

ENGINEERING DESIGN GUIDELINES

FOR

CITY OF CALGARY FIRE STATIONS

2011

Prepared By:

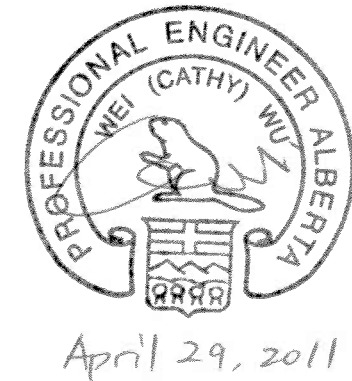
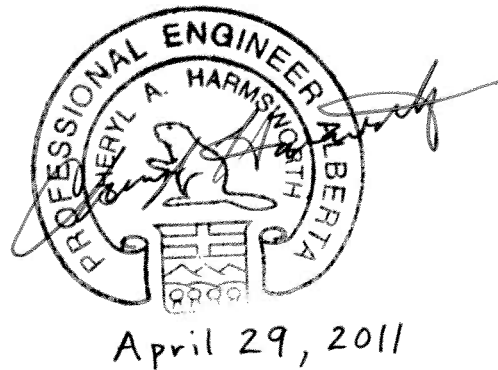
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1.1 Intent

- .1 To apply to design of all new fire stations and their associated sites, and to design of additions, upgrades and renovations to existing fire stations.
- .2 To aid consultants and Calgary Fire Department (CFD) in developing appropriate technical designs for fire stations.
- .3 To aid in evaluation and acceptance of designs by Corporate Engineering for CFD. One of the goals is to avoid unnecessary re-design time and effort, and avoidable changes during design, construction or post-occupancy.
- .4 To be followed with reasoned judgement as to applicability to specific and atypical situations.
- .5 To provide minimum requirements on components that affect serviceability, durability, sustainability, and anticipated life expectancy of a facility; to maximize functionality and efficient operation; and to avoid unnecessary expense (capital and operational) and premature obsolescence of facilities.
- .6 To provide proven solutions to, and avoidance of, design and construction aspects that are problematic.

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2.1 Guidelines Limitations

- .1 These guidelines are intended to supplement, and not to replace or duplicate, the requirements of codes including, but not limited to, *Alberta Building Code*, national codes (e.g. plumbing, gas, electrical), *National Building Code Commentaries*, CSA and industry design standards, and City of Calgary Development & Building Approvals in respect of permits and inspections. The Calgary Fire Department also has Fire Station Design Standards, which consultants should obtain and abide by along with these guidelines.
- .2 These guidelines and receipt of any other information or documentation from City of Calgary employees in no way relieve consultants from the professional obligation to meet all applicable regulatory codes and standards.
- .3 Consult with Corporate Engineering where these guidelines are seen as inappropriate or contrary to reasonable design solutions for special situations.

END OF SECTION

Section 3 Other City of Calgary Design Requirements

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Section 3 Other City of Calgary Design Requirements

3.1 Other City of Calgary Design Requirements

Refer to the most current version of these other documents for requirements specific to certain types of related facilities, structures, and systems:

- .1 Calgary Fire Department – *Fire Station Design Standards*
- .2 Corporate Engineering – *City of Calgary Sustainable Building Policy*.
- .3 Advisory Committee on Accessibility - *City of Calgary Access Design Guidelines* (for barrier-free accessibility).
- .4 Development and Building Approvals - *Fire Stopping Service Penetrations in Buildings*.
- .5 Contracts Committee - *Guidelines for the Preparation of Tender Documents and Contract Administration*.
- .6 Utilities and Environmental Protection Land Information and Mapping - *Design Guidelines for Development Permits and Development Site Servicing Plans*.
- .7 Wastewater and Drainage – *Effective Erosion and Sediment Control*; as it pertains to the site associated with the facility.
- .8 Wastewater and Drainage – *Stormwater Management and Design Manual*.
- .9 Infrastructure Services – *Sustainable Building Best Practices*
- .10 IT Communication Infrastructure Standards

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Section 4 General Consultant Requirements

4.1 CFD Requirements and Design Intent

- .1 Consultant should confirm with CFD the specific project requirements including but not limited to the following:
 1. Design Life; See clause 8.6
 2. Project schedule and capital budget.
 3. Project documentation requirements, including format for submittals, training materials, and reports. Consideration should be given to use of electronic format documents and records where appropriate.
 4. User requirements.
 5. Occupancy requirements and schedules.
 6. Quality (durability) requirements of materials and construction.
 7. Performance requirements (i.e. energy use, water use).
 8. Utility Metering requirements.
 9. Green building rating system target (refer to Sustainable Building Policy).
 10. Other specialized requirements (accessibility, indoor environmental quality, acoustical, aesthetic, security, community, information technology) as applicable.
 11. Operation and maintenance criteria for the facility that reflect CFD's expectations, including equipment and system maintainability expectations, including capabilities of operating and maintenance personnel.
 12. Commissioning, turnover and process scope and budget (as applicable).
 13. Training requirements for CFD's personnel.
 14. Applicable Codes and Standards.
 15. Relevant City of Calgary policies and guidelines (e.g. Sustainable Building Policy, Green Housekeeping Guideline, Sustainable Environmental and Ethical Procurement Policy) .
 16. Warranty requirements.

Section 4 General Consultant Requirements

- .2 CFD's requirements should be documented as a brief by the prime consultant and provided to CFD, the project manager and design team (including the commissioning agent as applicable).
- .3 The CFD Project Requirements brief should be updated to reflect changes in CFD's requirements and circulated as above.
- .4 The CFD Project Requirements brief should be referred to throughout the design process, particularly at decision points within the process.

