

## **Friends Center - Philadelphia, PA White Paper on Reducing Plug Loads**

### **Introduction**

The goal for the Friends Center project is to limit plug loads to no more than 0.75 watts per square foot of floor space. The intent is to reduce the use of electricity by computers and general office equipment. In addition, by limiting plug loads, the air conditioning load for the building will also be reduced and the required capacity, size and cost of the air conditioning system will be reduced.

Plug loads represent the peak electrical demand caused by all equipment plugged into the electrical system. For the purpose of energy usage and the sizing of air conditioning systems, the limitation of the peak demand rather than the total connected load is the determining factor. The total connected load is the total potential electrical consumption of all equipment plugged in while the peak demand takes into account that not all equipment is on or operating at peak load at all times.

In a typical office space plug loads include computers, computer monitors, printers, copy machines, pantry equipment such as coffee makers and refrigerators and miscellaneous equipment such as pencil sharpeners, cell phone chargers, fans and space heaters. Hard wired electrical equipment such as mechanical units, fans and elevators are not considered plug loads. Also, fixed in place task lighting, such as task lighting integral to the furniture system is accounted for in the lighting load allowance and not in the plug load allowance.

Plug loads consume electrical energy and generate heat, which is then removed from the space by the air conditioning system. In many office buildings, the heat released by plug loads and lighting systems can require air conditioning year around. The reduction of plug loads within a space will reduce energy costs directly and indirectly through reductions in the air conditioning load. If reduced plug loads are taken into account when designing HVAC systems, first cost savings can be realized by reducing the installed capacity of the air conditioning system.

### **Conclusion**

The goal of a plug load power density of 0.75 watts/square foot is achievable for the Friends Center. In order to maintain the power density at or below this level over time, a comprehensive policy for use of electrical devices will need to be adopted and followed by the staff. The policy should provide guidelines for the types of plug-in equipment that may be used in individual workstations and offices. It is important to note, that in order to gain the maximum benefit of this policy, the air conditioning system will be sized based on this criteria. Therefore it is critical that the target plug load density is not exceeded as the air conditioning system will not have the capacity to handle plug loads in excess of the criteria. The plug load policy should include the following:

1. Food service equipment should be limited to the designated pantry area(s) and only appliances with the highest Energy Star ratings should be utilized.
2. Flat panel LCD monitors or laptops should be used in lieu of CRT monitors.
3. All computers should be set to hibernate after 5 minutes of inactivity.
4. Procedures for use of screen savers, games and general computer configuration should be established to ensure that hibernation mode is not affected.
5. Use of other miscellaneous plug-in devices (radios, electric pencil sharpeners, clocks, etc.) should be limited to no more than 30 watts continuous use per work station.

Friends Center – Philadelphia, PA  
White Paper on Reducing Plug Loads

6. Portable plug-in watt meters should be provided for use by staff to check electrical consumption of miscellaneous electrical devices to enable them to follow the policy.
7. The electrical system should be configured for floor-by-floor plug load metering.
8. Use of plug-in fans, heaters, refrigerators and additional task lighting beyond the furniture mounted task light should be prohibited in work stations and offices.
9. Pantry appliances should be limited to a total demand of 2000 W per pantry.
10. Major maintenance and cleaning operations should be limited to off hours.

**Calculation of Plug Load Allowances**

It is important to determine a reasonable and realistic allowance for plug loads. Overstating the requirements will lead to oversized HVAC systems with a resultant first cost penalty and some operating inefficiencies. Under estimating the allowance will limit flexibility and may result in the need to add supplemental HVAC capacity at a later date.

In order to determine realistic plug load criterion, it is advisable to benchmark existing installations that are similar to the proposed design. By metering the actual electrical demand and consumption for these spaces, an accurate “real-world” base line of the current loads can be determined. Reasonable factors for growth and flexibility can then be added to the base-line numbers to arrive at final design criteria. These numbers can then be input into a computer load calculation program that will take into account other factors affecting the peak loads such as the operating schedule and building mass.

