

FACILITY SERVICES' BUILDING DESIGN STANDARDS - BUILDING DEVELOPMENT

III. BUILDING DEVELOPMENT

A. Design Principles

1. The City of Fort Collins expects the architect to maintain a high standard of architectural design, based upon recognition of contemporary design principles. All design elements; planning, architectural, engineering, and landscaping must be fully coordinated, and consistent in adherence to good design principles. The design should be based upon quality environmentally sensitive materials to provide a facility having a useful life of 40 years or longer.
2. All primary entrances, that are required to be ADAAG accessible, shall have automatic doors.
3. Design strictly within the budget and in accordance with sound investment economics and operating/maintenance expenditures.
4. Design for the optimum ratio of net useable space to buildings gross areas with a minimum being 75%.
5. Design for future expansion as determined by the project program statement such that permanent built-in space functions such as service rooms, duct spaces, etc., are sized and located for ease of future additional capacity and construction.
6. Quality of materials and construction methods shall be commensurate with the type of building and the budget. Avoid experimental materials. Take into account the total life cycle of the building. Use renewable, indigenous building materials to the greatest extent possible. Use cradle-to-grave analysis in decision making for material selection and construction techniques.
7. The City expects imaginative design and good aesthetic expression throughout all projects. Design shall be compatible with adjacent buildings, or with the existing building in extension work.
8. The overall philosophy of the building design should be trend setting in compliance with the latest general aims of the City.
9. It is the City's goal to build buildings that accommodates the latest advances in office technology and communication. Flexibility to accommodate the future evolution of technology is necessary.

Making this concept a reality requires comprehensive design for architectural and engineering systems. In the interest of building system integration, it is mandatory to develop the design work of all disciplines simultaneously with the architectural concept rather than retrofitting engineering systems into a solidified architectural design.

10. Use of raised Access Floor Delivery of power and communication lines is highly desirable to maintain flexibility in modifying office areas. Minimum of 2 inches.
11. Where possible and practical, designed space functions should be adaptable and flexible for alternative uses or multi-purpose functions in order that maximum usage may be derived from those spaces.
12. All entrance areas require an entry removable mat and drainage system to prevent the tracking of dirt, melting snow and rain water into the building.
13. Entrance lobbies have high levels of visibility and public use, this warrants the highest degree of visual detail and finish.
14. Indoor Air Quality follow ASHRAE standard 62 "Ventilation for Acceptable Indoor Air Quality" to provide good indoor air quality. Check the "Indoor Air Quality" prior to moving into the facility. Use of Indoor Air Quality sensors tied in with the HVAC control system are to be considered in extreme use areas (I.E. community rooms, council room, training rooms).
15. Provide restroom facilities, particularly women's, commensurate with the building's function (i.e., a performing arts facility would have a high usage over a short time (intermission) thus would need more stalls/urinals than the minimum required by code). Floors shall be sloped to the floor drains.
16. The City requires that the drawings be done in AutoCAD format. The A & E will provide the City a disk(s) containing "Facility Record Management Record Drawings" as delineated on page 44 of the CAD LAYER GUIDELINE (1990) published by the AIA
17. Custodial spaces - see Appendix E for requirements.
18. To prevent cross-contamination in public restrooms, the restroom door shall swing outward with no knob or lever turning required to exit.

B. Building Code Requirements

Prior to the commencement of conceptual design, a review and understanding of all City building code requirements as they are applicable to the type of building being designed is required.

C. Natural Light and Outdoor Awareness

The provision of fenestration and skylights to allow the penetration of natural light into interior spaces and the creation of exterior views is a mandatory requirement for quality of space values when inhabited by visitors or working people. In addition, exterior views will allow visitors and users a greater perception of outdoor awareness for the purposes of orientation with respect to the interior and a means of visual relief. Natural light and exterior views would be required for most areas. Direct sunlight penetrating the interior space should be avoided. Coordination between the electric lighting system and the daylight system should create brightness ratios no greater than 5:1.

D. Circulation and Functional Orientation

1. The system of public movement in the building should encourage the use of the building and penetration into its areas. Provide the public with access to and activity on various levels of the building to permit familiar and routine use of the entire building.
2. The ground plane should be the principal level of public activity and all other levels and systems of circulation should be related to it. The public circulation system should be a fine grain extension of the principal public space and should structure the building in a clear and comprehensible manner. Where possible, it should refer the user back to the ground plane and/or the lobby by means of selective views.
3. For areas requiring a high degree of public accessibility, the design of the circulation space should provide some visibility from the main circulation spine or ground plane.
4. The public image of the building will be determined to a large degree by the characteristics of the circulation system. The quality of the space, the ease of orientation, the availability of locational cues all contribute to the impression of the visitor. As a public oriented building, the circulation system must also take into account the requirements of disabled persons.

E. Fine Art Focus

For the benefit of a facilities user, visitors and the public at large, a focal point in the building should be created whereby art or public information displays, temporary or permanent, may be erected.

F. Orientation

1. Take advantage of natural light, heat gain and minimizing exposure to northerly winter winds.
2. Allow the indirect penetration of sunlight into the inner spaces by possible means of atriums and skylights.
3. Design wall systems to maximize the impact of natural energy conservation measures along southerly and westerly facing perimeter areas through concepts as overhangs/sun shades to minimize and maximize heat gain at various seasons.
4. Keep glazed areas to a minimum in pools, ice rinks and other high humidity areas. Use insulating glass and framing systems with thermal breaks.
5. Locate structures to take advantage of passive energy technologies for human comfort.
6. Energy efficiency related to site, architecture, electrical and mechanical systems shall be considered during programming and conceptual design for the project. The conceptual site planning and architectural design can dramatically reduce the energy loads, providing more opportunities for the electrical and mechanical systems.