4.2 Design Reviews

- .1 Corporate Engineering should be involved in conceptual and schematic design meetings, integrated design charrettes, detailed consultant design meetings, and stakeholder/consultant meetings in order to establish the basis of design. These will aid in understanding design rationale.
- .2 Submit design information for technical review by Corporate Engineering at the following design stages:
 - .1 Schematic Design Brief or Design Development Report (Basis-of-Design Document);
 - .2 50%-complete drawings and specifications;
 - .3 90%-complete drawings and specifications;
 - .4 Tender drawings and specifications;
 - .5 Issued For Construction drawings and specifications (if magnitude of addenda warrant issue).
- .3 All design review comments will be channelled through The City's project manager.
- .4 Address review comments in a timely manner to avoid any requirement for significant redesign.

4.3 Schematic Design Brief

The Schematic Design Brief is to address the following:

- .1 Facility Program:
 - .1 Change in use of existing areas.
 - .2 Building gross and net areas (as measured per BOMA guidelines).
 - .3 Provisions for future expansion.
- .2 Scope of Work: extent and areas of:
 - .1 Demolition.
 - .2 Renovation.
 - .3 Upgrade.
 - .4 New construction and addition.
- .3 Schematic Plans:
 - .1 Site plan, with building location, utility locations, and firefighting access.
 - .2 Building floor plans.
- .4 Building Codes review.
- .5 Outline descriptions of systems and components, including rationale for any replacement of existing systems, and any energy and water efficiency initiatives:
 - .1 Architectural / structural:
 - a. Abnormal geotechnical conditions & ramifications e.g. deep foundations, structural slabs on grade, sulphate resistance.
 - b. Structural:
 - Roofs, floors, foundations, and vertical and lateral support systems and materials.
 - All live, superimposed dead, snow, rain, ponding, wind and seismic design loadings, including for on-grade floors.
 - Importance Factors (both S&W and E).
 - Whether W and E loadings will be designed through dynamic or static analysis.
 - c. Building envelope system, including roofing, walls, windows, doors, insulation, air barriers, and vapour retarders.
 - d. Exterior walls and finishes.
 - e. Interior walls and finishes.
 - f. Floor finishes.
 - g. Ceiling finishes.
 - h. Acoustics.
 - i. Handicapped access provisions and any alterations.

Section 4 General Consultant Requirements

- j. Site:
 - site and building grades, drainage, and extent of any re-grading.
 - parking.
- k. Roof fall protection intentions.
- .2 Mechanical:
 - a. Codes and Standards.
 - b. Design Conditions.
 - c. Site Services; gas, water, sanitary, storm.
 - d. Plumbing: proposed fixtures.
 - e. Fire protection:
 - Sprinkler system.
 - Modification of existing standpipe and hose system.
 - Fire extinguishers.
 - f. Heating system:
 - Primary heating source.
 - Terminal units; fin tube radiation, radiant panel, radiant floor.
 - Zoning; reheat coils.
 - Pumping arrangement.
 - g. Cooling system:
 - Primary cooling source.
 - DX Cooling.
 - Chiller.
 - h. Supply air handling:
 - Central system air handling units:
 - Makeup air.
 - Mixed return/supply air system.
 - Heat reclaim device.
 - Dedicated outdoor air system.
 - Furnaces.
 - Natural ventilation.
 - Humidification: wet cell ; gas fired; or other.
 - Room air distribution:
 - Mixed air.
 - Displacement.
 - i. Exhaust systems.
 - j. Controls:
 - DDC; pneumatic; electric.

Section 4 General Consultant Requirements

- k. Extent of communication to central monitoring area.
 - l. Schematic Mechanical drawings.
 - m. Preliminary HVAC equipment list.
- .3 Electrical:
- a. Electrical Standards and Guidelines.
 - b. Power and distribution Systems: description of existing conditions, modification and new components of the systems listed below:
 - Main service: load summary, voltage, main breaker size, service entrance, main/sub electrical room location.
 - Central distribution panelboard and branch panelboards.
 - Transient voltage surge suppression protection.
 - Motor Control Center.
 - Transformer (if applicable).
 - Emergency power systems:
 - Generator set (if applicable) size and location.
 - UPS (if applicable).
 - Batteries.
 - c. Lighting system:
 - Proposed interior and exterior illuminance level and light fixtures at different application areas.
 - Emergency lighting and exit lights.
 - d. Auxiliary systems: description of existing conditions, modification and new components of the systems listed below:
 - Telephone/data systems.
 - Paging, intercom, and sound systems.
 - Security systems.
 - Fire alarm systems.
 - Broadcast centre and equipment.
 - CCTV (if applicable).
 - e. Schematic Electrical drawings.
- .4 Sustainability:
- a. Specify the applicable building rating system as outlined in the Sustainable Building Policy and the target level. Identify date of project registration with the applicable rating system, and key contact (ie. sustainability consultant, architect, owner, other).
 - b. Include a preliminary checklist of proposed credits if pursuing certification through the Canadian Green Building Council (CAGBC) Green Building Rating System.

Section 4 General Consultant Requirements

- c. If the project will not be pursuing registration or certification under a rating system, identify which sustainable building best practices will be incorporated into the site planning, building design, construction and operation.
- .5 Hazardous materials considerations.
- .6 Phasing / sequencing of construction and occupancy.

4.4 Coordination

- .1 It is paramount to project schedule and budget success that each consultant, regardless of coordination fee or whether acting as prime consultant or subconsultant, coordinate its work with other disciplines; in particular:
 - .1 Structural with building envelope air barrier and vapour retarder paths, continuity and details.
 - .2 Architectural, structural, electrical with mechanical ductwork, return air openings, flue and major plumbing and drainage.
 - .3 Architectural and structural with major electrical cable horizontal chase requirements.
 - .4 Clearances to architectural and structural elements for services and structural deflections.

Document revision and resubmission will be requested if coordination is found lacking.

