
	TOTAL or (Layer 0)			29.292	(13.0)	(0.073)	(0.058)

APPENDIX I.B: WALL SECTIONS



Baseline Wall Section for the New York Times Building



Redesigned Wall Section for the New York Times Building

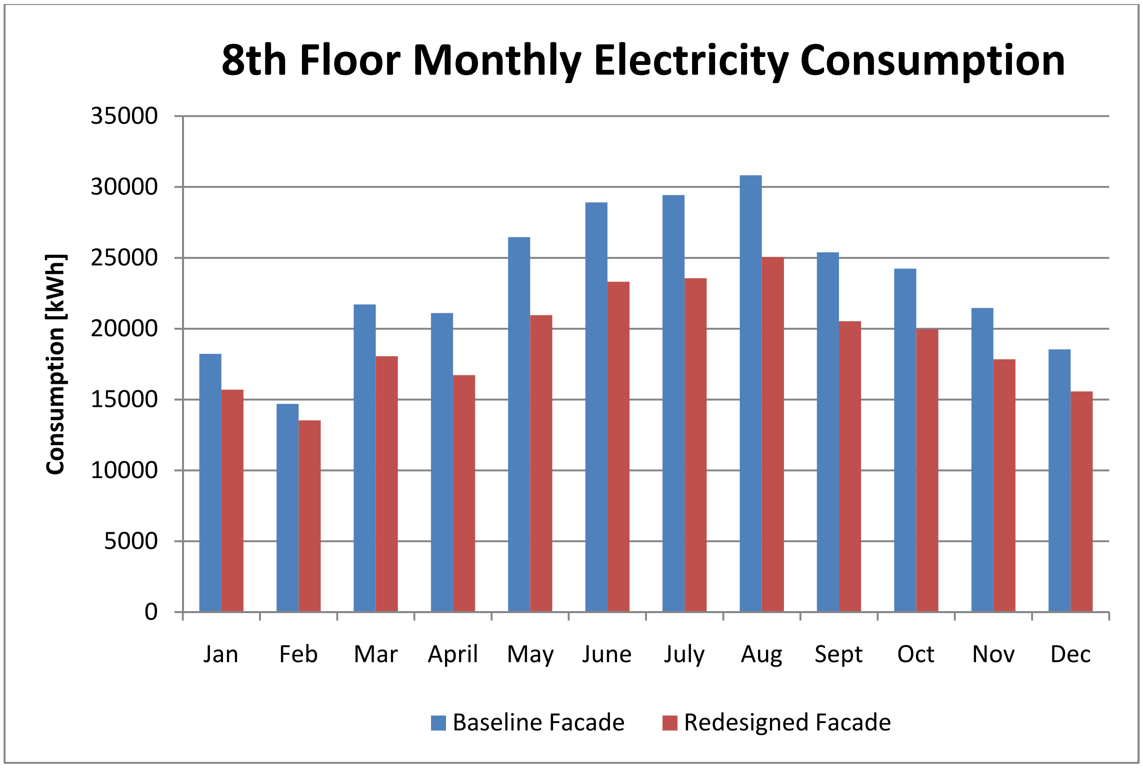
APPENDIX I.C: ENERGY MODELING REPORTS

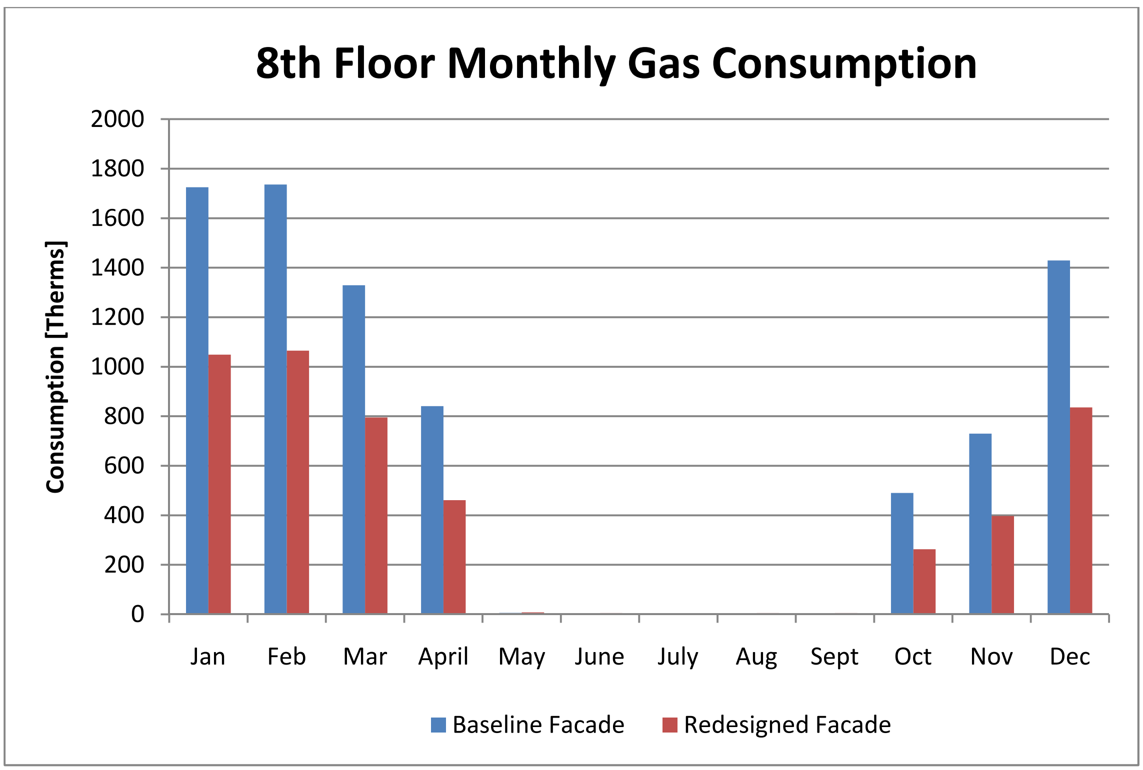
Trane TRACE Results Summary

		Baseline	Redesign	Percent Reduction [%]
Envelope Loads				
	Cooling Coil Peak [Btu/h]	447,375	182,861	59.1
	Heating Coil Peak [Btu/h]	321,391	182,164	43.3
Internal Loads				
	Cooling Coil Peak [Btu/h]	194,499	194,499	NA
	Heating Coil Peak [Btu/h]	0	0	NA
Total Loads				
	Cooling Coil Peak [Btu/h]	843,642	544,623	35.4
	Heating Coil Peak [Btu/h]	460,150	364,238	20.8
Energy Density				
	Cooling Density [Btu/hr-ft^2]	39.7	25.7	35.3
	Heating Density [Btu/hr-ft^2]	51.9	30.6	41.1
Energy Consumption				
	Electrical Consumption [kWh]	281,009	230,785	17.9
	Natural Gas Consumption [kBtu]	829,277	489,163	41.0
	Total Building Energy [kBtu/yr]	1,788,361	1,276,830	28.6
	Total Source Energy [kBtu/yr]	3,750,464	2,878,147	23.3

IES Results Summary

	Baseline	Redesign	Percent Reduction [%]
Cooling Peak Load [Btu/h]	824,700	479,900	41.8
Heating Peak Load [Btu/h]	536,200	454,100	15.3
Cooling Density [Btu/hr-ft^2]	34.0	20.0	41.2
Heating Density [Btu/hr-ft^2]	26.0	19.0	26.9


8th Floor Monthly Electricity Consumption
Consumption [kWh]
35000
30000
25000
20000
15000
10000
5000
0
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Baseline Facade
Redesigned Facade


8th Floor Monthly Gas Consumption
Consumption [Therms]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Baseline Facade
Redesigned Facade

Baseline Facade - 8th Floor NYTB

System Checksums

By Trial

Core VAV

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 87 / 72 / 94

CLG Space Peak — Mo/Hr: 7 / 15; OADB: 87

	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	0	0	0	0	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	19,073		19,073	7	7,580	8
Sub Total ==>	19,073	0	19,073	7	7,580	8
Internal Loads						
Lights	25,178	20,819	45,998	18	25,178	26
People	48,131	0	48,131	19	27,634	28
Misc	24,766	0	24,766	10	24,766	25
Sub Total ==>	98,076	20,819	118,896	46	77,578	79
Ceiling Load	10,221	-10,221	0	0	10,221	10
Ventilation Load	0	0	122,008	48	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	2,235		2,235	1	2,257	2
Exhaust Heat		-13,812	-13,812	-5		
Sup. Fan Heat			4,295	2		
Ret. Fan Heat		3,210	3,210	1		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	129,605	-3	255,904	100.00	97,636	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 15

	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	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-34,741	-34,741	19.83
Sub Total ==>	-34,741	-34,741	19.83
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.		-140,494	80.17
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 ==>	-34,741	-175,235	100.00

TEMPERATURES

	Cooling	Heating
SADB	50.8	86.7
Ra Plenum	77.6	70.0
Return	78.4	70.0
Ret/OA	87.0	70.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	3,625	1,871
Terminal	3,625	1,871
Main Fan	3,625	1,871
Sec Fan	0	0
Nom Vent	3,625	0
AHU Vent	3,625	0
Infil	567	567
MinStop/Rh	1,871	1,871
Return	3,611	2,380
Exhaust	3,611	509
Rm Exh	580	58
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	0.0
cfm/ft²	0.30	0.15
cfm/ton	169.97	
ft²/ton	574.53	
Btu/hr-ft²	20.89	-25.02
No. People	111	

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	21.3	255.9	150.4	3,624	87.0	71.9	93.8	49.8	49.7	52.9
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	21.3	255.9								

AREAS

	Gross Total	Glass ft²	(%)
Floor	12,252		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	0	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-76.9	1,871	49.8	86.7
Aux Htg	0.0	0	0.0	0.0
Preheat	-140.5	3,625	15.0	49.8
Humidif	-89.1	4,191	2.4	32.7
Opt Vent	0.0	0	0.0	0.0
Total	-306.5			

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_BASELINE.TRC

TRACE® 700 v6.2.4 calculated at 07:50 PM on 03/20/2010
Alternative - 1 System Checksums Report Page 1 of 2

Baseline Facade - 8th Floor NYTB

System Checksums

By Trial

Perimeter VAV		**VAV w/Baseboard Skin Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 17; Outside Air: OADB/WB/HR: 86 / 71 / 92

Clg Space Peak — Mo/Hr: 7 / 17; OADB: 86

	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	0	0	0	0	0	0
Glass Solar	324,310	0	324,310	55	324,310	75
Glass/Door Cond	35,950	0	35,950	6	35,950	8
Wall Cond	17,212	37,950	55,162	9	17,212	4
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	12,880		12,880	2	4,886	1
Sub Total ==>	390,352	37,950	428,302	73	382,357	88
Internal Loads						
Lights	17,351	16,247	33,597	6	17,351	4
People	27,236	0	27,236	5	15,131	3
Misc	14,770	0	14,770	3	14,770	3
Sub Total ==>	59,356	16,247	75,603	13	47,251	11
Ceiling Load	4,317	-4,317	0	0	4,317	1
Ventilation Load	0	0	26,683	5	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		-3,287	-3,287	-1		
Sup. Fan Heat			34,325	6		
Ret. Fan Heat		26,112	26,112	4		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	454,025	72,704	587,738	100.00	433,926	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 15

	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	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-187,956	-187,956	65.97
Wall Cond	-23,391	-73,319	25.73
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-25,375	-25,375	8.91
Sub Total ==>	-236,721	-286,650	100.61
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	-10,659	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		1,734	-0.61
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 ==>	-247,381	-284,915	100.00

TEMPERATURES

	Cooling	Heating
SADB	61.6	0.0
Ra Plenum	76.5	0.0
Return	77.3	0.0
Ret/OA	77.6	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	28,962	9,141
Terminal	28,962	9,141
Main Fan	28,962	9,141
Sec Fan	0	0
Nom Vent	857	0
AHU Vent	857	0
Infil	414	414
MinStop/Rh	9,141	9,141
Return	29,376	9,555
Exhaust	1,271	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	3.0	0.0
cfm/ft²	3.24	1.02
cfm/ton	591.32	
ft²/ton	182.71	
Btu/hr-ft²	65.68	-89.03
No. People	61	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Enter DB/WB/HR °F	Enter DB/WB/HR gr/lb	Leave DB/WB/HR °F	Leave DB/WB/HR °F	Leave DB/WB/HR gr/lb
Main Clg	49.0	587.7	551.1	28,962	77.6	63.6	65.6	60.5	56.9	63.7
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	49.0	587.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	8,949		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	9,665	5,412	56
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	-247.4	0	0.0	0.0
Preheat	-43.5	857	15.0	60.5
Reheat	-96.9	9,141	60.5	70.0
Humidif	-656.4	30,885	2.4	32.7
Opt Vent	0.0	0	0.0	0.0
Total	-1,044.1			

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_BASELINE.TRC

TRACE® 700 v6.2.4 calculated at 07:50 PM on 03/20/2010
Alternative - 1 System Checksums Report Page 2 of 2

Baseline Facade - 8th Floor NYTB

ENERGY CONSUMPTION SUMMARY

By Trial

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating		829,277		46.4 %	829,277	872,923
Other Htg Accessories	10,056			1.9 %	34,322	102,977
Heating Subtotal	**10,056**	**829,277**		**48.3 %**	**863,599**	**975,900**
Primary cooling						
Cooling Compressor	46,422			8.9 %	158,439	475,364
Tower/Cond Fans	19,750		305	3.8 %	67,408	202,244
Condenser Pump	6,801			1.3 %	23,211	69,641
Other Clg Accessories	4,563			0.9 %	15,574	46,725
Cooling Subtotal....	**77,536**		**305**	**14.8 %**	**264,632**	**793,974**
Auxiliary						
Supply Fans	28,383			5.4 %	96,870	290,639
Pumps	9,552			1.8 %	32,601	97,813
Stand-alone Base Utilities				0.0 %	0	0
Aux Subtotal....	37,935			7.2 %	129,471	388,453
Lighting						
Lighting	102,728			19.6 %	350,612	1,051,940
Receptacle						
Receptacles	52,754			10.1 %	180,048	540,197
Cogeneration						
Cogeneration				0.0 %	0	0
Totals						
Totals**	**281,009**	**829,277**	**305**	**100.0 %**	**1,788,361**	**3,750,464**

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_BASELINE.TRC

TRACE® 700 v6.2.4 calculated at 07:50 PM on 03/20/2010
Alternative - 1 Energy Consumption Summary report page 1

Baseline Facade - 8th Floor NYTB

MONTHLY ENERGY CONSUMPTION

By Trial

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**NYTB 8th floor - with shading**												
Electric													
On-Pk Cons. (kWh)	18,229	14,697	21,713	21,103	26,465	28,910	29,428	30,826	25,390	24,241	21,463	18,543	281,009
On-Pk Demand (kW)	82	81	78	88	102	114	123	116	104	93	91	83	123
Gas													
On-Pk Cons. (therms)	1,725	1,736	1,329	841	6	2	1	2	3	490	730	1,429	8,293
On-Pk Demand (therms/hr)	4	5	3	2	0	0	0	0	0	1	2	3	5
Water													
Cons. (1000gal)	4	0	9	14	35	49	60	56	40	20	13	5	305

Energy Consumption		
Building	84,353	Btu/(ft2-year)
Source	176,900	Btu/(ft2-year)
Floor Area	21,201	ft2

Environmental Impact Analysis	
CO2	475,342 lbm/year
SO2	1,821 gm/year
NOX	555 gm/year

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_BASELINE.TRC

TRACE® 700 v6.2.4 calculated at 07:50 PM on 03/20/2010
Alternative - 1 Monthly Energy Consumption report Page 1 of 1

Redesigned Facade - 8th Floor NYTB

System Checksums

By PENN STATE UNIVERSITY

Core VAV — Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 87 / 72 / 94

Clg Space Peak — Mo/Hr: 7 / 15; OADB: 87

	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	0	0	0	0	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	20,644		20,644	8	8,195	8
Sub Total ==>	20,644	0	20,644	8	8,195	8
Internal Loads						
Lights	25,178	20,819	45,998	18	25,178	25
People	48,131	0	48,131	19	27,634	28
Misc	24,766	0	24,766	10	24,766	25
Sub Total ==>	98,076	20,819	118,896	46	77,578	78
Ceiling Load	10,203	-10,203	0	0	10,203	10
Ventilation Load	0	0	122,612	47	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	2,864		2,864	1	2,870	3
Exhaust Heat		-13,839	-13,839	-5		
Sup. Fan Heat			4,312	2		
Ret. Fan Heat		3,221	3,221	1		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	131,786	-1	258,709	100.00	98,846	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 15

	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	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-37,559	-37,559	16.96
Sub Total ==>	-37,559	-37,559	16.96
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.		-140,181	63.30
RA Preheat Diff.		-43,703	19.74
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-37,559	-221,443	100.00

TEMPERATURES

	Cooling	Heating
SADB	50.6	87.6
Ra Plenum	77.6	70.0
Return	78.4	70.0
Ret/OA	87.0	70.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	3,638	1,918
Terminal	3,638	1,918
Main Fan	3,638	1,918
Sec Fan	0	0
Nom Vent	3,638	0
AHU Vent	3,638	0
Infil	613	613
MinStop/Rh	1,918	1,918
Return	3,624	2,468
Exhaust	3,624	550
Rm Exh	627	63
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	0.0
cfm/ft²	0.30	0.16
cfm/ton	168.76	
ft²/ton	568.30	
Btu/hr-ft²	21.12	-25.45
No. People	111	

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	21.6	258.7	151.8	3,638	87.0	71.9	93.8	49.6	49.5	52.5
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	21.6	258.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	12,252		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	0	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-81.3	1,918	49.6	87.6
Aux Htg	0.0	0	0.0	0.0
Preheat	-140.2	3,638	15.0	49.6
Humidif	-90.4	4,251	2.4	32.7
Opt Vent	0.0	0	0.0	0.0
Total	-311.8			

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_SHADING.trc

TRACE® 700 v6.2.4 calculated at 04:18 PM on 02/26/2010
Alternative - 1 System Checksums Report Page 1 of 2

Redesigned Facade - 8th Floor NYTB

System Checksums

By PENN STATE UNIVERSITY

Perimeter VAV — **VAV w/Baseboard Skin Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 17; Outside Air: OADB/WB/HR: 86 / 71 / 92

Clg Space Peak — Mo/Hr: 7 / 17; OADB: 86

	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	0	0	0	0	0	0
Glass Solar	79,647	0	79,647	28	79,647	42
Glass/Door Cond	6,471	0	6,471	2	6,471	3
Wall Cond	43,060	19,159	62,219	22	43,060	23
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	13,880		13,880	5	5,282	3
Sub Total ==>	143,058	19,159	162,217	57	134,460	71
Internal Loads						
Lights	17,351	16,247	33,597	12	17,351	9
People	27,236	0	27,236	10	15,131	8
Misc	14,770	0	14,770	5	14,770	8
Sub Total ==>	59,356	16,247	75,603	26	47,251	25
Ceiling Load	6,544	-6,544	0	0	6,544	3
Ventilation Load	0	0	30,290	11	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		-4,929	-4,929	-2		
Sup. Fan Heat			12,763	4		
Ret. Fan Heat		9,970	9,970	3		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	208,958	33,903	285,914	100.00	188,255	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 15

	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	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-32,895	-32,895	23.04
Wall Cond	-58,519	-84,277	59.02
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-27,433	-27,433	19.21
Sub Total ==>	-118,847	-144,605	101.27
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	-10,288	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		1,810	-1.27
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 ==>	-129,135	-142,795	100.00

TEMPERATURES

	Cooling	Heating
SADB	59.3	0.0
Ra Plenum	77.3	0.0
Return	78.1	0.0
Ret/OA	78.8	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	10,769	3,342
Terminal	10,769	3,342
Main Fan	10,769	3,342
Sec Fan	0	0
Nom Vent	976	0
AHU Vent	976	0
Infil	447	447
MinStop/Rh	3,342	3,342
Return	11,216	3,790
Exhaust	1,424	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	9.1	0.0
cfm/ft²	1.20	0.37
cfm/ton	451.97	
ft²/ton	375.59	
Btu/hr-ft²	31.95	-37.67
No. People	61	

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	23.8	285.9	246.5	10,769	78.8	64.4	67.5	58.3	55.7	62.3
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	23.8	285.9								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	8,949		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	9,665	2,126	22
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	-129.1	0	0.0	0.0
Preheat	-47.1	976	15.0	58.3
Reheat	-43.8	3,342	58.3	70.0
Humidif	-246.3	11,588	2.4	32.7
Opt Vent	0.0	0	0.0	0.0
Total	-466.3			

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_SHADING.trc

TRACE® 700 v6.2.4 calculated at 04:18 PM on 02/26/2010
Alternative - 1 System Checksums Report Page 2 of 2

Redesigned Facade - 8th Floor NYTB

ENERGY CONSUMPTION SUMMARY

By PENN STATE UNIVERSITY

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating		489,163		38.3 %	489,163	514,908
Other Htg Accessories	8,640			2.3 %	29,489	88,475
Heating Subtotal	**8,640**	**489,163**		**40.6 %**	**518,651**	**603,383**
Primary cooling						
Cooling Compressor	24,581			6.6 %	83,894	251,708
Tower/Cond Fans	11,636		165	3.1 %	39,713	119,152
Condenser Pump	3,988			1.1 %	13,612	40,839
Other Clg Accessories	4,145			1.1 %	14,147	42,445
Cooling Subtotal....	**44,350**		**165**	**11.9 %**	**151,366**	**454,144**
Auxiliary						
Supply Fans	16,180			4.3 %	55,221	165,681
Pumps	6,133			1.6 %	20,932	62,802
Stand-alone Base Utilities				0.0 %	0	0
Aux Subtotal....	22,313			6.0 %	76,153	228,483
Lighting						
Lighting	102,728			27.5 %	350,612	1,051,940
Receptacle						
Receptacles	52,754			14.1 %	180,048	540,197
Cogeneration						
Cogeneration				0.0 %	0	0
Totals						
Totals**	**230,785**	**489,163**	**165**	**100.0 %**	**1,276,830**	**2,878,147**

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_SHADING.trc

TRACE® 700 v6.2.4 calculated at 04:18 PM on 02/26/2010
Alternative - 1 Energy Consumption Summary report page 1

Redesigned Facade - 8th Floor NYTB

MONTHLY ENERGY CONSUMPTION

By PENN STATE UNIVERSITY

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**NYTB 8th floor - with shading**												
Electric													
On-Pk Cons. (kWh)	15,692	13,533	18,051	16,724	20,956	23,319	23,560	25,058	20,522	19,953	17,842	15,575	230,785
On-Pk Demand (kW)	50	51	54	59	71	77	83	80	74	64	60	51	83
Gas													
On-Pk Cons. (therms)	1,049	1,065	795	461	8	5	4	5	5	263	397	836	4,892
On-Pk Demand (therms/hr)	3	4	3	2	0	0	0	0	0	1	1	2	4
Water													
Cons. (1000gal)	0	0	2	4	17	29	39	36	24	9	4	1	165

Energy Consumption		
Building	60,225	Btu/(ft2-year)
Source	135,755	Btu/(ft2-year)
Floor Area	21,201	ft2

Environmental Impact Analysis	
CO2	339,378 lbm/year
SO2	1,300 gm/year
NOX	395 gm/year

Project Name: IPD/BIM Thesis - NYTB
Dataset Name: NYTB_MANUAL_SHADING.trc

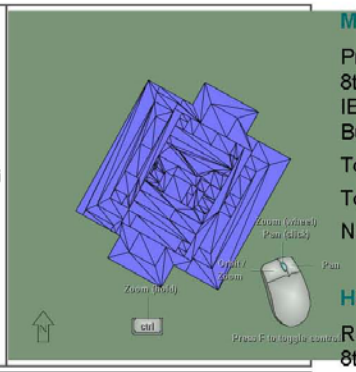
TRACE® 700 v6.2.4 calculated at 04:18 PM on 02/26/2010
Alternative - 1 Monthly Energy Consumption report Page 1 of 1

INTEGRATED ENVIRONMENTAL SOLUTIONS

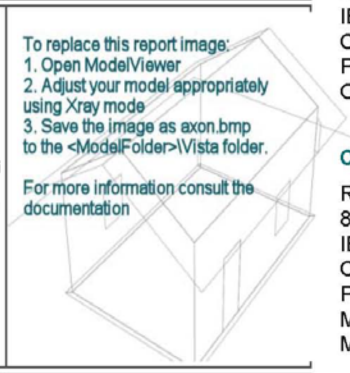
8th floor mechanical model - Baseline - IESiesve.mit
13/Mar/2010

Project summary

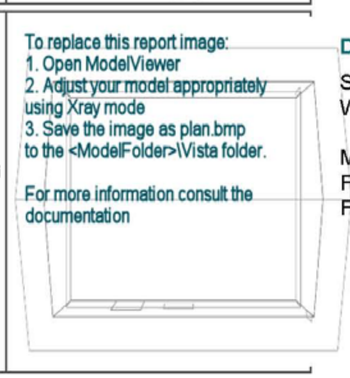
Building



Building Form



Building Plan



Model data:

Project file
8th floor mechanical model - Baseline - IESiesve.mit

Building floor area	24356.35 ft^2
Total conditioned floor area	21328.68 ft^2
Total conditioned volume	283499.66 ft^3
Number of conditioned rooms	45

Heating calculation data:

Results file
8th floor mechanical model - Baseline - IESiesve.htg

Calculated	18:10 13/Mar/2010
Profile month	January
Outdoor winter design temp	13.1 °F

Cooling calculation data:

Results file
8th floor mechanical model - Baseline - IESiesve.clg

Calculated	18:10 13/Mar/2010
Profile month	May - Sep
Max outdoor temp. dry bulb	95.7 °F
Max outdoor temp. wet bulb	76.6 °F

Design weather:

Source ASHRAE design weather database
Weather location
New York/JFK Int'l Airport, New York
Monthly percentile:

For heating loads design weather	99.6 %
For cooling loads design weather	0.4 %

ASHRAE Loads provides the heating and cooling loads for the building and rooms using the ASHRAE Heat Balance Method. For each analyzed zone, the Heat Balance Method calculates the conductive, convective, and radiative heat balance for each room surface and a heat balance for the room air.

The Heat Balance Method directly solves these equations and reports the results of each calculation. It also allows for a great deal of customization of the simulation inputs.

A detailed description of the Heat Balance Method can be found in the 2005 ASHRAE Fundamentals Handbook.

ASHRAE system loads

Heating loads:

	System name	Room heating plant load(kBtu/h)		Outdoor primary air load (kBtu/h)		Plant load	
		Sensible	Humid	Mech vent	Aux Vent	kBtu/h	Btu/h•ft^2
	A-Z	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo
ASHRAE - system heating loads	Central Heating Radiators	0.0	0.0	0.0	0.0	0.0	n/a
	VAV Single Duct	536.2	0.0	0.0	0.0	628.5	30.4
	Fan Coil System	0.0	0.0	0.0	0.0	0.0	0.0

ASHRAE - system cooling loads	System name	Peak time	Room cooling plant load (kBtu/h)		Outdoor primary air load (kBtu/h)				Peak plant load	
			Sens	Dehum	Mech vent sens	Mech vent lat	Aux vent sens	Aux vent lat	kBtu/h	Btu/h•ft²
	A-Z		Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo
	Central Heating Radiators	May 00:30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
	VAV Single Duct	Jul 17:30	734.0	72.4	0.0	0.0	0.0	0.0	824.4	39.9
	Fan Coil System	Sep 19:30	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.5

Total central plant load kBtu/h 536.2 kBtu/h
Cooling loads: 26 Btu/h•ft² 628.5

ASHRAE room loads

Total room plant load 806.7 kBtu/h
Total central plant load 824.7 kBtu/h
34 Btu/h•ft²

Air flow rates:

Total room air flows	FALSE8th floor mec
	FALSE8th floor mec

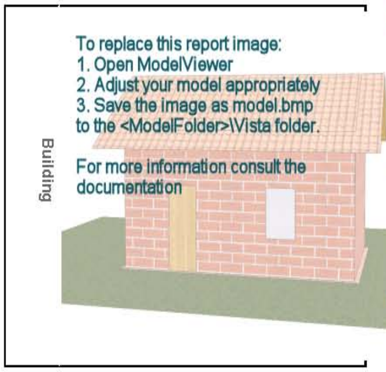
System assignments:

VAV Single Duct	**VAV Single Duct**	**VAV Single Duct**

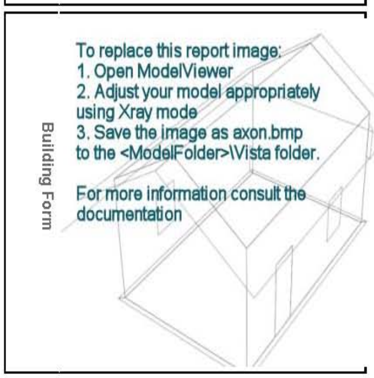
INTEGRATED ENVIRONMENTAL SOLUTIONS

NYTB - Redesign.mit
13/Mar/2010

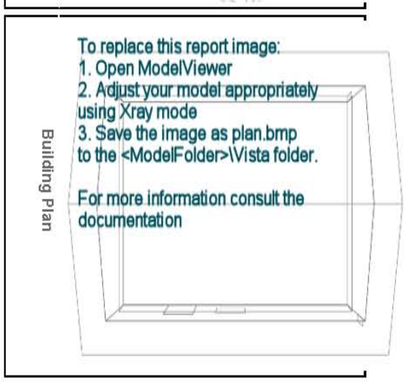
Project summary



Building



Building Form



Building Plan

Model data:

Project file	NYTB - Redesign.mit
Building floor area	24356.35 ft^2
Total conditioned floor area	21328.68 ft^2
Total conditioned volume	231422.17 ft^3
Number of conditioned rooms	45

Heating calculation data:

Results file	NYTB - Redesign.htg
Calculated	19:39 13/Mar/2010
Profile month	January
Outdoor winter design temp	13.1 °F

Cooling calculation data:

Results file	NYTB - Redesign.clg
Calculated	19:39 13/Mar/2010
Profile month	May - Sep
Max outdoor temp. dry bulb	95.7 °F
Max outdoor temp. wet bulb	76.6 °F

Design weather:

Source	ASHRAE design weather database
Weather location	New York/JFK Int'l Airport, New York
Monthly percentile:	
For heating loads design weather	99.6 %
For cooling loads design weather	0.4 %

ASHRAE Loads provides the heating and cooling loads for the building and rooms using the ASHRAE Heat Balance Method. For each analyzed zone, the Heat Balance Method calculates the conductive, convective, and radiative heat balance for each room surface and a heat balance for the room air.

The Heat Balance Method directly solves these equations and reports the results of each calculation. It also allows for a great deal of customization of the simulation inputs.

A detailed description of the Heat Balance Method can be found in the 2005 ASHRAE Fundamentals Handbook.

ASHRAE system loads

ASHRAE - system heating loads

System name	Room heating plant load (kBtu/h)		Outdoor primary air load (kBtu/h)		Plant load	
	Sensible	Humid	Mech vent	Aux Vent	kBtu/h	Btu/h•ft²
A-Z	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo
Central Heating Radiators	0.0	0.0	0.0	0.0	0.0	n/a
VAV Single Duct	387.4	0.0	0.0	0.0	454.1	22.0
Fan Coil System	0.0	0.0	0.0	0.0	0.0	0.0

ASHRAE - system cooling loads

System name	Peak time	Room cooling plant load (kBtu/h)		Outdoor primary air load (kBtu/h)				Peak plant load	
		Sens	De hum	Mech vent sens	Mech vent lat	Aux vent sens	Aux vent lat	kBtu/h	Btu/h•ft²
A-Z		Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo	Hi/Lo
Central Heating Radiators	May 00:30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
VAV Single Duct	Jul 17:30	400.5	68.7	0.0	0.0	0.0	0.0	479.7	23.2
Fan Coil System	Jul 18:30	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.3

Heating loads:

Total room plant load 387.4 kBtu/h
Total central plant load 454.1 kBtu/h
19 Btu/h•ft²

Cooling loads:

Total room plant load 469.4 kBtu/h
Total central plant load 479.9 kBtu/h
20 Btu/h•ft²

Air flow rates:

Total room air flows FALSENYTB - Red
FALSENYTB - Red /

System assignments:

VAV Single Duct	VAV Single Duct	VAV Single Duct
sp-3-Office sp-4-Conference sp-5-Office sp-6-Office sp-21-Copy sp-26-Office sp-27-Copy sp-28-Closet sp-32-Office	sp-47-Toilets sp-48-Pantry sp-49-Mail sp-50-Corridor sp-52-Int_Stairs sp-53-Int_Stairs sp-61-N_Ext_Stair	sp-71-N_Per_Office

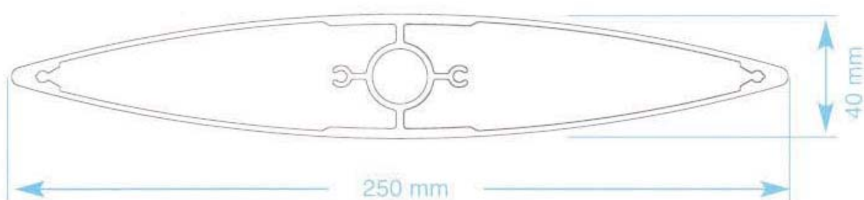
APPENDIX I.D: NACO BLADE DESIGN BROCHURE

EXTRUDED SUNBREAKER

BLADE 25 E

This blade is 250 mm wide, 40 mm thick and weighs 3800 g/m. Its ellipsoid shape recalls, in a smaller scale, that of the other sections. The aluminium is 18/10 thick.
The endcaps are in 3 mm thick aluminium and are screwed on the blade by means of 4 self-tapping steel screws per side.
Accessories, frames and controls are those used for ellipsoid blades type 15 and 21.

25 E



TYPE 21

Table for calculating number of blades

In the closed position the installation should allow a gap of 5 mm each side, so that the blades do not foul the walls or structure.
The width A of the opening must thus be larger than or equal to B. For the height H of the opening and the distance between the supporting brackets, in case of embossed application, the maximum tolerance is ± 1 cm.

The standard thread is 20 cm, for the blades overlap 1 cm. Thus the standard formula:

$$B = (N \times 20\text{ cm}) + 2\text{ cm} \quad \text{with} \quad N = \frac{B - 2\text{ cm}}{20\text{ cm}}$$

where N indicates the number of blades and B the modular width in cm.

APPENDIX I.E: EXTERIOR LIGHTING FIXTURE CUT SHEETS

Date: ______________________ Type: ______________________

Firm Name: ____

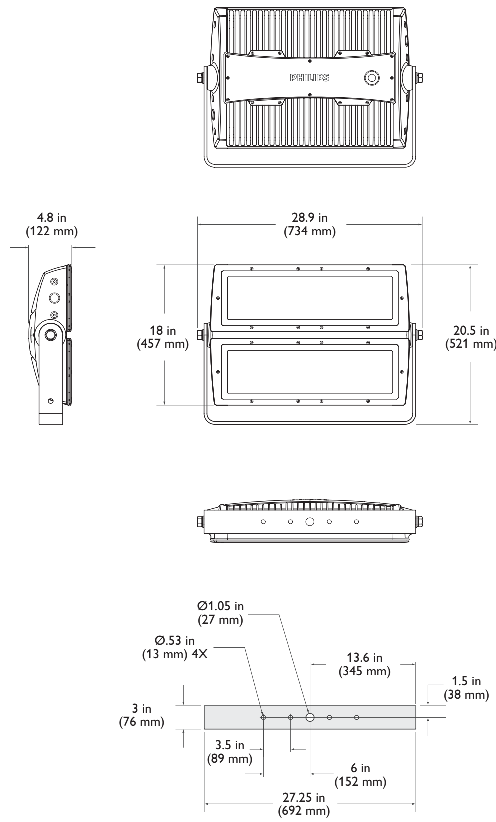
Project: ____

iW Reach Powercore

8° Spread Lens

Intelligent white LED floodlight for signature façades and structures

iW® Reach Powercore, the intelligent white light version of our flagship, high-performance exterior architectural floodlight, is the first LED fixture powerful enough to brilliantly illuminate large architectural façades with washes of white light in color temperatures ranging from a warm 2700 K to a cool 6500 K. iW Reach Powercore combines all the benefits of LED-based lighting in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions. With significantly more lumen output than any other competitive fixture and unprecedented light projection of over 800 ft (243.8 m), this powerful fixture represents the next generation in exterior illumination.



- Integrates Powercore® technology — Powercore technology rapidly, efficiently, and accurately controls power output to iW Reach Powercore fixtures directly from line voltage. The Philips iW Data Enabler merges line voltage with control data and delivers them to the fixture over a single standard wire, dramatically simplifying installation and lowering total system cost.
- Unparalleled light output — With an output of over 10,000 lumens and light projection of over 800 ft (243.8 m), iW Reach Powercore is the first fixture to offer legitimate LED-based, color-controllable white light illumination of large-scale structures and objects.
- Wide range of color temperature and brightness — Channels of warm white and cool white LEDs produce color temperatures ranging from 2700 K to 6500 K. Fixture brightness can be adjusted while varying or maintaining constant color temperature.
- Versatile optics — Exchangeable spread lenses of 8°, 13°, 23°, 40°, 63°, and an asymmetric 5° x 17° support a variety of photometric distributions for a multitude of applications, including spotlighting, wall grazing, and asymmetric wall washing. Bezel and gasket ship with spread lenses for easy user installation.
- Simple fixture positioning — Rugged, slim-profile mounting bracket allows simple positioning and fixture rotation through a full 360°. Side locking bolts reliably secure fixture with standard wrench.
- Universal power input range — iW Reach Powercore accepts a universal power input range of 100 to 240 VAC, allowing simple, location-independent installation.

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

PHILIPS

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Beam Angle	8° / 13° / 23° / 40° / 63° spread lenses, 5° x 17° asymmetric spread lens
	Lumens†	4,902 (8° spread lens, half unit)
	Color Temperature	2700 K – 6500 K
	Efficacy (lm/W)	39.2 (8° spread lens, half unit)
	CRI	68.5
	Mixing Distance	50 ft (15.2 m) to uniform light
	Lumen Maintenance‡	70,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 68,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	250 W maximum at full output, steady state (full unit)
	Power Factor	.981 (8° spread lens, half unit)
Physical	Dimensions *(Height x Width x Depth)*	20.5 x 28.9 x 4.8 in (521 x 734 x 122 mm)
	Weight	75 lb (34 kg)
	Effective Projected Area (EPA)	0.42 m^2
	Housing	Die-cast aluminium, powder-coated finish
	Lens	Tempered glass
	Fixture Connections	6 ft (1.8 m) unified power / data cable
	Operating Temperature	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths Per iW Data Enabler*	5 @ 110 VAC 6 @ 120 VAC 11 @ 220 VAC 12 @ 240 VAC *Configuration: 20 A circuit, standard 6 ft (1.8 m) Leader Cables, 5 ft (1.5 m) jumper cables*
Certification and Safety	Certification	UL / cUL, FCC Class A, CE
	LED Class	Class 2 LED product
	Environment	Dry / Damp / Wet Location, IP66

† Lumen measurement complies with IES LM-79-08

‡ See iW Reach Powercore Product Guide for specific applications

* These figures, provided as a guideline, are accurate for this configuration only. Changing the configuration can affect the fixture run lengths.

Fixtures and Accessories

Item	Type	Item Number	Philips 12NC
iW Reach Powercore *Includes 6 ft (1.8 m) leader cable*	UL / cUL and CE / PSE	523-000045-00	910503700625
Replacement Leader Cable 6 ft (1.8 m)	UL / cUL	108-000043-02	910503700453
	CE / PSE	108-000043-03	910503700454
iW Reach Powercore Spread Lens with bezel	13°	120-000068-00	910503700506
	23°	120-000068-01	910503700507
	40°	120-000068-02	910503700508
	63°	120-000068-03	910503700509
	5° x 17°	120-000068-04	910503700510
	8°	120-000068-05	910503700511
iW Data Enabler	UL / cUL	506-000001-00	910503700190
iW Data Enabler / Data Enabler Aux *For CE / PSE installations only*		506-000001-01	910503700791
iW Scene Controller		503-000001-00	910503700189

Use Item Number when ordering in North America.

iW Reach Powercore fixtures are part of a complete line-voltage system which includes fixtures and:

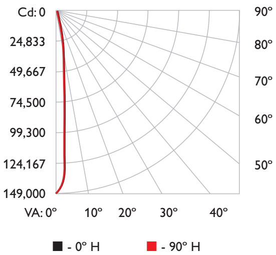
- One or more iW Data Enablers.
- One Leader Cable to connect each fixture to a junction box or iW Data Enabler.
- 4-conductor copper wire to connect fixtures in series or in parallel.
- iW Scene Controller (up to four per single run of iW Data Enablers).

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

Photometrics

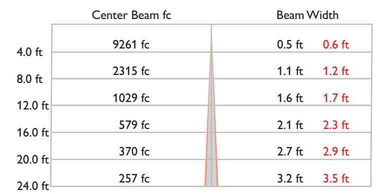
8° Spread Lens

Polar Candela Distribution



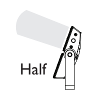
	0	22.5	44	67.5	90
0	148168	148168	148168	148168	148168
5	44700	46114	49240	52562	54461
15	1284	1410	2059	4818	15513
25	452	474	566	749	1525
35	294	241	273	317	409
45	134	143	146	179	224
55	9	16	40	74	108
65	2	1	6	18	40
75	0	0	0	0	9
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



385 ft (117.3 m)
1 fc maximum distance

Vert. Spread: 7.6°
Horiz. Spread: 8.3°

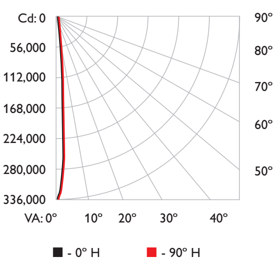


Power Consumption	125 W
Lumens	4,902
Efficacy	39.2 lm/W

For lux multiply fc by 10.7

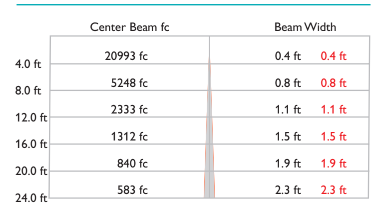
Without spread lens, half unit

Polar Candela Distribution



	0	22.5	44	67.5	90
0	335892	335892	335892	335892	335892
5	40839	40961	41410	40649	40264
15	1558	1586	1571	1556	1565
25	475	492	482	463	472
35	315	320	304	275	270
45	201	208	148	158	165
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



579 ft (176.5 m)
1 fc maximum distance

Vert. Spread: 5.4°
Horiz. Spread: 5.4°

Power Consumption	125 W
Lumens	5,406
Efficacy	43.2 lm/W

Philips Color Kinetics
3 Burlington Woods Drive
Burlington, Massachusetts 01803 USA
Tel 888.385.5742
Tel 617.423.9999
Fax 617.423.9998
www.colorkinetics.com

Date: ______________________ Type: ______________________

Firm Name: ______________________

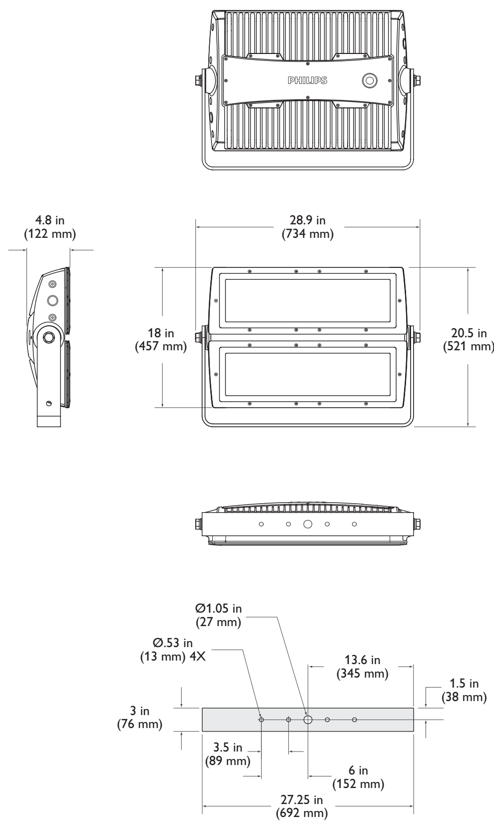
Project: ______________________

iW Reach Powercore

13° Spread Lens

Intelligent white LED floodlight for signature façades and structures

iW® Reach Powercore, the intelligent white light version of our flagship, high-performance exterior architectural floodlight, is the first LED fixture powerful enough to brilliantly illuminate large architectural façades with washes of white light in color temperatures ranging from a warm 2700 K to a cool 6500 K. iW Reach Powercore combines all the benefits of LED-based lighting in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions. With significantly more lumen output than any other competitive fixture and unprecedented light projection of over 800 ft (243.8 m), this powerful fixture represents the next generation in exterior illumination.



- Integrates Powercore® technology — Powercore technology rapidly, efficiently, and accurately controls power output to iW Reach Powercore fixtures directly from line voltage. The Philips iW Data Enabler merges line voltage with control data and delivers them to the fixture over a single standard wire, dramatically simplifying installation and lowering total system cost.
- Unparalleled light output — With an output of over 10,000 lumens and light projection of over 800 ft (243.8 m), iW Reach Powercore is the first fixture to offer legitimate LED-based, color-controllable white light illumination of large-scale structures and objects.
- Wide range of color temperature and brightness — Channels of warm white and cool white LEDs produce color temperatures ranging from 2700 K to 6500 K. Fixture brightness can be adjusted while varying or maintaining constant color temperature.
- Versatile optics — Exchangeable spread lenses of 8°, 13°, 23°, 40°, 63°, and an asymmetric 5° x 17° support a variety of photometric distributions for a multitude of applications, including spotlighting, wall grazing, and asymmetric wall washing. Bezel and gasket ship with spread lenses for easy user installation.
- Simple fixture positioning — Rugged, slim-profile mounting bracket allows simple positioning and fixture rotation through a full 360°. Side locking bolts reliably secure fixture with standard wrench.
- Universal power input range — iW Reach Powercore accepts a universal power input range of 100 to 240 VAC, allowing simple, location-independent installation.

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

PHILIPS

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Beam Angle	8° / 13° / 23° / 40° / 63° spread lenses, 5° x 17° asymmetric spread lens
	Lumens†	4,873 (13° spread lens, half unit)
	Color Temperature	2700 K – 6500 K
	Efficacy (lm/W)	38.9 (13° spread lens, half unit)
	CRI	68.5
	Mixing Distance	50 ft (15.2 m) to uniform light
	Lumen Maintenance‡	70,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 68,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	250 W maximum at full output, steady state (full unit)
	Power Factor	.981 (13° spread lens, half unit)
Physical	Dimensions *(Height x Width x Depth)*	20.5 x 28.9 x 4.8 in (521 x 734 x 122 mm)
	Weight	75 lb (34 kg)
	Effective Projected Area (EPA)	0.42 m^2
	Housing	Die-cast aluminium, powder-coated finish
	Lens	Tempered glass
	Fixture Connections	6 ft (1.8 m) unified power / data cable
	Operating Temperature	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths Per iW Data Enabler*	5 @ 110 VAC 6 @ 120 VAC 11 @ 220 VAC 12 @ 240 VAC *Configuration: 20 A circuit, standard 6 ft (1.8 m) Leader Cables, 5 ft (1.5 m) jumper cables*
Certification and Safety	Certification	UL / cUL, FCC Class A, CE
	LED Class	Class 2 LED product
	Environment	Dry / Damp / Wet Location, IP66

† Lumen measurement complies with IES LM-79-08

‡ See iW Reach Powercore Product Guide for specific applications

* These figures, provided as a guideline, are accurate for this configuration only. Changing the configuration can affect the fixture run lengths.

Fixtures and Accessories

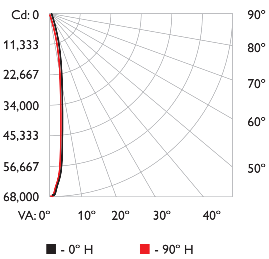
Item	Type	Item Number	Philips 12NC
iW Reach Powercore *Includes 6 ft (1.8 m) leader cable*	UL / cUL and CE / PSE	523-000045-00	910503700625
Replacement Leader Cable 6 ft (1.8 m)	UL / cUL	108-000043-02	910503700453
	CE / PSE	108-000043-03	910503700454
iW Reach Powercore Spread Lens with bezel	13°	120-000068-00	910503700506
	23°	120-000068-01	910503700507
	40°	120-000068-02	910503700508
	63°	120-000068-03	910503700509
	5° x 17°	120-000068-04	910503700510
	8°	120-000068-05	910503700511
iW Data Enabler	UL / cUL	506-000001-00	910503700190
iW Data Enabler / Data Enabler Aux *For CE / PSE installations only*		506-000001-01	910503700791
iW Scene Controller		503-000001-00	910503700189

Use Item Number when ordering in North America.

Photometrics

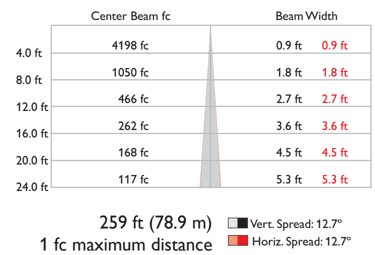
13° Spread Lens

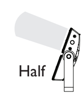
Polar Candela Distribution



	0	22.5	44	67.5	90
0	67171	67171	67171	67171	67171
5	42926	43031	43006	42931	43002
15	3400	3373	3317	3282	3269
25	624	618	624	628	622
35	284	281	297	315	312
45	151	149	152	179	179
55	42	40	40	48	48
65	6	6	7	8	11
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



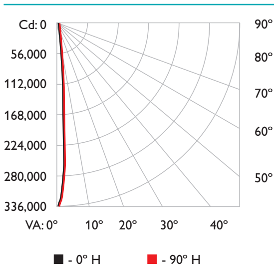


Power Consumption	125 W
Lumens	4,873
Efficacy	38.9 lm/W

For lux multiply fc by 10.7

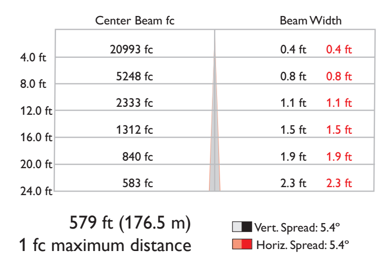
Without spread lens, half unit

Polar Candela Distribution



	0	22.5	44	67.5	90
0	335892	335892	335892	335892	335892
5	40839	40961	41410	40649	40264
15	1558	1586	1571	1556	1565
25	475	492	482	463	472
35	315	320	304	275	270
45	201	208	148	158	165
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



Power Consumption	125 W
Lumens	5,406
Efficacy	43.2 lm/W

iW Reach Powercore fixtures are part of a complete line-voltage system which includes fixtures and:

- One or more iW Data Enablers.
- One Leader Cable to connect each fixture to a junction box or iW Data Enabler.
- 4-conductor copper wire to connect fixtures in series or in parallel.
- iW Scene Controller (up to four per single run of iW Data Enablers).

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Tel 888.385.5742
Tel 617.423.9999
Fax 617.423.9998
www.colorkinetics.com

DAS-000030-03 R01 08-09

Date: ______________________ Type: ______________________

Firm Name: ______________________

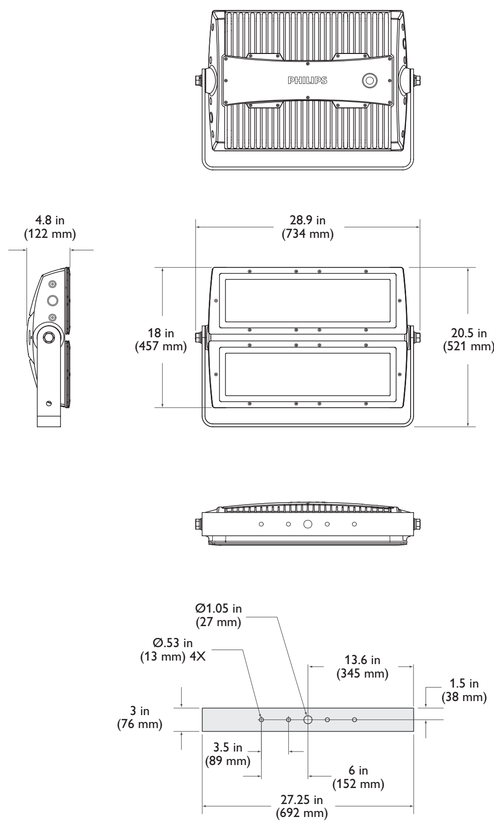
Project: ______________________

iW Reach Powercore

23° Spread Lens

Intelligent white LED floodlight for signature façades and structures

iW® Reach Powercore, the intelligent white light version of our flagship, high-performance exterior architectural floodlight, is the first LED fixture powerful enough to brilliantly illuminate large architectural façades with washes of white light in color temperatures ranging from a warm 2700 K to a cool 6500 K. iW Reach Powercore combines all the benefits of LED-based lighting in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions. With significantly more lumen output than any other competitive fixture and unprecedented light projection of over 800 ft (243.8 m), this powerful fixture represents the next generation in exterior illumination.



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For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

PHILIPS

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Beam Angle	8° / 13° / 23° / 40° / 63° spread lenses, 5° x 17° asymmetric spread lens
	Lumens†	4,766 (23° spread lens, half unit)
	Color Temperature	2700 K – 6500 K
	Efficacy (lm/W)	38.1 (23° spread lens, half unit)
	CRI	68.5
	Mixing Distance	50 ft (15.2 m) to uniform light
	Lumen Maintenance‡	70,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 68,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	250 W maximum at full output, steady state (full unit)
	Power Factor	.981 (23° spread lens, half unit)
Physical	Dimensions *(Height x Width x Depth)*	20.5 x 28.9 x 4.8 in (521 x 734 x 122 mm)
	Weight	75 lb (34 kg)
	Effective Projected Area (EPA)	0.42 m^2
	Housing	Die-cast aluminium, powder-coated finish
	Lens	Tempered glass
	Fixture Connections	6 ft (1.8 m) unified power / data cable
	Operating Temperature	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths Per iW Data Enabler*	5 @ 110 VAC 6 @ 120 VAC 11 @ 220 VAC 12 @ 240 VAC *Configuration: 20 A circuit, standard 6 ft (1.8 m) Leader Cables, 5 ft (1.5 m) jumper cables*
Certification and Safety	Certification	UL / cUL, FCC Class A, CE
	LED Class	Class 2 LED product
	Environment	Dry / Damp / Wet Location, IP66

† Lumen measurement complies with IES LM-79-08

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Fixtures and Accessories

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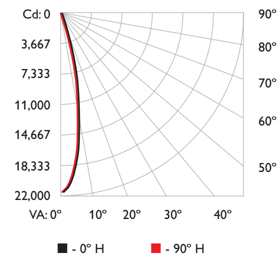
	23°	120-000068-01	910503700507
	40°	120-000068-02	910503700508
	63°	120-000068-03	910503700509
	5° x 17°	120-000068-04	910503700510
	8°	120-000068-05	910503700511
iW Data Enabler	UL / cUL	506-000001-00	910503700190
iW Data Enabler / Data Enabler Aux *For CE / PSE installations only*		506-000001-01	910503700791
iW Scene Controller		503-000001-00	910503700189

Use Item Number when ordering in North America.

Photometrics

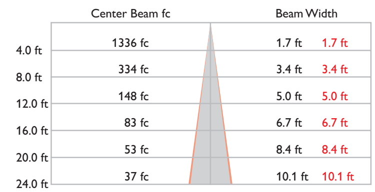
23° Spread Lens

Polar Candela Distribution



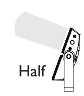
	0	22.5	44	67.5	90
0	21368	21368	21368	21368	21368
5	18824	18854	18849	18826	18871
15	7159	7155	7165	7166	7187
25	1426	1415	1403	1404	1411
35	353	352	360	368	368
45	161	161	168	182	183
55	77	77	79	91	92
65	27	27	28	34	35
75	0	0	2	4	5
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



146 ft (44.5 m)
1 fc maximum distance

Vert. Spread: 23.7°
Horiz. Spread: 23.8°

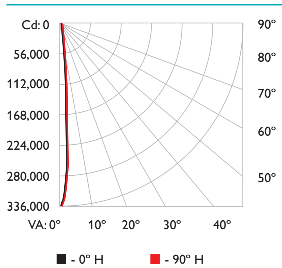


Power Consumption	125 W
Lumens	4,766
Efficacy	38.1 lm/W

For lux multiply fc by 10.7

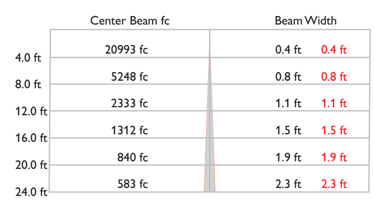
Without spread lens, half unit

Polar Candela Distribution



	0	22.5	44	67.5	90
0	335892	335892	335892	335892	335892
5	40839	40961	41410	40649	40264
15	1558	1586	1571	1556	1565
25	475	492	482	463	472
35	315	320	304	275	270
45	201	208	148	158	165
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



579 ft (176.5 m)
1 fc maximum distance

Vert. Spread: 5.4°
Horiz. Spread: 5.4°

Power Consumption	125 W
Lumens	5,406
Efficacy	43.2 lm/W

iW Reach Powercore fixtures are part of a complete line-voltage system which includes fixtures and:

- One or more iW Data Enablers.
- One Leader Cable to connect each fixture to a junction box or iW Data Enabler.
- 4-conductor copper wire to connect fixtures in series or in parallel.
- iW Scene Controller (up to four per single run of iW Data Enablers).

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

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DAS-000030-04 R01 08-09

Date: ______________________ Type: ____________________

Firm Name: ____

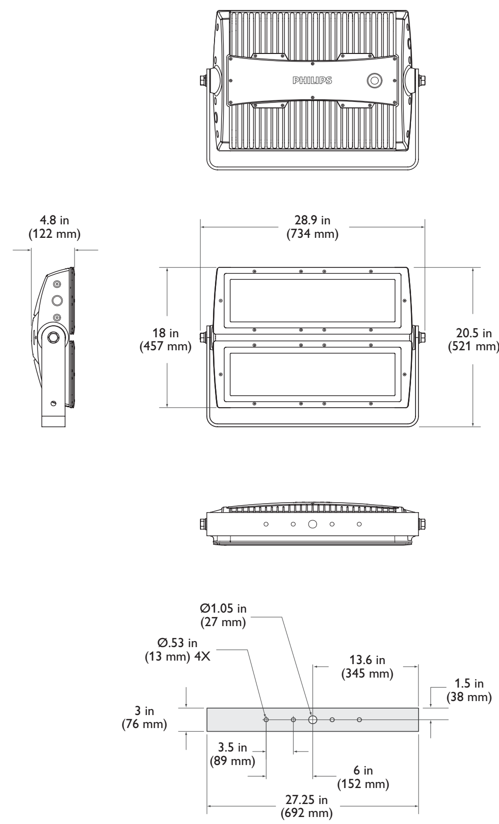
Project: ____

iW Reach Powercore

40° Spread Lens

Intelligent white LED floodlight for signature façades and structures

iW® Reach Powercore, the intelligent white light version of our flagship, high-performance exterior architectural floodlight, is the first LED fixture powerful enough to brilliantly illuminate large architectural façades with washes of white light in color temperatures ranging from a warm 2700 K to a cool 6500 K. iW Reach Powercore combines all the benefits of LED-based lighting in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions. With significantly more lumen output than any other competitive fixture and unprecedented light projection of over 800 ft (243.8 m), this powerful fixture represents the next generation in exterior illumination.



- Integrates Powercore® technology — Powercore technology rapidly, efficiently, and accurately controls power output to iW Reach Powercore fixtures directly from line voltage. The Philips iW Data Enabler merges line voltage with control data and delivers them to the fixture over a single standard wire, dramatically simplifying installation and lowering total system cost.
- Unparalleled light output — With an output of over 10,000 lumens and light projection of over 800 ft (243.8 m), iW Reach Powercore is the first fixture to offer legitimate LED-based, color-controllable white light illumination of large-scale structures and objects.
- Wide range of color temperature and brightness — Channels of warm white and cool white LEDs produce color temperatures ranging from 2700 K to 6500 K. Fixture brightness can be adjusted while varying or maintaining constant color temperature.
- Versatile optics — Exchangeable spread lenses of 8°, 13°, 23°, 40°, 63°, and an asymmetric 5° x 17° support a variety of photometric distributions for a multitude of applications, including spotlighting, wall grazing, and asymmetric wall washing. Bezel and gasket ship with spread lenses for easy user installation.
- Simple fixture positioning — Rugged, slim-profile mounting bracket allows simple positioning and fixture rotation through a full 360°. Side locking bolts reliably secure fixture with standard wrench.
- Universal power input range — iW Reach Powercore accepts a universal power input range of 100 to 240 VAC, allowing simple, location-independent installation.

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Beam Angle	8° / 13° / 23° / 40° / 63° spread lenses, 5° x 17° asymmetric spread lens
	Lumens†	4,692 (40° spread lens, half unit)
	Color Temperature	2700 K – 6500 K
	Efficacy (lm/W)	37.5 (40° spread lens, half unit)
	CRI	68.5
	Mixing Distance	50 ft (15.2 m) to uniform light
	Lumen Maintenance‡	70,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 68,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	250 W maximum at full output, steady state (full unit)
	Power Factor	.981 (40° spread lens, half unit)
Physical	Dimensions *(Height x Width x Depth)*	20.5 x 28.9 x 4.8 in (521 x 734 x 122 mm)
	Weight	75 lb (34 kg)
	Effective Projected Area (EPA)	0.42 m^2
	Housing	Die-cast aluminium, powder-coated finish
	Lens	Tempered glass
	Fixture Connections	6 ft (1.8 m) unified power / data cable
	Operating Temperature	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths Per iW Data Enabler*	5 @ 110 VAC 6 @ 120 VAC 11 @ 220 VAC 12 @ 240 VAC *Configuration: 20 A circuit, standard 6 ft (1.8 m) Leader Cables, 5 ft (1.5 m) jumper cables*
Certification and Safety	Certification	UL / cUL, FCC Class A, CE
	LED Class	Class 2 LED product
	Environment	Dry / Damp / Wet Location, IP66

† Lumen measurement complies with IES LM-79-08

‡ See iW Reach Powercore Product Guide for specific applications

* These figures, provided as a guideline, are accurate for this configuration only. Changing the configuration can affect the fixture run lengths.

Fixtures and Accessories

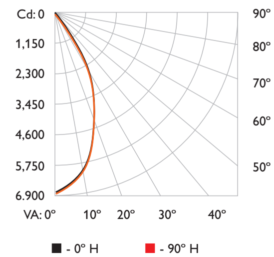
Item	Type	Item Number	Philips 12NC
iW Reach Powercore *Includes 6 ft (1.8 m) leader cable*	UL / cUL and CE / PSE	523-000045-00	910503700625
Replacement Leader Cable 6 ft (1.8 m)	UL / cUL	108-000043-02	910503700453
	CE / PSE	108-000043-03	910503700454
iW Reach Powercore Spread Lens with bezel	13°	120-000068-00	910503700506
	23°	120-000068-01	910503700507
	40°	120-000068-02	910503700508
	63°	120-000068-03	910503700509
	5° x 17°	120-000068-04	910503700510
	8°	120-000068-05	910503700511
iW Data Enabler	UL / cUL	506-000001-00	910503700190
iW Data Enabler / Data Enabler Aux *For CE / PSE installations only*		506-000001-01	910503700791
iW Scene Controller		503-000001-00	910503700189

Use Item Number when ordering in North America.

Photometrics

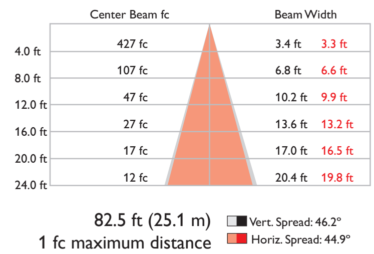
40° Spread Lens

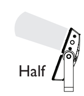
Polar Candela Distribution



	0	22.5	44	67.5	90
0	6833	6833	6833	6833	6833
5	6541	6548	6544	6525	6537
15	5057	5049	5016	4974	4972
25	3024	3002	2946	2895	2887
35	1300	1285	1251	1222	1216
45	408	403	399	403	405
55	144	144	148	158	160
65	67	67	69	77	80
75	17	18	23	27	30
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



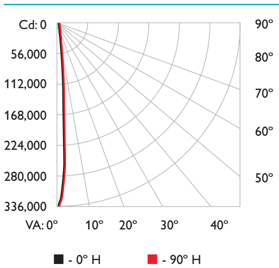


Power Consumption	125 W
Lumens	4,692
Efficacy	37.5 lm/W

For lux multiply fc by 10.7

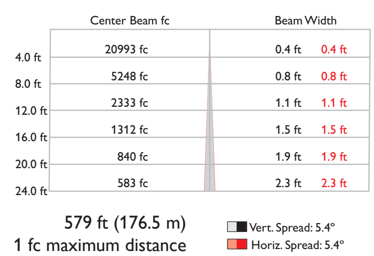
Without spread lens, half unit

Polar Candela Distribution



	0	22.5	44	67.5	90
0	335892	335892	335892	335892	335892
5	40839	40961	41410	40649	40264
15	1558	1586	1571	1556	1565
25	475	492	482	463	472
35	315	320	304	275	270
45	201	208	148	158	165
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



Power Consumption	125 W
Lumens	5,406
Efficacy	43.2 lm/W

iW Reach Powercore fixtures are part of a complete line-voltage system which includes fixtures and:

- One or more iW Data Enablers.
- One Leader Cable to connect each fixture to a junction box or iW Data Enabler.
- 4-conductor copper wire to connect fixtures in series or in parallel.
- iW Scene Controller (up to four per single run of iW Data Enablers).

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

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DAS-000030-05 R01 08-09

Date: ______________________ Type: ______________________

Firm Name: ____

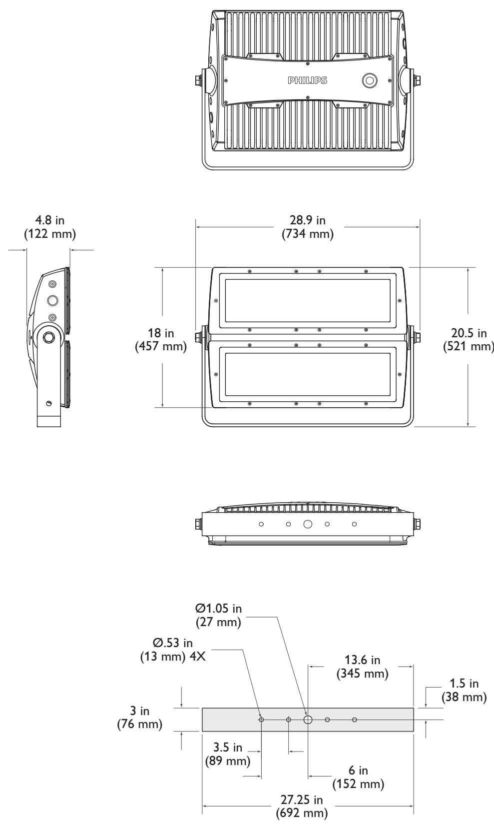
Project: ____

iW Reach Powercore

63° Spread Lens

Intelligent white LED floodlight for signature façades and structures

iW® Reach Powercore, the intelligent white light version of our flagship, high-performance exterior architectural floodlight, is the first LED fixture powerful enough to brilliantly illuminate large architectural façades with washes of white light in color temperatures ranging from a warm 2700 K to a cool 6500 K. iW Reach Powercore combines all the benefits of LED-based lighting in an elegant fixture specifically designed for large-scale installations, such as commercial skyscrapers, casinos, large retail exteriors, bridges, piers, public monuments, and themed attractions. With significantly more lumen output than any other competitive fixture and unprecedented light projection of over 800 ft (243.8 m), this powerful fixture represents the next generation in exterior illumination.



- Integrates Powercore® technology — Powercore technology rapidly, efficiently, and accurately controls power output to iW Reach Powercore fixtures directly from line voltage. The Philips iW Data Enabler merges line voltage with control data and delivers them to the fixture over a single standard wire, dramatically simplifying installation and lowering total system cost.
- Unparalleled light output — With an output of over 10,000 lumens and light projection of over 800 ft (243.8 m), iW Reach Powercore is the first fixture to offer legitimate LED-based, color-controllable white light illumination of large-scale structures and objects.
- Wide range of color temperature and brightness — Channels of warm white and cool white LEDs produce color temperatures ranging from 2700 K to 6500 K. Fixture brightness can be adjusted while varying or maintaining constant color temperature.
- Versatile optics — Exchangeable spread lenses of 8°, 13°, 23°, 40°, 63°, and an asymmetric 5° x 17° support a variety of photometric distributions for a multitude of applications, including spotlighting, wall grazing, and asymmetric wall washing. Bezel and gasket ship with spread lenses for easy user installation.
- Simple fixture positioning — Rugged, slim-profile mounting bracket allows simple positioning and fixture rotation through a full 360°. Side locking bolts reliably secure fixture with standard wrench.
- Universal power input range — iW Reach Powercore accepts a universal power input range of 100 to 240 VAC, allowing simple, location-independent installation.

For detailed product information, please refer to the iW Reach Powercore Product Guide at www.colorkinetics.com/ls/intelliwhite/iwreach/

PHILIPS

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Beam Angle	8° / 13° / 23° / 40° / 63° spread lenses, 5° x 17° asymmetric spread lens
	Lumens†	4,626 (63° spread lens, half unit)
	Color Temperature	2700 K – 6500 K
	Efficacy (lm/W)	37.0 (63° spread lens, half unit)
	CRI	68.5
	Mixing Distance	50 ft (15.2 m) to uniform light
	Lumen Maintenance‡	70,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 68,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	250 W maximum at full output, steady state (full unit)
	Power Factor	.981 (63° spread lens, half unit)
Physical	Dimensions *(Height x Width x Depth)*	20.5 x 28.9 x 4.8 in (521 x 734 x 122 mm)
	Weight	75 lb (34 kg)
	Effective Projected Area (EPA)	0.42 m^2
	Housing	Die-cast aluminium, powder-coated finish
	Lens	Tempered glass
	Fixture Connections	6 ft (1.8 m) unified power / data cable
	Operating Temperature	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths Per iW Data Enabler*	5 @ 110 VAC 6 @ 120 VAC 11 @ 220 VAC 12 @ 240 VAC *Configuration: 20 A circuit, standard 6 ft (1.8 m) Leader Cables, 5 ft (1.5 m) jumper cables*
Certification and Safety	Certification	UL / cUL, FCC Class A, CE
	LED Class	Class 2 LED product
	Environment	Dry / Damp / Wet Location, IP66

† Lumen measurement complies with IES LM-79-08

‡ See iW Reach Powercore Product Guide for specific applications

* These figures, provided as a guideline, are accurate for this configuration only. Changing the configuration can affect the fixture run lengths.

Fixtures and Accessories

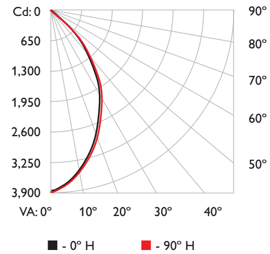
Item	Type	Item Number	Philips 12NC
iW Reach Powercore *Includes 6 ft (1.8 m) leader cable*	UL / cUL and CE / PSE	523-000045-00	910503700625
Replacement Leader Cable 6 ft (1.8 m)	UL / cUL	108-000043-02	910503700453
	CE / PSE	108-000043-03	910503700454
iW Reach Powercore Spread Lens with bezel	13°	120-000068-00	910503700506
	23°	120-000068-01	910503700507
	40°	120-000068-02	910503700508
	63°	120-000068-03	910503700509
	5° x 17°	120-000068-04	910503700510
	8°	120-000068-05	910503700511
iW Data Enabler	UL / cUL	506-000001-00	910503700190
iW Data Enabler / Data Enabler Aux *For CE / PSE installations only*		506-000001-01	910503700791
iW Scene Controller		503-000001-00	910503700189

Use Item Number when ordering in North America.

Photometrics

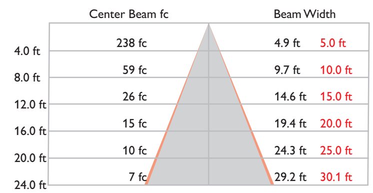
63° Spread Lens

Polar Candela Distribution



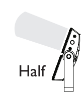
	0	22.5	44	67.5	90
0	3807	3807	3807	3807	3807
5	3696	3700	3700	3697	3705
15	3103	3109	3114	3117	3129
25	2393	2400	2413	2425	2438
35	1610	1623	1649	1668	1679
45	881	895	923	948	959
55	366	375	398	420	429
65	130	133	145	161	166
75	35	37	44	53	56
85	0	0	0	0	1
90	0	0	0	0	0

Illuminance at Distance



61.7 ft (18.8 m)
1 fc maximum distance

Vert. Spread: 62.6°
Horiz. Spread: 64.1°



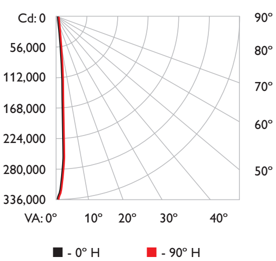
Half

Power Consumption	125 W
Lumens	4,626
Efficacy	37.0 lm/W

For lux multiply fc by 10.7

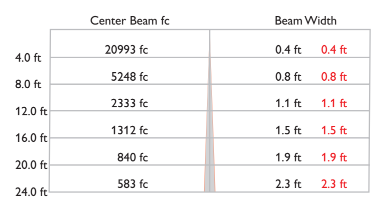
Without spread lens, half unit

Polar Candela Distribution



	0	22.5	44	67.5	90
0	335892	335892	335892	335892	335892
5	40839	40961	41410	40649	40264
15	1558	1586	1571	1556	1565
25	475	492	482	463	472
35	315	320	304	275	270
45	201	208	148	158	165
55	0	0	0	0	0
65	0	0	0	0	0
75	0	0	0	0	0
85	0	0	0	0	0
90	0	0	0	0	0

Illuminance at Distance



579 ft (176.5 m)
1 fc maximum distance

Vert. Spread: 5.4°
Horiz. Spread: 5.4°

Power Consumption	125 W
Lumens	5,406
Efficacy	43.2 lm/W

iW Reach Powercore fixtures are part of a complete line-voltage system which includes fixtures and:

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- One Leader Cable to connect each fixture to a junction box or iW Data Enabler.
- 4-conductor copper wire to connect fixtures in series or in parallel.
- iW Scene Controller (up to four per single run of iW Data Enablers).

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Tel 617.423.9999
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www.colorkinetics.com

Date: ______________________ Type: ______________________

Firm Name: ____

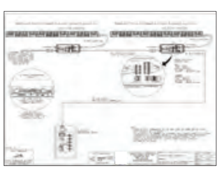
Project: ____

iW Data Enabler

Data formatting and power for IntelliWhite series fixtures

For device mounting details, refer to the Installation Instructions included in the product packaging, or download documentation from www.colorkinetics.com/ls/pds/iwdataenabler/

To calculate the number of fixtures your specific installation can support, download the Configuration Calculator from www.colorkinetics.com/support/install_tool/



iW Data Enabler wiring diagrams are available online at www.colorkinetics.com/support/wiring/

iW® Data Enabler is a data formatting power / data supply designed for IntelliWhite® series LED lighting fixtures employing Powercore® technology from Philips Color Kinetics.

Engineered for use in zone control network configurations, iW Data Enabler is compatible iW Scene Controller.

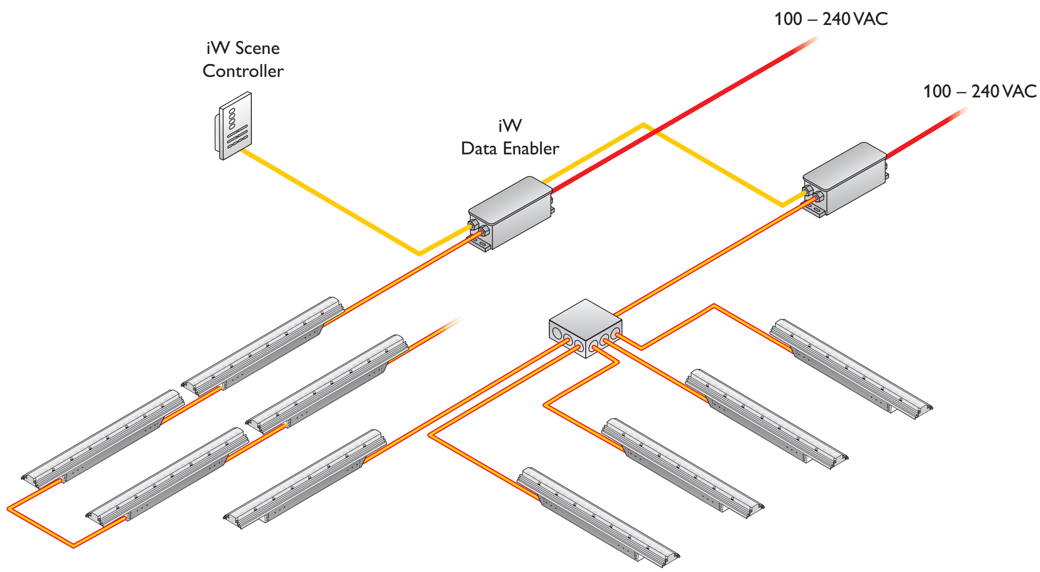
iW Data Enabler accommodates input voltages ranging from 100 VAC to 240 VAC where the maximum connected base load does not exceed 20 Amps.

Featuring a NEMA 4 (IP66) enclosure, iW Data Enabler installs in dry, damp, and wet locations.

Multiple conduit entries accommodate 3/4 in (19 mm) NPT conduit.

Compatible Fixtures

IntelliWhite series fixtures employing Powercore technology from Philips Color Kinetics — intelligent white light fixtures with onboard power processing technology

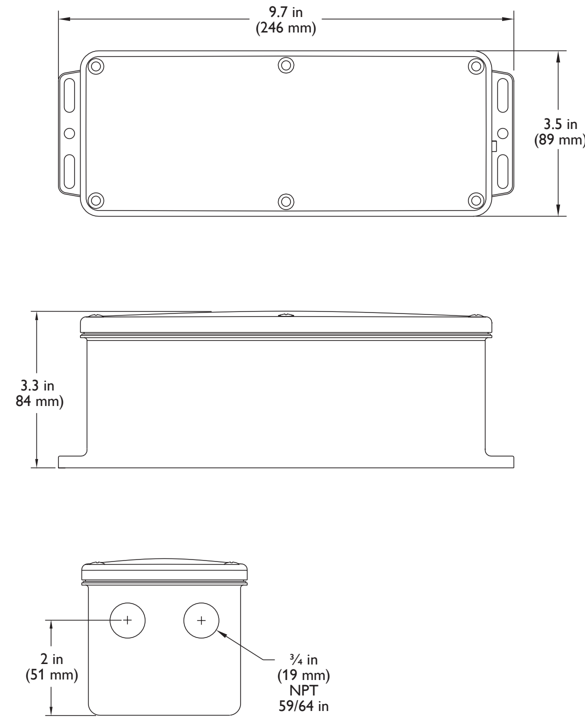


PHILIPS

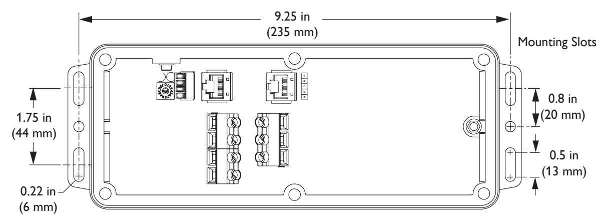
Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details	
Electrical	Input Voltage	100 – 240 VAC, auto-switching, 50 / 60 Hz	
	Maximum Input Current	Maximum connected load should not exceed 20 A	
	Internal Load	10 W	
Physical	Dimensions *(Height x Width x Depth)*	3.3 x 3.5 x 9.7 in (84 x 89 x 246 mm)	
	Weight	2.5 lb (1.1 kg)	
	Construction	NEMA 4 enclosure, cast aluminum, with slots for surface mounting	
	Finish	Gray matte	
	Connectors	Data Input	4-wire terminal block controller input; RJ-45 connector
		Power Input	3-wire terminal block connector
		Power / Data Output	4-wire terminal block connector
	Operating Temperature	-40° – 122° F (-40° – 50° C)	
	Humidity	0 – 95%, non-condensing	
	Cooling	Convection	
	Heat Dissipation	10 W	
	Data Input Source	iW Scene Controller	
Certification and Safety	Certification	UL / cUL, CE, PSE	
	Environment	Dry / Damp / Wet Location, IP66	



Overall Dimensions

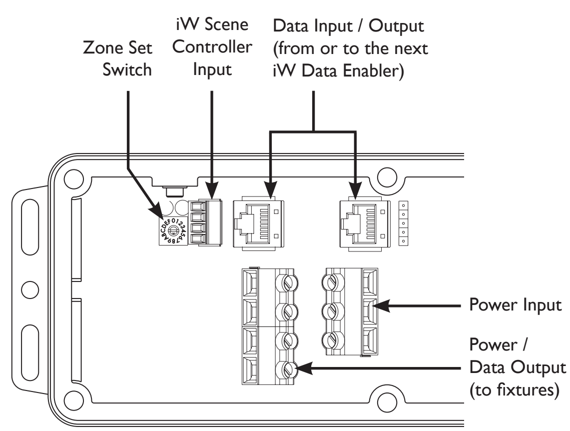


Mounting Dimensions

Ordering Information

Item	Included Components	Item Number	Philips 12NC
iW Data Enabler	iW Data Enabler with cover and attaching screws, gasket, (4) NPT threaded seal plugs, and Installation Instructions	506-000001-00	910503700190
iW Scene Controller	iW Scene Controller with leader cable, standard single-gang wall box, (2) self-threading flathead screws, and Decora® style faceplate	503-000001-00	910503700189

Use Item Number when ordering in North America.



iW Data Enabler uses a zone set switch to assign zone control settings. For complete iW Data Enabler configuration instructions, refer to the *Addressing and Configuration Guide* available online at www.colorkinetics.com/support/addressing/

Philips Color Kinetics
3 Burlington Woods Drive
Burlington, Massachusetts 01803 USA
Tel 888.385.5742
Tel 617.423.9999
Fax 617.423.9998
www.colorkinetics.com

DAS-000055-01 R00 12-09

APPENDIX I.F: OFFICE LIGHTING FIXTURE CUT SHEETS

Recessed

Armstrong® TechZone™ Compatible

Fluorescent
One or Two Lamp
T5, T5 HO, T8

Recessed Bivergence®

6" x 4'
6" x 5'

online Find it Fast 288

Applications: The Bivergence fixture is a high performance recessed mounted fixture guaranteeing photometric accuracy and high efficiency. The superior louver design provides maximum visual comfort through perfect control of glare and veiling reflections. The Bivergence range provides high performance lighting for such critical environments as VDT-intensive office spaces, retail spaces, laboratories and open plan offices.

Meets RP-1-04 for intensive (C 1285 and 1328) and normal (C 1545, 2285, 2328, 1355, 1805 and 2355) VDT-use offices.

Type: Open Office

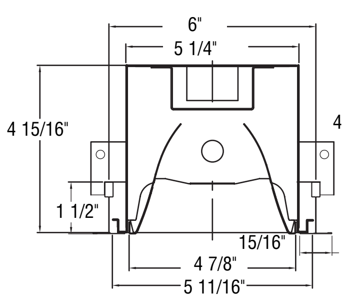
Project: New York Times Building Thesis - Redesign

ORDERING NOTE: Specify fixture/ceiling type, louver, length, lamping, voltage and options.

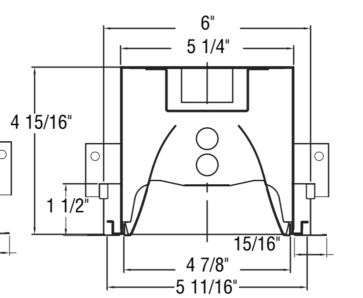
▼ Fixture/Ceiling Type	▼ Louver	▼ Length	▼ Lamping	▼ Voltage	▼ Options
RB_	DX	65	1355	DD	WN
RBU Recessed Bivergence, 15/16" Lay-In, Flush 9/16" Slot-Grid, Flush 9/16" Lay-In, Tegular **RBF** Recessed Bivergence, 9/16" Lay-In, Flush ***See page R-16A for TechZone and common ceiling mounting details***	**C** Matte **DX** Specular	**64** 6" x 4' **65** 6" x 5'	**1285** (1) 28W T5 **1545** (1) 54W T5 HO **2285** (2) 28W T5 **1328** (1) 32W T8 **2328** (2) 32W T8 **2545** (2) 54W T5 HO **1355** (1) 35W T5 **2355** (2) 35W T5 **1805** (1) 80W T5 HO **1408** (1) 40W T8 **2408** (2) 40W T8	**U** Universal 120/277V **347** 347V (consult factory for availability; not available with EM, dimming) **DA_*** Dimming, Analog (0-10V) **DD_*** Dimming, DALI (consult factory) **DE_*** Dimming, Lutron ECO-10™ **DH_*** Dimming, Lutron Hi-Lume® **DSC_*** Dimming, Lutron EcoSystem Control Fixture **DSN_*** Dimming, Lutron EcoSystem Non-control Fixture	**WF** Whip Flex 3/8" x 6' 14/3 AWG **WN_*** Whip Flex 3/8" x 6' 14/3 AWG (NYC) **EM1_*** Standby Battery Pack for 1-Lamp Operation **SS** Separate Switching (consult factory) **F** Fusing **AR** Air Return **CP** Chicago Plenum

* Indicate 120V (1) or 277V (2). Some lamp types may not be available. Consult factory for availability.

End View – (1) Lamp T5 Fixture

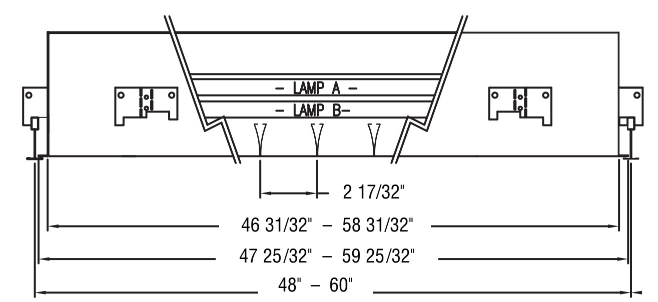


End View – (2) Lamp T5 Fixture



See page R-16A for TechZone and common ceiling mounting details

Side View – (2) Lamp T5 Fixture **NOTE: (2) Lamp T8 positioned side by side.**



c UL us LISTED

Suitable for damp locations
NYC Approved

IBEW Union Made

1. Housing - 20 gauge cold rolled steel. Fixtures are painted white.

2. Sockets - Bi-pin. Twist lock lamp installation.

3. Lamping - One or two 28W T5 (4'), 35W T5 (5'), 54W T5 HO (4'), 32W T8 (4') or 40W T8 (5'), or one 80W T5 HO (5'), fluorescent lamps, supplied by others. Access to lamps is from below the fixture after the removal of the louver.

4. Ballast - Universal voltage electronic 120/277V ballast is mounted in housing of luminaire.

5. Louvers - Matte silver or specular anodized aluminum. Louver blades are 1 7/16" deep and 2 1/2" on center. The 4' unit has a total of 18 cells, and the 5' unit has a total of 23 cells. Louver is held by internal spring clips and can be suspended from one side for maintenance.

6. Mounting - Fixtures for mounting in lay-in ceilings. Depth of housing is 4 7/8". Electrical access plate in housing top. Fixtures can mounted in continuous run.

7. Stand-by Battery Pack - Integral stand-by battery pack for one lamp operation with integral test switch. Light and test switch located on wireway cover.

8. Weight - 16.0 lbs.

ECO-10 and EcoSystem are trademarks of Lutron Electronics Co., Inc. HiLume is a registered trademark of Lutron Electronics Co., Inc.