The key energy loads and operating costs that can be responded to in the site planning and building design are heating, cooling, and lighting. Through proper site layout, architectural form, orientation, and building envelope characteristics, the thermal loads can be reduced substantially over a typical building that meets current energy codes and standards of practice. In other words, through design, the building will gain little solar heat in the summer, appropriate amounts of solar heat in the winter, and receive daylight throughout the year.

Daylighting strategies are suitable and cost effective techniques. Daylighting--the use of natural light to effectively reduce electric lighting requirements--can improve the visual quality of the interior

environment and lower operating costs. The energy use and cost is reduced not only for the electric lighting, but cooling needs are reduced too, since there is less heat given off with daylight than with electric light. Further, daylighting often works best at times of summer peak demands and therefore reduces the demand and use charges. Proper daylighting includes solar control, a benefit for both cooling and heating as well.

The common architectural “form givers” for daylighting are building form or geometry, sun control, surfaces, and glazing strategies. The architectural treatment of the facades should vary as it relates to different orientations. For example, the south and north orientations are going to be the best overall performers. The north should be relatively unobstructed to achieve a good exposure for a relatively stable, cool color north light. The south should have controls through landscape and/or architectural features (i.e. overhangs, light shelves, etc.) to best respond to year around conditions. This is relatively easy to do on the south. The southern orientation gives the most amount of daylight so that a little bit of glazing goes a long way. Deeper effective lighting can be achieved, but it must be controlled.

The east and west orientations are the least effective for daylighting and the most difficult to control due to the low sun angles throughout the year. Again, the size and type of glazing, along with control strategies, are important to achieve comfort conditions and use daylight when desirable. This can be done through landscape, architectural features, and glazing characteristics, each of which should be different than southern and northern exposures.

G. Security

1. The design of the proposed facilities must achieve a balance between a desired image of openness and a necessary degree of security. It should be possible to maintain security without excessive reliance upon locked doors. Use proximity card readers for controlled access. The Security philosophy is to have access control on all perimeter entrances minimally, with Department areas as a second level of access control if funds are available. Integrated into this is use of the city primus key hierarchy on all exterior doors, with Department areas that are on access control also having primus cylinders on entry doors. (Refer to Appendix F).
2. Light walkways and parking areas through the night hours so as not to create any personal security problems. Follow IES current standards for average, minimum and uniformity illuminance levels.

3. Design Facilities so as to not create hidden corners, overhangs or visual black holes that may invite surreptitious behavior or vandalism.
4. A minimum number of doors opening to the exterior should be provided in order to preclude forced entry. Exterior doors should be readily visible.

H. Engineering

1. General Engineering Design Approach:
Each of the Engineering disciplines involved in designing structural, mechanical and electrical services for the City of Fort Collins buildings and/or site services should approach the design in the following overall manner.
 - a. Attend the City's project pre-design briefing and receive requirements, design philosophy and parameters to follow. They should understand the purpose, usage goals of the building and the people who will occupy structure.
 - b. Each discipline shall study the design criteria provided at the initial and subsequent meetings and as presented here for full consideration as a general approach. Generally, principles of design shall;
 - 1) meet the performance requirements with the least life cycle costing;
 - 2) be designed to use a minimum amount of energy consistent with required performance standards;
 - 3) include safety to personnel during operation and maintenance;
 - 4) have ease of maintaining equipment and the facility itself;
 - 5) have flexibility and reliability;
 - 6) and comply with all applicable Codes and Standards.
 - c. Together with the preliminary design drawings and specifications each discipline shall submit preliminary cost estimates for their portion of the work outlined. As the cost

changes during the design and working drawings, the Architect and Engineer shall inform the City of these changes in writing stating the reason for the change.

- d. When the City has studied and approved a preliminary design, the Architect and Engineer shall proceed with the final design and contract documents.
- e. Working drawings shall be prepared on bond or vellum with separate systems on separate drawings. Submit drawings at end of preliminary design and at 95% review and at 100%.
- f. Specify "As-Built" Mylar drawings reflecting all field and change order changes, Operation Manuals and equipment operating procedures to be provided by the Contractor.
- g. Specifications shall be prepared with the same format as outlined for the architectural work. All equipment specified shall consist of at least three equivalent manufacturer's products with full catalogue numbers, ratings and full description to allow a clear understanding of what is required.
Alternate products should be allowed to be proposed stating a cost difference but not carried in the base bid. Equivalent products requirement does not apply for specific items denoted in Section IV. (Specifications)
- h. Construction administration or review by each discipline shall be as spelled out in the Architect and Engineer/City contracts. This should list the responsibility undertaken, frequency of visits, report writing, changes to the contract, etc.
- i. Computer-aided drawing is required (AUTO-CAD). The City requires an AUTO-CAD copy of the record drawings on CD.

I. Structural Systems

1. General Approach

- a. During the life span of a typical City building, many minor and major alterations are necessary as the missions of department change. The capability to accommodate alterations must be incorporated into the building from the outset. In some cases structural systems should be designed to provide some leeway for increase in load

concentrations in the future. They should be designed to facilitate future alterations, e.g., the cutting of openings for new vertical elements, such as piping, conduit and ductwork.

- b. The structural framing system should combine economy with a minimum overall story height. Preferred systems enable services to run within the depth of the framing.
- c. Multiple story buildings shall be designed to reduce floor bounce and deflection.

2. Future Expansion

Perimeter building elements should be designed and detailed to facilitate future building expansion when this is required. When it is possible at the design stage to define the direction of future expansion, only those elements that will be affected by the expansion need be proportioned to facilitate the expansion.