- .2 Ensure that consultant responsibility is assigned for design and drawing of all facility components e.g. weeping tile / dewatering systems, guardrails, and cladding vertical and lateral support.
- .3 Ensure adequate treatment for all envelope penetrations from mechanical and electrical equipment.
- .4 Consultants are to obtain from CFD any specific occupant and/or operational requirements e.g. special ventilation, lighting.
- .5 Codes, standards and guidelines referenced are to be latest edition.

4.5 Submittals

- .1 Consult with the City of Calgary Project Manager for submittal requirement and submission timelines. Provide PDF files of Operation and Maintenance Manual along with hard copies.

Section 4 General Consultant Requirements

4.6 Design Process

- .2 Building systems and assembly options are to be presented to CFD and value engineered early in the design process to ensure that CFD's Requirements are met at the lowest cost over the life of the building.
- .3 Energy modelling should be used where appropriate to assess design options and optimize building design with respect to energy performance. To best utilize the energy modeller as a resource, a contract should be established early in the design process (i.e. during schematic design). Energy modelling should be approached as:
 - .1 An iterative process that involves the whole design team.
 - .2 A tool to assess the impact of design decisions on building performance and lifecycle operating costs.
 - .3 An input to decision-making on orientation of the building within the site, building massing, balancing of provision of views and envelope performance, and material and equipment selection.

Performing energy modelling only to demonstrate compliance with green building rating systems is not an acceptable practice.

4.7 Site reviews

- .1 Corporate Engineering may attend site meetings and conduct site reviews on a case by case basis as requested by the Project Manager or CFD.

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5.1 The City of Calgary's Sustainable Building Policy

- .1 Sustainable Buildings:
 - .1 Sustainable development refers to the ability to meet the needs of the current generation without restricting future generations from meeting their needs. As such, sustainable buildings shall seek to use energy, water, land and material resources efficiently and reduce impacts on the environment and human health.
 - .2 Use an integrated design approach when designing a sustainable building. An integrated design approach brings together multiple design disciplines (such as architects, engineers, and interior designers), consultants (such as sustainability consultants, energy modelling experts, and commissioning agents), and CFD representatives and building operators. Ideally, building occupants and other user groups are also involved in the process.
 - .3 In order to achieve a sustainable building, carefully consider site selection, building orientation, and building massing. Maximize the potential of the site by responding to the unique site conditions such as climatic conditions and topography.
 - .4 Consider passive systems wherever feasible as simplicity of controls allows to reduce dependence on active systems. Any strategies in this regard need to be thoroughly discussed with CFD prior to implementation.
 - .5 Design to integrate the built and natural environments so as to enhance green and open space and create connectivity through the urban form.
 - .6 Make use of design tools such as energy modelling to optimize lifecycle building performance (refer to section 4.5).
 - .7 The City of Calgary approaches sustainable building within the triple bottom line framework and seeks to evaluate economic, environmental, and social impacts as a part of the decision-making process.
- .2 The City of Calgary's Sustainable Building Policy:
 - .1 The purpose of The City of Calgary's Sustainable Building Policy is to ensure planning, design, construction, management, renovation, operation, and demolition of all City-owned and City-financed facilities is carried out:
 - a. in a sustainable manner and,

- b. considering all triple bottom line (TBL) impacts
 - c. while enhancing The City of Calgary's reputation as a fiscally responsible municipal government, and addressing the health and well-being of the people who use and occupy these facilities.
- .2 Refer to http://www.calgary.ca/docgallery/bu/cityclerks/council_policies/amcw005.pdf for further information on the building rating system targets for various building project types and for procedural information.
 - .3 Contact the Director of Infrastructure & Information Services for interpretation of the Policy.
- .3 Sustainable Building Best Practices:
 - .1 Sustainable building best practices should be incorporated wherever feasible. Sustainable building best practices are identified processes, practices or systems widely recognized as ways of improving building sustainability. A guide to Sustainable Building Best Practices is available from Corporate Engineering.
 - .4 Project Registration and Certification
 - .1 The City of Calgary has a corporate membership in the Canada Green Building Council and thus City projects receive a discounted rate for both project registration and certification. Contact Corporate Engineering for further information.
 - .2 There are numerous LEED Accredited Professionals working for the City of Calgary. Contact Corporate Engineering for more information and to determine if a LEED AP within the City may be available to support the project and certification of the project.
 - .5 Documentation and Submittals
 - .1 Green building rating system checklists (e.g. LEED® checklists) should be provided to Corporate Engineering throughout the design process, construction, and commissioning whenever significantly revised.
 - .2 A copy of the submittals for green building certification (i.e. LEED® submittals including those required for audit regardless of whether or not it is actually requested from the Green Building Council) should be provided to Corporate Engineering (an electronic copy is preferred).

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6.1 Retaining Walls

- .1 These Guidelines apply to retaining walls designed and constructed as part of a building or site development for a building project. For other transportation-related retaining walls, refer to *City of Calgary Guidelines For Bridges & Structures* and coordinate with Transportation Infrastructure - Bridges and Structures.
- .2 For retaining walls higher at any point than 1.0m, engage a geotechnical engineer to provide a geotechnical investigation and report that includes information for design and construction, with the recommendations sealed and signed by a Professional Engineer experienced in this type of structure.
- .3 For retaining walls higher at any point than 1.0m, do not use modular blocks with only keying between blocks where there is potential for frost heave, subgrade settlement, differential settlement or other vertical movement that could disrupt keying.
- .4 Retaining wall design to take into account: soil pressure; hydrostatic pressure; adjacent structure surcharge loads; adjacent traffic surcharge loads; potential for future slope build-up behind wall; and potential for excavation (e.g. for road or sidewalk replacement, utilities, or plantings) behind wall if tiebacks / deadmen / straps are utilized or in front of wall if passive resisting soil pressure is utilized.
- .5 Refer to the Structural Section in these Guidelines for other considerations and requirements.