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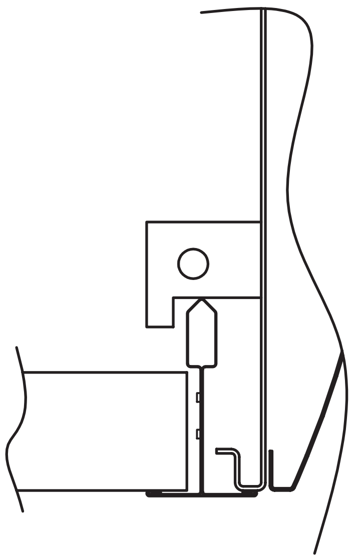
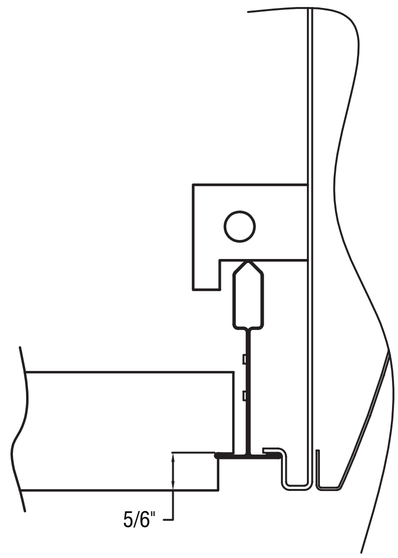
www.zumtobel.us
TEL (845) 691-6262 • (800) 932-0633 • FAX (845) 691-6289
10/27/09

ZUMTOBEL

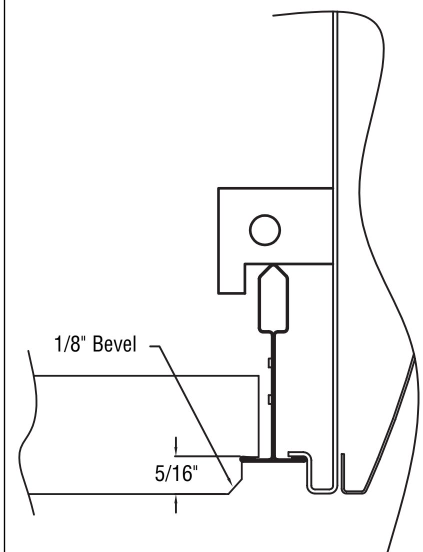
Ceiling Mounting Details



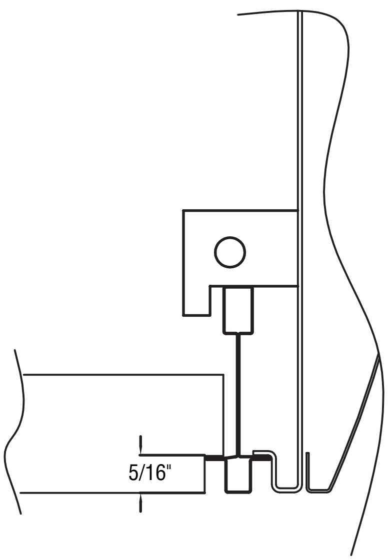
TechZone – 15/16" Square Lay-In Prelude (15/16" Lay-In Flush)



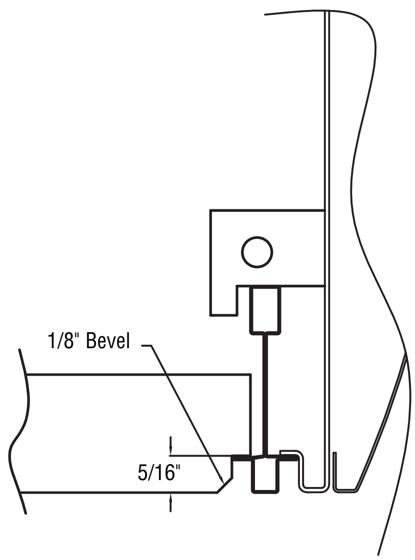
TechZone – 9/16" Square Tegular Suprafine (9/16" Lay-In Tegular)



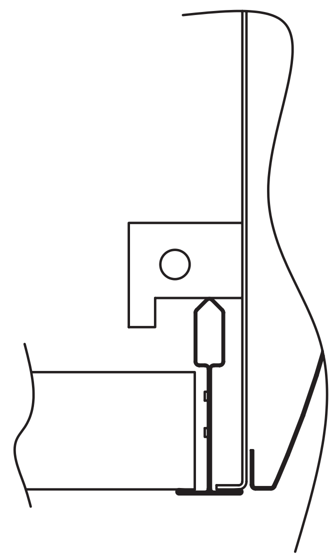
TechZone – 9/16" Square Tegular Suprafine (9/16" Lay-In Tegular)



TechZone – 9/16" Square Tegular Interlude (9/16" Slot-Grid)



TechZone – 9/16" Beveled Tegular Interlude (9/16" Slot-Grid)



9/16" Lay-In Flush

Photometric Data

RB C 64 1285 (1) 28W T5

6" x 4' RECESSED BIVERGENCE, MATTE SILVER LOUVER

LTL 11046

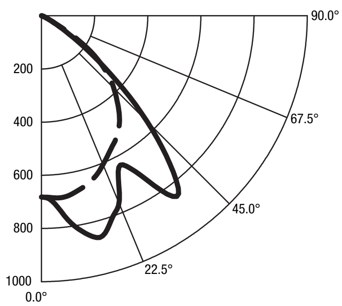
Total Luminaire Efficiency 64%

0% Uplight 100% Downlight

Spacing Criteria Lateral Plane	0°	90°
	1.2	1.7

TOTAL LAMP LUMENS = 2610
INPUT WATTS = 33

Candela Distribution



Vertical Angle	Horizontal Angle 0°	45°	90°	Zonal Lumens
0°	682	682	682	
5°	688	709	725	65.4
15°	658	815	862	220.9
25°	585	753	686	323.9
35°	509	559	816	401.2
45°	385	588	562	394.3
55°	208	262	163	202.3
65°	32	36	20	40.2
75°	9	6	4	7.0
85°	1	0	0	0.6
90°	0	0	0	

Luminance Data in Candela / Sq. Meter

Angle in Vertical°	Average 0°	Average 45°	Average 90°
45°	4218	6441	6156
55°	2809	3538	2201
65°	587	660	367
75°	269	180	120
85°	89	0	0

Coefficients of Utilization

Effective Floor Cavity Reflectance = 20%

pcc	0.8				0.7				0.5			0.3		
pw	0.7	0.5	0.3	0.1	0.7	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
0	76	76	76	76	74	74	74	74	71	71	71	68	68	68
1	71	69	67	65	70	68	66	64	65	64	62	63	61	60
2	66	62	59	56	65	61	58	56	59	56	54	57	55	53
3	62	56	52	49	60	55	51	48	53	50	47	52	49	47
4	57	51	46	43	56	50	46	42	48	45	42	47	44	41
5	53	46	41	37	52	45	41	37	44	40	37	43	39	37
6	49	42	37	33	48	41	37	33	40	36	33	39	35	33
7	46	38	33	30	45	38	33	30	37	33	29	36	32	29
8	43	35	30	27	42	35	30	27	34	30	27	33	29	26
9	40	32	27	24	39	32	27	24	31	27	24	30	27	24

RB C 64 1328 (1) 32W T8

6" X 4' RECESSED BIVERGENCE, MATTE SILVER LOUVER

PRORATED FROM LTL 11085

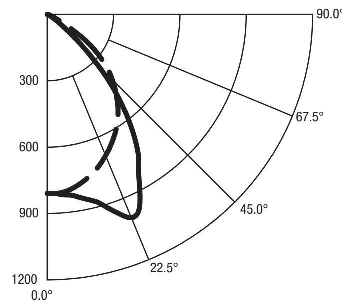
Total Luminaire Efficiency 56%

0% Uplight 100% Downlight

Spacing Criteria Lateral Plane	0°	90°
	1.1	1.4

TOTAL LAMP LUMENS = 2900
INPUT WATTS = 31

Candela Distribution



Vertical Angle	Horizontal Angle 0°	45°	90°	Zonal Lumens
0°	809	809	809	
5°	807	816	819	72.7
15°	754	820	879	232.4
25°	667	843	980	378.8
35°	559	748	696	420.2
45°	416	456	326	326.3
55°	228	156	64	148.0
65°	45	23	12	32.2
75°	11	5	2	6.7
85°	2	1	0	1.2
90°	0	0	0	

Luminance Data in Candela / Sq. Meter

Angle in Vertical°	Average 0°	Average 45°	Average 90°
45°	4560	4991	3566
55°	3083	2109	859
65°	823	429	224
75°	335	141	57
85°	169	80	0

Coefficients of Utilization

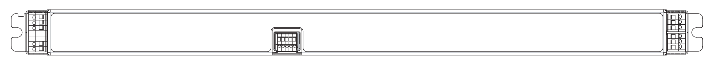
Effective Floor Cavity Reflectance = 20%

pcc	0.8				0.7				0.5			0.3		
pw	0.7	0.5	0.3	0.1	0.7	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
0	67	67	67	67	66	66	66	66	63	63	63	60	60	60
1	63	61	60	58	62	60	58	57	58	56	55	56	55	54
2	59	56	53	50	58	55	52	50	53	50	49	51	49	48
3	55	50	47	44	54	50	46	44	48	45	43	47	44	42
4	51	46	42	39	50	45	41	39	44	41	38	43	40	38
5	48	42	38	35	47	41	37	34	40	37	34	39	36	34
6	44	38	34	31	43	38	34	31	37	33	31	36	33	30
7	42	35	31	28	41	35	31	28	34	30	28	33	30	27
8	39	32	28	25	38	32	28	25	31	28	25	31	27	25
9	36	30	26	23	36	29	26	23	29	25	23	28	25	23

EcoSystem Multiple Control Input Ballasts

Digital electronic dimming ballasts maximize the benefits of a lighting management system. *EcoSystem* Ballasts offer 100% to 10% dimming; ideal for use where saving energy, increasing flexibility, and maximizing productivity are the goals of the lighting design.

***EcoSystem* case type G**



***EcoSystem* case type J**

Features

- Continuous, flicker-free dimming from 100% to 10%
- Provides power for and responds to one occupancy sensor, one photo sensor, and one personal control input (infrared receiver or wallstation)
- Communicates status and sensor inputs over the *EcoSystem* Bus
- Programmed rapid start design ensures full rated lamp life while dimming and cycling
- Lamps turn on to any dimmed level without flashing to full brightness
- Low harmonic distortion throughout the entire dimming range
- Frequency of operation ensures that ballast does not interfere with infrared devices
- End-of-lamp-life protection circuitry ensures safe operation throughout entire lamp life
- Ultra-quiet operation
- Nonvolatile memory restores all ballast settings after power failure
- Ballasts maintain consistent light output for linear lamp lengths (i.e. 4 ft., 3 ft., 2 ft. have same relative output)
- 100% performance tested at factory

Job Name:	Model Numbers:
Job Number:	

Specifications

Standards

- California Energy Commission (CEC) Listed
- UL Listed (evaluated to the requirements of UL935)
- CSA certified (evaluated to the requirements of C22.2 No. 74)
- NOM Listed for 32 W T8 Ballasts
- S Mark Certified
- Class P thermally protected
- Meets ANSI C82.11 High Frequency Ballast Standard
- Meets FCC Part 18 Non-Consumer requirements for EMI/RFI emissions
- Meets ANSI C62.41 Category A surge protection standards up to and including 4 kV
- Manufacturing facilities employ ESD reduction practices that comply with the requirements of ANSI/ESD S20.20
- Lutron Quality Systems registered to ISO 9001.2000

Performance

- Operating Voltage: 120, 220/240, 277 V∼ at 50 or 60 Hz
- Grounding: ballast and fixture must be grounded for proper dimming
- Dimming Range: 100% to 10% measured relative light output
- Lamp Starting: programmed rapid start
- Lamp Current Crest Factor: less than 1.7
- Light Output Variation: Constant ±2% light output for line voltage variations of ±10%
- Lamp Life: Average lamp life meets or exceeds specified lamp ratings
- Power Factor: 0.95 minimum
- Total Harmonic Distortion (THD): Less than 20%
- Inaudible in a 27 dBA ambient
- Maximum Inrush Current: 3 A per ballast at 277 V∼, 7A per ballast at 120 V∼
- Class 2 Output: +20 V⎓, 50mA maximum (one daylight sensor, one keypad and one occupancy sensor can be connected)

Environment

- Minimum lamp starting temperature: 50 °F (10 °C)
- Relative humidity: less than 90% non-condensing
- Sound Rating: inaudible in a 27 dB ambient
- Maximum ballast case temperature: 75 °C (167 °F)

Ballast Wiring & Mounting

- Ballast is grounded by a mounting screw to the fixture
- Terminal blocks on the ballast accept the following wire gauges:
  Power Wiring, Lamp Wiring, and *EcoSystem* Bus:
  only one #18 AWG solid per terminal
  Class 2 Sensors:
  only one #22 AWG solid per terminal
- Only one wire per terminal
- Class 2 sensor wiring must be separated from all power and Class 1 wiring, consult all applicable local and national codes
- Ballast mounts using two screws (or sheet metal feature and one screw) within a fluorescent fixture
- Wiring from the ballast to lamp sockets shall not exceed 7 ft. for T8, T5, and T5HO lamps
- Wiring from the ballast to lamps sockets shall not exceed 3 ft. for T5 Twin Tube lamps

Lamp Seasoning

Refer to lamp manufacturer for lamp seasoning requirements prior to dimming

Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballasts for linear and U bend T8 Lamps

Lamp	No. of Lamps	Model	Case Size	Input Voltage (VAC)	Input Current (A)	Input Power (W)	Ballast Factor (BF)	System Lumens (lm)	System Efficacy (lm/W)	Ballast Efficacy Factor	Relative Efficacy (RSE)
F32T8 (48 in)	1	EC5 T832 J UNV 1	J	277 240 120	0.11 0.13 0.26	31.6 31.0 31.3	0.85 0.85 0.85	2550 2550 2550	81 82 81	2.69 2.74 2.72	0.86 0.87 0.87
	2	EC5 T832 G UNV 2L	G	277 240 120	0.22 0.25 0.49	59.6 57.6 58.8	0.85 0.85 0.85	5100 5100 5100	86 89 87	1.43 1.48 1.45	0.91 0.94 0.93
		EC5 T832 J UNV 2	J	277 240 120	0.21 0.25 0.49	57.4 59.0 59.1	0.85 0.85 0.85	5100 5100 5100	89 86 86	1.48 1.44 1.44	0.95 0.92 0.92
	3	EC5 T832 G UNV 3L	G	277 240 120	0.31 0.36 0.72	86.5 84.0 85.9	0.85 0.85 0.85	7650 7650 7650	88 89 89	0.98 1.01 0.99	0.94 0.97 0.95
		EC5 T832 G UNV 317L	G	277 240 120	0.41 0.47 0.95	105.7 106.5 106.8	1.17 1.17 1.17	10,530 10,530 10,530	100 99 99	1.11 1.10 1.10	1.06 1.05 1.05
F25T8 (36 in)	1	EC5 T825 J UNV 1	J	277 240 120	0.10 0.11 0.23	27.6 27.0 26.9	0.85 0.85 0.85	1828 1828 1828	66 68 68	3.08 3.15 3.16	0.77 0.79 0.79
	2	EC5 T825 J UNV 2	J	277 240 120	0.18 0.20 0.41	48.9 49.0 49.0	0.85 0.85 0.85	3665 3665 3665	75 75 75	1.74 1.73 1.73	0.87 0.87 0.87
F17T8 (24 in)	1	EC5 T817 J UNV 1	J	277 240 120	0.08 0.08 0.17	20.6 20.0 20.1	0.85 0.85 0.85	1190 1190 1190	68 60 70	4.13 4.25 4.23	0.70 0.72 0.72
	2	EC5 T817 J UNV 2	J	277 240 120	0.13 0.15 0.31	36.2 37.0 37.0	0.85 0.85 0.85	2380 2380 2380	66 64 64	2.35 2.30 2.30	0.80 0.78 0.78

EcoSystem Ballasts for linear T5 Lamps

Lamp	No. of Lamps	Model	Case Size	Input Voltage (VAC)	Input Current (A)	Input Power (W)	Ballast Factor (BF)	System Lumens (lm)	System Efficacy (lm/W)	Ballast Efficacy Factor	Relative Efficacy (RSE)
F35T5 (57.1 in)	1	EC5 T535 J UNV 1	J	277 240 120	0.15 0.18 0.35	42.0 42.3 42.2	1.0 1.0 1.0	3650 3650 3650	87 87 87	2.38 2.38 2.38	0.83 0.83 0.83
F28T5 (45.2 in)	1	EC5 T528 J UNV 1	J	277 240 120	0.12 0.14 0.27	32.6 32.9 32.9	1.0 1.0 1.0	2900 2900 2900	89 88 88	3.07 3.04 3.04	0.86 0.85 0.85
	2	EC5 T528 J UNV 2	J	277 240 120	0.23 0.27 0.54	64.5 65.0 65.2	1.0 1.0 1.0	5800 5800 5800	90 89 89	1.55 1.54 1.53	0.87 0.86 0.86
F21T5 (33.4 in)	1	EC5 T521 J UNV 1	J	277 240 120	0.09 0.12 0.22	25.8 25.8 25.8	1.0 1.0 1.0	2100 2100 2100	81 81 81	3.88 3.88 3.88	0.81 0.81 0.81
	2	EC5 T521 J UNV 2	J	277 240 120	0.17 0.20 0.39	46.0 47.2 47.2	1.0 1.0 1.0	4200 4200 4200	91 89 89	2.17 2.12 2.12	0.91 0.89 0.89
F14T5 (21.6 in)	1	EC5 T514 J UNV 1	J	277 240 120	0.07 0.08 0.16	19.0 19.2 19.2	1.0 1.0 1.0	1350 1350 1350	71 70 70	5.26 5.21 5.21	0.74 0.74 0.74
	2	EC5 T514 J UNV 2	J	277 240 120	0.12 0.14 0.28	32.8 33.3 33.3	1.0 1.0 1.0	2700 2700 2700	82 81 81	3.05 3.00 3.00	0.85 0.85 0.85

Job Name: Job Number:	Model Numbers:

EcoSystem Ballasts for linear T5 HO Lamps

Lamp	No. of Lamps	Model	Case Size	Input Voltage (VAC)	Input Current (A)	Input Power (W)	Ballast Factor (BF)	System Lumens (lm)	System Efficacy (lm/W)	Ballast Efficacy Factor	Relative Efficacy (RSE)
F54T5 (45.2 in)	1	EC5 T554 J UNV 1	J	277 240 120	0.21 0.24 0.48	56.5 58.0 57.9	1.0 1.0 1.0	5000 5000 5000	88 86 86	1.77 1.73 1.73	0.96 0.93 0.93
	2	EC5 T554 J UNV 2	J	277 240 120	0.40 0.52 0.99	110.1 119.0 119.3	1.0 1.0 1.0	10,000 10,000 10,000	91 84 84	0.91 0.84 0.84	0.98 0.91 0.91
F39T5 (33.4 in)	1	EC5 T539 J UNV 1	J	277 240 120	0.16 0.18 0.37	43.3 44.0 44.0	1.0 1.0 1.0	3500 3500 3500	81 80 80	2.31 2.27 2.27	0.90 0.89 0.89
	2	EC5 T539 J UNV 2	J	277 240 120	0.30 0.35 0.70	83.0 84.0 84.3	1.0 1.0 1.0	7000 7000 7000	84 83 83	1.20 1.19 1.19	0.94 0.93 0.93
F24T5 (21.6 in)	1	EC5 T524 J UNV 1	J	277 240 120	0.11 0.13 0.24	30.0 28.8 28.8	1.0 1.0 1.0	2000 2000 2000	67 69 69	3.33 3.47 3.47	0.80 0.83 0.83
	2	EC5 T524 J UNV 2	J	277 240 120	0.20 0.23 0.45	54.8 54.0 53.9	1.0 1.0 1.0	4000 4000 4000	73 74 74	1.82 1.85 1.86	0.89 0.89 0.89

Job Name:	Model Numbers:
Job Number:	

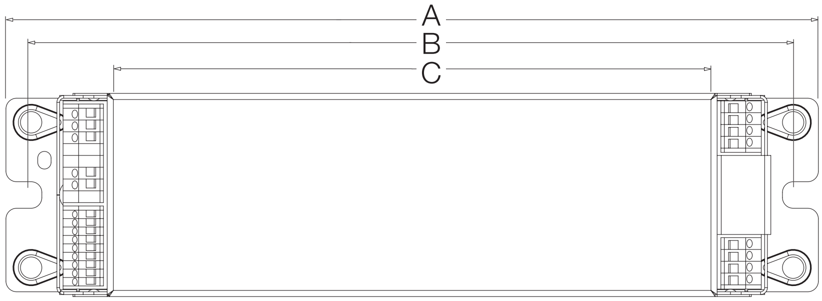
EcoSystem Ballasts for T5 Twin Tube Lamps

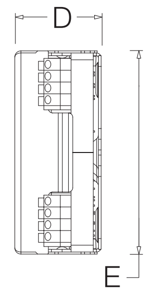
Lamp	No. of Lamps	Model	Case Size	Input Voltage (VAC)	Input Current (A)	Input Power (W)	Ballast Factor (BF)	System Lumens (lm)	System Efficacy (lm/W)	Ballast Efficacy Factor	Relative Efficacy (RSE)
FT55 (20.7 in)	1	EC5 T555 J UNV 1	J	277 240 120	0.20 0.23 0.46	55.4 55.2 55.2	0.9 0.9 0.9	4320 4320 4320	70 70 70	1.62 1.63 1.63	0.89 0.90 0.90
	2	EC5 T555 J UNV 2	J	277 240 120	0.40 0.46 0.92	110.8 110.4 110.4	0.9 0.9 0.9	8640 8640 8640	78 78 78	0.81 0.82 0.82	0.99 0.90 0.90
FT50 (22.5 in)	1	EC5 T550 J UNV 1	J	277 240 120	0.20 0.23 0.45	55.4 54.0 54.0	1.0 1.0 1.0	4000 4000 4000	72 72 74	1.81 1.85 1.85	0.90 0.93 0.93
	2	EC5 T550 J UNV 2	J	277 240 120	0.36 0.42 0.84	99.7 100.8 100.8	1.0 1.0 1.0	8000 8000 8000	80 79 79	1.00 0.99 0.99	1.00 0.99 0.99
FT40 (22.5 in)	1	EC5 T540 J UNV 1	J	277 240 120	0.16 0.18 0.36	44.3 43.2 43.2	1.0 1.0 1.0	3100 3100 3100	70 72 72	2.26 2.31 2.31	0.90 0.93 0.93
	2	EC5 T540 J UNV 2	J	277 240 120	0.27 0.32 0.64	74.8 76.8 76.8	1.0 1.0 1.0	6200 6200 6200	83 81 81	1.34 1.30 1.30	1.07 1.04 1.04
	3	EC5 T540 G UNV 3L	G	277 240 120	0.40 0.47 0.95	111.3 112.4 113.2	1.0 1.0 1.0	9300 9300 9300	84 83 82	0.90 0.89 0.88	1.08 1.07 1.06
FT39 FT36 (15.5 in)	1	EC5 T536 J UNV 1	J	277 240 120	0.14 0.17 0.33	38.8 39.6 39.6	1.0 1.0 1.0	2850 2850 2850	74 72 72	2.57 2.53 2.53	0.93 0.91 0.91
	2	EC5 T536 J UNV 2	J	277 240 120	0.26 0.31 0.61	72.0 73.2 73.2	1.0 1.0 1.0	5700 5700 5700	79 78 78	1.39 1.37 1.37	1.00 0.98 0.98

Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballast Case Dimensions

G Case





G Case Dimensions

A = 9.5 in (241 mm)

B = 8.9 in (226 mm)

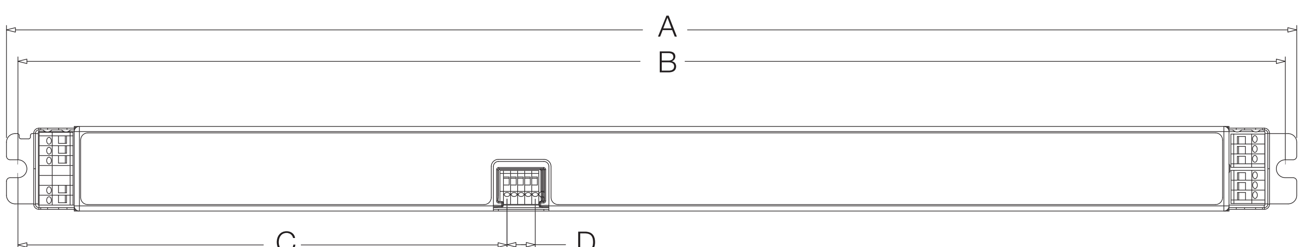
C = 7.1 in (180 mm)

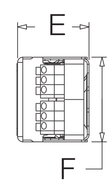
D = 1.0 in (25 mm)

E = 2.38 in (60 mm)

G case ballasts ship with 36 in. leads for lamp connections and 18 in. leads for Hot, Neutral, E1 and E2 connections

J Case





J Case Dimensions

A = 18.0 in (457 mm)

B = 17.68 in (449 mm)

C = 6.82 in (173 mm)

D = .394 in (10 mm)

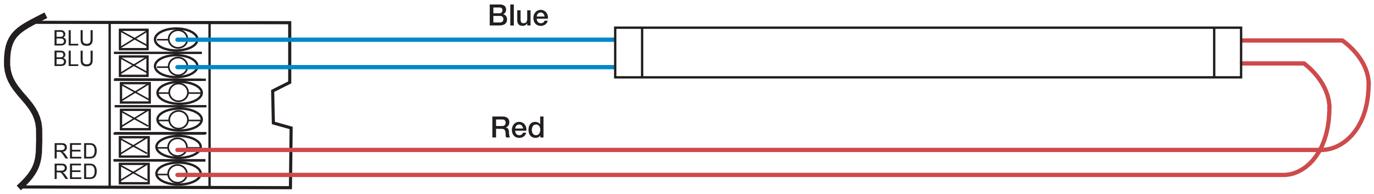
E = 1.0 in (25 mm)

F = 1.18 in (30 mm)

Job Name:	Model Numbers:
Job Number:	

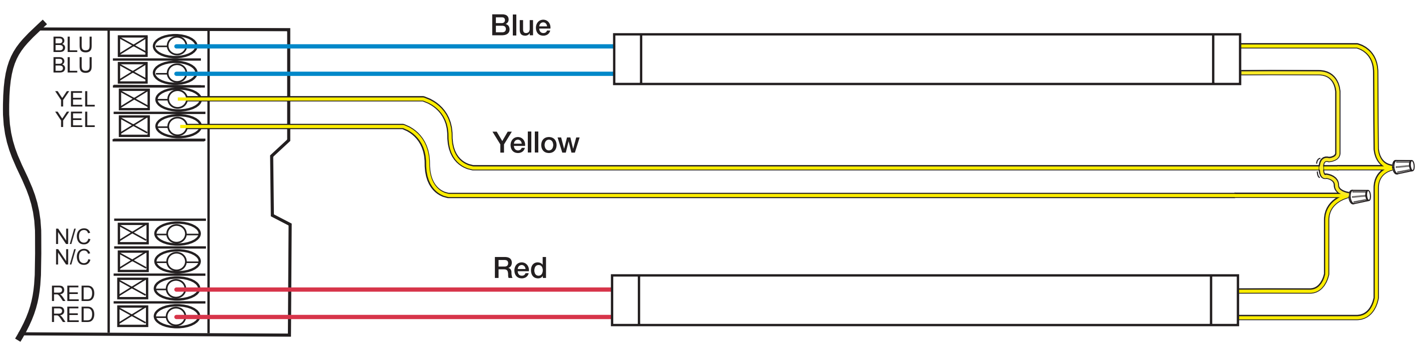
EcoSystem Ballast Wiring Diagrams - T8, T5, T5 HO

Wiring to One Lamp (J case shown)

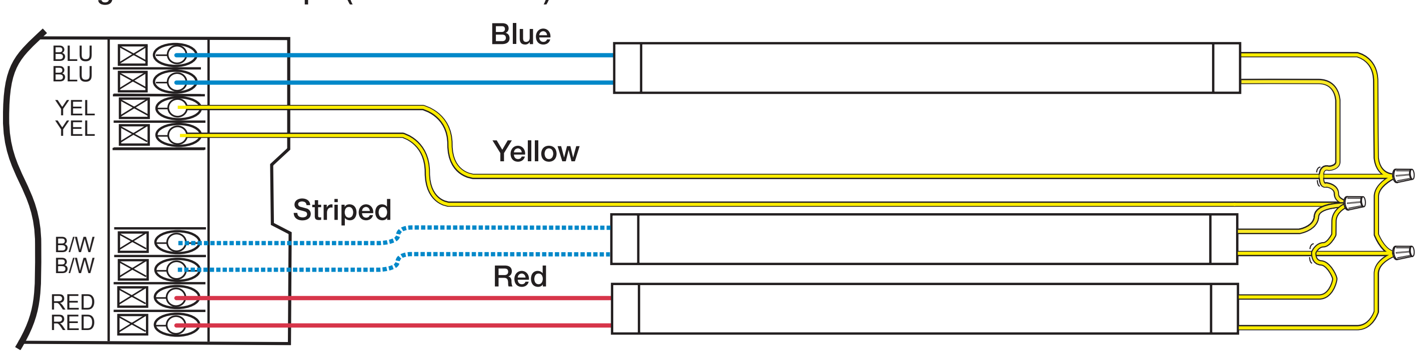


Wiring to Two Lamps (J case shown)

Wiring to Two Lamps (G case shown)



Wiring to Three Lamps (G case shown)



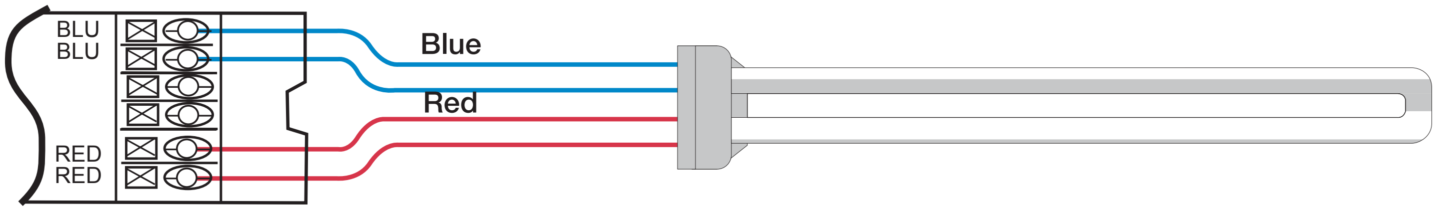
NOTICE

- Maximum ballast to lamp socket lead length is 7 feet (2 m)
- Wire colors shown are labeled on the ballast, but may vary depending upon fixture construction

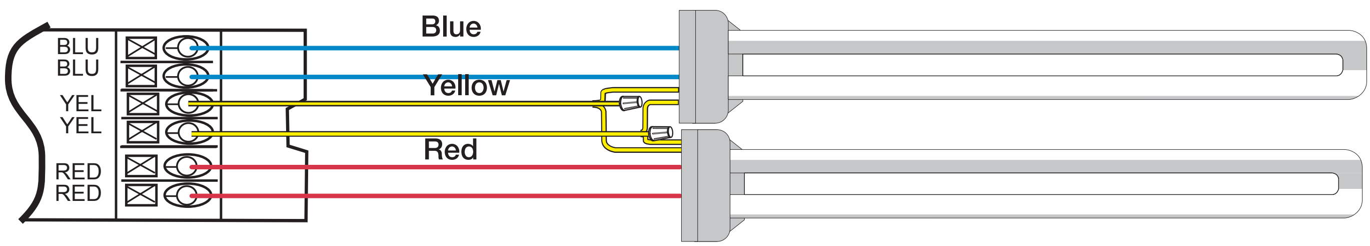
Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballast Wiring Diagrams - T5 Twin-Tube

Wiring to One Lamp



Wiring to Two Lamps



NOTICE

- Maximum ballast to lamp socket lead length is 3 feet (1 m)
- Wire colors shown are labeled on the ballast, but may vary depending upon fixture construction

Job Name:	Model Numbers:
Job Number:	

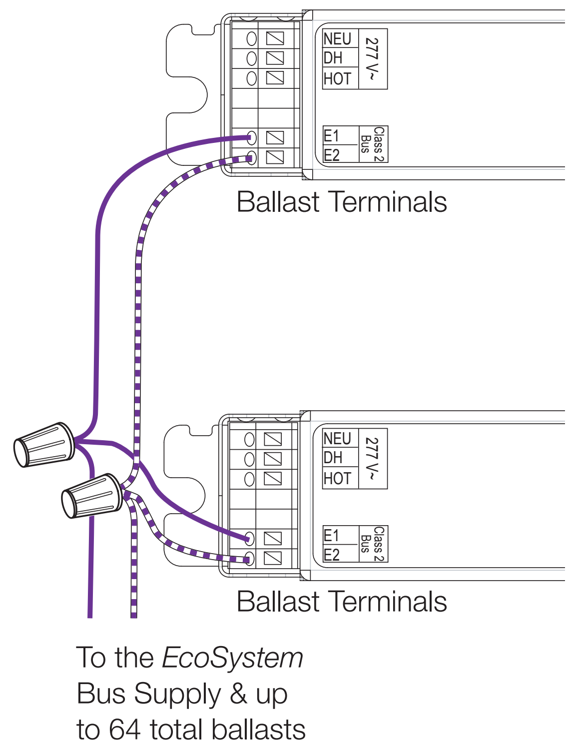
EcoSystem Ballast Wiring: *EcoSystem* Bus

EcoSystem Bus Overview

- The *EcoSystem* Bus wiring (E1 and E2) connects the digital ballasts together to form a lighting control system
- Each *EcoSystem* Bus supports up to 64 digital ballasts, 32 occupant sensors, 8 daylight sensors, and 64 wallstations or IR receivers
- E1 and E2 (*EcoSystem* bus wires) are polarity insensitive and can be wired in any topology
- An *EcoSystem* Bus Supply provides power for the *EcoSystem* Bus and supports system programming
- All *EcoSystem* Bus programming is completed by using the *EcoSystem* Programmer

EcoSystem Bus Wiring

- Ballast *EcoSystem* Bus terminals only accept one #18 AWG solid wire
- Make sure that the supply breaker to the Digital Ballast and *EcoSystem* Bus Supply is OFF when wiring
- Connect the two conductors to the two Digital Ballast terminals E1 and E2 as shown
- Using two different colors for E1 and E2 will reduce confusion when wiring several ballasts together
- The *EcoSystem* bus may be wired Class 1 or Class 2. Consult applicable electrical codes for proper wiring practices



Notes

- The *EcoSystem* Bus Supply does not have to be located at the end of the Digital Loop
- E1 and E2 wires are not polarity sensitive
- *EcoSystem* Bus length is limited by the wire gauge used for E1 and E2 as follows:

Wire Gauge	Bus Length (max)
12 AWG	2200 ft (670 m)
14 AWG	1400 ft (427 m)
16 AWG	900 ft (274 m)

EcoSystem Ballast Wiring: Class 2 Sensors

Electrical Contractors and Engineers:

- Always follow applicable national and local electrical code requirements when connecting circuits to *EcoSystem* devices
- All field installed Class 2 wiring must be separated from line voltage wiring by at least 0.25 in. (6.4 mm)
- Some local electrical codes require Class 2 wiring to be separately routed in a metal conduit
- Ballasts Class 2 Sensor terminals only accept 22 AWG solid conductors

Lutron Requires:

- Keep class 1 and class 2 wiring separate.
- Where separation is not possible, use a 600 V insulated cable with an internal shield. Connect the shield to ground to provide better noise immunity for low voltage circuits
- Refer to Application note #142 for additional information

Fixture Manufacturers:

- UL 1598 6.17.1 allows:
  Factory installed power limited wiring and branch circuit wiring that come in random contact within the luminaire shall have insulation rated for the maximum voltage that exists in any of the circuits. (*EcoSystem* ballast circuits require minimum 600 V insulated wire)
- UL 1598 6.17.2.1 requires:
  Luminaires designed for the field installation of power limited circuits shall be provided with a means of segregating or separating the field-installed power limited circuit wiring from the branch circuit wiring within the luminaire (see UL 1598 6.17 for details)

Lutron Requires:

- Keep class 1 and class 2 wiring separate
- Where separation is not possible, use a 600 V insulated cable with an internal shield. Connect the shield to ground to provide better noise immunity for low voltage circuits

EcoSystem Ballast Wiring: Daylight Sensor

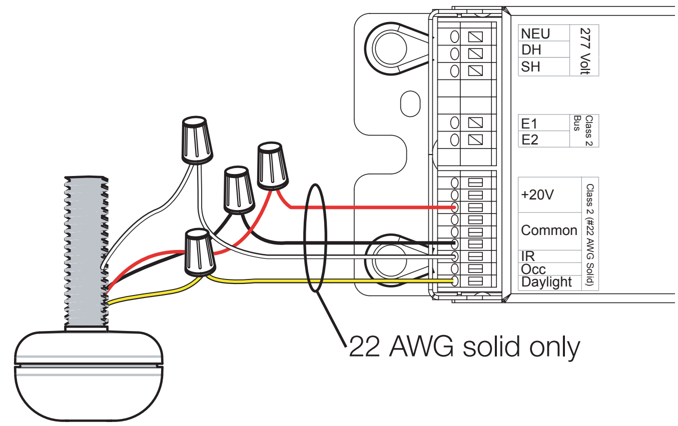
Wiring to a Daylight Sensor

- Sensor wiring summary:

Sensor Wire	Ballast Terminal	Terminal Color
Red	+20 V⎓	Red
Black	Common	Black
White	IR	White
Yellow	Daylight	Yellow

- Make sure that the supply breaker to the Digital Ballast is OFF when wiring.
- Connect the four conductors to the four Digital Ballast terminals as shown.
- Daylight sensor must be placed within 50 feet (15 m) of the ballast.
- Ballast Class 2 terminals only accept one 22 AWG solid wire.

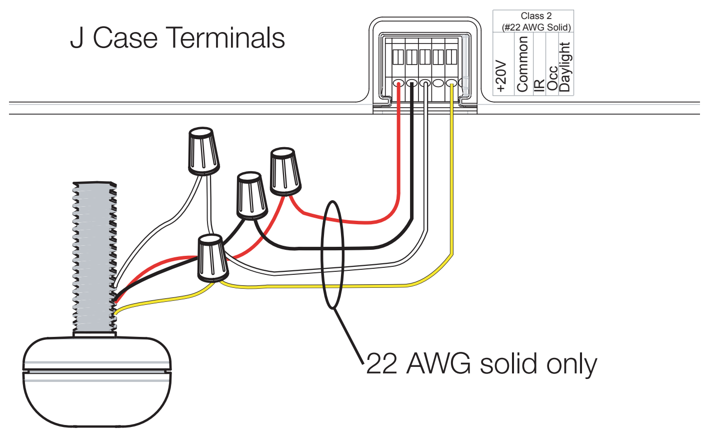
G Case Terminals



Notes

- Consult the daylight sensor specification sheet to properly locate the sensor.
- Do not place the sensor above pendant fixtures, directly below lighting fixtures, or within skylight wells.
- When wiring both a wallstation and daylight sensor to one ballast, only connect the IR wire (white) from the keypad, cap off the white wire from the daylight sensor.
- All sensor and wallstation wiring is Class 2. Follow all applicable national and local codes for proper circuit separation and protection.

J Case Terminals



Job Name:	Model Numbers:
Job Number:	

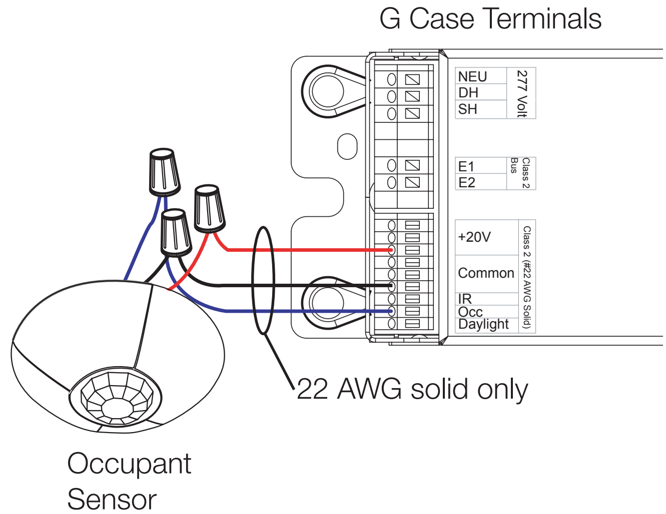
EcoSystem Ballast Wiring: Occupancy Sensor

Wiring to a Lutron Occupant Sensor (LOS-XX)

- Sensor wiring summary:

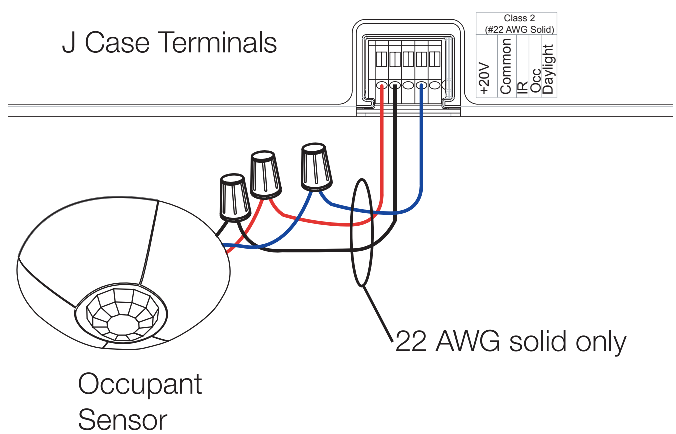
Sensor Wire	Ballast Terminal	Terminal Color
Red	+20 V⎓	Red
Black	Common	Black
Blue	Occ	Blue

- Make sure that the supply breaker to the Digital Ballast is OFF when wiring
- Connect the three conductors to the three ballast terminals as shown
- Occupant sensor must be placed within 50 feet (15 m) of the ballast
- Ballast Class 2 terminals only accept one 22 AWG solid wire



Notes

- Occupant sensors from other manufacturers may be used with *EcoSystem* ballasts if the sensor meets the following criteria:
  Vin = +20 V⎓, current draw less than 35 mA
- If other manufacturer's occupant sensors are used terminal colors and sensor wire colors may not match
- All sensor and wallstation wiring is Class 2. Follow all applicable national and local codes for proper circuit separation and protection.



Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballast Wiring Diagrams
(continued)

Wiring to an IR Receiver and Wallstation

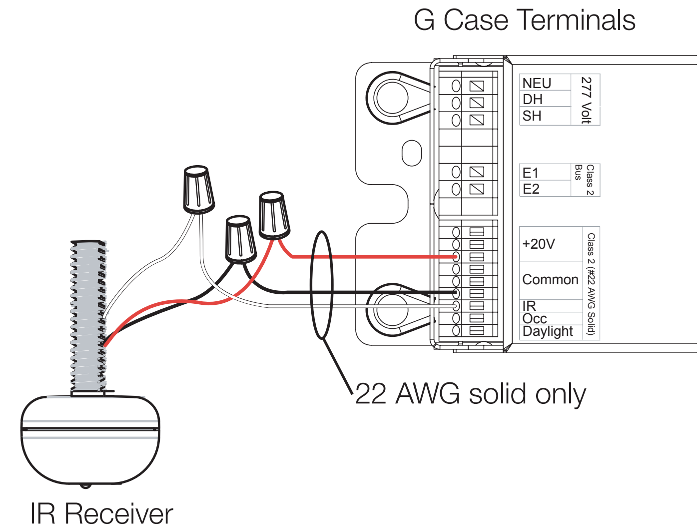
- Wiring summary:

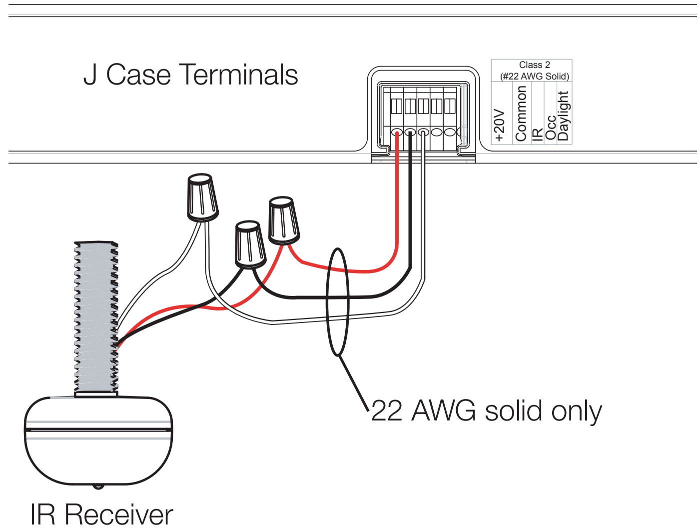
Sensor Wire	Ballast Terminal	Terminal Color
Red	+20 V⎓	Red
Black	Common	Black
White	IR	White

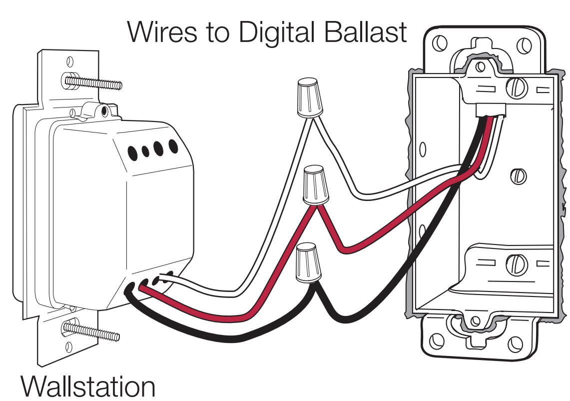
- Make sure that the supply breaker to the Digital Ballast is OFF when wiring
- Connect the three conductors to the three Digital Ballast terminals as shown
- Receiver must be placed within 50 feet (15 m) of the ballast
- Ballast Class 2 terminals only accept one 22 AWG solid wire

Notes

- Only one wallstation or IR receiver can be wired to a digital ballast
- If a daylight sensor and wallstation/IR receiver are connected to one ballast, do not connect the daylight sensor's IR output
- All sensor and wallstation wiring is Class 2. Follow all applicable national and local codes for proper circuit separation and protection.





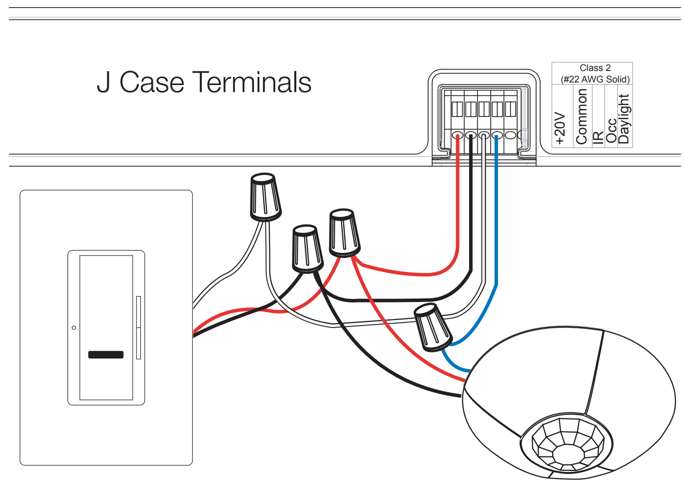


Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballast Wiring: Multiple Devices

Multiple Sensors with One Ballast

- *EcoSystem* ballasts accept wiring for one daylight sensor input, one occupant sensor input and one IR input (wallstation or IR receiver)
- *EcoSystem* daylight sensors have IR outputs that allow the device to operate as a programming port. In applications where a daylight sensor and wallstation are wired to the same ballast, do not connect the white wire of the daylight sensor to the ballast. The wallstation operates as the programming port through its integral IR receiver
- Use the chart below as a guide for wiring multiple devices to a ballast



How to Use the Chart

Connect a senor to a ballast from the "Devices" column (in bold). Along the selected device row, are "Y's" and "N's". Where a "Y" is placed, the device at the top of that column can also be connected to the same ballast. An "N" indicates no connection allowed.

Devices	**Daylight sensor (with IR)**	**Occupant sensor**	**Wallstation or IR receiver**	**Daylight Sensor (no IR)**
Daylight sensor (with IR)		Y	N	N
Occupant sensor	Y		Y	Y
Wallstation or IR Receiver	N	Y		Y
Daylight sensor (no IR)	N	Y	Y	

Example: When a Daylight Sensor with its internal IR are connected to a ballast, then only an occupancy sensor can be added for the system to properly function.

Job Name:	Model Numbers:
Job Number:	

EcoSystem Ballast Wiring: Line Voltage Dimmers

EcoSystem Ballasts and 3-wire dimmers

- Lutron 3-wire dimmers only control the ballast they are wired to; *EcoSystem* does not support grouping of 3-wire control input.

3-Wire Control Wiring

- Make sure that the supply breaker to the Digital Ballast is OFF when wiring.

- Wire as shown

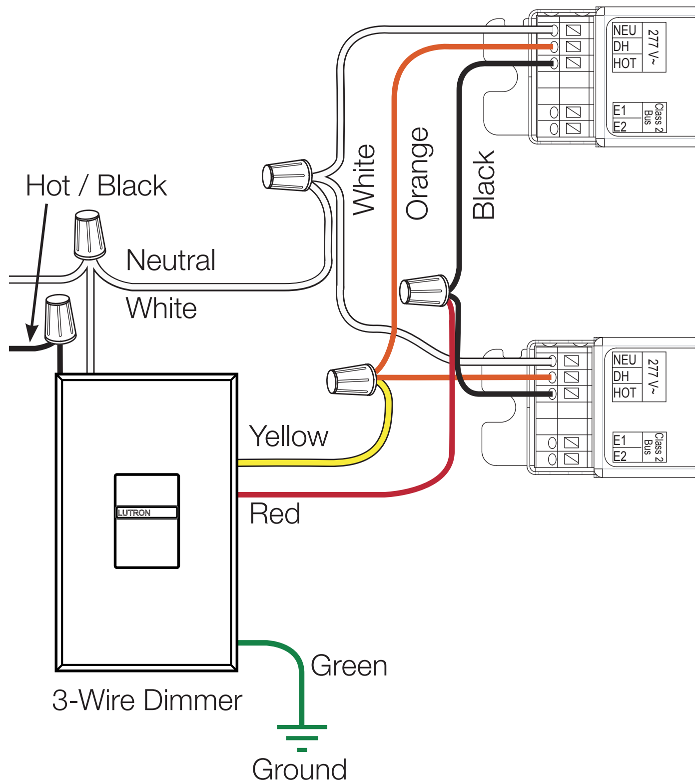
Line input	Connects to
Hot	Dimmer Black Wire
Neutral	Dimmer White Wire

Dimmer wire	Connects to
Yellow	Ballast Orange (DH)
Red	Ballast Black (HOT)
White	Ballast White (NEU)
Green	Earth Ground

- *EcoSystem* ballast line voltage and 3-wire input terminals only accept one 18 AWG solid wire.

Emergency and 3-wire

- *EcoSystem* ballasts controlled by a wallbox dimmer should not be used for emergency/egress lighting unless an external emergency ballast is used in the fixture. See Lutron Ap. Note #50.
- *EcoSystem* ballasts may be used for emergency/ egress lighting when controlled by a Lutron dimming panel (GP); where the panel is a dedicated emergency panel.



Notice

3-Wire control turns off digital ballasts when the control is in the off position. The digital ballast inputs: daylight sensor, wallstation, occupant sensor, and IR receiver will not function when the digital ballast is turned off

Job Name:	Model Numbers:
Job Number:	

Attention Electricians and Fixture Manufacturers

Ballast/Socket Leads

Lead lengths from ballast to socket must not exceed 7 feet (2 m) for linear lamps (T5, T5HO, T8). Lead lengths must not exceed 3 feet (1 m) for T5 twin tube lamps.

Lamp Sockets

Lamp sockets as per IEC 60400 are required to ensure positive lamp-pin to socket contact.

Mounting for T5 and T5HO Lamps

Mount lamps 3/8 in. ± 1/8 in. away from the grounded metal surface.

Mounting for T8 & T5 Twin Tube Lamps

Mount lamps 1/2 in. ± 1/4 in. away from the grounded metal surface.

Having a lamp too close to the grounded metal will reduce lamp life. Having a fluorescent lamp too far away from the grounded metal will make the lamp flicker or not turn on at all.

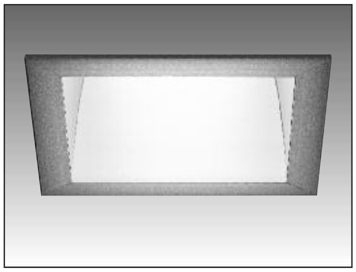
Lamp Seasoning Requirements

Some fluorescent lamp manufacturers recommend that new fluorescent lamps be operated at full output (“seasoned”) before they can be dimmed, to render lamp impurities inert, ensuring proper dimming performance and average rated lamp life. Please contact your lamp manufacturer for seasoning requirements.

Further Information

For further information please visit www.lutron.com/ecosystem or contact our 24-hour Technical Support Center at 1-800-523-9466

Job Name:	Model Numbers:
Job Number:	



BASYS™	Recessed	Square	Non-IC	4"
Downlight	Horizontal	13W	GX24q-1	

Type: Open Office

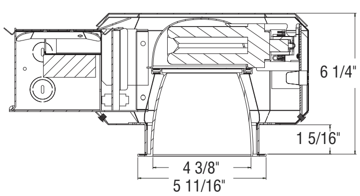
Project: Thesis - Redesign

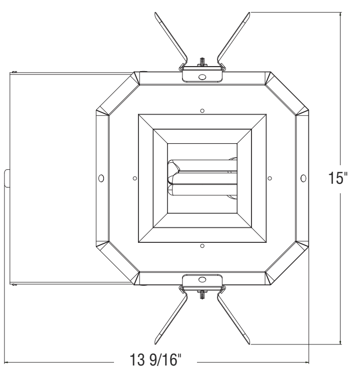
Compact Fluorescent

online Find it Fast 354

BRS4N1D	1H13GX24Q1	U	MS	CB	W	DCA	
FIXTURE		**BALLAST/VOLTAGE**	**DISTRIBUTION**	**TRIM FINISH**	**FLANGE**	**LENS OPTIONS**	**OPTIONS**
BASYS Recessed Square 4" Aperture Non-IC Downlight Horizontal, 13W GX24q-1 Base		**U** Universal 120V/277V **S3** Dedicated 347V	**MS** Medium Distribution	**CB** Clear Brushed (Semi Specular) **CM** Clear Matte **WH** White Matte	**N** Unfinished **W** White **C** Custom	**DCA** Clear Acrylic, Damp Location **DMP** Micro-Pyramidal, Damp Location **DOP** Opal, Damp Location	**EM** Standby Battery Pack - Standard Lumen **EH** Standby Battery Pack - High Lumen **F** Fusing **9930** 2 - 27" C-Channel mounting bars **9952** 2 - 52" C-Channel mounting bars **9956** 2 - 28" 10-gauge, one-piece universal mounting bars **CP** Chicago Plenum

VIEWS





Ceiling cutout 5 1/4" x 5 1/4"
Weight - 8.5 lbs

MECHANICAL

Housing
Enclosed octagonal housing is of 20-gauge cold-rolled steel, post-painted in black powder coat finish to diminish inter-reflected light within the housing.

Removable top secured with latch pins allows for ventilation and top housing access. Lamp module with socket and reflector is removable for ease of top relamping.

20-gauge aluminum plaster frame in black powder coat finish has a fixed throat of 1 5/16" to accommodate double-thickness plasterboard.

Rigid mounting brackets provide 4" vertical adjustment from inside aperture and plenum side of housing. Brackets accommodate 1½" C-Channel, ½" EMT, ¾" lathing channel, and Caddy 517A, B, and C-Channels for flexibility in mounting (mounting bars ordered as an optional accessory).

Code Compliance/Listing
c UL us LISTED
UL Listed for Damp Locations. Fixtures with standby battery packs are rated for Dry Locations only. Approved for thru wiring. Above ceiling access not required.

ELECTRICAL

Thru Wire Box
Oversized junction box is 18-gauge steel, post powder coat painted in Titan.

Two combination ½" - ¾" knockouts allow straight through conduit runs, additional six ½" knockouts allow for installation flexibility. UL Listed for thru wiring (4 in and 4 out at 90°C) and has 7/8" and 1 1/8" knockouts.

Captive swing-open ballast door provides access to ballast and thru wire box through fixture aperture.

Ballast
Unitized ballast tray can be pulled either through aperture or back of thru wire box for replacement and ease of wire connection.

Electronic 120/277 universal voltage Class P electronic ballast is thermally-protected, high power factor, with auto-reset shutdown circuit for one compact fluorescent lamp.

Socket
Swing-down socket holder allows for ease of re-lamping by visually aligning the socket base pins.

OPTICAL SYSTEM

Upper Reflector
Reflector is spun anodized aluminum of high specularity, vacuum metalized, designed to provide highest efficiency and effective beam distribution.

Lower Reflector
Compound parabolic reflector provides optical and physical 45-degree cutoff. Square extruded aluminum reflector designed to provide precise mitered corners with integral self-trim providing iridescent-free finish.

Lower Reflector Finishes
Brushed – High specularity finish provides lower visual luminance providing and up to a 15% increase in overall efficiency over Matte. Extrusion finish visually accentuates the square shape.

Matte – Soft, diffused and evenly illuminated surface provides a congruous appearance between the downlight and the ceiling.

Optional Micro-Pyramidal structure lens provides innovative cross-patterned layers to provide maximum efficiency and cutoff.

COMPANION DOWNLIGHTS USING SAME SOCKET/WATTAGE

TYPE	CATALOG NUMBER	FIF #	SPEC SHEET PAGE
Vertical Lamp Downlight	BRS4N3D1V13GX24Q1	353	BSA-1
Lensed Wallwasher	BRS4N1W1H13GX24Q1	355	BSA-3

PHOTOMETRICS

REFLECTOR	REPORT #	%EFF	NOTES
Brushed	LTL #13015	42.0 %	Osram CFT Lamp
Matte	LTL #12643-13W	34.4 %	Prorated

ZUMTOBEL

LTL LUMINAIRE TESTING LABORATORY, INC.

SUSTAINING MEMBER of the IESNA

905 Harrison Street · Allentown, PA 18103 · 610-770-1044 · Fax 610-770-8912 · www.LuminaireTesting.com

LTL NUMBER: 13015 DATE: 05-13-2008
PREPARED FOR: ZUMTOBEL LIGHTING, INC.
CATALOG NUMBER: BRS4N1D1H13GX24Q1UMSBSC
LUMINAIRE: FORMED STEEL HOUSING, SPUN SPECULAR ALUMINUM UPPER REFLECTOR, FORMED "BRUSHED" ALUMINUM LOWER REFLECTOR, NO ENCLOSURE.
LAMP: ONE HORIZONTAL 13 WATT TRIPLE TUBE COMPACT FLUORESCENT LAMP RATED AT 900 LUMENS.
LAMP CATALOG NUMBER: SYLVANIA CF13DT/E/835
BALLAST: ONE UNIVERSAL LIGHTING TECHNOLOGIES C213UNVBE
MOUNTING: RECESSED
TOTAL INPUT WATTS = 12.8 AT 120.0 VOLTS
THE 0 DEGREE PLANE IS PARALLEL WITH THE LAMPS.

CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	FLUX
0	347	347	347	347	347	347	347	347	347	
5	345	343	340	337	337	338	340	342	342	32
15	302	305	308	299	296	295	288	281	276	83
25	214	235	254	229	222	239	227	205	194	104
35	132	158	146	148	147	168	173	153	130	94
45	52	63	64	64	58	70	77	53	42	49
55	12	13	9	12	12	12	10	11	10	11
65	4	4	4	3	4	4	3	3	3	3
75	2	2	2	2	2	2	2	2	2	2
85	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	

ZONAL LUMEN SUMMARY

ZONE	LUMENS	%LAMP	%FIXT
0- 30	219	24.3	58.0
0- 40	313	34.8	82.9
0- 60	373	41.5	98.8
0- 90	378	42.0	100.0
90-180	0	0.0	0.0
0-180	378	42.0	100.0

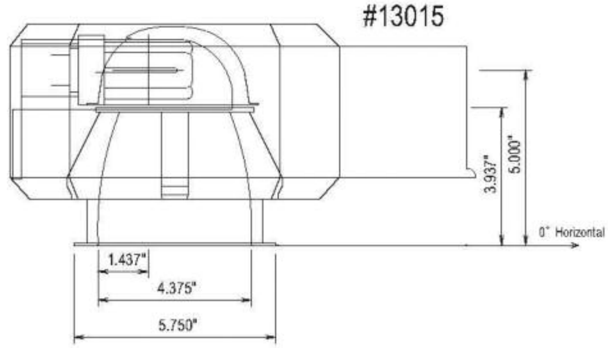
TOTAL LUMINAIRE EFFICIENCY: 42.0%
CIE TYPE: DIRECT

PLANE:	0-DEG	90-DEG	180-DEG
SPACING CRITERIA:	0.9	0.9	0.8
LUMINOUS LENGTH:	4.375	4.375	

LUMINANCE IN CANDELA PER SQUARE METER

ANGLE IN DEG	AVERAGE 0-DEG	AVERAGE 45-DEG	AVERAGE 90-DEG
0	28098.	28098.	28098.
45	5955.	7329.	6642.
55	1694.	1271.	1694.
65	766.	766.	766.
75	626.	626.	626.
85	0.	0.	0.

#13015



Approved By: MG

THIS REPORT BASED ON LM-41 AND OTHER PERTINENT IESNA PROCEDURES.

LTL **LUMINAIRE TESTING LABORATORY, INC.**

SUSTAINING MEMBER of the IESNA

905 Harrison Street · Allentown, PA 18103 · 610-770-1044 · Fax 610-770-8912 · www.LuminaireTesting.com

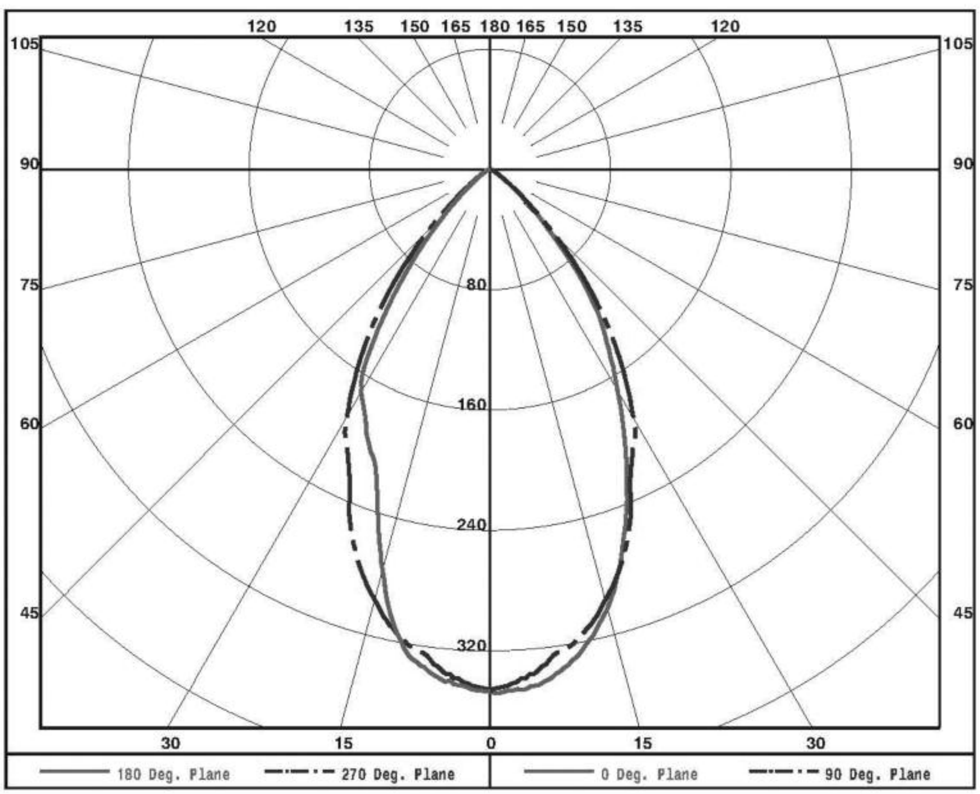
LTL NUMBER: 13015 DATE: 05-13-2008
PREPARED FOR: ZUMTOBEL LIGHTING, INC.

CANDELA DISTRIBUTION

	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0
0	347	347	347	347	347	347	347	347	347
5	345	343	340	337	337	338	340	342	342
10	329	326	320	321	320	316	318	325	325
15	302	305	308	299	296	295	288	281	276
20	260	274	284	273	265	269	252	234	221
25	214	235	254	229	222	239	227	205	194
30	170	193	205	191	191	207	201	184	172
35	132	158	146	148	147	168	173	153	130
40	93	115	99	102	102	121	130	101	81
45	52	63	64	64	58	70	77	53	42
50	27	30	27	29	28	31	29	23	21
55	12	13	9	12	12	12	10	11	10
60	5	6	5	5	7	7	5	6	5
65	4	4	4	3	4	4	3	3	3
70	2	2	2	2	2	2	2	2	2
75	2	2	2	2	2	2	2	2	2
80	1	1	1	1	1	1	1	1	0
85	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0

ZONAL LUMEN SUMMARY

0- 5	8.
5- 10	24.
10- 15	37.
15- 20	46.
20- 25	51.
25- 30	53.
30- 35	51.
35- 40	43.
40- 45	32.
45- 50	17.
50- 55	8.
55- 60	4.
60- 65	2.
65- 70	1.
70- 75	1.
75- 80	1.
80- 85	0.
85- 90	0.



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905 Harrison Street · Allentown, PA 18103 · 610-770-1044 · Fax 610-770-8912 · www.LuminaireTesting.com

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COEFFICIENTS OF UTILIZATION - ZONAL CAVITY METHOD

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
0	50	50	50	50	49	49	49	49	47	47	47	45	45	45	43	43	43	42
1	48	46	45	44	47	46	45	44	44	43	42	42	42	41	41	40	40	39
2	45	43	41	40	44	42	41	39	41	40	38	40	39	38	39	38	37	36
3	43	40	38	36	42	39	37	36	38	37	35	37	36	35	36	35	34	33
4	40	37	35	33	40	37	34	33	36	34	32	35	33	32	34	33	31	31
5	38	34	32	30	37	34	31	30	33	31	29	32	31	29	32	30	29	28
6	36	32	29	27	35	32	29	27	31	29	27	30	29	27	30	28	27	26
7	34	30	27	25	33	29	27	25	29	27	25	28	26	25	28	26	25	24
8	32	28	25	23	31	27	25	23	27	24	23	26	24	23	26	24	23	22
9	30	25	23	21	29	25	22	21	25	22	21	24	22	21	24	22	20	20
10	28	23	21	19	27	23	21	19	23	20	19	23	20	19	22	20	19	18

NOTE: THE ZONAL CAVITY CALCULATION TECHNIQUE IS ACCURATE WHEN LUMINAIRES WITH SYMMETRIC CANDELA DISTRIBUTIONS ARE EMPLOYED AND WHEN THE LUMINAIRES ARE LOCATED SYMMETRICALLY THROUGHOUT THE ROOM. THIS UNIT HAS SPECIAL CHARACTERISTICS AND THEREFORE THESE COEFFICIENTS SHOULD BE USED WITH CAUTION.

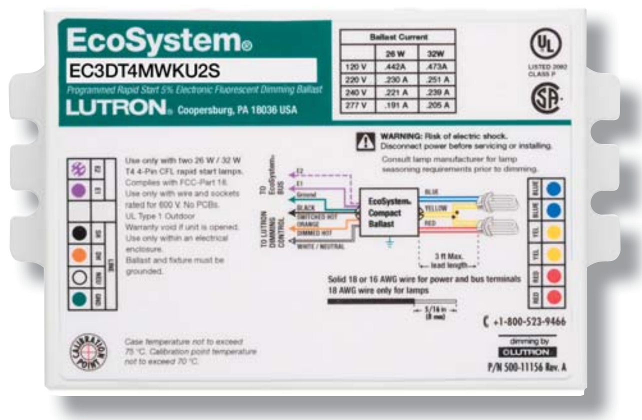
THIS TEST WAS CONDUCTED USING RELATIVE PHOTOMETRY TECHNIQUES ACCORDING TO STANDARD IESNA PROCEDURES. THE USER MUST THEREFORE USE CAUTION IN THE FOLLOWING SITUATIONS: 1) THIS TEST WAS PERFORMED USING A SPECIFIC BALLAST/LAMP COMBINATION. EXTRAPOLATION OF THESE DATA FOR OTHER BALLAST/LAMP COMBINATIONS MAY PRODUCE ERRONEOUS RESULTS. 2) ACCORDING TO IESNA PROCEDURES, THE BALLAST(S) AND LAMP(S) ARE PRESUMED TO PRODUCE 100% OF RATED OUTPUT. AN APPROPRIATE BALLAST FACTOR MUST BE APPLIED TO THE LUMEN OUTPUT RATINGS AND LUMINOUS INTENSITY VALUES GIVEN. 3) THIS TEST WAS CONDUCTED IN A CONTROLLED LABORATORY ENVIRONMENT WHERE THE AMBIENT TEMPERATURE WAS HELD AT 25°C ±1°C. FIELD PERFORMANCE MAY DIFFER PARTICULARLY IN REGARDS TO CHANGE IN LUMINOUS OUTPUT AS A RESULT OF DIFFERENCE IN AMBIENT TEMPERATURE AND METHOD OF MOUNTING THE LUMINAIRE.

EcoSystem Digital Ballasts

EcoSystem compact ballasts provide high-performance dimming for any compact fluorescent application, including within an *EcoSystem*. *EcoSystem* compact ballasts offer 100% to 5% dimming, providing both energy savings and lighting flexibility.

Features

- Continuous, flicker-free dimming from 100% to 5%
- Compatible with *EcoSystem* Digital Bus control, GRAFIK Eye® QS, and Quantum®, allowing for integration into an existing/planned *EcoSystem*
- Supports standard 3-wire line-voltage phase control technology
- Programmed rapid start design ensures full-rated lamp life while dimming and cycling
- Lamps turn on to any dimmed level without flashing to full brightness
- Low harmonic distortion throughout the entire dimming range
- Frequency of operation ensures that ballast does not interfere with infrared devices
- Inrush current limiting circuitry eliminates circuit breaker tripping, switch arcing, and relay failure
- Ultra-quiet operation
- Protected from miswires of any input power to control lead, or from lamp leads to each other and/or ground
- 100% performance tested at factory
- 5-year limited warranty with Lutron field service commissioning (3-year standard warranty) from date of purchase.



***EcoSystem* case type K**

Specifications

Standards

- UL Listed (evaluated to the requirements of UL935)
- UL Type 1 Outdoor for damp locations
- CSA Certified (evaluated to the requirements of C22.2 No. 74)
- Class P thermally protected
- Meets ANSI C82.11 High Frequency Ballast Standard
- Meets FCC Part 18 Non-Consumer requirements for EMI/RFI emissions
- Meets ANSI C62.41 Category A surge protection standards up to and including 4 kV
- Manufacturing facilities employ ESD reduction practices that comply with the requirements of ANSI/ESD S20.20
- Lutron Quality Systems registered to ISO 9001.2000

Performance

- Operating Voltage: 120, 220/240, 277 V∼ at 50 or 60 Hz
- Grounding: ballast and fixture must be grounded for proper dimming
- Dimming Range: 100% to 5% measured relative light output
- Lamp Starting: programmed rapid start
- Lamp Current Crest Factor: less than 1.7
- Light Output Variation: Constant ±2% light output for line voltage variations of ±10%
- Lamp Life: Average lamp life meets or exceeds specified lamp ratings
- Power Factor: 0.95 minimum
- Total Harmonic Distortion (THD): Less than 20%
- Inaudible in a 27 dBA ambient
- Maximum Inrush Current: 3 A per ballast at 277 V∼, 7A per ballast at 120 V∼
- Standby power: Less than 1 W

Environment

- Minimum lamp starting temperature: 50 °F (10 °C)
- Relative humidity: less than 90% non-condensing
- Sound Rating: inaudible in a 27 dB ambient
- Maximum ballast case temperature: 75 °C (167 °F)

Ballast Wiring & Mounting

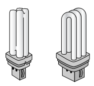
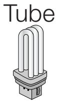
- Ballast is grounded by the specified terminal or by a mounting screw to the fixture
- Terminal blocks on the ballast accept the following wire gauges:
  Power Wiring and *EcoSystem* Bus:
  only one 18 AWG solid per terminal
  Lamp Wiring:
  only one 18 AWG solid per terminal
- Only one wire per terminal
- Ballast mounts using two mounting tabs or studs within a fluorescent fixture
- Wiring from the ballast to lamp sockets shall not exceed 3 feet for T4 compact lamps
- Ballast does not have sensor terminals

Lamp Seasoning

Refer to lamp manufacturer for lamp seasoning requirements prior to dimming

Job Name:	Model Numbers:
Job Number:	

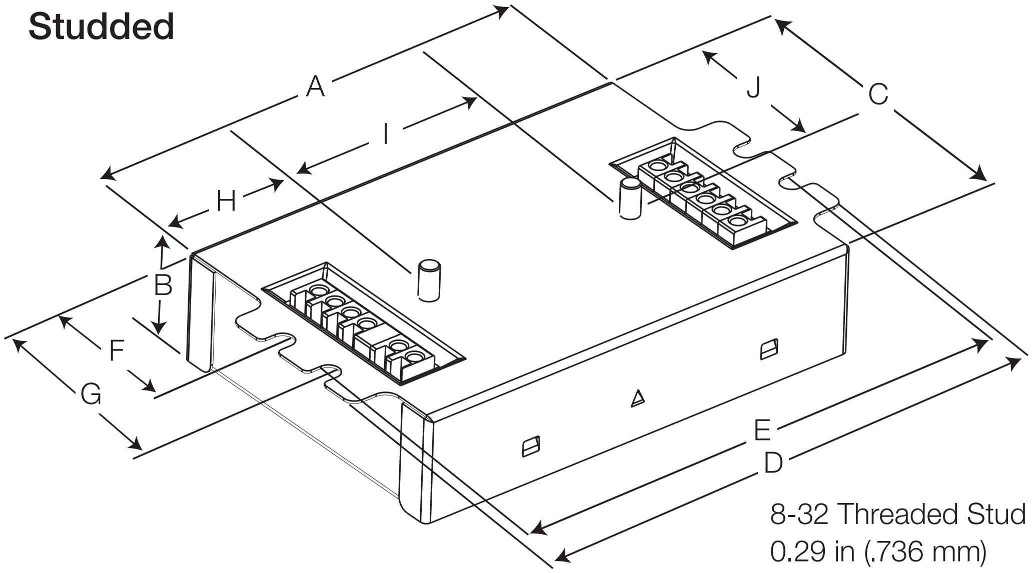
EcoSystem Compact Fluorescent Ballast Models

Lamp Type	Lamp Watts	No. of Lamps	Model	Case Size	Input Voltage (VAC)	Input Current (A)	Input Power (W)	Ballast Factor (BF)	System Lumens (lm)	System Efficacy (lm/W)	Ballast Efficacy Factor	Relative Efficacy (RSE)
T4 4-Pin Quad-Tube or Triple-Tube 	18 W	1	EC3DT418KU1S (Studded)	K	120	0.180	21.3	0.95	1140	53.5	4.46	0.80
				K	220	0.098	21.1	0.95	1140	54.0	4.50	0.81
			EC3DT418KU1 (Non-studded)	K	240	0.092	21.4	0.95	1140	53.3	4.44	0.80
				K	277	0.080	20.8	0.95	1140	54.8	4.57	0.82
		2	EC3DT418KU2S (Studded)	K	120	0.34	41.1	0.95	2280	55.5	2.31	0.83
				K	220	0.18	39.6	0.95	2280	57.6	2.40	0.86
			EC3DT418KU2 (Non-studded)	K	240	0.17	39.4	0.95	2280	57.9	2.41	0.87
				K	277	0.15	39.9	0.95	2280	57.1	2.38	0.86
	26 W	1	EC3DT4MWKU1S (Studded)	K	120	0.22	26.4	0.95	1710	64.8	3.60	0.94
				K	220	0.12	26.8	0.95	1710	63.9	3.55	0.92
			EC3DT4MWKU1 (Non-studded)	K	240	0.11	26.9	0.95	1710	63.7	3.54	0.92
				K	277	0.10	27.0	0.95	1710	63.4	3.52	0.92
		2	EC3DT4MWKU2S (Studded)	K	120	0.43	51.6	0.95	3420	66.3	1.84	0.96
				K	220	0.23	49.9	0.95	3420	68.5	1.90	0.99
			EC3DT4MWKU2 (Non-studded)	K	240	0.21	50.6	0.95	3420	67.5	1.88	0.98
				K	277	0.19	51.4	0.95	3420	66.6	1.85	0.96
T4 4-Pin Triple-Tube 	32 W	1	EC3DT4MWKU1S (Studded)	K	120	0.27	32.4	0.95	2280	70.4	2.93	0.94
				K	220	0.14	31.6	0.95	2280	72.1	3.00	0.96
			EC3DT4MWKU1 (Non-studded)	K	240	0.13	31.7	0.95	2280	72.0	3.00	0.96
				K	277	0.11	31.7	0.95	2280	71.9	3.00	0.96
		2	EC3DT4MWKU2S (Studded)	K	120	0.55	66.0	0.95	4560	69.1	1.44	0.92
				K	220	0.29	64.5	0.95	4560	70.7	1.47	0.94
			EC3DT4MWKU2 (Non-studded)	K	240	0.26	63.0	0.95	4560	72.3	1.51	0.96
				K	277	0.24	65.5	0.95	4560	69.7	1.45	0.93
	42 W	1	EC3DT442KU1S (Studded)	K	120	0.36	43.2	0.95	3040	70.4	2.20	0.92
				K	220	0.20	42.9	0.95	3040	70.8	2.21	0.93
			EC3DT442KU1 (Non-studded)	K	240	0.18	42.7	0.95	3040	71.2	2.23	0.93
				K	277	0.15	42.6	0.95	3040	71.3	2.23	0.94
		2	EC3DT442KU2S (Studded)	K	120	0.73	87.6	0.95	6080	69.4	1.08	0.91
				K	220	0.39	85.9	0.95	6080	70.8	1.11	0.93
			EC3DT442KU2 (Non-studded)	K	240	0.35	85.1	0.95	6080	71.5	1.12	0.94
				K	277	0.31	85.4	0.95	6080	71.2	1.11	0.93

NOTE: The "S" at the end of the ballast model number indicates a studded option. Remove the "S" for a non-studded ballast.

EcoSystem Compact Fluorescent Ballast Case Dimensions

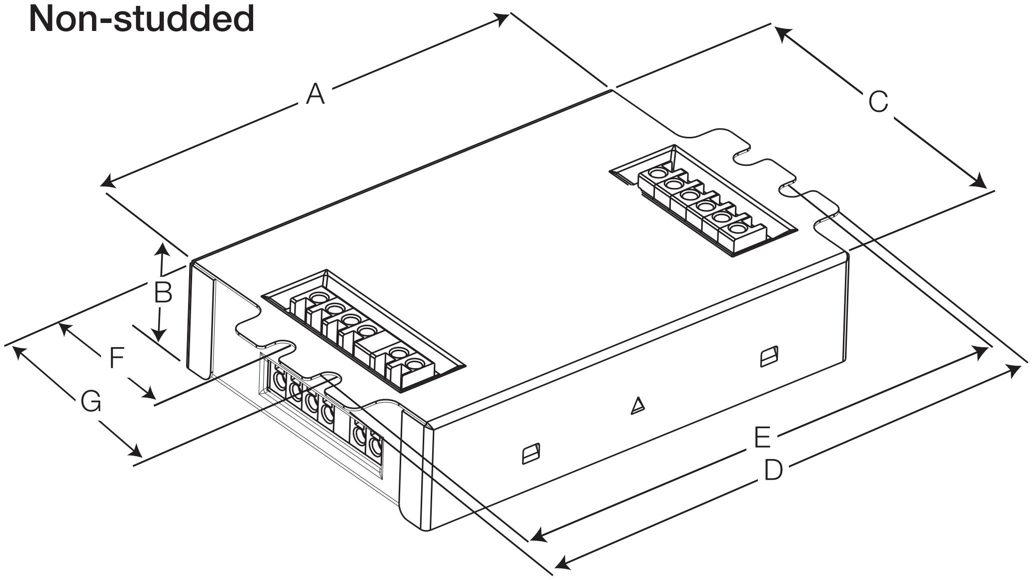
Studded



A	4.20 in (107 mm)
B	1.00 in (25 mm)
C	3.00 in (76 mm)
D	4.90 in (124 mm)
E	4.60 in (117 mm) (mounting centers)
F	1.42 in (36 mm)
G	1.99 in (51 mm)
H	1.09 in (28 mm)
I	2.00 in (51 mm)
J	1.60 in (41 mm)

NOTE: Studded version does not have side connectors.

Non-studded

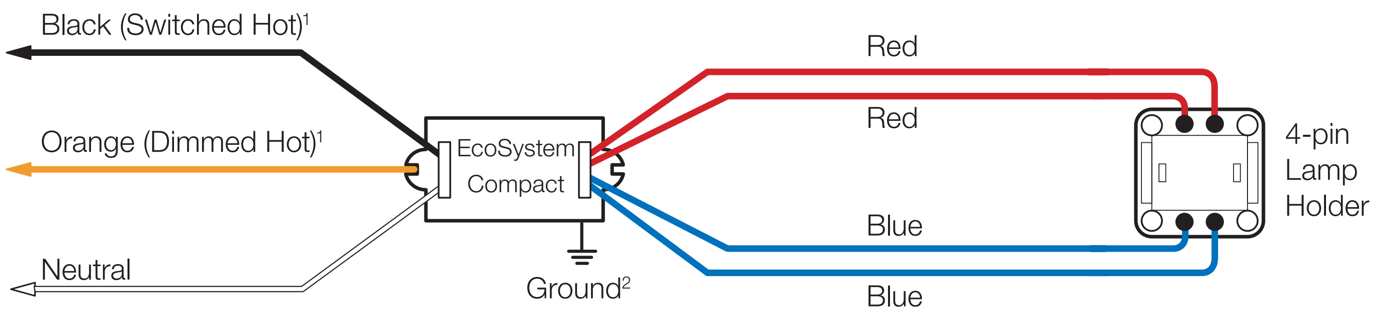


A	4.20 in (107 mm)
B	1.00 in (25 mm)
C	3.00 in (76 mm)
D	4.90 in (124 mm)
E	4.60 in (117 mm) (mounting centers)
F	1.42 in (36 mm)
G	1.99 in (51 mm)

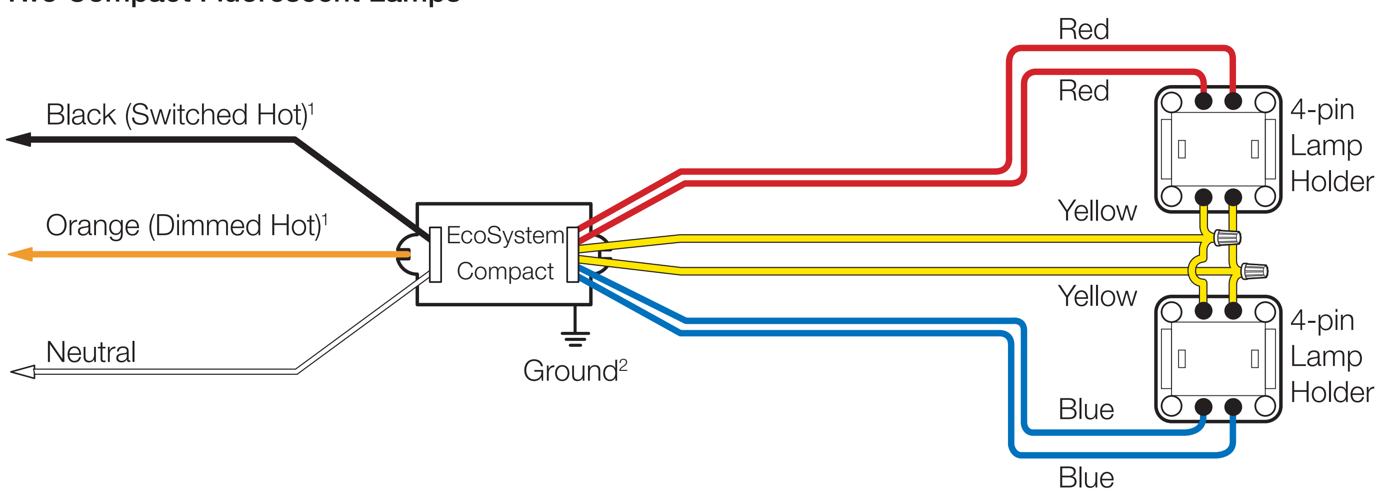
Job Name:	Model Numbers:
Job Number:	

Wiring Diagrams

One Compact Fluorescent Lamp



Two Compact Fluorescent Lamps



[1] Wire colors shown are for Lutron controls and ballasts only. Dimming control wires may not match ballast wire colors.
[2] Ballast is grounded via the case or terminal.

Note: For T4 compact lamps, maximum lamp-to-ballast wire length is 3 feet (1 m) to guarantee proper performance.

Job Name:	Model Numbers:	
Job Number:		

EcoSystem Bus Wiring Diagrams

EcoSystem Bus Overview

- The *EcoSystem* Bus wiring (E1 and E2) connects the digital ballasts together to form a lighting control system
- Each *EcoSystem* Bus supports up to 64 digital ballasts, 32 occupant sensors, 8 daylight sensors, and 64 wallstations or IR receivers
- Sensors do not directly connect to *EcoSystem* compact ballasts
- E1 and E2 (*EcoSystem* bus wires) are polarity insensitive and can be wired in any topology
- An *EcoSystem* Bus Supply provides power for the *EcoSystem* Bus and supports system programming
- All *EcoSystem* Bus programming is completed by using the *EcoSystem* Programmer, GRAFIK Eye® QS with *EcoSystem*, or Quantum™

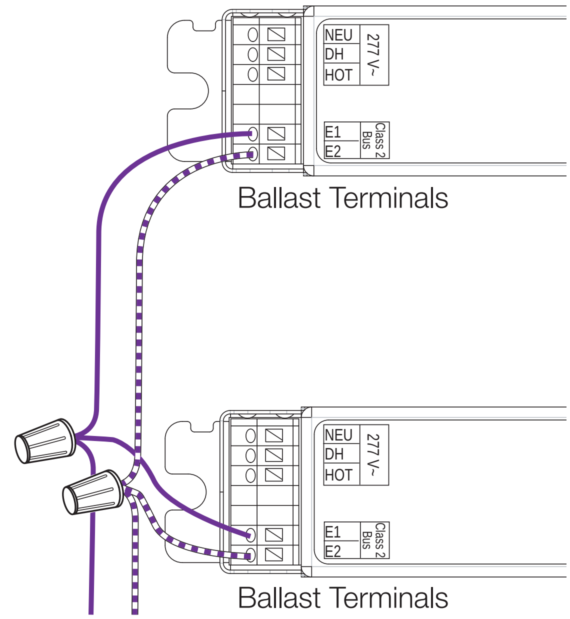
EcoSystem Bus Wiring

- Ballast *EcoSystem* Bus terminals only accept one 16 AWG or 18 AWG solid wire
- Make sure that the supply breaker to the Digital Ballast and *EcoSystem* Bus Supply is OFF when wiring
- Connect the two conductors to the two Digital Ballast terminals E1 and E2 as shown
- Using two different colors for E1 and E2 will reduce confusion when wiring several ballasts together
- The *EcoSystem* bus may be wired Class 1 or Class 2. Consult applicable electrical codes for proper wiring practices

Notes

- The *EcoSystem* Bus Supply does not have to be located at the end of the Digital Loop
- *EcoSystem* Bus length is limited by the wire gauge used for E1 and E2 as follows:

Wire Gauge	Bus Length (max)
12 AWG	2200 ft (670 m)
14 AWG	1400 ft (427 m)
16 AWG	900 ft (274 m)



To the *EcoSystem* Bus Supply & up to 64 total ballasts

ELECTRICIANS AND CONTRACTORS

Ballast/Socket Leads

Lead lengths from ballast to socket must not exceed 3 feet (1 m) for T4 linear lamps.

Lamp Sockets

Lamp sockets as per IEC 60400 are required to ensure positive lamp-pin to socket contact. T4 compact sockets must be the 4-pin type, and must be used with 4-pin compact lamps.

Ballast Operating Temperature

Ballast case temperature must not exceed 75 °C at any point on ballast. Calibration point temperature must not exceed 70 °C.

Wiring and Grounding

Ballast and lighting fixture must be effectively grounded. Ballasts must be installed per national and local electrical codes.

FACILITIES MANAGERS

PERFORMANCE

Lamp Seasoning Requirements

Some fluorescent lamp manufacturers recommend that new fluorescent lamps be operated at full output ("seasoned") before they can be dimmed to render lamp impurities inert, ensuring proper dimming performance and average rated lamp life. Please contact your lamp manufacturer for seasoning requirements.

SERVICE

Replacement Parts

Use replacement parts with exact Lutron model numbers. Consult Lutron if you have any questions.

Further Information

For further information, please visit us at www.lutron.com/ballasts or contact our 24-hour Technical Support Center at 1-800-523-9466.

System Overview

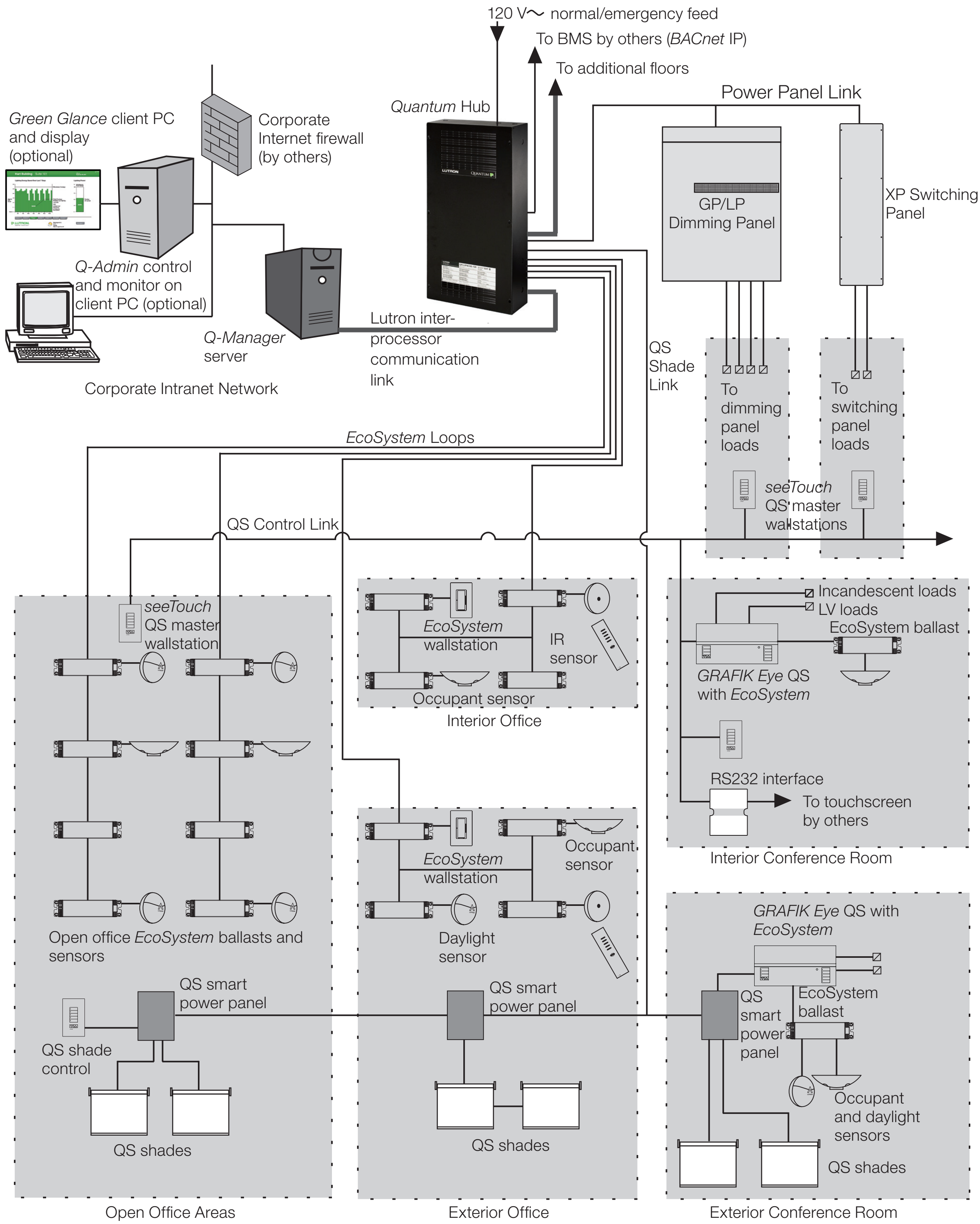
Quantum is a facility management solution that creates a flexible, productive, and energy-efficient environment for an entire building or campus. A single system provides dimming, switching, motorized shade control, system integration and energy management. It is used to manage the electric and natural light in multiple spaces using both automatic and manual control options.