J. Roofs

1. Roofing design should follow the recommendations of the National Roofing Contractors Association as contained in NRCA publication, NRCA Roofing and Waterproofing Manual. The design of metal flashing, trim, and roofing should follow the recommendations of the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) publication, Architectural Sheet Metal Manual.
2. *Roof Drainage*. Dead level roofs are not permitted. Roof drains or scuppers are the only low points permitted. Provide a minimum slope to drains of 1/4" per foot.
3. *Access to Roof*. An interior permanent stair would be first priority to access the roof, the second priority would be a ladder or ship's ladder with no less than 45° slope with handrails.
4. *Roof-Mounted Equipment*. Roof-mounted equipment should be kept to a minimum and must be housed in penthouses or screened by walls. Penthouses and screen walls should be integrated into the building design and constructed of materials used elsewhere in the building exterior. Some roof-mounted equipment, such as antennae, lighting rods, flagpoles, etc., does not have to be screened, but these elements must be integrated into the building design.

K. Acoustics

The design must consider the acoustical environment as a whole; integrating ceilings, masking sound, furniture, panels, and carpeting to obtain optimum acoustical privacy. For open offices the following guidelines apply:

1. Ceilings - should have a noise reduction co-efficiently (NRC) of .85 or higher; have articulation class (AC) rating from 180 to 200; a Ceiling Attenuation Class (CAC) minimum of 35 and a minimum Light Reflectance (LR) of .83.
2. Partitions - should have a Sound Transmission Class (STC) rating of 20 or higher; have a NRC of .70 or higher; and a speech frequency sound absorption average of .80 or greater. Recommended height of partitions is 65 inches.
3. Walls - have NRC of .80 or higher.
4. Carpeting - have a NRC of .30 or higher.
5. Sound Masking System - use to bring ambient noise level to 40 to 45 decibels, as necessary.

L. General Mechanical System Design

1. Principles of Design:
 - a. Use the latest available, proven technologies to provide energy efficient and cost effective heating, cooling, lighting, and hot water. Use the most current solar heating technologies for hot water heating that are suitable for the facility. Select systems based on consideration for maintenance, operation and availability of spare parts. System and equipment shall be failsafe and of a quality consistent with anticipated building life.
 - b. Consideration must be given to expansion, contraction and vibration control. Floating isolation floors or pads under the mechanical equipment are recommended for all major mechanical rooms.
 - c. Design separate HVAC systems to serve areas expected to operate on widely differing operating schedules or design conditions. Use CO₂ sensors to control outside air in spaces of high occupant load. Separate systems are also

recommended for buildings where perimeter zones have heating and/or cooling loads very different from interior zones. When a single system serves a large floor, provisions should be made to shut off or set-back the heating and cooling to each area independently.

- d. Large air handling units serving multiple floors are not practical for buildings with scattered loads after normal office hours. Consider multiple air handlers or floor by floor systems. Where practical, a cooling/heating loop dedicated to operation after hours should be considered.
- e. Spaces with relatively constant and weather-independent loads should be served with systems separate from those serving perimeter spaces. Areas with special temperature or humidity requirements, such as telecom and computer rooms should be served by separate supplementary or auxiliary systems.
- f. The supply of zone cooling and heating shall be sequenced to prevent the simultaneous operation of heating and cooling systems for the same space. Where sequencing is not possible due to ventilation or air circulation requirements, air quantities should be reduced as much as possible before reheating, re-cooling, or mixing hot and cold air streams.
- g. Supply air temperature should be reset to extend economizer operations and to reduce reheating, cooling or mixing.
- h. Adjustable frequency drives/variable speed drivers permit optimum operation on fan and pump systems. These shall be used whenever possible.
- i. An HVAC System Commissioning will be conducted and should follow the current ASHRAE Guidelines 1 on commissioning. In new construction, commissioning will follow sustainable design requirements and be completed by a third party.
- j. Duct detectors for fire shall be installed as required by code.

2. Cooling Systems

a. Chilled Water Systems

Chilled water systems include chillers, chilled water pumps, piping and cooling towers.

Select the chilled water temperature differential to minimize life cycle cost of the system. Larger temperature differentials will reduce pumping and piping costs but may increase coil sizes.

Specify Chillers in accordance with Air-conditioning and Refrigeration Institute (ARI) ratings procedures in ASHRAE/IES 90.1.

Microprocessor-based controls shall be used. They shall have self-diagnostic capability, set point displays, run time, and output/input (COP) information.

All chiller systems must consist of multiple machines. Generally, machines should be of equal size and be controlled via the lead-lag control method. No single machine should run for more than 160 consecutive hours.

Environmental Protection. The design of refrigeration machines must comply with Clean Air Act amendment Title VI: Stratospheric Ozone Protection.

Refrigeration machines must be equipped with isolation valves, fittings and service apertures as appropriate for refrigerant recovery during servicing and repair. Protection systems including low electrical voltage or loss of one phase shall be provided. Chillers must also be easily accessible for internal inspections and cleaning.

Design mechanical equipment rooms in accordance with the requirements of ASHRAE Standard 1.5, Safety Code for Mechanical Refrigeration

Connect chiller leak detection and remote alarming to the building automation system if installed.

Chilled Water Pumps: Select pumps to operate at 1750 RPM. Both partial load and full load must fall on the pump curve. The number of primary chilled water pumps should

correspond to the number of chillers, and a separate pump should be designed for each condenser water circuit.

Piping. Reverse return piping is appropriate for systems with many terminal units of similar pressure drop. Direct-return piping system should be used where non-uniform pressure drops through equipment must be accommodated. For all systems, proper consideration must be given to location of balancing valves.