6.2 Grade Surfaces

- .1 All exterior pedestrian surfaces to have a 2% drainage slope.
- .2 Allow for long-term settlement of excavation backfill and avoidance of consequent back-drainage in design of grading for aprons, sidewalks, plazas, etc., for instance adjacent to basements, trenches and retaining walls. Consider a bridging structural slab in those areas.
- .3 Refer to the Structural Section in these Guidelines for other considerations and requirements.

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7.1 Codes and Standards

- .1 New design, additions, upgrades and repairs to conform to or exceed the latest edition of the following codes and standards:
 - .1 *Alberta Building Code.*
 - .2 *Alberta Fire Code.*
 - .3 *CAN/CSA-A440 Windows; and Special Publication A440.1 User Selection Guide to CSA Standard CAN/CSA-A440 Windows.*
 - .4 *AAMA/WDMA/CSA/101/I.S.2/A440 Standard/Specification for Windows, Doors and Unit Skylights.*
 - .5 *AAMA/WDMA/CSA/101/I.S.2/A440S1 Canadian Supplement to AAMA/WDMA/CSA/101/I.S.2/A440 Standard/Specification for Windows, Doors, and Unit Skylights.*
 - .6 *CAN/CSA-A440.2 / A440.3 Energy Performance of Windows and Other Fenestration Systems / User Guide to CAN/CSA-A440.2 Energy Performance of Windows and Other Fenestration Systems.*
 - .7 *CAN/CSA-A440.4 Window, Door, and Skylight Installation.*
 - .8 *CSA-S478 Guideline on Durability in Buildings.*
 - .9 *The City of Calgary – Sustainable Building Policy.*

7.2 Design Principles

- .1 Design a building envelope system for all occupied facilities and other facilities requiring separation from the exterior environment and/or energy efficiency by limiting air, moisture and heat exfiltration and infiltration. There may be some facilities (e.g. storage or equipment sheds) where a full building envelope system is not required: consult with CFD.
- .2 The building envelope design approach generally preferred is the Pressure Equalized Rain Screen Insulated Structure Technique (PERSIST), comprising:

- .1 Exterior rain screen cladding with drainage openings, covering an air space pressure-equalized with the exterior. Air space to be minimum 25mm wide, allowing for adjoining material and mortar installation tolerances, and compartmentalized to maximum 4m dimensions;
- .2 Insulation, located exterior to structural components where practical, and immediately exterior to an air barrier and vapour retarder system.
- .3 Air barrier and vapour retarder systems (which may be combined into one system), exterior to structural components where practical.

7.3 Insulation

- .1 Insulation for a heated facility is to be minimum overall RSI 4.8 (R27) for walls, overall RSI 6.2 (R35) (at minimum for tapered thicknesses) for roofs, and RSI 1.8 (R10) for exposed perimeter foundation elements.
- .2 Metal spandrels within curtain walls are to have a minimum RSI 2.1 (R12) insulation.
- .3 The overall R-value is to, as described in *ASHRAE Fundamentals 2001* Chapter 25, take into account thermal breaks such as Z-girts and framing materials.
- .4 Provide protection to insulation or use non-susceptible insulation material where it may be exposed to gasoline or other chemicals causing deterioration (e.g. below an upper parking area) or to sunlight.
- .5 Check against incompatibility of materials e.g. plasticized PVC and self-adhering rubberized asphalt flashings

7.4 Roofs

- .1 Follow requirements of ARCA Roofing Application Standards Manual.
- .2 For flat or low-slope roofs, a 2-ply modified bitumen membrane is preferred for durability. Consult with CFD if proposing an elastomeric, built-up or other membrane. Provide a supplementary protective surface for any high-volume pedestrian traffic. Specify a trade contractor extended warranty.
- .3 On roof plan(s) indicate high and low point elevations, drainage directions, backslopes, crickets, all drains, all other roof penetrations (e.g. vents, fans, RTU ducts), and all roof-mounted equipment.
- .4 Provide minimum 2% roof drainage slopes, including in valleys and across parapets.

- .5 Minimum roof slopes for other roofing materials to be as follows:
 - .1 1 : 3 for triple tab asphalt shingles; to be minimum 25-year interlocking.
 - .2 1 : 2.4 for cedar shingles.
 - .3 1 : 2 for cedar shakes.
- .6 Provide roof overflow scuppers where there are no internal drains or where there is no alternate flow path for water from a potentially-blocked drain to another drain without ponding overload. Design scupper size to prevent ice blockage. Extend scuppers minimum 50mm beyond building face and with drip edge to avoid risk of draining into wall cavity, and avoid draining onto pedestrian routes.
- .7 Avoid controlled-flow roof drainage design where possible.
- .8 Metal roofing is to be considered to be water-shedding only, and requires a waterproof membrane and drainage below.
- .9 Form roof drainage slopes with the structure instead of with tapered insulation, except for backslopes and crickets.
- .10 Provide minimum 300mm high curbs at all roof penetrations other than drains.
- .11 Attics to be unheated, unless by consultation with CFD.
- .12 Where re-roofing is required prior to its normal life expectancy, investigate the reasons for premature failure prior to re-roofing design, and include remedial measures in the re-design to prevent reoccurrence (e.g. ice damming, inadequate attic venting, poor flashing, etc.).
- .13 Do not set mechanical equipment, pipe supports, or concrete pavers directly on roofing: utilize minimum 350mm high curbs for mechanical equipment, or support on high-density polystyrene insulation. Refer to Mechanical guidelines for minimum clearance off roof for large units.
- .14 Roof-level glazing is preferred to be by vertical clerestory. Sloped skylights and glazing to be avoided except by consultation with CFD. Where skylights or sloped glazing are incorporated:
 - .1 Slope glazing minimum 30 degrees from horizontal.
 - .2 Air seal connections to curbs and adjacent walls to be fully accessible during construction.