Features

- Saves energy through occupancy/vacancy controls, daylighting, light level space tuning, shade control, and IntelliDemand load shedding.
- Increases productivity through maintaining optimal light level needed for tasks by daylighting, space tuning, and wallstation controls to activate desired preset scenes for the given activity.
- Centrally manage, monitor, and control EcoSystem® ballasts, *EcoSystem* ballast modules, Grafik Eye® dimming and switching panels, *Grafik Eye* QS scene controller, and Sivoia® QS shades in a building or whole campus environment.
- Uses Lutron's Q-Admin™ Graphical User Interface for easy management of the system
- Built-in timeclock allows scheduling of events based on time of day and relative to local sunrise and sunset.
- Easily interfaces with audiovisual equipment, security systems, fire alarms, and building management systems.
- Partitioned space control combines/separates control station and occupancy control based on the status of movable walls.
- Controls can be programmed using recommended templates or on a button-by-button basis.

Job Name:	Model Numbers:
Job Number:	

System Overview



Job Name:	Model Numbers:
Job Number:	

System Components and Capacities

Light Management Hubs (LMH)

- 16 processors per sub-system. 8 to 16 LMHs per sub-system, depending on number of processors per hub.
- Up to 128 sub-systems, for a total of 2048 processors (1024 to 2048 LMH).
- Control links can be configured as *EcoSystem*, QS control links, or *Grafik Eye* power panel.
- Up to 4 control links per LMH (2 per processor).
- One configurable link pre-configured as an *EcoSystem* link for communication to EcoSystem bus supply modules, which are normally internal to the LMH.
- 5-port Ethernet device for connecting LMHs together and connection to the Q-Manager™ server.
- 3 configurable links can supply power for up to 32 keypad/control stations. For more controls on the QS link, additional power supplies are needed.

Control Links:

EcoSystem® Link

- Up to 4 *EcoSystem* bus supplies for up to 8 *EcoSystem* loops (per bus supply).
- to 64 ballasts per EcoSystem loop
- to 8 daylight sensors per loop
- to 32 occupant sensors per loop

Wire Gauge	Bus Length (max)
12 AWG (4.0 mm2)	2200 ft (671 m)
14 AWG (2.5 mm2)	1400 ft (427 m)
16 AWG (1.5 mm2)	900 ft (275 m)
18 AWG (1.0 mm2)	570 ft (175 m)

Job Name:

Job Number:

Model Numbers:

QS Control Link

- Up to 99 QS controls per link
- Up to 512 switch legs or zones per link

QS Device Consumption Rules

The table below lists the devices available on the QS link. See below for each device's count toward the link maximums for zones, switch legs, and devices.

A *Quantum* QS link can have up to 512 switch legs (outputs), 99 devices, and 32 power draw units.

QS Device Description	Switch Leg Count	Device Count	Power Draw Units
3-zone GRAFIK Eye® QS	3	1	0
4-zone *GRAFIK Eye* QS	4	1	0
6-zone *GRAFIK Eye* QS	6	1	0
seeTouch® QS	0	1	1
Sivoia® QS Roller 64™	1	1	0
Sivoia QS Roller 100™	1	1	0
Sivoia QS Roller 225™	1	1	0
6-Zone *GRAFIK Eye* QS with EcoSystem®	up to 64	1	0
8-Zone *GRAFIK Eye* QS with *EcoSystem*	up to 64	1	0
16-Zone *GRAFIK Eye* QS with *EcoSystem*	up to 64	1	0
QS contact closure interface	up to 5	1	3
QS network interface	0	1	2
QS smart power panel	0	1	0

Wiring Rules

- Free wiring topology (daisy chain, T-tap, etc.).
- No link terminators needed.
- Total length of control link must not exceed 2000 ft (610 m).
- Up to 3 link repeaters each adding an additional 2000 ft (610 m).

Wire Gauge	Bus Length (max) (recommended GRX-CBL-46L)
12 AWG (4.0 mm^2)	2000 ft (600 m)
16 AWG (1.5 mm^2)	800 ft (250 m)
18 AWG (1.0 mm^2)	500 ft (150 m)

Power Panel Link

- Up to 32 power panels per link.
- Daisy chain wiring only.
- LT-1 link terminators needed on each end of the link.
- Power panel link connects the processor to the power panels, including: GP, LP, XP, CCP, JDP, JCP, DCI, and DP.
- PELV (Class 2: USA) wiring link requires:
  - Two 12 AWG (2.5 mm^2) conductors for control power.
  - One twisted, shielded pair of 18 AWG (1.0 mm^2) for data link.
  - One 18 AWG (1.0 mm^2) conductor for emergency (essential) sense line, from panel to panel.
  - Total length of control link may be no more than 2000 ft (600 m).
  - If MUX-RPTR interface and GRX-CBL-46L cable is used, length may be up to 4000 ft. (1200 m).

Job Name:	Model Numbers:
Job Number:	

Q-Manager™ System Server

The *Q-Manager* server is used to collect and record data from the *Quantum* system components. It is also required for communicating to the *Q-Admin* client software and the *Green Glance* client display.

Q-Admin™ System Management Software

- Up to two clients.
- *Q-Admin* is *Quantum*'s software that allows facilities staff to manage their electric light and daylight for maximum energy efficiency, comfort, and productivity.
- Allows control of lights on an area basis for sending lights to a level, enabling and disabling of occupancy, and changing target light levels for areas that are daylighting.
- Monitors light status, occupancy status, and energy consumption.
- Real-time diagnostics of ballast lamp failures and equipment failures.

Green Glance™

- Up to six displays.
- The screen displays lighting energy savings, real-time lighting power savings, and equivalent savings such as coal not burned or CO_2 not emitted. Data are organized into an easy-to-read format intended for public viewing.

Control Strategies

Scheduling

- Built-in timeclock allows scheduling of events based on time of day and relative to local sunrise and sunset.
- Create separate timeclocks for each related group of outputs, i.e., parking lots, common spaces, landscape lighting, etc.
- Each timeclock can contain different daily schedules.
- Astronomic events can be set up to 2 hours before or after sunrise or sunset.
- Daylight savings time can be defined according to any system used anywhere in the world.

Vacancy/Occupancy Detection

- Use occupant sensors to automatically turn the lights off in an area a fixed time after it becomes vacant.
- Use occupant sensors to automatically turn the lights on in an area when it becomes occupied and to automatically turn the lights off in an area a fixed time after it becomes vacant.
- Multiple areas may be grouped together to respond to vacancy/occupancy together.
- Each area's occupied level/scene and unoccupied level/scene can be programmed.
- Dependent occupancy groups allow you to keep an areas lights on when adjacent areas are occupied.

Daylighting

Automatically dim the electric lights in an area based on the amount of natural light entering through the windows.

Control Station Programming

- Select lighting scenes and/or shade presets in an area.
- Control individual lighting zones and/or shade groups using button-by-button programming.
- LED indicator displays the status of programmed lights.

Job Name:	Model Numbers:	
Job Number:		

Integration

Contact closures

- Simple integration with fire alarms systems, security systems, and audio/visual systems.

RS-232

- Advanced integration primarily used with audio/visual systems.

Telnet® via Ethernet

- Advanced integration primarily used with audio/visual systems.

BACnet® IP

- Integrate with the building management system.

Q-Admin™ Software

Control of Lights and Shades

Allows the building manager to control and monitor the lighting and shading system as follows:

Lights

- Area lights can be monitored for on/off status.
- All lights in an area can be turned on/off or sent to a specific level.
- For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
- Area lighting scenes can be modified in real time, changing the levels zones go to when a scene is activated.

Shades

- Area shades can be monitored for current preset or position.
- Area shades can be opened/closed, sent to a preset, or sent to a specific position.

Occupancy

Occupancy allows the building manager (or security guard) to monitor occupancy status and make occupancy-setting changes as follows:

- Area occupancy can be monitored.
- Area occupancy can be disabled to override occupancy control or in case of occupant sensor problems.
- Area occupancy settings, including level lights turn on to when area is occupied, and level lights turn off to when area is unoccupied, can be changed in real time.

Daylighting

Daylighting allows the building manager to control and monitor the daylighting settings as follows:

- Daylighting can be enabled/disabled. This can be used to override the control currently taking place in the space.
- Daylight target levels can be changed for each daylit area. This is particularly useful when new departments move into a space.

IntelliDemand Load Shedding

Load shedding allows the building manager to monitor whole-building lighting power usage and apply a load shed reduction to selected areas, thereby reducing a building's power usage.

Scheduling

Schedule time of day and astronomic timeclock events to automate functions for lights and shades.

Job Name:	Model Numbers:
Job Number:	

Reporting

Reports allow the building manager to gather real-time and historical information about the system as follows:

- Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas.
- Power Reports: Show power usage trend over a period of time for one or more areas.
- Activity Report: Shows what activity has taken place over a period of time for one or more areas. Activity includes occupancy activities (i.e., areas going occupied/unoccupied, wall controls being pressed), building manager operation (controlling/changing areas using the control and monitor tool), and device failures (keypads, ballasts, etc. not responding).
- Lamp Failure Report: Shows which areas are currently reporting lamp failures.

Diagnostics

Diagnostics allow the building manager to check on the status of all equipment in the lighting control system. Devices will be listed with a reporting status of OK, missing, or unknown.

Administration

The administration tab appears only for users who have been assigned the role “Admin” when their user account was created or last modified. The administration features are as follows:

- Users: Allows new user accounts to be created and existing user accounts to be edited.
- Publish Graphical Floor Plan: Allows admin user to publish new graphical floor plan files, allowing users to monitor the status of lights, occupancy of areas, and daylighting status.
- Back-up Project Database: Allows admin user to backup the project database. The project database holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and timeclock. The Control and Monitor tool can be used to adjust some of these settings, and thus it is important to back up the project database prior to changing settings in the Design and Setup tool.
- Publish Project Database: Allows the admin user to send a new project database to the server and download the new configuration to the system. The project database holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and timeclock.

Graphical Floor Plan Design Service

The Q-Admin™ system navigation and status reporting can be performed using customized CAD-based drawings of your building. Pan and zoom feature allows for easy navigation.

- Contact Lutron for hourly rate for graphics creation.
- Customer must supply vector-based (.dwg, .dxf, .wmf, etc.) drawings for each floor plan to be displayed.

Dual Technology Ceiling Mount Sensor

The LOS-CDT Series ceiling-mount dual-technology sensors can integrate into Lutron systems or function as stand-alone controls using a Lutron power pack. The technology eliminates manual sensitivity and timer adjustments during installation and over the life of the product.

Features

- Intelligent, continually adapting sensor
- Ultrasonic (US) combined with passive infrared (PIR) sensing provide high sensitivity, high noise immunity, and excellent false tripping immunity
- Suited for complex environments that are difficult to control with single-technology sensors
- Snap-locks to ceiling-mounted cover plate
- Non-Volatile Memory: settings saved in protected memory are not lost during power outages
- 500 to 2000 sq.ft. (46 to 186 m^2) coverage when mounted on an 8 - 12 ft. (2.4 to 3.7 m) ceiling; 180° and 360° field of view
- Affords choice of turning lights off or dimming to a preset level in the unoccupied state when integrated with a Lutron system.

Models Available

Cat. No.	Color	Coverage	Field of View
LOS-CDT-500-WH	White	500 sq.ft. (46 m^2)	180°
LOS-CDT-500R-WH	White	500 sq.ft. (46 m^2)	180°
LOS-CDT-1000-WH	White	1000 sq.ft. (93 m^2)	180°
LOS-CDT-1000R-WH	White	1000 sq.ft. (93 m^2)	180°
LOS-CDT-2000-WH	White	2000 sq.ft. (186 m^2)	360°
LOS-CDT-2000R-WH	White	2000 sq.ft. (186 m^2)	360°

Self-Adaptive Feature

The LOS-CDT Series ceiling-mount occupant sensors combine both (US) motion detection for maximum sensitivity and passive infrared (PIR) motion detection for false triggering immunity. The self-adapting internal microprocessor analyzes the composite sum of both signals to eliminate time-consuming adjustments and callbacks found in non-intelligent sensors.

Job Name:	Model Numbers:
Job Number:	

Specifications

Timer Adjustment

- Automatic mode: Continually adapting sensor automatically adjusts settings to the space
- Manual mode: 8 to 30 minutes
- Test mode: 8 seconds

LED Lamp

- Red: infrared motion detected
- Green: ultrasonic motion detected

Housing

- Rugged, high-impact, injection-molded plastic
- Color-coded leads 6 in. (15 cm)

Power

- Operating voltage: 20 - 24 V⎓, PELV (Class 2: USA) low-voltage
- Operating current: 33 mA nominal
- Control output: 20 - 24 V⎓ active high logic control signal with short-circuit protection, open collector when unoccupied

Operating Environment

- Temperature: 32 to 104 °F (0 to 40 °C)
- Relative humidity: less than 95%, non-condensing
- For indoor use only

Adaptive Functions

- Installation: 60 minutes
- Learning: 4 weeks for response to error conditions, air current adaptation, and timer optimization
- Post-learning occupancy periods
  —24-hour circadian occupancy periods learned
  —Weekly occupancy periods learned
- Adjustments in post-learning period
  —Generally occupied periods (threshold = high-sensitivity mode)
  —Generally unoccupied periods (threshold = miser mode)

Contact Rating (R Models only)

- SPDT 500 mA rated at 24 V⎓ isolated relay

Photo Cell (R Models only)

- Prevents light from turning on when there is sufficient natural light
- Sensitivity: 0 - 1,000 LUX adjustable

Dimensions

Front View

Side View

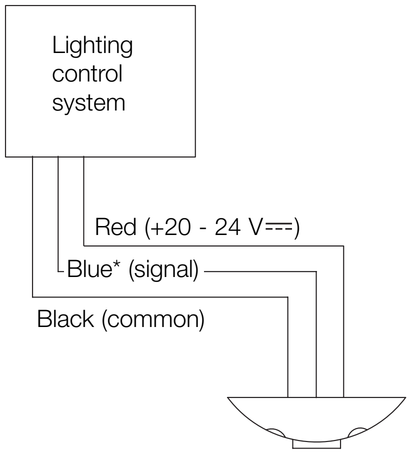
Measurements are in inches (mm)

Job Name:	Model Numbers:
Job Number:	

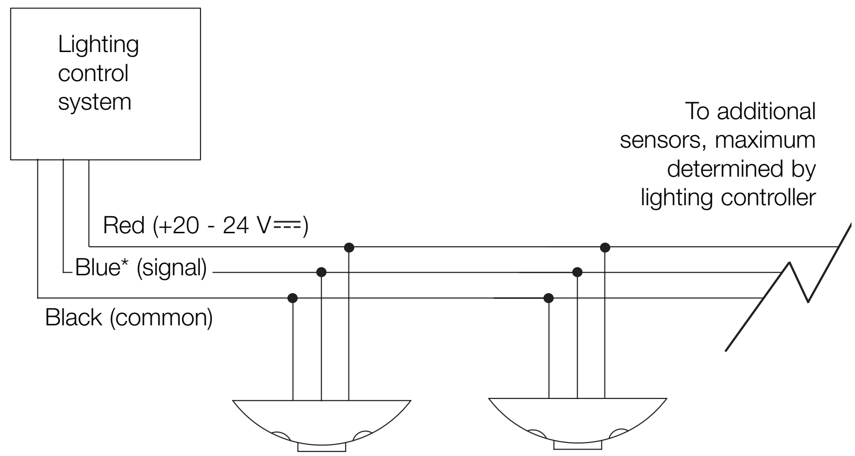
Wiring

Note: Power pack may be required when interfaced to lighting control system; see below.

Single Sensor to System



2 or More Sensors to System



*Note: Use gray wire for -R model.

Power Supply Options

Lutron Lighting Control System	Power Pack Required?
Digital microWATT™	No
EcoSystem®	No
GRAFIK 5000 / 6000 / 7000™	No, when used with seeTouch® wallstations with occupant sensor connections.
GRAFIK Eye® 3000 / 4000	Yes
HomeWorks®	Yes
LCP128™	No, when used with *seeTouch* wallstations with occupant sensor connections.
microWATT®	No
RadioRA®	Yes
RadioTouch®	No
Softswitch128®	No, when used with *seeTouch* wallstations with occupant sensor connections.

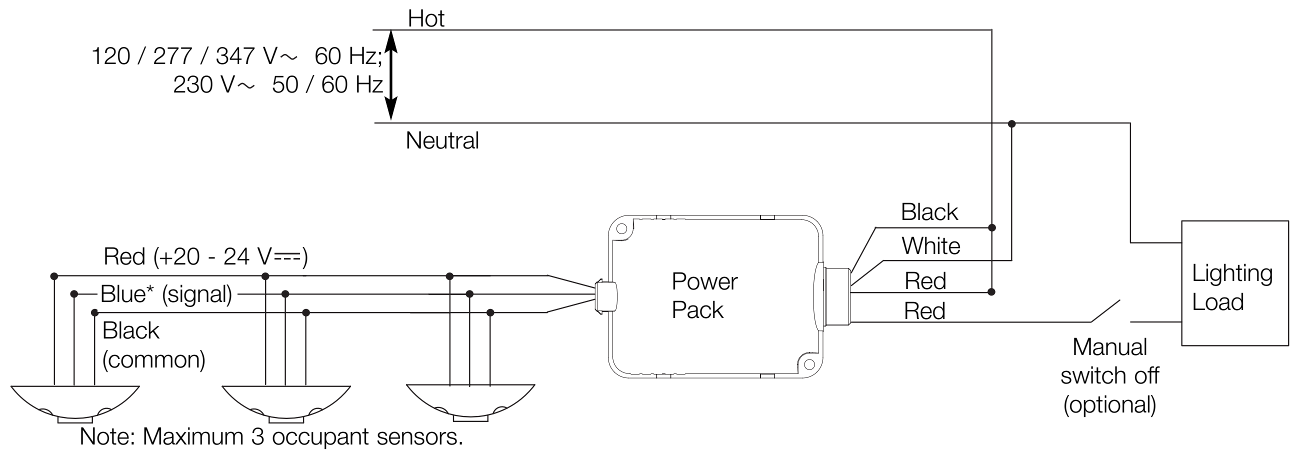
Job Name:

Job Number:

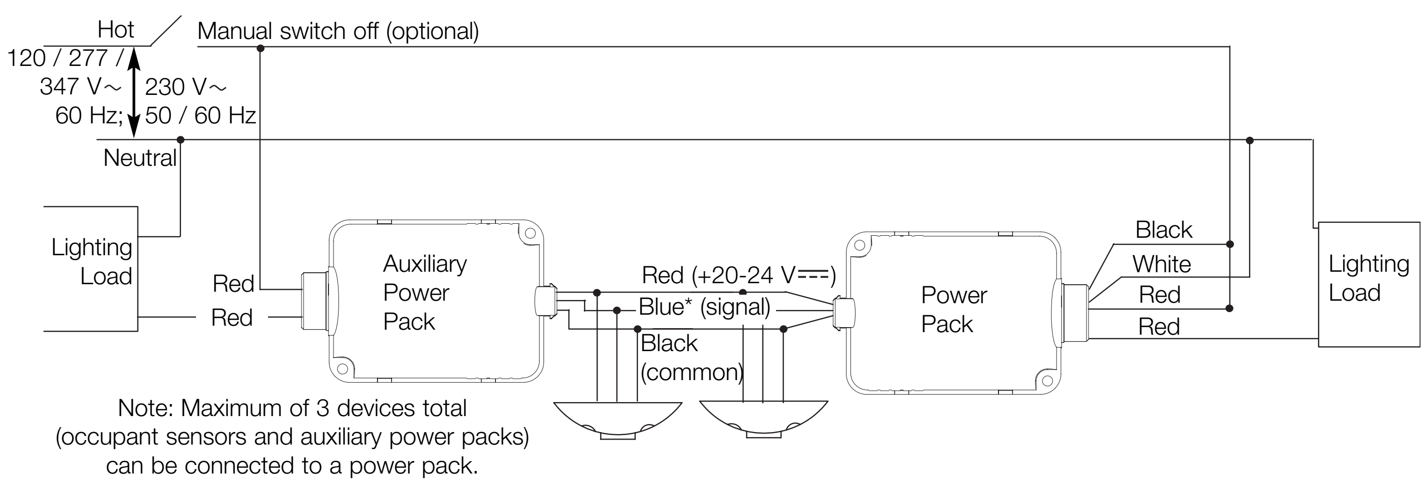
Model Numbers:

Wiring: Stand-Alone Control

1 to 3 Sensors with Power Pack



Switching Multiple Loads with Auxiliary Power Packs



*Note: Use gray wire for -R model.

Job Name:

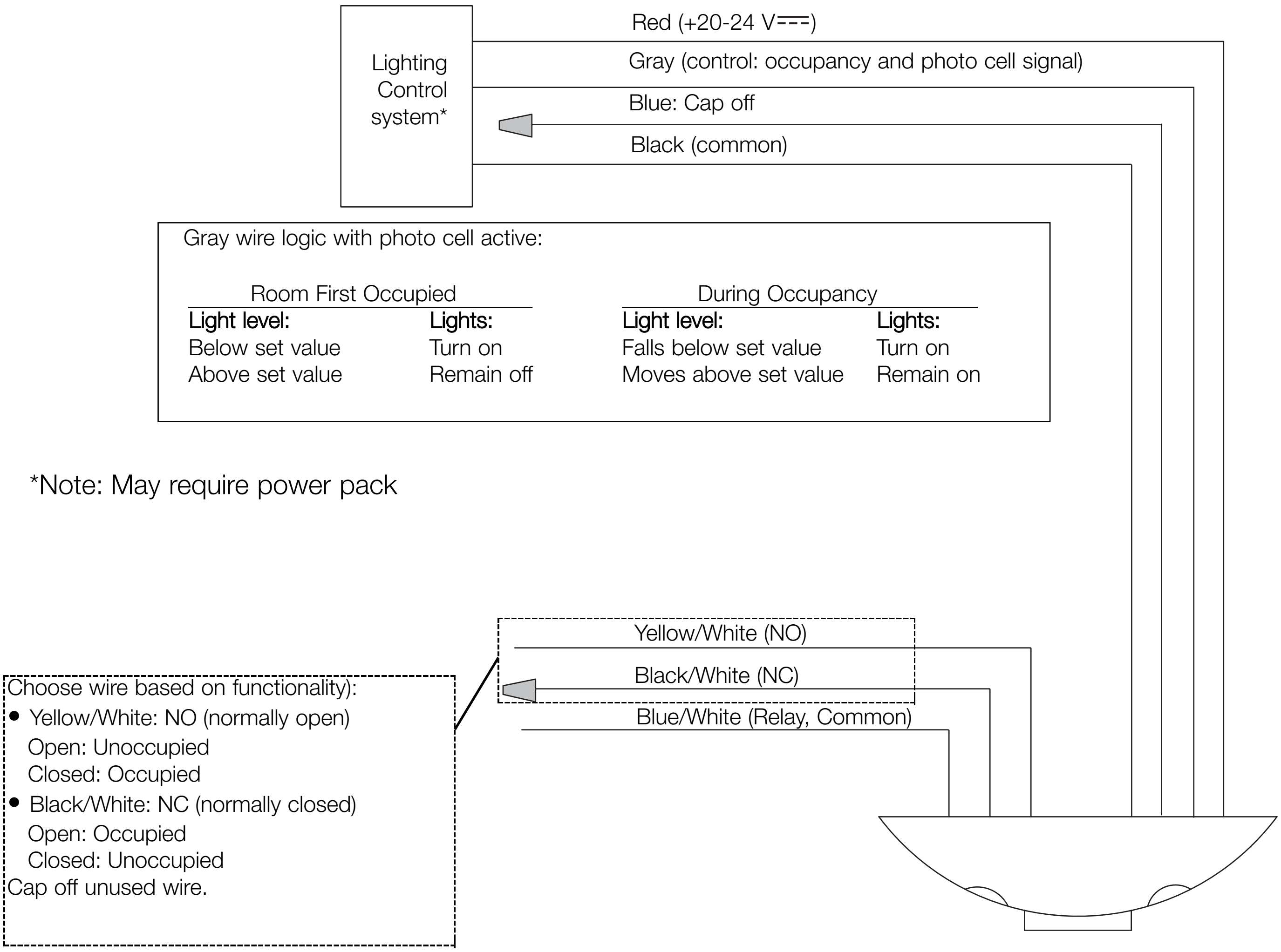
Job Number:

Model Numbers:

Wiring

Relay Model Option

LOS-CDT-xxxxR only



Gray wire logic with photo cell active:

Room First Occupied		During Occupancy	
Light level:	Lights:	Light level:	Lights:
Below set value	Turn on	Falls below set value	Turn on
Above set value	Remain off	Moves above set value	Remain on

*Note: May require power pack

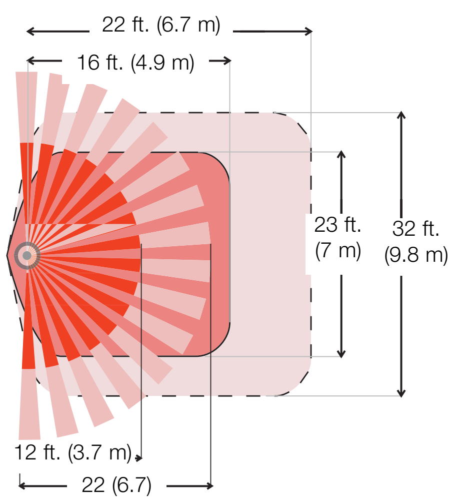
Job Name:	Model Numbers:
Job Number:	

Installation

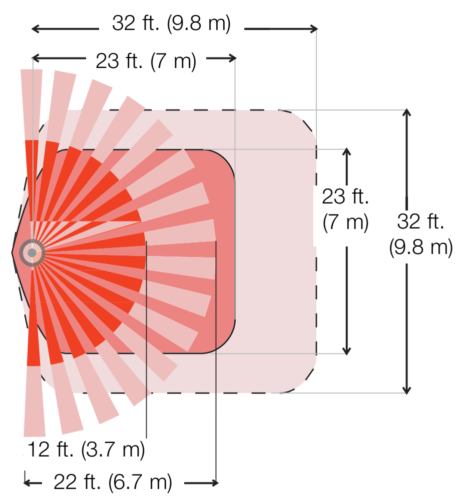
Sensor Placement

- The occupant sensor must have an unobstructed view of the room. Do not mount behind or near tall cabinets, shelves, indirect hanging fixtures, etc.
- Keep the occupant sensor away from air flow from ventilation outlets, windows, fans, etc.
- If installing a 180° occupant sensor (500 and 1000 models), place the sensor on the same wall as the doorway so that traffic in a hallway will not affect the sensor; otherwise, place in center of room.
- Closely follow the diagrams shown concerning major and minor motion coverage. The sensor can detect major motion (such as a person taking a half-step) at a greater distance than it can detect minor motion (such as writing or typing at a desk).
- Decrease total coverage area by 15% for “soft” rooms (for example, heavy draperies or heavy carpeting).

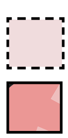
Range Diagrams

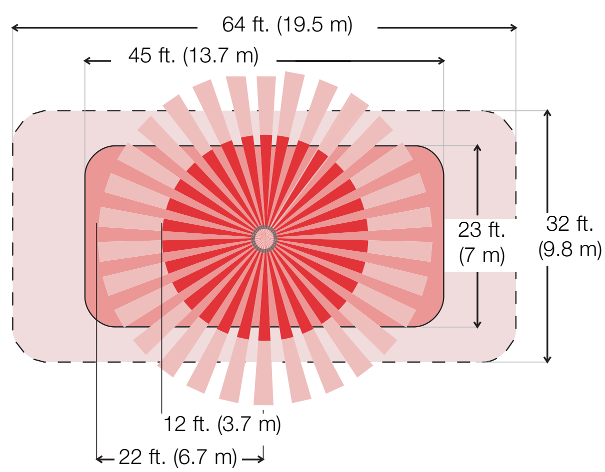


LOS-CDT-500



LOS-CDT-1000





LOS-CDT-2000

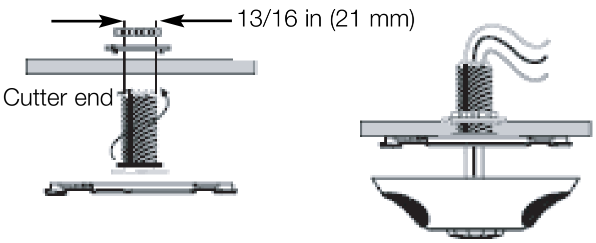
Job Name:	Model Numbers:
Job Number:	

Installation

Mounting

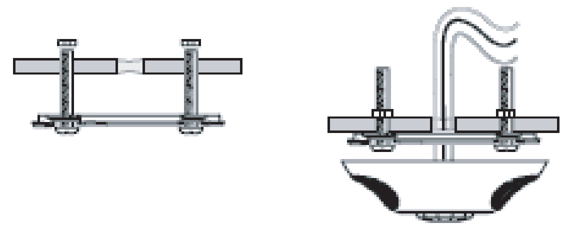
Normal Mounting

Twist and lock threaded mounting post onto cover plate. Drill through ceiling tile with assembly, using cutter end of the threaded mounting post. Secure with washer and nut.

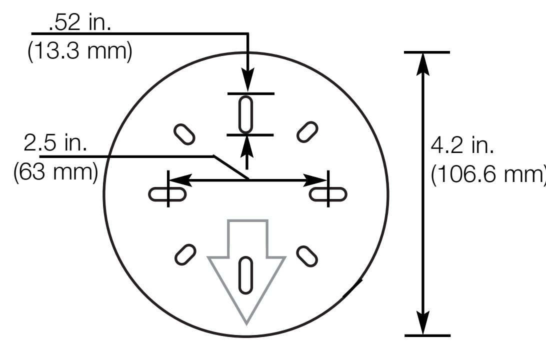


Mounting to Non-Standard Ceiling or Fixture

Mount twist-lock cover plate using mounting screws, nuts, and washers (included). Drill/punch wire routing hole through ceiling tile at center of cover plate.



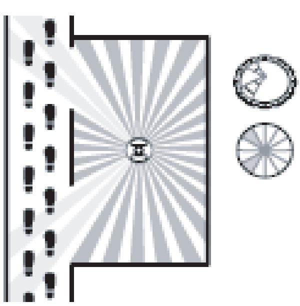
Mounting Plate Dimensions



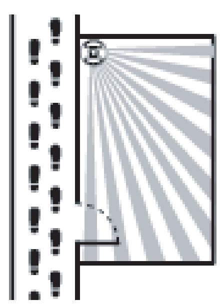
Wire Lengths

# Sensors	1	2	3	1	2	1
# Aux. PP	0	0	0	1	1	2
22 AWG	750 ft.	375 ft.	250 ft.	375 ft.	250 ft.	250 ft.
0.5 mm²	365 m	180 m	120 m	90 m	120 m	120 m
20 AWG	1200 ft.	600 ft.	400 ft.	600 ft.	400 ft.	400 ft.
0.75 mm²	730 m	365 m	240 m	365 m	240 m	365 m
18 AWG	2400 ft.	1200 ft.	800 ft.	1200 ft.	800 ft.	800 ft.

Using the Infrared Mask

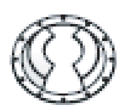


Center Ceiling Mount
(Mask blocks sensor seeing out doorway into hall)

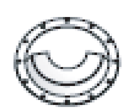


Corner Ceiling Mount
(No mask needed)

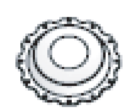
Typical Mask Patterns



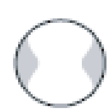
Conference Room Mask



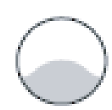
180° Mask



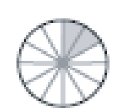
Full Mask



Rectangular Areas



Over the Door



Specific Areas You Wish to Mask

Job Name:	Model Numbers:
Job Number:	

Sensor Adjustments

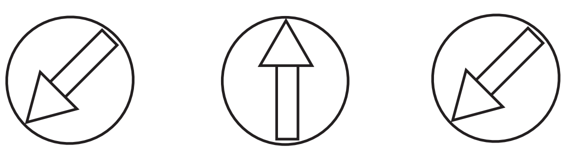
Override Settings

Setting	A	Off (Default)	On
Auto/Manual	1	Automatic (Normal)	Manual on/off (Override)
Threshold	2	Auto Threshold Adjustment	High Sensitivity (Low turn-on threshold)
LED Motion Indicator	3	Lights indicate motion	Disable LED Indicator
Reset Learned Settings	4	Retain Settings (Normal)	Erase all learned settings, restart Learning (Toggle On)

Setting	B	Off	On
Strong Airflow Compensation	1	Disable Compensation (Normal)	Enable Compensation
Over Doorway Installation	2	No (Normal)	Yes (Use increased turn-on threshold)
Timer Adjust	3	Adjust Timer Automatically	Use Manual Setting (No adjustment)
Auto Sensitivity	4	Adjust Sensitivity Automatically	Adjust Sensitivity Manually

Timer Test Mode

1. Remove the retainer cover.
2. Rotate the black timer adjustment knob to about midway (12 o'clock).
3. Return setting to minimum setting (full CCW).

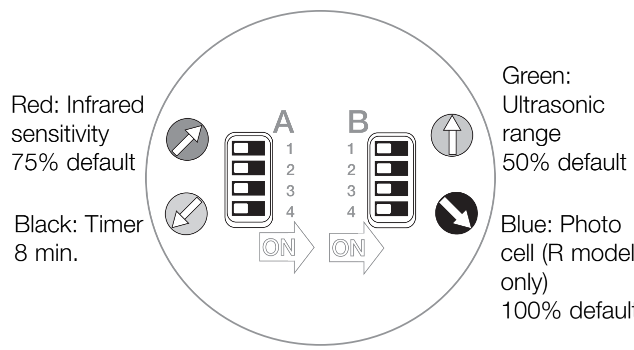


Factory Settings 12 o'clock Full CCW

Note: The timer will remain in the 8-second test mode for 1 hour, then automatically reset to 8 minutes.

4. To manually take the timer out of the 8-second test mode, turn the timer adjustment approximately 1/16" clockwise to make the setting slightly above minimum (just above the 8-minute setting).

Factory Settings



Job Name:	Model Numbers:
Job Number:	

Installation

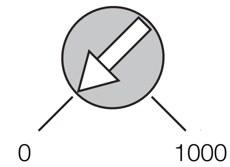
Adjusting the "Lights Not On" Level

LOS-CDT-xxxxR only

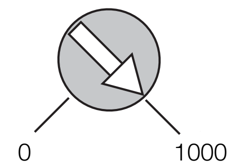
1. Place timer in Test Mode (see page 7).
2. Set photo cell to max.
   Turn the blue knob full clockwise (lights on no matter how bright the natural light is), then about 30 degrees counterclockwise.
3. Check for Lights-Out.
   Move from underneath the sensor, and remain still until the lights turn off. Move around normally to turn the light on.
4. Adjust to desired level.
   If lights remain off, adjust the blue knob another 30 degrees counterclockwise and repeat step 3 until the lights turn on.
   Note: Set blue knob to 100% to disable photo cell functionality and leave secondary dry contact closure output functionality intact.

Control Settings (Blue Knob)

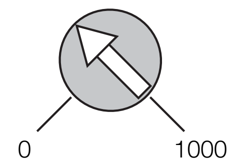
LOS-CDT-xxxxR only



Minimum (low):
Lights will never come on, even though room is occupied.



Maximum (high):
Photo cell has no effect on operation (factory setting).



Normal:
200 to 600 LUX is normal range.

Job Name:	Model Numbers:
Job Number:	

LP Dimming Panels

LP Dimming Panels are ideal for projects with many small loads. Each panel provides power and dimming for up to 32 dimming legs.

Features

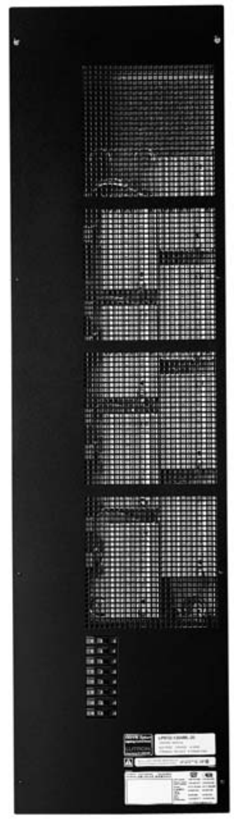
- Work directly with incandescent, magnetic low voltage, and neon/cold cathode lighting, as well as Lutron TuWire™ Fluorescent Dimming Ballasts.
- Work with electronic low voltage lighting via Power Interfaces.
- Work with 3-wire AC motors through motor modules.
- Panels are prewired - just bring in feed and load wiring.
- Surface or recess mount between 16” center to center studs.

Models available with:

- 100-127 V, 220-240 V (non CE), or 230 V (CE) input power.
- 1 to 8 Dimming Modules for 4 to 32 dimming legs.
- Different feed types and breakers.

LP Dimming Panels work with:

- GRX-4000 Control Units.
- GRAFIK 5000™, GRAFIK 6000®, and GRAFIK 7000® Systems.
- GP Dimming Panels and XP Switching Panels.
- DMX512 dimming systems via the 2LINK™ option.



Standard-Size
LP4/28–LP8/32

Mini
LP1/4–LP3/12

Specifications

Standards

- UL Listed (Reference: UL File 42071).
- Complies with CSA, NOM, or CE (where appropriate).

Power

- Input power: 100-127 V, 220-240 V (non CE), and 230 V (CE). All voltages 50/60 Hz, phase-to-neutral.
- Branch Circuit Breakers: UL-rated thermal magnetic.
  AIC ratings:
  100-127 V – 10,000
  220-240 V – 6,000
  230 V (CE) – 6,000
- Lighting strike protection: Meets ANSI/IEEE standard 62.41-1980. Can withstand voltage surges of up to 6000 V and current surges of up to 3000 A.
- 10-year power failure memory: Automatically restores lighting to scene selected prior to power interruption.

Short Circuit Current Ratings (other ratings available)

Panel Type	Voltage	Std. SCCR Rating
LP Main Lug Panels (all sizes)	120	25,000 A

Sources/Load Types

Operate these sources with a smooth continuous Square Law dimming curve or on a full-conduction non-dim basis:

- Incandescent (Tungsten)/Halogen
- Magnetic Low Voltage Transformer
- Lutron Tu-Wire™ Electronic Fluorescent Dimming Ballasts
- Neon/Cold Cathode

Operate these sources via Power Interfaces:

- Electronic Low Voltage Transformer via dedicated internal Dimming Modules or external Power Interfaces.
- Lutron Electronic Fluorescent Dimming Ballasts via external Power Interfaces.

Operate HID sources on a full conduction non-dim basis.

Dimming Modules

- Each Dimming Module can handle a fully loaded electrical circuit - up to four dimming legs per Module.
- Maximum Ratings:

Voltage	Capacity per Dimming Module	Capacity per Dimming Leg
100-127 V	16 A	16 A
220-240 V (non-CE)	16 A	16 A
230 V (CE)	13 A	10 A

- RTISS™ filter circuit technology compensates for incoming line voltage variations: No visible flicker with +/-2% change in RMS voltage/cycle and +/-2% Hz change in frequency/second.

Wiring

- Internal: Prewired by Lutron.
- System communications: Low-voltage Class 2 (PELV) wiring connects Dimming Panels to other components.
- Line (mains) voltage: Feed and load wiring only. No other wiring or assembly required.

Setup

Circuit Selector electronically assigns dimming legs to zones and sources. Permits reassignment of zones and sources without rewiring.

Physical Design

- Enclosure: NEMA-Type 1, IP-20 protection; #16 U.S. Gauge Steel. Indoors only.
- Weight: 27 lb (13 kg) for Mini LP, 63 lb (29 kg) for Standard-Size LP.

Mounting

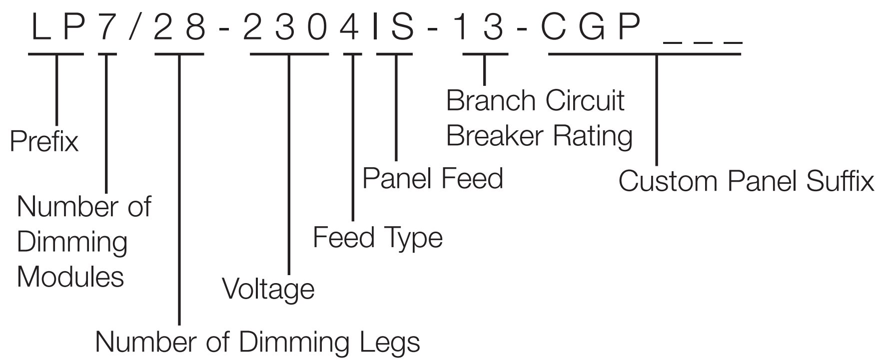
- Surface mount or recess mount between 16 in. (40 cm) studs.
- Allow space for ventilating.

Environment

32-104 °F (0-40 °C). Relative humidity less than 90% non-condensing.

Job Name:	Model Numbers:	
Job Number:		

How to Build a LP Model Number



Prefix:

LP for LP Dimming Panel

Number of Dimming Modules:

Indicates number of dimming modules in the panel.
Also indicates number of full load circuits.

Number of Dimming Legs:

Indicates number of dimming legs in the panel.
Each module has four dimming legs.

Voltage:

120 for 100-127 V
230 for 230 V (CE)
240 for 220-240 V (non-CE)

Feed Type:

2 for 1 phase 2 wire
3 for 1 phase 3 wire (split phase)
4 for 3 phase 4 wire

Panel Feed:

ML for Main Lugs only
Mxx for Main Breaker with **xx** = breaker size in Amps (custom panel option)
IS for Isolation Switch (CE/non-CE only)

Branch Circuit Breaker Rating:

20 for 20 A branch circuit breakers (120 V only)
15 for 15 A branch circuit breakers (120 V only)
13 for 13 A branch circuit breakers (230 V CE only)
16 for 16 A branch circuit breakers (240 V non-CE only)

Custom Panel Suffix:

Indicates panel with special options

Job Name:	Model Numbers:	
Job Number:		

Mini LP Models

Only standard Panels listed. Consult Lutron for further options.

100 - 127V Power

Number Of Dimming Modules	Number Of Dimming Legs	Feed Type	Maximum Feed	Panel Feed
LP1	4	1Ø, 2W	20 A	15 A or 20 A[1] Branch Circuit Breakers
LP2	8	1Ø, 2W	40 A	
		1Ø, 3W	20 A	
LP3	12	1Ø, 2W	40 A	
		1Ø, 3W	40 A	
		3Ø, 4W	20 A	

220 - 240V (non CE) Power

Number Of Dimming Modules	Number Of Dimming Legs	Feed Type	Maximum Feed	Panel Feed
LP1	4	1Ø, 2W	16 A	16 A Branch Circuit Breakers
LP2	8	1Ø, 2W	32 A	
LP3	12	1Ø, 2W	48 A	
		3Ø, 4W	16 A	

Wire Sizes

Feed Wiring

Power (Hot/Live) (connect directly to Branch Circuit Breakers):

100-127 V #14 AWG (2.0 mm^2) to #10 AWG (4.0 mm^2)
220-240 V #18 AWG (1.0 mm^2) to #4 AWG (25 mm^2)

Neutral (connects to Neutral Lug):

100-127 V #14 AWG (2.0 mm^2) to #2/0AWG (70 mm^2)
220-240 V #14 AWG (2.0 mm^2) to #8 AWG (6.0 mm^2)

Load Wiring

All Models #14 AWG (2.0 mm^2) to #10 AWG (4.0 mm^2)

[1] 20/16A, 15/12A continuous load rating.

Job Name:	Model Numbers:
Job Number:	

Standard-Size LP Models

Only standard Panels listed. Consult Lutron for further options.

100 - 127 V Power

Number Of Dimming Modules	Number Of Dimming Legs	Feed Type	Maximum Feed	Panel Feed	Branch Circuit Breakers
LP4	16	3Ø,4W	175 A	Main Lugs Only	15 A or 20 A[1]
LP5	20	3Ø,4W	175 A		
LP6	24	3Ø,4W	175 A		
LP7	28	3Ø,4W	175 A		
LP8	32	3Ø,4W	175 A		

220 - 240 V (non CE) Power

Number Of Dimming Modules	Number Of Dimming Legs	Feed Type	Maximum Feed	Panel Feed	Branch Circuit Breakers
LP4	16	3Ø,4W	125 A	Isolation Switch Only	16 A
LP5	20	3Ø,4W	125 A		
LP6	24	3Ø,4W	125 A		
LP7	28	3Ø,4W	125 A		
LP8	32	3Ø,4W	125 A		

Wire Sizes

Feed Wiring to Main Lugs (100-127 V Only):
Power (Hot/Live) (3) #14 AWG (2.0 mm^2) to #2/0 AWG (70 mm^2)
Neutral (1) #14 AWG (2.0 mm^2) to #2/0 AWG (70 mm^2)

Feed Wiring to Isolation Switch (CE/non-CE only):
Power (Hot/Live) (3) 2.5 mm^2 to 35 mm^2
Neutral (1) 2.5 mm^2 to 35 mm^2

Load Wiring
All Models #14 AWG (2.0 mm^2) to #10 AWG (4.0 mm^2)

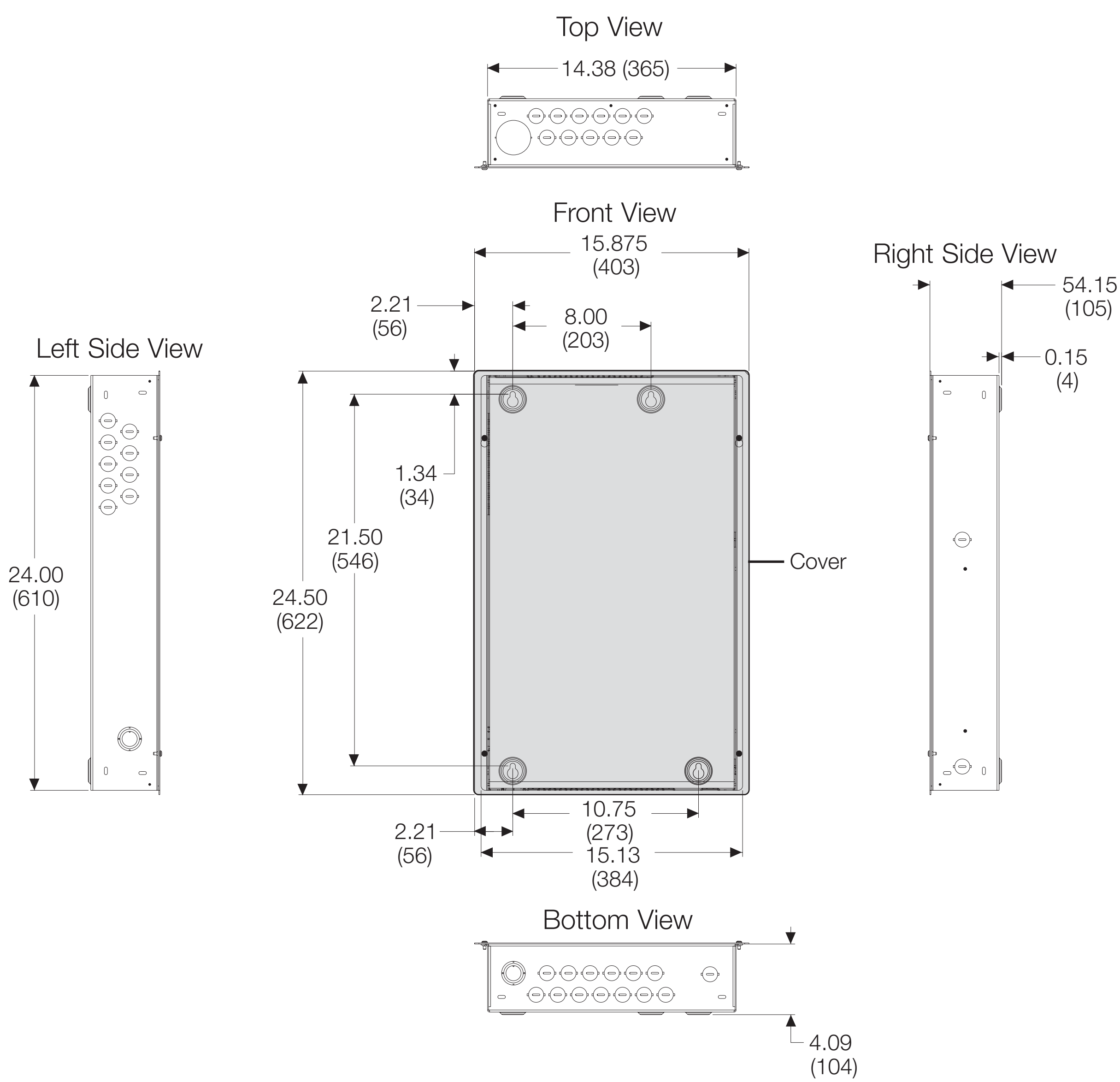
[1] 20/16A, 15/12A continuous load rating.

Job Name:

Job Number:

Model Numbers:

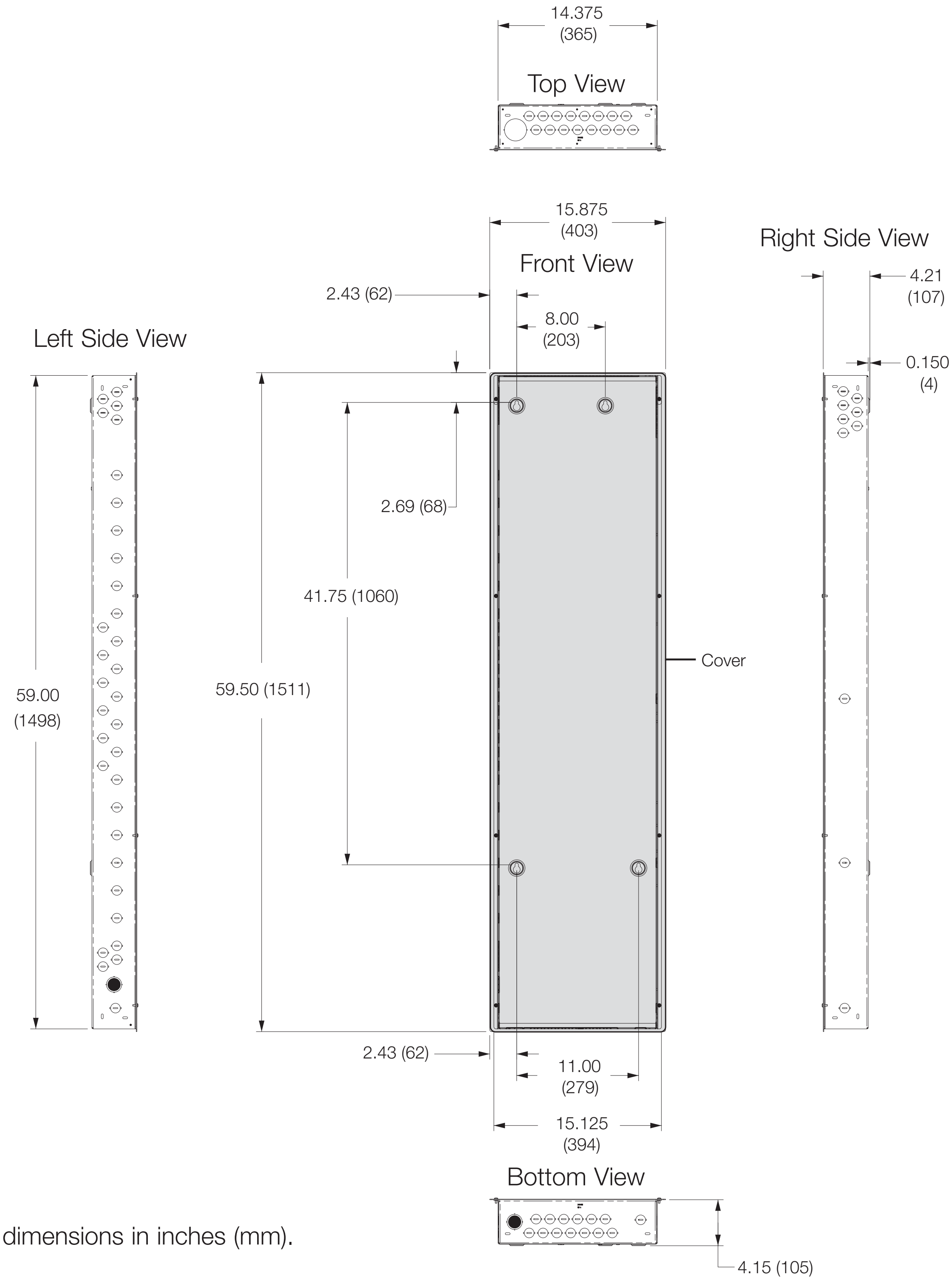
Mini LP Dimensions



All dimensions in inches (mm).

Job Name:	Model Numbers:
Job Number:	

Standard-Size LP Dimensions



All dimensions in inches (mm).

Job Name:	Model Numbers:
Job Number:	

Mini LP Mounting

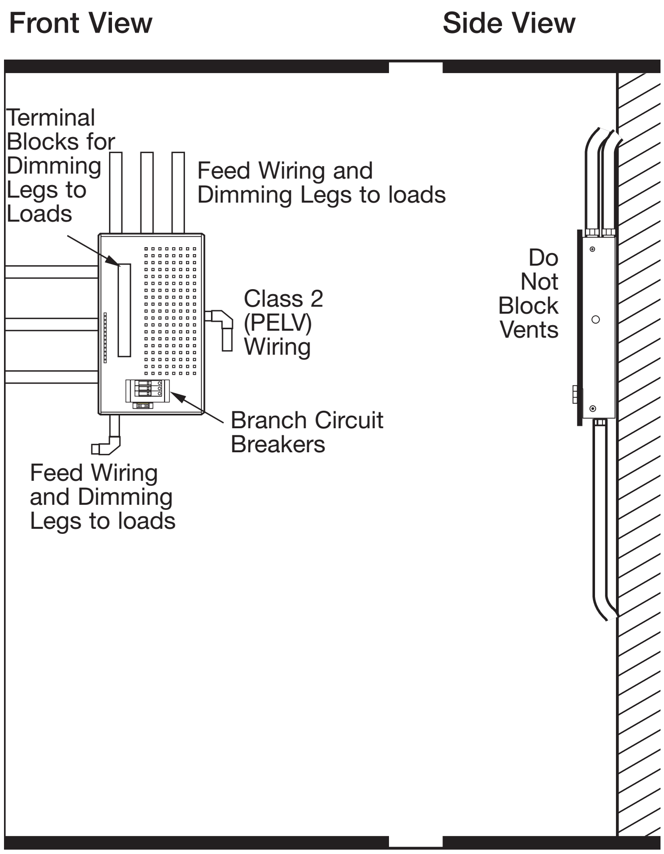
- Surface or recess mount indoors.
- Consult Dimensions page for dimensions and conduit knockout locations.
- Panel generates heat. Mount only where ambient temperature is 32 - 104 °F (0 - 40 °C).
- This equipment is air-cooled.
  Do not block vents or warranty will be void.
- Mount Panels where audible noise is acceptable (internal relays click).
- Mount Panels so line (mains) voltage wiring is at least 6 feet (1.8 m) from sound or electronic equipment and wiring.
- Mount Panel within 7° of true vertical.

Panel	Maximum BTUs/hour	Weight Without Packaging
LP1	90	33 lb (15 kg)
LP2	170	35 lb (16 kg)
LP3	250	37 lb (17 kg)

Maximum Feed and Wire Sizes
Consult Wiring Overview page.

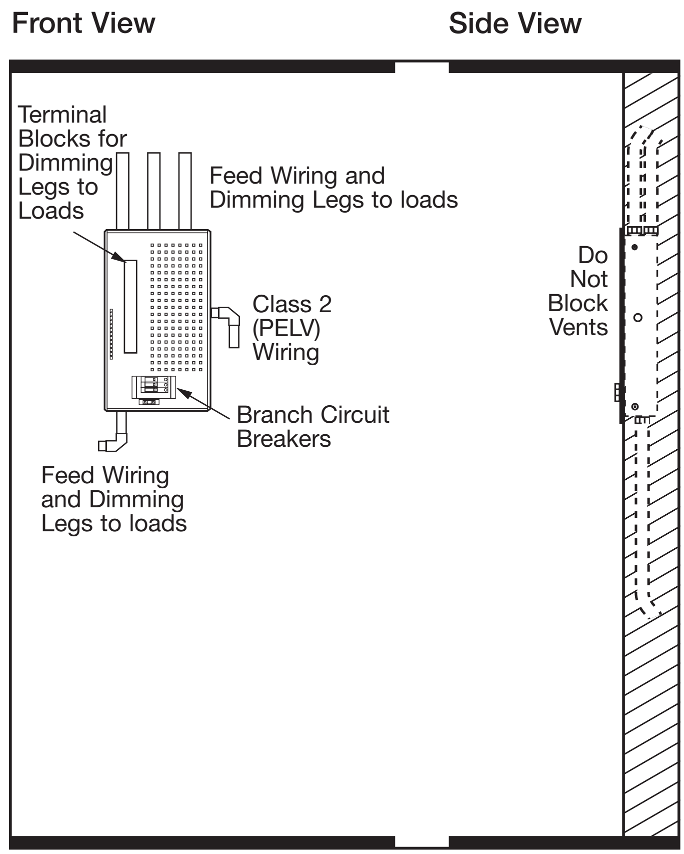
Surface Mounting

- Surface mounting keyholes accept 1/4 in. (6 mm) mounting bolts. This size is recommended.



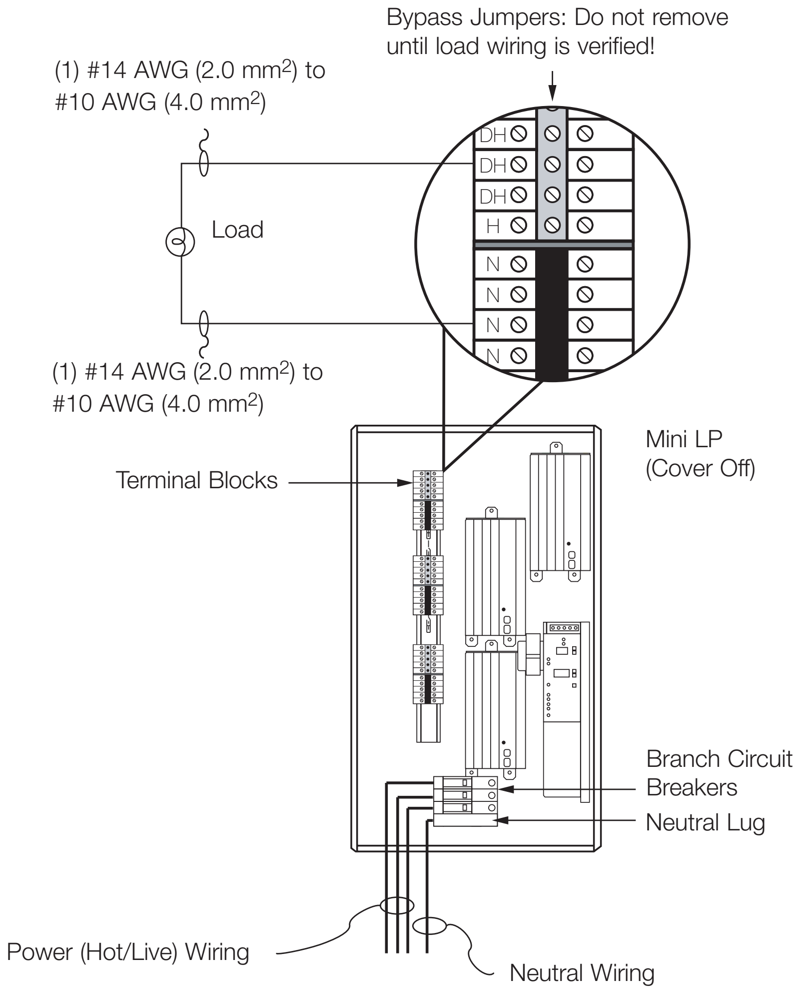
Recess Mounting

- Mount Panel flush to 1/8 in. (3mm) below finished wall surface.
- Allow room for top cover. Leave 1 1/2 in. (38mm) clearance to each side of Panel.



Job Name:	Model Numbers:
Job Number:	

Mini LP Wiring



Wiring Tips

Wire the Mini LP similar to wiring a lighting Distribution Panel:

- Run feed and load wiring. No other wiring or assembly required.
- Run separate neutrals for each module - no common neutrals across phases.

The Mini LP can provide temporary lighting:

- Wire all loads.
- Do not remove the bypass jumpers that protect the Dimming Modules.
- Use Branch Circuit Breakers to switch lights on and off.

Power (Hot/Live)

100-127 V	#14 AWG (2.0 mm²) to #10 AWG (4.0 mm²)
220-240 V 230 V (CE)	#18 AWG (1.0 mm²) to #4 AWG (25 mm²)

Neutral

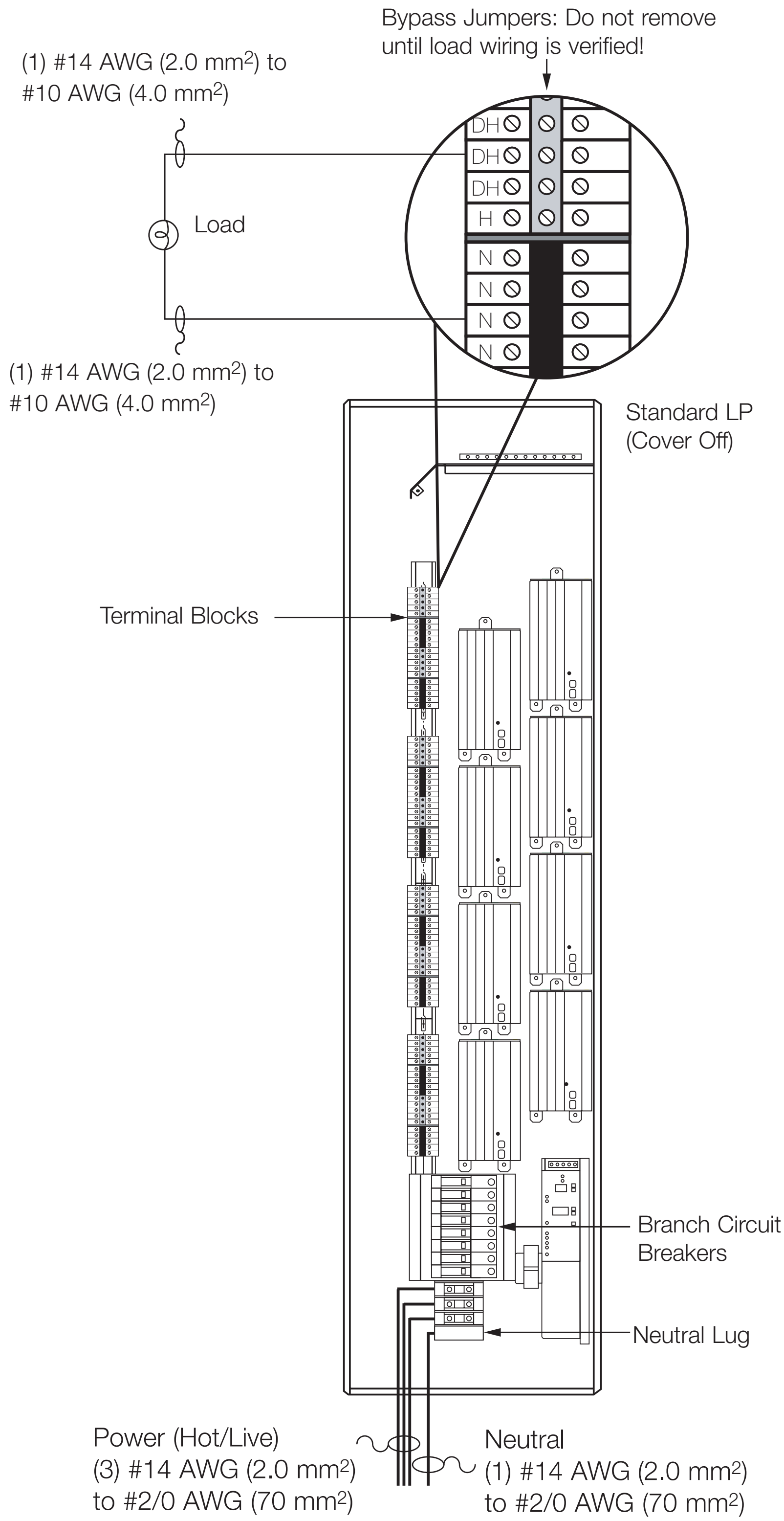
100-127 V	#14 AWG (2.0 mm²) to #2/0 AWG (70 mm²)
220-240 V 230 V (CE)	#14 AWG (2.0 mm²) to #8 AWG (6.0 mm²)

Job Name:

Job Number:

Model Numbers:

Standard-Size LP Wiring



Wiring Tips

Wire the Mini LP similar to wiring a lighting Distribution Panel:

- Run feed and load wiring. No other wiring or assembly required.
- Run separate neutrals for each module - no common neutrals across phases.

The LP can provide temporary lighting:

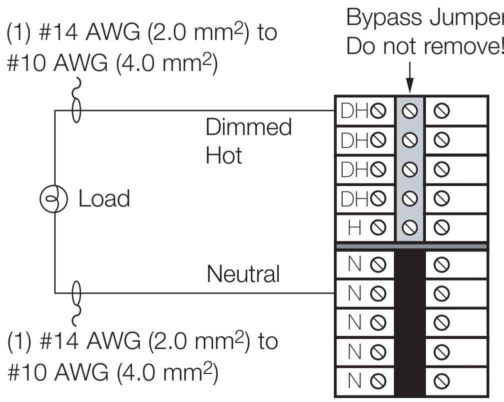
- Wire all loads.
- Do not remove the bypass jumpers that protect the Dimming Modules.
- Use Branch Circuit Breakers to switch lights on and off.

Job Name:	Model Numbers:	
Job Number:		

Typical Dimming Legs for 100-127 V

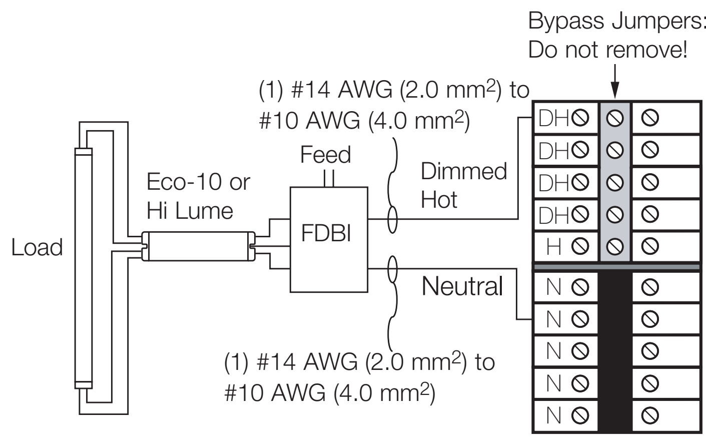
All Load Types except

- Lutron Hi-lume® or Eco-10™ (ECO-Series) Fluorescent Dimming Ballasts
- Electronic Low Voltage



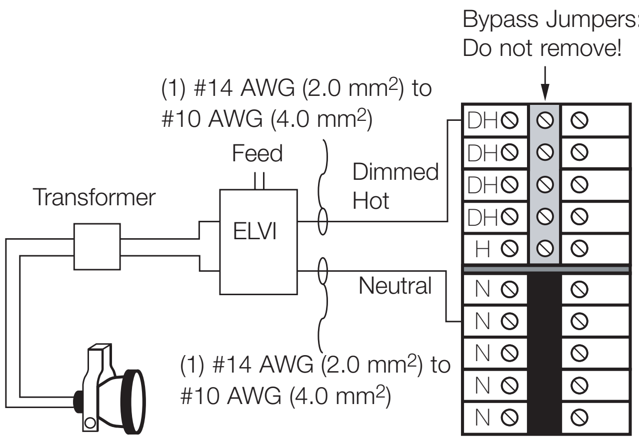
Lutron Hi-lume or Eco-10 (ECO-Series) Fluorescent Dimming Ballasts

- Use Lutron FDBI Fluorescent Dimming Ballast Interface.



Electronic Low Voltage

- Use Lutron ELVI Electronic Low Voltage Interface.
- Consult ELVI Specification Submittal for more details.



Job Name:	Model Numbers:
Job Number:	

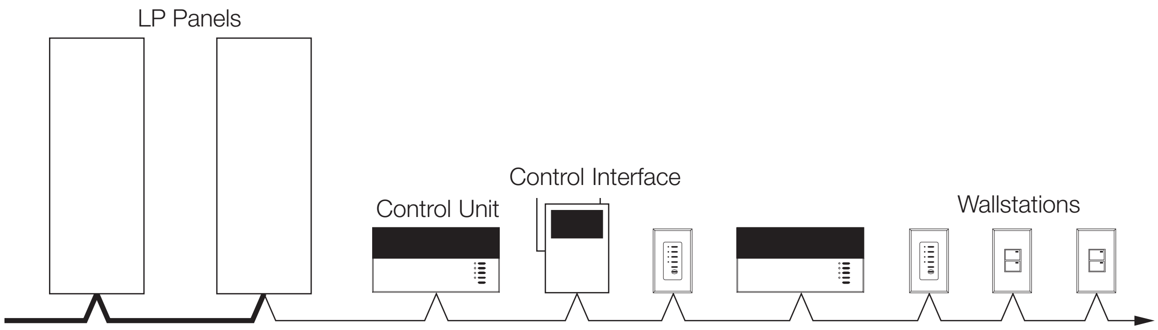
Low-Voltage Class 2 (PELV) Wiring (All Models)

System communications use low-voltage Class 2 wiring.
Wiring must be daisy-chained.
Wiring must run separately from line (mains) voltage.

GRAFIK Eye® 4000 System

Class 2 (PELV) wiring link requires:
Two #12 AWG (2.5 mm²) conductors for control power.
One twisted, shielded pair of #18 AWG (1.0 mm²) for data link.
One #18 AWG (1.0 mm²) conductor for Emergency (Essential) sense line, from panel to panel.

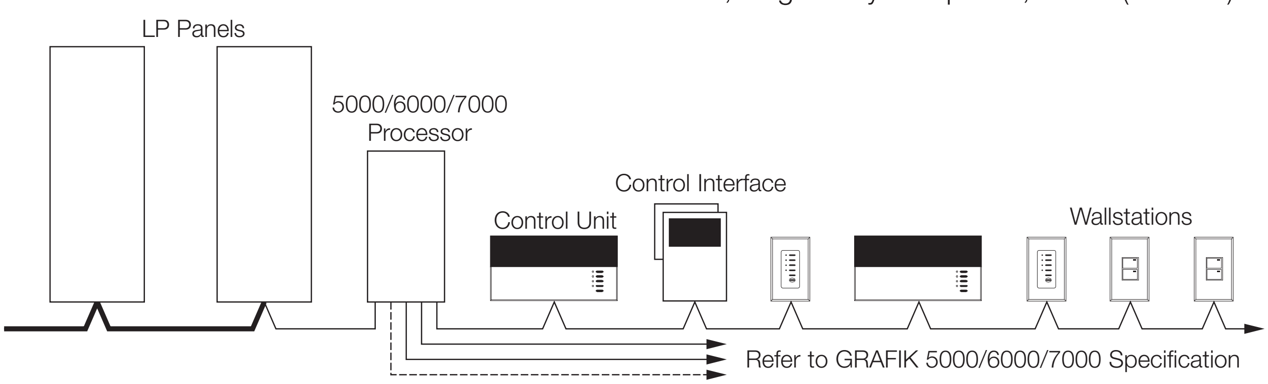
Total length of Control Link may be no more than 2,000 ft. (610 m).
Approved low-voltage cable is available from Lutron,[1] Belden, and Liberty. These are approved with #22 AWG data link wires.



GRAFIK 5000™/6000®/7000® System

Class 2 (PELV) wiring link requires:
Two #12 AWG (2.5 mm²) conductors for control power.
One twisted, shielded pair of #18 AWG (1.0 mm²) for data link.
One #18 AWG (1.0 mm²) conductor for emergency (essential) sense line, from panel to panel.

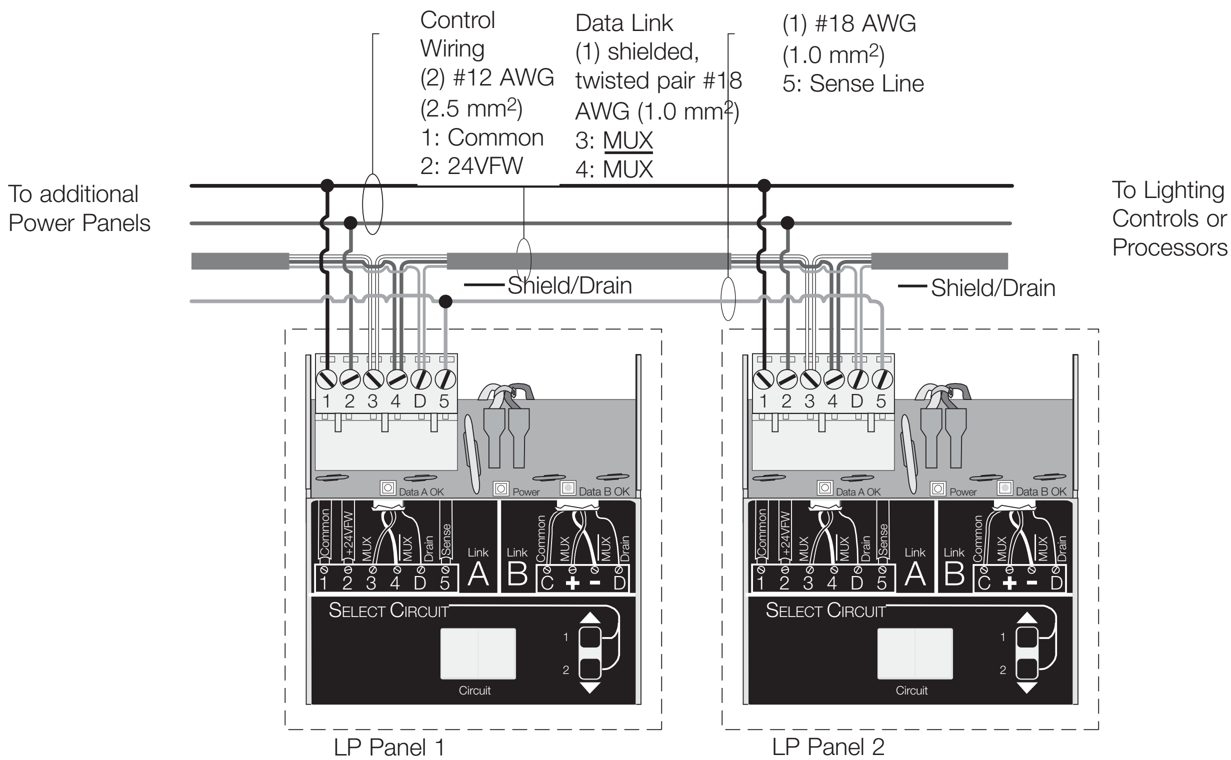
Total length of Control Link may be no more than 2,000 ft. (600 m).
If MUX-RPTR interface and GRX-CBL-46L cable[1] is used, length may be up to 4,000 ft. (1200 m).



[1] GRX-CBL-46L Class 2 (PELV) wiring cable is available from Lutron and contains:
Two #12 AWG (2.5 mm²) conductors for control power.
One twisted, shielded pair of #22 AWG (0.625 mm²) for data link.
One #18 AWG (1.0 mm²) conductor for emergency (essential) sense line.

Job Name:	Model Numbers:
Job Number:	

Class 2 (PELV) Panel-to-Panel Wiring (All Models)

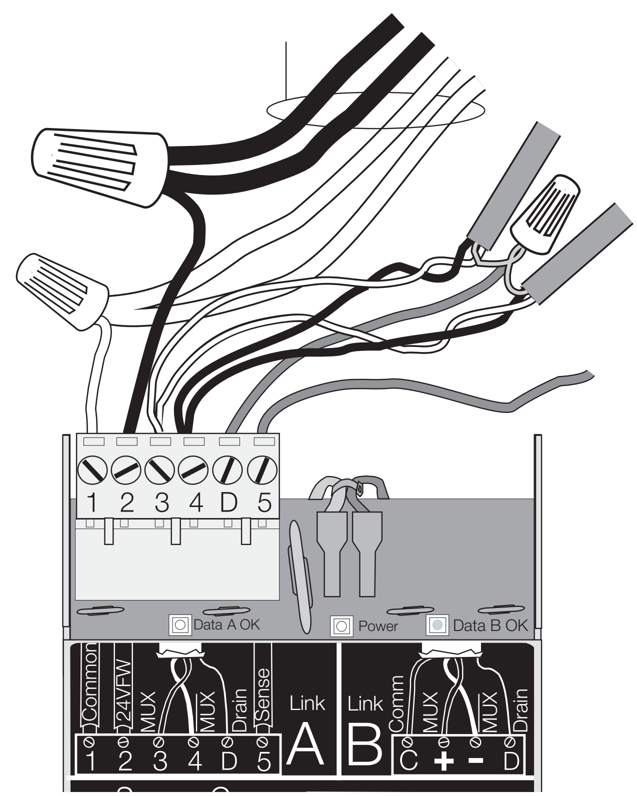


Notes:

- Emergency Power: The additional #18 AWG (1.0 mm^2) wire is a “sense” line from terminal 5 of another Panel. This sense line allows an Emergency (Essential) Lighting Panel to “sense” when Normal (Non-Essential) power is lost. If more than one Emergency Lighting Panel needs to sense from a specific Normal Panel, a dedicated wire between each pair of Normal (Non-Essential) and Emergency (Essential) panels may be required.
- Shield/Drain: Connect shielding as shown. Do not connect to Ground (Earth) or circuit board of Circuit Selector. Connect the bare drain wires and cut off the outside shield.

Class 2 (PELV) Terminal Connections

Each low-voltage Class 2 (PELV) terminal can accept only two #18 AWG (1.0 mm^2) wires. Two #12 AWG (2.5 mm^2) conductors won't fit. Connect as shown using appropriate wire connectors.



Job Name:	Model Numbers:
Job Number:	

Options

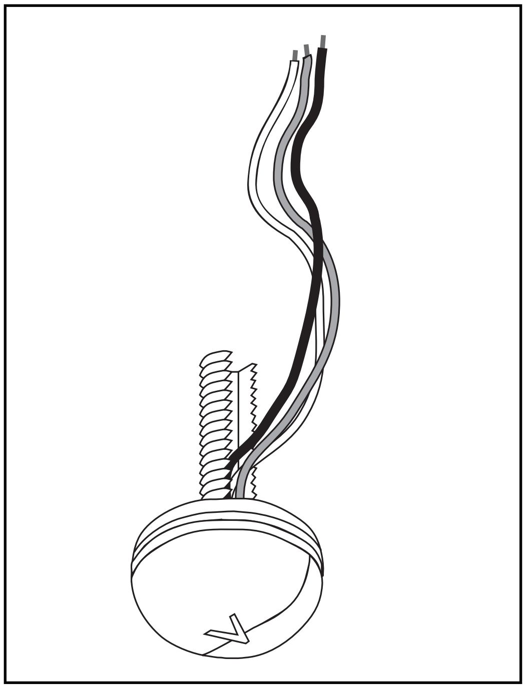
Consult Lutron for ordering information and model numbers. Dimensions and wiring may change based on options chosen.

Option	Description	Application
Double Lug Sets	Allows multiple Panels to be fed from the same feed.	A single feed and multiple LP Dimming Panels are required.
Branch Circuit Protection	Branch Circuit Breakers with higher AIC ratings than those on standard Panels. Panels can also have Branch Circuit Breakers with special ratings such as: • GFI (Ground Fault Interrupt) • ELB (Earth Leakage Breaker) • RCD (Residual Circuit Device).	
Lutron Ten Volt Module (TVM)	Allows Panels to operate fluorescent ballasts that meet IEC 929 standards for 0-10V control including: • Lutron's TVE ballasts • 0-10 V neon • PWM fluorescent • Tridonic DSI (Digital Serial Interface). The TVM can sink or source 50 mA (typically 25-50 ballasts) on each circuit.	Jobs with fluorescent ballasts that require 0-10 V, PWM, or DSI control.
2Link™	• Allows a DMX512 theatrical console to operate Dimming Panels' load circuits. • Allows a GRAFIK Eye® 4000 Series to handle 128 zone (two links of 64 zones). The two links are independent and do not communicate. Contact Lutron for further details.	• Control of architectural lighting from a DMX512 theatrical console is required. • A mix of architectural and theatrical lighting exists on the job.

Tridonic is a registered trademark of Zumtobel AG.

Job Name:	Model Numbers:
Job Number:	

Fixture Mountable Daylight Sensor



This daylight sensor is designed specifically to work with Lutron's Lighting Control Systems to implement daylight harvesting. It allows the Lighting Control System to automatically dim the lights when the available daylight is high, and brighten the lights when the available daylight is low, in order to maintain a specific light level in the space.

Features

- Meets IEC 801-2. Tested to withstand 15kV electrostatic discharge without damage or memory loss.
- Photopic response matches human eye.
- Constructed of Flame retardant material with UL94 HB rating.
- Mounts easily on any ceiling tile or fixture with 3/8 in. (10mm) diameter hole.
- Threaded mounting stud (may be shortened for applications with limited fixture height).
- Calibrated for daylight sensitivity through the Lighting Control System to which it is attached.
- Designed to replace the MW-PS in any application.

Job Name:	Model Numbers:	
Job Number:		

Specifications

Standards

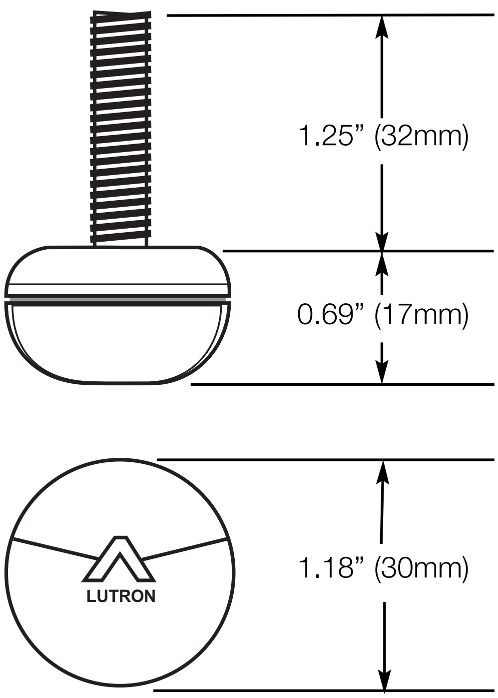
- Designed for Class 2 operation only. Voltages do not exceed 35VDC. Complies with requirements of NFPA 70, of the National Electric Code (NEC)
- Follow all applicable national and/or local wiring regulations when installing this sensor
- Designed to give a linear response to changes in viewed light level
- For use with Lutron products only

Power

- Operating Voltage: Low-voltage Class 2, 15VDC
- Analog Signal: 0 - 500uA

Environment

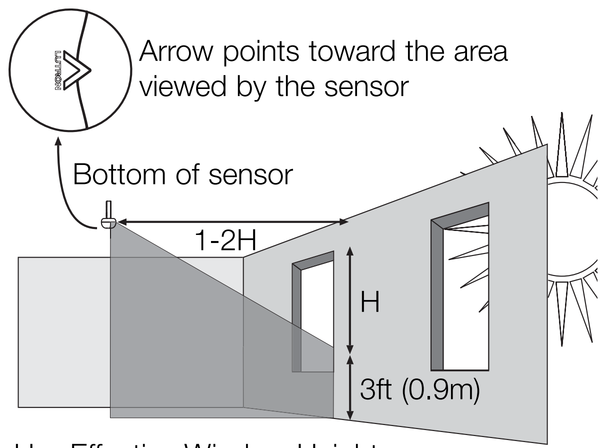
- Temperature: 32-113°F (0-45°C)
- Relative humidity: less than 90% non-condensing



Dimensions

Sensor lead length = 4” (101mm) minimum beyond threaded stud.
Total wire length from sensor to device must not exceed 200 ft (61m).
Threaded Stud Diameter = 3/8” (9.5mm) maximum.
Use 3/8-16 wing nut (provided) for mounting.

Job Name:	Model Numbers:
Job Number:	

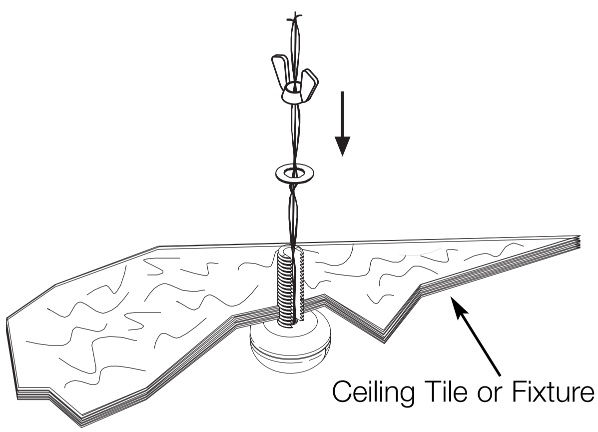


H = Effective Window Height

Mounting

Determine the proper location of the Daylight Sensor using the adjacent diagrams.

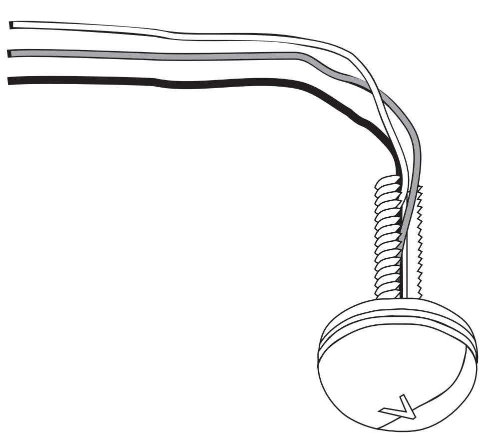
- The arrow on the Daylight Sensor defines the viewing direction
- Place the daylight sensor so its viewing area is centered upon the nearest window at a distance of between 1-2 H from the window
- The effective window height, H, starts 3 feet up from the floor or at the windowsill, whichever is higher, and ends at the top of the window.
- Ensure that the view of the Daylight Sensor is not obstructed
- Do not position the Daylight Sensor in the well of a skylight or above indirect lighting fixtures



Mount the Daylight Sensor

- Drill a 3/8 in. (10mm) diameter hole in the ceiling tile or indirect fixture mounting surface
- Thread the wires up through the hole
- Install the Daylight Sensor into the hole
- Secure the Daylight Sensor with the mounting hardware provided (hand tighten only).

Note - If the stem of the Daylight Sensor must be shortened due to its location (for instance, in a pendant fixture) this should be done prior to wiring.



Wiring

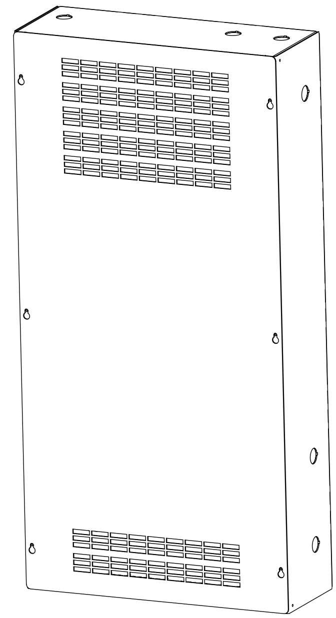
- Wire color designations:

  Yellow = Daylight
  Black = Common
  Red = 15VDC

To a Lighting Control System

- Make sure that the supply breaker to the control system is OFF
- Connect the three conductors to the appropriate terminals of the lighting control system

Light Management Hub



Description

The *Quantum* light management hub provides a centralized connection point for Lutron EcoSystem® digital ballast modules, Lutron power panels, GRAFIK Eye® QS, and Sivoia® QS shades.

Features

- Designed to control, manage, and monitor *EcoSystem* lighting, Lutron power panels, *GRAFIK Eye* QS, and *Sivoia* QS shade systems in a building or whole campus.
- Supports both astronomic and time-of-day events to automatically control the lights and shades in the system.
- Simple reconfiguration of a space without rewiring.
- Individually control, monitor, and adjust any light or shade in a space.
- *GRAFIK Eye* QS control links are topology-free.
- Accepts one normally closed (NC) emergency input per *Quantum* bus supply.
- *EcoSystem* bus may be wired NEC® Class 1 or PELV (Class 2: USA).