Freeze Protection. Propylene glycol is typically used for freeze protections, primarily in low temperature chilled water systems. Keep the concentration of antifreeze to a practical minimum because of its adverse effect on heat exchange efficiency and pump life. Cooling coil heat transfer de-rating can be about two to three times that of chillers.

Condenser Water. Condenser water circuits must always be recirculating systems. Once-through applications using domestic water are not permitted.

Water Treatment. Water chemistry may cause corrosion and/or scaling in recirculating systems, such as chillers, condensers and

Hot Water Systems. A complete water analysis is essential to the proper design of corrective measures. Since improper addition of chemicals to make-up water is likely to be more harmful than leaving the water untreated, water treatment for all hydronic systems should be designed by a qualified specialist.

Cooling Towers. Cooling water sizes should be based on the 1 percent column of the wet bulb temperature of ASHRAE weather data. Multiple cell towers and isolated basins are required to facilitated operations and maintenance. Piping should be manifolded to allow for any combination of equipment use. Cooling towers should have ladders and platforms for ease of inspections and replacement of components.

Consider dual speed fans or frequency drives. Induced draft is preferred since forced draft uses twice the amount of energy and requires multiple fan arrangement towers run continuously to avoid short circuiting. Induced draft towers must have a clear distance equal to the height of the tower

on the air intake side(s) to keep air velocity low. Forced draft towers require a clearance of twice the tower width on the intake side(s) to minimize air recirculation. Clean-outs for sediment removal and flushing from basin and piping should be provided.

Place cooling towers on the site so as not to interfere with the appearance of the building. Screen walls and planting may be used to conceal the tower. Locate cooling towers to prevent drift or plume fogging on the building or surrounding building. If located on the ground they should be kept away from any building wall or parking lot to prevent corrosion of finishes. The effect of start/stop noise and radiated noise on occupied spaces in the vicinity must also be considered. Start/stop noise can be mitigated by specifying A/C invertors.

Install cooling towers having corrosion resistant materials.

If the cooling tower is located on the building structure, provide vibration and sound isolation. Design supports to permit re-roofing under the tower.

Give special consideration to deicing cooling towers if they are to operate in sub-freezing weather. Provide a manual shut-down for the fan. If cooling towers operate intermittently during sub-freezing weather, make provisions for draining all piping during periods of shut-down. For this purpose indoor drain down basins are preferred to heated wet basins at the cooling water.

b. Special Cooling Applications

Water-side Economizer Cycle. In certain climate conditions cooling towers are capable of producing condenser water cold enough to cool the chilled water system without chiller operation. Consider this option in life cycle cost comparisons of water cooled chillers.

Computer Room Air-Conditioning Units. Mainframe computer rooms may be cooled by self-contained units for loads up to 280 kW. They should be sized to allow for 50 percent redundancy, either two units at 75 percent load or three units at 50 percent.

For loads above 280kW, chilled water air handling systems shall be used. A group of dedicated chillers is preferred, unless other parts of the building also require 24-hour

cooling. It should consist of three chillers, each capable of handling 50 percent of the sensible load. Connections should be available for the future addition of a fourth unit. Heat rejection should be of recalculating type, such as cooling towers or evaporative condensers. Use of once-through domestic water is prohibited.

3. Air Distribution Systems

a. Constant Volume Systems

Single Zone Systems. Single zones air handlers may be considered for systems with relatively constant loading.

Multi-Zone Systems. Multi-zone systems should be considered for small buildings. Multi-zone units should be of the three deck type to minimize reheat.

Reheat. Reheat permits close control of temperature and moisture levels but it is a high energy consumer. Its use should therefore be limited to computer rooms or similar spaces.

Dual Duct Systems. Conventional dual duct systems use high reheat and thus are high energy consumer and should not be used.

b. Variable Air Volume (VAV) Systems

Simple VAV without reheat should be considered for interior zones of office buildings that require year-round cooling.

Perimeter Zones. Designers are encouraged to consider the use of an entirely separate perimeter system, which may be central air or water type.

Volume Control. VAV systems depend on volume modulation to achieve the required ventilation and temperature, which makes volume control critical to the successful operation of the system. Room loads must be calculated accurately to avoid excessive throttling of air flow due to oversized fans and terminal units. Diffusers should be high entrainment type (3:1 minimum) to maximize air velocity at low flow rates. Also, the minimum volume setting should equal the larger of the following a) 30 percent of the peak supply volume. VAV terminal units must never be shut

down to zero when the system is operating. Also the fresh air requirements must be maintained under minimum flow conditions.

In building where simultaneous heating and cooling are required (heating in some zones and cooling in others), two separate systems should be considered.

Terminals. VAV terminals should be pressure dependant unless there is a compelling reason to use pressure independent units.

Terminal ceiling diffusers or booted-plenum slots should be specifically designed for VAV air distribution.

Noise Control in VAV Systems. System sound levels need to be checked at maximum flow. Inlet vanes and fan discharge dampers should be evaluated for noise in their most restricted position. Duct noise control should be achieved by controlling air velocity and by the use of sound attenuators not by over sizing terminal units.

- c. Mixing Boxes. Mixing dampers should be placed across the full width of the air handling unit. Thorough mixing of outdoor and return air is essential for good coil performance and to prevent chilled water coils from freezing. Have low returns or auxiliary fans to push the air down.

- d. General Air Distribution Requirements

Filtration. Air filtration should be provided in every air handling system. The air handling unit should have a disposable pre-filter and a final filter. Filter media should be rated in accordance with ASHRAE 52. Pre-filters should be 30 percent to 35 percent efficient. Final filters should be 80 percent of 85 percent efficient and housed in a factory fabricated frame with a maximum bypass leakage of 0.5 percent.