- .3 Water that enters the glazing rabbet to be contained within the rabbet and to drain back to the exterior in all seasons without contacting caulked joints or seals.
- .4 Provide an interior condensation gutter system, drained where warranted by a high-humidity interior environment.
- .5 Glazing seals to be dry mechanically keyed, and not utilizing caulking or other sealants.
- .6 Glazing to be minimum heat-strengthened exterior lite and laminated interior lite for safety.

7.5 Roof Drains and Rainwater Leaders

- .1 Provide a removable observation-access panel in fixed ceilings below roof drains.
- .2 Locate rainwater leader outlets to avoid draining onto pedestrian and vehicle areas, and to avoid draining or backflow against foundations.
- .3 Downspout extensions to be designed to prevent damage or removal during grasscutting or by vandalism (e.g. could use one or series of embedded precast concrete splashpads).
- .4 Ensure that rainwater leaders are not subject to freezing within the building (e.g. within perimeter unheated enclosed chases).

7.6 Detailing

- .1 Detail to ensure that:
 - .1 water, snow and ice can shed completely from exterior surfaces;
 - .2 draining water and falling snow and ice do not endanger pedestrians or property;
 - .3 roof ice damming is minimized;
 - .4 water cannot enter building components as a result of snow and ice build up (e.g. upturn membrane minimum 300mm at upstand walls), or of wind (e.g. at unprotected eaves or open wall assemblies adjacent to roof edges).

Section 7 Building Envelope

- .2 Fasteners and connections providing vertical and lateral support to cladding are corrosion-resistant for the design life of the building.
- .3 To avoid condensation on interior surfaces, buffer high-humidity interior spaces from the building envelope face or provide adequate ventilation against the interior envelope surface, and avoid thermal bridging (e.g. at exposed structural framing).
- .4 Air barrier and vapour retarder continuity and installation methods and sequencing must be fully described on design drawings. Provide large-scale and perspective details where needed to explain intent, in particular at:
 - .1 window and door frames.
 - .2 services penetrations.
 - .3 projecting structural members.
 - .4 wall / roof / parapet, wall / floor, and wall / wall intersections.
 - .5 deflection and control joints in architectural/structural framing.
 - .6 galvanic isolation joints between dissimilar materials.
- .5 Require and review mock-up or prototypical wall and roof sections with the general contractor and involved trades to ensure that envelope material laps, tie-ins to adjacent materials, and sealing around projections are demonstrated and achievable.
- .6 Concealed spaces to be provided with access hatches. Unheated concealed spaces to be vented to the exterior.
- .7 Provide a prefabricated sill pan or other means to drain to exterior any water that infiltrates windows and jambs.
- .8 Insulation to be in direct contact with the air barrier and to be mechanically fastened to secure substrate. Fasteners must demonstrably avoid compromising the air barrier and vapour retarder integrity.
- .9 Windows to meet *CAN/CSA A440*-series Standards: minimum requirement is double-glazed with at least one low-e surface. Do not use post-applied tinting films.
- .10 Exterior access stairs and ladders, hose tower stairs and platforms, and interior pit/sump ladders to have framing and connections designed against corrosion for the design life of the building.
- .11 No gum cups are permitted for any roof penetrations. All penetrations to be curbed, exiting the curb minimum 300mm above finished roof.

7.7 Durability

- .1 The building envelope system to be durable for the construction environmental and traffic conditions and for the life expectancy of the structure, and to be easily constructable with techniques common to the local trades.
- .2 Polyethylene vapour barrier and friction-fit batt insulation are not best-practice building envelope materials, especially for non-residential construction.
- .3 Exterior surface material and texture considerations to include resistance to vandalism and accidental impact (e.g. balls), resistance to and removal of graffiti (e.g. masonry sealer), and resistance to ultraviolet radiation embrittlement, deterioration and chalking.

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8.1 Codes and Standards

- .1 New design, additions, upgrades and repairs to conform to or exceed the latest edition of the following codes and standards generally, plus those specifically referenced in following clauses:
 - .1 *Alberta Building Code.*
 - .2 *Alberta Fire Code.*
 - .3 *User's Guide – NBC: Structural Commentaries (Part 4 of Division B).*
 - .4 *CAN/CSA-A23.1 / A23.2 Concrete Materials and Methods of Concrete Construction Methods of Test and Standard Practices for Concrete.*
 - .5 *CSA-A23.3 Design of Concrete Structures.*
 - .6 *CSA-A23.4 Precast Concrete - Materials and Construction.*
 - .7 *CSA-A165.1 Concrete Block Masonry Units.*
 - .8 *CSA-A165.2 Concrete Brick Masonry Units.*
 - .9 *CSA-A165.3 Prefaced Concrete Masonry Units.*
 - .10 *CSA-A179 Mortar and Grout for Unit Masonry.*
 - .11 *CSA-A283 Qualification Code for Concrete Testing Laboratories.*
 - .12 *CSA-A370 Connectors for Masonry.*
 - .13 *CSA-A371 Masonry Construction for Buildings.*
 - .14 *CAN/CSA-A438 Concrete Construction for Housing and Small Buildings.*
 - .15 *CSA-A864 Guide to the Evaluation and Management of Concrete Structures Affected by Alkali-Aggregate Reaction.*
 - .16 *CAN/CSA-G30.18 Billet-Steel Bars for Concrete Reinforcement.*
 - .17 *CAN/CSA-G40.20 / 40.21 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.*
 - .18 *CAN/CSA-G164 Hot Dip Galvanizing of Irregularly Shaped Articles.*