It is not always possible to benchmark an existing facility. Recognizing this, the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) sponsored research to determine real world office equipment heat rejection values and therefore resultant plug loads. The research indicates that office equipment heat rejection values are significantly less than the nameplate ratings and that when real world diversity is taken into account, the loads are even lower. Actual peak heat rejection for most office equipment was found to range from 25% to 50% of nameplate ratings and real world diversity was measured to range from 37% to 78% with the average being 46%. Based on this, ASHRAE developed the following guidelines:

<b>Load Density</b>	<b>Load Factor Watts/sf</b>	<b>Description (equipment for each 1000 sf of office space)</b>
Light	0.5	Assumes 167 sf/workstation (6 total) each with computer and monitor plus (1) printer and (1) fax. Computer, monitor and fax diversity 0.67, printer diversity 0.33
Medium	1.0	Assumes 125 sf/workstation (8 total) each with computer and monitor plus (1) printer and (1) fax. Computer, monitor and fax diversity 0.75, printer diversity 0.50
Medium/Heavy	1.5	Assumes 100 sf/workstation (10 total) each with computer and monitor plus (1) printer and (1) fax. Computer and monitor diversity 0.75, fax and printer diversity 0.50
Heavy	2.0	Assumes 83 sf/workstation (12 total) each with computer and monitor plus (1) printer and (1) fax. Computer and monitor diversity 1.00, fax and printer diversity 0.50

Friends Center – Philadelphia, PA  
White Paper on Reducing Plug Loads

The article also states that research sponsored by Lawrence Berkley National Laboratories projected equipment energy intensities would decrease slowly through 2002 and then increase slowly through 2010. Office equipment has gotten significantly more efficient over the last several years with more efficient power supplies and “sleep modes” for reduced heat output during dormant periods.

**Calculation of Friends Center Plug Loads**

For the calculation of plug loads at Friends Center, the penthouse and basement areas were not included in the analysis. The penthouse is equipment space and is not fully conditioned. The basement has diverse uses and needs and the plug load requirements vary significantly per area. The various spaces within the Friends Center for the purpose of this study can be characterized and grouped as follows:

<b>Equipment Spaces</b>	These spaces house the electrical, telecom/data, and mechanical equipment.
Plug Loads	Plug loads in these spaces will not be counted. These spaces will have very intermittent plug loads due to occasional maintenance and cleaning.
<b>Storage</b>	Spaces used for storage, including janitor’s closets.
Plug Loads	There will be no plug loads in these spaces
<b>Toilet rooms</b>	Two on each floor
Plug Loads	Toilet rooms will have a receptacle located at the sink however use is very limited. No plug loads will be assigned to these rooms.
<b>Pantry/Coffee</b>	One per floor each with a refrigerator, microwave oven, and a coffee maker.
Plug Loads	The pantries will have a large plug load. The estimated loads are refrigerator at 600 W, microwave at 500 W and the coffee maker at 900 W. Total plug loads for each pantry are 2000 watts. A diversity factor of 75% will be applied to the pantry loads due to the intermittent use and cycling of the equipment. Appendix A indicates each pantry to have a load of 1500 W.
<b>Offices</b>	This category consists of both enclosed and cubicle type workstations. This space contains the bulk of all of the buildings plug loads.
Plug Loads	Each workstation or office will have one computer (55W), a flat panel LCD monitor (40W), and a 30 watt load representing miscellaneous item such as a radio, cell phone charge, etc. Total load assigned to each workstation will be 125 watts. All workstations will have their computers and monitors set to hibernate when not used after several minutes. All workstations will not be used at the same time. A diversity factor of 60 % (60% on, 40% hibernating) will be assumed resulting in a typical computer load of 65 W assigned to each workstation. In hibernation a computer consumes 20 W and a monitor zero watts. Total workstation load will be 95 W when used to calculate the total building plug loads.  Four printers and two copiers will be assumed for each floor. The average printer consumes 320 W and a diversity factor of 60% will be applied to the

Friends Center – Philadelphia, PA  
White Paper on Reducing Plug Loads

	four printers (1280 x 0.6 = 768 W/floor). Each copier consumes 400 W with no diversity factor applied to two copiers. A load of 1568 W is added to each floor for this equipment.
<b>Circulatory spaces</b>	These spaces consist of all other areas that are not categorized above. These will include corridors, stairs, lobbies, elevators, etc. In open office areas the difference between the gross area and the cubicle area is considered to be circulatory space.
Plug Loads	These spaces will have convenience receptacles to support cleaning equipment and the occasional maintenance activity. It is assumed that such activity will only take place after hours when the bulk of the buildings plug loads are off.

**Analysis:**

When the loads described above are applied to all the spaces the total load for the three occupied floors is 27,024 Watts resulting in an average power density of 0.75 W/SF. While floors one and three are below the target power density of 0.75 W/SF, the second floor exceeds this with a density of 0.89 W/SF. This is due to a higher density of cubicles on the second floor.

<b>Floor</b>	<b>Area(SF)</b>	<b>Plug Loads(Watts)</b>	<b>Average Power Density (w/sf)</b>
First Floor	12,584	8,293	0.66
Second Floor	12,244	10,858	0.89
Third Floor	12,252	8,673	0.71
Total – All Floors	37,080	27,824	0.75