The filter change-out pressure drop, not the initial clean filter rating, must be used in determining fan pressure requirements. Differential pressure gauges should be placed across filter banks to allow quick and accurate assessment of filter dust loading as reflected by air loss through the filter.

Cooling Coils. The preferred configuration consists of no more than six row coils with fins spacing to allow for easy coil cleaning.

If a higher cooling performance is required, a second cooling coil should be installed. The two coils can be piped in series making them in effect one coil that is easier to clean.

Heating Coils. As with cooling coils, heating coils with fins spaced for easy coil cleaning are preferred.

Humidification. Humidification should be limited to building areas requiring special conditions. General office space should not be humidified unless severe winter conditions are likely to cause indoor humidity to fall below 25 percent. Where humidification is provided, vapor barriers should be provided and the dew point of walls and windows must be documented.

Supply Air Fans. Vane-axial fans are preferred.

All fans should be isolated. Thrust arresters should be designed for horizontal discharge fans operating at high static pressure.

An air-side economizer cycle should be provided if feasible.

Enthalpy economizer controls are not recommended because they drift out of calibration easily and may cause energy use to increase. Dry bulb sensors are recommended for use in this area. Economizer cycles should not be used for humidified spaces because of the increased difficulty of maintaining space humidification and control.

4. Special Systems

a. Heat Recovery

Heat Reclaim Chillers. Consider heat recovery chillers for buildings that will require cooling year round. If used in conjunction with air-side economizer cycles, a careful controls design is required to present the two approaches from working against each other.

Heat Exchangers. The condenser water system or a separate 24-hour critical load system can be connected via heat exchange to the hot water heating system.

b. Solar Heating and Cooling

For each new project, consider renewable energy sources for heating, cooling and domestic hot water heating. If cost effective, use renewable sources (solar energy, wind, water).

c. Ice Storage

Uses cooling energy storage at night when electrical demand is less and deliver cooling comfort during the daytime.

d. Geothermal Storage

Uses the natural heat storage ability of the earth and/or the earth's ground water to heat and cool.

5. Layout of Mechanical Spaces

a. Generally locate mechanical equipment within the building in an enclosed mechanical room (s). Room shall be of sufficient size to accommodate all equipment (present and future) and with sufficient clearances to permit servicing and replacement of all components. All equipment must have isolating valves, unions for removal and service; thermometers; pressure gauges liquid filled where applicable; valved bypasses to be provided on all control devices. All mechanical rooms are to have floor drains to accommodate condensate drainage from equipment. Where maintenance requires lifting of heavy parts, hoists should be installed.

b. Lighting. Lighting in equipment rooms should be laid out so as not to interfere with equipment. Provide dual switch level lighting for general and working level (manual).

c. Housekeeping Pads. Housekeeping pads should be at least 3 inches larger than the mounted equipment on all sides.

d. Piping. Layout piping in orderly fashion. Access to the underside of the structure should not be completely cut off.

e. Ductwork. Layout ductwork with minimum bends. Access to piping and the underside of the structure should not be

obstructed.

- f. Operation and Maintenance Manuals. Provide documentation on all building systems for the guidance of the maintenance staff. This should show the actual elements that have been installed, how they performed during testing, and how they operate as system in the completed facility. Included in the manuals shall be a defined maintenance schedule with maintenance task delineated in the schedule.

Provide the maintenance staff with the following:

Autocad Record drawings and Specifications on CD.

Operating manuals with a schematic diagram, sequence of operation and system operating criteria for each system installed.

Maintenance manuals with complete information for all major components in the facility including an electronic version.

- g. Operating Instruction. Provide operating instructions for maintenance staff at the time of commissioning the mechanical systems. The amount of instruction time provided should be commensurate with the complexity of each system.
- h. Network data connection for laptops.

6. Control Systems

- a. Automatic Temperature and Humidity Controls

All controls must be compatible with Johnson Controls Metasys.

Controls. Use pre-programmed single or multiple loop controllers to control all HVAC and plumbing sub-systems.

Temperature Controls. Control heating and cooling energy in each zone by a thermostat located in that zone. Independent perimeter systems must have at least one thermostat for each facade of the building with a different orientation.

Night set-back controls for the heating season for summer conditions must be provided for all comfort conditioned spaces, even if initial building occupancy plans are for 24-hour operation. Morning warm-up must be part of the control systems.

- b. **Air Systems.** Systems supplying heated or cooled air to multiple zones must include controls that automatically reset supply air temperature by representative building loads or by outside air temperature. Temperature should be reset by at least 25 percent of the design supply-air to room-air temperature differential. Zones that are expected to experience relatively constant loads, such as interior zones, may be designed for the fully reset supply temperature.

Hydronic Systems. Systems supplying heated and/or chilled water to comfort conditioning systems must also include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature.

- c. **Testing and Balancing Equipment and Systems**

Testing Stations. Provide permanent or temporary testing stations to permit testing of building systems. Design connections so temporary testing equipment can be installed and removed without shutting down the system.

Water flow measuring devices are required for each refrigeration machine and for chilled water lines serving computer rooms.

Thermometers and Gauges. Provide instrumentation at each measuring point to verify capacities, temperatures, flow rates and any other critical parameters.

Provide duct static pressure gauges for the air supply fan or in individual duct runs, if multiple pressure measurement is used.

Pressure sensors on both sides of filters in the air handling unit shall map back to BAS.

- d. Control fans in restrooms automatically so they do not operate during unoccupied periods.