- .19 CAN/CSA-O86 *Engineering Design in Wood*, and O86S1 *Supplement No. 1*.
- .20 CSA-O121 *Douglas Fir Plywood*.
- .21 CAN/CSA-O122 *Structural Glued-Laminated Timber*.
- .22 CAN/CSA-O141 *Softwood Lumber*.
- .23 CSA-O151 *Canadian Softwood Plywood*.
- .24 CSA-O153 *Poplar Plywood*.
- .25 CAN/CSA-O177 *Qualification Code for Manufacturers of Structural Glued-Laminated Timber*.
- .26 CSA-O325 *Construction Sheathing*.
- .27 CSA-O437.0, O437.1, O437.2 *CSA Standards for OSB and Waferboard*.
- .28 CAN/CSA-S16 *Limit States Design of Steel Structures*, S16S1 *Supplement #1*, and replacement pages issued June 2003 and December 2003.
- .29 CAN/CSA-S136 *North American Specification for the Design of Cold-Formed Steel Structural Members*, and *Supplement 2004*.
- .30 CAN/CSA-S269.3 *Concrete Formwork*.
- .31 CSA-S304.1 *Design of Masonry Structures*.
- .32 CSA-S350 *Code of Practice for Safety in Demolition of Structures*.
- .33 CSA-S448.1 *Repair of Reinforced Concrete in Buildings*.
- .34 CSA-S478 *Guideline on Durability in Buildings*.
- .35 CSA-W47.1 *Certification of Companies for Fusion Welding of Steel*.
- .36 CSA-W55.3 *Resistance Welding Qualification Code for Fabricators of Structural Members Used in Buildings*.
- .37 CSA-W59 *Welded Steel Construction (Metal Arc Welding)*.
- .38 CSA-W178.1 *Certification of Welding Inspection Organizations*.
- .39 CSA-W178.2 *Certification of Welding Inspectors*.
- .40 CSA-W186 *Welding of Reinforcing Bars in Reinforced Concrete Construction*.

- .41 *PCI MNL-116 Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products.*
- .42 *PCI MNL-117 Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products.*
- .43 *The City of Calgary – Sustainable Building Policy.*

8.2 Drawings Information

- .1 Include the following design parameters on design drawings, concisely grouped on the first drawing where logical, regardless of whether also included in specifications (for future information if specifications are lost):
 - .1 Geotechnical design parameters, including allowable bearing pressures, skin friction, and required sulphate resistance.
 - .2 Structural design parameters, including:
 - a. Edition of building code and standards being designed and constructed to.
 - b. Design loads, including LL, superimposed DL, snow, rain, ponding, wind and seismic, and their Importance Factors; including for on-grade slabs.
 - c. Design LL and DL vertical and horizontal deflection limits, and any cambers.
 - d. Assumed support points for gravity and lateral loading from curtain walls and other cladding.
 - e. Any provisions for future additions.
 - f. Required material properties.
 - g. Description of load paths (e.g. lateral loads) where not obvious from the framing configuration.
 - h. Elements to be designed by contractors, and design criteria (e.g. loadings, load combinations, shoring movement and vibration acceleration limits, adjacent ground movement limits).
 - i. Assumptions and requirements for any special construction procedures.

- .3 For antenna-supporting towers and structures:
 - a. Items listed in Appendix A of *CSA Standard S37 Antennas, Towers, and Antenna-Supporting Structures*.
 - b. Corrosion protection measures and details for all required components.
 - c. Grounding configuration and information.
 - d. Access climbing and safety information (ladders, platforms, cages, fall-arrest devices).

8.3 Loads and Analysis

- .1 Fire stations are to be designed as Post-Disaster buildings.
- .2 Design all floors of office-type occupancy, including upper-storey floors, for minimum 4.8 kPa Live Load plus partition load unless otherwise approved. Include in design loadings for potential alternate uses of facility as advised by CFD or project manager e.g. if heavier live loadings for records storage etc.
- .3 Mechanical units to be considered as live loads and not dead loads.
- .4 Unless otherwise directed, design roof Snow loading to include drift and sliding build-up caused by potential adjacent buildings or tree belts, and design wind exposure factor is not to be reduced below 1.0.

- .5 Roof water ponding design in multi-bay situations to take into account where Gerber-beam design, unequal spans or other conditions might allow a negative-deflection situation in adjacent bays to contribute water to the ponded bay, and where a roof drain may be plugged. Detail the design ponding loads on the design drawings, if a more severe case in any location than design snow-plus-rain loading.
- .6 Discuss with CFD the potential for solar panels, and include resultant loading from panels, ballast and snow drifting.
- .7 Design for installation and future replacement of mechanical or other heavy equipment. This may entail knock-out wall panels, removable roof panels, and/or heavy loading on floor travel paths.
- .8 In mechanical and other similar equipment rooms, allow for minimum 100mm thick concrete housekeeping pads at any location on the floor.
- .9 Include in design loadings for potential additional dead load if roofing, flooring and wall/partition material selections make it probable that future rehabilitations or renovations will add to instead of replace such material.
- .10 For major upgrades and renovations of existing buildings, investigate safety and adequacy of existing structure and non-structural attachments with respect to current seismic design loading. Discuss with CFD whether seismic upgrading is to be considered.
- .11 Design for 1:100 return year flood considerations.
- .12 Fall Protection: as well as providing typical roof exterior anchor points, coordinate with CFD whether there is a requirement for interior fall protection anchor points (e.g. for tall truck servicing).
- .13 Provide design calculations if requested.

8.4 Materials

- .1 Constructability: in structural framing material choices, one of the paramount decision-makers is to be consideration of construction sequencing / delays / seasonal requirements and costs e.g. load-bearing masonry could be undesirable if it would delay important framed-in deadline, or requires hoarding/heating, demobilization and remobilization for cladding masonry, etc.
- .2 Do not use unbonded post-tensioned concrete reinforcement.