Panel Capabilities

- Supports up to 8 *EcoSystem* loops, (4 *Quantum* bus supplies)
- Each loop can have a combination of 64 ballasts and ballast modules, plus a maximum of 16 daylight sensors and 32 occupant sensors.
- Each *Quantum* bus supply has one normally closed emergency input.
- Supports up to 2 *Quantum* processors with 2 links each that can be individually configured as:
  - *EcoSystem* bus supply
  - Lutron power panels
  - *GRAFIK Eye* QS
  - *Sivoia* QS shades

Job Name:	Model Numbers:
Job Number:	

Specifications

Power

- Input voltage: 120 V∼, normal/emergency feeder.
  50 / 60 Hz 15 A
- Output: *EcoSystem* - 18 V⎓ 250 mA per loop
  Processor - 24 V⎓ 1 A per link

Physical Design

- Enclosure: NEMA Type 1, IP-20 protection
  16 U.S. gauge steel
- Weight: 45 pounds (20.4 kg)

Mounting

- Surface mount only

Environment

- For indoor use only
- 32 - 104 ºF (0 - 40 ºC)
- Relative humidity less than 90% non-condensing

Job Name:

Job Number:

Model Numbers:

How to Build a Model Number

Example

QP2 - 2P8CSE - 120

- QP2: Prefix
- 2P: Number of Processors
- 8C: Number of Loops
- SE: Switch Type
- 120: Voltage

Prefix
QP2 = *Quantum* Processor

Number of Processors
0P = 0 *Quantum* processors
1P = 1 *Quantum* processor
2P = 2 *Quantum* processors

Number of Loops
0C = 0 EcoSystem® loops
2C = 2 *EcoSystem* loops
4C = 4 *EcoSystem* loops
6C = 6 *EcoSystem* loops
8C = 8 *EcoSystem* loops

Switch Type
SE = Ethernet 5-port

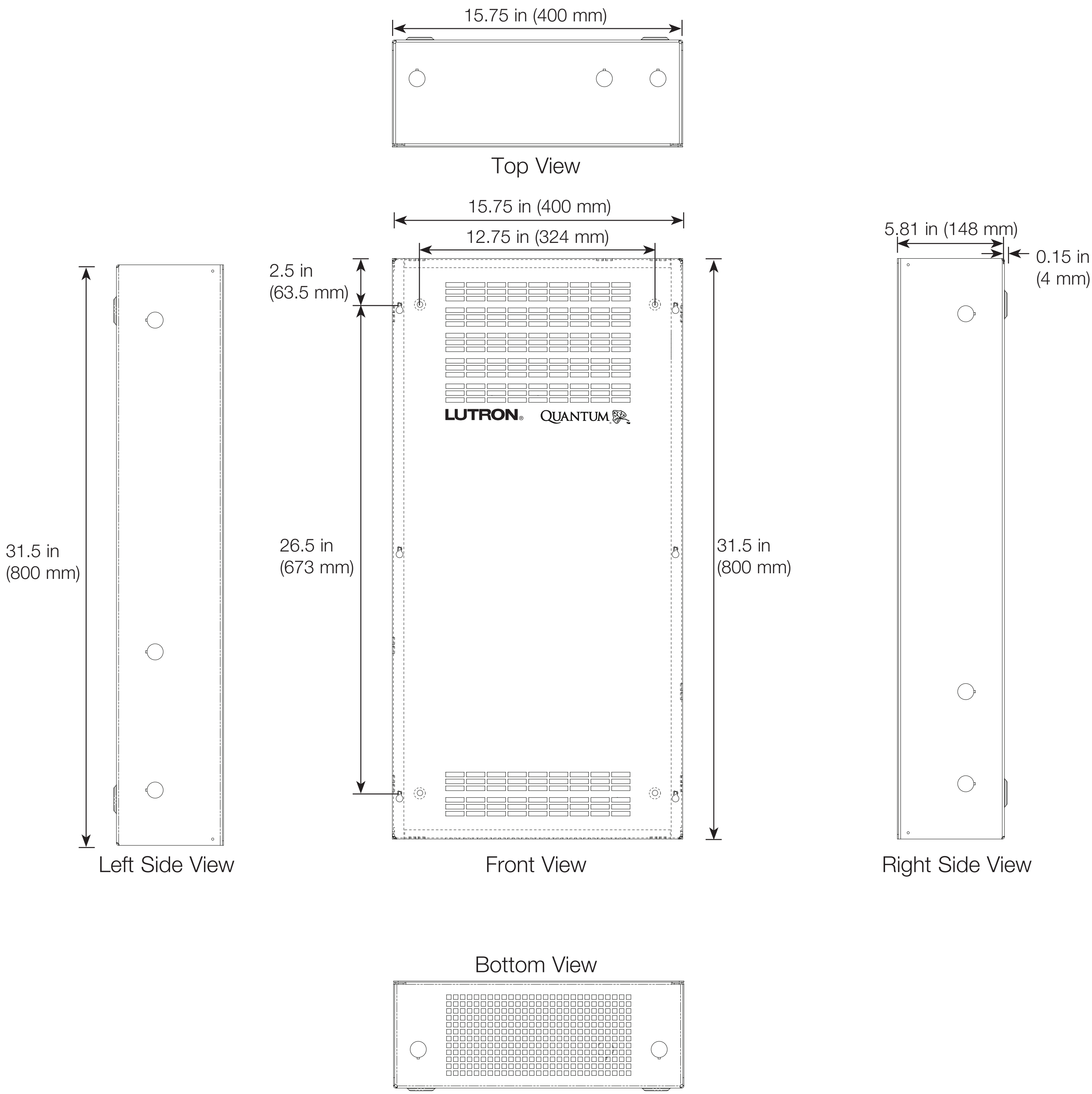
Voltage
120 for 120 V~

Available Model Numbers

Contact Lutron for options not listed below.

QP2-0P0CSE-120 (for rough-in use)
QP2-1P0CSE-120
QP2-1P2CSE-120
QP2-1P4CSE-120
QP2-1P6CSE-120
QP2-1P8CSE-120
QP2-2P0CSE-120
QP2-2P2CSE-120
QP2-2P4CSE-120
QP2-2P6CSE-120
QP2-2P8CSE-120

Dimensions



Job Name:

Job Number:

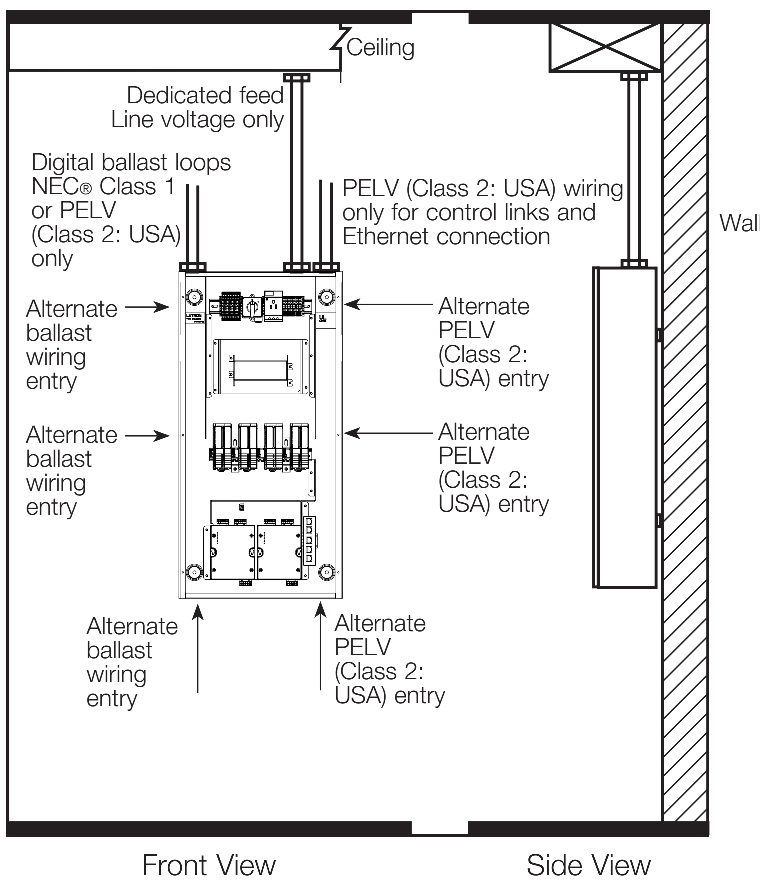
Model Numbers:

Mounting and Conduit Entry

- Surface mount indoors.
- Panel generates heat. Mount only where temperature will be 0 - 40 °C (32 - 104 °F).
- This equipment is air-cooled. Do not block vents or warranty will be void. A minimum of 12 in (305 mm) of unobstructed space is required in front of and below the panel for ventilation.
- Water damages equipment. Mount in a location where the panel and processors will not get wet. Mount within 7° of true vertical.
- Digital ballast wiring can be Class 1 or Class 2; always keep Class 1 and Class 2 wiring separate, and follow all applicable local and national electric codes.
- Reinforce wall structure for weight and local codes.

Panel	Maximum BTUs/Hour	Weight (without packaging)
All models	220	40 lb (18 kg)

- Mount panels so line (mains) voltage wiring is at least 6 feet (1.8 m) from sound or electric equipment and wiring.

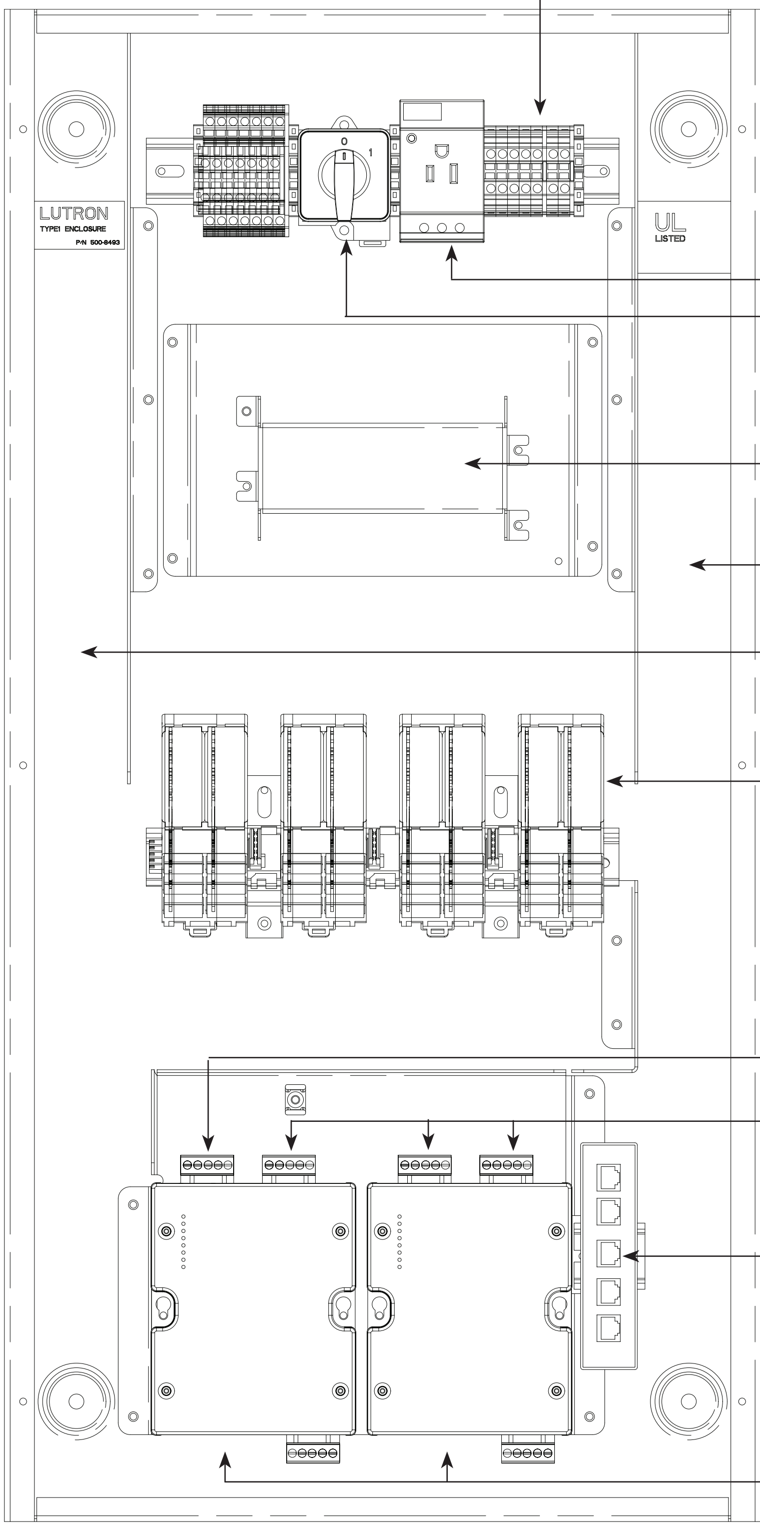


Job Name:

Job Number:

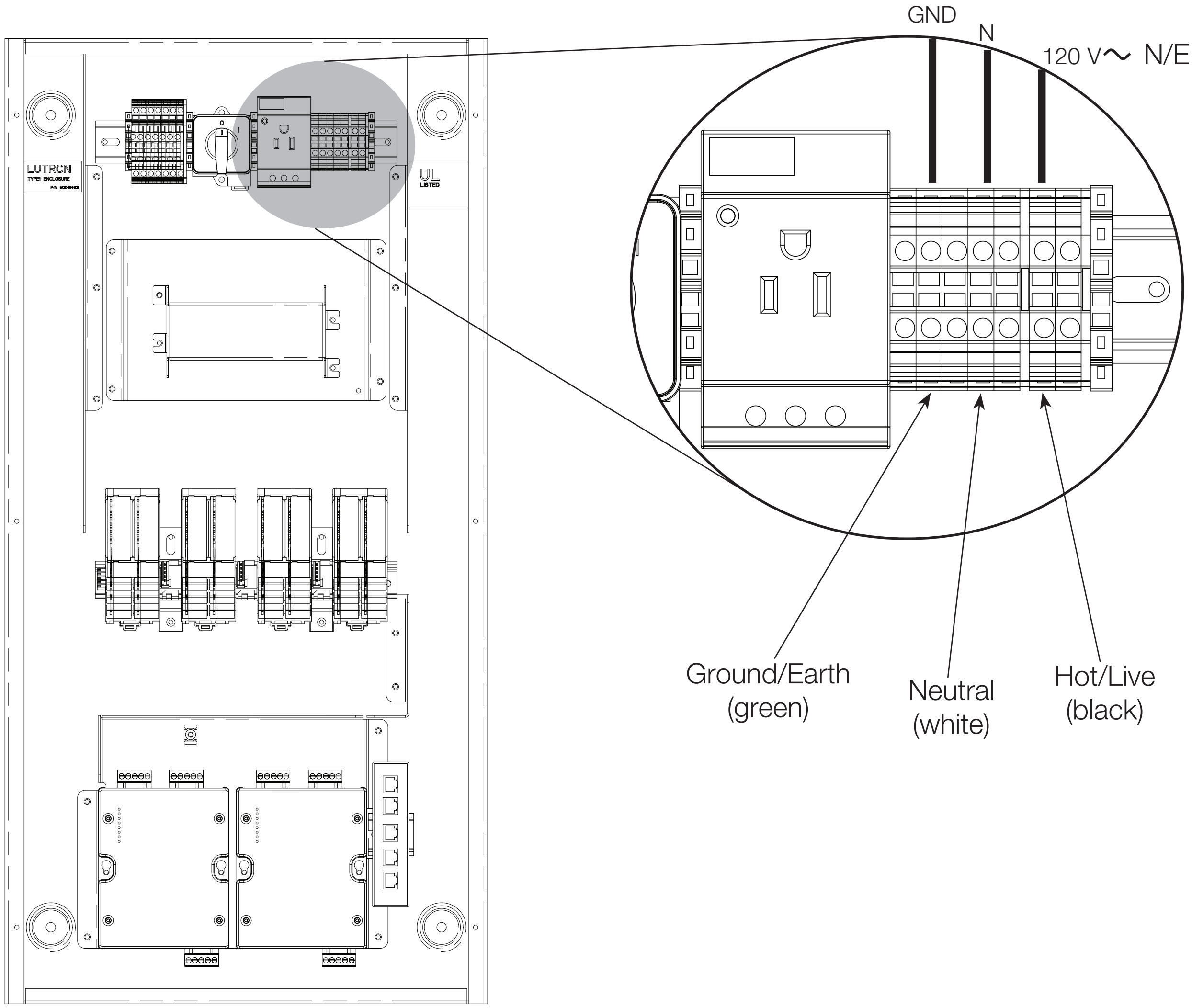
Model Numbers:

Panel Overview



Job Name:	Model Numbers:
Job Number:	

Line Voltage Wiring



Notes

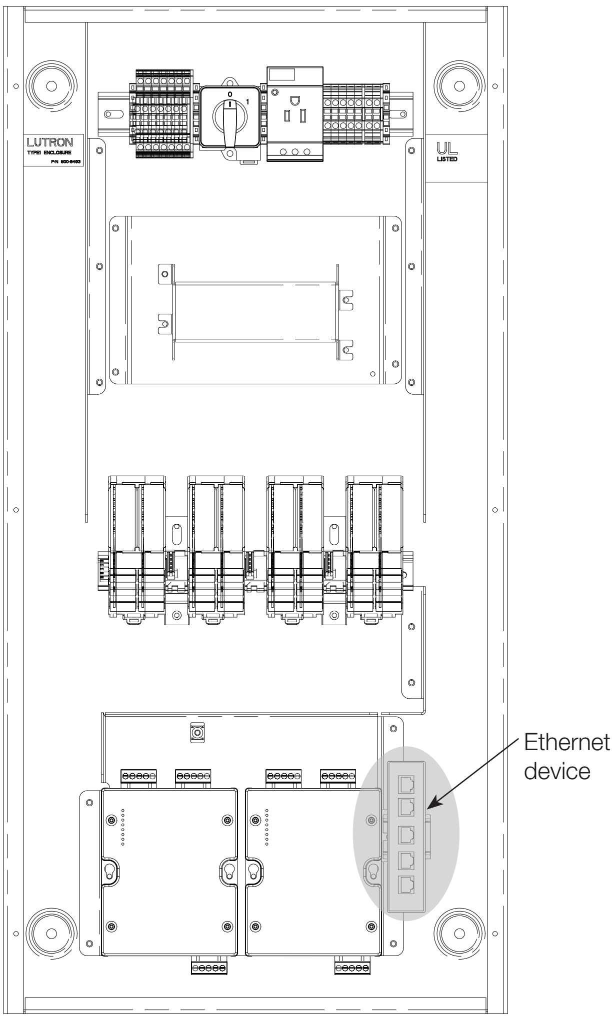
- Line voltage must enter panel from top right of panel
- Run a dedicated 120 V~ normal/emergency feed
- Lutron recommends that no more than four Light Management Hubs are powered by a single derated 20 A circuit
- Run wiring so line (mains) Class 1 voltage is separate from PELV (Class 2: USA) wiring

Job Name:

Job Number:

Model Numbers:

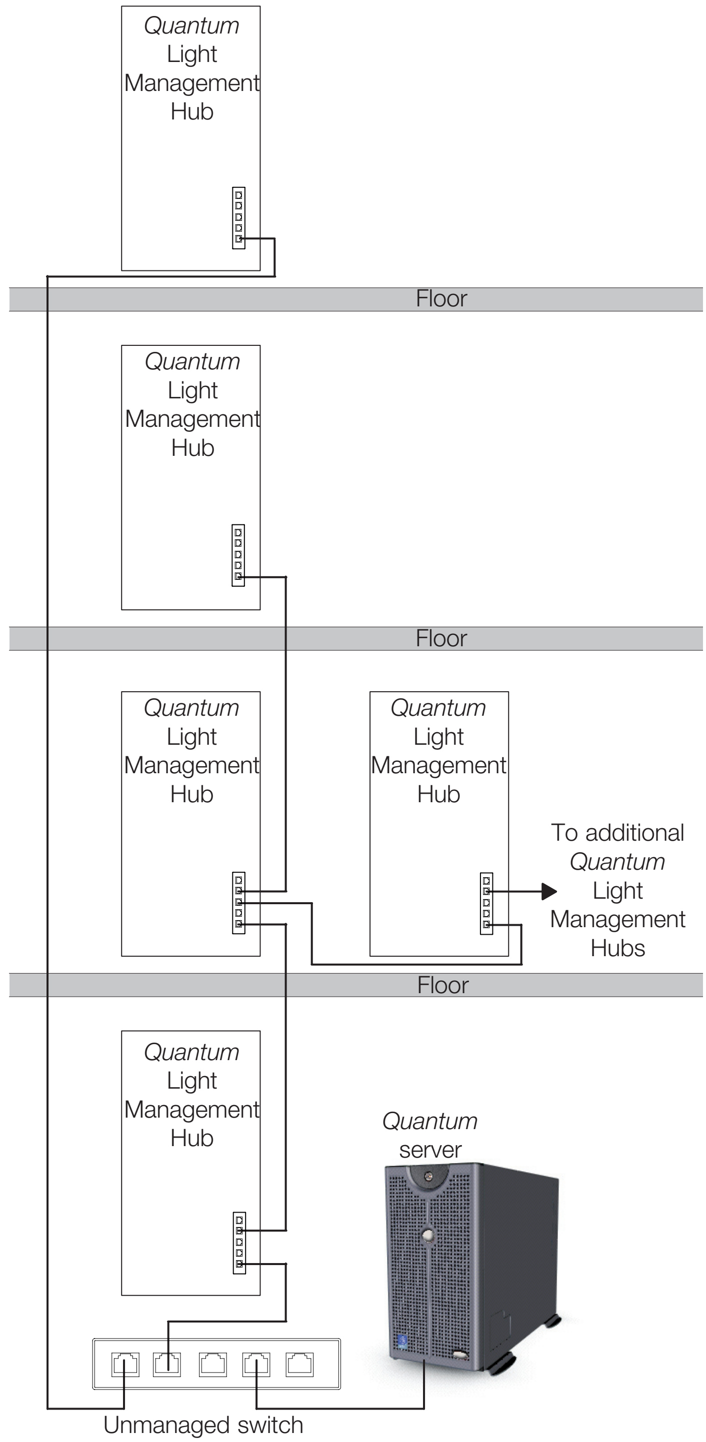
Quantum Inter-Processor Link Wiring



Notes

- The inter-processor wiring is considered PELV (Class 2: USA); do not run in the same conduit as line (mains) voltage wiring.
- Wiring distance for any single link segment is 330 ft (100 m) max; use Lutron-provided Ethernet switches for longer distances.
- Processors cannot be more than 6 "hops" from the server.
- Processors communicate over the interprocessor link using multicast UDP; a dedicated network must be used for the lighting control system.

Example of Inter-Processor Wiring: Riser Diagram

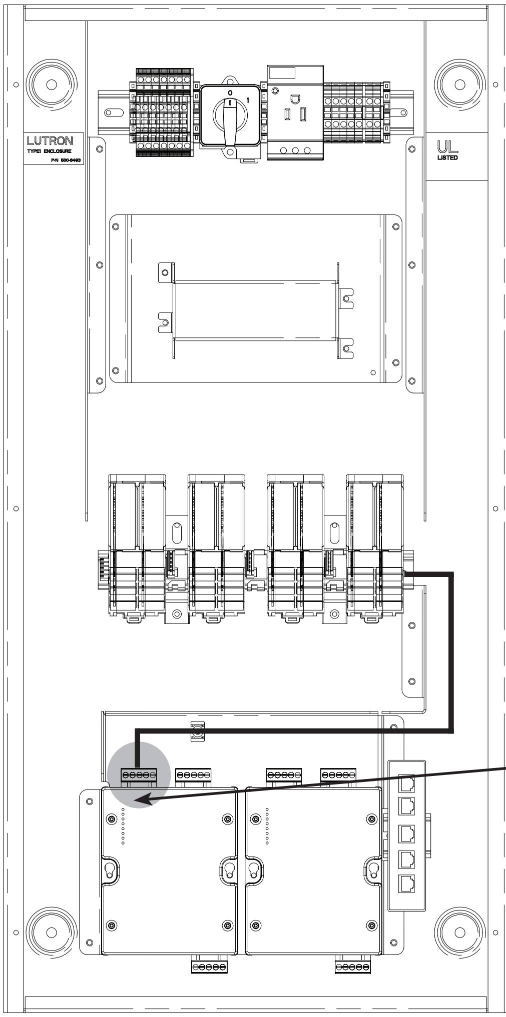


Job Name:

Job Number:

Model Numbers:

Dedicated *Quantum* Bus Supply Link



QP2-2P8CSE-120 shown

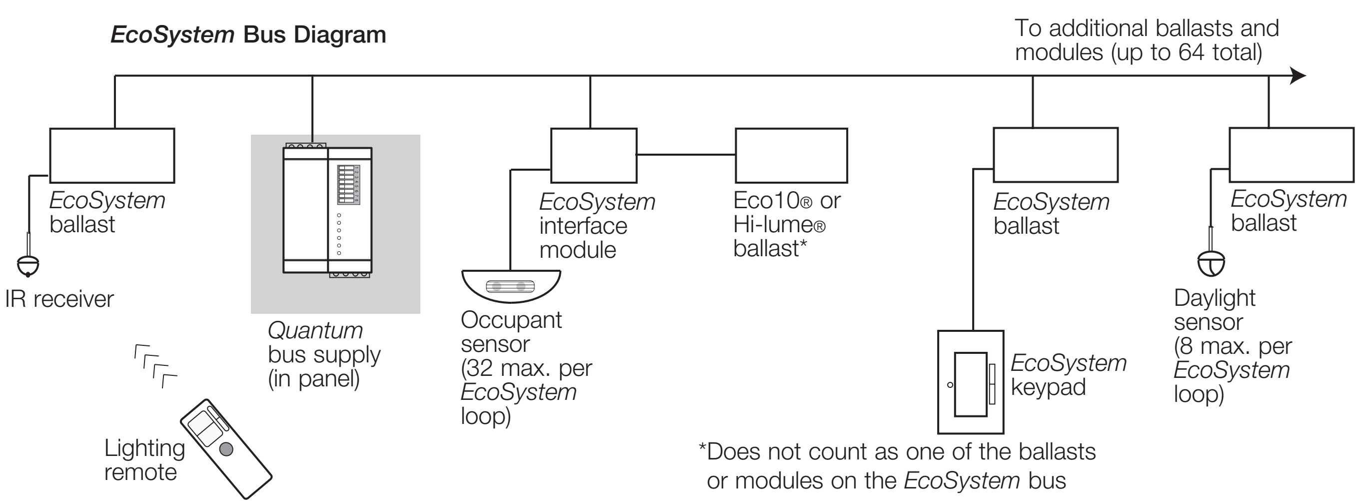
Notes

- EcoSystem® bus may be wired in accordance with NEC® Class 1 or PELV (Class 2: USA) practices
- Sensors and *Quantum* bus supply contact closures must be wired PELV (Class 2: USA)

Dedicated *Quantum* bus supply link; prewired by Lutron to *Quantum* Bus Supply located in panel

Note: If *Quantum* bus supply link is not required, this can be used as a configurable link. Power is not available from the *Quantum* panel on this link. An external power supply is required to power devices on this link.

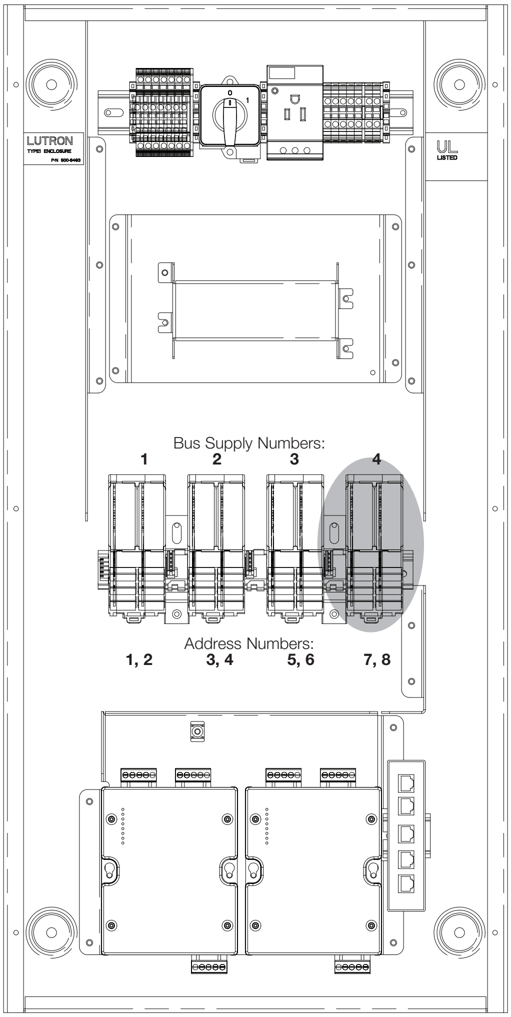
***EcoSystem* Bus Diagram**

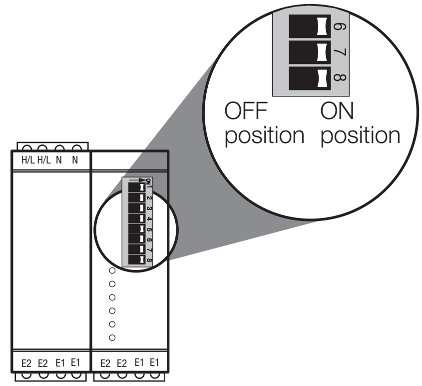


*Does not count as one of the ballasts or modules on the *EcoSystem* bus

Job Name:	Model Numbers:
Job Number:	

Quantum Bus Supply OPT Switches and LEDs





OPT Switches

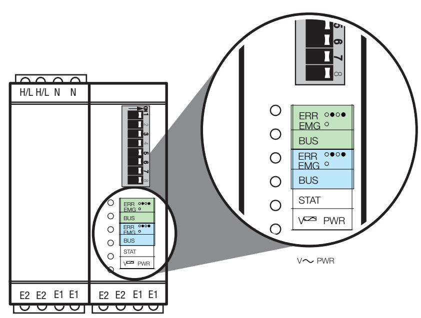
OPT switches are used to configure the Bus Supply. The tables below describe the options. To place an OPT switch in the OFF position, slide the switch to the left; away from the switch's number. Default is ON (next to the switch's number).

OPT Switch Functions

1, 2, 3	Addressing Set address for bus supply's loops (2 loops per bus supply)	Bus Supply 1 Addresses 1, 2	Bus Supply 2 Addresses 3, 4	Bus Supply 3 Addresses 5, 6	Bus Supply 4 Addresses 7, 8
4, 5	Green Loop (right side) Manual override levels	Lights stay at current level	Lights go to "high" level	Lights go to "low" level	Lights go to Off
6, 7	Blue Loop (left side) Manual Override levels	Lights stay at current level	Lights go to "high" level	Lights go to "low" level	Lights go to Off
8	Manual Override	Manual override levels will be used		Lights will go to the level specified by the system	

Status LEDs

LEDs on the *Quantum* Bus Supply indicate network status. The specific LEDs, color and flashing method is detailed below.



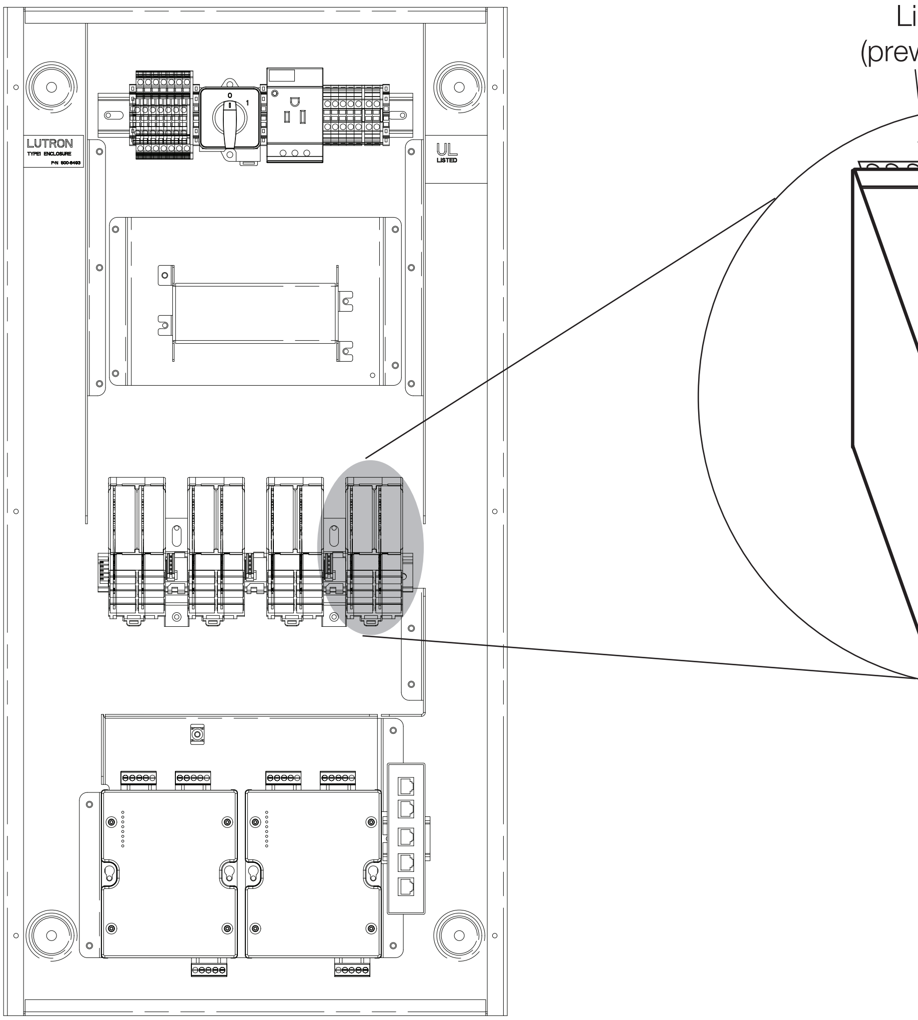
LED	Normal Operation	Problem Indicator	Probable Cause
V∼ PWR	On	Off	No Mains power
STAT	Steady flash	Off	No Mains power or unit fault
		On	Unit fault
BUS	Intermittent flash or Off	On	Unit fault
ERR / EMG	Off	On	Emergency contact closure is active
		Steady flash	Miswire detected on corresponding bus

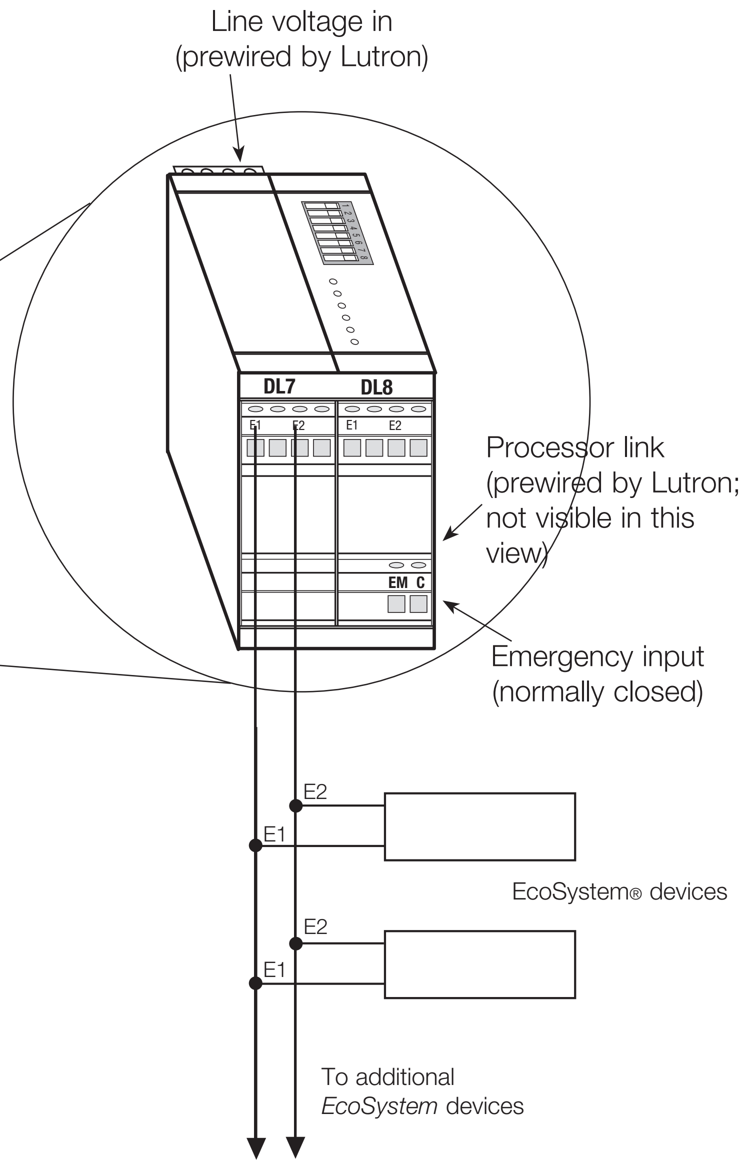
Job Name:

Job Number:

Model Numbers:

Quantum Bus Supply Wiring





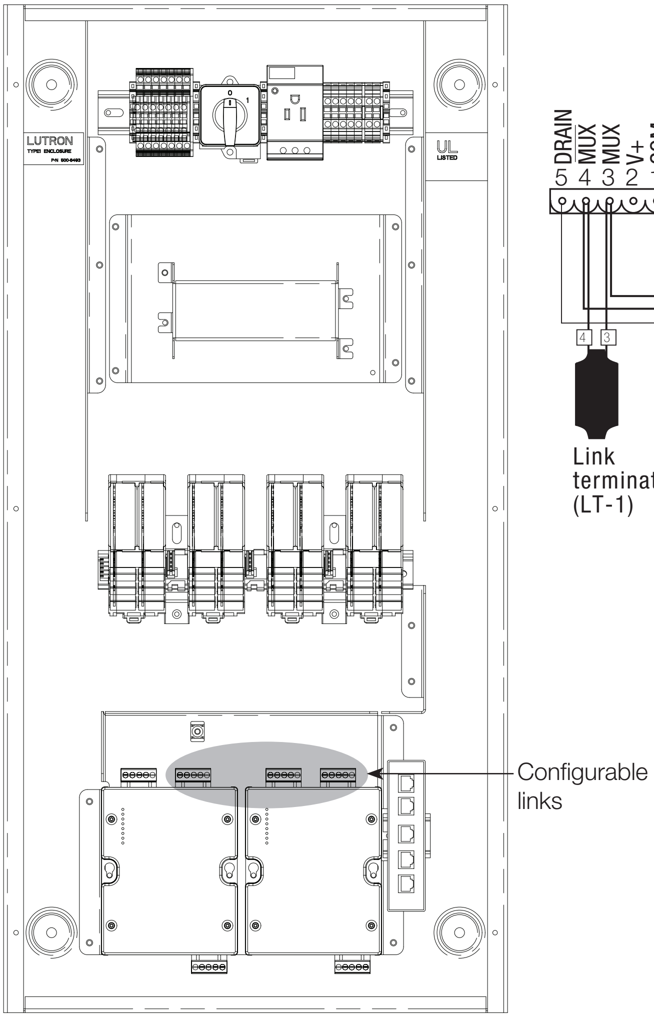
Wire Gauge	Max. Bus Length
12 AWG (2.5 mm2)	2200 ft (670 m)
14 AWG (2.5 mm2)	1400 ft (427 m)
16 AWG (1.5 mm2)	900 ft (274 m)
18 AWG (1.0 mm2)	570 ft (175 m)

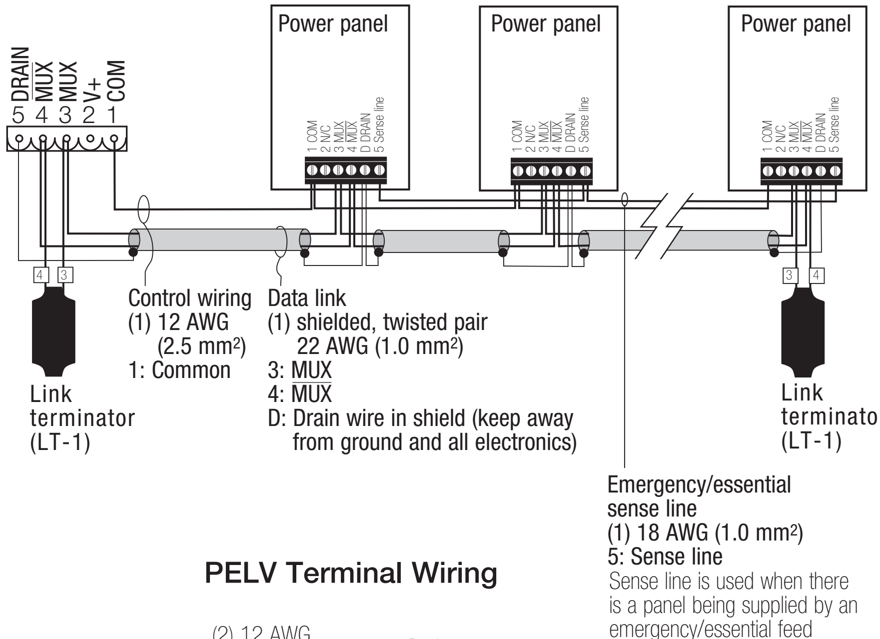
Notes

- E1 and E2 wires are not polarity sensitive.
- Hot/live, neutral, and ground wires are also connected to each lighting fixture; some may have an emergency feed.
- Free wire topology.

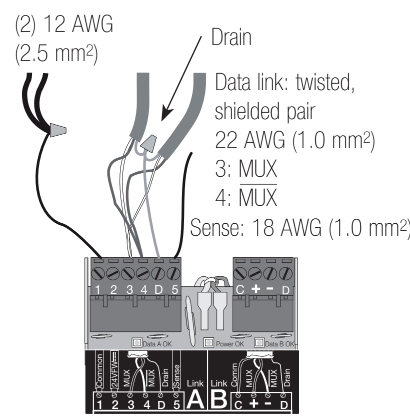
- If 15 V⎓ +/- 1 V⎓ is not present between E1 and E2, check the *Quantum* bus supply wiring. A short between E1 and E2 will cause the bus supply to stop providing voltage on the bus and will cause the ERR indicator to flash. Removing the short between E1 and E2 will allow the bus supply to operate properly.
- To wire the *Quantum* bus supply for PELV (Class 2: USA), the *Quantum* bus supply wires must be separated from the mains wiring. Otherwise, the PELV wiring must be classified as NEC® Class 1.

Configurable Link Wiring: Power Panel Link





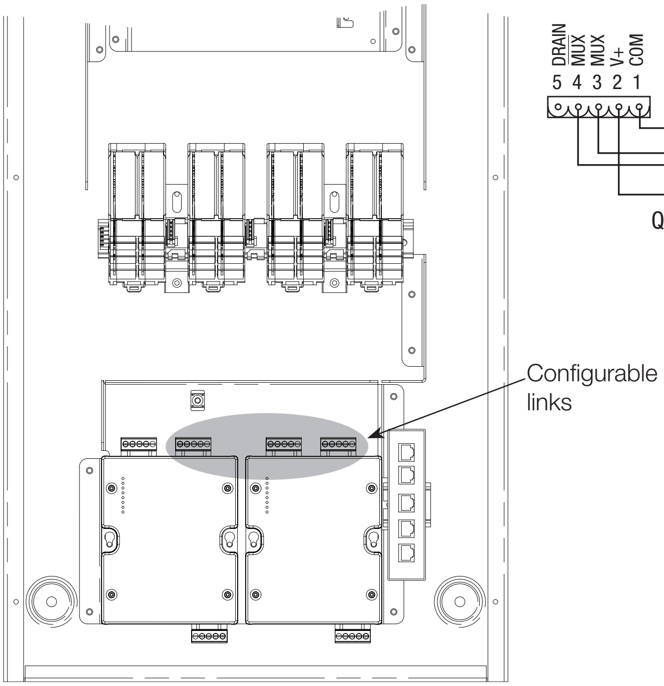
PELV Terminal Wiring



Notes

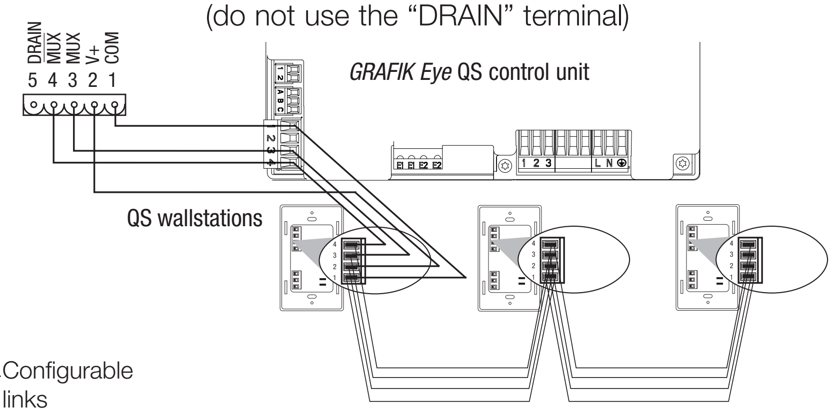
- Power panel link must be daisy-chained (no T-taps).
- Maximum of 32 power panels per link.
- It is not necessary to have the Quantum panel at the end of the link.
- The sense wire (terminal 5) is used whenever there is a panel being supplied by an emergency/essential feed; see power panel instructions for details.
- Each low-voltage PELV (Class 2: USA) terminal can accept only two 18 AWG (1.0 mm²) wires. Two 12 AWG (2.5 mm²) conductors will not fit. Connect as shown using appropriate wire connectors.
- Total length of control link may be no more than 2000 ft. (600 m). If MUX-RPTR interface and GRX-CBL-46L cable are used, length may be up to 4000 ft. (1200 m).
- GRX-CBL-46L PELV (Class 2: USA) wiring cable is available from Lutron and contains two 12 AWG (2.5 mm²) conductors for control power, one twisted, shielded pair of 22 AWG (1.0 mm²) for data link, and one 18 AWG (1.0 mm²) conductor for emergency (essential) sense line.

Configurable Link Wiring: GRAFIK Eye® QS and Sivoia® QS Shades



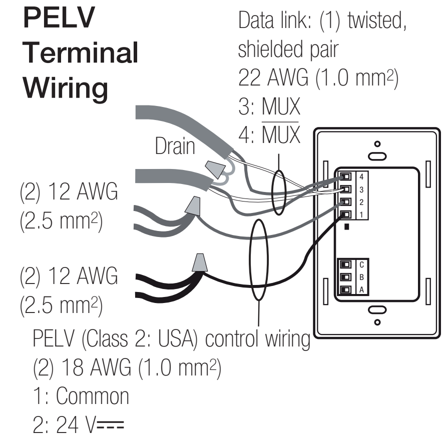
GRAFIK Eye QS Link

(do not use the "DRAIN" terminal)



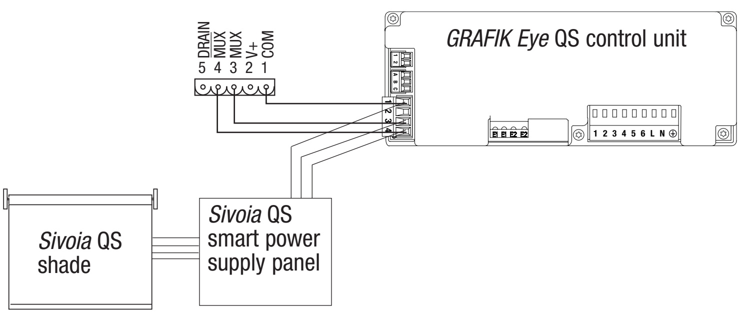
Note: Wallstations are powered directly from the lighting management panel (not the *GRAFIK Eye* QS control unit)

PELV Terminal Wiring



Sivoia QS Shade Link

(do not use the "DRAIN" terminal)



V+ and COM Wire Gauge	QS Link Max. Total Length
12 AWG (2.5 mm^2)	2000 ft (600 m)
16 AWG (1.5 mm^2)	800 ft (250 m)
18 AWG (1.0 mm^2)	500 ft (150 m)

Notes

- System communication uses PELV (Class 2: USA) low-voltage wiring.
- Follow all local and national electrical codes when installing PELV (Class 2: USA) wiring with line voltage/mains wiring.
- Each terminal accepts up to two 18 AWG (1.0 mm^2) wires.
- Total length of control link must not exceed 2000 ft (600 m); extend using up to 3 link repeaters (each adds 2000 ft/600 m).
- Make all connections in the control unit's wallbox.
- A *Quantum* QS link can have up to 512 switch legs (outputs), 99 devices, and 32 power draw units (see table on next page).
- Wiring can be T-tapped or daisy-chained.
- Wire sizes:
  - Two 12 AWG (2.5 mm^2) conductors for control power.
  - One twisted, shielded pair of 22 AWG (1.0 mm^2) for data link.
  - Cable is available from Lutron: GRX-CBL-46L.

QS Device Consumption Rules

The table below lists the devices available on the QS link. See below for each device's count toward the link maximums for zones, switch legs, and devices.

A *Quantum* QS link can have up to 512 switch legs (outputs), 99 devices, and 32 power draw units.

QS Device Description	Switch Leg Count	Device Count	Power Draw Units
3-zone GRAFIK Eye® QS	3	1	0
4-zone *GRAFIK Eye* QS	4	1	0
6-zone *GRAFIK Eye* QS	6	1	0
seeTouch® QS	0	1	1
Sivoia® QS Roller 64	1	1	0
Sivoia QS Roller 100	1	1	0
Sivoia QS Roller 225	1	1	0
6-zone *GRAFIK Eye* QS with EcoSystem®	up to 64	1	0
8-zone *GRAFIK Eye* QS with *EcoSystem*	up to 64	1	0
16-zone *GRAFIK Eye* QS with *EcoSystem*	up to 64	1	0
QS contact closure interface	up to 5	1	3
QS network interface for audio-visual integration	0	1	2
QS smart power panel	0	1	0

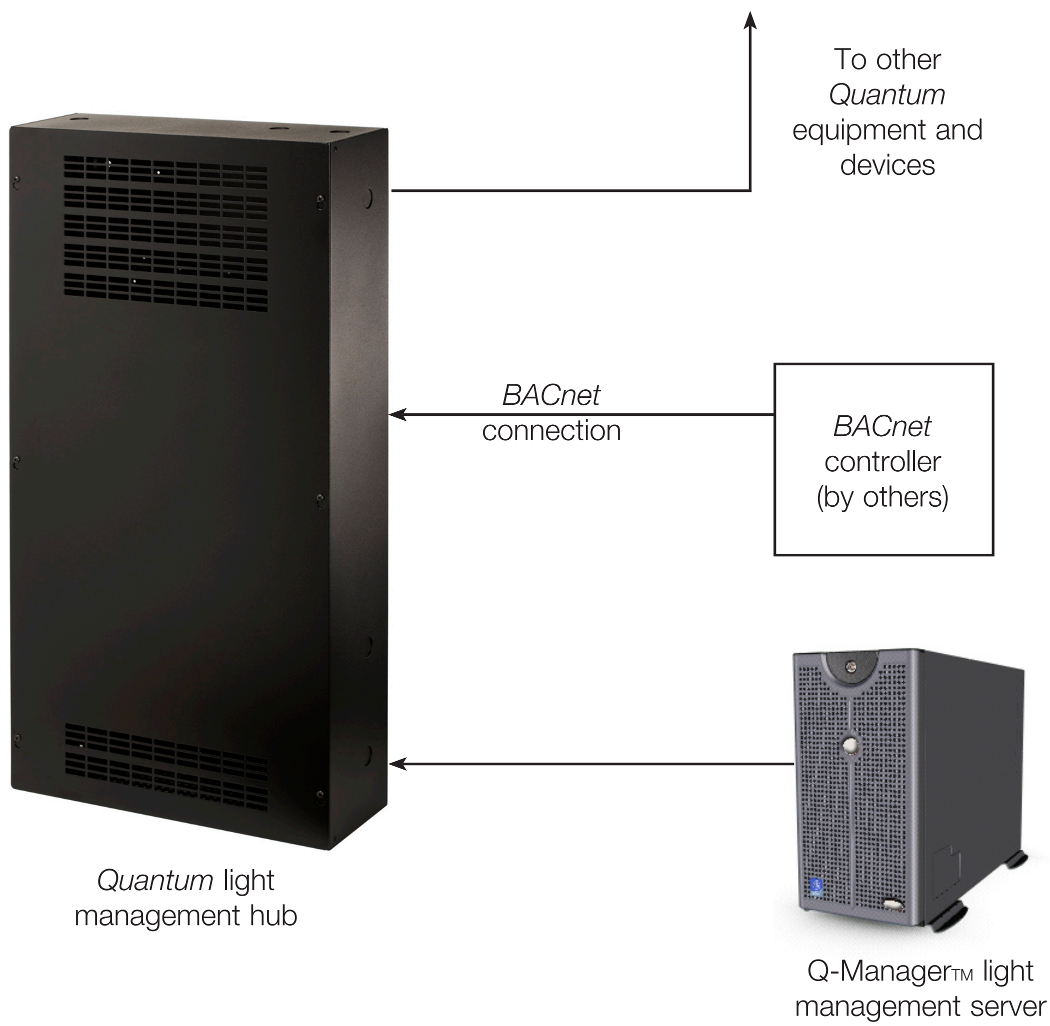
BACnet® Software License for *Quantum* Lights

Description

This license for *BACnet* software enables a building management system to control, monitor, and manage energy for lights in the *Quantum* system. This license must be activated by a Lutron Field Service Engineer. One license is required for each processor.

System Network Diagram

Note: Requires use of Q-Admin™ software package



Job Name:	Model Numbers:
Job Number:	

BACnet® Protocol Implementation Conformance Statement (PICS)

Date: January 20, 2010
Vendor Name: Lutron Electronics Co., Inc.
Product Name: *Quantum BACnet* Integration
Product Model Number: QSW-BAC-L-PP-A
Applications Software Version: 1.9
Firmware Revision: 1.9
BACnet® Protocol Revision: 4

Version History

Applications Software Versions: 1.6, 1.7, 1.8
Firmware Revisions: 1.6, 1.7, 1.8
BACnet® Protocol Revision: 2

Product Description

License for *Quantum* light management hub to enable *BACnet* IP Integration. Allows control of *Quantum* system components. *BACnet* IP is embedded in the *Quantum* light management hub.

BACnet Interoperability Building Blocks Supported (Annex K):

K.1.1 BIBB	Data Sharing	ReadProperty-B (DS-RP-B)
K.1.8 BIBB	Data Sharing	WriteProperty-B (DS-WP-B)
K.1.4 BIBB	Data Sharing	ReadPropertyMultiple-B (DS-RPM-B)
K.1.10 BIBB	Data Sharing	WritePropertyMultiple-B (DS-WPM-B)
K.1.12 BIBB	Data Sharing	DS-COV-B
K.5.2 BIBB	Device Management	DynamicDeviceBinding-B (DM-DDB-B)
K.5.6 BIBB	Device Management	DeviceCommunicationControl-B (DM-DCC-B)

***BACnet* Standardized Device Profile (Annex L):**

BACnet Application Specific Controller (B-ASC)

Segmentation Capability:

Segmented requests supported? **No.** Window Size: **n/a**
Segmented responses supported? **No.** Window Size: **n/a**

Non-Standard Application Services:

Non-standard application services are not supported.

Standard Object Types Supported:

Device

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **None.**

Analog Value

1. Dynamically creatable using the *BACnet*® CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **Min, Max.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Binary Value

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Multi-State Value

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Data Link Layer Options:

BACnet IP

Device Address Binding:

Is static device binding supported? No.

Networking Options:

None

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

ANSI X3.4

If this product is a communication gateway, describe the types of non-*BACnet* equipment/network(s) that the gateway supports:

The device is a communication gateway between the *BACnet* protocol and EcoSystem® ballasts and modules in Lutron's *Quantum* light control system.

Job Name:	Model Numbers:	
Job Number:		

BACnet® Objects												
Area Device	Read	Write	Type	Instance	{Area Name}	COV Supported	Units	Min PV	Max PV	Active Text	Inactive Text	State Text
Lighting Level: Allows you to set all the lights in an area to a level.	X1	X	AV	2	Lighting Level		%	0	100 101=Mixed On			
Lighting State: Control/Monitor the lights in an area. On indicates that there is at least one light on in the area. Off indicates that all lights are off in the area.	X	X	BV	3	Lighting State	X		0	1	On (1)	Off (0)	
Lighting Scene: Control/Monitor the lighting scenes in an area.	X	X	MSV	4	Lighting Scene			1	Total Scenes +1			{Scene Name}
Daylighting Enabled: Control/Monitor the daylighting function in the area.	X	X	BV	5	Daylighting Enabled			0	1	Enabled (1)	Disabled (0)	
Daylighting Level: Configuration parameter to adjust the daylighting target level in the area.	X	X	AV	6	Daylighting Amount		none	0	90			
Permanently Disable Occupancy: Prevent any occupancy events or occupancy mode changes from having any effect.	X	X	BV	7	Permanently Disable Occupancy			0	1	True (1)	False (0)	
Occupancy State: Indicates if an area is currently occupied.	X		MSV	8	Occupancy State	X		1	4			1 = Unoccupied, 2 = Occupied, 3 = After Hours, 4 = Unknown
Unoccupied Level: Configuration parameter to adjust the level the lights in an area should go to when it becomes unoccupied.	X	X	AV	9	Unoccupied Level		%	0	100 101=Unaffected 102=Daylighting			
Occupied Level: Configuration parameter to adjust the level the lights in an area should go to when it becomes occupied.	X	X	AV	10	Occupied Level		%	0	100 101=Unaffected 102=Daylighting			
Additional Occupied Timeout: Configuration parameter to adjust the occupancy timeout.	X	X	AV	11	Additional Occupied Timeout		min	0	42			
(continued on the next page)												

BACnet® Objects												
Area Device	**Read**	**Write**	**Type**	**Instance**	**{Area Name}**	**COV Supported**	**Units**	**Min PV**	**Max PV**	**Active Text**	**Inactive Text**	**State Text**
Loadshed Allowed: Indicates if an area is allowed to load shed.	X	X[1]	BV	12	Loadshed Allowed			0	1	Yes (1)	No (0)	
Loadshed Goal: Indicates how much load an area will shed when the load shed function is enabled.	X	X[1]	AV	13	Loadshed Goal		none	0	90			
Occupancy Mode: Control/ monitor the occupancy mode in an area	X	X	MSV	14	Occupancy Mode			1	4			1 = Inactive, 2 = Occupancy & Vacancy, 3 = Vacancy, 4 = Not applicable
Number of Lamp Failures: Indicates the number of failed lamps in an area.	X		AV	15	Number of Lamp Failures	X	none	0	none			
Number of Devices Not Responding: Indicates the number of control devices not responding in an area.	X		AV	16	Number of Devices Not Responding	X	none	0	none			
Zone Level: Control/Monitor the level of individual lighting zones in an area.	X	X	AV	1000 - 1999	{ZoneName} Level		%	0	100 101=Unaffected 102=Daylighting			
System Device					**{System Name}**							
Master Loadshed Enabled: Control/Monitor the system-wide load shed function.	X	X	BV	2	Master Loadshed Enabled	X		0	1	Enabled (1)	Disabled (0)	
Timeclock Enabled: Control/ Monitor the state of each system timeclock.	X	X	BV	1000 - 1999	{TimeclockName} Enabled			0	1	Enabled (1)	Disabled (0)	

AV = Analog Value

BV = Binary Value

MSV = Multi-State Value

COV = Change of Value

PV = Present Value

{ } = Name specified in the system by Lutron

1 = Features only available in Quantum 1.7 or later.

2 = “Timeclock” will be prefixed if the name does not include the word “Timeclock”.

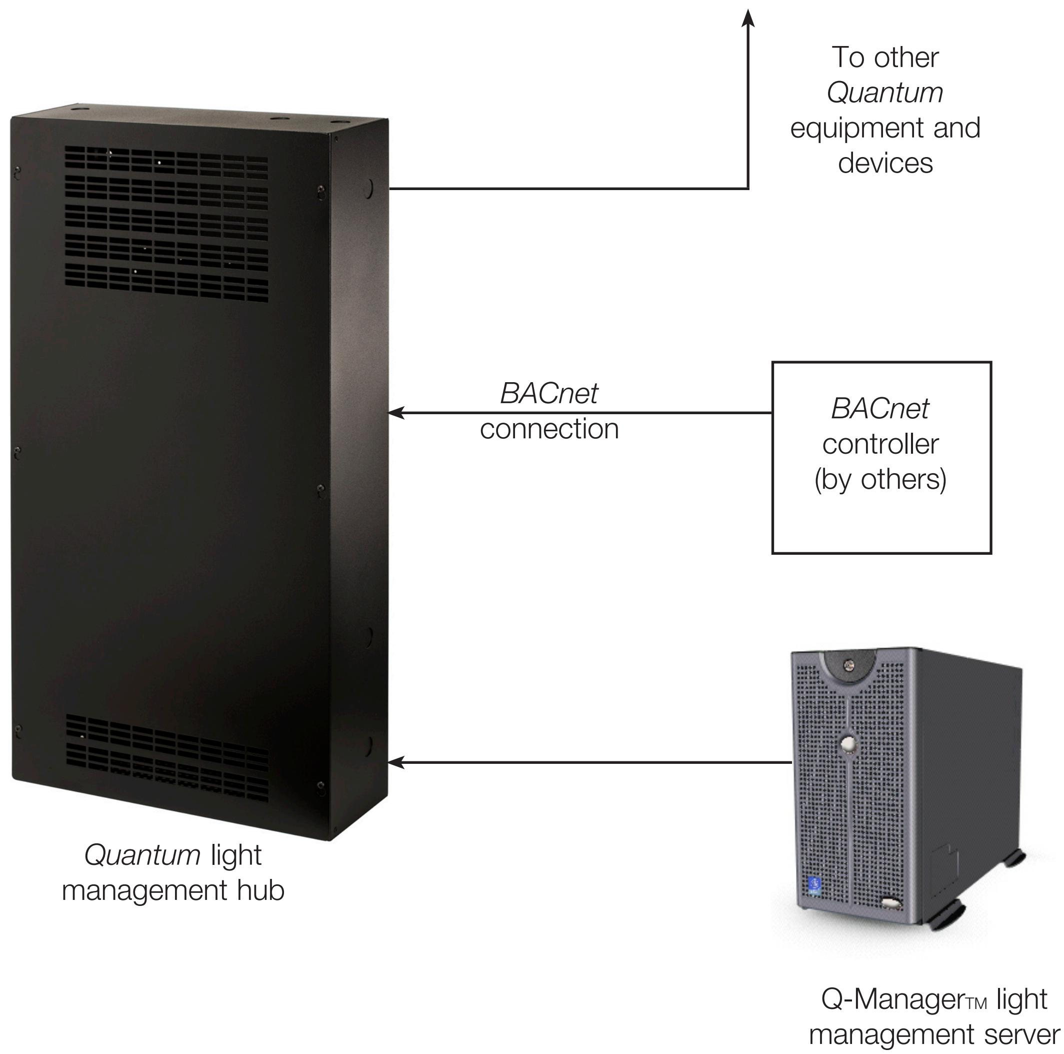
BACnet® Software License for *Quantum* Shades

Description

This license for *BACnet* software enables a building management system to control, monitor, and manage energy for shades in the *Quantum* system. This license must be activated by a Lutron Field Service Engineer. One license is required for each processor.

System Network Diagram

Note: Requires use of Q-Admin™ software package



BACnet® Protocol Implementation Conformance Statement (PICS)

Date: September 10, 2008
Vendor Name: Lutron Electronics Co., Inc.
Product Name: *Quantum BACnet* Integration
Product Model Number: QSW-BAC-L-PP-A
Applications Software Version: 1.9
Firmware Revision: 1.9
BACnet® Protocol Revision: 4

Version History

Applications Software Versions: 1.6, 1.7, 1.8
Firmware Revisions: 1.6, 1.7, 1.8
BACnet® Protocol Revision: 2

Product Description

License for *Quantum* light management hub to enable *BACnet* IP Integration. Allows control of *Quantum* system components. *BACnet* IP is embedded in the *Quantum* light management hub.

BACnet Interoperability Building Blocks Supported (Annex K):

K.1.1 BIBB	Data Sharing	ReadProperty-B (DS-RP-B)
K.1.8 BIBB	Data Sharing	WriteProperty-B (DS-WP-B)
K.1.4 BIBB	Data Sharing	ReadPropertyMultiple-B (DS-RPM-B)
K.1.10 BIBB	Data Sharing	WritePropertyMultiple-B (DS-WPM-B)
K.5.2 BIBB	Device Management	DynamicDeviceBinding-B (DM-DDB-B)
K.5.6 BIBB	Device Management	DeviceCommunicationControl-B (DM-DCC-B)

BACnet Standardized Device Profile (Annex L):

BACnet Application Specific Controller (B-ASC)

Segmentation Capability:

Segmented requests supported? **No.** Window Size: **n/a**
Segmented responses supported? **No.** Window Size: **n/a**

Non-Standard Application Services:

Non-standard application services are not supported.

Standard Object Types Supported:

Device

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **None.**

Job Name:
Model Numbers:
Job Number:

Analog Value

1. Dynamically creatable using the BACnet® CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **Min, Max.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Binary Value

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Multi-State Value

1. Dynamically creatable using *BACnet*'s CreateObject service? **No.**
2. Dynamically deletable using *BACnet*'s DeleteObject service? **No.**
3. List of optional properties supported: **None.**
4. List of all properties that are writable where not otherwise required by this standard: **None.**
5. List of proprietary properties: **None.**
6. List of any property value range restrictions: **See Table.**

Data Link Layer Options:

BACnet IP

Device Address Binding:

Is static device binding supported? No.

Networking Options:

None

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

ANSI X3.4

If this product is a communication gateway, describe the types of non-*BACnet* equipment/network(s) that the gateway supports:

The device is a communication gateway between the *BACnet* protocol and EcoSystem® ballasts and modules in Lutron's *Quantum* light control system.

Job Name:	Model Numbers:	
Job Number:		

BACnet® Objects												
Area Device	**Read**	**Write**	**Type**	**Instance**	**{Area Name}**	**COV Supported**	**Units**	**Min PV**	**Max PV**	**Active Text**	**Inactive Text**	**State Text**
Hyperion Enabled 1	X	X	BV	17	Hyperion Enabled			0	1	Enabled (1)	Disabled (0)	
Shade Group Level: Control/Monitor the position of a shade group in an area.	X	X	AV	2000-2999	{GroupName} Level		%	0	100 101=Mixed On 102=Unknown			
Shade Group Preset: Control/Monitor the preset positions for a shade group in an area.	X	X	MSV	3000-3999	{GroupName} Preset		--	1	34			{Preset Name}
System Device					**{System Name}**							
Master Hyperion Enabled 1	X	X	BV	3	Master Hyperion Enabled			0	1	Enabled	Disabled	

AV = Analog Value
BV = Binary Value
MSV = Multi-State Value
COV = Change of Value
PV = Present Value
{ } = Name specified in the system by Lutron

1 = Features only available in Quantum 1.7 or later.
2 = “Shade Group” will be prefixed if the name does not include the phrase “Shade Group”.

APPENDIX I.G: OFFICE LIGHTING ELECTRICAL DESIGN

PANELBOARD SCHEDULE

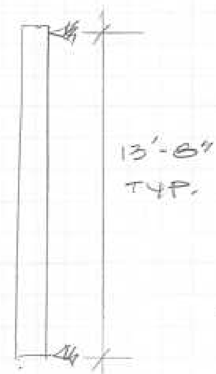
VOLTAGE: 480Y/277V,3PH,4W SIZE/TYPE BUS: 225A SIZE/TYPE MAIN: 225A/3P C/B	PANEL TAG: LP-8-1 PANEL LOCATION: 8th Floor Electrical (1) PANEL MOUNTING: SURFACE	MIN. C/B AIC: 10K OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	SW	2695	20A/1P	1	*			2	20A/1P	2268	S	Lighting
Lighting	SE	2895	20A/1P	3		*		4	20A/1P	2895	NW	Lighting
Lighting	N	2268	20A/1P	5			*	6	20A/1P	2695	NE	Lighting
SPARE	0	0	20A/1P	7	*			8	20A/1P	0	0	SPARE
SPARE		0	20A/1P	9		*		10	20A/1P	0		SPARE
SPARE		0	20A/1P	11			*	12	20A/1P	0		SPARE
SPACE		0	20A/1P	13	*			14	100A/3P	40000	Transformer	Subfeed
SPACE		0	20A/1P	15		*		16	100A/3P	40000		Subfeed
SPACE		0	20A/1P	17			*	18	100A/3P	40000		Subfeed
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	44.96	TOTAL DESIGN LOAD (KW)	162.86
CONNECTED LOAD (KW) - B Ph.	45.79	POWER FACTOR	0.99
CONNECTED LOAD (KW) - C Ph.	44.96	TOTAL DESIGN LOAD (AMPS)	197

APPENDIX I.H: STRUCTURAL MULLION CALCULATION

MULLION SIZING: SAMPLE
NY TIMES



bay width = 5'

max wind pressure = 52 psf @ TOP

$w = 5' \cdot 52 = 260$ plf

$M_{max} = qL^2/8 = (260)(13.75)^2/8\,(12) = 73734$ #·in

@ middle of mullion

$V_{max} = qL/2 = (260)(13.75)/2 = 1787.5$# @ supports

$\Delta_{max} = \frac{5qL^4}{384EI} = \frac{5(260)(13.75)^4(1728)}{384(10000)I} = 20.91/I$

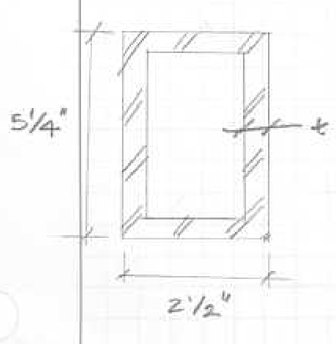
vs. Δ allow = $\frac{13.75 \cdot 12}{180} = 0.917"$; 20 mm = 0.787" ← controls

<u>bending</u>:

$\sigma_{bend} = \frac{Mc}{I} = \frac{M}{S} = 10005$ psi allowable

[69 N/mm² * 145 = 10005 psi]

$S_{req} \geq 73734/10005 = 7.37$ in³ (EXTERIOR MULLION DIMENSIONS KEPT THE SAME AS EXISTING)



$7.37 \leq \frac{\frac{1}{12}(2.5)(5.25)^3 - \frac{1}{12}(2.5-2t)(5.25-2t)^3}{5.25/2}$

$232.2 \leq 2.5(5.25)^3 - (2.5-2t)(5.25-2t)^3$

$129.6 \geq (2.5-2t)(5.25-2t)^3$

try t = ½" : 129.6 ≥ 115.1 <u>OK</u> check t = ½" shear :

$\sigma_{shear} = 5365$ psi

$\tau_{max} = \frac{3}{2}\frac{V}{A} \rightarrow A_{req'd} \geq \frac{3}{2}\cdot\frac{1788}{5365} = 0.50$ in²

$A_{prov} = 5.25(2.5) - (4.25)(1.5) = 6.75$ in² >> 0.50 in²

OK for shear

deflection :

$\Delta_{max} = 20.91/I \rightarrow I \geq \frac{20.91}{0.787''} = 26.6$ in⁴

$I_{prov} = \frac{1}{12}(2.5)(5.25)^3 - \frac{1}{12}(2.5 - 2(1/2))(5.25 - 2(1/2))^3$

$= 20.6$ in⁴ < 26.6 in⁴ NG → try 7/8" thickness

$I_{prov} = 27.5$ in⁴ > 26.6 in⁴ OK check t = 7/8"

bearing :

shear @ support = $V_{max} = 1788$#

bolt size required : $\sigma_{by} = 117$ N/mm² = 16965 psi

$16965 = \frac{V_{max}}{2t \cdot D_b} \rightarrow D_b \geq \frac{1788}{16965(2 \cdot 7/8)} = 0.0602''$

so, a standard 1/2" bolt would be sufficient for this load.

∴ USE A 5 1/4 × 2 1/2 × 7/8" MULLION WITHIN THE UNITIZED PANEL.

AT THE SPLIT MULLIONS BETWEEN PANELS, THE THICKNESS WILL LIKELY NEED TO INCREASE TO 1".

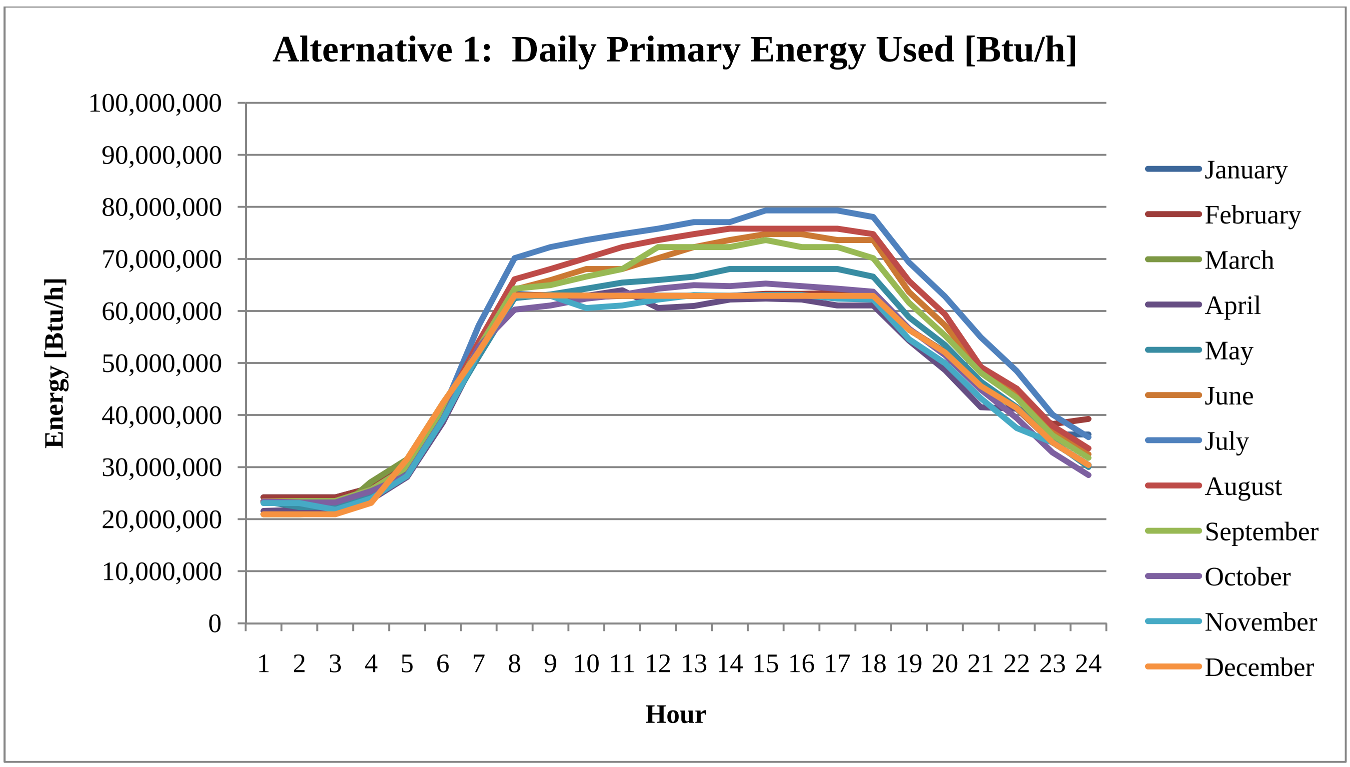
From ASCE Fig. 6-17	
GC_p	0.8
	-1.53
GC_{pi}	0.18
A_{net}	68.8 sf

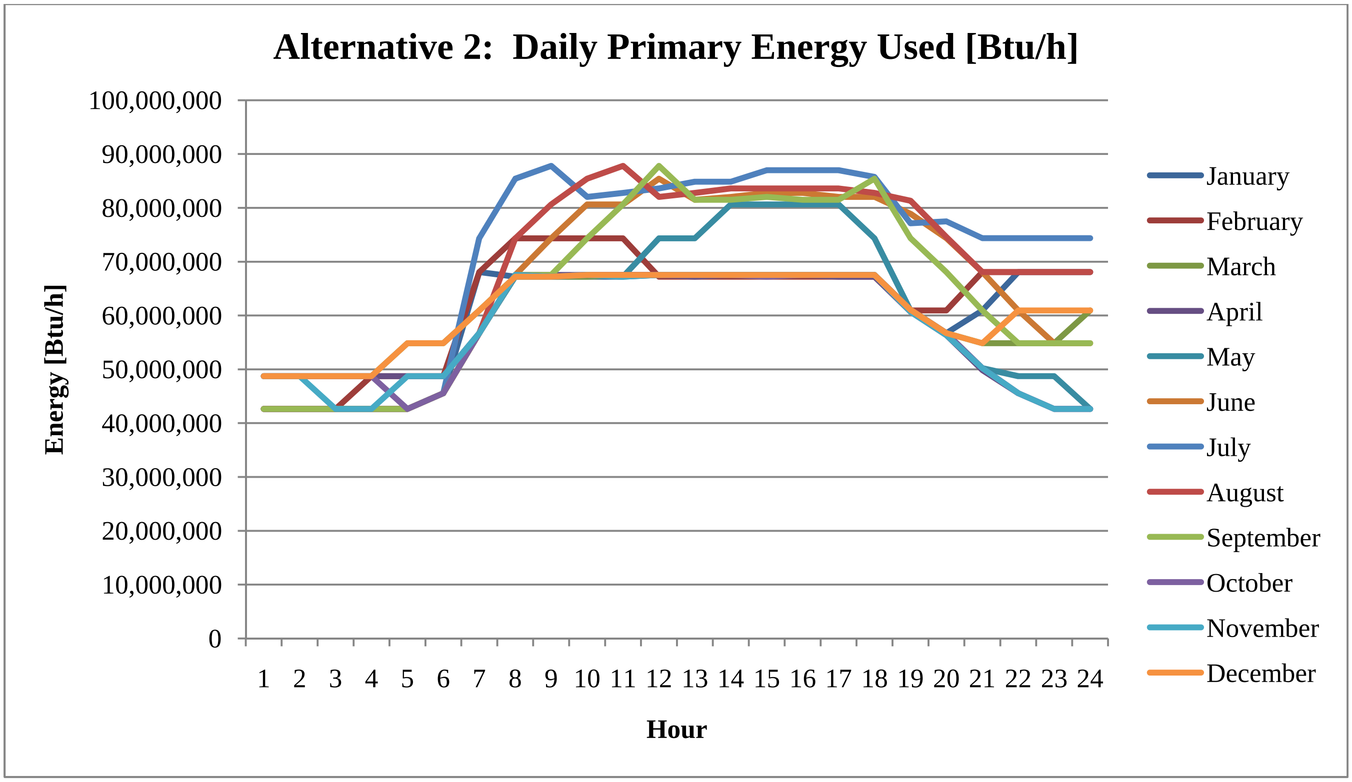
COMPONENTS & CLADDING WIND PRESSURE

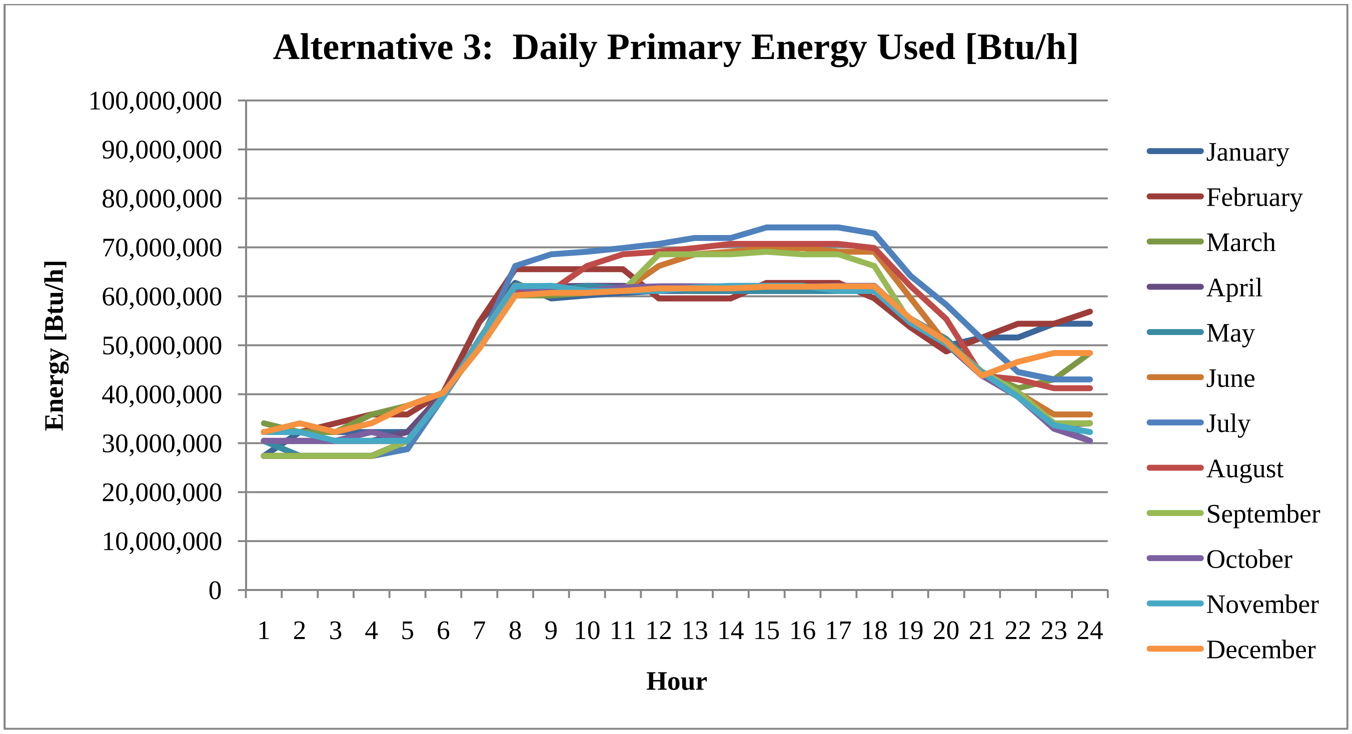
				ext	int	net pressure	
floor	*height*	$K_z{}^a$	*q*	qGC_p	$q_h GC_{pi}$	*ext - int*	*ext + int*
ROOF	732	1.75	52.8	42.3	9.5	32.8	51.8
52	711	1.73	52.4	41.9	9.4	32.5	51.4
51	697	1.72	52.1	41.7	9.4	32.3	51.1
50	684	1.71	51.8	41.5	9.3	32.1	50.8
49	670	1.70	51.5	41.2	9.3	31.9	50.5
48	656	1.69	51.2	41.0	9.2	31.8	50.2
47	642	1.68	50.9	40.7	9.2	31.6	49.9
46	629	1.67	50.6	40.5	9.1	31.4	49.6
45	615	1.66	50.3	40.2	9.0	31.2	49.3
44	601	1.65	50.0	40.0	9.0	31.0	49.0
43	587	1.64	49.6	39.7	8.9	30.8	48.6
42	574	1.63	49.3	39.4	8.9	30.6	48.3
41	560	1.62	48.9	39.2	8.8	30.3	48.0
40	546	1.61	48.6	38.9	8.7	30.1	47.6
39	532	1.59	48.2	38.6	8.7	29.9	47.3
38	519	1.58	47.9	38.3	8.6	29.7	46.9
37	505	1.57	47.5	38.0	8.6	29.5	46.6
36	491	1.56	47.2	37.7	8.5	29.2	46.2
35	477	1.54	46.8	37.4	8.4	29.0	45.8
34	464	1.53	46.4	37.1	8.3	28.8	45.5
33	450	1.52	46.0	36.8	8.3	28.5	45.1
32	436	1.51	45.6	36.5	8.2	28.3	44.7
31	422	1.49	45.2	36.1	8.1	28.0	44.3
30	402	1.47	44.5	35.6	8.0	27.6	43.6
29	381	1.45	43.8	35.1	7.9	27.2	43.0
28	367	1.43	43.4	34.7	7.8	26.9	42.5
27	353	1.42	42.9	34.3	7.7	26.6	42.0
26	339	1.40	42.4	33.9	7.6	26.3	41.6
25	325	1.38	41.9	33.5	7.5	26.0	41.1
24	312	1.37	41.4	33.1	7.5	25.7	40.6
23	298	1.35	40.9	32.7	7.4	25.3	40.1
22	284	1.33	40.3	32.3	7.3	25.0	39.5
21	270	1.31	39.8	31.8	7.2	24.6	39.0
20	257	1.29	39.2	31.3	7.0	24.3	38.4
19	243	1.27	38.6	30.8	6.9	23.9	37.8
18	229	1.25	37.9	30.3	6.8	23.5	37.2
17	215	1.23	37.3	29.8	6.7	23.1	36.5
16	202	1.21	36.6	29.3	6.6	22.7	35.9
15	188	1.18	35.9	28.7	6.5	22.2	35.1
14	174	1.16	35.1	28.0	6.3	21.7	34.4
13	160	1.13	34.2	27.4	6.2	21.2	33.6
12	147	1.10	33.4	26.7	6.0	20.7	32.7
11	133	1.07	32.4	26.0	5.8	20.1	31.8
10	119	1.04	31.5	25.2	5.7	19.5	30.8
9	105	1.00	30.4	24.3	5.5	18.8	29.8
8	92	0.96	29.2	23.3	5.3	18.1	28.6
7	86	0.95	28.7	22.9	5.2	17.8	28.1
6	78	0.92	27.9	22.3	5.0	17.3	27.3
5	64	0.87	26.3	21.0	4.7	16.3	25.8
4	49	0.81	24.4	19.5	4.4	15.1	23.9
3	33	0.72	21.9	17.5	3.9	13.6	21.4
2	15	0.57	17.4	13.9	3.1	10.8	17.1
Leeward	All	---	53.1	-81.3	9.6	-90.8	-71.7

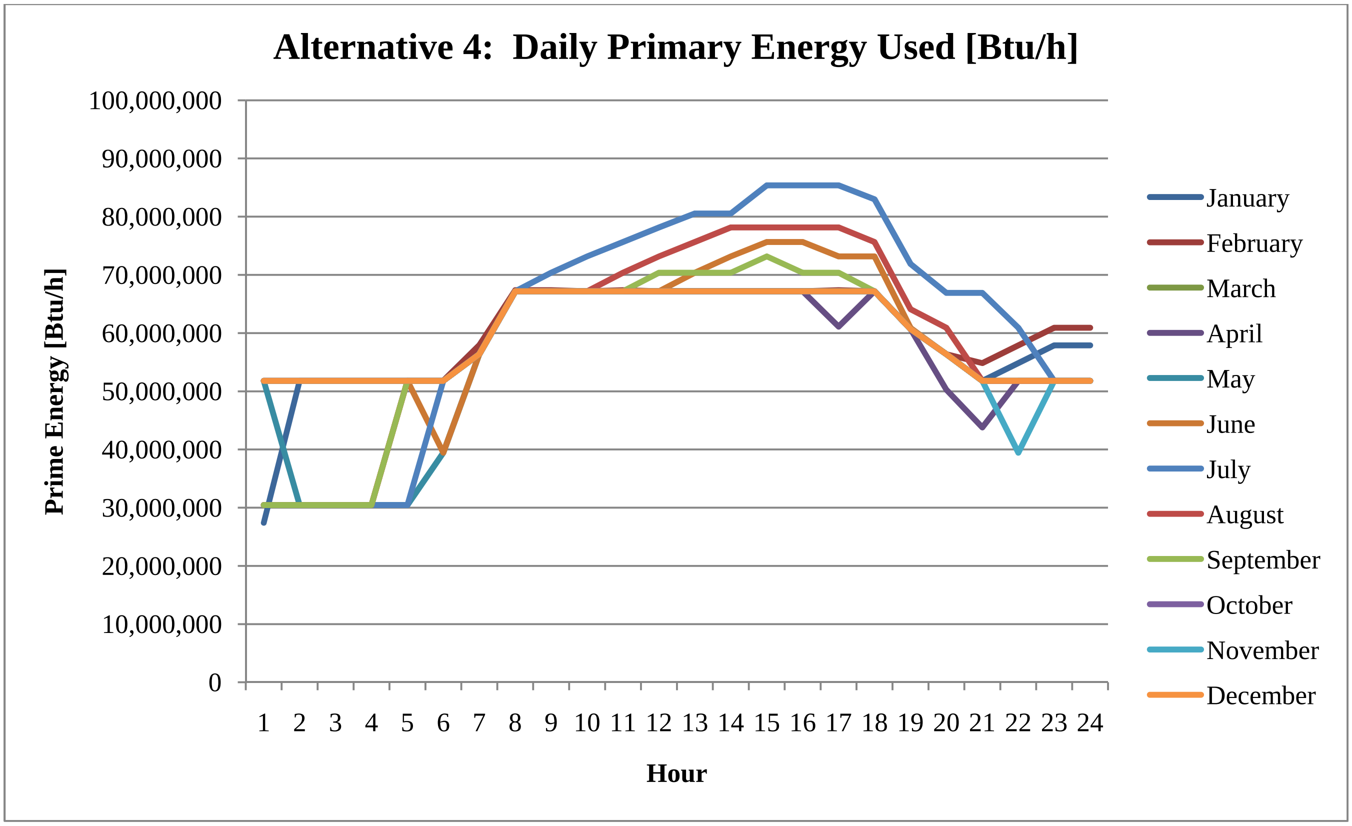
APPENDIX II.A: RESULTS FROM PLANT ALTERNATIVE STUDY

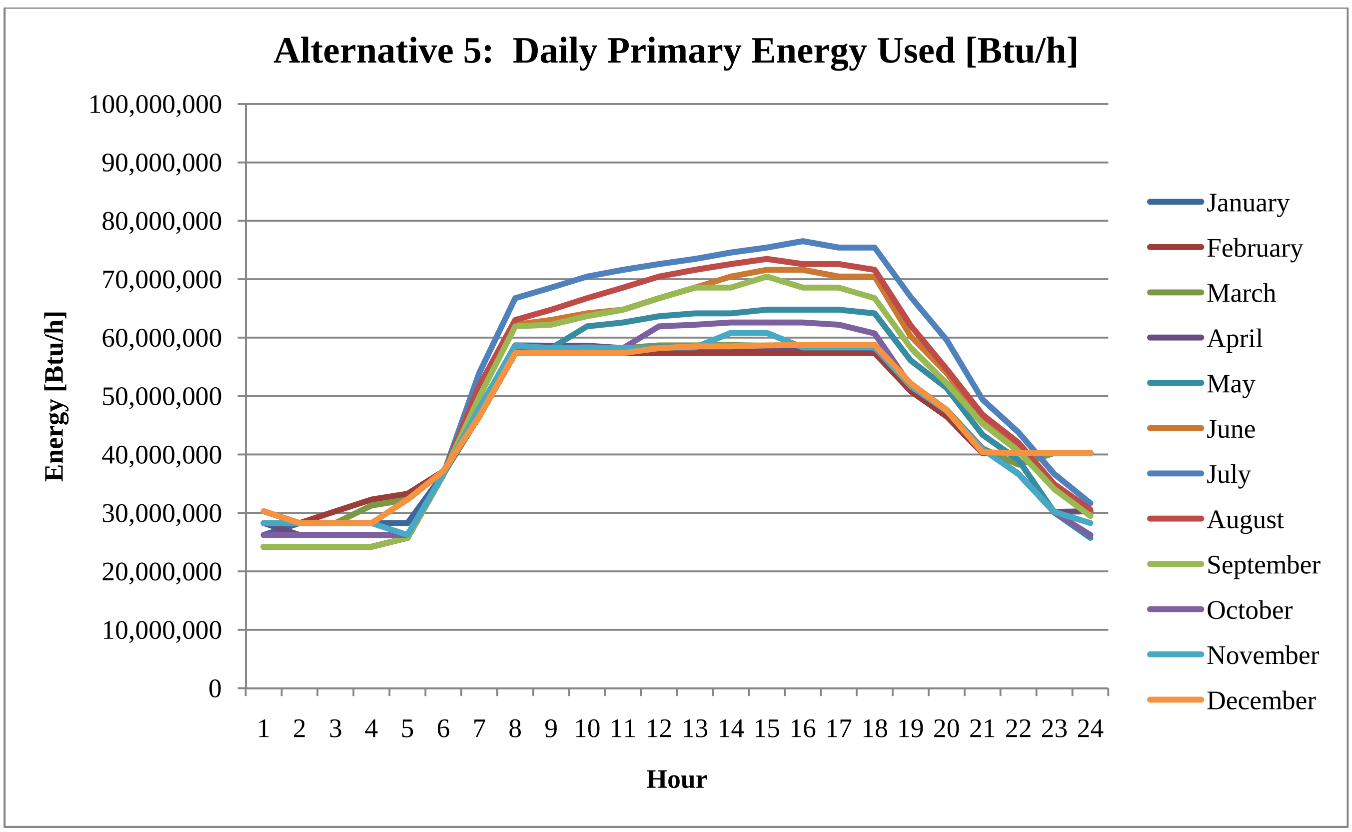
Chiller and CHP Plant Alternatives						
		Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Chiller Plant	**Low range CV**	Electric	Absorption (1-stage)	Absorption (2-stage)	Absorption (2-stage)	Absorption (2-stage)
	Mid range VFD	Electric	Absorption (1-stage)	Absorption (2-stage)	Steam Comp. (2-stage)	Electric
	High range VFD	Electric	Electric	Electric	Steam Comp. (2-stage)	Electric
Prime Movers	**Low range**	IC Engine (VFD)	Gas Turbine (CV)	Gas Turbine (CV)	Gas Turbine (CV)	IC Engine (VFD)
	Mid range	Gas Turbine (CV)	Steam Generator (VFD)	IC Engine (VFD)	Gas Turbine (CV)	Gas Turbine (CV)
	High range	IC Engine (VFD)		Steam Gen. (VFD)	Steam Gen. (VFD)	IC Engine (VFD)




Alternative 2: Daily Primary Energy Used [Btu/h]
Energy [Btu/h]
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December


Alternative 3: Daily Primary Energy Used [Btu/h]
Energy [Btu/h]
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December


Alternative 4: Daily Primary Energy Used [Btu/h]
Prime Energy [Btu/h]
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December


Alternative 5: Daily Primary Energy Used [Btu/h]
Energy [Btu/h]
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December

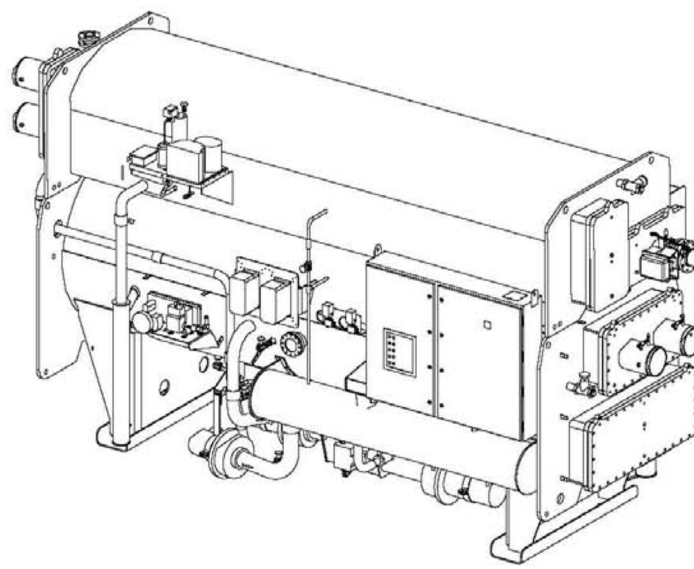
APPENDIX II.B: MANUFACTURER DATA FOR PLANT EQUIPMENT

TRANE

Operation/ Maintenance

Horizon™

Single-Stage Steam or Hot Water Absorption Chiller



Unit Model: ABSD

X39640542-02

ABS-M-10A

TRANE

General Information

Nameplate

The ABSD unit nameplate is located on the chiller control panel. The nameplate illustrated is an ABSD 800 ton, Single - Stage Steam Absorption.