7. Building Automation System (BAS)
 - a. A BAS is not required for every project but is mandatory on large, new buildings and major modernizations based on areas greater than 5,000 sq. ft. The City uses Johnson Control's Metasys as its standard equipment controllers.
 - b. Energy Measurement Instrumentation. The ability to measure energy consumption and monitor performance of system specific loads (i.e. HVAC separate from lighting). is critical to the overall success of the system. Electrical values, such as V, A, KW, KVAR, KVA, PF, KVAH, Frequency and Percent TDH, should be measured. Installation of a G.E. Power Management Control System is highly desirable.

M. Plumbing Systems

1. Provide water pressure reducing valves to limit water distribution pressure to 80 psig. Minimum pressure during heavy usage is not to be less than 60 psig.
2. Provide sufficient domestic hot water storage tanks to accommodate peak load demands of building. Locate tanks close to point of application to minimize hot water and recirculation water requirements. Hot water recirculation is to be provided for distribution systems over 50 feet from heater. Provide floor drain within 5 feet of hot water heater to accommodate pop-off and any water leaks.
3. Provide plumbing systems with sufficient shut-off/isolation, and drain valves to permit localized repairs without need to shut down complete systems. Place unions at all equipment, etc. that may require removal or replacement.
4. Domestic hot water systems should be capable of maintaining 90-105 degrees F. Where higher temperature is required provide local reheaters.
5. For shower rooms provide a thermostatic temperature control or individual shower mixer cabinet and pipe tempered water to shower fittings. Use flow restrictors on showers to reduce water consumption. Consider use of push-button or automatic shower controls. Maximum flow rate: 2.00 g.p.m.

6. Locate exterior frost proof keyed hose bibbs around perimeter of building to permit watering of all landscaped areas with a standard 100 foot hose. Also provide frost proof hose bib on roof to allow for cleaning HVAC units with a standard 50 foot hose.
7. Use commercial grade, vitreous china plumbing fixtures. Water closets shall be wall mounted to permit cleaning of floors. Where building is unattended provide vandal proof fixtures and fittings.

Toilets are to be water conserving or low-consumption (1.6 gallons/flush) types. Install automatic flush valves on all water closets, urinals and sinks. Use of waterless urinals should be considered.

8. Provide floor drain in each restroom.
9. Consider feasibility of heat recovery and solar hot water preheat where large volumes of hot water is required.
10. All pipes (including roof drains) in mechanical rooms, shafts, ceilings and other spaces accessible to maintenance personnel must be identified with color coded bands indicating type of material piped and direction of flow. Gas piping and sprinkler lines must be identified as prescribed by NFPA. Apply at every point of entry/egress through walls/ceilings.

Valves and other operable fittings must be tagged.

11. All non-metal underground piping shall have a trace wire to aid in location.

N. Insulation

1. Insulate all piping that will result in an increase in energy consumption for the building if not insulated.
2. Insulate all cold water piping and cold air duct work with sufficient insulation with vapor barrier to prevent surface condensation.
3. Insulate all hot air supply duct work.
4. Insulate all hot air and cold air duct work located outdoors or in unconditioned spaces.
5. Insulate underside of roof drains and any horizontal rainwater piping.

6. Label all insulated pipe in hot water supply system.
7. Roof and ceilings shall have R-30 or greater thermal resistance; walls shall have R-19 or greater rating.
8. Use spray foam insulation on penetration openings.

O. General Electrical System

1. Service

- a. Primary service should be based on the estimated demand load plus 35 percent spare capacity.
- b. Provide the following:
 - 1) For loads up to 175 KVA, use a 120/208V 3 phase 4 wire 600A service if possible
 - 2) For loads greater than 175 KVA, use a 480/277 3 phase 4 wire service
- c. If a vault is required, plan for a first floor location on an outside wall for natural ventilation and road access but not at the front of the building. If a transformer pad will be required check Code required clearances from the building and building openings as windows, doorways, etc. Verify with Fort Collins Utilities, Project Engineering any other clearances that may be required.
- d. Motors: Specify high efficiency motors. Refer to the latest Consortium for Energy Efficiency (CEE) – CEE Premium Efficiency Motors Initiative.

2. Distribution

- a. Except for the small services (175 KW and below) use 480/277V power for all motors ½ HP and larger, all fluorescent and HID lighting loads and all electric heating loads. This will minimize copper, conduit and equipment sizes.
- b. Locate the service panelboard adjacent to the service transformer and as close to the load center as possible. A

centrally located distribution center will reduce feeder length, voltage drop and costs substantially.

- c. Power elevators from a shunt trip circuit breaker located in the elevator equipment room. See ANSI A17.1.
- d. Panelboards shall use circuit breaker protection. Allow for 25% spare capacity or more if future additions are known.

Maximum 42 poles per panel board. Panelboards serving personal computers, computer terminals or dedicated work stations should have an isolated ground bus. The service to the electronic panelboard should be supplied from an isolation transformer. Size equipment with consideration given to higher harmonic currents in the neutral wire.

- e. Motor controls shall be provided in centralized motor control centers (MCC's) or grouped motor control modules - located in mechanical rooms where there is the greatest concentration of motor loads.

Protection and control for motors operating heating equipment, pumps, boilers, hot water systems, sump pumps, food and refrigeration systems and other critical loads should be designed to be automatically turned "ON" in timed sequence when power is restored after a power failure. Motor controls and power wiring to motors and equipment should generally be specified by the Electrical Consultant and work done by Division 16. Control wiring should be specified and installed by Mechanical Division 15.