- .3 Provide protection for components that may be exposed to spills or leaks of corrosive solutions (e.g. mechanical room floors supporting brine tanks or water softeners).
- .4 Guardrail and other structural posts subject to frequent application or spray of de-icing salts or water; ladders, platforms and covers in areas of continuing moisture exposure such as hose towers and sumps; and their supporting frames, baseplates and anchor bolts are to be galvanized, stainless steel, or cathodically-isolated aluminum. Connection site-welding is to be avoided. Any galvanizing repairs to be done by metalizing in accordance with *ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings*. Coordinate with Architect to avoid unnecessary painting, or to ensure compatible finish paint types and surface preparation.
- .5 Guardrails prone to vehicle impact and their anchorages, as well as being designed for vehicle impact loads, are to be designed for ease of repair e.g. modular construction, replaceable anchorage connections, and easy replacement of only the damaged components.
- .6 Exposed concrete surfaces to be high quality and consistent in colour and texture, with construction joints located in reglets or other architectural details, and formwork ties in a regular pattern and sealed.
- .7 Concrete reinforcement within 100mm of surfaces exposed to rain, chlorides or other de-icing chemicals to be galvanized Grade 400W reinforcing steel bars, or alternately stainless steel –clad or FRP upon approval of CFD. Galvanized steel to conform to *ASTM A767/A767M Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement*, as modified by The City of Calgary Specification Section 003201 Galvanized Reinforcing steel, and to be fabricated, galvanized, handled and placed in accordance with that same City specification section.
- .8 Where galvanized reinforcing steel is used, the chairs, tie wires, nuts, bolts, washers, other devices and miscellaneous hardware used to support, position or fasten the galvanized reinforcement to also be galvanized or to be plastic or plastic-coated. Contact points between galvanized and black reinforcing steel to be separated by a non-conductive material such as rubberized pads or rubber hose rings.
- .9 Where concrete curbs, walls, slabs etc. are placed on previously-cast components, these elements to have additional reinforcement of small size and spacing to mitigate relative shrinkage cracking. Any finishes (e.g. tiling), waterproofing etc. applied to these items are to allow for the inevitable shrinkage cracking.

- .10 Supplementary cementing materials (SCM's) such as fly ash, metakaolin and silica fume are strongly encouraged as partial replacement for concrete cement.
 - .1 SCM's can provide concrete property advantages in increased compressive strength and in durability through decreased permeability, mitigation of alkali-silica reaction, reduced shrinkage, increased sulphate resistance and increased scaling resistance.
 - .2 SCM's can contribute to sustainability goals such as LEED credits for recycled content, regional materials and durable building.
- .11 Consider specification of concrete properties at 56 days instead of 28 days where not crucial for immediate strength, for greater flexibility in end-use mix designs.
- .12 To minimize shrinkage and curling of slabs on grade, and to enable inserts, do not specify concrete strength stronger than minimum required for slab performance, and avoid air entrainment of interior slabs.
- .13 For all HSS and pipe members subject to freezing:
 - .1 Provide drain holes at lowest point.
 - .2 Provide seals (e.g. neoprene) around all fastening penetrations exposed to water.
- .14 For galvanized structural, pipe or plate steel shapes (not including reinforcing bars), specify provision of a 10-year guarantee against corrosion or defects in the galvanizing quality or workmanship. Under the guarantee, the supplier will repair or replace (including shipping) any components that fail during the guarantee period.
- .15 Provide drain holes in galvanized components, to facilitate proper galvanization and drainage of condensation moisture.
- .16 Design wood framing to allow for vertical shrinkage of sawn lumber floor joists, studs and columns without causing noticeable unevenness or sloping from adjacent non-shrinking components such as engineered-wood beams or masonry / concrete shafts.

8.5 Soils Considerations

- .1 Design exterior apron slabs to resist frost heave where this could cause binding of doors or water drainage against the perimeter wall.

- .2 Where a floor slab will be constructed over a significant depth of backfill or replacement fill (> 1m), even if the fill is engineered, determine probable long-term settlements with the geotechnical consultant. Consider whether the facility function could accommodate resultant on-grade slab joint and mid-slab movements, and design as a structural slab to bridge over the backfill if necessary. Ensure that services piping allows for those settlements at junctions between such floor slabs / subgrades and fixed-structure supports.
- .3 Where a buried utility enters a structure, provide an oversized sleeved waterproofed opening and/or a utility-support “bridge” to accommodate relative utility settlement and movement in conjunction with soil settlement and movement, especially in backfill areas.
- .4 Coordinate with CFD on content of recommended legal agreements between the client and adjacent property owners for pre-construction surveys of adjacent properties and possibly vibration monitoring in situations of temporary or permanent shoring for excavation, underpinning of adjacent structures or retaining walls adjacent to other properties, dynamic compaction of soils, or driven or dynamically compacted piles.
- .5 Refer also to Civil section in these Guidelines for retaining walls.

8.6 Design Life

- .1 Design life of new structures to be 75 years (“Long life” per *CSA-S478*), unless of a temporary or relocatable nature as coordinated with CFD.

8.7 Contractor Design

- .1 Contractor Design: Design of permanent non-proprietary components such as underpinning should be by the client’s design Engineer, who can best design for in-service loading and other conditions. However where design of shoring, soil anchors, falsework, connections, proprietary retaining walls, proprietary guardrail components etc. is specified to be by the contractor, the contractor is to submit design drawings, specifications and/or calculations signed and sealed by a Professional Engineer registered in the Province of Alberta to The City and The City’s design consultant for review and comment.

- .2 The contractor's design Engineer (and geotechnical engineer if applicable) is to perform site/shop reviews to ensure that construction satisfies their design requirements and standards such as CSA Standards *CSA-S16* and *CSA-S269.1*, and shall copy their review reports to The City's design consultant. Any changes made to the original design during construction are to be shown on submitted As-Built drawings.