Note: For temperature, pressure drops, and water flow data see the order write-up.

The Unit Nameplate contains very important service information such as the unit serial number, sales order number and the service model number. Always have this information readily available when requesting service.

Nameplate

TRANE

Trane Horizon Absorption Series
Single-Stage Absorption Liquid Chiller

Catalog Model Number
ABSD800

Service Model Number
ABSD060GF0KXXXXXANXXAVAMBEEBGAHDCAXXXXAXAXXXX0

Sales Order Number	Unit Serial Number
AXB123	L00D12345M

Maximum Inlet Steam Pressure: 14PSIG

Electrical Characteristics

Rated Voltage:	460 Volt 60 HZ 3 PH
Voltage Utilization Range:	414-506 VAC
Rated Current:	39.0 Amps
Minimum Circuit Ampacity:	47.0 Amps
Max Overcurrent Protective Device:	50.0 Amps
Purge Compressor RLA:	4.8 Amps
Control Circuit:	115 VAC 2000VA

Motors	KW	FLA
Purge Pump:	.19	4.4
Refrigerant Pump:	3.7	2.0
Absorber Solution Pump:	5.6	15.0
Low Temp Solution Pump:	3.7	12.0

Service Literature

Installation Manual	ABS-IN-10A
Oper/Maint. Manual	ABS-M-10A

Manufactured Under the Following U.S. Patents:
4223539, Other Patents Pending

This advanced model ABSD HORIZON Single-Stage Absorption Unit was developed with the assistance of the Gas Research Institute.

Product Description:

MODL ABSD	DSEQ FO	NTON 800
VOLT 460	BURN NSEL	BOPA NSEL
FTAA NSEL	SMHC NSEL	ENSR STM
ENPR 50	PVCN STD	PURG AUTO
LGTM SB04	HGTM NSEL	CDTM SB09
EVTM ES12	ABTM SB00	GNWA GN02
CAWA CA17	EVWA EV01	CAWC RERE
EVWC LEFR	CAFT WTR	EVFT WTR
EVLV BF03	EVIN FACT	EVPN SSTL
UPNT SFPT	WCNM SNMP	SPKG DAU
ELPP SELP	PPCO NFDS	LCLD CLDO
WVUO YES	OPTM YES	AFDS YES

General Information

Service Model Number
Single Stage Absorption
Standard Options Only

Service Model digit / variable		Description	Selection
1 - 4		Absorption Unit Model	
	ABSD		Single Stage Absorption
5 - 7		Unit Nominal Tonnage	
	050		500 Nominal Tons
	060		600 Nominal Tons
	070		700 Nominal Tons
	080		800 Nominal Tons
	097		975 Nominal Tons
	110		1100 Nominal Tons
	122		1225 Nominal Tons
	135		1350 Nominal Tons
8		Unit Voltage	
	A		190 Volt - 50 HZ
	B		200 Volt - 60 HZ
	C		220 Volt - 50 HZ
	D		230 Volt - 60 HZ
	E		380 Volt - 50 HZ
	F		415 Volt - 50 HZ
	G		460 Volt - 60 HZ
	H		575 Volt - 60 HZ
9		Unit Energy Source	
	J		Steam Energy Source
	G		Hot Water Energy Source
10		Design Sequence	
11		Design Sequence	
12		Generator Waterbox Design Pressure	
	K		Steam - 50 PSIG ASME Required
	M		Hot Water - 150 PSIG ASME Required
	N		Hot Water - 400 PSIG ASME Required
	E		Pressure Vessel Construction Standard construction (includes ASME generator)
13	X	Not Applicable	
14	X	Not Applicable	
15	X	Not Applicable	
16	X	Not Applicable	
17	X	Not Applicable	
18 - 19		Low-Temperature Generator Tubes	
	AN		.028 Wall 90-10 CUNI Smooth Surface
	AP		.035 Wall 90-10 CUNI Smooth Surface
	AR		.049 Wall 90-10 CUNI Smooth Surface
	BD		.028 wall 409 SST Smooth Surface
20	X	Not Applicable	
21	X	Not Applicable	

TRANE

Sequence of Operation

To understand the Horizon chiller operation, a thorough understanding of the various aspects of the machine are required. This section of the manual, therefore, explains the lithium bromide cycle, the controls utilized to control the lithium bromide cycle, and the sequence of operation of the cycle and associated controls.

Machine Solution Cycle

The machine solution cycle is discussed in this section. Refer to the cooling cycle schematic, Figure 3, during the cycle explanation and reference Table 1.

Figure 3 – Single-Stage Absorption Refrigeration Cycle

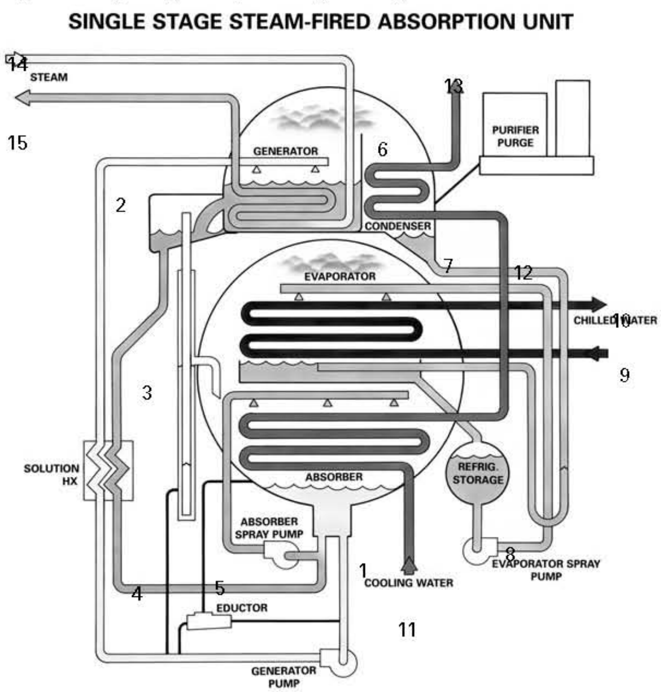


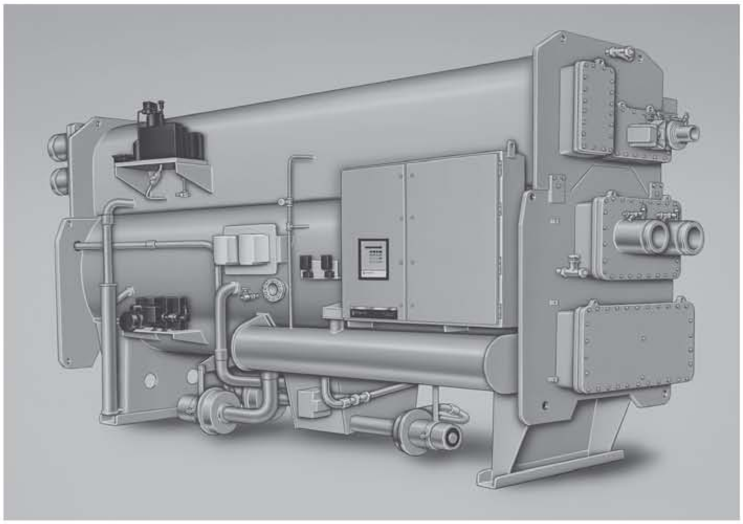
Table 1 – Machine Cooling Cycle (Ref. Figure 3) (Typical Temperatures)

Point	LiBr Solution or Refrigerant Water	Concentration %	Temperature (°F)	Temperature (°C)
1	Absorber Dilute Solution	60.8	107	42
2	Absorber Dilute Solution Entering the LTG	60.8	185	85
3	Solution Leaving the LTG	64.4	216	102
4	Solution Entering ABS Sump/Spray Pump	64.4	129	54
5	ABS Spray Solution (Mixed w/abs dilute)	63.1	121	49
6	LTG Refrigerant Vapor	NA	208	98
7	Condensed Refrigerant	NA	110	43
8	Evaporator Pump Refrigerant	NA	41	5
9	System Chilled Water/Entering	NA	54	12
10	System Chilled Water/Leaving	NA	44	7
11	Absorber Cooling Water	NA	85	29
12	Absorber Leaving/Condenser Entering Cooling Water	NA	94	34
13	Condenser Leaving Cooling Water	NA	101.6	38.6
14a	Steam Entering Unit @12 psig @ Sea Level	NA	244	118
14b	Hot Water Entering Unit @270°F (option)	NA	270	132
15a	Condensate Leaving Generator	NA	244	118
15b	Hot Water Leaving Generator (option)	NA	222	106

Trane Horizon™ Absorption Series

Two-Stage Steam-Fired or Hot Water Absorption Water Chillers 380-1650 Tons – 50-60 Hz

Built for Industrial and Commercial Applications



September 2005 ABS-PRC004-EN

Features and Benefits

Refrigeration Cycle

Absorption Refrigeration Cycle
Figure FB-1 is an example of typical machine operation at a standard rating point condition (i.e., 85° tower, 44° leaving chilled water) at full load. Dilute solution is a relatively high refrigerant content and low lithium bromide content. An intermediate solution is a mixture of dilute and concentrated solutions. A concentrated solution is one with a relatively low refrigerant content and high lithium bromide content.

High Temperature Generator (1)
Solution (intermediate) enters the bottom of the high temperature generator where the refrigerant water vapor is separated from the solution via the energy source inside the tube bundle (steam or hot water). The refrigerant vapor travels to the low temperature generator. The now concentrated solution returns to the absorber through the high and low temperature heat exchangers.

Solution 300 F (149 C), Refrigerant Vapor 300 F (149 C), Tube Bundle 115 PSIG steam or 346 F (174 C)

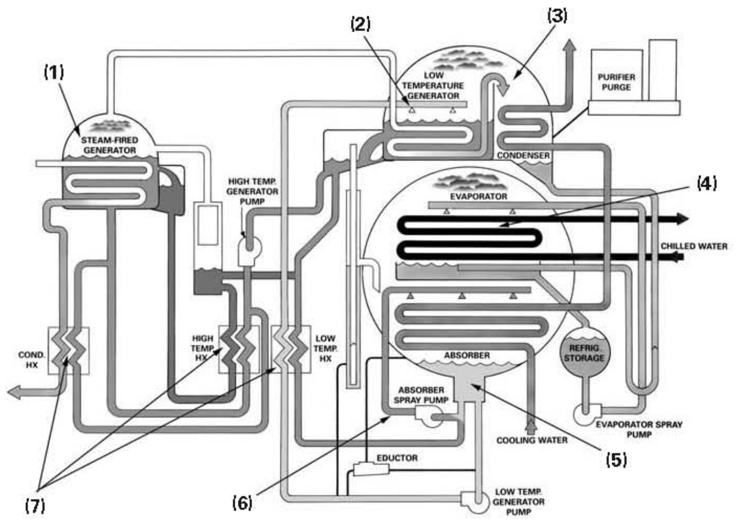
Low Temperature Generator (2)
Solution (dilute) is pumped into the low temperature generator where the solution is boiled creating additional refrigerant vapor via the refrigerant vapor inside the tube bundle. The refrigerant vapor then condenses and flows to the condenser. The now intermediate solution then flows to one of two locations: the absorber spray system to mix with strong concentrated solution from the high temperature generator or to the high temperature generator.

Solution 180 F (82 C), Vapor 190 F (88 C)

Condenser (3)
Refrigerant vapor (produced by the low temperature generator) and refrigerant liquid (via the tube bundle) enter the condenser to be reduced in pressure/ temperature via expansion device for delivery to the evaporator. The heat of condensation is rejected to the cooling water inside the tube bundle.

Refrigerant 100 F (38 C), Entering/ Leaving Cooling Water 93 F/97 F (34 C/36 C)

Figure FB-1 – Absorption Refrigeration Cycle



Evaporator (4)
System water runs through the tube bundle where its heat is transferred to the refrigerant causing the refrigerant to vaporize/boil. The refrigerant vapor flows to the slightly lower pressure in the absorber.

Entering/Leaving System Water 54 F/44 F (12 C/7 C), Evaporator Pump Refrigerant 42 F (6 C)

Absorber (5)
Refrigerant vapor is absorbed by the lithium bromide solution (dilute) to be circulated and cycled again. The solution is pumped to the low temperature generator. Heat (acquired in the evaporator) is rejected via the cooling water inside the tube bundle.

Leaving Solution 95 F (35 C), Entering / Leaving Cooling Water 85 F/93 F (29 C/34 C)

Absorption Process (6)
Solution (concentrated) enters the spray system from the high and low temperature generators enters the spray system wetting the tubes and providing a liquid surface for the refrigerant vapor from the evaporator to absorb into the lithium bromide solution. The solution temperature/concentration sprayed in the absorber controls the absorber pressure thereby controlling the evaporator refrigerant temperature.

Entering Solution 112 F (44 C)

Low, High and Condensate Heat Exchangers (7)
Solution flows through the high and low temperature heat exchangers to be preheated reducing the heat energy required to induce boiling within the generators and to decrease the temperature of the solution being returned to the absorber, thus decreasing the load on the cooling tower.

TRANE

Application Considerations General

General

The Horizon two-stage steam-fired or hot water absorption chiller is designed to provide 40 F to 60 F (+4.4 C - +15.6 C) chilled water for comfort or process cooling applications within all three market segments – commercial, industrial and institutional. The primary advantage of the absorption chiller over other chiller options, is its ability to use steam or hot water to provide energy-saving cooling.

Operating Limits

Trane two-stage absorption chillers operate with nominal 120 PSIG steam or nominal 370 F hot water. In all applications, superheat should be limited so steam temperature does not exceed 400 F. Hot water machines can use up to 370 F hot water.

Water flows within the limits indicated on the appropriate selection charts will insure tube water velocities not exceeding 10 feet per second in copper tubes and 11 feet per second in cupronickel tubes. Changes in condenser water temperature should not exceed 1-degree F per minute between the range of 75 -95 F.

Sound and Vibration

Absorption units are well suited for areas where low sound levels are required. The Trane Horizon two-stage steam absorption chiller will operate under normal load conditions at less than an 85 dBA sound pressure level. During operation there is no vibration of any components that could be damaging to the chiller or could transmit objectionable sound or vibration to the building.

Chiller Installation

The following should be taken into consideration when installing an absorption chiller:

- Rigging and service clearances
- Foundation support
- Chiller isolation for sound/vibration reduction
- Condensate handling
- Steam supply control
- Condenser water temperature control
- Chilled water flow control
- Chilled and condenser water flow limit
- Generator hot water application

Cooling Tower Water Flow

The ARI standard gpm/ton for absorption chillers is 4.0 but lower flow through the condenser and absorber section will present an opportunity for a smaller tower and smaller condenser pump. By designing a system around lower flows there will likely be significant annual chiller plant electrical energy savings. For more information on lower flows on the cooling tower water circuit refer to the appropriate engineering bulletin.

Water Treatment

The use of untreated or improperly treated water may result in scaling, erosion, and corrosion, algae or slime. It is recommended that the services of a qualified water treatment specialist be used to determine what treatment, if any is advisable. The Trane Company assumes no responsibility for the results of untreated, or improperly treated water.

Combination Systems

Peak energy savings can be achieved when using a combination of electric chillers and absorption chillers for air conditioning loads. The absorption chiller is used to shave seasonal billable peak power demands during summer operation, and the electric chiller is run below the allowed demand limit, reducing costly demand charges. Trane offers both electric chillers and absorption chillers with the unit control panel (UCP2) as standard. Although the chillers have different features and modes of operation, the chiller control panel looks and acts the same across all chiller lines. Each control panel is programmed to monitor the particular chiller for which it was designed but maintenance and service personnel need only become familiar with one control panel. Combined with a Trane Tracer™ system a chiller plant has almost unlimited operational flexibility and all equipment is supplied from a single source.

Multiple Machines

The Trane absorption machine can be applied to series or parallel chilled water flow depending upon the design requirement. Accurate chilled water temperatures can be maintained on individual machines between 100 percent and 10 percent chiller load which allows for a wide range of control options. Each chiller has a stand-alone control system to manage the desired water temperature and also the ability to receive remote commands to support various system demands from a control center. This versatility of control makes the management of more than one machine relatively easy.

Parallel flow allows minimum chilled water pressure drop through the machines. However, with one machine "off," it is not usually possible to maintain the design chilled water temperature unless one machine is valved-off and the chilled water flow decreased.

Series flow permits design chilled water temperature at light loads with one machine "off." However, at all operating conditions, the chilled water pressure drop through the machine is high.

A decision concerning which arrangement is best for an individual system should be based on an analysis of system water and temperature rise requirements, system and machine pressure drop characteristics, and installation cost.

TRANE

Selection Procedure

Model Number Description

Selection

Product Coding Description
The coding block precisely identifies all characteristics of a any Horizon™ Two-Stage Steam-Fired or Hot Water Absorption Chiller.

Table S-1 — Product Coding Description

MODL - Absorption Unit Model
ABTF Horizon Two-Stage
DSEQ - Unit Design Sequence
E0 Design Sequence
NTON - Unit Nominal Tonnage
380 380 Tons
440 440 Tons
500 500 Tons
575 575 Tons
660 660 Tons
750 750 Tons
850 850 Tons
950 950 Tons
1050 1050 Tons
1150 1150 Tons
1200 1200 Tons
1350 1350 Tons
1500 1500 Tons
1650 1650 Tons
VOLT - Unit Voltage
190 190/50/3
200 200/60/3
220 220/50/3
230 230/60/3
380 380/50/3
415 415/50/3
460 460/60/3
575 575/60/3
ENSR - Unit Energy Source
HOTW Hot Water
STM Steam
ENPR - Unit Energy Pressure
115 115 Psig Steam
400 400 Psig Hot Water
PVCN - Pressure Vessel Construction
ASME ASME Evp-Abs-Cds
ISPL Ispesl Evp-Abs-Cds
LMIN Les-Mines Evp-Abs-Cds
TUV Tuv Evp-Abs-Cds
STD Standard
LGTM - Low-Temp Generator Tube Material/ Surface
SB01 .028 Wall 95-5 CuNi Smooth
SB04 .028 Wall 90-10 CuNi Smooth
SB05 .035 Wall 90-10 CuNi Smooth
SB06 .049 Wall 90-10 CuNi Smooth
HGTM - High-Temp Generator Tube Material/ Surface
SB16 .028 Wall 409 Sstl Smooth
EVTM - Evaporator Tube Material/Surface
ES01 .028 Wall 95-5 CuNi Enhanced
ES11 .025 Wall 90-10 CuNi Enhanced
ES05 .035 Wall 90-10 CuNi Enhanced
ES09 .028 Wall Copper Enhanced
ES12 .025 Wall Copper Enhanced
CDTM - Condenser Tube Material
SB04 .028 Wall 90-10 CuNi Smooth
SB05 .035 Wall 90-10 CuNi Smooth
SB06 .049 Wall 90-10 CuNi Smooth
SB09 .028 Wall Copper Smooth
SB10 .035 Wall Copper Smooth
ABTM - Absorber Tube Material/Surface
SB00 .022 Wall 95-5 CuNi Smooth
SB01 .028 Wall 95-5 CuNi Smooth
SB02 .035 Wall 95-5 CuNi Smooth
SB03 .049 Wall 95-5 CuNi Smooth
SB04 .028 Wall 90-10 CuNi Smooth
SB05 .035 Wall 90-10 CuNi Smooth
SB06 .049 Wall 90-10 CuNi Smooth
GNWA - Generator Water Box Arrangement
GN02 1-Pass 150 PSI Non-Marine RF Flange
GN04 2-Pass 150 PSI Non-Marine RF Flange
CAWA - Condenser and Absorber Water Box Arrangement
CA01 1-Pass Cond, 2-Pass Abs 150 PSI Marine Victaulic
CA02 1-Pass Cond, 2-Pass Abs 150 PSI Marine RF Flange
CA05 2-Pass Cond, 2-Pass Abs 150 PSI Marine Victaulic
CA06 2-Pass Cond, 2-Pass Abs 150 PSI Marine RF Flange
EVWA - Evaporator Water Box Arrangement
EV01 2-Pass 150 Psi Non-Marine Victaulic
EV02 2-Pass 150 Psi Non-Marine RF Flange
CAWC - Condenser and Absorber Water Connections
LELE In LH End - Out LH End
LERE In LH End - Out RH End
RERE In RH End - Out RH End
EVWC - Evaporator Water Connections
LEBK Inlet Connection Left Back
LEFR Inlet Connection Left Front
REBK Inlet Connection Right Back
REFR Inlet Connection Right Front
LEND Inlet LH End
REND Inlet RH End
CAFT - Condenser and Absorber Water Box Fluid Type
WTR Water
EGLY Ethylene Glycol Solution
PGLY Propylene Glycol Solution
EVFT - Evaporator Water Box Fluid Type
WTR Water
EGLY Ethylene Glycol Solution
PGLY Propylene Glycol Solution

10 ABS-PRC004-EN

TRANE

Performance Data

Table PD-1 — Performance Data at ARI Conditions

English Units*

Model	Capacity (Tons)	Coefficient of Performance	Steam Rate (lbm/ton/hr)	Chilled Water Flow Rate (gpm)	Chilled Water Press. Drop (ft Wtr)	Cond/Abs Water Flow Rate (gpm)	Cond/Abs Water Pr. Drop (ft Wtr)
ABTF-380	360	1.21	9.73	861	13.7	1520	26.5
ABTF-440	426	1.21	9.69	1018	14.6	1760	30.5
ABTF-500	493	1.22	9.65	1178	15.6	2000	34.9
ABTF-575	558	1.21	9.65	1333	26.9	2300	19.4
ABTF-660	659	1.22	9.62	1576	29.1	2640	20.9
ABTF-750	765	1.22	9.63	1833	31.6	3000	22.9
ABTF-850	915	1.24	9.51	2187	13.7	3400	13.3
ABTF-950	1030	1.24	9.51	2462	19.1	3800	17.5
ABTF-1050	1145	1.24	9.49	2736	25.8	4200	22.5
ABTF-1150	1259	1.24	9.48	3010	33.9	4600	28.3
ABTF-1200	1264	1.19	9.83	3022	13.2	4800	16.0
ABTF-1350	1419	1.19	9.84	3391	18.2	5400	21.2
ABTF-1500	1573	1.19	9.84	3759	24.4	6000	27.2
ABTF-1650	1721	1.20	9.77	4113	31.7	6600	34.1

SI Units**

Model	Capacity (kW)	Coefficient of Performance	Steam Rate (kg/kw-hr)	Chilled Water Flow Rate (m^3/hr)	Chilled Water Press. Drop (m wg)	Cond/Abs Water Flow Rate (m^3/hr)	Cond/Abs Water Pr. Drop (m wg)
ABTF-380	1266	1.20	1.25	196	4.5	345	8.7
ABTF-440	1498	1.21	1.25	231	4.8	400	10.0
ABTF-500	1734	1.21	1.24	268	5.1	454	11.5
ABTF-575	1963	1.21	1.24	303	8.8	522	6.4
ABTF-660	2318	1.22	1.24	358	9.5	600	6.9
ABTF-750	2691	1.21	1.24	416	10.4	681	7.5
ABTF-850	3218	1.23	1.23	497	4.5	772	4.4
ABTF-950	3623	1.23	1.23	559	6.3	863	5.7
ABTF-1050	4027	1.24	1.22	621	8.5	954	7.4
ABTF-1150	4428	1.24	1.22	684	11.1	1045	9.3
ABTF-1200	4446	1.19	1.27	686	4.3	1090	5.2
ABTF-1350	4991	1.19	1.27	770	6.0	1226	7.0
ABTF-1500	5533	1.19	1.27	854	8.0	1363	8.9
ABTF-1650	6053	1.20	1.26	934	10.4	1499	11.2

*English:
4.0 gpm/nominal ton, Pstm = 120 psig, TctwS = 85 F, TcwS = 44 F, TcwR = 54 F, 0.0001 Evaporator fouling and 0.00025 Absorber/Condenser fouling.

**Metric:
.26 m^3/kWh, Pstm = 120 psig, TctwS = 29.44 C, TcwS = 6.67 C, TcwR =12.2 C, 0.0001 Evaporator fouling and 0.00025 Absorber/Condenser fouling.

TRANE

Performance Data

Table PD-2 — Performance Data at Trane Rated Conditions

English Units*							
		Coefficient	Steam	Chilled Water		Cond/Abs Water	
Model	Capacity (Tons)	of Performance	Rate (lbm/ton/hr)	Flow Rate (gpm)	Press. Drop (ft Wtr)	Flow Rate (gpm)	Pr. Drop (ft Wtr)
ABTF-380	334	1.18	9.98	665	8.2	1368	21.7
ABTF-440	395	1.18	9.93	787	8.7	1584	25.0
ABTF-500	457	1.19	9.9	909	9.3	1800	28.5
ABTF-575	517	1.19	9.9	1029	15.7	2070	16.0
ABTF-660	611	1.19	9.86	1216	16.9	2376	17.2
ABTF-750	710	1.19	9.88	1413	18.3	2700	18.8
ABTF-850	843	1.21	9.76	1679	7.9	3060	11.0
ABTF-950	951	1.21	9.74	1893	11.0	3420	14.5
ABTF-1050	1058	1.21	9.73	2106	14.9	3780	18.6
ABTF-1150	1165	1.21	9.71	2319	19.6	4140	23.4
ABTF-1200	1167	1.16	10.09	2324	7.6	4320	13.2
ABTF-1350	1311	1.16	10.09	2611	10.5	4860	17.4
ABTF-1500	1455	1.16	10.09	2897	14.1	5400	22.4
ABTF-1650	1595	1.17	10.01	3175	18.4	5940	28.1

SI Units**							
		Coefficient	Steam	Chilled Water		Cond/Abs Water	
Model	Capacity (kW)	of Performance	Rate (kg/kw-hr)	Flow Rate (m^3/hr)	Press. Drop (m wg)	Flow Rate (m^3/hr)	Pr. Drop (m wg)
ABTF-380	1175	1.17	1.29	151	2.7	311	7.1
ABTF-440	1389	1.18	1.28	179	2.9	360	8.2
ABTF-500	1607	1.18	1.28	206	3.1	409	9.4
ABTF-575	1819	1.18	1.28	234	5.2	470	5.2
ABTF-660	2149	1.19	1.27	276	5.5	540	5.6
ABTF-750	2497	1.19	1.27	321	6.0	613	6.2
ABTF-850	2965	1.20	1.26	381	2.6	695	3.6
ABTF-950	3345	1.20	1.26	430	3.6	777	4.8
ABTF-1050	3721	1.21	1.25	478	4.9	858	6.1
ABTF-1150	4098	1.21	1.25	527	6.4	940	7.7
ABTF-1200	4105	1.16	1.30	528	2.5	981	4.3
ABTF-1350	4611	1.16	1.30	593	3.4	1104	5.7
ABTF-1500	5118	1.16	1.30	658	4.6	1226	7.3
ABTF-1650	5610	1.17	1.29	721	6.0	1349	9.2

*English:
4.0 gpm/nominal ton, Pstm = 120 psig, TctwS = 85 F, TcwS = 44 F, TcwR = 54 F, 0.0001 Evaporator fouling and 0.00025 Absorber/Condenser fouling.

**Metric:
.26 m^3/kWh, Pstm = 120 psig, TctwS = 29.44 C, TcwS = 6.67 C, TcwR =12.2 C, 0.0001 Evaporator fouling and 0.00025 Absorber/Condenser fouling.

Performance Data

Figure PD-1 – ABTF Capacity vs. Chilled Water Supply Temperature at Various Cooling Water Supply Temperatures

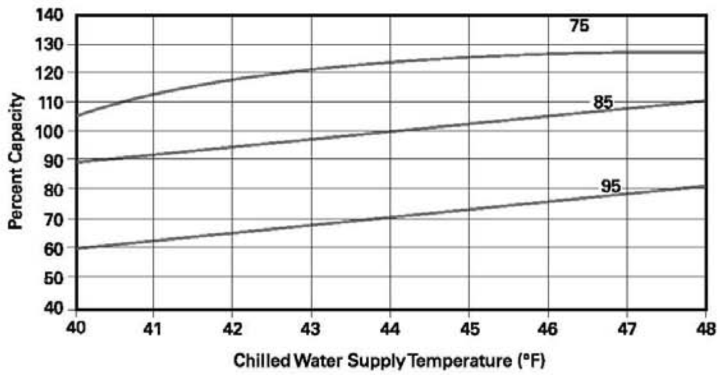
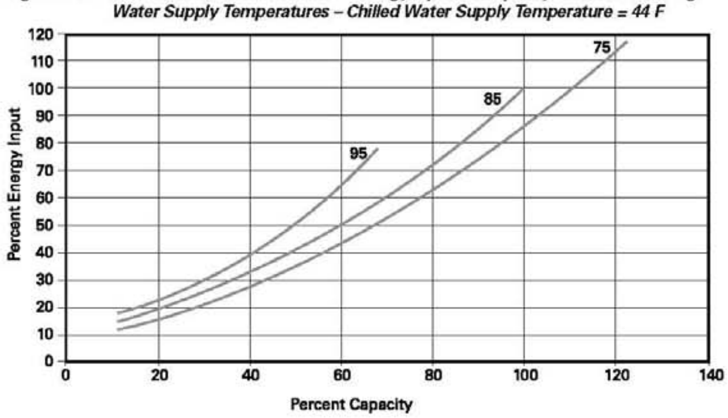


Figure PD-2 – ABTF Part Load Performance – Energy Input vs. Capacity at Various Cooling Water Supply Temperatures – Chilled Water Supply Temperature = 44 F



TRANE

Product Catalog

EarthWise™ CenTraVac™ Water-Cooled Liquid Chillers

170–3950 Tons, 50 and 60 Hz

Tonnage Ranges By CenTraVac Model Number

CVHE — Three-Stage Single Compressor CenTraVac — 50/60 Hz

170 500

CVHF — Two-Stage Single Compressor CenTraVac — 60 Hz

325 2000

CVHG — Three-Stage Single Compressor CenTraVac — 50 Hz

450 1300

CDHG — Dual Compressor CenTraVac — 50 Hz

1200 2500

CDHF — Dual Compressor CenTraVac — 60 Hz

1500 3950

GPC — Gas Powered CenTraVac Package — 60 Hz

170 3950

CVHE/CVHF/CVHG
CDHF/CDHG

January 2008 **CTV-PRC007-EN**

Features and Benefits

Comparing the Attributes of Low Pressure Chiller Operation to High Pressure Chiller Operation

Trane CenTraVac™ chillers continue to offer time-tested and proven low-pressure refrigerants, including environmental friendly HCFC-123. Trane CenTraVac chillers provide the safety of low pressure with continued product improvement in leak proof design. Consider the benefits of low-pressure over high-pressure chillers:

Table 1. Low pressure to high pressure comparison at ARI conditions

	Low Pressure	Medium/High Pressure
Evaporator	• Always at negative pressure • Air leaks inward at low rate • Refrigerant lost: (# air leak in) x purge efficiency[(a)] • No refrigerant loss into equipment room (vented to the relief line via purge)	• Always at positive pressure • Refrigerant leaks outward at moderate rate • Refrigerant loss is into equipment room
Condenser	• Usually at negative pressure during inactivity (air leaks inward) • At slightly positive pressure during operation • Refrigerant leaks outward at very low rate during operation	• Always at high positive pressure • Refrigerant leaks outward at very high rate

Monitoring of leak rate	• Trane EarthWise™ purge is able to continuously monitor in-leakage with the run meter.
	• Refrigerant monitor as required by ASHRAE.
	• Purge can be connected to a building automation system for notification of increased purge operation (in-leak). Similarly, the refrigerant monitor can be connected to the building automation system.
		• Only ways to monitor leak rate on high pressure chiller are:
		  • periodic leak checks
		  • purchase refrigerant monitor
		• Refrigerant monitor as required by ASHRAE.
		• Normally the only time that a leak is detected on a high pressure chiller is during spring startup. This means that a chiller which develops a leak in the summer may leak continuously until the following spring.

Typical Pressures (38°F evap.) (100°F cond.)	**HCFC-123** Evap: -9.2 psig (-18.1 in. Hg) Cond: 6.1 psig	**HFC-134a** Evap: 33.1 psig Cond: 124.1 psig

(a) Trane EarthWise purge efficiency does not exceed 0.02 lb·refrigerant/lb·air

TRANE

Performance Data

Evaporator Flow Rates

Performance Data

Table 3. Minimum and maximum evaporator flow rates (gpm)

Shell Size EVSZ	Bundle Size EVBS	One Pass IMCU Min	One Pass IMCU Max	One Pass TECU Min	One Pass TECU Max	One Pass IECU Min	One Pass IECU Max	Two Pass IMCU Min	Two Pass IMCU Max	Two Pass TECU Min	Two Pass TECU Max	Two Pass IECU Min	Two Pass IECU Max	Three Pass IMCU Min	Three Pass IMCU Max	Three Pass TECU Min	Three Pass TECU Max	Three Pass IECU Min	Three Pass IECU Max
032S	200	154	1129	241	1324	155	1136	77	564	121	662	78	568	52	376	81	441	52	379
032S	230	178	1302	271	1485	179	1311	89	651	135	742	90	655	60	434	90	495	60	437
032S	250	190	1389	298	1635	191	1399	95	694	149	817	96	699	64	463	100	545	64	466
032S/L	280	217	1584	340	1865	218	1595	109	782	170	932	109	797	72	528	114	622	73	531
032S/L	320	246	1801	379	2084	248	1814	13	901	190	1042	124	907	82	600	127	694	83	605
032S/L	350	270	1975	—	—	272	1988	135	987	—	—	136	994	90	658	—	—	91	662
050S	320	249	1823	379	2084	251	1836	125	911	190	1042	126	918	83	607	127	694	84	612
050S	360	273	1997	428	2349	275	2010	137	998	214	1174	138	1005	91	665	143	783	92	670
050S	400	305	2235	474	2602	307	2251	153	1118	237	1301	154	1125	102	745	158	867	103	750
050S/L	450	347	2540	539	2959	349	2557	174	1270	270	1480	175	1278	1116	847	180	986	117	852
050S/L	500	388	2843	597	3281	391	2962	194	1421	299	1641	196	1431	130	948	199	1093	131	954
050S/L	550	427	3126	—	—	430	3147	214	1563	—	—	215	1573	143	1042	—	—	144	1049
080S	500	388	2843	597	3281	391	2862	194	1421	299	1641	196	1431	130	948	199	1093	131	954
080S	560	430	3148	673	3696	433	3169	215	1573	337	1848	217	1584	144	1049	224	1232	145	1056
080S	630	486	3561	754	4145	489	3584	243	1780	377	2072	245	1792	162	1187	252	1382	163	1194
080S/L	710	551	4038	846	4652	555	4065	276	2018	423	2325	279	2032	184	1346	282	1551	185	1355
080S/L	800	619	4537	961	5286	623	4567	310	2268	481	2642	312	2284	207	1512	321	1761	208	1522
080S/L	890	690	5058	—	—	695	5093	345	2529	—	—	348	2546	230	1685	—	—	232	1697
142M/L	890	693	5080	964	5297	692	5069	347	2540	482	2648	346	2534	231	1693	321	1765	231	1689
142M/L	980	770	5645	1079	5930	769	5632	385	2822	540	2965	384	2816	257	1881	360	1976	256	1877
142M/L	1080	868	6361	1200	6598	866	6347	434	3180	600	3299	433	3173	290	2120	400	2199	289	2115
142M/L/E	1220	963	7056	1349	7416	961	7040	482	3528	675	3708	480	3520	321	2351	450	2472	320	2346
142M/L/E	1420	1120	8206	1502	8256	1116	8188	560	4103	751	4128	559	4094	373	2735	501	2752	373	2729
210L	1610	1232	9031	1470	8083	1229	9011	616	4515	735	4041	615	4506	411	3010	490	2694	410	3003
210L	1760	1383	10139	1642	9029	1380	10117	692	5069	821	4514	690	5058	461	3379	548	3009	460	3372
210L	1900	1528	11203	1824	10030	1525	11178	764	5601	912	5014	763	5589	510	3734	608	3343	509	3726
210L	2100	1623	11898	2010	11055	1619	11871	812	5948	1005	5527	810	8935	541	3965	670	3685	540	3957
250E	2280	1587	11637	1935	10642	1590	11663	793	5819	967	5321	795	5832	Not Applicable					
250E	2300	1750	12832	2174	11953	1762	12917	875	6415	1087	5976	881	6458	584	4277	725	3984	588	4306
250E	2480	1757	12882	2127	11699	1761	12911	878	6441	1064	5850	880	6456	Not Applicable					
250E	2500	1916	14047	2394	13162	1929	14141	958	7023	1197	6581	965	7070	639	4682	798	4387	643	4713
210D	1610	1216	8913	1421	7814	1224	8973	Not Applicable						Not Applicable					
210D	1850	1388	10175	1680	9239	1397	10243												
210D	2100	1557	11414	1935	10641	1567	11490												
250D	2100	1557	11414	1943	10686	1567	11490	Not Applicable						Not Applicable					
250D	2300	1724	12633	2101	11554	1735	12717												
250D	2500	1887	13830	2314	12723	1899	13922												
250M	2100	1557	11414	1943	10686	1567	11490	Not Applicable						Not Applicable					
250M	2300	1724	12633	2101	11554	1735	12717												
250M	2500	1887	13830	2314	12723	1899	13922												
250X	2100	1557	11414	1943	10686	1567	11490	Not Applicable						Not Applicable					
250X	2300	1724	12633	2101	11554	1735	12717												
250X	2500	1887	13830	2314	12723	1899	13922												

Note: The minimum evaporator water velocity is 1.5 ft/sec for IECU tubes and 2.0 ft/sec for all other tubes. For a variable evaporator water flow system, the minimum GPME is generally not applicable at full load, and may be limited by other factors such as glycol. Confirm actual minimum and maximum flows for each selection before operating near flow boundaries. In the above table, 0.025" wall tubes were used for M, L, S, and E bundles and 0.028 wall tubes were used for D, M, and X bundles.

TRANE

Performance Data

Evaporator Flow Rates

Minimum and maximum evaporator flow rates (liter/second)

Shell Size	Bundle Size	One Pass						Two Pass						Three Pass					
		IMCU		TECU		IECU		IMCU		TECU		IECU		IMCU		TECU		IECU	
EVSZ	EVBS	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
032S	200	10	71	15	84	10	72	5	36	8	42	5	36	3	24	5	28	3	24
032S	230	11	82	17	94	11	83	6	41	9	47	6	41	4	27	6	31	4	28
032S	250	12	88	19	103	12	88	6	44	9	52	6	44	4	29	6	34	4	29
032S/L	280	14	100	21	118	14	101	7	49	11	59	7	50	5	33	7	39	5	34
032S/L	320	16	114	24	131	16	114	8	57	12	66	8	57	5	38	8	44	5	38
032S/L	350	17	125	—	—	17	125	9	62	—	—	9	63	6	42	—	—	6	42
050S	320	16	115	24	131	16	116	8	57	12	66	8	58	5	38	8	44	5	39
050S	360	17	126	27	148	17	127	9	63	14	74	9	63	6	42	9	49	6	42
050S	400	19	141	30	164	19	142	10	71	15	82	10	71	6	47	10	55	6	47
050S/L	450	22	160	34	187	22	161	11	80	17	93	11	81	7	53	11	62	7	54
050S/L	500	24	179	38	207	25	187	12	90	19	104	12	90	819	60	13	69	8	60
050S/L	550	27	197	—	—	27	199	14	99	—	—	14	99	9	66	—	—	9	66
080S	500	24	17	38	207	25	181	12	90	19	104	12	90	8	60	13	69	8	60
080S	560	27	199	42	233	27	200	14	99	21	117	14	100	9	66	14	78	9	67
080	630	31	225	48	262	31	226	15	112	24	13	115	113	10	75	16	87	10	75
080S/L	710	35	255	53	293	35	256	17	127	27	147	18	128	12	85	18	98	12	85
080S/L	800	39	286	61	333	39	288	20	143	30	167	20	144	13	95	20	111	13	96
080S/L	890	44	319	—	—	44	321	22	160	—	—	22	161	15	106	—	—	15	107
142M/L	890	44	320	61	334	44	320	22	160	30	167	22	160	15	107	20	111	15	107
142M/L	980	49	356	68	374	49	355	24	178	34	187	24	178	16	119	23	125	16	118
142M/L	1080	55	401	76	416	55	400	27	201	38	208	7	200	18	134	25	139	18	133
142M/L/E	1220	61	445	85	468	61	444	30	223	43	234	30	222	20	148	28	156	20	148
142M/L/E	1420	71	518	95	521	70	517	35	259	47	260	35	258	24	173	32	174	24	172
210L	1610	78	570	93	510	78	569	39	285	46	25	39	284	26	190	31	170	26	189
210L	1760	87	640	104	570	87	638	44	320	52	285	44	319	29	213	35	190	29	213
210L	1900	96	707	115	633	96	705	48	353	58	316	48	353	32	236	38	211	32	235
210L	2100	102	751	127	697	102	749	51	375	63	349	51	564	34	250	42	232	34	250
250E	2280	100	934	122	671	100	736	50	367	61	336	50	368	Not Applicable					
250E	2300	110	810	137	754	111	815	55	405	69	377	56	407	37	270	46	251	37	272
250E	2480	111	813	134	738	111	815	55	406	67	369	56	407	Not Applicable					
250E	2500	121	886	151	830	122	892	60	443	76	415	61	446	40	295	50	277	41	297
210D	1610	77	562	90	493	77	566												
210D	1850	88	642	106	583	88	646	Not Applicable						Not Applicable					
210D	2100	98	720	122	671	99	725												
250D	2100	98	720	123	674	99	725												
250D	2300	109	797	133	729	109	802	Not Applicable						Not Applicable					
250D	2500	119	873	14	803	120	878												
250M	2100	98	720	123	674	99	725												
250M	2300	109	797	133	729	109	802	Not Applicable						Not Applicable					
250M	2500	119	873	146	803	120	878												
250X	2100	98	720	123	674	99	725												
250X	2300	109	797	133	729	109	802	Not Applicable						Not Applicable					
250X	2500	119	873	146	803	120	878												

Note: The minimum evaporator water velocity is .457 m/s for IECU tubes and .610 m/s for all other tubes. For a variable evaporator water flow system, the minimum LPS is generally not applicable at full load, and may be limited by other factors such as glycol. Confirm actual minimum and maximum flows for each selection before operating near flow boundaries. In the above table, 0.025" wall tubes were used for M, L, S, and E bundles and 0.028" wall tubes were used for D, M, and X bundles.

TRANE

Performance Data

Condenser Flow Rates

Table 4. Minimum and Maximum condenser flow rates (gpm)

Shell Size CDSZ	Bundle Size CDBS	Two Pass							
		SBCU		TECU		IECU		IMCU	
		Min	Max	Min	Max	Min	Max	Min	Max
032S	230	214	784	209	763	217	795	216	792
032S/L	250	239	877	233	854	245	896	244	892
032S/L	280	267	980	261	954	272	997	271	992
032S/L	320	295	1083	288	1055	305	1117	304	1112
050S	360	336	1233	328	1201	347	1269	345	1263
050S/L	400	378	1388	369	1351	391	1430	389	1423
050S/L	450	26	1563	416	1522	440	1611	438	1604
050S/L	500	473	1733	461	1688	489	1792	787	1784
080S	500	473	1733	461	1688	489	1792	487	1784
080S	560	529	1940	516	1889	547	2004	545	1995
080S/L	630	595	2182	580	2126	613	2246	610	2235
080S/L	710	691	2466	656	2402	687	2518	584	2506
080S/L	800	756	2770	736	2698	772	2830	769	2821
142L	890	853	3125	834	3055	874	3203	870	3190
142L	980	949	3476	927	3398	973	3565	968	3549
142L	1080	1060	3884	1036	3796	1088	3988	1083	3970
142L	1220	1185	4343	1158	4245	1215	4452	1209	4431
142L	1420	1335	4895	1305	4785	1404	5147	1398	5123
210L	1610	1331	4879	1301	4769	1492	5469	1301	4769
210L	1760	1473	5400	1440	5279	1651	6053	1644	6025
210L	1900	1615	5921	1579	5788	1808	6627	1800	6597
210L	2100	1760	6452	1721	6307	1959	7181	1950	7148
250L	2100	1760	6452	1721	6307	1956	7171	1947	7138
250L	2300	1935	7092	1891	6932	2149	7876	2139	7840
250L	2500	2103	7747	2066	7573	2338	8571	2327	8532
		One Pass							
210D	1610	2662	9758	2602	9539	2984	10938	2970	10888
120D	1760	2946	10800	2880	10558	3302	12107	3287	12051
210D	1900	3231	11873	3158	11576	2616	13255	3599	13194
210D	2100	3520	12906	3441	12615	3918	14363	3900	14297
250D	2100	3520	12906	3441	12615	3912	14343	3894	14297
250D	2300	3869	14186	3782	13865	4297	15753	4277	15680
250D	2500	4226	15494	4131	15146	4676	17143	4654	17064
250M	2100	3520	12906	3441	12615	3912	14343	3894	14277
250M	2300	3959	14186	3782	13865	4297	15753	4277	15680
250M	2500	4226	15494	4131	15146	4676	171743	4654	17064
250X	2100	3520	12906	3441	12615	3912	14343	3894	14277
250X	2300	3869	14186	3782	13865	4297	15753	4277	15680
250X	2500	4226	15494	4131	15146	4676	17143	654	17064

Note: The minimum condenser water velocity is 3 ft/sec and the maximum is 11 ft/sec, and may be limited by other factors such as glycol. Confirm actual minimum and maximum flows for each selection before operating near flow boundaries. Table values based on 0.028" wall tubes.

TRANE

Performance Data

Condenser Flow Rates

Minimum and maximum condenser flow rates (liter/second)

Shell Size	Bundle Size	Two Pass							
		SBCU		TECU		IECU		IMCU	
CDSZ	CDBS	Min	Max	Min	Max	Min	Max	Min	Max
032S	230	14	49	13	48	14	50	14	50
032S/L	250	15	55	15	54	15	57	15	56
032S/L	280	17	62	16	60	17	63	17	63
032S/L	320	19	68	18	67	19	70	19	70
050S	360	21	78	21	76	22	80	22	80
050S/L	400	24	88	23	85	25	90	25	90
050S/L	450	27	99	26	96	28	102	28	101
050S/L	500	30	109	29	106	31	113	31	113
080S	500	30	109	29	106	31	113	31	113
080S	560	33	122	33	119	35	126	34	126
080S/L	630	38	138	37	134	39	142	38	141
080S/L	710	44	156	41	152	43	159	37	158
080S/L	800	48	175	46	170	49	179	49	178
142L	890	54	197	53	193	55	202	55	201
142L	980	60	219	58	214	61	225	61	224
142L	1080	67	245	65	239	69	252	68	250
142L	1220	75	274	73	268	77	281	76	280
142L	1420	84	309	82	302	89	325	88	323
210L	1610	84	308	82	301	94	345	82	301
210L	1760	93	341	91	333	104	382	104	380
210L	1900	102	374	100	365	114	418	114	416
210L	2100	111	407	109	398	124	453	123	451
250L	2100	111	407	109	398	123	452	123	450
250L	2300	122	447	119	437	136	497	135	495
250L	2500	133	489	130	478	148	541	147	538
		One Pass							
210D	1610	168	616	164	602	188	690	187	687
210D	1760	186	681	182	666	208	764	207	760
210D	1900	204	747	199	730	165	836	227	832
210D	2100	222	814	217	796	247	906	246	902
250D	2100	222	814	217	796	247	905	246	902
250D	2300	244	895	239	875	271	994	270	989
250D	2500	267	978	261	956	295	1082	294	1077
250M	2100	222	814	217	796	247	905	246	901
250M	2300	250	895	239	875	271	994	270	989
250M	2500	267	978	261	956	295	1082	294	1077
250X	2100	222	814	217	796	247	905	246	901
250X	2300	244	895	239	975	271	994	270	989
250X	2500	267	978	261	956	295	1082	294	1077

Note: The minimum condenser water velocity is 0.914 m/s, and the maximum is 3.35 m/s, and may be limited by other factors such as glycol. Confirm actual minimum and maximum flows for each selection before operating near flow boundaries. Table values based on 0.028" wall tubes.

G3516 TA

GAS ENGINE TECHNICAL DATA CATERPILLAR®

ENGINE SPEED:	1200	FUEL:	NAT GAS
COMPRESSION RATIO:	9:1	FUEL SYSTEM:	HPG IMPCO
AFTERCOOLER - MAX. INLET (°F):	130		
JACKET WATER - MAX. OUTLET (°F):	210	FUEL PRESS. RANGE (PSIG):	35.0 - 40.0
COOLING SYSTEM:	JW+OC, AC	MIN. METHANE NUMBER:	80
IGNITION SYSTEM:	EIS	RATED ALTITUDE (FT):	5000
EXHAUST MANIFOLD:	WC	AT AIR TO TURBO. TEMP. (°F):	77
COMBUSTION:	STANDARD	EXHAUST O2 EMISSION LEVEL:	2.0 %O2
		FUEL LHV (BTU/SCF):	905
		APPLICATION:	60 Hz GENSET

RATING AND EFFICIENCY		NOTES	LOAD	100%	75%	50%
ENGINE POWER	(WITHOUT FAN)	(1)	BHP	1053	790	526
GENERATOR POWER	(WITHOUT FAN)	(2)	EKW	740	555	370
ENGINE EFFICIENCY	**(ISO 3046/1)**	**(3)**	**%**	**33.9**	**32.2**	**29.3**
ENGINE EFFICIENCY	(NOMINAL)	(3)	%	33.9	32.2	29.3
THERMAL EFFICIENCY	(NOMINAL)	(4)	%	51.7	53.4	55.8
TOTAL EFFICIENCY	(NOMINAL)	(5)	%	85.5	85.6	85.1

ENGINE DATA						
FUEL CONSUMPTION	**(ISO 3046/1)**	**(6)**	**BTU/bhp-hr**	**7514**	**7909**	**8676**
FUEL CONSUMPTION	(NOMINAL)	(6)	BTU/bhp-hr	7514	7909	8676
AIR FLOW (77 °F, 14.7 psi)		(7)	SCFM	1555	1244	964
AIR FLOW		(7)	lb/hr	6892	5514	4271
COMPRESSOR OUT PRESSURE			in. HG (abs)	61.3	59.1	52.2
COMPRESSOR OUT TEMPERATURE			°F	268	240	202
AFTERCOOLER AIR OUT TEMPERATURE			°F	129	129	129
INLET MAN. PRESSURE		(8)	in. HG (abs)	58.7	49.6	40
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(9)	°F	134	133	133
TIMING		(10)	°BTDC	23	23	23
EXHAUST STACK TEMPERATURE		(11)	°F	864	840	793
EXHAUST GAS FLOW (@ stack temp.)		(12)	CFM	4267	3350	2489
EXHAUST MASS FLOW		(12)	lb/hr	7291	5829	4501

EMISSIONS DATA					
NOx (as NO2)	(13)	g/bhp-hr	24.22	21.29	16.97
CO	(14)	g/bhp-hr	1.16	1.25	1.32
THC (molecular weight of 15.84)	(14)	g/bhp-hr	1.42	1.54	2.06
NMHC (molecular weight of 15.84)	(14)	g/bhp-hr	0.22	0.24	0.31
EXHAUST O2	(15)	% DRY	2.0	1.6	1.3
LAMBDA			1.09	1.10	1.16

HEAT BALANCE DATA					
LHV INPUT	(16)	BTU/min	131833	104073	76110
HEAT REJECTION TO JACKET (JW)	(17) (22)	BTU/min	44248	36955	29044
HEAT REJECTION TO ATMOSPHERE	(18)	BTU/min	4554	3795	3037
HEAT REJECTION TO LUBE OIL (OC)	(19) (22)	BTU/min	6599	5511	4332
HEAT REJECTION TO EXHAUST (LHV to 77°F)	(20)	BTU/min	26959	20896	15158
HEAT REJECTION TO EXHAUST (LHV to 350°F)	(20)	BTU/min	17245	13127	9102
HEAT REJECTION TO A/C (AC)	(21) (23)	BTU/min	3853	2457	1242
HEAT REJECTION TO ENGINE PUMPS		BTU/min	977.2	977.2	977.2

CONDITIONS AND DEFINITIONS

ENGINE RATING OBTAINED AND PRESENTED IN ACCORDANCE WITH ISO 3046/1STD. REF. CONDITIONS OF 77°F, 29.6 IN HG BAROMETRIC PRESSURE, 500 FT ALTITUDE). NO OVERLOAD PERMITTED AT RATING SHOWN. CONSULT ALTITUDE CHARTS FOR APPLICATIONS ABOVE MAXIMUM RATED ALTITUDE AND/OR TEMPERATURE.

EMISSION LEVELS ARE BASED ON THE ENGINE OPERATING AT STEADY STATE CONDITIONS. EMISSION TOLERANCES SPECIFIED ARE DEPENDANT UPON FUEL QUALITY. METHANE NUMBER CANNOT VARY MORE THAN ± 3. PUBLISHED PART LOAD DATA MAY REQUIRE ENGINE ADJUSTMENT.

ENGINE RATING IS WITH 2 ENGINE DRIVEN WATER PUMPS.

FOR NOTES INFORMATION CONSULT PAGE THREE.

DM5144-01 PAGE 1 OF 3 14-Oct-08

G3516 GAS ENGINE TECHNICAL DATA CATERPILLAR®

FUEL USAGE GUIDE

CAT METHANE NUMBER	<30	30	35	40	45	50	55	60	65	70	75	80-100
IGNITION TIMING	-	14	15	16	17	14	15	16	16	18	20	23
DERATION FACTOR	0	0.59	0.59	0.59	0.59	9.00	9.00	9.00	1.00	1.00	1.00	1.00

ALTITUDE DERATION FACTORS

AIR TO TURBO (°F)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.00	1.00	1.00	0.98	0.95	0.91	0.88	0.84	0.81	0.78	0.75	0.72	0.69
120	1.00	1.00	1.00	1.00	0.96	0.93	0.89	0.86	0.82	0.79	0.76	0.73	0.70
110	1.00	1.00	1.00	1.00	0.98	0.94	0.91	0.87	0.84	0.80	0.77	0.74	0.71
100	1.00	1.00	1.00	1.00	1.00	0.96	0.92	0.89	0.85	0.82	0.79	0.75	0.72
90	1.00	1.00	1.00	1.00	1.00	0.98	0.94	0.90	0.87	0.83	0.80	0.77	0.74
80	1.00	1.00	1.00	1.00	1.00	0.99	0.96	0.92	0.88	0.85	0.81	0.78	0.75
70	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.94	0.90	0.86	0.83	0.80	0.76
60	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.95	0.92	0.88	0.85	0.81	0.78
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.94	0.90	0.86	0.83	0.79

ALTITUDE (FEET ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS (ACHRF)

AIR TO TURBO (°F)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.48	1.56	1.64	1.73	1.82	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
120	1.38	1.46	1.54	1.63	1.71	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
110	1.28	1.36	1.44	1.53	1.61	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
100	1.19	1.26	1.34	1.43	1.51	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
90	1.09	1.17	1.24	1.32	1.41	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
80	1.00	1.07	1.14	1.22	1.30	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
70	1.00	1.00	1.04	1.12	1.20	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
60	1.00	1.00	1.00	1.02	1.10	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
50	1.00	1.00	1.00	1.00	1.00	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07

ALTITUDE (FEET ABOVE SEA LEVEL)

FREE FIELD MECHANICAL & EXHAUST NOISE

100% Load Data			dB(A)	(dB)							
			Overal SPL	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 khz
Free Field Mechanical	DISTANCE FROM THE ENGINE (FEET)	3.2	96.3	95.5	92.1	86.3	87.3	90.0	91.6	88.4	80.0
		22.9	86.7	85.9	82.5	76.7	77.7	80.4	82.0	78.8	70.4
		49.2	81.3	80.6	77.2	71.4	72.4	75.1	76.7	73.5	65.0
Free Field Exhaust	DISTANCE FROM THE ENGINE (FEET)	4.9	111.6	99.8	103.6	105.7	102.2	103.0	105.1	106.9	100.3
		22.9	98.3	89.5	91.8	93.2	89.6	92.0	91.8	92.2	85.2
		49.2	91.6	82.9	85.2	86.6	83.0	85.4	85.2	85.6	78.5

Octave Band Center Frequency (OBCF)

FUEL USAGE GUIDE:
This table shows the derate factor required for a given fuel. Note that deration occurs as the methane number decreases. Methane number is a scale to measure detonation characteristics of various fuels. The methane number of a fuel is determined by using the Caterpillar Methane Number Calculation program.

ALTITUDE DERATION FACTORS:
This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

ACTUAL ENGINE RATING:
It is important to note that the Altitude/Temperature deration and the Fuel Usage Guide deration are not cumulative. They are not to be added together. The same is true for the Low Energy Fuel deration (reference the Caterpillar Methane Number Program) and the Fuel Usage Guide deration. However, the Altitude/Temperature deration and Low Energy Fuel deration are cumulative; and they must be added together in the method shown below. To determine the actual power available, take the lowest rating between 1) and 2).

1) (Altitude/Temperature Deration) + (Low Energy Fuel Deration)
2) Fuel Usage Guide Deration

Note: For NA's always add the Low Energy Fuel deration to the Altitude/Temperature deration. For TA engines only add the Low Energy Fuel deration to the Altitude/Temperature deration whenever the Altitude/Temperature deration is less than 1.0 (100%). This will give the actual rating for the engine at the conditions specified.

AFTERCOOLER HEAT REJECTION FACTORS (ACHRF):
Aftercooler heat rejection is given for standard conditions of 77°F and 500 ft altitude. To maintain a constant air inlet manifold temperature, as the air to turbo temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor (ACHRF) to adjust for ambient and altitude conditions. Multiply this factor by the standard aftercooler heat rejection. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail.

SOUND DATA:
Data determined by methods similar to ISO Standard DIS-8528-10, Accuracy Grade 3. SPL = Sound Pressure Level.

DM5144-01 PAGE 2 OF 3 14-Oct-08

G3516 **GAS ENGINE TECHNICAL DATA** CATERPILLAR®

NOTES

1 ENGINE RATING IS WITH 2 ENGINE DRIVEN WATER PUMPS. TOLERANCE IS ± 3% OF FULL LOAD.

2 GENERATOR POWER DETERMINED WITH AN ASSUMED GENERATOR EFFICIENCY OF 94.27% AND POWER FACTOR OF 0.8 [GENERATOR POWER = ENGINE POWER x GENERATOR EFFICIENCY].

3 ISO 3046/1 ENGINE EFFICIENCY TOLERANCE IS (+)0, (-)5% OF FULL LOAD % EFFICIENCY VALUE. NOMINAL ENGINE EFFICIENCY TOLERANCE IS ± 5% OF FULL LOAD % EFFICIENCY VALUE.

4 THERMAL EFFICIENCY: JACKET HEAT + LUBE OIL HEAT + EXH. HEAT TO 350°F.

5 TOTAL EFFICIENCY = ENGINE EFF. + THERMAL EFF. TOLERANCE IS ± 10% OF FULL LOAD DATA.

6 ISO 3046/1 FUEL CONSUMPTION TOLERANCE IS (+)5, (-)0% OF FULL LOAD DATA. NOMINAL FUEL CONSUMPTION TOLERANCE IS ± 5 % OF FULL LOAD DATA.

7 UNDRIED AIR. FLOW TOLERANCE IS ± 5 %

8 INLET MANIFOLD PRESSURE TOLERANCE IS ± 5 %

9 INLET MANIFOLD TEMPERATURE TOLERANCE IS ± 9°F.

10 TIMING INDICATED IS FOR USE WITH THE MINIMUM FUEL METHANE NUMBER SPECIFIED. CONSULT THE APPROPRIATE FUEL USAGE GUIDE FOR TIMING AT OTHER METHANE NUMBERS.

11 EXHAUST STACK TEMPERATURE TOLERANCE IS (+)63°F, (-)54°F.

12 WET EXHAUST. FLOW TOLERANCE IS ± 6 %

13 NOX VALUES ARE "NOT TO EXCEED".

14 CO, CO2, THC, and NMHC VALUES ARE "NOT TO EXCEED".

15 O2% TOLERANCE IS ± 0.5.

16 LHV INPUT TOLERANCE IS ± 5%.

17 HEAT REJECTION TO JACKET TOLERANCE IS ± 10 % OF FULL LOAD DATA, BASED ON TREATED WATER.

18 HEAT REJECTION TO ATMOSPHERE TOLERANCE IS ± 50% OF FULL LOAD DATA, BASED ON TREATED WATER.

19 HEAT REJECTION OF LUBE OIL TOLERANCE IS ± 20% OF FULL LOAD DATA, BASED ON TREATED WATER.

20 HEAT REJECTION TO EXHAUST TOLERANCE IS ± 10% OF FULL LOAD DATA, BASED ON TREATED WATER.

21 HEAT REJECTION TO A/C TOLERANCE IS ± 5 % OF FULL LOAD DATA, BASED ON TREATED WATER.

SITE SPECIFIC COOLING SYSTEM SIZING EQUATIONS (WITH TOLERANCES)

22 TOTAL JACKET CIRCUIT (JW+OC) = (JW x 1.1) + (OC x 1.2).

23 TOTAL AFTERCOOLER CIRCUIT (AC) = AC x ACHRF x 1.05.

DM5144-01 **PAGE 3 OF 3** **14-Oct-08**

CATERPILLAR®

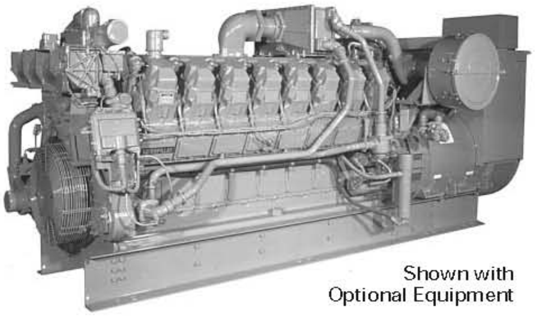
Gas Generator Set

G3516

1800 rpm

1040 ekW 60 Hz

Standby Power



Shown with Optional Equipment

CATERPILLAR® ENGINE SPECIFICATIONS

V-16, 4-Stroke-Cycle Spark-Ignited

Bore — in (mm)	6.7 (170)
Stroke — in (mm)	7.5 (190)
Displacement — cu in (L)	4210 (67.4)
Aspiration	Turbocharged-Aftercooled
Compression ratio	11:1

ISO 9001 CERTIFIED — ENGINE FACILITIES

FEATURES

- **CATERPILLAR® FACTORY PACKAGE**
  Factory designed, assembled, and tested. Supported by Caterpillar parts and labor warranty through your local Caterpillar dealer.
- **DIESEL STRENGTH BUILT IN**
  Blocks, crankshafts, liners, and connecting rods are common with higher loaded Cat® diesel engines. Robust design provides prolonged life at lower gas engine loads.
- **ELECTRONIC IGNITION SYSTEM WITH DETONATION SENSITIVE TIMING**
  The Caterpillar Electronic Ignition System (EIS) provides optimized spark timing for all operating conditions. Timing is automatically controlled to maintain continuous detonation protection.
- **LOW EXHAUST EMISSIONS**
  2.0 gram/bhp-hr NO_X. Lower emissions are achievable for selected applications; consult your Caterpillar dealer.

CATERPILLAR® SR4B GENERATOR

Type	Static regulator, brushless excited
Construction	Single bearing, close coupled
Three phase	Wye connected
Insulation	Class H
Enclosure	Drip proof IP/22, guarded
Alignment	Caterpillar pilot shaft
Overspeed capability	150%
Waveform	Less than 5% deviation
Voltage regulator	3-phase sensing with Volts-per-Hertz response
Voltage regulation	Less than ± 1%
Voltage gain	Adjustable to compensate for engine speed droop and line loss
TIF	Less than 50
THF	Less than 5%

CATERPILLAR CONTROL PANEL

24 Volt DC Control

Terminal box mounted
Vibration isolated
NEMA 1/IP 22 enclosure
Electrically dead front
Lockable door
Generator instruments meet ANSI C-39-1

Voltages Available
60 Hz
240, 480

(Adjustable a minimum of ±10%)
Other voltages available – consult your Caterpillar dealer.
Some voltages require derating.

CATERPILLAR®

G3516 GAS GENERATOR SET

STANDARD EQUIPMENT

Engine
Air cleaner with service indicator
Breather, crankcase
Cooler, lubricating oil
EMCP II, generator control, engine start/stop logic
Filter, lubricating oil, RH
Flywheel housing, SAE No. 0
Governor, Woodward 2301A
Ignition system, Caterpillar EIS
Instrument panel, RH
intake manifold pressure, intake manifold temperature, oil pressure differential, exhaust pyrometer, and thermocouples
Jacket water heater
Lifting eyes
Manifold, exhaust, watercooled
Paint, Caterpillar yellow
Protection devices
Pumps,
aftercooler water, lubricating oil, jacket water, gear driven
Rails, mounting, 13 inch
SAE standard rotation
Thermostats and housing
Torsional vibration damper
Valve, 24V gas shutoff

Generator
All metal components are plated or painted
Optimum winding pitch for minimum total harmonic distortion
Self excitation (300% short circuit current)
Standards: meets or exceeds the requirements of IEC 34-1, NEMA MG1-22, BS4999, VDE0530, UTE5100, CSA 22.2, ISO 8528-3
Three-phase sensing automatic voltage regulator
VR3 voltage regulator
Wet layer wound rotors individually tested to 125% overspeed; prototypes to 150% @ 338° F (170° C)
Windings coated with a fungus-resistant varnish

OPTIONAL EQUIPMENT

Engine
Battery chargers
Battery, rack, and cables
Air inlet adapters
Customer Communications Module (CCM)
Exhaust fittings
Muffler
Power takeoffs
Prelube pump
Lube oil

Generator
DVR – Digital Voltage Regulator, adjustable volts/H_3 regulation for large block loads. Diode monitor, under- and over-voltage protection
Extra dips and bakes of insulating resins
Manual voltage control
RFI filter – 82/499/EEC, VDE 875/10.84 A2 Level N, BS800 standards, and MIL-STD-461B (conducted, radiated, and susceptibility
VR3F for enhanced transient response and block loading
Permanent magnet excitation

ENGINE AND GENERATOR CONTROLS

The EMCP II comes complete with many control features competitive manufacturers only offer as options.

Standard Features
Adjustable purge cycle from 0-20 seconds (factory set at 5 seconds)
Auto start-stop engine control with programmable safety shutdowns
Cooldown timer, adjustable from 0 to 30 minutes
Cycle cranking, with adjustable crank/rest periods of 1 to 60 seconds
Delayed ignition (magneto) "kill" after gas valve is closed. Five second delay
Emergency stop button
Flashing LED indicators for protection and diagnostics, including: low oil pressure, high coolant temperature, low coolant level (when optional coolant sensor is installed), overspeed, overcrank, emergency stop, fault shutdown, spare fault alarm
Generator voltage adjust potentiometer
Indicator/display test switch
LCD digital readout for: engine oil pressure, coolant temperature, engine rpm, system DC volts, generator AC volts and amps, and generator frequency
NEMA 1/IP 22 enclosure
Programmable for energize to shutoff or energize to run
Spare alarm and fault inputs for customer use

Optional Features
Alarm modules and remote annunciators to meet NFPA 99 or NFPA 110 codes
Auxiliary relay
Coolant loss sensor
Customer interface module
Dustproof enclosure
Frequency adjust potentiometer
Panel lights
Reverse power relay
Synchronizing modules

G3516 GAS GENERATOR SET

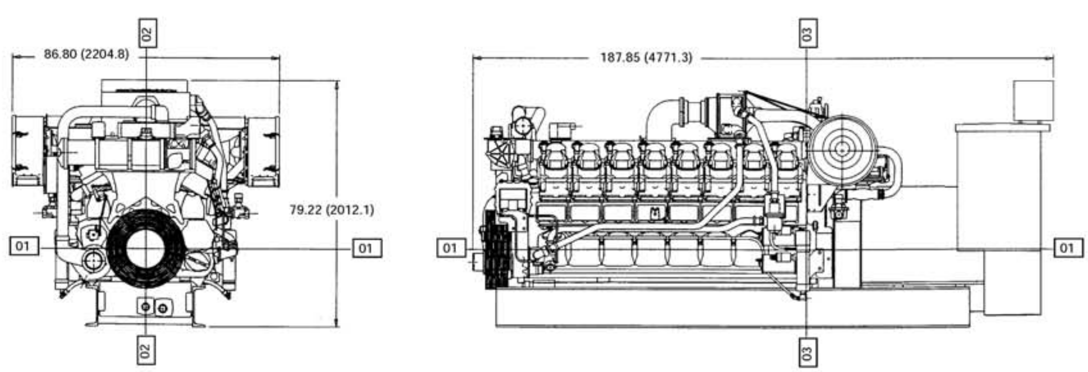
CATERPILLAR®

TECHNICAL DATA

G3516 LE Standby Power Gas Generator Sets — 1800 rpm		
Power Rating @ 0.8 PF without Fan	ekW kV•A	1040 1300
Generator Frame Size		693
Engine Lubricating Oil Capacity	gal	106
System Backpressure (Max Allowable)	in water	27
Exhaust Flange Size — (Internal Diameter)	in	7.1
Length	in	187.9
Width	in	86.8
Height	in	79.2
Shipping Weight	lbs	20 560
Engine Coolant Capacity with Radiator	gal	
100% Load Fuel Consumption (100% load) with Fan per ISO3046/1: +5%, -0% tolerance	BTU/bhp-hr	7899
Motor Starting (35% voltage dip)	SkVA (volt)	2626 (480)
Combustion Air Inlet Flow Rate	ft^3/min	3435
Exhaust Gas Flow Rate (at stack temp)	ft^3/min	8583
Heat Rejection to Aftercooler	BTU/min	9746
Heat Rejection to Exhaust (total)	BTU/min	54 853
Heat Rejection to Jacket Water (total)	BTU/min	58 557
Heat Rejection to Atmosphere from Engine	BTU/min	7155
Heat Rejection to Atmosphere from Generator	BTU/min	2821
Exhaust Gas Stack Temperature	Deg F	1603
Deration for Engine Altitude – 3.5% per 500 feet above 2% per 10° F above	 ft Deg F	 4000 77
* Note: For permitting see TMI data.		

CATERPILLAR®

G3516 GAS GENERATOR SET



01	Centerline of Crankshaft
02	Centerline of Engine
03	Rear Face of Cylinder Block

See general dimension drawing 127-8351 for additional information.

Dimensions are in in (mm).

Note: General configuration not to be used for installation.

RATINGS DEFINITIONS AND CONDITIONS

Ratings are based on SAE J1349 standard conditions of 29.61 in Hg (100 kPa) and 77° F (25° C). These ratings also apply at ISO3046/1, DIN6271, and BS5514 standard conditions of 29.61 in Hg (100 kPa) and 81° F (27° C); and API 7B-11C standard conditions of 29.38 in Hg (99 kPa) and 85° F (29° C) also apply.

Ratings are based on dry natural gas having a low heat value of 905 btu/ft^3 (35.22 MJ/m^3). Variations in altitude, temperature, and gas composition from standard conditions may require a reduction in engine horsepower.

Turbocharged-aftercooled ratings apply to 4000 ft (1525 m) and 77° F (25° C). For applications which exceed these limits consult your Caterpillar dealer.

Standby — Output available with varying load for the duration of the interruption of the normal source power. Fuel stop power in accordance with ISO3046/1, AS2789, DIN6271, and BS5514.

Additional ratings may be available for specific customer requirements. Consult your Caterpillar representative for details.

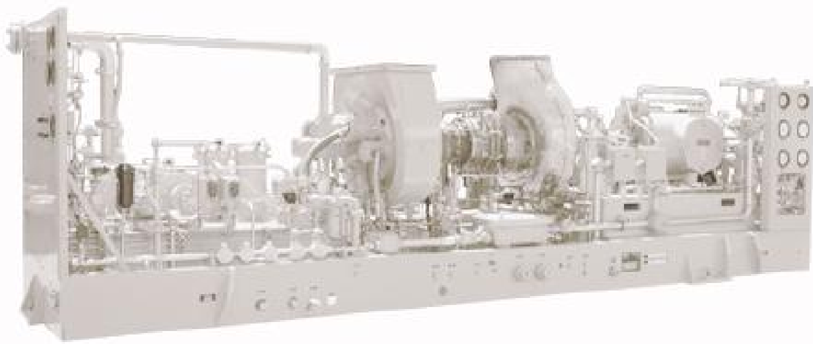
Materials and specifications are subject to change without notice. The International System of Units (SI) is used in this publication.