- f. Branch wiring within the buildings shall be specified as THHN-R90 copper conductors (minimum No. 12 gauge) run in EMT above grade and in rigid PVC below grade or below slab on grade. Underground branch wiring outside the building shall be RWU-90 installed in rigid PVC at 30 inches below grade. Splices made on #10 wire or smaller shall have conductors twisted together before placing warrant connectors on splices. Splices made on #6 and larger shall utilize either mechanical - or compression-type lugs; wirenuts shall NOT be used. All wiring beneath a raised access floor should be routed in metal conduit or cable to underfloor distribution boxes.
- g. Wiring devices shall be "Specification Grade" with matching nylon plates.

- h. Mark or identify panel and circuit number on all J-Boxes.

3. Lighting System

Illumination for the parking areas, roadways and walkways shall be designed according to the City plan lighting requirements and the latest version of ASHRAE / IES90.1. Building lighting shall be designed in accordance with LEED requirements. Lighting quality also needs to be given high priority in occupied spaces.

- a. Illumination design shall be based strictly on the task(s) and confined to the task areas, to be carried out in the space and the level of performance set by the user, i.e. do not light a hockey rink to professional standards when only amateurs will play. Likewise, provide additional illuminance for senior citizens engaged in close or detailed work in a hobby shop. Indirect lighting in office areas shall be provided if feasible.
 - 1) Design circulation areas to one third the task illuminance level in that room.
 - 2) Walls, ceilings and other room surfaces should be lit with either direct or indirect light so that the overall room luminance ratios are approximately 5:1. An example of poor luminance ratios would be from a low glare troffer system or from an area lit with only down lights. The floor and working surfaces are bright, yet the walls and ceilings are dark. Another example would be the luminance ratio between a window and the wall where it is located. The wall should be lighted and also painted a light color.
 - 3) Lamps used for interior use should have at least a color rendering index equal to 80 or greater and a minimum average lamp efficacy of 80 lumens per watts. Different lamps within a same area should have similar color temperature and color rendering index.
 - 4) Minimize reflected and direct glare. Luminaire selection and locations should be coordinated with particular tasks in an area. An example of this would be to specify low glare fluorescent in an office where computer terminals are used. The fluorescents should be located such that the luminaire image cannot be seen in the screen.

- 5) Vandal resistant use luminaires in all outdoor area lighting with IES recommended cut-off distribution. Shield luminaires so there will be no light trespass or pollution.
- b. In the interest of energy savings and operating economics, incorporate the following principles:
- 1) Use the highest efficiency lighting sources available considering color rendition and cost. Sources shall be energy efficient fluorescent (with few if any, 2 feet, 3 feet, or U-bent lamps), 4 ft. T5 or T8 rapid start lamps where possible, metal halide (MH), or high pressure sodium (HPS). If HPS lamps are proposed indoors, only lamps with acceptable color rendition should be specified, otherwise use MH. All outdoor lighting is a good candidate for HPS. Twin tube and double twin tube high intensity fluorescent compact lamps with high power factor ballasts, and double ended metal halide lamps should be used in lieu of incandescent located in down lights and wall sconces. Metal halide lamps may be considered outside when color rendering is important.
 - 2) Use 18,000 to 20,000 hour life lamps wherever possible for lower maintenance costs. When twin tube, double twin tube fluorescent and low wattage metal halide lamps are used, then longer service life (compared to incandescent) will be acceptable.
 - 3) Avoid incandescent luminaires due to their low efficiency, very short life and high power and heating content. Limit use to special areas. If incandescent lamps are used, specify 125V-130V 2,000 hours life, standard "A" type lamp for area lighting. Use low voltage MR-16, Par-36 or quartz in framing projectors for artwork and display lighting systems and limited area lighting. All incandescent systems should be dimmed in order to lengthen the lamp life.
 - 4) Ballasts shall be electronic unless otherwise approved by the City. Ballasts for outdoor usage, ice arenas, outdoor parking, etc., shall be low temperature-30F type (with appropriate lamps).

- 5) Luminaires shall be chosen for high efficiency consistent with good lighting quality i.e., low brightness and low glare rating. They should be selected and located for the anticipated tasks and ambience in the area.
- 6) Good quality lighting should produce the required illumination with an overall maximum connected load of 1.75 watts/square foot. Maximum power densities allowed by ASHRAE 90.1 by space type using the building area method. However, depending upon the type of building, lower wattage densities can be achieved and designs should be based on the latest I.E.S. Energy Management Series of Publications (LEM's). Higher watts/square foot may be allowed if automatic light level controls are installed. This would include the design of using higher wattage lamps that are dimmed down to a desired light level in order to maximize lamp life.
- 7) Interior wall and ceiling finishes should have a high reflective, matte finish.
- 8.) Use premium efficiency motors whenever possible. See attached premium – efficiency motors initiative.

4. Luminaire Types

- a. Specify high efficiency luminaires - fluorescent troffers at least 70%. All luminaires should have well designed optical systems with reflectors and refractors which distribute the light where it is required. An example of a poorly designed luminaires would be a post top globe luminaires designed for outdoor use where the majority of the light goes up into the sky versus down on the pavement where it is needed.
- b. Specify wire guards and/or lexan diffusers for all luminaires where units will be exposed to the public as washrooms, change rooms, athletic facilities and outdoors. HID luminaires shall have hi-stress glass gasket enclosure.
- c. Select luminaires with good maintenance characteristics. Maintenance procedures to be reviewed by City Maintenance staff I.E. ease of cleaning, repair

5. Lighting Control and Energy Consumption

Limiting or managing energy consumption (i.e. connected wattage x time of usage) is the only effective key in reducing energy usage and thereby cut operating costs. Accordingly the design of the lighting controls must be thoroughly studied and proposed to provide a three to five year life cycle payback for the capital investment over a "standard" system. The following controls shall be considered:

- a. Provide switching in every room preferably two level where usage changes. Consider multi-level (electronic) ballasts and dimming controls for spaces requiring different levels of lighting.
- b. Consider automatic dimming devices for perimeter or skylight areas separately from interior areas. Consider automated daylight controls for perimeter or skylight areas.
- c. Control outdoor lighting by photo cell "ON" and time switch and/or photocell "OFF". Only security lighting shall be left "ON" all night.
- d. Consider infrared or ultrasonic sensors for small, enclosed office spaces and toilet areas. Each occupancy sensor should control no more than 12 fixtures. Each occupancy sensor should be marked by a label identifying the panel and circuit number. Occupancy sensors should not be used in open office areas, spaces housing heat producing equipment or corridors.
- e. Consider photoelectric sensors for fixtures adjacent to glazed areas and for parking structures.
- f. Consider lighting control panels for complete building lighting system control with network compatibility to centralized computer system.

6. Emergency/Exit Lighting

Provide certified emergency battery sources for remote high efficiency quartz heads to meet the Codes for emergency lighting. For larger buildings, i.e., office complexes, consideration should be given to a diesel generator or a UPS to supply emergency power for lighting and essential loads and as covered by Code.

7. Fire Alarm System

Provide a fire/visual alarm system as required in a facility in strict accordance with the current Codes and ANSI A 117, 1-92.

8. Communication Services

After requirements are known, coordinate design for this service with the City's MIS Division. See Appendix G.

9. Wiring and Grounding Techniques

Wiring recommendations for proper operation of computers/programmable controllers/microprocessor-based electronic equipment of all types are:

- A. Distribution systems must be designed around the harmonics problems. (Double neutral size, de-rating transformers, etc)
- B. True R.M.S. metering for voltage and current must be utilized.
- C. Earthing conductors should be CAD welded (chemical bond) to the earth/grounding rod.
- D. Earthing conductor (from Main Distribution Panel to earth/ground rod) should be at least 500 mcm, or larger as determined by actual need.
- E. Grounding conductors (from load and sub-distribution panels) should be sized parity (same size) with the phase conductors feeding that panel. Sensitive load panels should have grounding conductor run uninterrupted to the MDP main building ground bus.
- F. Avoid ground loops by avoiding multiple grounding points.
- G. Use a SINGLE REFERENCE POINT for all GROUNDING.
- H. Ground reference should ONLY BE TO THE BUILDING SERVICE ENTRANCE GROUND BUS (usually at the MDP panel.)
- I. Use only insulated grounding conductors (to avoid multiple ground references inadvertently to steel, conduit, etc.) This

will also avoid RFI introduced through the “antenna” of the building steel and conduit.

- J. Up size conductors by one size for each 75 feet of run from distribution point. Computer circuits will operate better when #10 awg is minimum size for a 15-20 amp circuit.
- K. Neutral conductors feeding a three phase distribution (or a three phase electronic power supply load with a single neutral) should be TWICE THE SIZE OF THE PHASE CONDUCTORS.
- L. DERATE TRANSFORMERS due to high peak current crest factors (HARMONICS) with computer and electronic power supplies of all types (UPS or other rectifiers, VFD motor controllers, etc.) Specify high efficiency transformers. Refer to the latest Consortium for Energy Efficiency (CEE) High-Efficiency Commercial and Industrial Transformers Initiative.
- M. Plan wiring/circuit breaker loading at 50%.
- N. For electric loads DO NOT “DAISY CHAIN” OR RUN “HOME RUNS” with separate neutral only on GFI’s or computer racks.
- O. Transient Voltage Surge Suppression (TVSS) equipment SHOULD BE INSTALLED WITHIN 6" OF LOAD PANEL WHENEVER POSSIBLE for maximum effectiveness. Install as close as possible to the load bus bars or load wiring when 6" is not possible.

UNIVERSAL STANDARDS

DESCRIPTION	AREA (SF)
SUPPORT SPACES:	
LARGE BREAK/LUNCH ROOM	240
SMALL BREAK ROOM/LOUNGE	160
COFFEE BAR	80
COPY ROOM	80
FILE ROOM	80
OPEN FILES AREA	80
DAY ROOM	NA
EXTRA LARGE CONFERENCE ROOM	NA
INSPECTOR'S CONFERENCE ROOM	NA
LARGE CONFERENCE ROOM	320
LARGE CONFERENCE ROOM	NA
LIBRARY	NA
LIBRARY/RESOURCE	80
LOBBY	VARIES
MAP/DRAWING ROOM UNIT	160
MEDIUM CONFERENCE ROOM	240
PHOTO LAB	NA
PRINT ROOM & SUPPLIES	NA
RECEPTION AREA 1	80
RECEPTION AREA 2	NA
REPAIR SHOP AREA	VARIES
RESTROOM WITH SHOWER	80
SMALL CONFERENCE	160
STORAGE ROOM	160
WORK AREA	80
"PHONE BOOTH"	80
WORK SPACES:	
CLERK/TYPIST	80
COMPUTER WORK STATION	80
SERVICE DIRECTOR OFFICE	240
SERVICE DIRECTOR OFFICE	NA
SERVICE DIRECTOR OFFICE	NA
OFFICE 1A	NA
OFFICE 1B	NA
OFFICE 2A	NA
DIVISION HEAD OFFICE	160
DEPARTMENT HEAD OFFICE	160
DEPARTMENT HEAD OFFICE	NA
WORK STATION 1	80
WORK STATION 2A	80
WORK STATION 2B	80
DRAFTING WORK STATION	80

UNIVERSAL SPACE STANDARDS FOR THE CITY OF FORT COLL

9-11-98
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