LEHX7576

Solar Turbines
A Caterpillar Company

SATURN 20
Gas Turbine Compressor Set

Oil & Gas Applications



General Specifications

Saturn® 20 Gas Turbine

- Industrial, Two-Shaft
- Axial Compressor
  - 8-Stage
  - Pressure Ratio: 6.7:1
  - Inlet Airflow: 6.4 kg/sec (14.2 lb/sec)
- Combustion Chamber
  - Annular-Type
  - 12 Fuel Injectors
  - Torch Ignitor System
- Gas Producer Turbine
  - 2-Stage, Reaction
  - Max. Speed: 15,000 rpm
- Power Turbine
  - 1-Stage, Reaction
  - Max. Speed: 22,300 rpm
- Bearings
  - Journal: Multi-Ramp Sleeve
  - Thrust: Fixed Tapered Land
- Coatings
  - Compressor: Inorganic Aluminum
  - Turbine and Nozzle Blades: Precious Metal Diffusion Aluminide
- Velocity Vibration Transducer

Key Packages Features

- Base Frame with Drip Pans
- Compressor
  - Compressor Auxiliary Systems
- 316L Stainless Steel Piping ≤4" dia
- Compression-Type Tube Fittings
- Digital Gauge Panel
  - Fluid Gauges
  - Electrical System Options
  - NEC, Class I, Group D, Div. 1
  - CENELEC, Zone 1
- *Turbotronic™* Microprocessor Control System
  - Freestanding Control Console
  - Color Video Display
  - Vibration Monitoring
- Control Options
  - 24-VDC Control Battery/Charger System
  - Turbine and Package Temperature Monitoring
  - Serial Link Supervisory Interface
  - Turbine Performance Map
  - Compressor Performance Map
  - Historical Displays
  - Printer/Logger
  - Process Controls
  - Compressor Anti-Surge Control
  - Field Programming
- Start Systems
  - Pneumatic
  - Direct-Drive AC
- Fuel System
  - Natural Gas
- Integrated Lube Oil System
  - Turbine-Driven Accessories
  - Tank Vent Separator
  - Flame Trap
- Oil System Options
  - Oil Cooler
  - Oil Heater
- Axial Compressor Cleaning Systems
  - On-Crank/On-Line
  - Cleaning Tank
- Gearbox (if applicable)
  - Speed Increaser
  - Speed Decreaser
- Air Inlet and Exhaust System Options
- Enclosure and Associated Options
- Factory Testing of Turbine and Package
- Documentation
  - Drawings
  - Quality Control Data Book
  - Inspection and Test Plan
  - Test Reports
  - Operation and Maintenance Manuals

Solar Turbines
A Caterpillar Company

SATURN 20
Gas Turbine Compressor Set

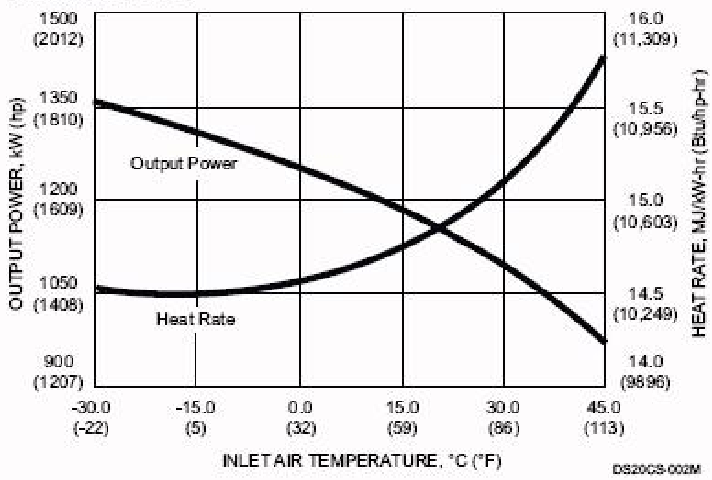
Oil & Gas Applications

Performance

Output Power	1185 kW (1590 hp)
Heat Rate	14 670 kJ/kW-hr (10,370 Btu/hp-hr)
Exhaust Flow	23 410 kg/hr (51,615 lb/hr)
Exhaust Temp.	520°C (970°F)

Nominal Rating – per ISO
At 15°C (59°F), at sea level
No inlet/exhaust losses
Relative humidity 60%
Natural gas fuel with
LHV = 35 MJ/nm³ (940 Btu/scf)
Optimum power turbine speed
AC-driven accessories
Engine efficiency: 24.5%

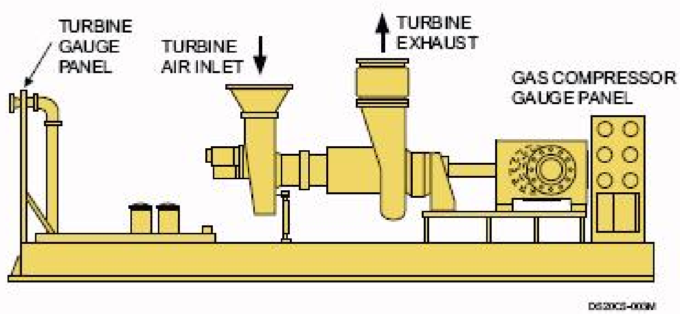
Available Power



Package Dimensions*

Length: 4.7 m (15' 4")
Width: 1.9 m (6' 1")
Height: 2.0 m (6' 8")
Typical Weight: 6805 kg (15,000 lb)

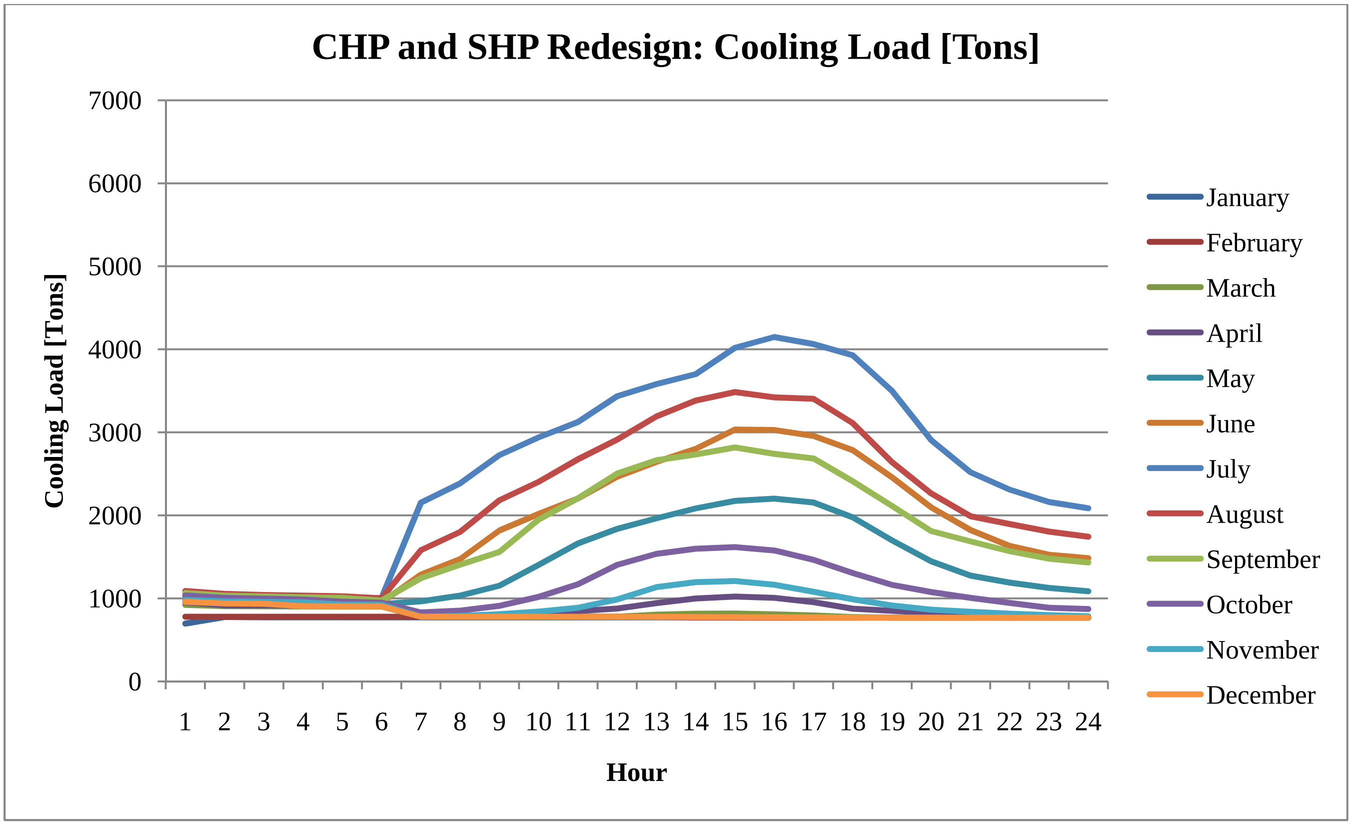
*Driver package only

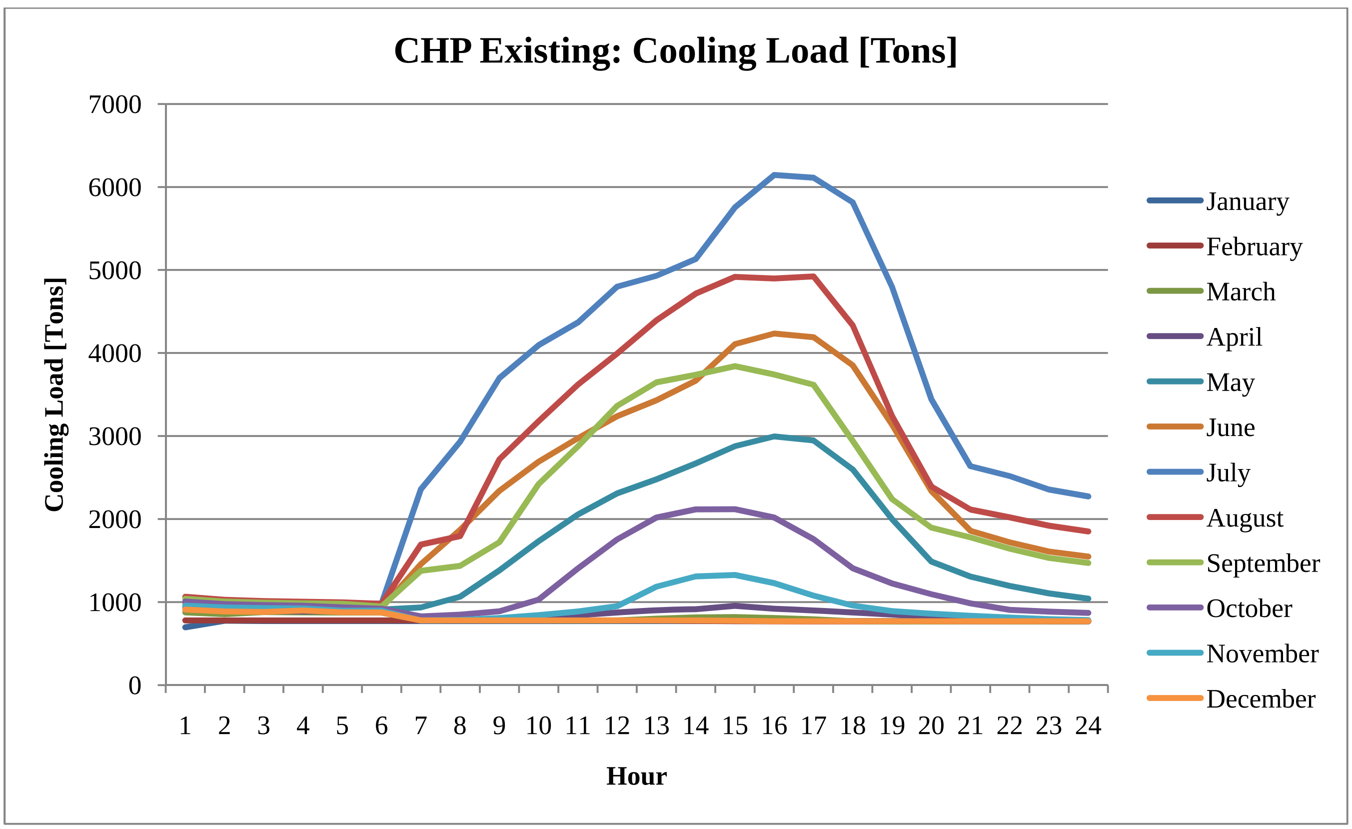


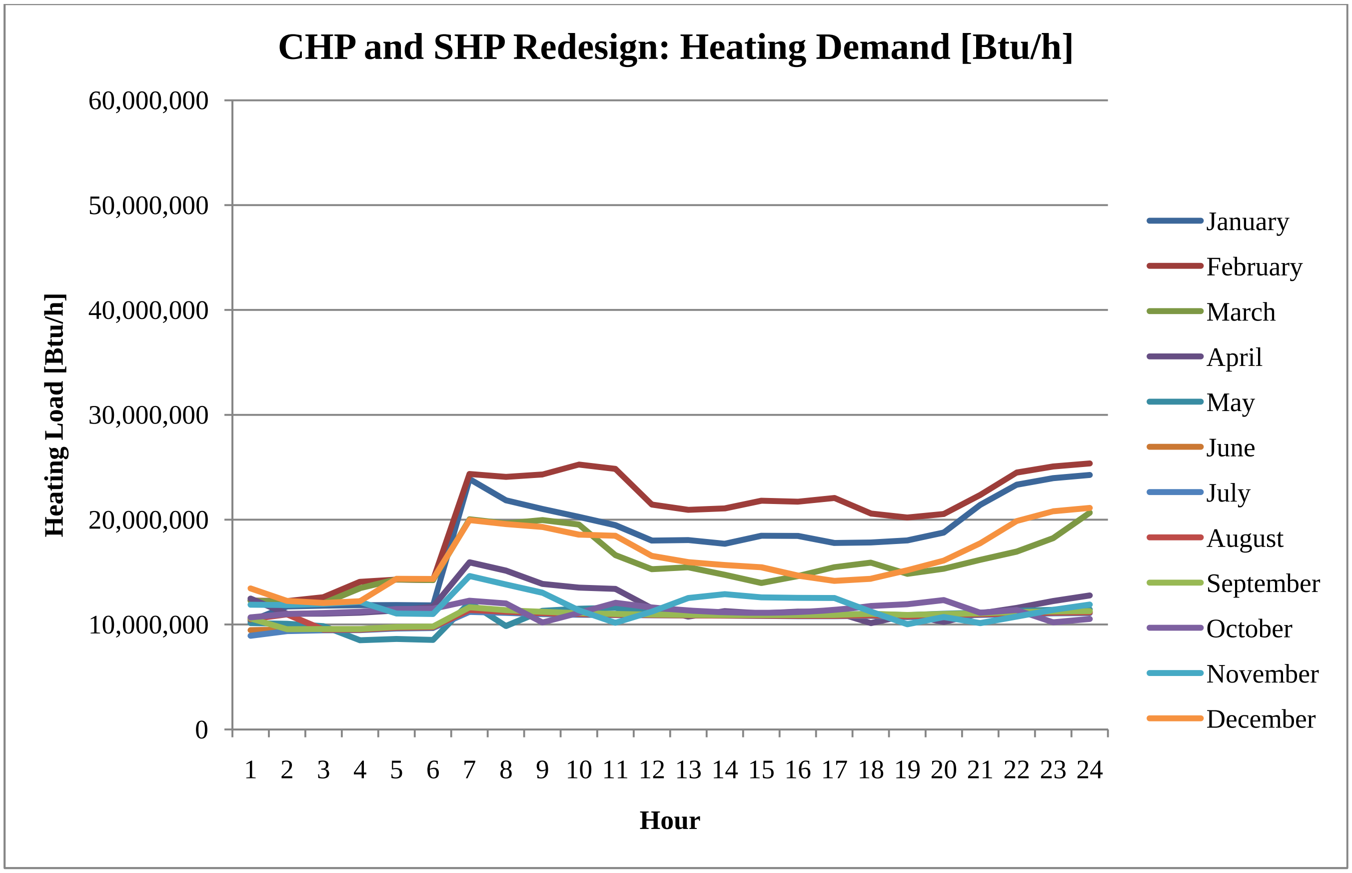
Solar Turbines Incorporated
P.O. Box 85376
San Diego, CA 92186-5376

FOR MORE INFORMATION
Telephone: (+1) 619-544-5352
Internet: www.solarturbines.com

APPENDIX II.C: RESULTS FROM DETAILED CHP SIMULATION


CHP and SHP Redesign: Cooling Load [Tons]
Cooling Load [Tons]
0
1000
2000
3000
4000
5000
6000
7000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December


CHP Existing: Cooling Load [Tons]
Cooling Load [Tons]
0
1000
2000
3000
4000
5000
6000
7000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
April
May
June
July
August
September
October
November
December


CHP and SHP Redesign: Heating Demand [Btu/h]
Heating Load [Btu/h]
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
January
February
March
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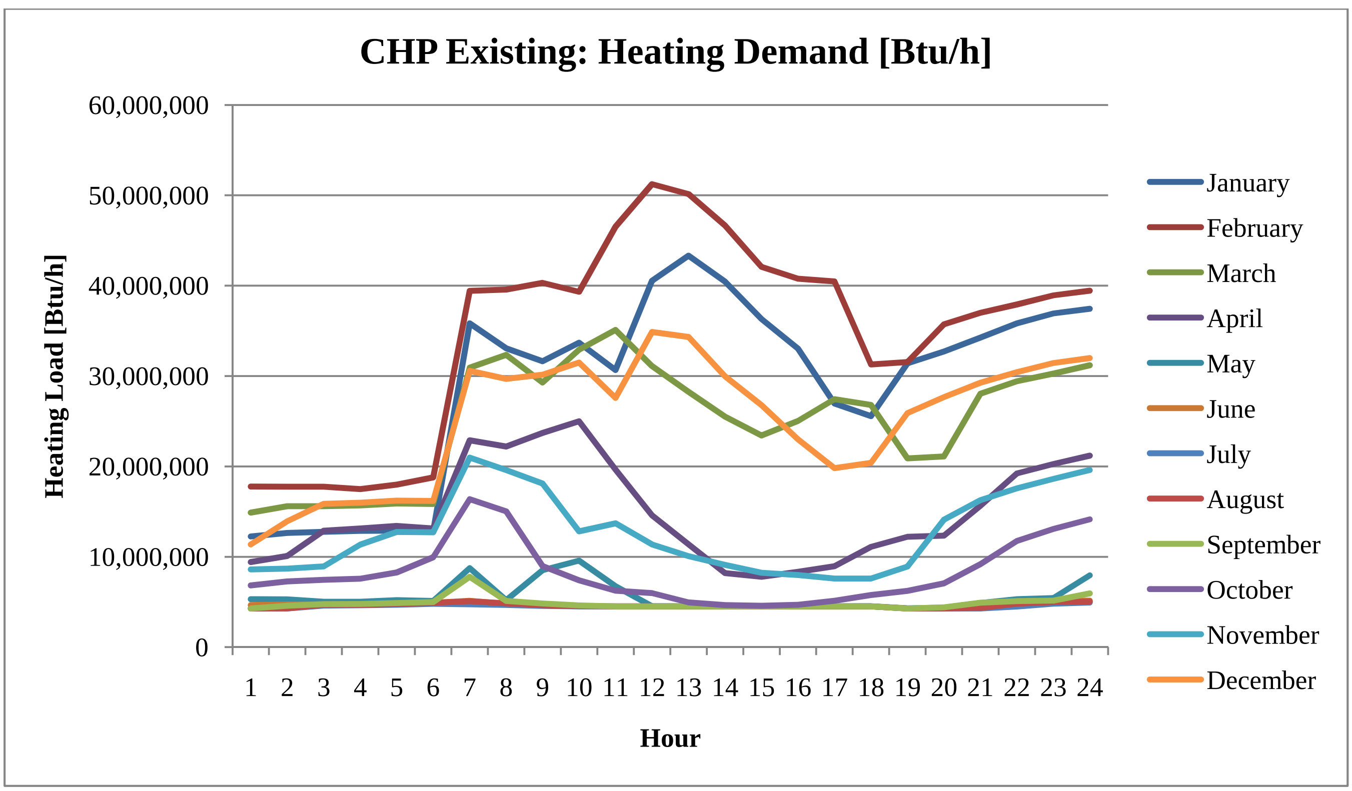
July
August
September
October
November
December


CHP Existing: Heating Demand [Btu/h]
Heating Load [Btu/h]
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
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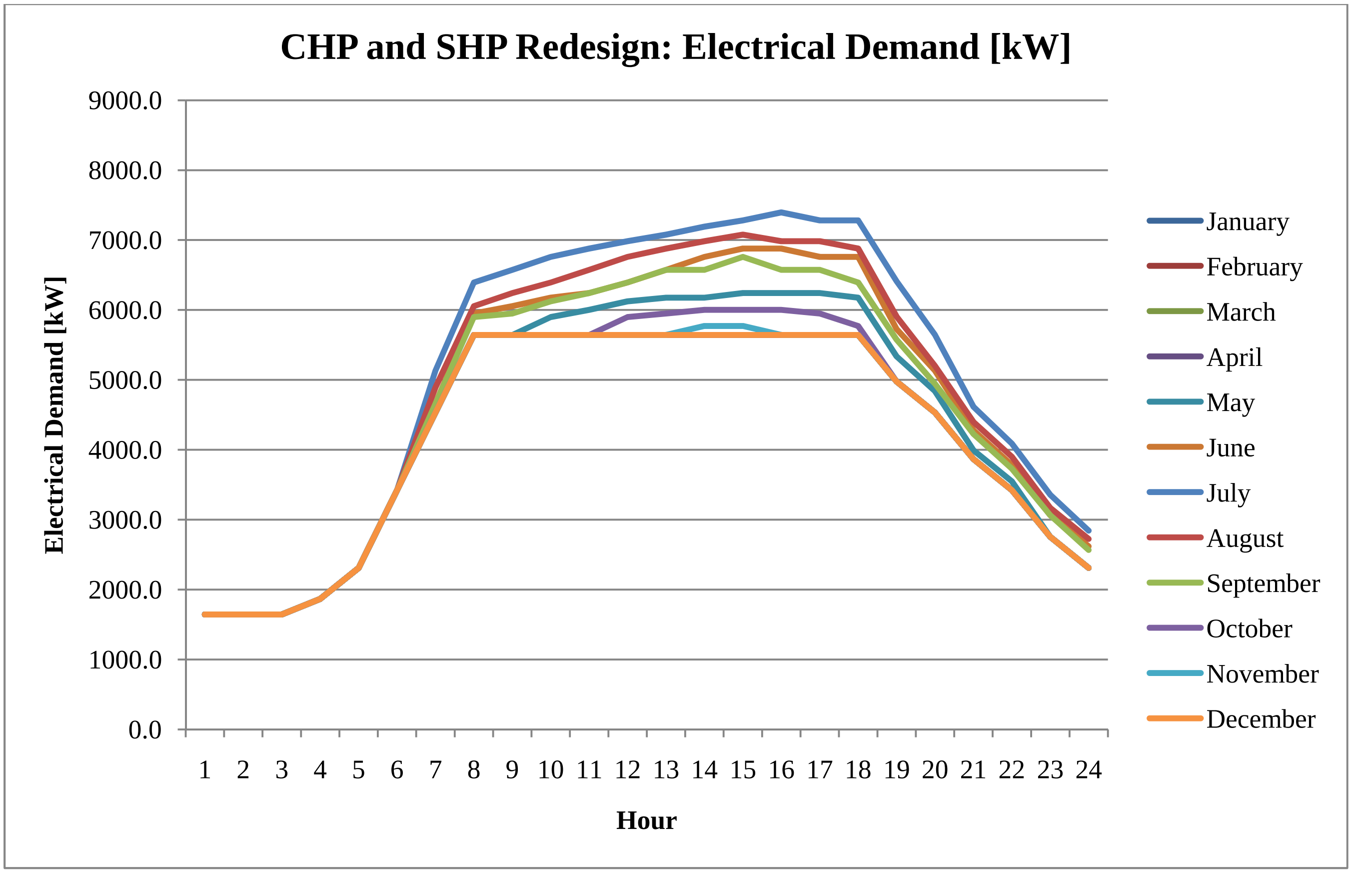
December


CHP and SHP Redesign: Electrical Demand [kW]
Electrical Demand [kW]
9000.0
8000.0
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
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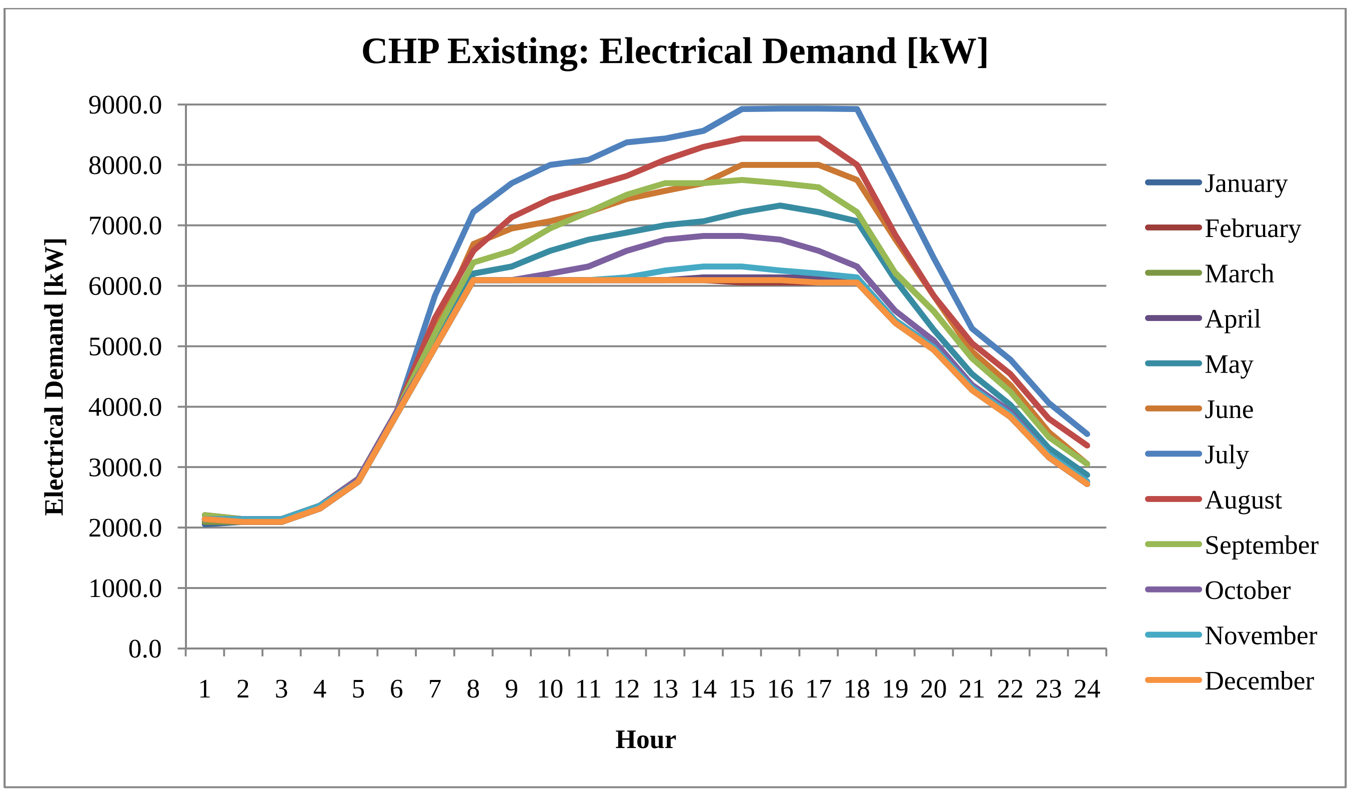
December


CHP Existing: Electrical Demand [kW]
Electrical Demand [kW]
9000.0
8000.0
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
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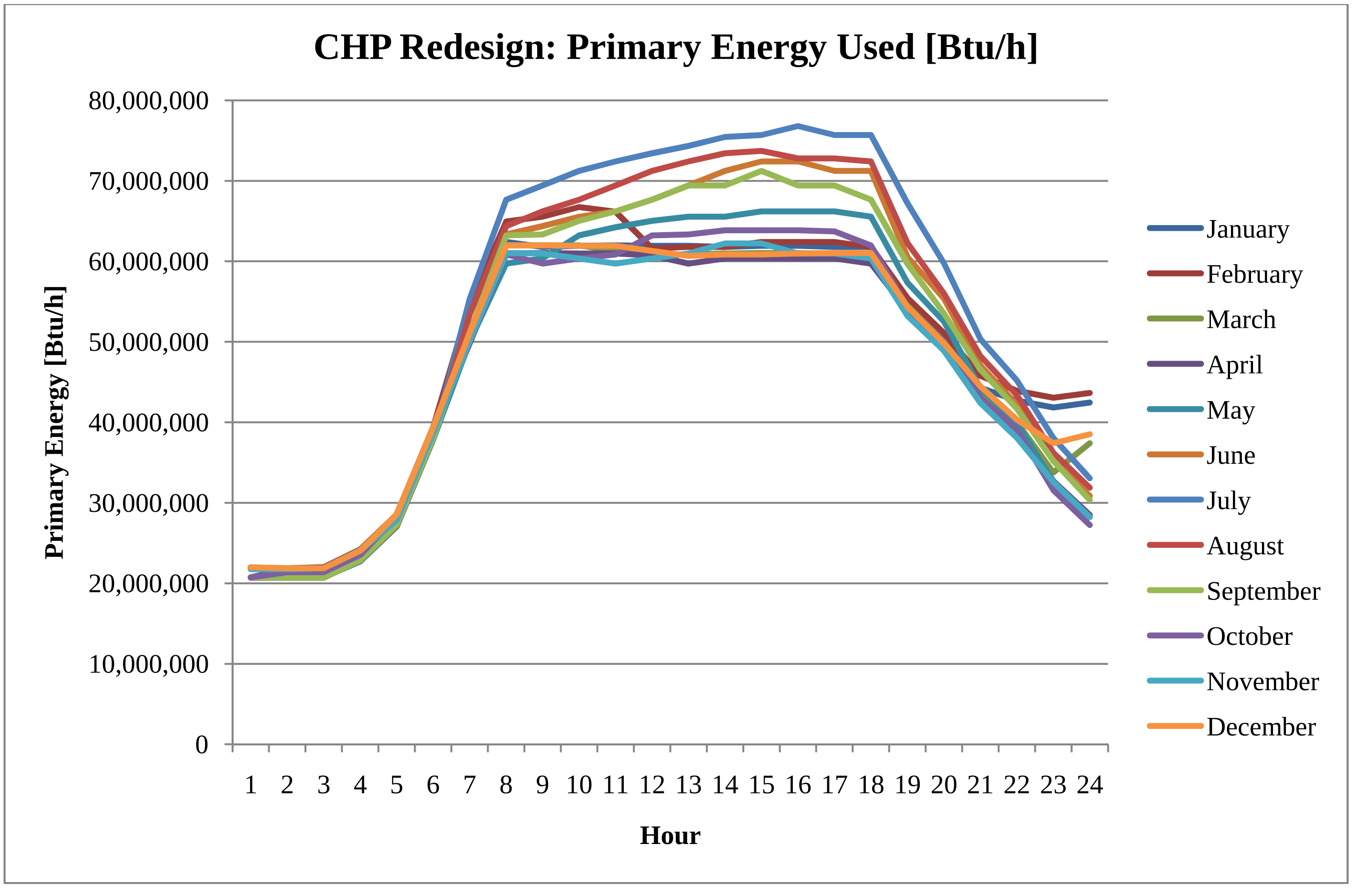
CHP Redesign: Primary Energy Used [Btu/h]
Primary Energy [Btu/h]
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
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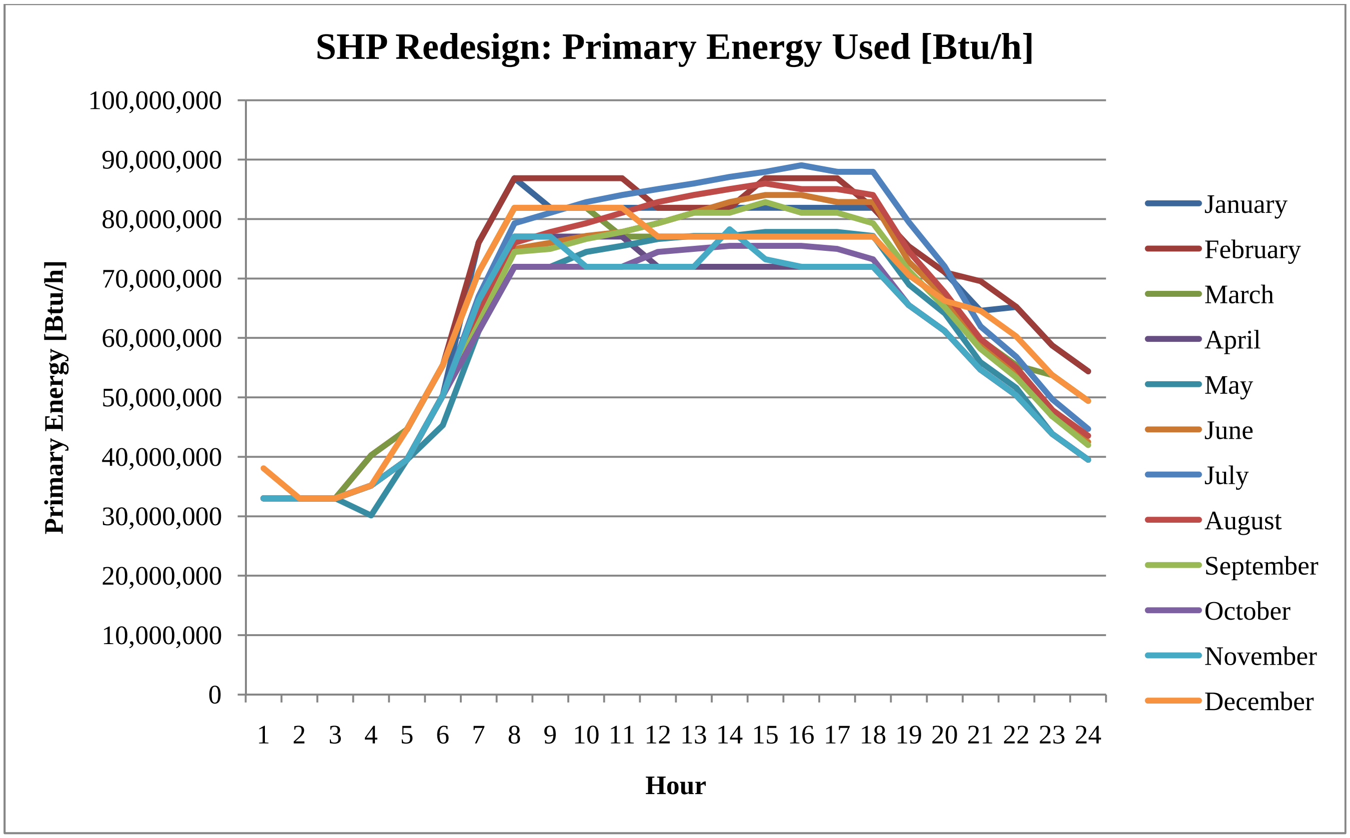
SHP Redesign: Primary Energy Used [Btu/h]
Primary Energy [Btu/h]
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
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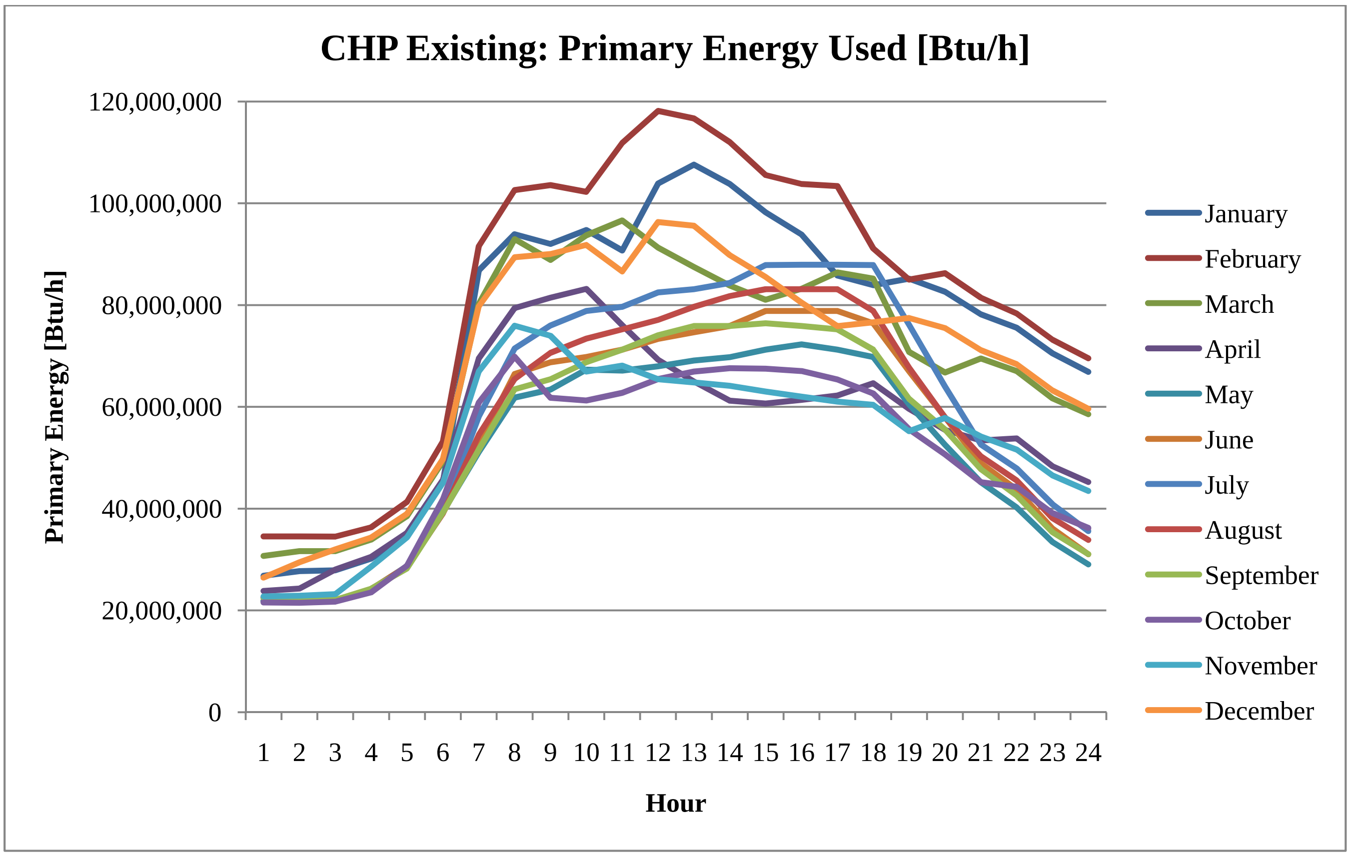
CHP Existing: Primary Energy Used [Btu/h]
Primary Energy [Btu/h]
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
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November
December

APPENDIX II.D: CRANE SELECTION

Manitowoc 16000
Product Guide

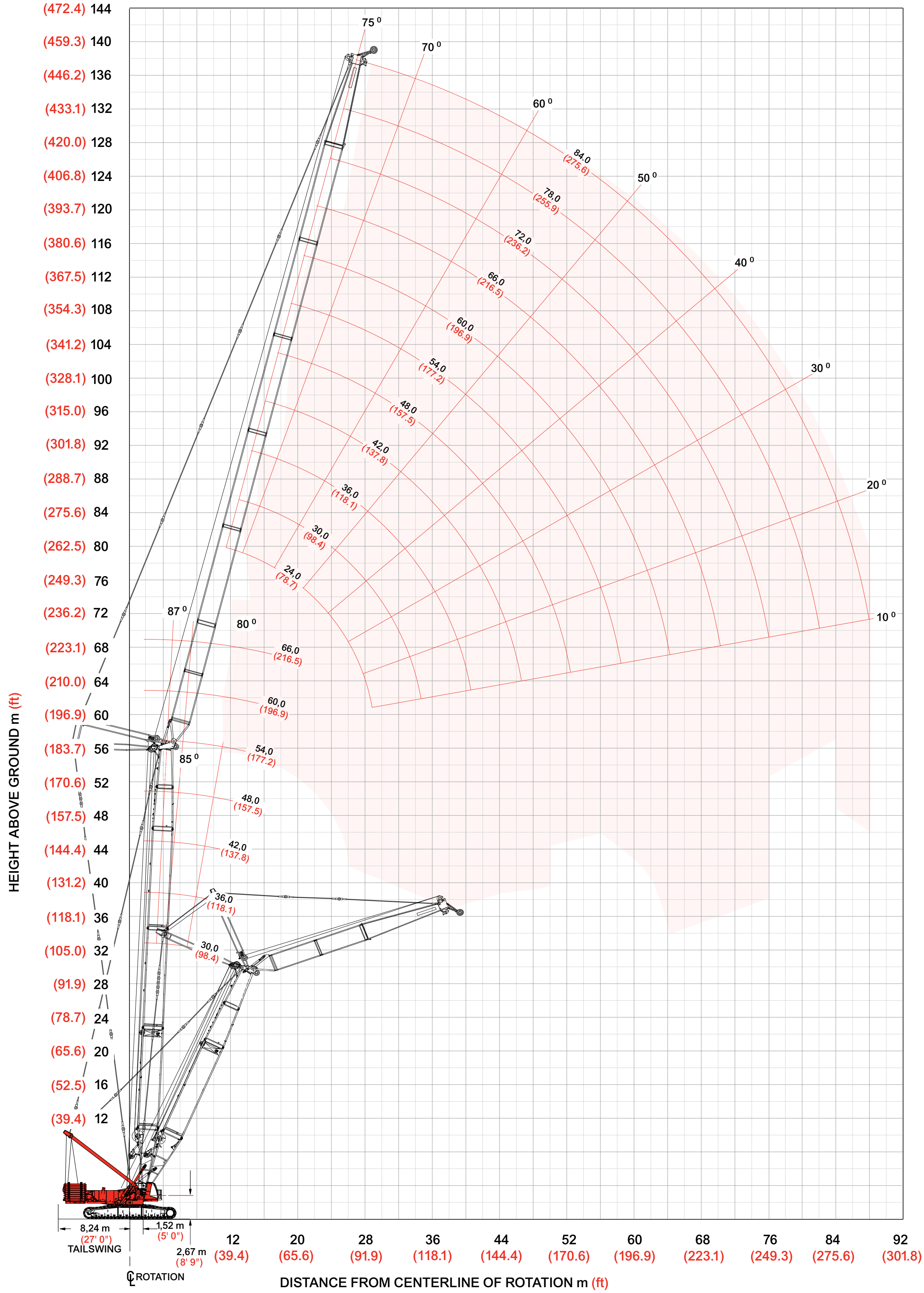
Features

- 400 m-ton (440 ton) capacity
- 2 599 m-ton (18,800 ft-kips) Maximum Load Moment
- 5 066 mton-m (36,405 ft-kips) Maximum Load Moment with MAX-ER®
- 96 m (315’) Heavy-Lift Boom
- 138 m (453’) Luffing Jib on Heavy-Lift Boom
- 372 kW (500 HP) engine

Luffing jib range diagram

ANSI B30.5

Liftcrane Boom Capacities - Model 16000 Series 3
No. 58 Heavy -lift Main Boom with No. 59 Luffing Jib



ANSI B30.5

Liftcrane Boom Capacities - Model 16000 Series 3
No. 59 Luffing Jib on No. 58 Heavy Lift Main Boom

150 590 kg (332,000 lb) Counterweight 54 430 kg (120,000 lb) Carbody Counterweight

360° Rating kg (lb) x 1 000

87° Boom Angle

Luffing Jib Length 24,0 m (78.7 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	66,0 (216.5)
11,6 (38)	185,2 (408.5)			
14,0 (45)	157,7 (354.2)	151,0 (333.0)	117,4 (262.3)	99,6 (222.2)
18,0 (60)	121.1 (260.7)	112,6 (244.8)	97,8 (213.0)	84,8 (184.8)
22,0 (75)	92,7 (194.7)	92,7 (194.5)	82,2 (174.9)	72,3 (154.3)
26,0 (90)	74,6 (147.9)	73,9 (147.8)	69,5 (144.3)	62,1 (129.5)
32,0 (105)				
38,0 (125)				
44,0 (145)				
52,0 (175)				
56,0 (185)				
60,0 (195)				

Luffing Jib Length 36,0 m (118.1 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
15,2 (50)	136,1 (300.2)	116,8 (252.6)		
16,0 (55)	131,2 (278.3)	113,3 (242.0)	— (205.4)	— (194.5)
18,0 (60)	118,9 (258.6)	104,3 (227.5)	89,0 (194.3)	84,5 (184.4)
22,0 (75)	92,3 (193.7)	89,1 (190.3)	77,1 (165.1)	73,3 (157.0)
26,0 (90)	74,4 (153.3)	74,3 (152.9)	67,1 (141.2)	64,0 (134.6)
32,0 (105)	57,0 (125.8)	56,9 (125.5)	55,2 (121.7)	52,5 (115.8)
38,0 (125)	45,6 (100.2)	45,5 (100.0)	44,8 (98.5)	43,0 (94.7)
44,0 (145)				
52,0 (175)				
56,0 (185)				
60,0 (195)				

Luffing Jib Length 48,0 m (157.5 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
18,3 (60)	107,4 (236.8)	92,1 (203.2)		
22,0 (75)	91,9 (191.9)	81,6 (175.1)	70,3 (151.1)	66,6 (142.9)
24,0 (80)	81,6 (176.5)	75,6 (166.8)	66,2 (144.3)	62,6 (136.6)
30,0 (100)	61,2 (132.2)	61,0 (131.8)	55,5 (120.9)	52,6 (144.6)
34,0 (115)	52,0 (110.2)	51,8 (109.9)	49,5 (106.2)	47,0 (100.7)
38,0 (125)	44,9 (98.8)	44,8 (98.6)	44,4 (97.7)	42,0 (92.5)
42,0 (140)	39,3 (85.0)	39,2 (84.8)	39,1 (84.4)	37,6 (81.5)
46,0 (155)	34,8 (74,0)	34,7 (73.8)	34,5 (73.4)	33,7 (71.7)
52,0 (175)				27,0 (54.3)
56,0 (185)				
60,0 (195)				

Luffing Jib Length 60,0 m (196.9 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
21,3 (70)	86,0 (189.7)	73,5 (162.2)		
24,0 (80)	79,1 (172.5)	69,3 (151.1)	58,2 (128.1)	51,8 (114.1)
28,0 (95)	65,9 (139.2)	62,1 (133.6)	53,2 (114.7)	49,6 (107.3)
34,0 (115)	51,1 (108.2)	50,9 (107.8)	45,8 (98.3)	43,2 (92.8)
40,0 (135)	41,1 (87.2)	40,9 (86.9)	39,4 (84.4)	37,2 (79.7)
48,0 (160)	31,9 (69.0)	31,8 (68.7)	31,7 (68.3)	30,4 (65.9)
56,0 (185)	25,6 (55.9)	25,5 (355.7)	35,3 (55.3)	24,9 (54.4)
64,0 (210)	18,4 (40.7)	18,3 (40.5)	18,2 (40.3)	18,1 (40.1
72,0 (240)				
84,0 (280)				
88,0 (290)				

Luffing Jib Length 72,0 m (236.2 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)
21,3 (70)			
24,0 (80)	— (132.1)	— (115.1)	
28,0 (95)	58.3 (127.7)	51,2 (112.4)	43,1 (94.6)
34,0 (115)	49.9 (105.8)	48,2 (103.7)	40,6 (88.0)
40,0 (135)	40.0 (84.8)	39,8 (84.5)	36,3 (78.1)
48,0 (160)	30.9 (66.6)	30.7 (66.3)	30.3 (65.7)
56,0 (185)	24.5 (53.5)	24.4 (53.3)	24.2 (52.9)
64,0 (210)	19.8 (43.7)	19.7 (43.5)	19.5 (43.2)
72,0 (240)	16.1 (34.6)	15,7 (32.5)	15,2 (31.6)
84,0 (280)			
88,0 (290)			

Luffing Jib Length 84,0 m (275.6 ft)

Radius m (ft)	Boom 30,0 (98.4)	42,0 (137.8)	54,0 (177.2)
21,3 (70)			
24,0 (80)			
28,0 (95)	42,6 (93.3)	37,9 (83.3)	— (70.9)
34,0 (115)	40,7 (89.2)	36,7 (80.5)	31,4 (68.9)
40,0 (135)	38,7 (82.5)	35,4 (77.7)	30,0 (65.2)
48,0 (160)	29,8 (64.2)	29,6 (63.9)	26,4 (57.4)
56,0 (185)	23,4 (51.2)	23,3 (50.9)	22,7 (49.8)
64,0 (210)	18,8 (41.5)	18,6 (41.2)	18,5 (40.9)
72,0 (240)	15,2 (32.5)	15,1 (32.3)	14,9 (32.0)
84,0 (280)	10,6 (21.4)	9,6 (19.5)	9,1 (18.4)
88,0 (290)		6,8 (14.2)	6,6 (14.0)

Luffing jib load charts

ANSI B30.5

Liftcrane Boom Capacities - Model 16000 Series 3
No. 59 Luffing Jib on No. 58 Heavy Lift Main Boom

150 590 kg (332,000 lb) Counterweight 54 430 kg (120,000 lb) Carbody Counterweight

360° Rating **kg (lb) x 1 000**

75° Boom Angle

Luffing Jib Length 24,0 m (78.7 ft)

Radius / Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	66,0 (216.5)
24,0 (80)	75,6 (163.2)			
26,0 (90)	68,1 (140.3)	65,0 (133.9)		
28,0 (95)	61,9 (130.9)	59,1 (124.9)		
32,0 (105)	52,1 (114.9)	49,7 (109.7)	46,9 (103.4)	43,5 (96.0)
36,0 (120)		42,5 (91.8)	40,2 (213.0)	37,2 (80.5)
38,0 (125)			37,3 (82.1)	32,3 (76.3)
42,0 (140)				30,2 (65.1)
46,0 (155)				
52,0 (175)				
54,0 (180)				
56,0 (185)				

Luffing Jib Length 36,0 m (118.1 ft)

Radius / Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
24,0 (80)				
26,0 (90)				
28,0 (95)	61,1 (128.9)			
32,0 (105)	51,4 (113.3)	48,7 (107.4)		
36,0 (120)	44,0 (95.2)	41,7 (90.2)	39,1 (84.4)	— (81.0)
38,0 (125)	41,0 (90,3)	38,9 (125.5)	36,3 (79.9)	34,9 (76.7)
42,0 (140)	35,9 (77.5)	34,0 (85.5)	31,8 (68.6)	30,4 (65.8)
46,0 (155)		30,0 (63.7)	28,0 (59.5)	26,8 (57.1)
52,0 (175)				22,4 (47.5)
54,0 (180)				
56,0 (185)				

Luffing Jib Length 48,0 m (157.5 ft)

Radius / Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
34,0 (110)	46,4 (104.2)			
36,0 (120)	43,0 (92.9)	— (87.5)		
38,0 (125)	40,0 (87.9)	37,6 (82.8)		
40,0 (135)	37,3 (79.3)	35,1 (74.6)	32,6 (69.2)	
42,0 (140)	34,9 (75.5)	32,9 (71.0)	30,5 (65.8)	29,1 (62.8)
44,0 (145)	32,8 (71.9)	30,8 (67.6)	28,5 (62.6)	27,2 (59.8)
46,0 (155)	30,8 (65.6)	29,0 (61.6)	26,8 (56.9)	25,6 (54.3)
50,0 (165)	27,4 (60,0)	25,7 (56.3)	23,7 (52.0)	22,6 (49.6)
56,0 (185)	23,2 (50.6)	21,7 (47.5)	20,0 (43.7)	19,0 (41.6)
60,0 (200)		19,5 (41.8)	17,9 (38.6)	17,0 (36.7)
64,0 (215)			16,0 —	15,2 (32.2)

Luffing Jib Length 60,0 m (196.9 ft)

Radius / Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
40,0 (135)	36,1 (76.7)			
44,0 (145)	31,6 (69.4)	29,6 (64.9)		
48,0 (160)	27,9 (60.3)	26,0 (56.2)	23,9 (51.5)	22,7 (48.9)
54,0 (180)	23,5 (50.6)	21,8 (47.0)	19,9 (42.9)	18,8 (40.6)
60,0 (200)	19,9 (42.9)	18,4 (39.8)	16,8 (36.1)	15,8 (34.0)
66,0 (220)	17,0 (36.6)	15,7 (33.8)	14,2 (30.5)	13,3 (28.7)
72,0 (240)		13,4 (28.6)	12,0 (25.8)	11,3 (24.2)
76,0 (250)			10,7 (23.6)	10,0 (22.1)
80,0 (265)				
84,0 (280)				
88,0 (300)				

Luffing Jib Length 72,0 m (236.2 ft)

Radius / Boom m (ft)	30,0 (98.4)	42,0 (137.8)	48,0 (157.5)
40,0 (135)			
44,0 (145)			
48,0 (160)	26,6 (57.4)	24,7 (53.1)	
54,0 (180)	22,2 (47.8)	20,5 (44.1)	19,5 (41.9)
60,0 (200)	18,7 (40.2)	17,1 (36.9)	16,3 (35.0)
66,0 (220)	15,9 (31.4)	14,5 (31.1)	13,6 (29.3)
72,0 (240)	13,5 (28.9)	12,2 (26.2)	11,5 (24.7)
76,0 (250)	12,1 (26.7)	10,9 (24.1)	10,3 (22.6)
80,0 (265)		9,8 —	9,1 —
84,0 (280)		8,7 (18,2)	8,1 (17,1)
88,0 (300)			

Luffing Jib Length 84,0 m (275.6 ft)

Radius / Boom m (ft)	30,0 (98.4)
40,0 (135)	
44,0 (145)	
48,0 (160)	
54,0 (180)	21,0 (45.1)
60,0 (200)	17,5 (37.6)
66,0 (220)	14,7 (31.5)
72,0 (240)	12,3 (26.4)
76,0 (250)	11,0 (24.2)
80,0 (265)	9,8 —
84,0 (280)	8,7 (18.5)
88,0 (300)	7,7 (15.2)

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Liftcrane Boom Capacities - Model 16000 Series 3
No. 59 Luffing Jib on No. 58 Heavy Lift Main Boom

150 590 kg (332,000 lb) Counterweight 54 430 kg (120,000 lb) Carbody Counterweight

360° Rating **kg (lb) x 1 000**

65° Boom Angle

Luffing Jib Length 24,0 m (78.7 ft)

Radius \ Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	66,0 (216.5)
32,0 (105)	47,9 (105.7)			
36,0 (120)	41,0 (88.7)	— (80.8)		
40,0 (135)	61,9 —	32,4 (68.9)		
44,0 (145)		28,2 (61.9)	25,0 (60.6)	
48,0 (160)			21,9 (47.2)	18,5 (39.8)
52,0 (175)				16,2 (34.3)
56,0 (185)				
60,0 (200)				
62,0 (205)				
68,0 (225)				
72,0 (240)				

Luffing Jib Length 36,0 m (118.1 ft)

Radius \ Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)	60,0 (196.9)
32,0 (105)				
36,0 (120)				
40,0 (135)	34,8 (74.0)			
44,0 (145)	30,6 (67.1)	27,4 (60.1)		
48,0 (160)	27,0 (58.4)	24,2 (52.2)	— (44.9)	
52,0 (175)		21,5 (45.7)	18,4 (39.2)	16,6 (35.4)
54,0 (180)		20,3 (43.7)	17,4 (34.3)	15,7 (33.8)
60,0 (200)			14,6 (31.2)	13,1 (28.2)
62,0 (205)				12,3 (26.9)
68,0 (225)				
72,0 (240)				

Luffing Jib Length 48,0 m (157.5 ft)

Radius \ Boom m (ft)	30,0 (98.4)	42,0 (137.8)	54,0 (177.2)
32,0 (105)			
36,0 (120)			
40,0 (135)			
44,0 (145)			
48,0 (160)	26,0 (56.1)		
52,0 (175)	23,1 (49.2)	20,3 (43.1)	
54,0 (180)	21,9 (47.1)	19,1 (41.2)	
60,0 (200)	18,5 (39.9)	16,2 (34.8)	13,3 (28.7)
62,0 (205)	17,5 (38.2)	15,3 (33.3)	12,6 (27.5)
68,0 (225)			10,6 (23.0)
72,0 (240)			9,3 (19.8)

Luffing Jib Length 60,0 m (196.9 ft)

Radius \ Boom m (ft)	30,0 (98.4)	42,0 (137.8)
54,0 (180)	20,6 (44.5)	
56,0 (185)	19,5 (42.6)	
58,0 (190)	18,4 (40.8)	15,7 (34.9)
60,0 (200)	17,4 (37.5)	14,8 (31.9)
64,0 (210)	15,6 (34.5)	13,2 (29.3)
68,0 (225)	14,0 (30.5)	11,8 (25.7)
72,0 (240)	12,6 (26.9)	10,5 (22.5)
74,0 (245)	11,8 (25.7)	9,9 (21.5)
76,0 (250)		9,3 (20.6)
80,0 (260)		— (18.7)
84,0 (280)		

Luffing Jib Length 72,0 m (236.2 ft)

Radius \ Boom m (ft)	30,0 (98.4)
54,0 (180)	
56,0 (185)	
58,0 (190)	
60,0 (200)	16,1 (34.5)
64,0 (210)	14,3 (31.6)
68,0 (225)	12,7 (27.7)
72,0 (240)	11,3 (24.3)
74,0 (245)	10,7 (23.2)
76,0 (250)	10,1 (22.2)
80,0 (260)	9,0 (20.3)
84,0 (280)	7,9 (16.8)

APPENDIX II.E: EXISTING SITE LOGISTICS PLANS

APPENDIX III.A: CALCULATIONS

SEISMIC FORCE CALCULATIONS								
		w_i (psf)						
floor	*area (sf)*	*floor*	*façade*	*wall area (sf)*	W_i *(lbs)*	h_x *(ft)*	h_i *(ft)*	$w_i * h_i^k$
1	21550	127	25	17639	3177814	25.2	25	2.02E+09
2	21550	127	25	10828	3007553	15.5	41	4.97E+09
3	21550	127	25	10828	3007553	15.5	56	9.48E+09
4	21550	127	25	10026	2987501	14.3	70	1.48E+10
5	21550	127	25	9625	2977475	13.8	84	2.11E+10
6	21550	127	25	9625	2977475	13.8	98	2.86E+10
7	21550	125	25	9625	2934375	13.8	112	3.66E+10
8	21550	125	25	9625	2934375	13.8	125	4.62E+10
9	21550	125	25	9625	2934375	13.8	139	5.69E+10
10	21550	125	25	9625	2934375	13.8	153	6.87E+10
11	21550	125	25	9625	2934375	13.8	167	8.16E+10
12	21550	125	25	9625	2934375	13.8	180	9.56E+10
13	21550	125	25	10442	2954792	14.9	195	1.13E+11
14	21550	123	25	8808	2870858	12.6	208	1.24E+11
15	21550	123	25	9625	2891275	13.8	222	1.42E+11
16	21550	123	25	9625	2891275	13.8	235	1.60E+11
17	21550	123	25	9625	2891275	13.8	249	1.80E+11
18	21550	123	25	9625	2891275	13.8	263	2.00E+11
19	21550	123	25	9625	2891275	13.8	277	2.21E+11
20	21550	121	25	9625	2848175	13.8	290	2.40E+11
21	21550	121	25	9625	2848175	13.8	304	2.64E+11
22	21550	121	25	9625	2848175	13.8	318	2.88E+11
23	21550	121	25	9625	2848175	13.8	332	3.13E+11
24	21550	121	25	9625	2848175	13.8	345	3.40E+11
25	21550	121	25	9625	2848175	13.8	359	3.68E+11
26	21550	119	25	9625	2805075	13.8	373	3.90E+11
27	21550	119	25	10179	2818929	14.5	388	4.23E+11
28	21550	119	25	19279	3046429	27.5	415	5.25E+11
29	21550	119	25	9625	2805075	13.8	429	5.16E+11
30	21550	119	25	9625	2805075	13.8	443	5.49E+11
31	21550	119	25	9625	2805075	13.8	456	5.84E+11
32	21550	117	25	9625	2761975	13.8	470	6.10E+11
33	21550	117	25	9625	2761975	13.8	484	6.46E+11
34	21550	117	25	9625	2761975	13.8	498	6.84E+11
35	21550	117	25	9625	2761975	13.8	511	7.22E+11
36	21550	117	25	9625	2761975	13.7	525	7.61E+11
37	21550	117	25	9625	2761975	13.8	539	8.02E+11
38	21550	115	25	9625	2718875	13.8	553	8.30E+11
39	21550	115	25	9625	2718875	13.8	566	8.72E+11
40	21550	115	25	9625	2718875	13.8	580	9.15E+11
41	21550	115	25	9625	2718875	13.8	594	9.59E+11
42	21550	115	25	9625	2718875	13.8	608	1.00E+12
43	21550	115	25	9625	2718875	13.8	621	1.05E+12
44	21550	113	25	9625	2675775	13.8	635	1.08E+12
45	21550	113	25	9625	2675775	13.8	649	1.13E+12
46	21550	113	25	9625	2675775	13.8	663	1.17E+12
47	21550	113	25	9625	2675775	13.8	676	1.22E+12
48	21550	113	25	9625	2675775	13.8	690	1.27E+12
49	21550	113	25	9625	2675775	13.8	704	1.33E+12
50	21550	111	25	10063	2643613	14.4	718	1.36E+12
51	21550	111	25	18664	2858658	26.7	745	1.59E+12
52	21550	111	25	12306	2699700	17.6	762	1.57E+12
ROOF	27400	111	25	0	3041400	0.0	762	1.77E+12
				ΣW	150381.475	k	$\Sigma w_i * h_i^k$	2.97504E+13

Table 1: Seismic force calculations

Soil Classification					
NYCBC:	2-65 (medium hard rock)				
	4-65 (soft rock)				
ASCE 7-05:	seismic design category C				
	Occ. Cat. III		*T 11.5-1*		
	Importance factor= 1.25				

Spectral Response Acceleration					
(using USGS Ground Motion Parameter Calculator)					
latitude: 40.756192			F_a= 1.2		
longitude: -73.990130			F_v= 1.7		

site class C					
T=0.2s			*T=1.0s*		
S_{MS}	0.436	g	S_{M1}	0.119	g
S_{DS}	0.291	g	S_{D1}	0.08	g
ASCE 7-05:	S_{DS} -> SDC B		*T 11.6-1*	therefore, use SDC B	
	S_{D1} -> SDC B		*T 11.6-2*		

Period of Building					
C_u*T_a	4.93	s			
T	6.25	s	*via ETABS, min of E/W & N/S*		
T_L	6.00	s	$C_u*T_a < T_L < T$	: use 4.93 s for C_s calc	
$T_a = C_t*h_n^x$ =	2.902	s			
C_t	0.02		*T 12.2.1.B*		
x	0.75		*T 11.5-1*		
h	762.4				

Seismic Base Shear					
$V = C_s * W$	1503.8	k	*12.8-1*		
C_s = min{	0.1119		$S_{DS}/(R/I)$		
	0.0076		$S_{D1}*T_L/(T^2*R/I)$		
		>=	0.01 min	: use 0.01 for E/W & N/S	
R	3.25		*T 12.2.1.B*		
I	1.25		*T 11.5-1*		

Table 2A: Seismic force calculation variables

SEISMIC DRIFT CHECKS (inches)								
level	*E/W*	*story drift*	*allowable*	*check*	*N/S*	*story drift*	*allowable*	*check*
Roof	12.87	0.53	2.40	OK	11.91	1.42	2.40	OK
52	12.61	0.55	2.40	OK	11.16	0.47	2.40	OK
51	12.34	0.62	2.59	OK	10.91	0.52	3.16	OK
50	12.04	0.58	2.48	OK	10.64	0.50	2.59	OK
49	11.75	0.59	2.48	OK	10.38	0.54	2.48	OK
48	11.46	0.61	2.48	OK	10.09	0.51	2.48	OK
47	11.17	0.62	2.48	OK	9.82	0.51	2.48	OK
46	10.87	0.63	2.48	OK	9.55	0.52	2.48	OK
45	10.56	0.64	2.48	OK	9.28	0.52	2.48	OK
44	10.24	0.64	2.48	OK	9.00	0.53	2.48	OK
43	9.93	0.63	2.48	OK	8.73	0.53	2.48	OK
42	9.62	0.64	2.48	OK	8.45	0.53	2.48	OK
41	9.31	0.64	2.48	OK	8.17	0.53	2.48	OK
40	9.00	0.65	2.48	OK	7.89	0.54	2.48	OK
39	8.68	0.65	2.48	OK	7.61	0.54	2.48	OK
38	8.36	0.65	2.48	OK	7.32	0.54	2.48	OK
37	8.04	0.65	2.48	OK	7.04	0.53	2.48	OK
36	7.73	0.65	2.47	OK	6.76	0.53	2.47	OK
35	7.41	0.65	2.48	OK	6.48	0.53	2.48	OK
34	7.10	0.65	2.48	OK	6.20	0.53	2.48	OK
33	6.78	0.64	2.48	OK	5.93	0.52	2.48	OK
32	6.47	0.64	2.48	OK	5.65	0.52	2.48	OK
31	6.16	0.63	2.48	OK	5.38	0.50	2.48	OK
30	5.85	0.60	2.48	OK	5.12	0.50	2.48	OK
29	5.55	0.73	2.48	OK	4.85	1.11	2.48	OK
28	5.19	0.83	4.96	OK	4.27	0.47	4.96	OK
27	4.79	0.59	2.62	OK	4.02	0.47	2.62	OK
26	4.50	0.57	2.48	OK	3.77	0.46	2.48	OK
25	4.22	0.55	2.48	OK	3.53	0.44	2.48	OK
24	3.95	0.54	2.48	OK	3.30	0.42	2.48	OK
23	3.69	0.53	2.48	OK	3.08	0.41	2.48	OK
22	3.43	0.51	2.48	OK	2.86	0.40	2.48	OK
21	3.18	0.50	2.48	OK	2.65	0.39	2.48	OK
20	2.94	0.48	2.48	OK	2.45	0.37	2.48	OK
19	2.71	0.45	2.48	OK	2.25	0.34	2.48	OK
18	2.49	0.42	2.48	OK	2.07	0.33	2.48	OK
17	2.28	0.40	2.48	OK	1.90	0.31	2.48	OK
16	2.09	0.39	2.48	OK	1.74	0.30	2.48	OK
15	1.90	0.37	2.48	OK	1.58	0.29	2.48	OK
14	1.71	0.36	2.27	OK	1.43	0.27	2.27	OK
13	1.54	0.32	2.69	OK	1.29	0.25	2.69	OK
12	1.38	0.33	2.48	OK	1.16	0.25	2.48	OK
11	1.22	0.30	2.48	OK	1.03	0.23	2.48	OK
10	1.07	0.28	2.48	OK	0.90	0.21	2.48	OK
9	0.94	0.27	2.47	OK	0.79	0.21	2.47	OK
8	0.81	0.25	2.48	OK	0.68	0.20	2.48	OK
7	0.68	0.23	2.48	OK	0.58	0.18	2.48	OK
6	0.57	0.22	2.48	OK	0.49	0.17	2.48	OK
5	0.46	0.21	2.48	OK	0.40	0.16	2.48	OK
4	0.36	0.21	2.58	OK	0.31	0.10	2.58	OK
3	0.26	0.20	2.78	OK	0.26	0.18	2.78	OK
2	0.16	0.32	2.78	OK	0.16	0.30	2.78	OK

Table 3: Seismic drift calculation and checks

COLUMN INTERACTION CHECK (1.2D + 0.5L +1.6W)															
				M ('k)		Fe	ΦP_n (k)		ΦM_n ('k)		Interaction				
Dead Load (ksf)	*Live Load (ksf)*	*Ext col Atrib (sf)*	*Ext col load (k)*	*E/W*	*N/S*		*E/W*	*N/S*	*E/W*	*N/S*	*E/W col*	*check*	*N/S col*	*check*	
0.11	0.04	750	5901	254	253	245	13550	13550	4830	768	0.68	OK	0.96	OK	
0.11	0.04	750	5791	152	152	673	14308	14308	4830	768	0.62	OK	0.78	OK	
0.11	0.04	750	5681	147	147	673	14308	14308	4830	768	0.61	OK	0.77	OK	
0.11	0.04	750	5571	136	137	785	14372	14372	4830	768	0.59	OK	0.74	OK	
0.11	0.04	750	5461	146	147	708	14330	14330	4830	768	0.58	OK	0.74	OK	
0.11	0.04	750	5351	123	123	1044	14467	14467	4830	768	0.56	OK	0.70	OK	
0.11	0.04	750	5241	138	138	852	14402	8606	4830	768	0.56	OK	0.71	OK	
0.11	0.04	750	5131	140	141	852	14402	8606	4320	1008	0.55	OK	0.66	OK	
0.11	0.04	750	5021	142	142	852	14402	8606	4320	1008	0.54	OK	0.65	OK	
0.11	0.04	750	4911	143	144	852	14402	8606	4320	1008	0.53	OK	0.64	OK	
0.11	0.04	750	4802	151	152	852	14402	8606	4320	1008	0.52	OK	0.63	OK	
0.11	0.04	750	4692	147	148	852	14402	8606	4320	1008	0.51	OK	0.62	OK	
0.11	0.04	750	4582	154	155	724	14208	7082	4320	1008	0.50	OK	0.62	OK	
0.11	0.04	750	4472	137	138	1017	14327	7141	4320	1008	0.48	OK	0.59	OK	
0.11	0.04	750	4362	151	152	852	14270	7113	4320	1008	0.48	OK	0.59	OK	
0.11	0.04	750	4252	152	153	852	14270	7113	3750	1155	0.47	OK	0.56	OK	
0.11	0.04	750	4142	153	155	852	14270	7113	3750	1155	0.46	OK	0.55	OK	
0.11	0.04	750	4032	154	156	852	14270	7113	3750	1155	0.45	OK	0.54	OK	
0.11	0.04	750	3922	156	157	852	13260	6454	3750	1155	0.47	OK	0.56	OK	
0.11	0.04	750	3812	157	158	852	13260	6454	3750	1155	0.46	OK	0.55	OK	
0.11	0.04	750	3702	158	160	852	13260	6454	3750	1155	0.45	OK	0.54	OK	
0.11	0.04	750	3592	159	161	852	13260	6454	3750	1155	0.44	OK	0.53	OK	
0.11	0.04	750	3482	160	162	852	13260	6454	3750	1155	0.42	OK	0.52	OK	
0.11	0.04	750	3372	161	163	852	13260	6454	3120	1579	0.42	OK	0.47	OK	
0.11	0.04	750	3262	167	169	852	14226	6454	3120	1579	0.39	OK	0.44	OK	
0.11	0.04	750	3152	250	253	852	14226	6454	3120	1579	0.40	OK	0.48	OK	
0.13	0.13	750	3042	262	265	757	14182	6435	3120	1579	0.39	OK	0.48	OK	
0.11	0.04	750	2850	331	335	213	13215	5996	3120	1579	0.42	OK	0.53	OK	
0.11	0.04	750	2740	166	169	852	14226	6454	3120	1579	0.33	OK	0.39	OK	
0.11	0.04	750	2630	167	170	852	14226	6454	3120	1579	0.32	OK	0.38	OK	
0.11	0.04	750	2520	168	170	852	8782	4435	3120	1579	0.47	OK	0.52	OK	
0.11	0.04	750	2410	169	171	852	8782	4435	2430	1512	0.47	OK	0.51	OK	
0.11	0.04	750	2300	169	172	852	8782	4435	2430	1512	0.45	OK	0.49	OK	
0.11	0.04	750	2190	170	173	852	8782	4435	2430	1512	0.43	OK	0.48	OK	
0.11	0.04	750	2080	171	174	852	8782	4435	2430	1512	0.41	OK	0.46	OK	
0.11	0.04	750	1970	172	174	852	8782	4435	2430	1512	0.40	OK	0.44	OK	
0.11	0.04	750	1860	172	175	852	8782	3319	2430	1512	0.38	OK	0.42	OK	
0.11	0.04	750	1750	173	176	852	8782	3319	2430	1512	0.36	OK	0.41	OK	
0.11	0.04	750	1640	174	177	852	8782	3319	2430	1512	0.34	OK	0.39	OK	
0.11	0.04	750	1530	175	177	852	8782	3319	1680	1528	0.36	OK	0.37	OK	
0.11	0.04	750	1420	175	178	852	8782	3319	1680	1528	0.34	OK	0.35	OK	
0.11	0.04	750	1310	176	179	852	8782	3319	1680	1528	0.32	OK	0.33	OK	
0.11	0.04	750	1200	177	180	852	7552	2507	1680	1528	0.34	OK	0.35	OK	
0.11	0.04	750	1090	177	180	852	7552	2507	1680	1528	0.31	OK	0.33	OK	
0.11	0.04	750	980	178	181	852	7552	2507	1680	1528	0.29	OK	0.31	OK	
0.11	0.04	750	870	179	182	852	7552	2507	1680	1528	0.27	OK	0.29	OK	
0.11	0.04	750	761	179	182	852	7552	2507	1680	1528	0.25	OK	0.27	OK	
0.11	0.04	750	651	184	187	852	7552	2507	870	1456	0.34	OK	0.25	OK	
0.11	0.04	750	541	271	276	852	7552	2108	870	1456	0.42	OK	0.29	OK	
0.11	0.04	750	431	310	399	775	7534	2102	870	1456	0.44	OK	0.36	OK	
0.11	0.04	750	321	341	440	897	7561	2110	870	1456	0.45	OK	0.36	OK	
0.16	0.13	750	211	353	495	897	7580	2115	870	1456	0.45	OK	0.38	OK	

Table 4: Column spot checks

Table 5: Bracing strength calculations

LATERAL SIZE CALCULATION BASED ON WIND LOAD

			Shear at Each Level (k)		Force in Each Frame (k)*		Axial Force per Brace (k)				Brace Axial Area Required (in^2)				Brace Section Required			
Level	*Elevation*	*Level Height*	*E/W*	*N/S*	*E/W*	*N/S*	*E/W Long Bay*	*E/W Short Bay*	*N/S Chevron*	*N/S Single Diag.*	*E/W (40' V)*	*E/W (25' V)*	*N/S (30' V)*	*N/S (30' diag)*	*E/W (40' V)*	*E/W (25' V)*	*N/S (30' V)*	*N/S (30' diag)*
Roof	745.5	13.4	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	W10X12	W10x12	W10x12	W10x12
52	732.1	13.4	254	262	152	157	46	52	42	34	1.0	1.1	0.9	0.7	W10X12	W10x12	W10x12	W10x12
51	718.7	14.4	469	483	281	290	87	100	80	64	1.8	2.1	1.7	1.4	W10X12	W10x12	W10x12	W10x12
50	704.3	13.8	666	644	400	386	121	139	105	85	2.6	2.9	2.2	1.8	W10X12	W10x12	W10x12	W10x12
49	690.5	13.8	800	753	480	452	146	167	123	99	3.1	3.5	2.6	2.1	W10X12	W10x12	W10x12	W10x12
48	676.8	13.8	930	859	558	515	169	194	140	113	3.6	4.1	3.0	2.4	W10X12	W10x12	W10x12	W10x12
47	663.0	13.8	1060	965	636	579	193	221	157	127	4.1	4.7	3.3	2.7	W10X12	W10X12	W10x12	W10x12
46	649.3	13.8	1189	1070	714	642	217	248	174	141	4.6	5.2	3.7	3.0	W10X15	W10X12	W10X12	W10x12
45	635.5	13.8	1318	1175	791	705	240	275	191	155	5.1	5.8	4.0	3.3	W10X17	W10X15	W10X12	W10X12
44	621.8	13.8	1447	1280	868	768	263	302	208	169	5.6	6.4	4.4	3.6	W10X17	W10X17	W10X15	W10X12
43	608.0	13.8	1575	1384	945	830	287	328	225	183	6.1	6.9	4.8	3.9	W10X19	W10X17	W10X17	W10X15
42	594.3	13.8	1702	1487	1021	892	310	355	242	196	6.5	7.5	5.1	4.1	W10X22	W10X19	W10X17	W10X17
41	580.5	13.8	1829	1591	1097	954	333	381	259	210	7.0	8.1	5.5	4.4	W10X22	W10X22	W10X19	W10X17
40	566.8	13.8	1956	1693	1173	1016	356	408	276	224	7.5	8.6	5.8	4.7	W10X22	W10X22	W10X22	W10X19
39	553.0	13.8	2082	1796	1249	1078	379	434	292	237	8.0	9.2	6.2	5.0	W14X26	W10X22	W10X22	W10X22
38	539.3	13.8	2207	1898	1324	1139	402	460	309	251	8.5	9.7	6.5	5.3	W14X26	W14X26	W10X22	W10X22
37	525.5	13.8	2332	1999	1399	1200	424	486	325	264	9.0	10.3	6.9	5.6	W14X30	W14X26	W14X26	W10X22
36	511.8	13.8	2456	2100	1474	1260	447	512	342	277	9.5	10.8	7.2	5.9	W14X30	W14X30	W14X26	W14X26
35	498.0	13.8	2580	2201	1548	1321	470	538	358	291	9.9	11.4	7.6	6.1	W10X33	W14X30	W14X30	W14X26
34	484.3	13.8	2703	2301	1622	1381	492	564	375	304	10.4	11.9	7.9	6.4	W12X35	W10X33	W14X30	W14X30
33	470.5	13.8	2826	2401	1696	1440	514	589	391	317	10.9	12.5	8.3	6.7	W12X35	W12X35	W10X33	W14X30
32	456.8	13.8	2948	2500	1769	1500	537	615	407	330	11.3	13.0	8.6	7.0	W14X38	W12X35	W12X35	W10X33
31	443.0	13.8	3070	2599	1842	1559	559	640	423	343	11.8	13.5	8.9	7.3	W12X40	W14X38	W12X35	W12X35
30	429.3	13.8	3191	2697	1914	1618	581	665	439	356	12.3	14.1	9.3	7.5	W12X40	W12X40	W14X38	W12X35
29	415.5	27.5	3311	2794	1987	1677	844	1079	700	455	21.1	26.9	17.5	11.3	W10X68	W12X40	W12X40	W14X38
28	388.0	14.6	3490	2940	2094	1764	648	749	492	392	13.8	15.9	10.5	8.3	W10X45	W10X68	W12X40	W12X40
27	373.4	13.8	3672	3087	2203	1852	668	765	503	408	14.1	16.2	10.6	8.6	W14X48	W10X45	W10X68	W12X40
26	359.7	13.8	3793	3185	2276	1911	690	791	519	420	14.6	16.7	11.0	8.9	W10X49	W14X48	W10X45	W10X68
25	345.9	13.8	3910	3280	2346	1968	712	815	534	433	15.0	17.2	11.3	9.2	W12X50	W10X49	W14X48	W10X45
24	332.2	13.8	4026	3374	2416	2024	733	839	549	445	15.5	17.7	11.6	9.4	W12X50	W12X50	W10X49	W14X48
23	318.4	13.8	4142	3468	2485	2081	754	863	564	458	15.9	18.2	11.9	9.7	W10X54	W12X50	W12X50	W10X49
22	304.7	13.8	4256	3560	2554	2136	775	887	580	470	16.4	18.8	12.3	9.9	W10X54	W10X54	W12X50	W12X50
21	290.9	13.8	4370	3653	2622	2192	796	911	595	482	16.8	19.3	12.6	10.2	W10X54	W10X54	W10X54	W12X50
20	277.2	13.8	4483	3744	2690	2246	816	935	609	494	17.3	19.8	12.9	10.4	W12X58	W10X54	W10X54	W10X54
19	263.4	13.8	4596	3835	2757	2301	837	958	624	506	17.7	20.2	13.2	10.7	W10X60	W12X58	W10X54	W10X54
18	249.7	13.8	4707	3925	2824	2355	857	981	639	518	18.1	20.7	13.5	11.0	W14X61	W10X60	W12X58	W10X54
17	235.9	13.8	4818	4014	2891	2408	877	1004	653	530	18.5	21.2	13.8	11.2	W14X61	W14X61	W10X60	W12X58
16	222.2	13.8	4927	4103	2956	2462	897	1027	668	542	19.0	21.7	14.1	11.4	W14X61	W14X61	W14X61	W10X60
15	208.4	12.6	5036	4190	3021	2514	892	1008	656	545	18.7	21.1	13.7	11.4	W14X61	W14X61	W14X61	W14X61
14	195.8	14.9	5139	4273	3083	2564	962	1116	723	573	20.5	23.8	15.4	12.2	W10X68	W14X61	W14X61	W14X61
13	180.9	13.8	5245	4359	3147	2616	955	1093	710	575	20.2	23.1	15.0	12.2	W10X68	W10X68	W14X61	W14X61
12	167.2	13.8	5355	4448	3213	2669	975	1116	724	587	20.6	23.6	15.3	12.4	W10X68	W10X68	W10X68	W14X61
11	153.4	13.8	5460	4532	3276	2719	994	1138	738	598	21.0	24.1	15.6	12.6	W10X68	W10X68	W10X68	W10X68
10	139.7	13.8	5563	4615	3338	2769	1013	1159	751	609	21.4	24.5	15.9	12.9	W12X72	W10X68	W10X68	W10X68
9	125.9	13.8	5664	4696	3399	2818	1031	1181	765	620	21.8	25.0	16.2	13.1	W12X72	W12X72	W10X68	W10X68
8	112.2	13.8	5764	4777	3459	2866	1049	1202	778	631	22.2	25.4	16.4	13.3	W14X74	W12X72	W12X72	W10X68
7	98.4	12.4	5863	4856	3518	2914	1035	1167	757	631	21.7	24.4	15.8	13.2	W12X72	W14X74	W12X72	W12X72
6	86.0	15.1	5960	4934	3576	2960	1120	1302	840	663	23.9	27.8	17.9	14.2	W12X79	W12X72	W14X74	W12X72
5	70.9	14.3	6055	5010	3633	3006	1117	1288	831	666	23.7	27.3	17.7	14.1	W12X79	W12X79	W12X72	W14X74
4	56.6	15.5	6151	5087	3690	3052	1166	1362	877	687	25.0	29.2	18.8	14.7	W14X82	W12X79	W12X79	W12X72
3	41.1	15.5	6249	5165	3749	3099	1185	1383	890	697	25.4	29.7	19.1	15.0	W14X82	W14X82	W12X79	W12X79
2	25.7	25.7	6348	5244	3809	3146	1549	1961	1247	828	37.6	47.5	30.2	20.1	W12X120	W14X82	W14X82	W12X79

* Force multiplied by 1.2 for a conservative estimate.

** Section decreases due to moment frame contribution on upper levels.

OVERTURNING:

W = 150382 k (taken from seismic data)

* $M_{E-W} = 3922512^{k}$

$d_{E-W} = 145'$

$\frac{W}{2} > \frac{M}{d}$ REQUIRED TO RESIST O.T.

$\frac{150382}{2} > \frac{3922512}{145}$

$75191^{k} > 27052^{k}$ OK

* $M_{N-S} = 3185465^{k}$

$d_{N-S} = 190'$

$75191^{k} > \frac{3185465}{190} = 16766^{k}$ OK

Figure 1: Overturning check

APPENDIX III.B: MEMBER SIZES

COLUMN SIZES (GENERALIZED)					
level	*new outrigger*	*corner*	*side*	*center*	*existing outrigger*
Roof	-	W14x342	W14X342	W14X311	W14x159
52	-	W14x342	W14X342	W14X311	W14x159
51	-	W14x342	W14X342	W14X311	W14x159
50	-	W14x342	W14X342	W14X311	W14x159
49	-	W14x605	W14X342	W14X311	W14X257
48	-	W14x605	W14X342	W14X311	W14X257
47	-	W14x605	W14X342	W14X311	W14X257
46	-	W14x605	W14X342	W14X311	W14X257
45	-	W14x605	W14X342	W14X311	W14X257
44	-	W14x605	W14X342	W14X311	W14X257
43	-	24.5x22x5.5"	W14X550	W14X550	W14X500
42	-	24.5x22x5.5"	W14X550	W14X550	W14X500
41	-	24.5x22x5.5"	W14X550	W14X550	W14X500
40	-	24.5x22x5.5"	W14X550	W14X550	W14X500
39	-	24.5x22x5.5"	W14X550	W14X550	W14X500
38	-	24.5x22x5.5"	W14X550	W14X550	W14X500
37	-	24.5x22x5.5"	W14X550	W14X550	W14X500
36	-	24.5x22x5.5"	W14X550	W14X550	W14X500
35	-	24.5x22x5.5"	W14X550	W14X550	W14X500
34	-	24.5x22x5.5"	W14X550	W14X550	W14X500
33	-	24.5x22x5.5"	W14X550	W14X550	W14X500
32	-	24.5x22x5.5"	W14X550	W14X550	W14X500
31	-	28x21x4.5"	24x21x6"	24x21x6"	W14x550
30	-	28x21x4.5"	24x21x6"	24x21x6"	W14x550
29	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
28	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
27	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
26	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
25	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
24	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
23	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
22	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
21	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
20	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x550
19	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
18	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
17	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
16	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
15	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
14	4"f x 2"w	28x21x4.5"	24x21x6"	24x21x6"	W14x665
13	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
12	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
11	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
10	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
9	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
8	4"f x 2"w	30x28x8"	30x28x8"	30x28x8"	W14x665
7	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
6	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
5	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
4	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
3	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
2	4"f x 2"w	30x30"solid	30x28x8"	30x28x8"	4"f x 2"w
* column dimensions formatted as depth x width x thickness are built-up members					

Table 6: Existing and new column sizes

BRACING SIZES											
	N/S Brace Existing			**E/W Brace Existing**		**Existing Structure**	**N/S Brace Proposed**		**E/W Brace Proposed**		**Proposed Structure**
Level	*Chevron*	*Eccentric*	*Single Diag.*	*Long Chevron*	*Short Chevron*	**Weight (lbs)**	*Section*	*Weight*	*Section*	*Weight*	**Weight (lbs)**
Roof	W14x159	W14x193	W14x159	W14x82	W14x68	279782	W14	68	W14	53	281263
52	W14x159	W14x193	W14x159	W14x82	W14x68	279442	W14	68	W14	53	280935
51	W14x159	W14x193	W14x159	W14x82	W14x68	289846	W14	68	W14	53	290946
50	W14x159	W14x193	W14x159	W14x82	W14x68	283018	W14	68	W14	53	284378
49	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
48	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
47	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
46	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
45	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
44	W14x257	W14x159	W14x398	W14x90	W14x68	308197	W14	82	W14	61	303275
43	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
42	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
41	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
40	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
39	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
38	W14x426	W14x211	W14x398	W14x90	W14x109	370434	W14	90	W14	68	353745
37	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
36	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
35	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
34	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
33	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
32	W14x283	W14x342	W14x455	W14x109	W14x109	410387	W14	99	W12	74	393530
31	W14x283	W14x342	W14x455	W14x109	W14x109	496969	W14	109	W14	82	492821
30	W14x283*	W14x342*	W14x455*	W14x109	W14x109	496969	W14	109	W14	82	492821
29	W14x176	W14x193	W14x159	W14x109	W14x90	843881	W14	109	W14**	82	809756
28	W14x176	W14x193	W14x159	W14x109	W14x90	651784	W14	109	W14	120	597785
27	W14x176	W14x193	W14x159	W14x109	W14x90	505205	W14	109	W14	120	478196
26	W14x176	W14x193	W14x159	W14x109	W14x90	505205	W14	109	W14	120	478196
25	W14x257	W14x120	W14x211	W14x109	W14x90	521027	W14	120	W14	132	493095
24	W14x257	W14x120	W14x211	W14x109	W14x90	521027	W14	120	W14	132	493095
23	W14x257	W14x120	W14x211	W14x109	W14x90	521027	W14	120	W14	132	493095
22	W14x257	W14x120	W14x211	W14x109	W14x90	521027	W14	120	W14	132	493095
21	W14x257	W14x120	W14x211	W14x120	W14x90	521027	W14	120	W14	132	493095
20	W14x257	W14x120	W14x211	W14x120	W14x90	521027	W14	120	W14	132	493095
19	W14x233	W14x132	W14x233	W14x120	W14x90	583366	W14	132	W14	145	558849
18	W14x233	W14x132	W14x233	W14x120	W14x90	583366	W14	132	W14	145	558849
17	W14x233	W14x132	W14x233	W14x120	W14x90	583366	W14	132	W14	145	558849
16	W14x233	W14x132	W14x233	W14x120	W14x90	583366	W14	132	W14	145	558849
15	W14x233	W14x132	W14x233	W14x120	W14x90	547860	W14	132	W14	145	523886
14	W14x233	W14x132	W14x233	W14x120	W14x90	618990	W14	132	W14	145	593903
13	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
12	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
11	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
10	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
9	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
8	W14x283	W14x90	W14x283	W14x120	W14x90	723811	W14	145	W14	159	700314
7	W14x283	W14x159	W14x311	W14x132	W14x109	750343	W14	159	W14	176	729576
6	W14x283	W14x159	W14x311	W14x132	W14x109	875152	W14	159	W14	176	853346
5	W14x283	W14x159	W14x311	W14x132	W14x109	839493	W14	159	W14	176	817996
4	W14x283	W14x159	W14x311	W14x132	W14x109	893245	W14	159	W14	176	871279
3	W14x283	W14x159	W14x311	W14x132	W14x109	893245	W14	159	W14	176	871279
2	W14x283	W14x159	W14x311	W14x132	W14x109	1374909	W14	159	W14	176	1348106
						21.93 psf					**21.16 psf**

* Bracing sizes in the North-South direction increase above the outrigger level because one bracing line drops out.

Table 7: Existing and new bracing sizes

APPENDIX III.C: PROGRESSIVE COLLAPSE ANALYSIS

PROGRESSIVE COLLAPSE LINEAR STATIC ANALYSIS

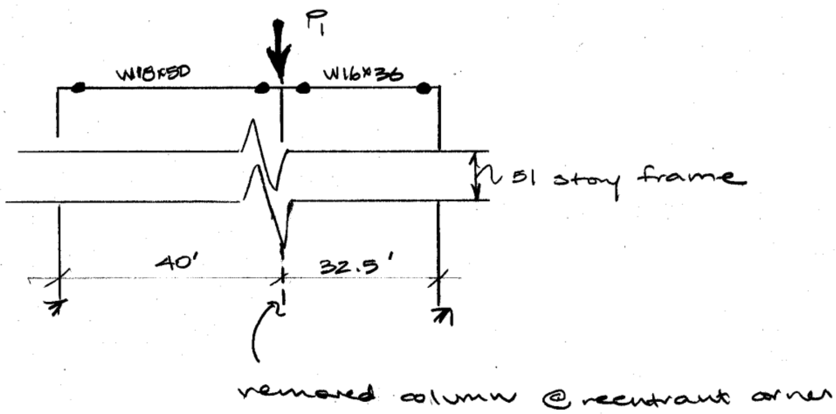
	beam shear (k)		beam moment ('k)		beam rotation (degrees)		allowable shear (k)				allowable moment (k)				required section			
	2, A&B	2, B&C	2, A&B	2, B&C	2, A&B	2, B&C	2, A&B	check	2, B&C	check	2, A&B	check	2, B&C	check	2, A&B	section	2, B&C	section
level	*W18x50*	*W16x36*	*W18x50*	*W16x36*	*W18x50*	*W16x36*	*W18x50*	*DCR<2*	*W16x36*	*DCR<2*	*W18x50*	*DCR<3*	*W16x36*	*DCR<3*	ΦM_p		ΦM_p	
2	190.90	198.40	3796.4	3214.1	8.04	4.42	192	OK	140	OK	379	NG!!	240	NG!!	1270	W30x108	1075	W30x99
3	189.82	199.01	3772.1	3222.4	7.96	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1262	W30x108	1078	W30x99
4	188.73	199.65	3752.1	3234.2	7.96	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1255	W30x108	1082	W30x99
5	187.62	199.99	3730.6	3239.9	7.88	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1248	W30x108	1084	W30x99
6	186.67	200.16	3711.6	3242.6	7.84	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1241	W30x108	1084	W30x99
7	185.85	200.23	3695.2	3243.7	7.84	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1236	W30x108	1085	W30x99
8	185.11	200.19	3680.1	3237.4	7.80	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1231	W30x108	1083	W30x99
9	184.43	200.02	3665.1	3240.3	7.76	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1226	W30x108	1084	W30x99
10	183.29	199.82	3638.7	3237.0	7.88	10.06	192	OK	140	OK	379	NG!!	240	NG!!	1217	W30x108	1083	W30x99
11	182.59	199.70	3624.9	3235.0	7.88	10.06	192	OK	140	OK	379	NG!!	240	NG!!	1212	W30x108	1082	W30x99
12	181.96	199.51	3612.4	3231.9	7.84	10.06	192	OK	140	OK	379	NG!!	240	NG!!	1208	W30x108	1081	W30x99
13	181.44	199.31	3601.8	3228.6	7.80	10.06	192	OK	140	OK	379	NG!!	240	NG!!	1205	W30x108	1080	W30x99
14	181.02	199.07	3593.8	3224.8	7.80	10.02	192	OK	140	OK	379	NG!!	240	NG!!	1202	W30x108	1079	W30x99
15	180.54	198.82	3584.0	3220.6	7.76	10.02	192	OK	140	OK	379	NG!!	240	NG!!	1199	W30x108	1077	W30x99
16	179.94	198.61	3572.0	3216.6	7.76	10.02	192	OK	140	OK	379	NG!!	240	NG!!	1195	W30x108	1076	W30x99
17	179.40	198.16	3561.4	3208.2	7.72	10.02	192	OK	140	OK	379	NG!!	240	NG!!	1191	W30x108	1073	W30x99
18	179.06	197.72	3554.6	3201.0	7.72	9.99	192	OK	140	OK	379	NG!!	240	NG!!	1189	W30x108	1071	W30x99
19	178.75	197.30	3548.3	3194.1	7.72	9.95	192	OK	140	OK	379	NG!!	240	NG!!	1187	W30x108	1068	W30x99
20	178.38	196.82	3539.8	3186.4	7.68	9.95	192	OK	140	OK	379	NG!!	240	NG!!	1184	W30x108	1066	W30x99
21	177.94	196.34	3530.8	3178.7	7.68	9.99	192	OK	140	OK	379	NG!!	240	NG!!	1181	W30x108	1063	W30x99
22	177.59	195.94	3523.7	3172.1	7.68	9.95	192	OK	140	OK	379	NG!!	240	NG!!	1178	W30x108	1061	W30x99
23	177.27	195.55	3517.4	3165.9	7.64	9.95	192	OK	140	OK	379	NG!!	240	NG!!	1176	W30x108	1059	W30x90
24	176.99	195.18	3511.5	3159.9	7.64	9.91	192	OK	140	OK	379	NG!!	240	NG!!	1174	W30x108	1057	W30x90
25	176.73	194.82	3506.3	3154.1	7.64	21.06	192	OK	140	OK	379	NG!!	240	NG!!	1173	W30x108	1055	W30x90
26	176.40	194.45	3499.9	3147.9	7.61	9.88	192	OK	140	OK	379	NG!!	240	NG!!	1171	W30x108	1053	W30x90
27	175.71	194.03	3487.7	3140.5	7.57	9.88	192	OK	140	OK	379	NG!!	240	NG!!	1166	W30x99	1050	W30x90
28	175.36	193.60	3482.6	3133.4	7.57	9.84	192	OK	140	OK	379	NG!!	240	NG!!	1165	W30x99	1048	W30x90
29	174.94	193.01	3473.8	3123.5	7.53	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1162	W30x99	1045	W30x90
30	174.79	192.82	3469.0	3120.7	7.53	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1160	W30x99	1044	W30x90
31	174.89	192.61	3469.6	3118.0	7.57	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1160	W30x99	1043	W30x90
32	174.31	192.35	3458.5	3113.3	7.53	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1157	W30x99	1041	W30x90
33	173.63	191.71	3445.5	3105.6	7.53	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1152	W30x99	1039	W30x90
34	173.39	191.28	3440.9	3098.6	7.49	9.80	192	OK	140	OK	379	NG!!	240	NG!!	1151	W30x99	1036	W30x90
35	173.17	190.92	3436.5	3092.7	7.49	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1149	W30x99	1034	W30x90
36	172.94	190.59	3431.8	3087.2	7.49	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1148	W30x99	1033	W30x90
37	172.71	190.28	3427.1	3082.2	7.49	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1146	W30x99	1031	W30x90
38	172.49	189.99	3422.7	3077.4	7.45	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1145	W30x99	1029	W30x90
39	172.28	189.72	3418.6	3073.0	7.45	9.70	192	OK	140	OK	379	NG!!	240	NG!!	1143	W30x99	1028	W30x90
40	172.09	189.46	3414.8	3068.9	7.45	9.70	192	OK	140	OK	379	NG!!	240	NG!!	1142	W30x99	1026	W30x90
41	171.93	189.22	3411.5	3065.0	7.45	9.70	192	OK	140	OK	379	NG!!	240	NG!!	1141	W30x99	1025	W30x90
42	171.84	189.02	3409.4	3061.5	7.45	9.66	192	OK	140	OK	379	NG!!	240	NG!!	1140	W30x99	1024	W30x90
43	171.68	188.76	3406.5	3057.6	7.45	9.66	192	OK	140	OK	379	NG!!	240	NG!!	1139	W30x99	1023	W30x90
44	170.84	187.98	3394.8	3047.9	7.37	9.66	192	OK	140	OK	379	NG!!	240	NG!!	1135	W30x99	1019	W30x90
45	169.22	186.54	3373.2	3030.1	7.29	9.77	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1013	W30x90
46	169.22	186.28	3372.3	3025.6	7.33	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1012	W30x90
47	169.19	186.01	3371.4	3021.1	7.29	9.73	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1010	W30x90
48	169.19	185.74	3371.3	3016.6	7.29	9.70	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1009	W30x90
49	169.27	185.45	3372.1	3012.2	7.29	9.70	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1007	W30x90
50	168.88	184.31	3373.0	2994.9	7.21	9.66	192	OK	140	OK	379	NG!!	240	NG!!	1128	W30x99	1002	W30x90
51	169.16	182.53	3392.3	2964.6	7.17	9.62	192	OK	140	OK	379	NG!!	240	NG!!	1135	W30x99	991	W30x90
52	162.44	181.94	3306.0	2955.9	6.57	9.59	192	OK	140	OK	379	NG!!	240	NG!!	1106	W30x99	989	W30x90
roof	157.96	176.16	3241.6	2897.1	6.17	9.62	192	OK	140	OK	379	NG!!	240	NG!!	1084	W30x99	969	W30x90

Table 8: Progressive collapse linear static analysis

PROGRESSIVE COLLAPSE ANALYLSIS: VIRTUAL WORK METHOD						
level	*P_{prov}*	*P_{req}*	*check*	*Q_{UD}*	*$M_{p,req}$*	*section*
roof	154.2	397.8	NG!!	2378	793	W24x84
52	308.2	795.6	NG!!	4755	1585	W33x130
51	462.2	1193.4	NG!!	7133	2378	W40x167
50	616.2	1591.2	NG!!	9511	3170	W40x199
49	770.2	1989	NG!!	11888	3963	W44x230
48	924.2	2386.8	NG!!	14266	4755	W44x262
47	1078.2	2784.6	NG!!	16644	5548	W44x335
46	1232.2	3182.4	NG!!	19021	6340	W40x392
45	1386.2	3580.2	NG!!	21399	7133	W40x431
44	1540.2	3978	NG!!	23777	7926	W36x487
43	1694.2	4375.8	NG!!	26154	8718	W40x593
42	1848.2	4773.6	NG!!	28532	9511	W40x593
41	2002.2	5171.4	NG!!	30910	10303	W40x593
40	2156.2	5569.2	NG!!	33287	11096	W36x800
39	2310.2	5967	NG!!	35665	11888	W36x800
38	2464.2	6364.8	NG!!	38042	12681	W36x800
37	2618.2	6762.6	NG!!	40420	13473	W36x800
36	2772.2	7160.4	NG!!	42798	14266	-
35	2926.2	7558.2	NG!!	45175	15058	-
34	3080.2	7956	NG!!	47553	15851	-
33	3234.2	8353.8	NG!!	49931	16644	-
32	3388.2	8751.6	NG!!	52308	17436	-
31	3542.2	9149.4	NG!!	54686	18229	-
30	3696.2	9547.2	NG!!	57064	19021	-
29	3850.2	9945	NG!!	59441	19814	-
28	4004.2	10342.8	NG!!	61819	20606	-
27	4158.2	10740.6	NG!!	64197	21399	-
26	4312.2	11138.4	NG!!	66574	22191	-
25	4466.2	11536.2	NG!!	68952	22984	-
24	4620.2	11934	NG!!	71330	23777	-
23	4774.2	12331.8	NG!!	73707	24569	-
22	4928.2	12729.6	NG!!	76085	25362	-
21	5082.2	13127.4	NG!!	78463	26154	-
20	5236.2	13525.2	NG!!	80840	26947	-
19	5390.2	13923	NG!!	83218	27739	-
18	5544.2	14320.8	NG!!	85596	28532	-
17	5698.2	14718.6	NG!!	87973	29324	-
16	5852.2	15116.4	NG!!	90351	30117	-
15	6006.2	15514.2	NG!!	92729	30910	-
14	6160.2	15912	NG!!	95106	31702	-
13	6314.2	16309.8	NG!!	97484	32495	-
12	6468.2	16707.6	NG!!	99862	33287	-
11	6622.2	17105.4	NG!!	102239	34080	-
10	6776.2	17503.2	NG!!	104617	34872	-
9	6930.2	17901	NG!!	106994	35665	-
8	7084.2	18298.8	NG!!	109372	36457	-
7	7238.2	18696.6	NG!!	111750	37250	-
6	7392.2	19094.4	NG!!	114127	38042	-
5	7546.2	19492.2	NG!!	116505	38835	-
4	7700.2	19890	NG!!	118883	39628	-
3	7854.2	20287.8	NG!!	121260	40420	-
2	8008.2	20685.6	NG!!	123638	41213	-

Table 9: Progressive collapse nonlinear static analysis: virtual work

VIRTUAL WORK:

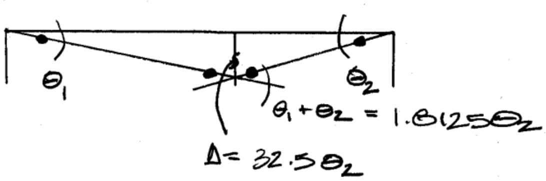


$P_1 = 2DL + 0.5LL$

$A_{trib} = \min \begin{cases} 40(30) + 32.5(30) + 32.5(20) = 2825\,sf \\ 1800\,sf \leftarrow \text{controls} \end{cases}$

$P_1 = 2(1800 * 0.093) + 0.5(1800 * 0.070)$

$= 397.8\,K$ ACTUAL LOAD



$40\theta_1 = 32.5\theta_2$

$\therefore \theta_1 = 0.8125\theta_2$

$W_{internal} = W_{external}$

$W_i = M_{p1}(0.8125\theta_2) + M_{p1}(1.8125\theta_2) + M_{p2}(1.8125\theta_2) + M_{p2}(\theta_2)$

$= 2.625\,M_{p1}\theta_2 + 2.8125\,M_{p2}\theta_2$

Figure 2: Progressive collapse virtual work analysis

$M_{p1} = M_{p\,W18x50} = 379\text{k}$

$M_{p2} = M_{p\,W16x36} = 240\text{k}$

$\therefore W_i = 1669.875\theta_2$

$W_e = 32.5\theta_2 P_1$

$W_i = W_e \rightarrow 32.5\not{\theta_2} P_1 = 1669.875\not{\theta_2}$

$\therefore P_1 \leq 51.4\text{k} \quad * \text{DCR} = 3 = 154.1\text{k}$

$397.8\text{k} >> 154.1\text{k}$ ultimate

→ members are not adequate, redesign is necessary

Figure 3: Progressive collapse virtual work analysis

APPENDIX IV.A: CIRCUIT BREAKER COORDINATION

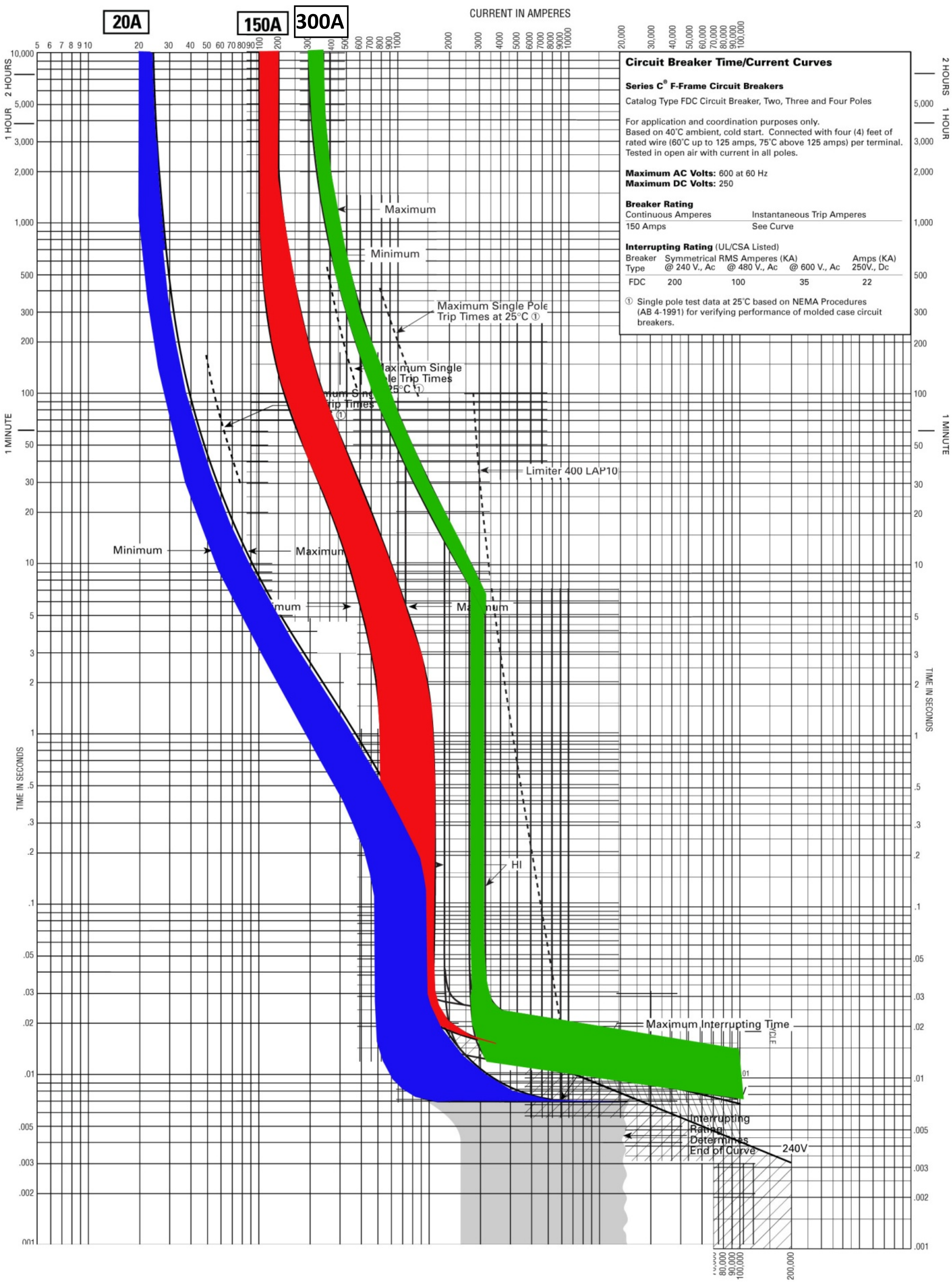


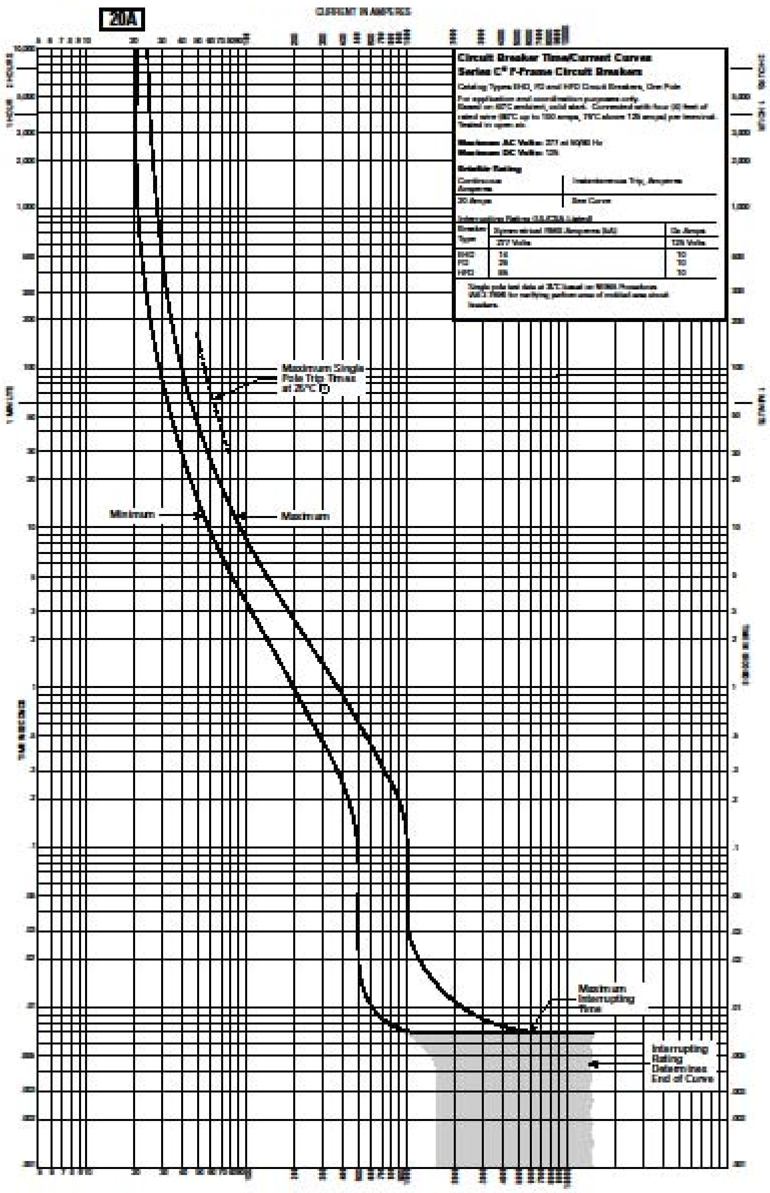
Figure 8: Circuit breaker timing curves

Application Data
29-167F

Page 4

AB DE-ION Circuit Breakers

Types EHD, FD and HFD 20 Amperes



Curve No. SC-4424-88A

October 1997

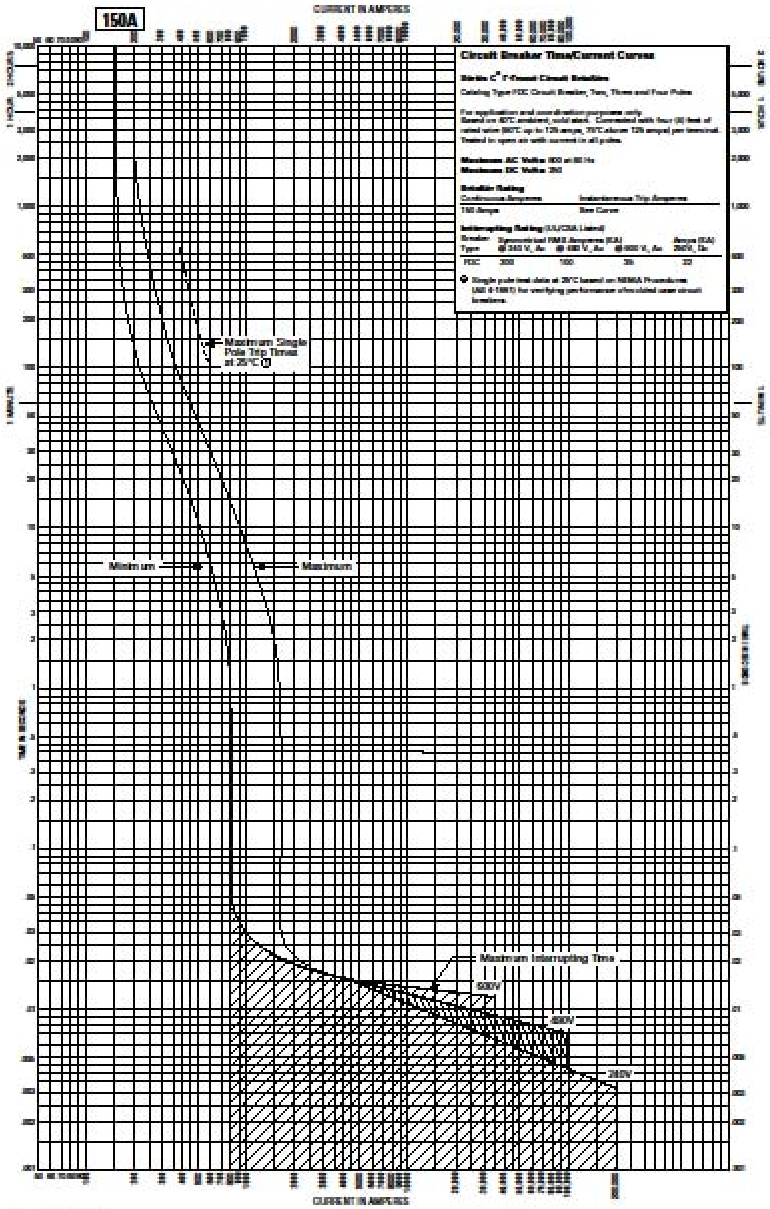
Figure 9: Circuit breaker timing curves

Application Data
29-167F

Page 52

AB DE-ION Circuit Breakers

Type FDC 150 Amperes



Curve No. SC-5531-93A

October 1997

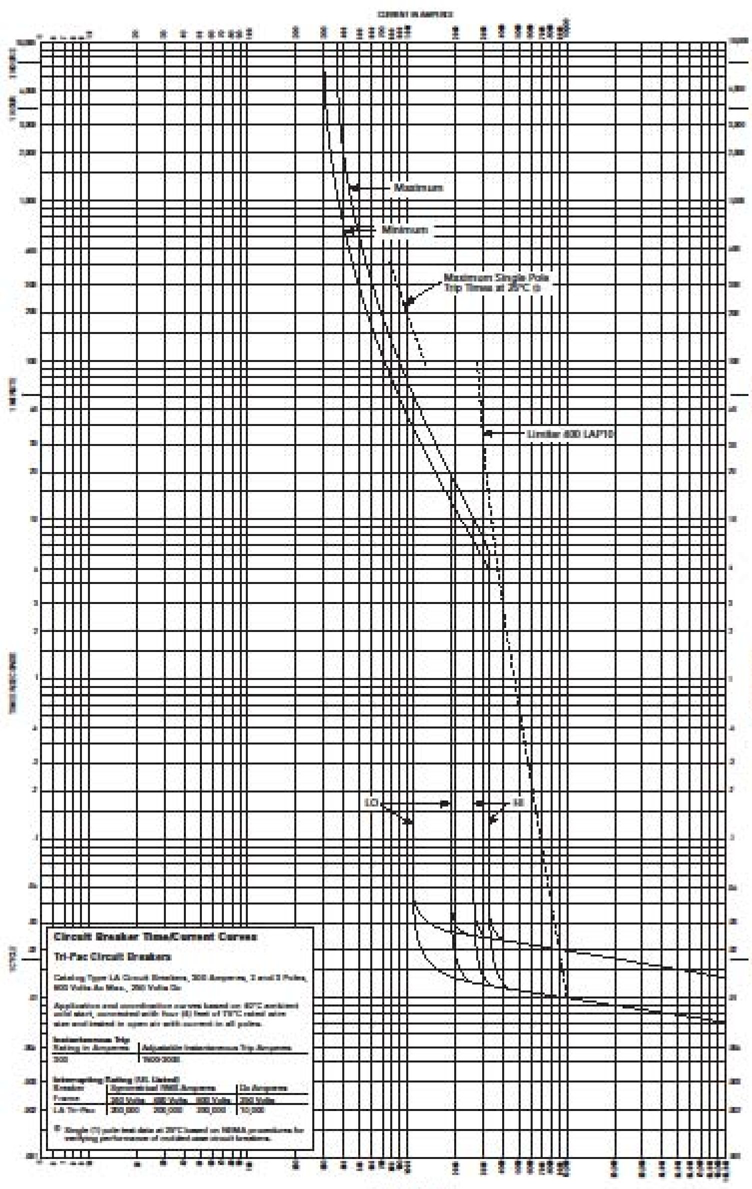
Figure 10: Circuit breaker timing curves

Application Data
29-167C

Page 37

AB DE-ION Tri Pac® Circuit Breakers

Type LA, 300 Amperes, 2 and 3 Poles



Curve No. SC-3589-76A

October 1997

Figure 11: Circuit breaker timing curves

APPENDIX IV.B: PANEL BOARD SPECIFICATIONS

NF Circuit Breaker Panelboards

Catalog
1670CT0701

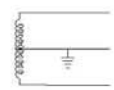
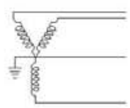
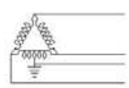
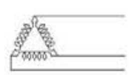
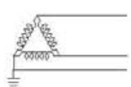
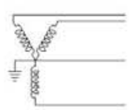
2008
Class 1670

CONTENTS

SQUARE D by Schneider Electric

Schneider Electric

NF Circuit Breaker Panelboards
Standards and Ratings

Voltage	System	System Diagram
120/240 Vac	1ϕ3W	
208Y/120 Vac	3ϕ4W	
240/120 Vac	3ϕ4W Delta	
240 Vac	3ϕ3W Delta	
240 Vac	3ϕ3W Grounded Bϕ Delta	
480Y/277 Vac	3ϕ4W	
600Y/347 Vac	3ϕ4W	

Standards and Ratings

NF circuit breaker panelboards are for use on ac systems. They are UL® Listed under File E33139 and marked cULus. NF circuit breaker panelboards accept EDB, EGB, and EJB branch circuit breakers.

Standards

NF circuit breaker panelboards are designed, manufactured, and tested to comply with the following standards:

- UL 67—Standard for Panelboards
- UL 50—Enclosures for Electrical Equipment
- UL Listed Class CTL panelboard
- CSA C22.2, No. 29-M1989—Panelboards and Enclosed Panelboards
- CSA C22.2, No. 94-M91—Special Purpose Enclosures
- NEMA PB 1—Panelboards
- NFPA 70—National Electrical Code® (NEC®)
- Federal Specification W-P-115C Type I Class 1—Circuit Breaker Panelboards
- 2003 IBC, NFPA 5000, ASCE/SE17—Seismic Qualification

Ratings

- Main lugs: 125–800 A
- Main circuit breaker: 125–600 A

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NF Circuit Breaker Panelboards
Main Circuit Breakers

HDL

Main Circuit Breakers

- 125 A maximum field-installable EDB, EGB, or EJB (110 A max at 600Y/347 Vac)
- 100 A maximum field-installable FI
- 125 A maximum field-installable HDL, HGL, HJL, or HLL
- 250 A maximum field-installable JDL, JGL, JJL, or JLL
- 400 A maximum field-installable LAL or LHL
- 400 A or 600 A maximum factory-installed LCL or LIL (LCL is 480Y/277 Vac maximum)

Factory-Installed Circuit Breaker Accessories

FIL, HDL, HGL, HJL, HLL, JDL, JGL, JJL, JLL, and KIL circuit breakers are available with shunt trip, ground fault shunt trip, undervoltage trip, time delay, auxiliary switches, and alarm switches.

JDL

Table 1: Main Circuit Breaker Adapter Kits (Circuit Breaker Not Included)

Adapter Kit Catalog Number	Ampere Rating	Main Circuit Breaker[1]
N100MFI	20–100 A	FIL
N150MH[2]	15–125 A[3]	HDL, HGL, HJL, HLL
N250MJ	150–250 A	JDL, JGL, JJL, JLL
N250MKC	110–250 A	KIL
N400M	125–400 A	LAL, LHL

1 Main circuit breakers are not included in the adapter kits. Order them separately.
2 For single phase applications of HDL and HGL, select a 3-pole main circuit breaker. For single-phase applications of HJL and HLL, select a 2-pole main circuit breaker.
3 RTI kit accepts maximum 125 A H-frame circuit breaker.

NOTE: See “Main Circuit Breaker Terminal Data” on page 18.

LAL

Field-Installable Circuit Breaker Accessories

Field-installable undervoltage release, alarm switch, shunt trip, and auxiliary contacts are available for LAL, LHL, LCL, and LIL 400 A main circuit breaker interiors.

NOTE: See Supplemental Digest for additional accessories.

N250MJ Main Circuit Breaker Kit

N400M Main Circuit Breaker Kit

Branch Circuit Breakers (Bolt-on)

Table 2: Standard Branches, 600Y/347 Vac Maximum

Branch Prefix	Availability			Short Circuit Current Rating[1]	
	1-Pole	2-Pole	3-Pole	at 480Y/277 Vac	at 600Y/347 Vac
EDB	15-70 A	15-125 A[2]	15-125 A[2]	18,000 A	14,000 A
EGB	15-70 A	15-125 A[2]	15-125 A[2]	35,000 A	18,000 A
EJB	15-70 A	15-125 A[2]	15-125 A[2]	65,000 A	25,000 A

1 Series ratings are also available.
In **Canada**: See Series Rating Guide (Data Bulletin #S1600PD0302EP).
In **USA**: See Switchboard/Panelboard Short Circuit Current Ratings (Data Bulletin #2700DB9901) or the Digest.

2 600Y/347 Vac is 110 A maximum.

Table 3: EPD Branches – 30 mA Ground Fault Equipment Protection Devices, 277 Vac Maximum

Branch Prefix	Availability 1-Pole[1]	Short Circuit Current Rating[2] at 277 Vac
EDB-EPD	15-70A	18,000 A
EGB-EPD	15-70A	35,000 A
EJB-EPD	15-70A	65,000 A

1 EPD branches are single-pole only, and require two pole spaces in the panelboard.

2 Also available with series ratings.

EDB Branch Circuit Breakers

Table 4: Standard and EPD Branches – Terminal Lug Data

Branch Circuit Breaker Prefix	Ampere Rating	Wire Size	
		Aluminum	Copper
EDB, EGB, EJB, EDB-EPD, EGB-EPD, EJB-EPD	15-30 A	#12 - #6	#14 - #6
	35-125 A	#12 - 2/0	#14 – 2/0

NF Circuit Breaker Panelboards
Interiors

250 A Maximum Main Lugs Interior (Deadfronts Installed)

Interiors

Main Lug Interiors

- Will accept bolt-on branch circuit breakers
- Top or bottom feed
- 65,000 A Short Circuit Current Rating (SCCR) maximum branch circuit breakers at 480Y/277 Vac
- 25,000 A SCCR maximum branch circuit breakers at 600Y/347 Vac
- Series rated to 200,000 A SCCR maximum when supplied by remote I-Limiter® circuit breaker at 480Y/277 Vac
- Series rated to 65,000 A SCCR maximum when supplied by remote I-Limiter circuit breaker at 600Y/347 Vac
- 125 A and 250 A interiors are suitable for use as cULus service entrance with back-fed EDB, EGB, or EJB circuit breakers
- Factory-installed main lugs on all interiors
- 125–400 A main lug interiors are convertible to main circuit breaker interiors by adding a main circuit breaker adapter kit and a main circuit breaker
- Several bus options:
  - — Silver-plated copper or tin-plated aluminum bus (aluminum is standard)
  - — Tin-plated copper bus is available as an option
  - — 600 A and 800 A only available with copper
- Branch connector fingers are tin-plated copper
  - — Silver-plated branch connector fingers are optional
- Line lugs are suitable for 75^0 C copper or aluminum wire

Factory-Installed Options for Main Lugs and Main Breaker Interiors

- Sub-Feed Lugs (on the Main)
  NOTE: Only available on 1ϕ or 3ϕ, 125–800 A main lug interiors
- Feed-Through Lugs
  NOTE: Available on 1ϕ or 3ϕ, 125–800 A main lug or 100–600 A main circuit breaker interiors
- Sub-Feed Circuit Breakers
  NOTE: Available on 1ϕ or 3ϕ, 125–800 A main lug or 100–600 A main circuit breaker interiors
  - — One sub-feed HDL, HGL, HJL, HLL, JDL, JGL, JJL, or JLL circuit breaker per 250 A panelboard
  - — Two sub-feed HDL, HGL, HJL, HLL, JDL, JGL, JJL, or JLL circuit breakers per 400 A panelboard
  - — One sub-feed LA, LH, LC, or LI circuit breaker (400 A maximum) and one HDL, HGL, HJL, HLL, JDL, JGL, JJL, or JLL circuit breaker, or two sub-feed HDL, HGL, HJL, HLL, JDL, JGL, JJL, or JLL circuit breakers per 600 A or 800 A panelboard

    NOTE: LC/LI circuit breakers cannot be combined with JJL or JLL circuit breakers
- Split bus
- Lighting contactors
- Compression lugs

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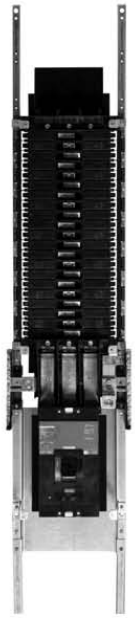
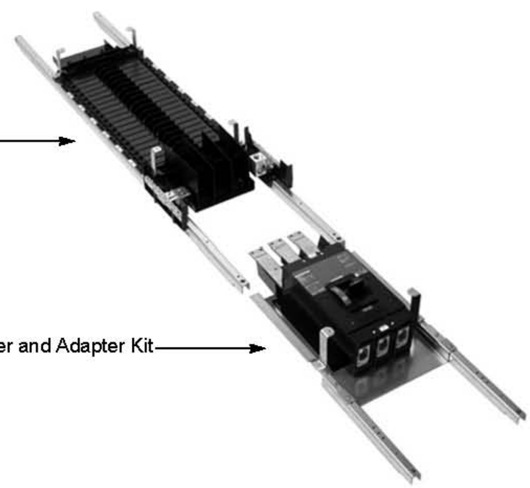


400 A LAL Main Circuit Breaker Interior

Main Circuit Breaker Interiors

- Will accept bolt-on branch circuit breakers
- Suitable for use as UL service entrance (statement found on wiring label on back of deadfront); meets local electrical codes (CSA type service entrance available factory-assembled)
- Top or bottom feed
- 65 k AIR maximum branch circuit breakers at 480Y/277 Vac
- 25 K AIR maximum branch circuit breakers at 600Y/347 Vac
- Series rated to 200 k AIR maximum when supplied by remote I-Limiter circuit breaker at 480Y/277 Vac
- Series rated to 65 k AIR maximum when supplied by remote I-Limiter circuit breaker at 600Y/347 Vac
- Available with silver-plated copper or tin-plated aluminum bus (aluminum is standard). Tin-plated copper bus is available as an option; 600 A only available with copper
- Branch connector fingers are tin-plated copper; silver-plated branch connector fingers are optional
- 125 A at 480Y/277 Vac (110 A at 600Y/347 Vac) main circuit breaker interiors contain back-fed EDB, EGB, or EJB main circuit breakers
- 100–250 A main circuit breaker panelboards consist of:
  - — Standard main lug interiors
  - — Main circuit breaker adapter kit (N150MH, N100MFI, N250MKC, N250MJ)
  - — Appropriate FIL, HDL, HGL, HJL, HLL, JDL, JGL, JJL, JLL, or KIL circuit breakers
  - — Line lugs are suitable for 75° C copper or aluminum wire
- 400 A main circuit breaker panelboard consists of:
  - — Standard main lug interior
  - — Main circuit breaker adapter kit (N400M)
  - — Appropriate LAL or LHL circuit breaker
  - — Factory-installed LCL or LIL main circuit breaker with 8 in. (203 mm) deep enclosure (Type 1 only)
- 600 A main circuit breaker panelboard:
  - — Factory-assembled only
  - — Use LCL, LIL main circuit breakers
  - — 8.75 in. (223 mm) deep enclosure (Type 1 only)



400 A Main Lugs Interior with 400 A Main Circuit Breaker and Adapter Kit

NF Circuit Breaker Panelboards
Interiors

400 A Main Lug Interior with Sub-Feed Lugs

400 A Sub-Feed Main Lug Kits

Field-Installable Options

- Feed-Through Lug Kits
  - — NF125FTL, NF250FTL, NF400FTL available for 125–400 A, 1ϕ or 3ϕ interiors
- Sub-Feed Circuit Breaker Kits
  - — NF250SFBH allows a single sub-feed HDL, HGL, HJL, or HLL circuit breaker on 250 A interiors
  - — NF250SFBJ allows a single sub-feed JDL, JGL, JJL, or JLL circuit breaker on 250 A interiors
  - — NF600SFBH allows twin sub-feed HDL, HGL, HJL OR HLL circuit breaker on 400 A main lug or main circuit breaker interiors and 600A main lug interiors
  - — N600SFBJ allows twin sub-feed JDL, JGL, JJL, or JLL circuit breakers on 400 A main lug or main circuit breaker interiors and 600 A main lug interiors
- Sub-Feed Lug Kits

Amperes	Catalog Number
125 A	NF125SFL
250 A	NF250SFL
400 A	NF400SFL

- 200% Neutral Kits

Amperes	Catalog Number
100 A	NFNL1
125 A	NFNL1
250 A	NFNL2
400 A	NFNL4[1]

[1] 200% neutrals not available with FTL, SFL, or SFB.

- Copper 100% Kits

Copper 100% Amperes	Copper Neutral Kits Catalog Number
125 A	NFN1CU
250 A	NFN2CU
400 A	NFN6CU
600 A	NFN6CU[1]

[1] Not to be used with SFL, FTL, or SFB. These combinations are factory-assembled only.

Compression Lugs

Compression Lugs

Compression lugs are available for 125–600 A main lug interiors and 100–400 A main circuit breaker interiors.

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Neutrals

Neutral Assembly

- All lugs are suitable for copper or aluminum wire
- 125–250 A interiors have a split neutral located on the same end as the mains
- 400–800 A interior neutrals can be located on either end depending on the configuration
- Neutral may be bonded for use as a UL service entrance
- Branch terminals are suitable for #14-2/0 copper or aluminum and #14-#6 copper or aluminum
- Provisions for larger branch terminal lug kits are available as options
- Suitable lug provided on neutrals for termination of the grounding conductor
- All unused neutral terminals may be used to terminate equipment grounding conductors when the panelboard is used as UL service equipment
- 100% rated neutrals are standard; one neutral termination provided per circuit in the panelboard
- 200% rated neutrals are optional see, "200% Neutral Kits" below

Neutral Bonding Provisions

125–250 A Neutral Bonding Provisions

The bonding strap may be field installed for UL service equipment requirements on 125–800 A interiors. Not applicable for CSA service entrance panels in Canada.

Table 5: Copper 100% Neutral Kits for Use with Single or Three Phase 125-600 A Interiors

Amperage	125 A	250 A	400 A	600 A	800 A
Catalog Number	NFN1CU	NFN2CU	NFN6CU	NFN6CU[1]	Kit not available, Factory-assembled only

1 Not to be used with SFL, FTL or SFB. These combinations are factory-assembled only.

200% Neutral Kits

Table 6: 200% Neutral Kits for Use with Single or Three Phase 125-400 A Interiors

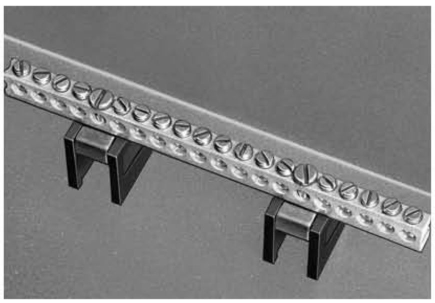
Amperage	125 A	250 A	400 A	600 A	800 A
Catalog Number	NFNL1	NFNL2	NFNL4[1]	Kit not available, Factory-assembled only	

1 Not to be used with SFL, FTL or SFB. These combinations are factory-assembled only.

NFNL2

NF Circuit Breaker Panelboards
Ground Bar Kits

Ground Bar Kit



Ground Bar with Insulator Kit

Ground Bar Kits

- Field installable in all panelboards
- Wire size of terminals (refer to the technical information below)

Table 7: Ground Bar Kits

Catalog Number	Terminals	Material
PK23GTAL	23	AL
PK27GTA	25[1]	CU
PK27GTACU	27	AL

1 24 small terminals and 1 large terminal

- Order enough ground bar kits to accommodate all the ground conductors used in the panel

Ground Bar Insulator Kits (Catalog No. PKGTAB)

- The insulator kit isolates the standard panelboard ground bar from the panelboard
- The insulator kit is field installable, and panelboard enclosures have ground bar mounting provisions in all four corners

Technical Information

All PK equipment grounding kits are supplied with mounting screws, installation instructions, and an "Equipment Grounding Terminal" self-adhesive label.

Table 8: Technical Information

Catalog Number	Terminals			Approximate Overall Length Inches (mm)	Distance Between Mounting Holes Inches (mm)
	Number of Terminals	Quantity Available for Each Size			
		Material	I / II[1]		
PK23GTAL	24	AL	23 / 1	9.125 (232)	3.125 (79)
PK27GTA	27	AL	24 / 1	9.125 (232)	3.125 (79)
PK27GTACU	27	CU	27 / 0	9.125 (232)	3.125 (79)

1 See wire range table below.

Table 9: Wire Range

Size	Cu	Al
I	(1) #14 to #4 or (2) #14 or #12	(1) #12 to #4 or (2) #12 or #10
II	(1) #1 to 4/0	(1) #1 to 4/0

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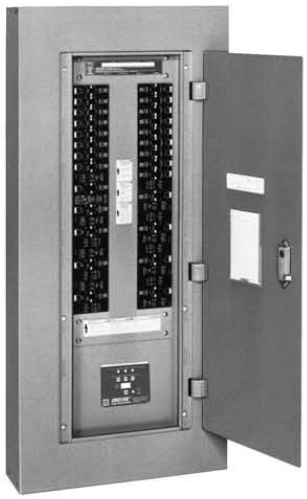
Surge Protection

The Surgelogic® IMA series surge protective device is a modular parallel transient voltage surge suppressor (TVSS). The IMA device is a multi-stage suppression circuit consisting of field-proven, fast-acting, 34 mm metal oxide varistors (MOVs).

A surge suppression path is provided for each mode, line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), and neutral-to-ground (N-G). Each surge suppression mode is individually fused and uses circuitry with thermal cutouts to isolate the TVSS and ensure shutdown in the event of MOV damage during severe overvoltages, even when operated on high fault current power systems.

The suppression elements are encapsulated in a UL recognized potting material—another performance element that provides additional protection. A filter provides a high level of EMI/RFI noise attenuation. On-line diagnostics continuously monitor the device status, and LEDs signal loss of a suppression circuit. An audible alarm with an enable/disable feature and dry contacts are included in the standard diagnostic package.



NF Main Lugs Panelboard with Integral TVSS

Table 10: NF Interiors with TVSS[1]

Mains Rating	Max Circuit Breaker Spaces	TVSS Rating		Interior Catalog Number[2]	Components for Adding a Vertical Main Circuit Breaker	
		Voltage	Surge Rating		Main Circuit Breaker Kit	Main Circuit Breaker Frames
250 A	42	480Y/277 Vac	120	NF442L2TVS412	N150MH[3]	HD, HG, HJ or HL
			160	NF442L2TVS416	N250MJ	JD, JG, JJ or, JL
		600Y/347 Vac	120	NF442L2TVS812	N250MKC	KI
400 A	42	480Y/277 Vac	120	NF442L4TVS412	N400M	LAL/LHL (LC and LI F/A only)
			160	NF442L4TVS416		
		600Y/347 Vac	120	NF442L4TVS812		

1 These interiors are available as catalog numbered devices. TVSS is not available as a field-installable kit.
2 To order an interior with copper bus, add a "C" to the end of the catalog number (example: NR442L2TVS412C).
3 RTI kit accepts maximum 125 A H-frame circuit breaker.

Table 11: IMA Series Voltage Specifications

Service Voltage	UL Suppression Voltage Rating (SVR)				
	L–N	L–G	N–G	L–L	MCOV[1]
120/240 Vac, 1-phase	400	400	400	800	150
208Y/120 Vac, 3-phase, 4-wire	400	400	400	800	150
240/120 Vac, 3-phase, high-leg delta	800/400	800/400	400	1500/800	275/150
480Y/277 Vac, 3-phase, 4-wire	800	800	800	1600	320
600Y/347 Vac, 3-phase, 4-wire	1200	1200	1200	2000	420

1 MCOV: maximum continuous operating voltage.

NF Circuit Breaker Panelboards
Surge Protection

Table 12: Performance Features

Surge Capacity	L–N	L–G	N–G (3-Phase Rating)
100 kA / phase	50 kA	50 kA	100 kA
120 kA / phase	60 kA	60 kA	120 kA
200 kA / phase	100 kA	100 kA	200 kA
160 kA / phase	80 kA	80 kA	120 kA
240 kA / phase	120 kA	120 kA	120 kA

Table 13: Specifications

Relative Humidity	0 to 95% non-condensing
Operating Frequency	47–63 Hz
Storage Temperature	-40 to +65 °C (-40 to +149 °F)
Operating Temperature	-40 to +65 °C (-40 to +149 °F)
Display Operating Temperature	-10 to +50 °C (+14 to +122 °F)
Standards	C-UL, UL 1449 Second Edition UL Category Section 37.3 (200 kA short-circuit current module rating)
Fusing	Individually fused suppression modules
Audible Alarm	Provides audible indication that there is a loss of protection
Dry Contacts	Provides remote indication of the TVSS device's operating status to a computer interface board or emergency management system

Table 14: Other Options

Option	Description
Surge Counter	Displays the combined total number of transient voltage surges detected from L–G, L–L, L–N, and N–G since the counter was last reset.
Remote Monitor	Displays the alarm status of the surge protective device up to 1,000 ft. (305 m) away from the unit. This option uses the dry contacts.

Design Features

- Individually fused suppression modules
- Thermal cutout
- Inline, copper bus bar connection
- Solid state bi-directional
- Push-to-Test on-line diagnostic display
- Audible alarm with enable/disable switch
- LED indicators indicate loss of protection, or fully operational circuit
- High-energy parallel design for IEEE C62.41 category A, B, and C3 applications
- Available in main circuit breaker and main lug only panelboards with sub-feed circuit breakers, feed-through lugs, or sub-feed lugs
- AC tracking filter with EMI/RFI filtering up to -50 dB from 100 kHz to 100 MHz

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Enclosures

Enclosure Types

Mono-Flat Type 1 Enclosure for 100–250 A Interiors

Type	Environment	Protects Against
Type 1	Indoor	Contact with the enclosed equipment, falling dirt
Type 2	Indoor	Type 1, plus • Dripping and light splashing of non-corrosive liquids
Type 3R	Outdoor	Type 2, plus • Rain, snow, and sleet
Type 4	Indoor/outdoor	Type 3R, plus • Circulating dust, lint, fibers and flyings • Settling airborne dust, lint, fibers and flyings • Windblown dust • Hosedown and splashing water
Type 4X	Indoor/outdoor	Type 4, plus • Corrosive agents
Type 5	Indoor	Type 2, plus • Settling airborne dust, lint, fibers, and flyings
Type 12	Indoor	Type 2, plus • Circulating dust, lint, fibers, and flyings • Settling airborne dust, lint, fibers, and flyings • Oil and coolant seepage

Indoor Enclosures (Types 1 and 2)

Type 1 Enclosure for 400–800 A Interiors

MH type Box

- Standard boxes are 20 in. (508 mm) wide by 5.75 in. (223 mm) deep
- NF interiors with an LC or LI main circuit breaker or with an 800 A MLO interior require an 8.75 in. (223 mm) deep box — therefore, they are available factory-assembled and fully-assembled only
- Boxes are galvanized steel with removable endwalls. On standard 5 3/4 inch depth boxes, one endwall is provided with knockouts, and the other endwall is blank. On deeper boxes, both are blank. Endwalls are removable and interchangeable
- Box and interior mounting instructions are included in the documentation shipped with the interior
- Keyhole slots are located in the box backwall to ease installation

  NOTE: Interiors mount directly to studs in MH boxes. No interior mounting brackets are required.

  NOTE: 800 A interiors and interiors that have LC/LI main circuit breakers require elevating brackets, due to the requirement of an 8.75 in. (223 mm) deep box.
- Type 2 boxes include a drip hood (available with surface mounted trim only)

NF Circuit Breaker Panelboards
Enclosures

Type 1 and 2 Trim Fronts

- Finished with gray-baked enamel electrodeposited over cleaned, phosphatized steel (ANSI 49)
- Order flush or surface mounted
- Door with flush lock; uses NSR-251 key
- Directory card located on the inside of the door
- Mono-Flat® fronts on 100–250 A interiors mount to the interior trim with trim screws. Both trim mounting screws and door hinges are concealed; fronts are not removable with the door closed and locked
- Fronts for 400–800 A interiors are ventilated and mount to the enclosure with trim screws; door hinges are concealed
- Fronts 56 in. (1422 mm) high or more on 250 A interiors or 74 in. (1880 mm) high or more on 600 A and 800 A interiors have two flush locks
- Fronts 68 in. (1727 mm) high or more on interiors with LC/LI main circuit breakers or LC sub-feed circuit breakers use a sliding vault lock with 3-point latching

Key NSR-251
(Catalog No. LP9618)

Concealed Hinge for 100–800 A Trim Fronts

Interiors Mount Directly to Enclosure Studs

Standard Flush Lock
(Catalog No. PK4FL)

Optional Sliding Vault Lock (Catalog No. PK5FL)

MH Box

14

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SQUARE D by Schneider Electric

NF Circuit Breaker Panelboards
Enclosures

Rainproof (Type 3R) Dust tight (Type 5 and 12)

- Finished with gray-baked enamel electrodeposited over cleaned, phosphatized galvanized steel (ANSI 49)
- Gasketed door with lockable vault handle (PK4NVL); uses NSR-251 key
- Directory card located on the inside of the door
- No knockouts in endwalls
- Trim kit included for end and side gutters
- Provisions for two ground bars
- 125 A, 250 A, 400 A main lug and main circuit breaker interiors
- 600 A and 800 A main lug only

Type 3R, 5, and 12 Enclosures

Vault Handle with Lock
(Catalog No. PK4NLV)

Corrosion-Resistant Fiberglass-Reinforced Polyester (Type 4X)

Type 4X Enclosure

- Watertight and dust-tight
- Gasketed door with trunk latches
- Directory card located on the inside of the door

Stainless Steel (Type 4 and 4x)

- Water and dust tight
- Gasketed door
- Directory card located on inside of door

15

SQUARE D by Schneider Electric

08/2008

NF Circuit Breaker Panelboards
Single Row (Column-Width) Panelboards

Column-Width Panelboard

Single Row (Column-Width) Panelboards

Application Data

Ratings

- Main lugs: 125 A, 225 A
- Main circuit breaker: 100 A, 225 A

Interiors

- 60 A maximum branch circuit breaker
- Bolt-on EDB/EGB/EJB circuit breakers
- Solid neutral opposite mains

Enclosures

- 8-5/8 in. (219 mm) wide by 5-5/8 in. (143 mm) deep for 10 in. (254 mm) H- or I-beam
- Galvanized steel
- Removable endwalls

Trim Fronts

- Screw mounted
- Door with two flush latches
- Finish: gray-baked enamel electrodeposited over cleaned, phosphatized steel

Line Lugs

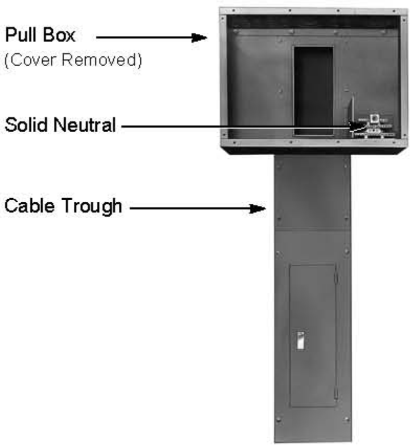
- All lugs are suitable for 75° C copper or aluminum wire

Table 15: Branch Circuit Breaker Short-Circuit Current Ratings

Branch Breaker Prefix 1, 2 and 3 pole 15 to 60A	Short Circuit Current Rating[1]	
	@ 480Y/277 Vac	@ 600Y/347 Vac
EDB	18,000 A	14,000 A
EGB	35,000 A	18,000 A
EJB	65,000 A	25,000 A

1 Series ratings are also available.
Canada: See the Series Rating Guide (data bulletin S1600PD0302EP R__).
USA: See Switchboard/Panelboard Short-Circuit Ratings (data bulletin 2700DB9901), or the Digest (http://ecatalog.squared.com/category.cfm).

NF Circuit Breaker Panelboards
Single Row (Column-Width) Panelboards



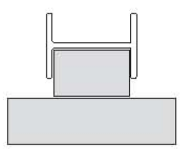
Single Row (Column-Width) Panelboard

Cable Trough

- Cable trough is stackable
- 8-5/8 in. (219 mm) wide by 5-5/8 in. (143 mm) deep for 10 in. (254 mm) I-beam or H-beam
- Galvanized steel trough uses enclosure endwall
- Screw-mounted two-piece front
  - — 15 in. (381 mm) long top piece of front removable for pull box mounting
  - — Finish: gray-baked enamel electrodeposited over cleaned, phosphatized steel

Table 16: Column-Width Cable Trough

Length of Cable Trough	Catalog No.
36 in. (914 mm)	NTX836
48 in. (1219 mm)	NTX848
56 in. (1422 mm)	NTX856
66 in. (1676 mm)	NTX866
84 in. (2134 mm)	NTX884
96 in. (2438 mm)	NTX896
104 in. (2642 mm)	NTX8104
112 in. (2845 mm)	NTX8112



Cable Trough Top View with I-Beam

Pull Box
(catalog number MPX81542)

- Mounts on cable trough
- 20 in. (508 mm) wide by 5-3/4 in. (146 mm) deep by 15 in. (381 mm) high
- Screw-mounted front
- Finish: gray-baked enamel electrodeposited over cleaned, phosphatized steel
- Removable top endwall with knockouts
- Solid neutral included

17

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NF Circuit Breaker Panelboards
Terminal Data

Terminal Data

Main Lugs Terminal Data

Table 17: Standard Aluminum and Copper Lugs

Amperes	Aluminum				Copper			
	Aluminum Mechanical		Aluminum Compression		Copper Mechanical		Copper Compression	
	Cat. #	Lug Wire Range	Cat. #	Lug Wire Range	Cat. #	Lug Wire Range	Cat. #	Lug Wire Range
125	NFALM1	(1) #6 - 2/0l[1]	NFALV1	(1) #4-300 kcmil	NFCUM1	(1) #6 - 350 kcmil	NFCUV 1	(1) #6 - 1/0
250	NFAML2	(1) #6 - 350 kcmil	NFALV2	(1) 250-350 kcmil	NFCUM2	(1) #6 - 350 kcmil	NFCUV 2	(1) 2/0 - 300 kcmil
400	NFALM4	(1) 1/0-750 kcmil or (2) 1/0-350 kcmil	NFALV4	(2) 2/0-500 kcmil	NFCUM4	(1) 1/0-750 kcmil or (2) 1/0-350 kcmil	NFCUV 4	(1) 400-750 kcmil
600	NFALM6	(2) 1/0-600 kcmil	NFALV6	(2) 2/0-500 kcmil	NFCUM6	(2) 1/0-750 kcmil	NFCUV 6	(2) 250-750 kcmil
800	Contact the Technical Applications Group (TAG)							

1 Neutral accepts #6-2/0 Al/Cu.

Main Circuit Breaker Terminal Data

See Digest section 7 for copper lugs.

Table 18: Standard Aluminum Mechanical Lugs

Panelboard Type	Ampere Rating	Circuit Breaker Type	Lug Wire Range
NF	100 A	FIL	(1) #14-1/0 Cu or (1) #12-1/0 Al
	125 A[1]	EDB, EGB, EJB	(1) #14-2/0 Al/Cu
	150 A	HDL, HGL, HJL, HLL	(1) #14-3/0 Al/Cu
	250 A	JDL, JGL, JJL, JLL, KI	(1) 3/0-350 kcmil Al/Cu
	400 A	LAL, LHL	(1) #1-600 kcmil Al/Cu or (2) #1-250 kcmil Al/Cu
	600 A	LCL, LIL, LEL, LXL LXIL	(2) 4/0-500 kcmil Al/Cu
	800 A	800 A main breaker panelboard not available.	

1 110 A maximum at 600Y/347 Vac.

Table 19: Aluminum Compression Lugs

Panelboard Type	Ampere Rating	Circuit Breaker Type	Catalog No.	Lug Wire Range
NF	100 A	FC, FI	VC100FA	(1) #8-1/0 Al/Cu
	125 A[1]	ED, EG, EJ	VC100FD	(1) #8-1/0 Al/Cu
	150 A	HDL, HGL, HJL, HLL	YA150HD	(1) #1–4/0 Al/Cu
	250 A	JDL, JGL, JJL, JLL	YA250J35	(1) 3/0–350 kcmil Al/Cu
	250 A	KI	VC250KA3	(1) #4-300 kcmil Al/Cu
	400 A	LA, LH	VC400LA5[2]	(1) 2/0-500 kcmil Al/Cu
	600 A	LC, LI, LE, LX, LXI	—	—
	800 A	800 A main breaker panelboard not available.		

1 110 A maximum at 600Y/347 Vac.

2 Other lug sizes available.

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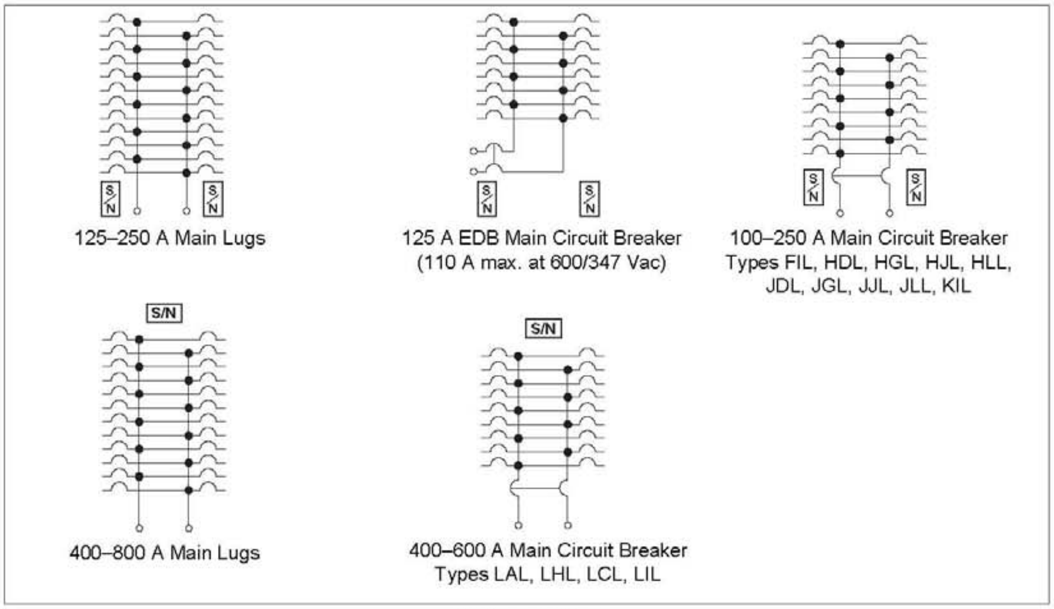
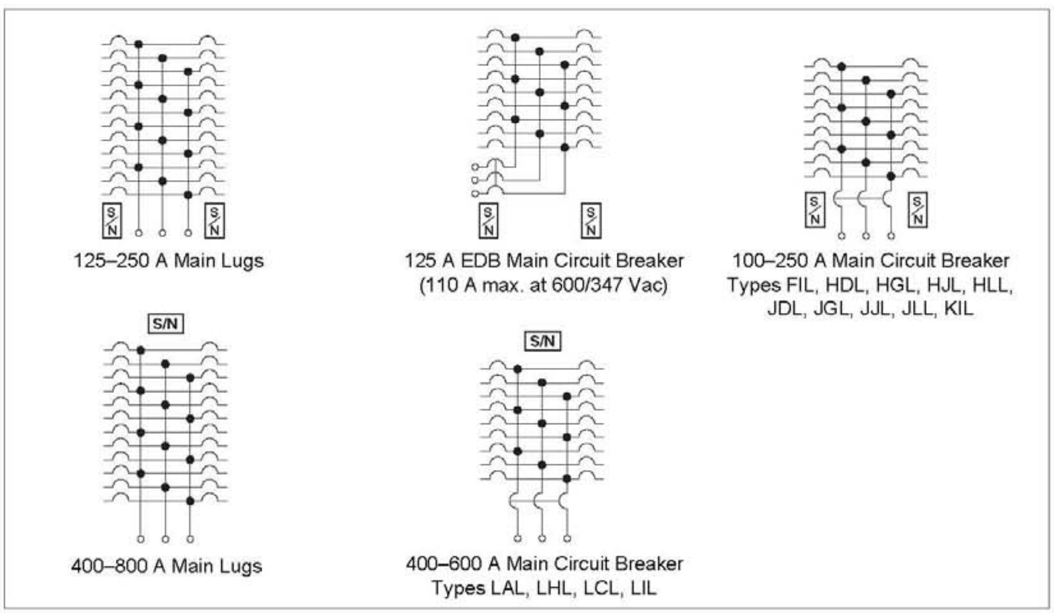
Typical Wiring Diagrams



1-Phase, 3-Wire



3-Phase, 4-Wire

APPENDIX IV.C: SHORT CIRCUIT ANALYSIS

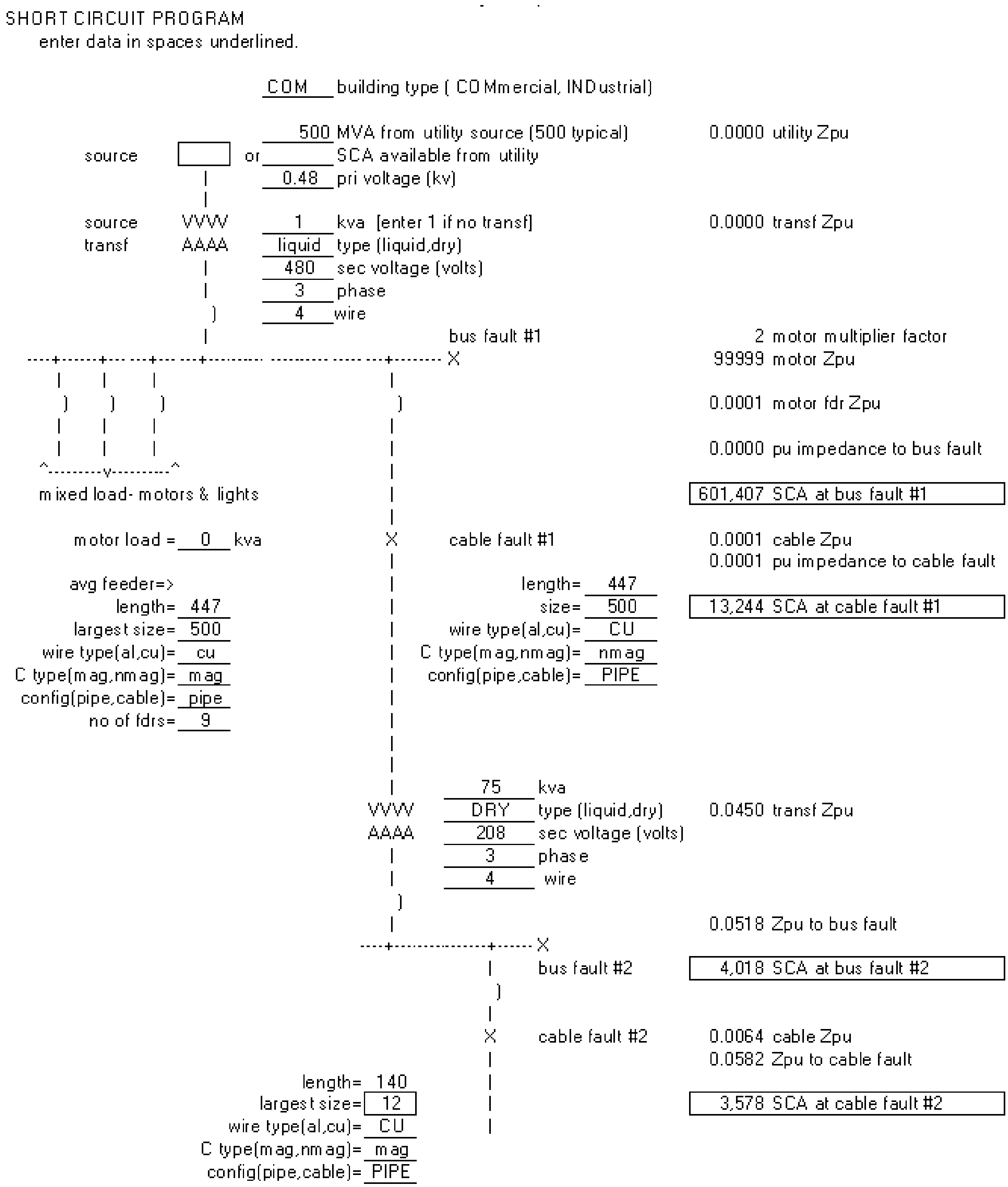


Figure 12: Short circuit analysis

APPENDIX IV.D: CHILLED BEAM CATALOGS

T 2.4/2/EN/1

Active Chilled Beams

Type DID300B

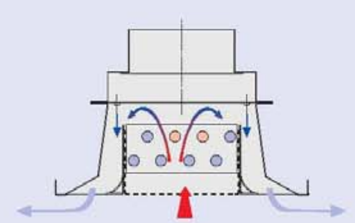
TROX® TECHNIK

TROX GmbH

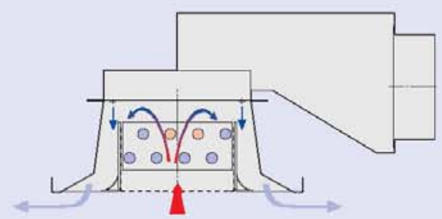
Heinrich-Trox-Platz
D-47504 Neukirchen-Vluyn

Telephone +49/28 45/2 02-0
Telefax +49/28 45/2 02-2 65
e-mail trox@trox.de
www.troxtechnik.com

Contents · Description



DID300B-...-V
Top entry air connection spigot



DID300B-...-H
Side entry air connection spigot

Description

TROX Active Chilled Beams type DID300B use a combination of air and water systems. They combine the air flow characteristics of ceiling diffusers with the energy benefits of load dissipation using water (heating/cooling).
The primary air volume flow required for fresh air supply enters the upper plenum box through a connecting spigot and is then discharged into the mixing zone via nozzles which are fitted into a diaphragm plate.
The induced air is drawn from the room through a water coil. In the mixing section of the DID300B the induced air is mixed with the primary air and the total discharged into the room via slots.
The DID300B can be used for cooling and/or heating.
An additional spigot for extract of exhaust air can be fitted adjacent to the primary air duct (supply and extract air construction).

Caution !
The cold water supply temperature must be selected such that it never falls below room dewpoint.

Max. pressure:
for 2-pipe and 4-pipe system
6 bar at 90°C
7 bar at 20°C
Other operating pressures available on request!

The type DID300B chilled beams are particularly suitable for use in low ceiling void spaces because of their shallow construction. Thus they are suitable not only for use in new buildings but are also excellent for refurbishment projects.
When connected appropriately, they can be used for both individual room control or form a grouped zone control.
The DID300B is available with either top or side entry air connection spigot for supply and extract air.
Between the upper and lower casing there is a diaphragm plate which contains two longitudinal rows of nozzles. These discharge nozzles are available in three different sizes, the selection depending on the volume flow rates required.
The induction grille can easily be removed for cleaning purposes.

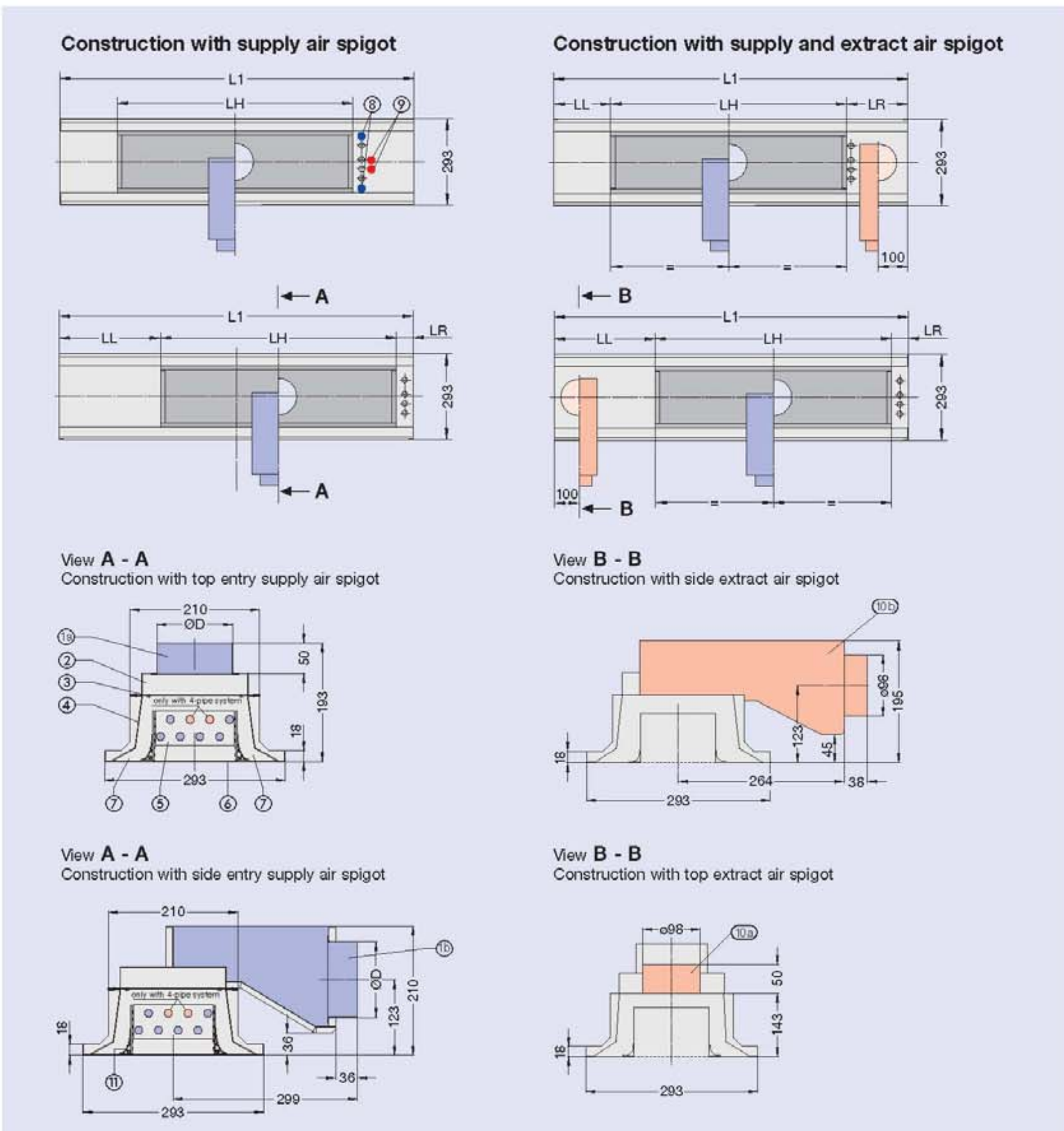
Materials
Casing, including the top plenum and perforated plate induction grille are made of galvanised steel sheet.
The standard finish of the casing and the induction grille is powder-coated white (RAL 9010), the top casing (plenum) and coil remain untreated - optionally can be finished in black (RAL 9005), nozzle plate only finished in black (RAL 9005).
The heat exchanger consists of copper tubes with formed aluminium fins. The flexible hose, available as an accessory, is made of special plastic with stainless steel sheathing.

2

Construction

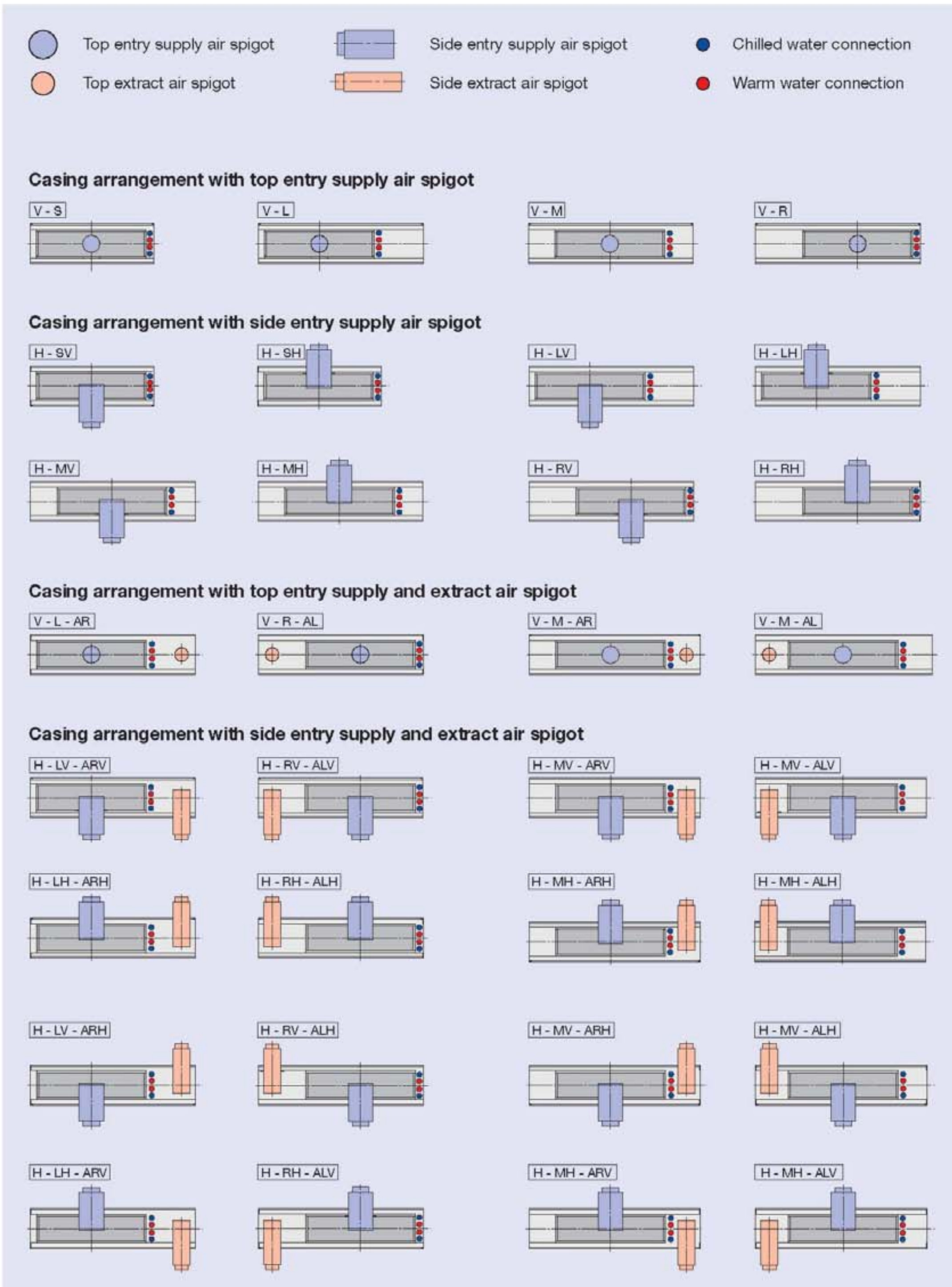
- (1a) Supply air top entry connecting spigot } L_N 900 to 1800 = Ø 123
- (1b) Supply air side entry connecting spigot } L_N 2100 to 3000 = Ø 158
- (2) Top of casing (plenum)
- (3) Discharge nozzles
- (4) Casing
- (5) Coil (pipe-Ø 12 mm)
- (6) Perforated plate induction grille
- (7) Discharge slots
- (8) Label chilled water (blue)
- (9) Label warm water (red)
- (10a) Extract air top connecting spigot
- (10b) Extract air side connecting spigot

L_1 = Total length (diffuser face)
L_N = Nominal length
(for dimensions of unit see page 5)



3

Casing arrangements



4

Dimensions

V - S | H - SV | H - SH

Supply air		Arrangement of the top active plenum: Extends over total length (standard)					
L_N	L_H	L_L		L_R		L_1	
		min	max	min	max	min	max
900	800	40	43	54	58	893	900
1200	1100	40	43	54	58	1193	1200
1500	1400	40	43	54	58	1493	1500
1800	1700	40	43	54	58	1793	1800
2100	2000	40	43	54	58	2093	2100
2400	2300	40	43	54	58	2393	2400
2700	2600	40	43	54	58	2693	2700
3000	2900	40	43	54	58	2993	3000

V - L | H - LV | H - LH

Supply air		Arrangement of the top active plenum (plenum shorter than L_1): left				
L_N	L_H	L_L	L_R		L_1	
			min	max	min	max
900	800	43	58	658	901	1500
1200	1100	43	58	658	1201	1800
1500	1400	43	58	658	1501	2100
1800	1700	43	58	658	1801	2400
2100	2000	43	58	658	2101	2700
2400	2300	43	58	658	2401	3000
2700	2600	43	58	358	2701	3000

V - M | H - MV | H - MH

Supply air		Arrangement of the top active plenum (plenum shorter than L_1): middle	
L_N	L_H	L_1	
		min	max
900	800	901	1500
1200	1100	1201	1800
1500	1400	1501	2100
1800	1700	1801	2400
2100	2000	2101	2700
2400	2300	2401	3000
2700	2600	2701	3000

V - R | H - RV | H - RH

Supply air		Arrangement of the top active plenum (plenum shorter than L_1): right				
L_N	L_H	L_L		L_R	L_1	
		min	max		min	max
900	800	43	643	58	901	1500
1200	1100	43	643	58	1201	1800
1500	1400	43	643	58	1501	2100
1800	1700	43	643	58	1801	2400
2100	2000	43	643	58	2101	2700
2400	2300	43	643	58	2401	3000
2700	2600	43	343	58	2701	3000

For construction and casing arrangements see pages 3 and 4

V - L - AR | H - LV - ARV | H - LH - ARV | H - LV - ARH | H - LH - ARH

Supply and extract air		Arrangement of the top active plenum (plenum shorter than L_1): left				
L_N	L_H	L_L	L_R		L_1	
			min	max	min	max
900	800	43	253	658	1096	1500
1200	1100	43	253	658	1396	1800
1500	1400	43	253	658	1696	2100
1800	1700	43	253	658	1996	2400
2100	2000	43	253	658	2296	2700
2400	2300	43	253	658	2596	3000
2700	2600	43	253	358	2896	3000

V - M - AL | H - MV - ALV | H - MV - ARV | H - MH - ALV | H - MH - ARV | V - M - AR | H - MV - ALH | H - MV - ARH | H - MH - ALH | H - MH - ARH

Supply and extract air		Arrangement of the top active plenum (plenum shorter than L_1): middle	
L_N	L_H	L_1	
		min	max
900	800	1290	1800
1200	1100	1590	1800
1500	1400	1890	2100
1800	1700	2190	2400
2100	2000	2490	2700
2400	2300	2790	3000

V - R - AL | H - RV - ALV | H - RH - ALV | H - RV - ALH | H - RH - ALH

Supply and extract air		Arrangement of the top active plenum (plenum shorter than L_1): right				
L_N	L_H	L_L		L_R	L_1	
		min	max		min	max
900	800	238	643	58	1095	1500
1200	1100	238	643	58	1395	1800
1500	1400	238	643	58	1695	2100
1800	1700	238	643	58	1995	2400
2100	2000	238	643	58	2295	2700
2400	2300	238	643	58	2595	3000
2700	2600	238	343	58	2895	3000

All dimensions in mm with normal tolerances for sheet construction!

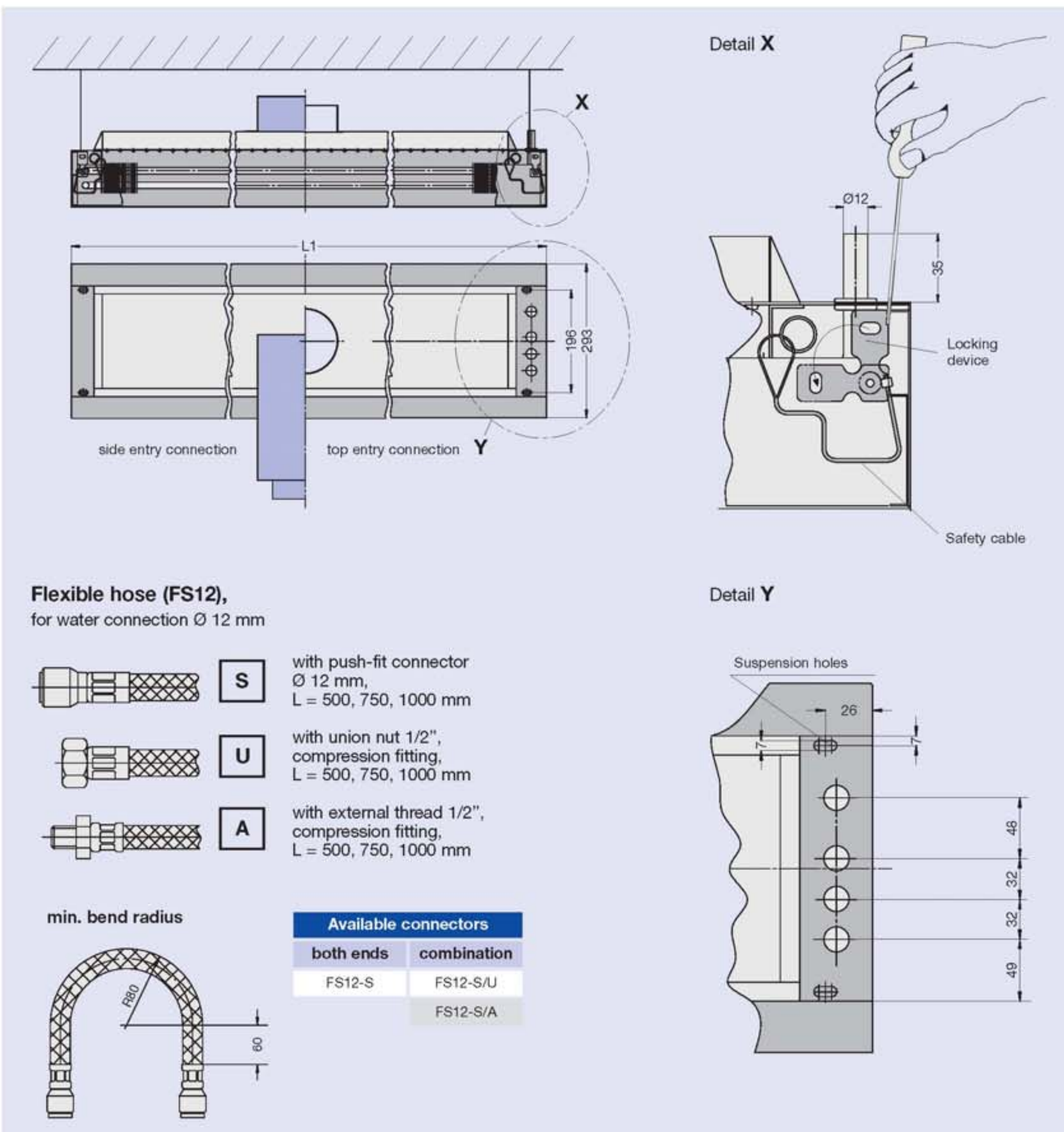
5

Assembly

Assembly

The two long sides of the DID300B are each provided with two suspension holes or for L_1 = 1500 4 holes are provided on each side. The assembly is installed on site using wire or metal hangers which must have the Building Authority certificate of approval. When the DID300B has been installed, 4 locking devices can be loosened with a screw driver (detail X) and the whole induction grille can be lowered down lengthways. The induction grille is supported by two safety cables.

The coil is accessible when the induction grille is removed. The coil connections are on the outside of the DID300B unit. The connection options to the flow and return pipes are, solid soldered, push fit or compression fittings (internal or external threaded end fittings).
The air connection is either from the side or from the top, depending on the construction.



Available connectors	
both ends	combination
FS12-S	FS12-S/U
	FS12-S/A

6

Installation

The DID300B unit is fitted with a border extrusion which is suitable for the usual range of ceiling constructions. This ensures the best possible ceiling design.

Installation into grid ceilings

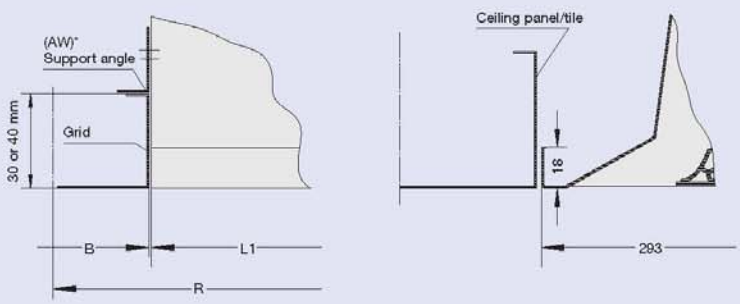
The DID300B can be installed on site at the ends using the support angles which are available as an accessory.
The support angles are supplied loose and can be fitted as appropriate for the grid on site. With this method it is no longer necessary to level the DID300B units.

Installation in T-bar ceilings or closed ceilings

These options allow for installation in a visible T-bar ceiling arrangement or in plasterboard or other closed ceiling systems.

Weight relative to the stability of the construction must be taken off the ceiling. Suspension holes are provided for this. The same also applies to preventing the units themselves from sagging.

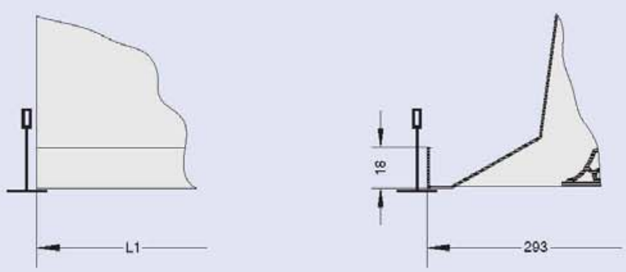
Installation in grid ceilings



B = Grid width
R = Grid pitch

* Support angle (AW) can be supplied loose

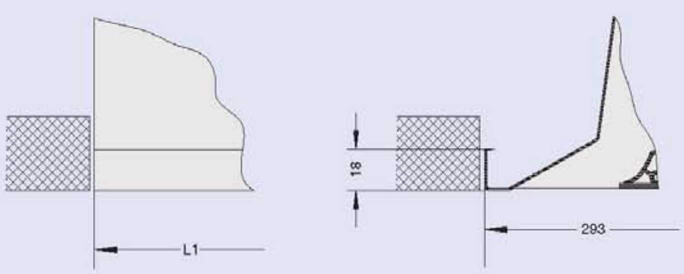
Installation in T-bar ceilings



Depending on the quality of the room air, there is the possibility of dust deposits as with all room air induction units.
If necessary the unit can be cleaned with ordinary, non-aggressive household cleaners. The coil can be cleaned with an industrial vacuum cleaner.

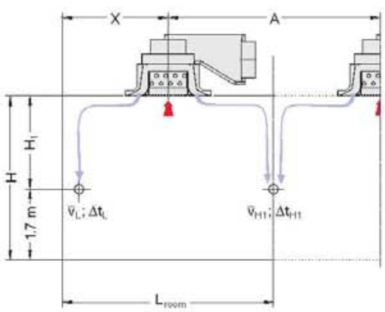
(See also VDI 6022, page 1 – "Hygiene requirements for room air-conditioning systems")

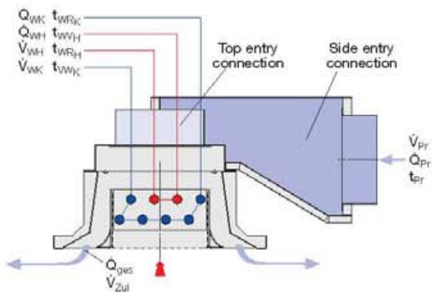
Installation in plasterboard ceilings or closed ceilings

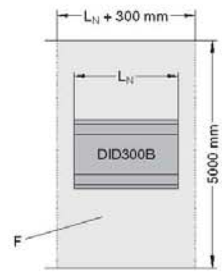


7

Nomenclature







Δt_L	in K:	Temp. diff. between room air t_R and core t_L at distance L = X + H_1
Δt_{H1}	in K:	Temp. diff. between room air t_R and core t_{H1} at distance L = A/2 + H_1
Δt_{Pr}	in K:	Temp. diff. between room air and primary air
Δt_Z	in K:	Temp. diff. between room air and supply air into space
Δt_W	in K:	Water temperature difference
Δt_{RW_V}	in K:	Temp. diff. between room air and water flow temperature
Δp_t	in Pa:	Primary air pressure drop
Δp_W	in kPa:	Water pressure drop
t_R	in °C:	Room temperature
t_{WV_K}	in °C:	Water flow temperature – cooling
t_{WR_K}	in °C:	Water return temperature – cooling
t_{WV_H}	in °C:	Water flow temperature – heating
t_{WR_H}	in °C:	Water return temperature – heating
t_{Pr}	in °C:	Primary air temperature
$\dot{Q}_{W_K}$	in W:	Water cooling capacity
$\dot{Q}_{W_H}$	in Watt:	Water heating capacity
$\dot{Q}_{ges}$	in Watt:	Total cooling capacity $\dot{Q}_{Pr} + \dot{Q}_S$
$\dot{Q}_{Pr}$	in Watt:	Primary air cooling capacity
$\dot{Q}_S$	in Watt:	Water side thermal capacity (for cooling $\dot{Q}_S = \dot{Q}_{W_K}$, for heating $\dot{Q}_S = \dot{Q}_{W_H}$)
$\dot{q}_{Zul}$	in W/m²:	Specific cooling capacity based on reference area F
$\dot{V}_{WK}$	in l/h:	Water volume flow rate – cooling
$\dot{V}_{WH}$	in l/h:	Water volume flow rate – heating
$\dot{V}_{Zul}$	in l/s:	Supply air volume flow rate to space
$\dot{V}_{Pr}$	in l/s:	Primary air volume flow rate
$\bar{v}_L$	in m/s:	Time average air velocity at distance L
$\bar{v}_{H_1}$	in m/s:	Time average air velocity at distance A/2 + H_1
L_{WA}	in dB(A):	A-weighted sound power level
A	in m:	Spacing between 2 diffusers
L	in m:	Horizontal plus vertical distance from diffuser, discharge down the wall L = X + H_1
X_{krit}	in m:	Horizontal distance from diffuser at which the supply air begins to separate from ceiling
H_1	in m:	Distance ceiling - occupied zone
H	in m:	Room height or height of installation
X	in m:	Distance from diffuser centre line to the wall
L_N	in mm:	Nominal length
F	in m²:	Reference area (L_N + 0.3) x 5

8

Performance overview – cooling

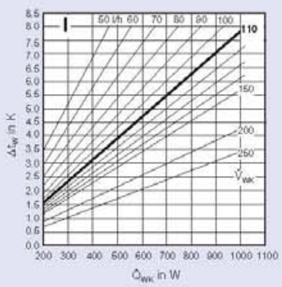
with 2-pipe and 4-pipe system

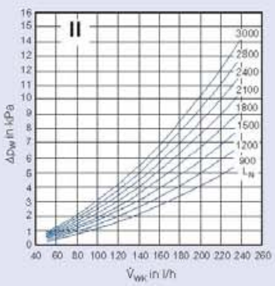
Correction factors

	$\dot{V}_{WK}$ in l/h	50	70	90	110	140	180	200	250
L_N	900	0.71	0.85	0.94	1.00	1.07	1.12	1.14	1.18
	1200	0.69	0.83	0.93	1.00	1.07	1.14	1.15	1.20
	1500	0.68	0.82	0.93	1.00	1.08	1.15	1.18	1.23
	1800	0.67	0.81	0.92	1.00	1.09	1.16	1.19	1.25
	2100	0.55	0.67	0.76	0.83	0.90	0.97	1.00	1.05
	2400	0.53	0.66	0.75	0.82	0.90	0.97	1.00	1.05
	2700	0.52	0.64	0.74	0.81	0.89	0.97	1.00	1.05
	3000	0.51	0.63	0.73	0.80	0.89	0.97	1.00	1.05

Reference values

$t_{WV_K} = t_{Pr} = 16\,°C$
$\dot{V}_{WK} = 110$ l/h (L_N 900 up to 1800)
$\dot{V}_{WK} = 200$ l/h (L_N 2100 up to 3000)
$\Delta t_{Pr} = t_{Pr} - t_R = -10$ K
$\Delta t_{RW_V} = t_{WV_K} - t_R = -10$ K





L_N	Type of nozzles	$\dot{V}_{Pr}$ l/s	$\dot{V}_{Pr}$ m³/h	$\dot{Q}_{Pr}$ (air) watts	$\dot{Q}_{s}$ (water) watts	$\dot{Q}_{ges}$ watts	Δt_W K	$\dot{q}_{Zul}$ W/m²	$\dot{V}_{Pr}$/m² l/(s·m²)	$\dot{V}_{Pr}$/m² m³/(h·m²)	L_{WA}, entry from top dB(A)	L_{WA}, entry from side dB(A)	ΔP_t (air) Pa	ΔP_W (water) kPa
900	K	3	11	36	116	152	0.9	25	0.5	1.8	< 20	< 20	29	1.3
		7	25	84	256	340	2.0	57	1.2	4.2	32.5	32.5	156	
		11	40	133	324	457	2.5	76	1.8	6.6	45.1	45.1	386	
	M	6	22	72	156	229	1.2	38	1.0	3.6	< 20	< 20	24	
		13	47	157	291	448	2.3	75	2.2	7.8	34.0	35.0	112	
		19	68	229	352	581	2.7	97	3.2	11.4	44.6	45.6	239	
	G	11	40	133	201	334	1.6	56	1.8	6.6	< 20	20.8	25	
		19	68	229	295	524	2.3	87	3.2	11.4	32.0	36.0	75	
		27	97	326	351	676	2.7	113	4.5	16.2	41.7	45.7	151	
1200	K	3	11	36	79	115	0.6	15	0.4	1.4	< 20	< 20	17	1.7
		8	29	96	303	399	2.4	53	1.1	3.8	31.4	31.4	124	
		13	47	157	399	556	3.1	74	1.7	6.2	44.9	44.9	326	
	M	8	29	96	202	298	1.6	40	1.1	3.8	< 20	< 20	24	
		15	54	181	347	528	2.7	70	2.0	7.2	33.1	34.1	85	
		23	83	277	437	714	3.4	95	3.1	11.0	45.0	46.0	201	
	G	15	54	181	267	448	2.1	60	2.0	7.2	22.5	26.5	28	
		23	83	277	363	640	2.8	85	3.1	11.0	34.4	38.4	65	
		30	108	362	418	780	3.3	104	4.0	14.4	41.8	45.8	110	
1500	K	4	14	48	113	161	0.9	18	0.4	1.6	< 20	< 20	21	2.0
		9	32	109	342	451	2.7	50	1.0	3.6	30.9	30.9	106	
		15	54	181	466	647	3.6	72	1.7	6.0	45.1	45.1	294	
	M	10	36	121	245	366	1.9	41	1.1	4.0	< 20	< 20	25	
		18	65	217	412	629	3.2	70	2.0	7.2	34.4	35.4	80	
		26	94	314	504	818	3.9	91	2.9	10.4	44.6	45.6	167	
	G	19	68	229	329	559	2.6	62	2.1	7.6	26.9	30.9	30	
		25	90	301	404	706	3.2	78	2.8	10.0	34.5	38.5	51	
		32	115	386	468	854	3.7	95	3.6	12.8	41.4	45.4	84	
1800	K	5	18	60	146	206	1.1	20	0.5	1.7	< 20	< 20	24	2.3
		11	40	133	406	539	3.2	51	1.0	3.8	34.3	33.3	115	
		17	61	205	527	732	4.1	70	1.6	5.8	46.5	45.5	275	
	M	12	43	145	287	432	2.2	41	1.1	4.1	< 20	21.0	25	
		21	76	253	472	725	3.7	69	2.0	7.2	34.5	36.5	76	
		29	104	350	565	915	4.4	87	2.8	9.9	43.5	45.5	146	
	G	22	79	265	374	639	2.9	61	2.1	7.5	26.1	32.1	28	
		29	104	350	462	811	3.6	77	2.8	9.9	33.8	39.8	49	
		36	130	434	526	960	4.1	91	3.4	12.3	39.8	45.8	76	
2100	K	6	22	72	199	271	0.9	23	0.5	1.8	< 20	< 20	26	7.6
		12	43	145	515	660	2.2	55	1.0	3.6	34.1	33.1	105	
		18	65	217	681	898	2.9	75	1.5	5.4	45.4	44.4	236	
	M	14	50	169	377	546	1.6	45	1.2	4.2	20.6	22.6	25	
		23	83	277	609	886	2.6	74	1.9	6.9	34.4	36.4	68	
		32	115	386	750	1136	3.2	95	2.7	9.6	43.6	45.6	132	
	G	26	94	314	503	817	2.2	68	2.2	7.8	29.2	35.2	30	
		32	115	386	598	984	2.6	82	2.7	9.6	35.0	41.0	46	
		38	137	458	673	1131	2.9	94	3.2	11.4	39.8	45.8	64	
2400	K	7	25	84	235	319	1.0	24	0.5	1.9	< 20	< 20	28	8.5
		13	47	157	555	711	2.4	53	1.0	3.5	34.1	33.1	98	
		19	68	229	729	958	3.1	71	1.4	5.1	44.7	43.7	208	
	M	16	58	193	425	618	1.8	46	1.2	4.3	22.0	24.0	25	
		25	90	301	659	961	2.8	71	1.9	6.7	34.5	36.5	62	
		34	122	410	807	1217	3.5	90	2.5	9.1	43.0	45.0	115	
	G	30	108	362	571	933	2.5	69	2.2	8.0	31.9	37.9	31	
		35	126	422	650	1072	2.8	79	2.6	9.3	36.2	42.2	43	
		40	144	482	715	1198	3.1	89	3.0	10.7	39.9	45.9	56	
2700	K	8	29	96	270	366	1.2	24	0.5	1.9	< 20	< 20	30	9.3
		14	50	169	592	761	2.5	51	0.9	3.4	34.2	33.2	92	
		21	76	253	797	1050	3.4	70	1.4	5.0	45.5	44.5	207	
	M	18	65	217	471	688	2.0	46	1.2	4.3	23.3	25.3	26	
		27	97	326	707	1033	3.0	69	1.8	6.5	34.6	36.6	58	
		37	133	446	873	1319	3.8	88	2.5	8.9	43.4	45.4	108	
	G	34	122	410	637	1047	2.7	70	2.3	8.2	34.2	40.2	33	
		37	133	446	684	1131	2.9	75	2.5	8.9	36.6	42.6	39	
		41	148	494	741	1235	3.2	82	2.7	9.8	39.4	45.4	47	
3000	K	9	32	109	304	413	1.3	25	0.5	2.0	20.1	< 20	32	10.2
		16	58	193	664	857	2.9	52	1.0	3.5	36.1	35.1	100	
		23	83	277	863	1140	3.7	69	1.4	5.0	46.2	45.2	207	
	M	20	72	241	517	758	2.2	46	1.2	4.4	24.4	26.4	26	
		30	108	362	773	1135	3.3	69	1.8	6.5	35.7	37.7	58	
		39	140	470	922	1393	4.0	84	2.4	8.5	43.0	45.0	98	
	G	38	137	458	701	1159	3.0	70	2.3	8.3	36.3	42.3	34	
		40	144	482	732	1214	3.1	74	2.4	8.7	37.7	43.7	37	
		43	155	518	775	1294	3.3	78	2.6	9.4	39.7	45.7	43	

9

Performance overview – heating

with 4-pipe system

Correction factors

$\dot{V}_{WH}$ in l/h		30	50	70	90	110	130	150
L_N	900	0.70	1.00	1.18	1.30	1.38	1.44	1.49
	1200	0.70	1.00	1.19	1.32	1.41	1.47	1.52
	1500	0.69	1.00	1.20	1.34	1.43	1.50	1.56
	1800	0.69	1.00	1.21	1.35	1.45	1.53	1.59
	2100	0.47	0.68	0.83	0.93	1.00	1.06	1.10
	2400	0.46	0.67	0.82	0.93	1.00	1.06	1.10
	2700	0.45	0.67	0.81	0.92	1.00	1.06	1.11
	3000	0.44	0.66	0.81	0.92	1.00	1.06	1.11

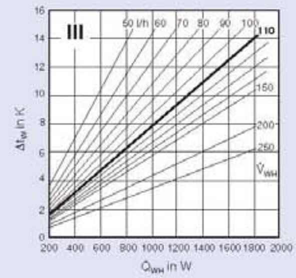
Reference values

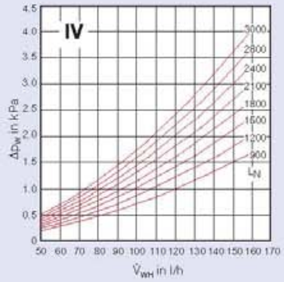
$t_R = t_{Pr} = 22\,^{\circ}C$ (isothermal)

$\dot{V}_{WH} = 50$ l/h (L_N 900 up to 1800)

$\dot{V}_{WH} = 110$ l/h (L_N 2100 up to 3000)

$\Delta t_{RW_V} = t_{WV_H} - t_R = 28$ K



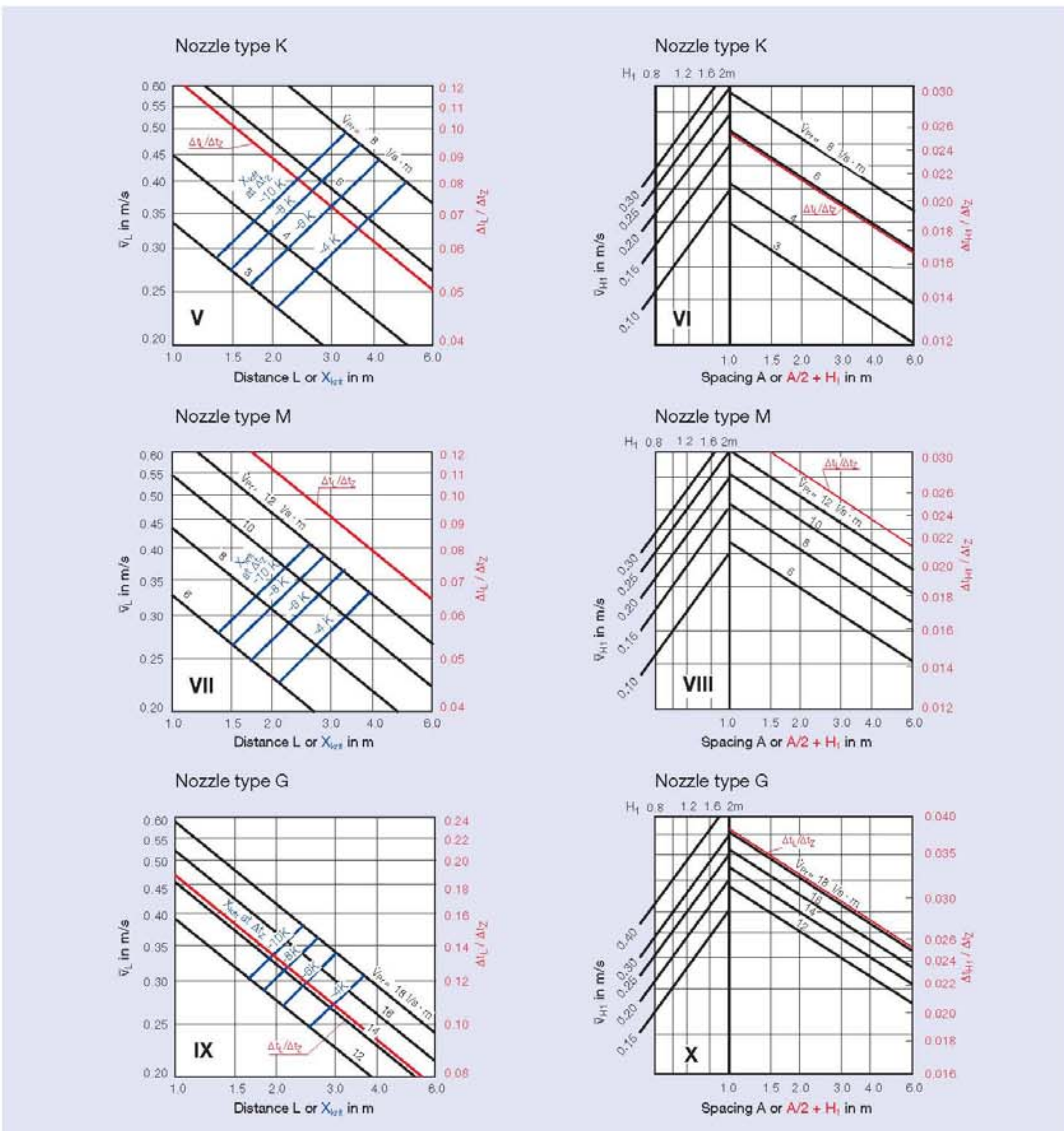


L_N	Type of nozzles	$\dot{V}_{Pr}$ l/s	$\dot{V}_{Pr}$ m³/h	$\dot{Q}_s = \dot{Q}_{ges}$ (water) watts	Δt_W K	$\dot{q}_{Zul}$ W/m²	$\dot{V}_{Pr}$/m² l/(s·m²)	$\dot{V}_{Pr}$/m² m³/(h·m²)	L_{WA}, entry from top dB(A)	L_{WA}, entry from side dB(A)	ΔP_t (air) Pa	ΔP_W (water) kPa
900	K	3	11	184	3.2	31	0.5	1.8	< 20	< 20	29	0.12
		7	25	399	6.9	66	1.2	4.2	32.5	32.5	156	
		11	40	502	8.6	84	1.8	6.6	45.1	45.1	386	
	M	6	22	246	4.2	41	1.0	3.6	< 20	< 20	24	
		13	47	452	7.8	75	2.2	7.8	34.0	35.0	112	
		19	68	543	9.3	90	3.2	11.4	44.6	45.6	239	
	G	11	40	316	5.4	53	1.8	6.6	< 20	20.8	25	
		19	68	457	7.9	76	3.2	11.4	32.0	36.0	75	
		27	97	542	9.3	90	4.5	16.2	41.7	45.7	151	
1200	K	3	11	125	2.2	17	0.4	1.4	< 20	< 20	17	0.14
		8	29	469	8.1	63	1.1	3.8	31.4	31.4	124	
		13	47	613	10.5	82	1.7	6.2	44.9	44.9	326	
	M	8	29	316	5.4	42	1.1	3.8	< 20	< 20	24	
		15	54	536	9.2	72	2.0	7.2	33.1	34.1	85	
		23	83	668	11.5	89	3.1	11.0	45.0	46.0	201	
	G	15	54	416	7.2	55	2.0	7.2	22.5	26.5	28	
		23	83	559	9.6	75	3.1	11.0	34.4	38.4	65	
		30	108	642	11.0	86	4.0	14.4	41.8	45.8	110	
1500	K	4	14	178	3.1	20	0.4	1.6	< 20	< 20	21	0.16
		9	32	529	9.1	59	1.0	3.6	30.9	30.9	106	
		15	54	711	12.2	79	1.7	6.0	45.1	45.1	294	
	M	10	36	383	6.6	43	1.1	4.0	< 20	< 20	25	
		18	65	632	10.9	70	2.0	7.2	34.4	35.4	80	
		26	94	767	13.2	85	2.9	10.4	44.6	45.6	167	
	G	19	68	509	8.8	57	2.1	7.6	26.9	30.9	30	
		25	90	621	10.7	69	2.8	10.0	34.5	38.5	51	
		32	115	714	12.3	79	3.6	12.8	41.4	45.4	84	
1800	K	5	18	229	3.9	22	0.5	1.7	< 20	< 20	24	0.18
		11	40	624	10.7	59	1.0	3.8	34.3	33.3	115	
		17	61	800	13.8	76	1.6	5.8	46.5	45.5	275	
	M	12	43	446	7.7	43	1.1	4.1	< 20	21.0	25	
		21	76	720	12.4	69	2.0	7.2	34.5	36.5	76	
		29	104	854	14.7	81	2.8	9.9	43.5	45.5	146	
	G	22	79	575	9.9	55	2.1	7.5	26.1	32.1	28	
		29	104	705	12.1	67	2.8	9.9	33.8	39.8	49	
		36	130	798	13.7	76	3.4	12.3	39.8	45.8	76	
2100	K	6	22	379	3.0	32	0.5	1.8	< 20	< 20	26	0.85
		12	43	965	7.5	80	1.0	3.6	34.1	33.1	105	
		18	65	1264	9.9	105	1.5	5.4	45.4	44.4	236	
	M	14	50	711	5.6	59	1.2	4.2	20.6	22.6	25	
		23	83	1135	8.9	95	1.9	6.9	34.4	36.4	68	
		32	115	1388	10.8	116	2.7	9.6	43.6	45.6	132	
	G	26	94	943	7.4	79	2.2	7.8	29.2	35.2	30	
		32	115	1114	8.7	93	2.7	9.6	35.0	41.0	46	
		38	137	1249	9.8	104	3.2	11.4	39.8	45.8	64	
2400	K	7	25	446	3.5	33	0.5	1.9	< 20	< 20	28	0.93
		13	47	1037	8.1	77	1.0	3.5	34.1	33.1	98	
		19	68	1350	10.6	100	1.4	5.1	44.7	43.7	208	
	M	16	58	799	6.2	59	1.2	4.3	22.0	24.0	25	
		25	90	1226	9.6	91	1.9	6.7	34.5	36.5	62	
		34	122	1488	11.6	110	2.5	9.1	43.0	45.0	115	
	G	30	108	1066	8.3	79	2.2	8.0	31.9	37.9	31	
		35	126	1208	9.4	89	2.6	9.3	36.2	42.2	43	
		40	144	1326	10.4	98	3.0	10.7	39.9	45.9	56	
2700	K	8	29	512	4.0	34	0.5	1.9	< 20	< 20	30	1.02
		14	50	1104	8.6	74	0.9	3.4	34.2	33.2	92	
		21	76	1471	11.5	98	1.4	5.0	45.5	44.5	207	
	M	18	65	884	6.9	59	1.2	4.3	23.3	25.3	26	
		27	97	1311	10.3	87	1.8	6.5	34.6	36.6	58	
		37	133	1605	12.5	107	2.5	8.9	43.4	45.4	108	
	G	34	122	1185	9.3	79	2.3	8.2	34.2	40.2	33	
		37	133	1271	9.9	85	2.5	8.9	36.6	42.6	39	
		41	148	1371	10.7	91	2.7	9.8	39.4	45.4	47	
3000	K	9	32	576	4.5	35	0.5	2.0	20.1	< 20	32	1.11
		16	58	1235	9.7	75	1.0	3.5	36.1	35.1	100	
		23	83	1587	12.4	96	1.4	5.0	46.2	45.2	207	
	M	20	72	967	7.6	59	1.2	4.4	24.4	26.4	26	
		30	108	1428	11.2	87	1.8	6.5	35.7	37.7	58	
		39	140	1692	13.2	103	2.4	8.5	43.0	45.0	98	
	G	38	137	1299	10.2	79	2.3	8.3	36.3	42.3	34	
		40	144	1355	10.6	82	2.4	8.7	37.7	43.7	37	
		43	155	1432	11.2	87	2.6	9.4	39.7	45.7	43	

10

Aerodynamic data

Correction factors for diagram values depending on length of unit L_N								
L_N in mm	900	1200	1500	1800	2100	2400	2700	3000
$\bar{v}_L$, $\bar{v}_{H1}$, $X_{krit.}$ from diagram	0.92	0.96	1.0	1.04	1.07	1.11	1.14	1.17
Δt_L, Δt_Z, $\Delta t_{H1}/\Delta t_Z$ from diagram	0.87	0.94	1.0	1.05	1.09	1.13	1.17	1.20



11

Order details

Specification text

The active chilled beam type DID300B is suitable for dealing with high internal heat loads using a combination of air and water.
It consists of the top plenum which serves as primary air duct and a diaphragm plate with nozzles in two longitudinal rows (different nozzle sizes are available). A coil is fitted underneath the primary air plenum and diaphragm plate. The induction grille below the coil is a perforated plate. The coil can be used either for heating or cooling (2-pipe system) as well as heating and cooling (4-pipe system).
The external diameter of the bare coil tube ends is 12 mm. Primary and conditioned induced air are mixed in the unit and discharged horizontally with coanda effect into the room via the two slots formed by the external frame and the internal extrusions. There are holes in the casing to enable the unit to be hung by the customer.
A construction incorporating an extract air spigot can be provided.
Spigots for supply and extract air can be either side or top mounted.

Support angles and flexible hoses are available as accessories for the DID300B unit.

Materials
Casing, including the top plenum and perforated plate induction grille are made of galvanised steel sheet.
The standard finish of the casing and the induction grille is powder-coated white (RAL 9010), the top casing (plenum) and coil remain untreated – optionally can be finished in black (RAL 9005), nozzle plate only finished in black (RAL 9005).
The heat exchanger consists of copper tubes with formed aluminium fins. The flexible hose, available as an accessory, is made of special plastic with stainless steel sheathing.

Order code

These codes do not need to be completed for standard products

DID300B - 2 - K - H - SV - ALV / 1800 x 1500 / 0 / 0 / P1 / RAL 9016 / G3

Coil:
Two-pipe 2
Four-pipe 4

Nozzle options:
small K
medium M
large G

Spigot and casing arrangements (see page 4)

Sizes L_1 x L_N (mm):

L_1 x L_N (mm)
900 x 900, 1200, 1500, 1800 1)
1200 x 1200, 1500, 1800
1500 x 1500, 1800, 2100
1800 x 1800, 2100, 2400
2100 x 2100, 2400, 2700
2400 x 2400, 2700, 3000
2700 x 2700, 3000
3000 x 3000

L_1 = Total length (diffuser face)
L_N = Nominal length

Not used

0 Standard finish
Powder-coated to RAL 9010
(GE 50 %) 2)
P1 Powder-coated to RAL . . .
(GE 70 %) 2)

Coil finish:
0 Standard untreated
G3 Finished to RAL 9005

Note:
L_1 = 893 ... 3000 mm
L_N only available in standard length
L_1 maximum 7 mm shorter than L_N

1) For casing arrangement M, MV and MH
2) GE = Gloss level

Accessory:
FS12-... (see table)
AW = Support angle

Accessory: Flexible hose (FS12) (see page 6)

Available connectors		
both ends	combination	length in mm
FS12-S	FS12-S/U	500, 750, 1000
	FS12-S/A	

Order example

Make: TROX
Type: DID300B - 2 - K - H - SV - ALV / 1800 x 1500 / P1 / RAL 9016 / G3

12

APPENDIX IV.E: REVISED FLOW DIAGRAMS

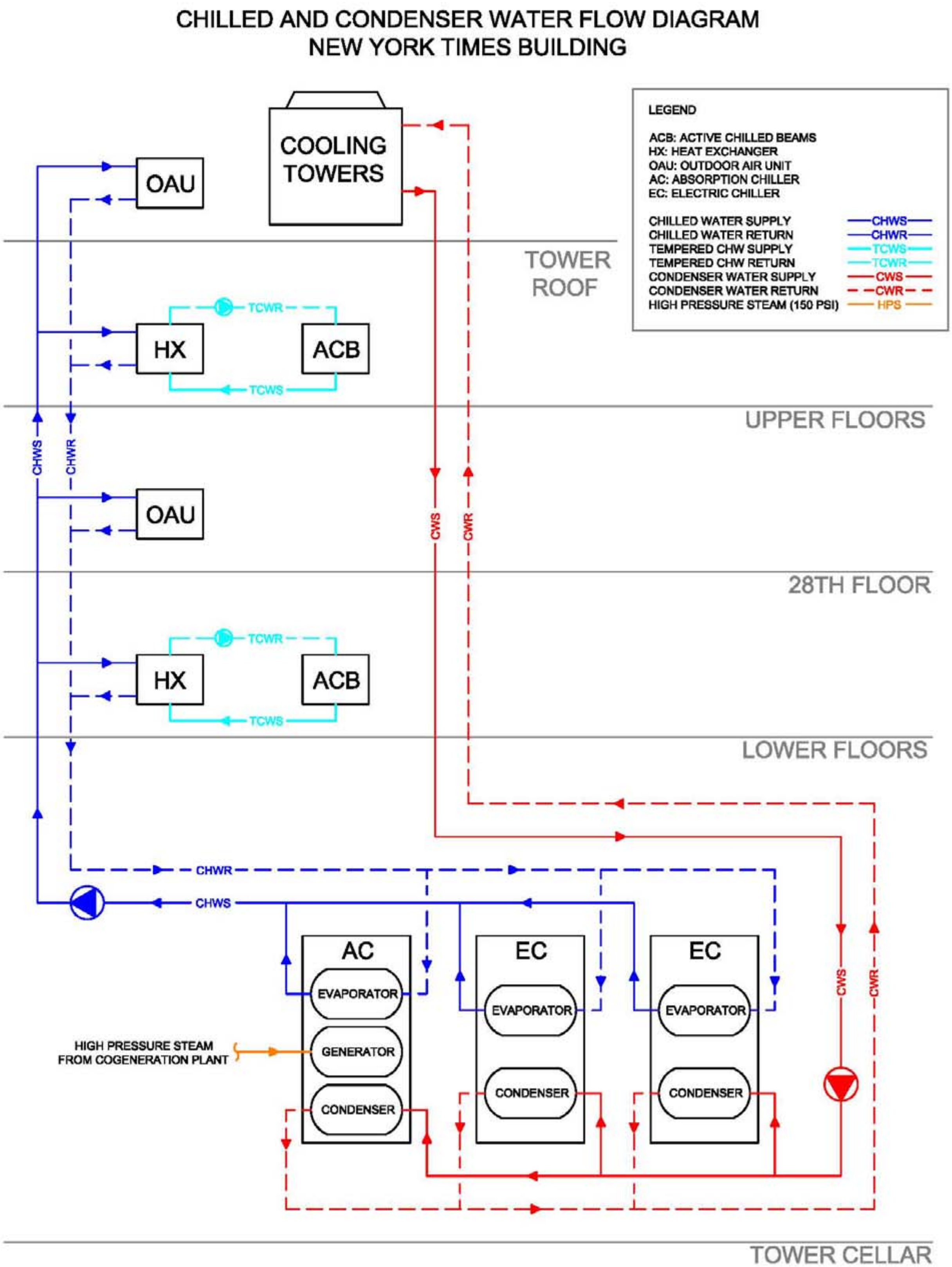


Figure 12: Chilled and condenser water flow diagram

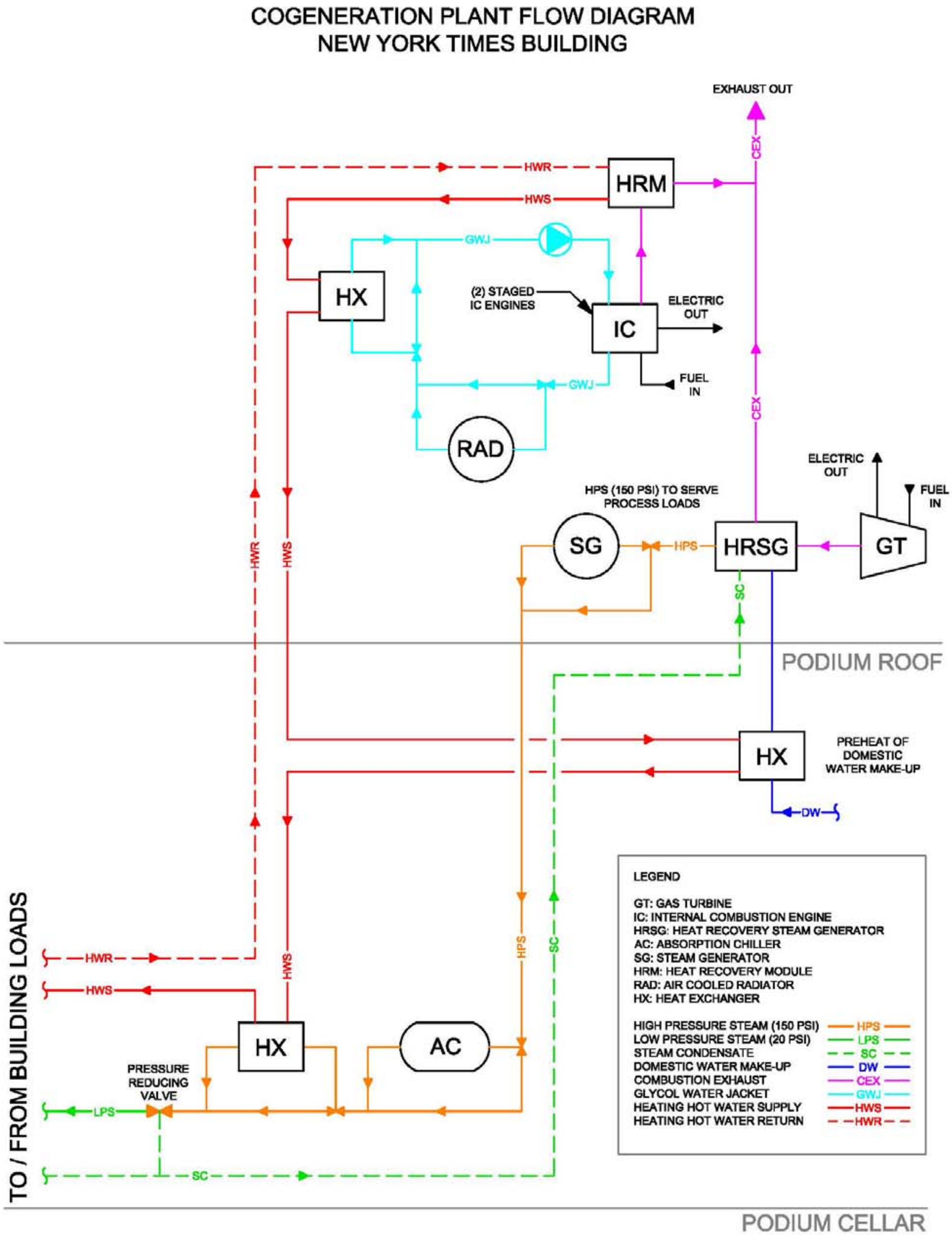


Figure 13: Cogeneration plant flow diagram

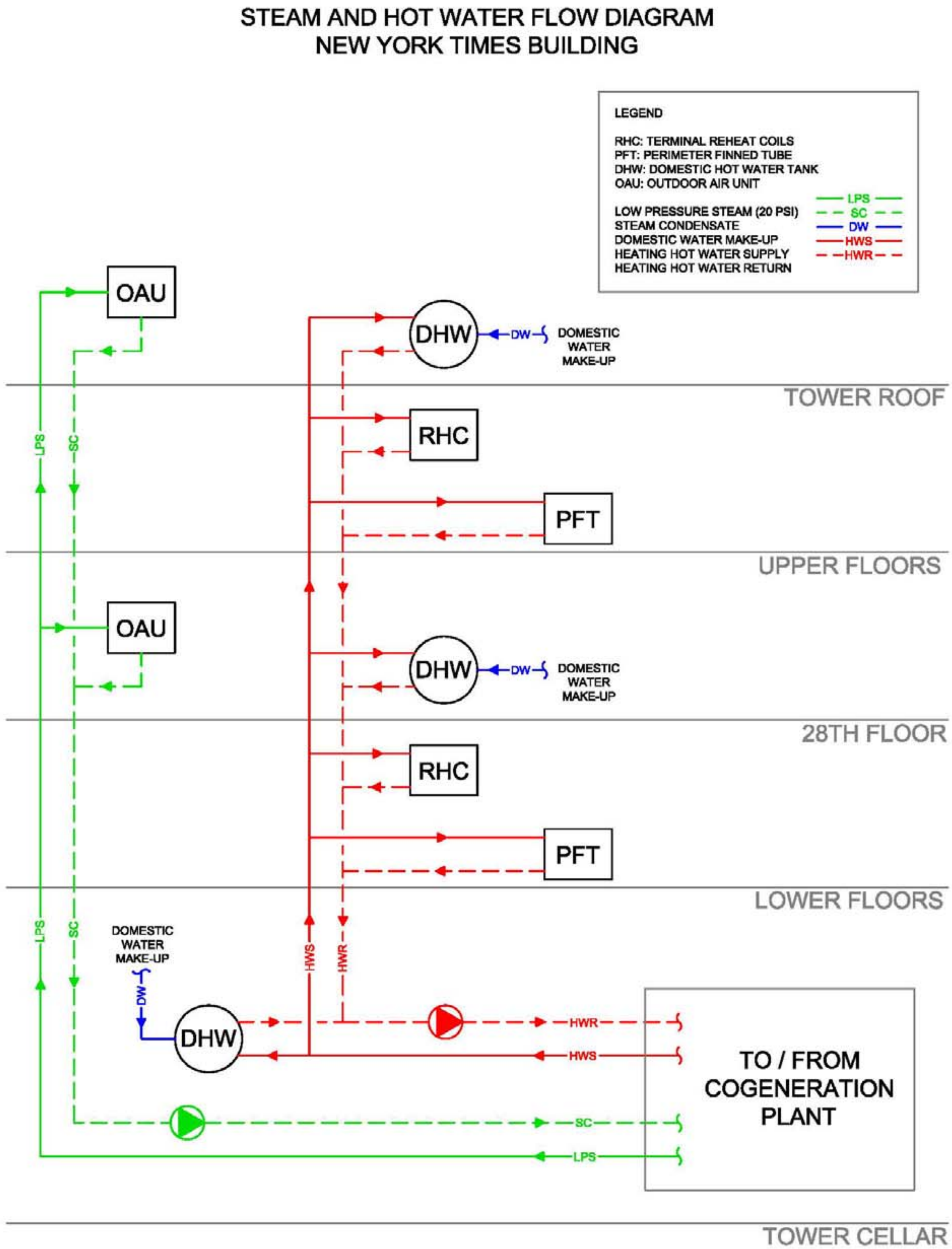


Figure 14: Steam and hot water flow diagram

APPENDIX IV.F: AIR STATE CALCULATIONS

Air state calculations for summer

Assumption: Mixed air ratio of 5:1 for ACBs.

Primary Air: 100 CFM (48 DB/46 WB/18.1 $\frac{Btu}{lb\ DA}$)

Return Air: 500 CFM (78 DB/64 WB/29.3 $\frac{Btu}{lb\ DA}$)

Mixed Air (No cooling coil):

$29.3 - 18.1 = 11.2 \rightarrow 29.3 - (11.2/5) = 27.1 \frac{Btu}{lb\ DA}$

(72 DB/62 WB)

Desired Supply Air (with cooling coil):

600 CFM (65 DB/57 WB/24.4 $\frac{Btu}{lb\ DA}$)

Enthalpy wheel conditions:

$\varepsilon_{apparent}$ (Unbalanced flow): $\varepsilon_{apparent} = \varepsilon \times \frac{V_{EA}}{V_{OA}} = 0.8 \times \left(\frac{0.8}{1.0}\right)$

$\varepsilon_{apparent} = 0.64$ (Latent/sensible)

State 3: 90 DB/72 WB/35.8 $\frac{Btu}{lb\ DA}$

State 11: 80 DB/64 WB/29.2 $\frac{Btu}{lb\ DA}$

$\Delta h = 35.8 - 29.2 = 6.6 \times 0.64 = 4.2 \frac{Btu}{lb\ DA}$

State 4: $35.8 - 4.2 \frac{Btu}{lb\ DA} = 31.6 \frac{Btu}{lb\ DA}$

(83 DB/67 WB)

Figure 15: Air state calculations, summer

Air State Calculations for winter

Assumption: Mixed air ratio of 5:1 for ACBs.

Primary Air: 100 CFM (67 DB/54 WB/22.4 $\frac{Btu}{lb\ DA}$)

Return Air: 500 CFM (74 DB/56 WB/23.9 $\frac{Btu}{lb\ DA}$)

Supply Air (No cooling coil):

$23.9 - 22.4 = 1.5 \rightarrow 23.9 - (1.5/5) = 23.6 \frac{Btu}{lb\ DA}$

72 DB/55 WB

Enthalpy Wheel Conditions:

$\varepsilon_{apparent} = 0.64$ (Unbalanced flow)

State 3: 37 DB/29 WB/10.3 $\frac{Btu}{lb\ DA}$

State 11: 76 DB/57 WB/ 24.4 $\frac{Btu}{lb\ DA}$

$\Delta h = 24.4 - 10.3 = 14.1 \times 0.64 = 9.0 \frac{Btu}{lb\ DA}$

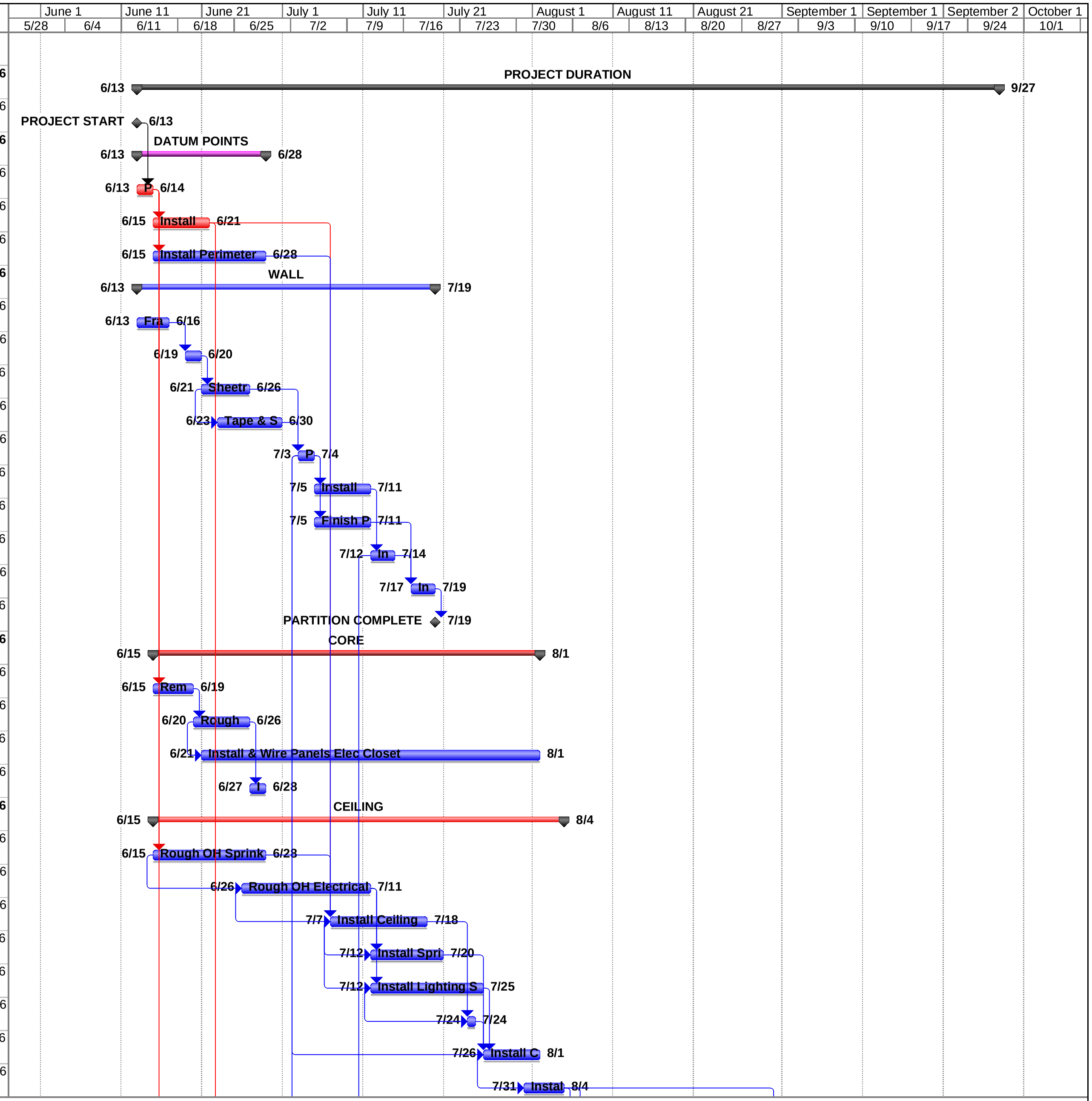
State 4: $24.4 - 9.0 = 15.4 \frac{Btu}{lb\ DA}$

51 DB/41 WB

Figure 16: Air state calculations, winter

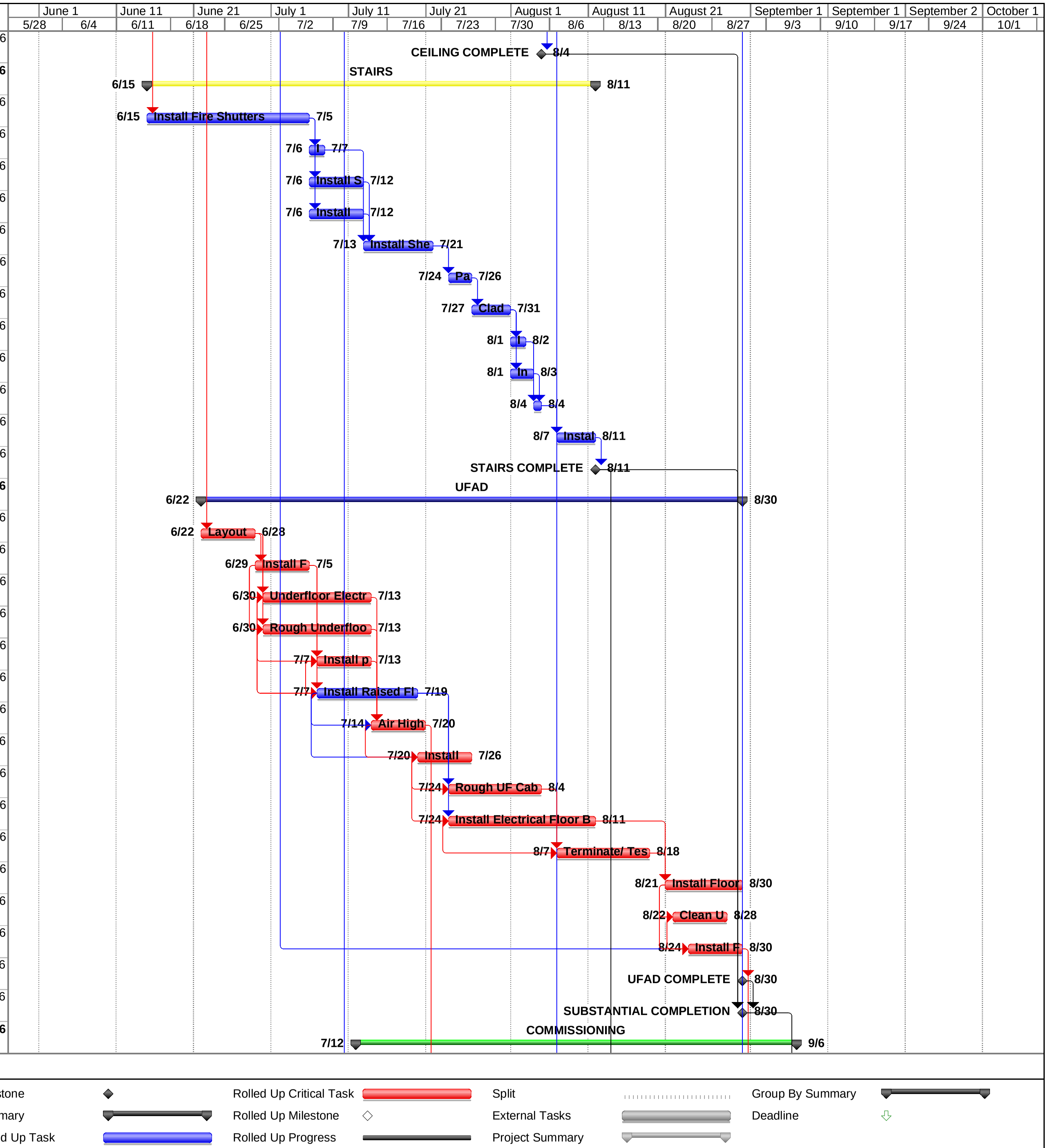
APPENDIX IV.G: EXISTING FIT OUT SCHEDULES

ID	Task Name	Duration	Early Start
1			
2	**PROJECT DURATION**	**77 days**	**Tue 6/13/06**
3	PROJECT START	0 days	Tue 6/13/06
4	**DATUM POINTS**	**12 days**	**Tue 6/13/06**
5	Paint Concrete Floor	2 days	Tue 6/13/06
6	Install Column Enclosures	5 days	Thu 6/15/06
7	Install Perimeter Sheetrock Fascia	10 days	Thu 6/15/06
8	**WALL**	**27 days**	**Tue 6/13/06**
9	Frame Partitions	4 days	Tue 6/13/06
10	Rough Wall Electrical	2 days	Mon 6/19/06
11	Sheetrock Partitions	4 days	Wed 6/21/06
12	Tape & Spackle Walls	6 days	Fri 6/23/06
13	Prime Paint	2 days	Mon 7/3/06
14	Install Office Fronts	5 days	Wed 7/5/06
15	Finish Paint	5 days	Wed 7/5/06
16	Install Devices	3 days	Wed 7/12/06
17	Install Doors & Hardware	3 days	Mon 7/17/06
18	PARTITION COMPLETE	0 days	Wed 7/19/06
19	**CORE**	**34 days**	**Thu 6/15/06**
20	Remove Ceilings at Core Bathroom	3 days	Thu 6/15/06
21	Rough Power Distrib at Core Bathrooms	5 days	Tue 6/20/06
22	Install & Wire Panels Elec Closet	30 days	Wed 6/21/06
23	Install Exhaust Fan Elec Closet	2 days	Tue 6/27/06
24	**CEILING**	**37 days**	**Thu 6/15/06**
25	Rough OH Sprinklers	10 days	Thu 6/15/06
26	Rough OH Electrical	12 days	Mon 6/26/06
27	Install Ceiling Grid	8 days	Fri 7/7/06
28	Install Sprinkler Heads in Grid Ceiling	7 days	Wed 7/12/06
29	Install Lighting System Grid Ceiling	10 days	Wed 7/12/06
30	Install Linear Diffusers	1 day	Mon 7/24/06
31	Install Ceiling Tile	5 days	Wed 7/26/06
32	Install Shades	5 days	Mon 7/31/06

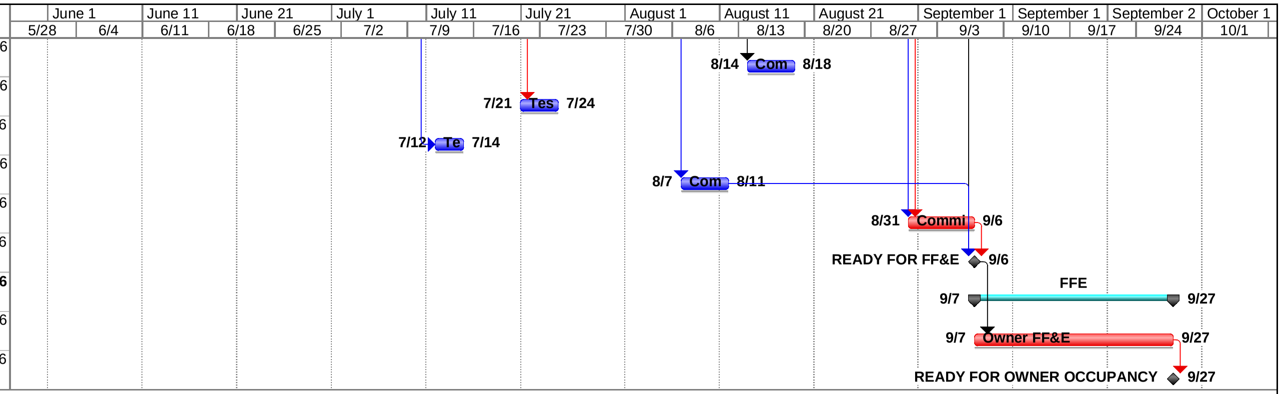


Full Project Existing Interior Fitout				
	Task	Milestone	Rolled Up Critical Task	Split	Group By Summary
	Critical Task	Summary	Rolled Up Milestone	External Tasks	Deadline
	Progress	Rolled Up Task	Rolled Up Progress	Project Summary	

ID	Task Name	Duration	Early Start
33	CEILING COMPLETE	0 days	Fri 8/4/06
34	**STAIRS**	**42 days**	**Thu 6/15/06**
35	Install Fire Shutters	15 days	Thu 6/15/06
36	Install Smoke Exhaust Fan	2 days	Thu 7/6/06
37	Install Steel Handrail Posts	5 days	Thu 7/6/06
38	Install M. Iron Glass Wall/ Smoke Baffle	5 days	Thu 7/6/06
39	Install Sheetrock Ceiling Fascia (Stairs)	7 days	Thu 7/13/06
40	Paint Stairs	3 days	Mon 7/24/06
41	Clad Spandrel Beams	3 days	Thu 7/27/06
42	Install Fin Tubes	2 days	Tue 8/1/06
43	Install Steel infill Panels	3 days	Tue 8/1/06
44	Install Wood Handrails	1 day	Fri 8/4/06
45	Install Glass Wall & Smoke Baffles	5 days	Mon 8/7/06
46	STAIRS COMPLETE	0 days	Fri 8/11/06
47	**UFAD**	**50 days**	**Thu 6/22/06**
48	Layout Raised Floor	5 days	Thu 6/22/06
49	Install Fan Powered Boxes & Mech Piping	5 days	Thu 6/29/06
50	Underfloor Electrical	10 days	Fri 6/30/06
51	Rough Underfloor Mechanical Piping	10 days	Fri 6/30/06
52	Install perimeter Ductwork	5 days	Fri 7/7/06
53	Install Raised Floor w/ Pedestals	9 days	Fri 7/7/06
54	Air Highway Walls	5 days	Fri 7/14/06
55	Install Cable Tray	5 days	Thu 7/20/06
56	Rough UF Cable	10 days	Mon 7/24/06
57	Install Electrical Floor Boxes	15 days	Mon 7/24/06
58	Terminate/ Test Data	10 days	Mon 8/7/06
59	Install Floor Diffusers	8 days	Mon 8/21/06
60	Clean Underfloor Plenum	5 days	Tue 8/22/06
61	Install Flooring	5 days	Thu 8/24/06
62	UFAD COMPLETE	0 days	Wed 8/30/06
63	SUBSTANTIAL COMPLETION	0 days	Wed 8/30/06
64	**COMMISSIONING**	**41 days**	**Wed 7/12/06**



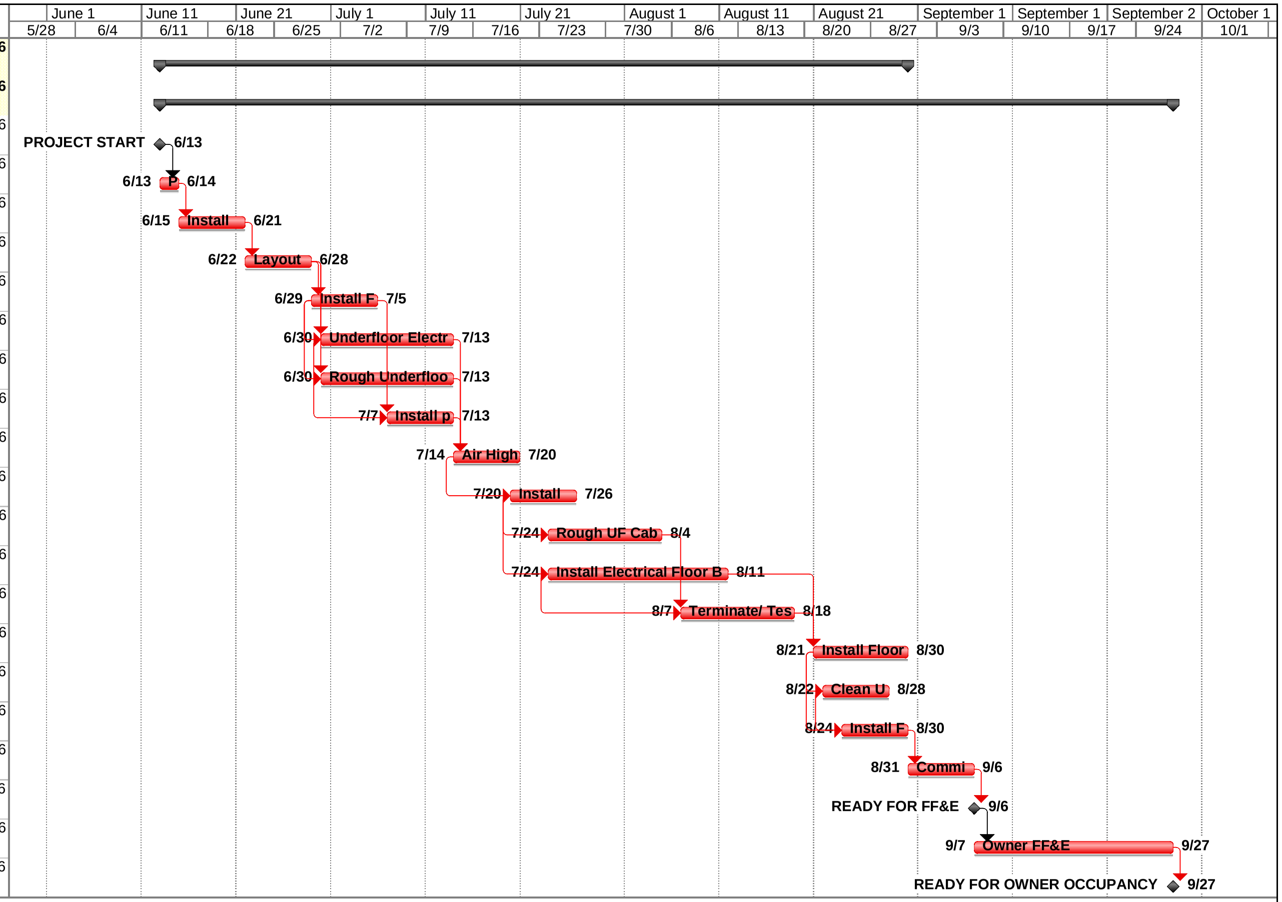
ID	Task Name	Duration	Early Start
65	Commission Fire Shutters	5 days	Mon 8/14/06
66	Test Air Highway	2 days	Fri 7/21/06
67	Test Fire Alarm	3 days	Wed 7/12/06
68	Commission Lighting/ Shades/ Sound Masking	5 days	Mon 8/7/06
69	Commission HVAC	5 days	Thu 8/31/06
70	READY FOR FF&E	0 days	Wed 9/6/06
71	**FFE**	**15 days**	**Thu 9/7/06**
72	Owner FF&E	15 days	Thu 9/7/06
73	READY FOR OWNER OCCUPANCY	0 days	Wed 9/27/06



Full Project
Existing Interior Fitout

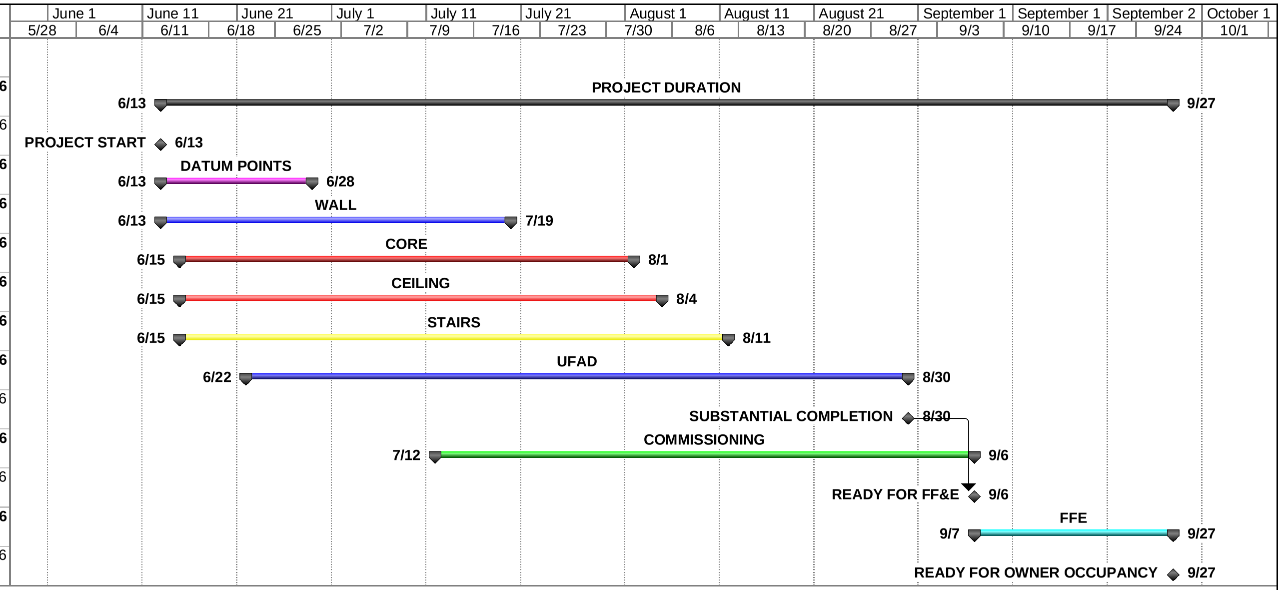
Task | Milestone | Rolled Up Critical Task | Split | Group By Summary
Critical Task | Summary | Rolled Up Milestone | External Tasks | Deadline
Progress | Rolled Up Task | Rolled Up Progress | Project Summary

ID	Task Name	Duration	Early Start
	Critical: No	**57 days**	**Tue 6/13/06**
	Critical: Yes	**77 days**	**Tue 6/13/06**
3	PROJECT START	0 days	Tue 6/13/06
5	Paint Concrete Floor	2 days	Tue 6/13/06
6	Install Column Enclosures	5 days	Thu 6/15/06
48	Layout Raised Floor	5 days	Thu 6/22/06
49	Install Fan Powered Boxes & Mech Piping	5 days	Thu 6/29/06
50	Underfloor Electrical	10 days	Fri 6/30/06
51	Rough Underfloor Mechanical Piping	10 days	Fri 6/30/06
52	Install perimeter Ductwork	5 days	Fri 7/7/06
54	Air Highway Walls	5 days	Fri 7/14/06
55	Install Cable Tray	5 days	Thu 7/20/06
56	Rough UF Cable	10 days	Mon 7/24/06
57	Install Electrical Floor Boxes	15 days	Mon 7/24/06
58	Terminate/ Test Data	10 days	Mon 8/7/06
59	Install Floor Diffusers	8 days	Mon 8/21/06
60	Clean Underfloor Plenum	5 days	Tue 8/22/06
61	Install Flooring	5 days	Thu 8/24/06
69	Commission HVAC	5 days	Thu 8/31/06
70	READY FOR FF&E	0 days	Wed 9/6/06
72	Owner FF&E	15 days	Thu 9/7/06
73	READY FOR OWNER OCCUPANCY	0 days	Wed 9/27/06

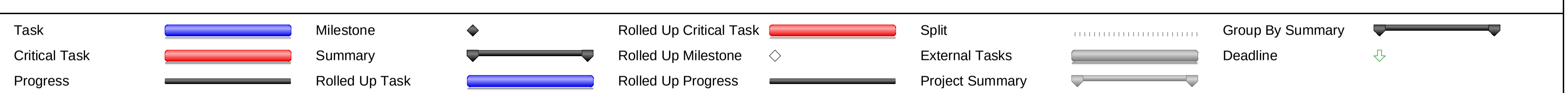


Critical Path Existing Interior Fitout	Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
	Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
	Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

ID	Task Name	Duration	Early Start
1			
2	**PROJECT DURATION**	**77 days**	**Tue 6/13/06**
3	PROJECT START	0 days	Tue 6/13/06
4	**DATUM POINTS**	**12 days**	**Tue 6/13/06**
8	**WALL**	**27 days**	**Tue 6/13/06**
19	**CORE**	**34 days**	**Thu 6/15/06**
24	**CEILING**	**37 days**	**Thu 6/15/06**
34	**STAIRS**	**42 days**	**Thu 6/15/06**
47	**UFAD**	**50 days**	**Thu 6/22/06**
63	SUBSTANTIAL COMPLETION	0 days	Wed 8/30/06
64	**COMMISSIONING**	**41 days**	**Wed 7/12/06**
70	READY FOR FF&E	0 days	Wed 9/6/06
71	**FFE**	**15 days**	**Thu 9/7/06**
73	READY FOR OWNER OCCUPANCY	0 days	Wed 9/27/06

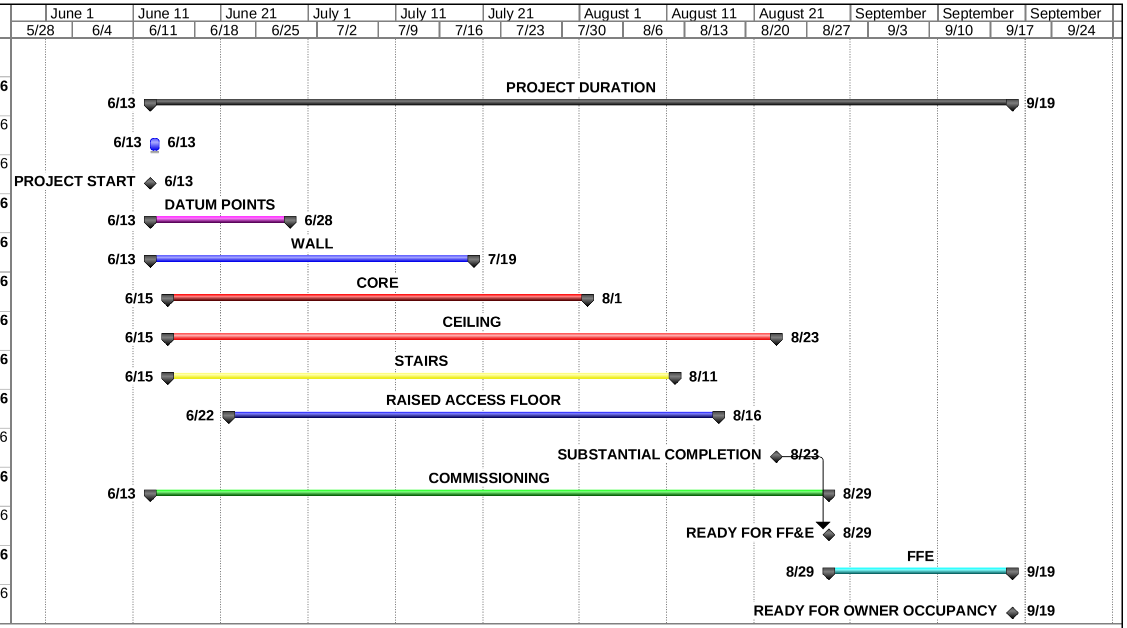


Project Overview/ Milestone
Existing Interior Fitout



APPENDIX IV.H: REDESIGNED FIT OUT SCHEDULES

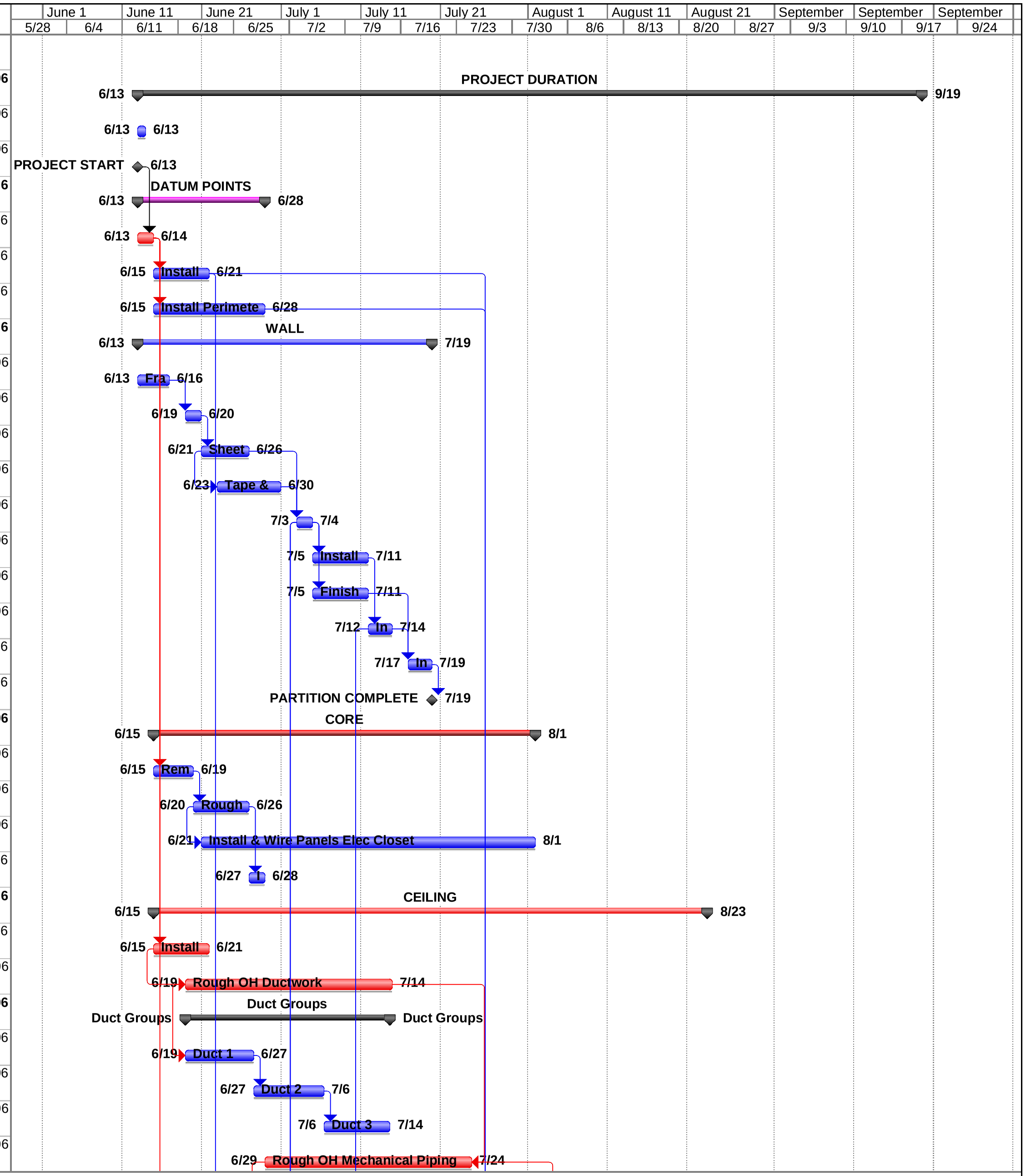
ID	Task Name	Duration	Early Start	Early Finish
1				
2	**PROJECT DURATION**	**70.67 days?**	**Tue 6/13/06**	**Tue 9/19/06**
3	Start - Substantial	1 day	Tue 6/13/06	Tue 6/13/06
4	PROJECT START	0 days	Tue 6/13/06	Tue 6/13/06
5	**DATUM POINTS**	**12 days**	**Tue 6/13/06**	**Wed 6/28/06**
9	**WALL**	**27 days**	**Tue 6/13/06**	**Wed 7/19/06**
20	**CORE**	**34 days**	**Thu 6/15/06**	**Tue 8/1/06**
25	**CEILING**	**49.67 days**	**Thu 6/15/06**	**Wed 8/23/06**
102	**STAIRS**	**42 days**	**Thu 6/15/06**	**Fri 8/11/06**
115	**RAISED ACCESS FLOOR**	**40 days**	**Thu 6/22/06**	**Wed 8/16/06**
125	SUBSTANTIAL COMPLETION	0 days	Wed 8/23/06	Wed 8/23/06
126	**COMMISSIONING**	**55.67 days**	**Tue 6/13/06**	**Tue 8/29/06**
132	READY FOR FF&E	0 days	Tue 8/29/06	Tue 8/29/06
133	**FFE**	**15 days**	**Tue 8/29/06**	**Tue 9/19/06**
135	READY FOR OWNER OCCUPANCY	0 days	Tue 9/19/06	Tue 9/19/06



Project Overview/ Milestone
Redesigned Interior Fitout

Task	Milestone	Rolled Up Critical Task	Split
Critical Task	Summary	Rolled Up Milestone	External Tasks
Progress	Rolled Up Task	Rolled Up Progress	Project Summary
Group By Summary	Deadline		

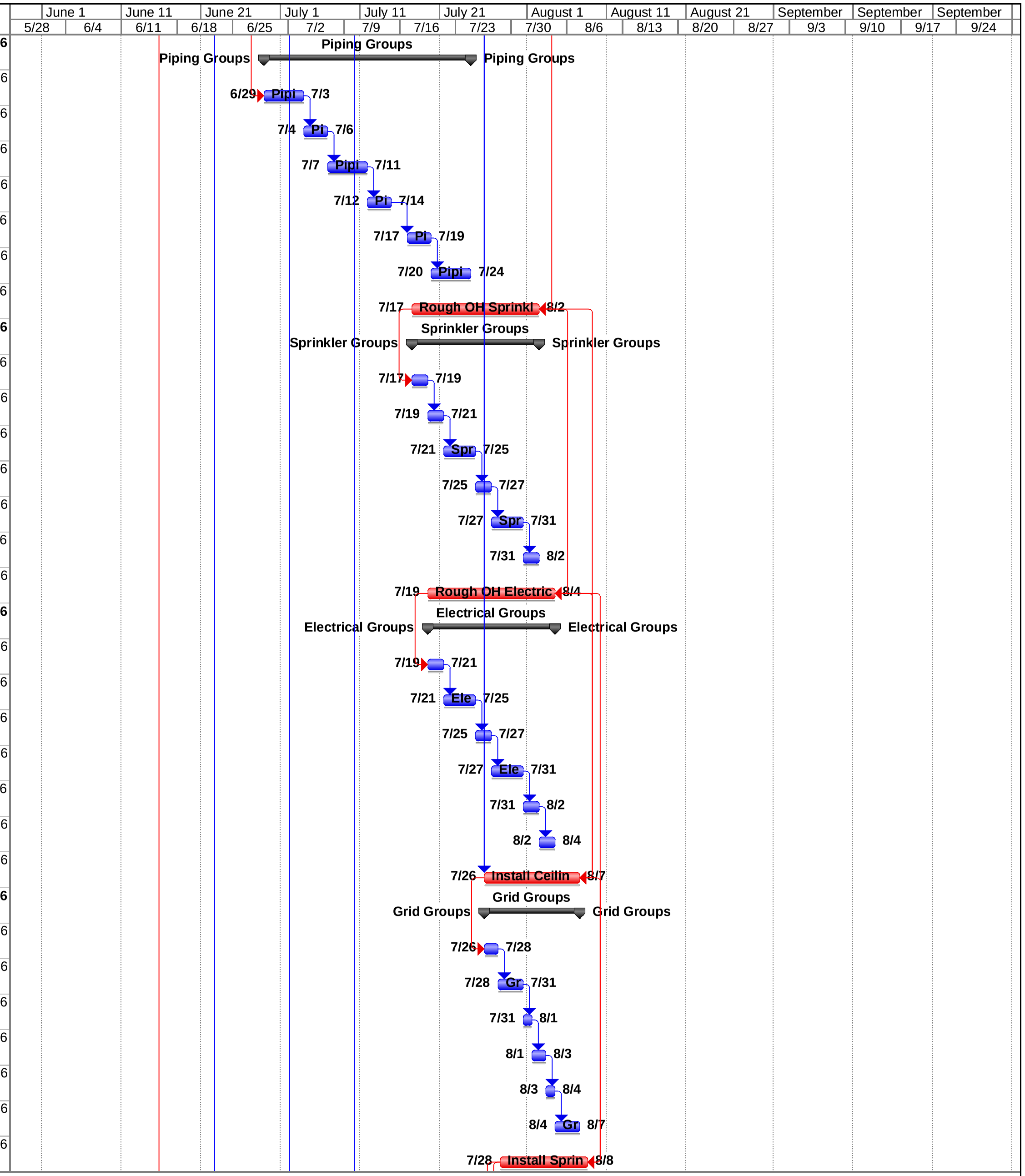
ID	Task Name	Duration	Early Start	Early Finish
1				
2	**PROJECT DURATION**	**70.67 days?**	**Tue 6/13/06**	**Tue 9/19/06**
3	Start - Substantial	1 day	Tue 6/13/06	Tue 6/13/06
4	PROJECT START	0 days	Tue 6/13/06	Tue 6/13/06
5	**DATUM POINTS**	**12 days**	**Tue 6/13/06**	**Wed 6/28/06**
6	Paint Concrete Floor	2 days	Tue 6/13/06	Wed 6/14/06
7	Install Column Enclosures	5 days	Thu 6/15/06	Wed 6/21/06
8	Install Perimeter Sheetrock Fascia	10 days	Thu 6/15/06	Wed 6/28/06
9	**WALL**	**27 days**	**Tue 6/13/06**	**Wed 7/19/06**
10	Frame Partitions	4 days	Tue 6/13/06	Fri 6/16/06
11	Rough Wall Electrical	2 days	Mon 6/19/06	Tue 6/20/06
12	Sheetrock Partitions	4 days	Wed 6/21/06	Mon 6/26/06
13	Tape & Spackle Walls	6 days	Fri 6/23/06	Fri 6/30/06
14	Prime Paint	2 days	Mon 7/3/06	Tue 7/4/06
15	Install Office Fronts	5 days	Wed 7/5/06	Tue 7/11/06
16	Finish Paint	5 days	Wed 7/5/06	Tue 7/11/06
17	Install Devices	3 days	Wed 7/12/06	Fri 7/14/06
18	Install Doors & Hardware	3 days	Mon 7/17/06	Wed 7/19/06
19	PARTITION COMPLETE	0 days	Wed 7/19/06	Wed 7/19/06
20	**CORE**	**34 days**	**Thu 6/15/06**	**Tue 8/1/06**
21	Remove Ceilings at Core Bathroom	3 days	Thu 6/15/06	Mon 6/19/06
22	Rough Power Distrib at Core Bathrooms	5 days	Tue 6/20/06	Mon 6/26/06
23	Install & Wire Panels Elec Closet	30 days	Wed 6/21/06	Tue 8/1/06
24	Install Exhaust Fan Elec Closet	2 days	Tue 6/27/06	Wed 6/28/06
25	**CEILING**	**49.67 days**	**Thu 6/15/06**	**Wed 8/23/06**
26	Install OH HVAC Equipment	5 days	Thu 6/15/06	Wed 6/21/06
27	Rough OH Ductwork	20 days	Mon 6/19/06	Fri 7/14/06
28	**Duct Groups**	**19.98 days**	**Mon 6/19/06**	**Fri 7/14/06**
29	Duct 1	6.66 days	Mon 6/19/06	Tue 6/27/06
30	Duct 2	6.66 days	Tue 6/27/06	Thu 7/6/06
31	Duct 3	6.66 days	Thu 7/6/06	Fri 7/14/06
32	Rough OH Mechanical Piping	18 days	Thu 6/29/06	Mon 7/24/06



Full Project
Redesigned Interior Fitout

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

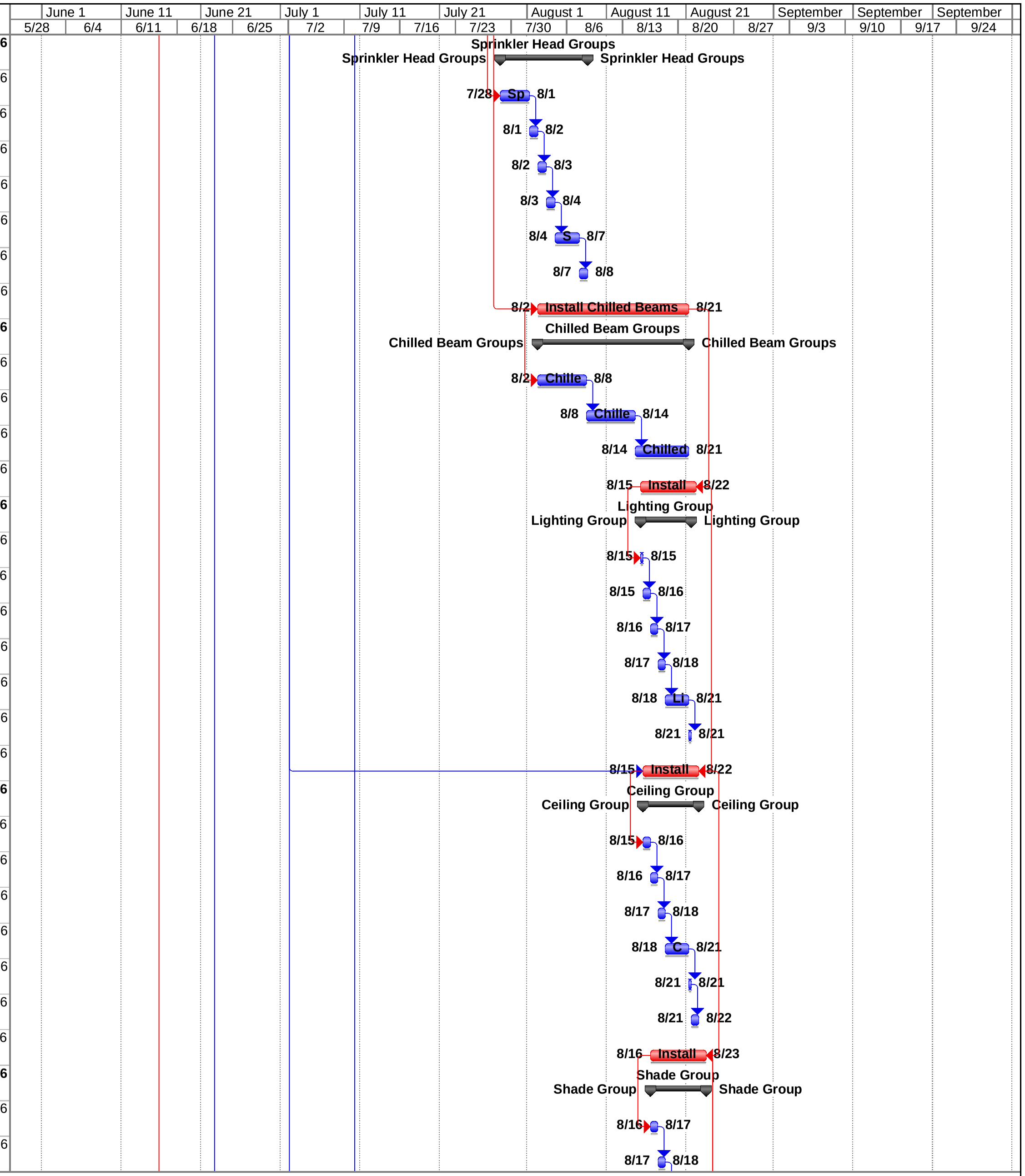
ID	Task Name	Duration	Early Start	Early Finish
33	**Piping Groups**	**18 days**	**Thu 6/29/06**	**Mon 7/24/06**
34	Piping 1	3 days	Thu 6/29/06	Mon 7/3/06
35	Piping 2	3 days	Tue 7/4/06	Thu 7/6/06
36	Piping 3	3 days	Fri 7/7/06	Tue 7/11/06
37	Piping 4	3 days	Wed 7/12/06	Fri 7/14/06
38	Piping 5	3 days	Mon 7/17/06	Wed 7/19/06
39	Piping 6	3 days	Thu 7/20/06	Mon 7/24/06
40	Rough OH Sprinklers	12 days	Mon 7/17/06	Wed 8/2/06
41	**Sprinkler Groups**	**12 days**	**Mon 7/17/06**	**Wed 8/2/06**
42	Sprinkler 1	2 days	Mon 7/17/06	Wed 7/19/06
43	Sprinkler 2	2 days	Wed 7/19/06	Fri 7/21/06
44	Sprinkler 3	2 days	Fri 7/21/06	Tue 7/25/06
45	Sprinkler 4	2 days	Tue 7/25/06	Thu 7/27/06
46	Sprinkler 5	2 days	Thu 7/27/06	Mon 7/31/06
47	Sprinkler 6	2 days	Mon 7/31/06	Wed 8/2/06
48	Rough OH Electrical	12 days	Wed 7/19/06	Fri 8/4/06
49	**Electrical Groups**	**12 days**	**Wed 7/19/06**	**Fri 8/4/06**
50	Electrical 1	2 days	Wed 7/19/06	Fri 7/21/06
51	Electrical 2	2 days	Fri 7/21/06	Tue 7/25/06
52	Electrical 3	2 days	Tue 7/25/06	Thu 7/27/06
53	Electrical 4	2 days	Thu 7/27/06	Mon 7/31/06
54	Electrical 5	2 days	Mon 7/31/06	Wed 8/2/06
55	Electrical 6	2 days	Wed 8/2/06	Fri 8/4/06
56	Install Ceiling Grid	8 days	Wed 7/26/06	Mon 8/7/06
57	**Grid Groups**	**7.98 days**	**Wed 7/26/06**	**Mon 8/7/06**
58	Grid 1	1.33 days	Wed 7/26/06	Fri 7/28/06
59	Grid 2	1.33 days	Fri 7/28/06	Mon 7/31/06
60	Grid 3	1.33 days	Mon 7/31/06	Tue 8/1/06
61	Grid 4	1.33 days	Tue 8/1/06	Thu 8/3/06
62	Grid 5	1.33 days	Thu 8/3/06	Fri 8/4/06
63	Grid 6	1.33 days	Fri 8/4/06	Mon 8/7/06
64	Install Sprinkler Heads in Grid Ceiling	7 days	Fri 7/28/06	Tue 8/8/06



Full Project
Redesigned Interior Fitout

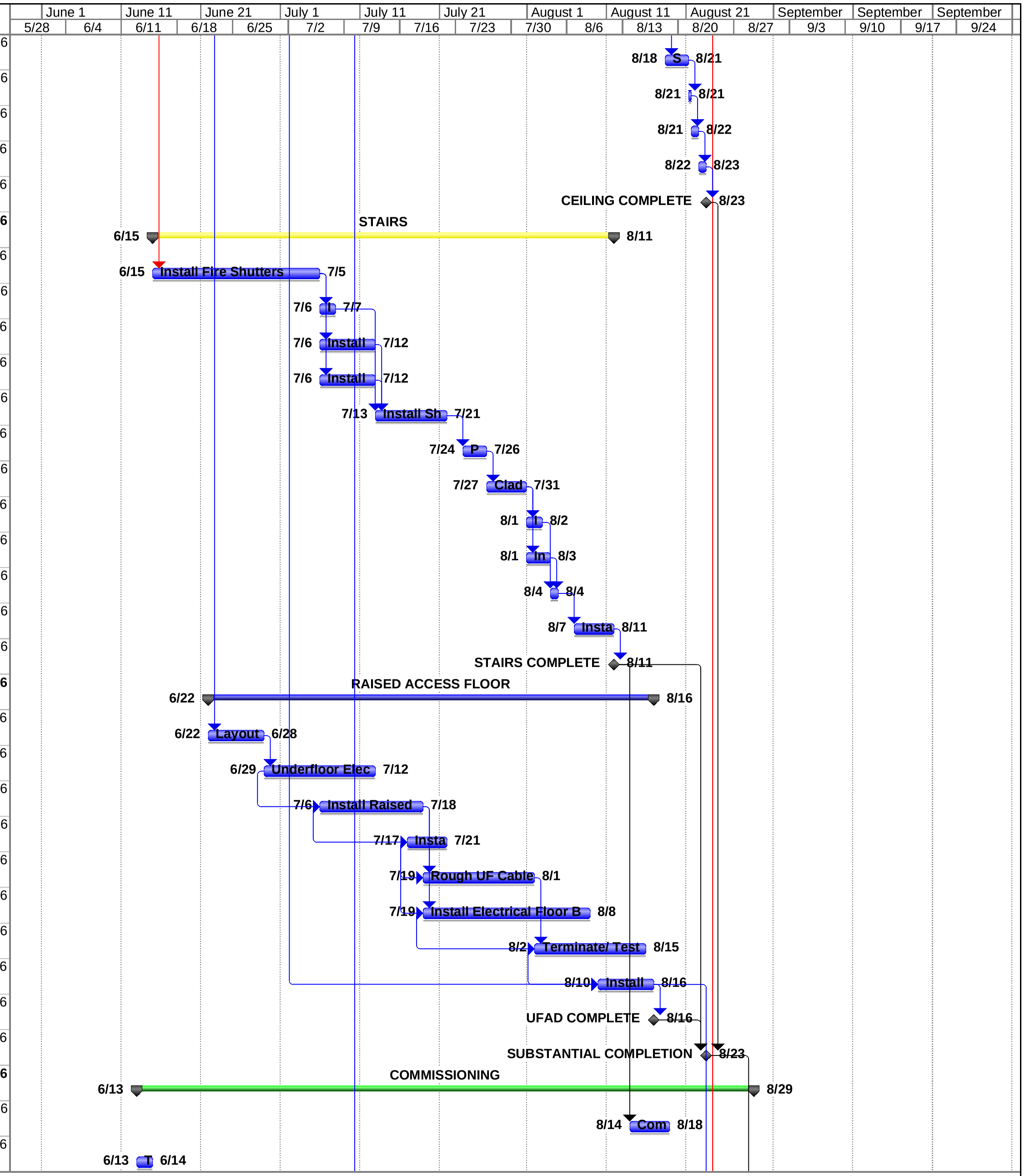
Task		Milestone	◆	Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone	◇	External Tasks		Deadline	⇩
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

ID	Task Name	Duration	Early Start	Early Finish
65	**Sprinkler Head Groups**	**7.02 days**	**Fri 7/28/06**	**Tue 8/8/06**
66	Sprinkler Head 1	1.17 days	Fri 7/28/06	Tue 8/1/06
67	Sprinkler Head 2	1.17 days	Tue 8/1/06	Wed 8/2/06
68	Sprinkler Head 3	1.17 days	Wed 8/2/06	Thu 8/3/06
69	Sprinkler Head 4	1.17 days	Thu 8/3/06	Fri 8/4/06
70	Sprinkler Head 5	1.17 days	Fri 8/4/06	Mon 8/7/06
71	Sprinkler Head 6	1.17 days	Mon 8/7/06	Tue 8/8/06
72	Install Chilled Beams	13 days	Wed 8/2/06	Mon 8/21/06
73	**Chilled Beam Groups**	**13.02 days**	**Wed 8/2/06**	**Mon 8/21/06**
74	Chilled Beam 1	4.34 days	Wed 8/2/06	Tue 8/8/06
75	Chilled Beam 2	4.34 days	Tue 8/8/06	Mon 8/14/06
76	Chilled Beam 3	4.34 days	Mon 8/14/06	Mon 8/21/06
77	Install Lighting System Grid Ceiling	5 days	Tue 8/15/06	Tue 8/22/06
78	**Lighting Group**	**4.98 days**	**Tue 8/15/06**	**Mon 8/21/06**
79	Lighting 1	0.83 days	Tue 8/15/06	Tue 8/15/06
80	Lighting 2	0.83 days	Tue 8/15/06	Wed 8/16/06
81	Lighting 3	0.83 days	Wed 8/16/06	Thu 8/17/06
82	Lighting 4	0.83 days	Thu 8/17/06	Fri 8/18/06
83	Lighting 5	0.83 days	Fri 8/18/06	Mon 8/21/06
84	Lighting 6	0.83 days	Mon 8/21/06	Mon 8/21/06
85	Install Ceiling Tile	5 days	Tue 8/15/06	Tue 8/22/06
86	**Ceiling Group**	**4.98 days**	**Tue 8/15/06**	**Tue 8/22/06**
87	CT 1	0.83 days	Tue 8/15/06	Wed 8/16/06
88	CT 2	0.83 days	Wed 8/16/06	Thu 8/17/06
89	CT 3	0.83 days	Thu 8/17/06	Fri 8/18/06
90	CT 4	0.83 days	Fri 8/18/06	Mon 8/21/06
91	CT 5	0.83 days	Mon 8/21/06	Mon 8/21/06
92	CT 6	0.83 days	Mon 8/21/06	Tue 8/22/06
93	Install Shades	5 days	Wed 8/16/06	Wed 8/23/06
94	**Shade Group**	**4.98 days**	**Wed 8/16/06**	**Wed 8/23/06**
95	Shade 1	0.83 days	Wed 8/16/06	Thu 8/17/06
96	Shade 2	0.83 days	Thu 8/17/06	Fri 8/18/06



Full Project Redesigned Interior Fitout	Task		Milestone		Rolled Up Critical Task	Split	Group By Summary
	Critical Task		Summary		Rolled Up Milestone	External Tasks	Deadline
	Progress		Rolled Up Task		Rolled Up Progress	Project Summary	

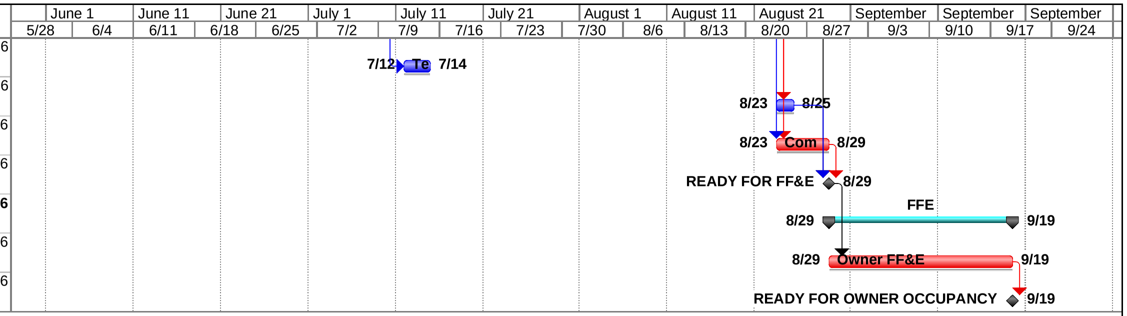
ID	Task Name	Duration	Early Start	Early Finish
97	Shade 3	0.83 days	Fri 8/18/06	Mon 8/21/06
98	Shade 4	0.83 days	Mon 8/21/06	Mon 8/21/06
99	Shade 5	0.83 days	Mon 8/21/06	Tue 8/22/06
100	Shade 6	0.83 days	Tue 8/22/06	Wed 8/23/06
101	CEILING COMPLETE	0 days	Wed 8/23/06	Wed 8/23/06
102	**STAIRS**	**42 days**	**Thu 6/15/06**	**Fri 8/11/06**
103	Install Fire Shutters	15 days	Thu 6/15/06	Wed 7/5/06
104	Install Smoke Exhaust Fan	2 days	Thu 7/6/06	Fri 7/7/06
105	Install Steel Handrail Posts	5 days	Thu 7/6/06	Wed 7/12/06
106	Install M. Iron Glass Wall/ Smoke Baffle	5 days	Thu 7/6/06	Wed 7/12/06
107	Install Sheetrock Ceiling Fascia (Stairs)	7 days	Thu 7/13/06	Fri 7/21/06
108	Paint Stairs	3 days	Mon 7/24/06	Wed 7/26/06
109	Clad Spandrel Beams	3 days	Thu 7/27/06	Mon 7/31/06
110	Install Fin Tubes	2 days	Tue 8/1/06	Wed 8/2/06
111	Install Steel infill Panels	3 days	Tue 8/1/06	Thu 8/3/06
112	Install Wood Handrails	1 day	Fri 8/4/06	Fri 8/4/06
113	Install Glass Wall & Smoke Baffles	5 days	Mon 8/7/06	Fri 8/11/06
114	STAIRS COMPLETE	0 days	Fri 8/11/06	Fri 8/11/06
115	**RAISED ACCESS FLOOR**	**40 days**	**Thu 6/22/06**	**Wed 8/16/06**
116	Layout Raised Floor	5 days	Thu 6/22/06	Wed 6/28/06
117	Underfloor Electrical	10 days	Thu 6/29/06	Wed 7/12/06
118	Install Raised Floor w/ Pedestals	9 days	Thu 7/6/06	Tue 7/18/06
119	Install Cable Tray	5 days	Mon 7/17/06	Fri 7/21/06
120	Rough UF Cable	10 days	Wed 7/19/06	Tue 8/1/06
121	Install Electrical Floor Boxes	15 days	Wed 7/19/06	Tue 8/8/06
122	Terminate/ Test Data	10 days	Wed 8/2/06	Tue 8/15/06
123	Install Flooring	5 days	Thu 8/10/06	Wed 8/16/06
124	UFAD COMPLETE	0 days	Wed 8/16/06	Wed 8/16/06
125	SUBSTANTIAL COMPLETION	0 days	Wed 8/23/06	Wed 8/23/06
126	**COMMISSIONING**	**55.67 days**	**Tue 6/13/06**	**Tue 8/29/06**
127	Commission Fire Shutters	5 days	Mon 8/14/06	Fri 8/18/06
128	Test Air Highway	2 days	Tue 6/13/06	Wed 6/14/06



Full Project
Redesigned Interior Fitout

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

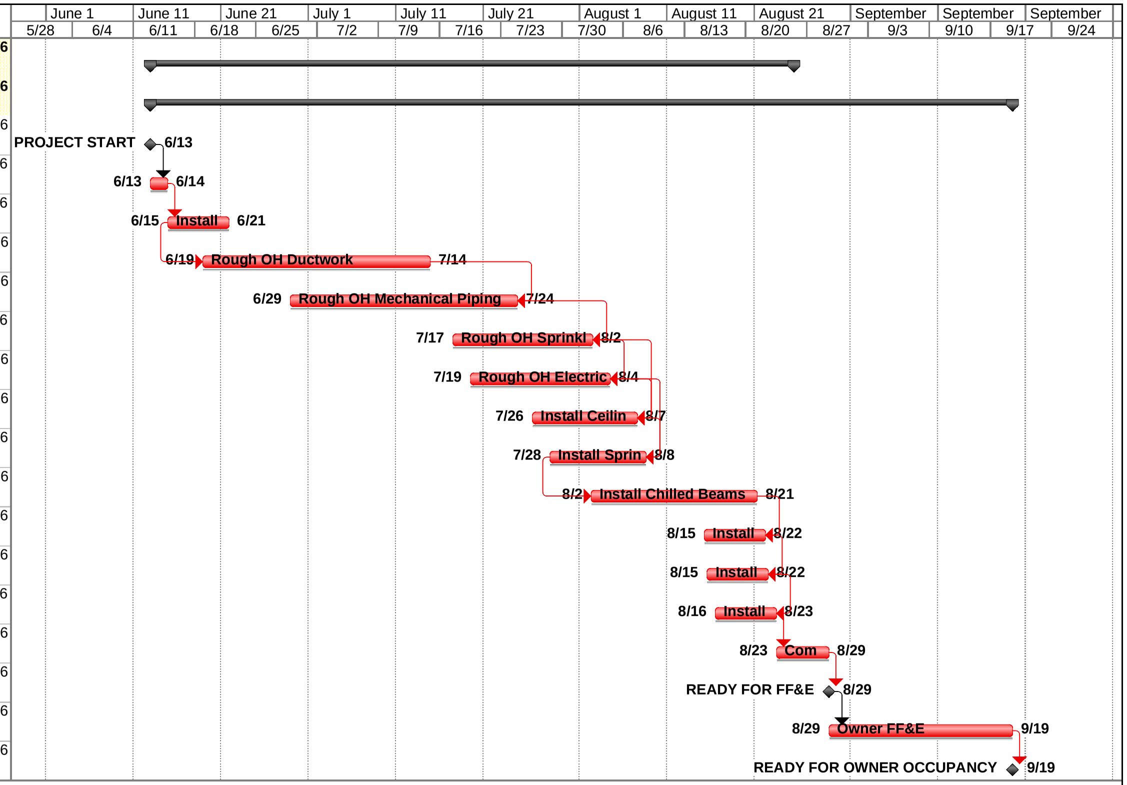
ID	Task Name	Duration	Early Start	Early Finish
129	Test Fire Alarm	3 days	Wed 7/12/06	Fri 7/14/06
130	Commission Lighting/ Shades/ Sound Masking	2 days	Wed 8/23/06	Fri 8/25/06
131	Commission HVAC	4 days	Wed 8/23/06	Tue 8/29/06
132	READY FOR FF&E	0 days	Tue 8/29/06	Tue 8/29/06
133	**FFE**	**15 days**	**Tue 8/29/06**	**Tue 9/19/06**
134	Owner FF&E	15 days	Tue 8/29/06	Tue 9/19/06
135	READY FOR OWNER OCCUPANCY	0 days	Tue 9/19/06	Tue 9/19/06



Full Project
Redesigned Interior Fitout

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

ID	Task Name	Duration	Early Start	Early Finish
	Critical: No	**53.67 days**	**Tue 6/13/06**	**Fri 8/25/06**
	Critical: Yes	**70.67 days**	**Tue 6/13/06**	**Tue 9/19/06**
4	PROJECT START	0 days	Tue 6/13/06	Tue 6/13/06
6	Paint Concrete Floor	2 days	Tue 6/13/06	Wed 6/14/06
26	Install OH HVAC Equipment	5 days	Thu 6/15/06	Wed 6/21/06
27	Rough OH Ductwork	20 days	Mon 6/19/06	Fri 7/14/06
32	Rough OH Mechanical Piping	18 days	Thu 6/29/06	Mon 7/24/06
40	Rough OH Sprinklers	12 days	Mon 7/17/06	Wed 8/2/06
48	Rough OH Electrical	12 days	Wed 7/19/06	Fri 8/4/06
56	Install Ceiling Grid	8 days	Wed 7/26/06	Mon 8/7/06
64	Install Sprinkler Heads in Grid Ceiling	7 days	Fri 7/28/06	Tue 8/8/06
72	Install Chilled Beams	13 days	Wed 8/2/06	Mon 8/21/06
77	Install Lighting System Grid Ceiling	5 days	Tue 8/15/06	Tue 8/22/06
85	Install Ceiling Tile	5 days	Tue 8/15/06	Tue 8/22/06
93	Install Shades	5 days	Wed 8/16/06	Wed 8/23/06
131	Commission HVAC	4 days	Wed 8/23/06	Tue 8/29/06
132	READY FOR FF&E	0 days	Tue 8/29/06	Tue 8/29/06
134	Owner FF&E	15 days	Tue 8/29/06	Tue 9/19/06
135	READY FOR OWNER OCCUPANCY	0 days	Tue 9/19/06	Tue 9/19/06



Critical Path
Redesigned Interior Fitout

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

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