8.8 Parking Areas

- .1 Areas used for parking and vehicular access to be designed to *CSA-S413 Parking Structures*.
- .2 Penetrating concrete sealers referred to in *CSA-S413* clause A2.3 to be restricted to the Approved Product List for Sealers Used on Concrete Bridge Elements, latest edition, by Alberta Transportation (reference <http://www.transportation.alberta.ca/Content/docType253/Production/BRSEALERS.pdf>). Utilize a silane sealer Apparatus Bays.
- .3 For concrete reinforcement close to chloride-exposed surfaces refer to Materials section above.
- .4 Required concrete permeability index prequalification tests to utilize ASTM C1202.
- .5 The suggested establishment of contractor procedures for quality assurance per *CSA-S413* Annex D.1.3, and responsibilities of designer, protection system specifier, prime consultant, contractor and owner per *CSA-S413* Annex F, are to be formalized in the design specifications.
- .6 Provide a draft copy of the Owner's Maintenance Program to Corporate Engineering for review and comment.
- .7 Non-structural building components in the splash zone near floor level to be corrosion-resistant.
- .8 If considering the use of High Performance Concrete (HPC), meet the design recommendations for HPC contained in *Guidelines for Bridges & Structures* by The City's Transportation Infrastructure - Bridges and Structures division.

8.9 Detailing

- .1 Design floor expansion joints to permit unencumbered and smooth wheeled travel.
- .2 Slope structure to match the major roof drainage slopes, where possible.
- .3 Ensure that weeping tile system design, drawing and specification responsibilities are delineated between consultants and satisfied.
- .4 Slab on grade jointing:
 - .1 To mitigate consequent slab cracking, slab-on-grade transverse and longitudinal shrinkage control joints to be spaced closer together where tied into previously-cast or non-shrinking components such as foundation walls / grade beams and trenches. Also consider moist-curing slab for minimum 7 days where crack widths will be a concern.
 - .2 Provide shrinkage control joint at edge of slab thickenings.
 - .3 A horizontal-smooth-dowel method of creating a horizontal slip joint is discouraged: inevitable variations off horizontal and perpendicular will negate movement. Instead, utilize a plate-dowel or diamond-dowel system.
 - .4 Control joint depth is to be 1/3 of slab thickness: ensure reinforcement depth allows for that.
- .5 At weld plates embedded in concrete close to ends/edges of concrete, leave either zero or sufficiently-large remaining concrete distance to end/edge so that plate thermal expansion under welding will not spall that remaining concrete.

8.10 Construction Inspection and Testing Agencies

- .1 Design documents are to note that The City will engage construction inspection and testing agencies for quality assurance including:
 - .1 Professional geotechnical inspection of allowable bearing pressure for all footings, and inspection of soil anchors, MSE walls etc. designed by City's consultants.
 - .2 Pile inspections. Part-time representative inspection is expected for typical bored cast-in-place piles: design, different pile type and/or soils may warrant full-time inspection.
 - .3 Plastic concrete sampling: scope per CAN/CSA-A23.1 / A23.2.

- .4 Soil compaction.
- .5 Structural steel connection inspections. Services expected are welding certificates confirmation, visual inspection of 100% of site and shop structural welds, ultrasonic inspection of 10% of site and shop structural welds, and visual inspection of 20% of metal deck connections. Design may warrant different levels/types of inspection.
- .6 Pre-construction surveys and vibration monitoring of adjacent properties.
- .2 The Contractor is to remain responsible for all quality control inspection and testing.

8.11 Antenna-supporting Towers and Structures - General

- .1 These requirements apply to Site Licensees (leases) and to City-operated antenna supports on City-owned land and facilities.
- .2 For these purposes, The City will mean CFD with copy of documents to Corporate Engineering.
- .3 For antenna supports extending 15m or more above adjacent grade or roof, *CSA Standard S37 Antennas, Towers, and Antenna-Supporting Structures* is to apply in its entirety [ref. S37 1.2(b)].
- .4 Unless confirmed otherwise in writing by The City, the Importance Factor for loading design and evaluation is to be taken as 1.0 [ref. S37 5.3].
- .5 Specify provision of warning signage on any existing or new support not having climbing and safety devices compliant with the current Standard.
- .6 For antenna supports of a height less than 15m, Items .4 and .5 above are to still apply, plus potentially other requirements of *CSA Standard S37* as may be noted by The City.

8.12 Antenna-supporting Towers and Structures - New Supports

- .1 Design of a new support to be carried out by an engineer who takes responsibility for the structural adequacy [ref. S37 3.4.1], with drawings or reports copied to The City under the engineer's seal and signature.
- .2 As part of design for a new support, an engineer is to confirm adequacy of any building or other structure that supports the antenna support [ref. S37 3.4.2], with confirmation copied to The City under the engineer's seal and signature.

- .3 Provide to The City a copy of the geotechnical investigation report prepared under the supervision of a professional engineer, for the support site [ref. S37 10.1.2.1].
- .4 The engineer responsible for design to review or supervise review of installation of the support [ref. S37 11.12], with reports copied to The City.
- .5 For antenna supports of a height less than 15m, Item .2 above is to still apply, plus potentially other requirements of *CSA Standard S37* as may be noted by The City.

END OF SECTION



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9.1 Codes and Standards

- .1 New design, additions, upgrades and repairs to conform to or exceed the latest edition of the following codes and standards generally, plus those specifically referenced in following clauses:
 - .1 *Alberta Building Code.*
 - .2 *Alberta Fire Code.*
 - .3 *National Plumbing Code.*
 - .4 *National Fire Protection Association (NFPA) including:*
 - a. *NFPA 10 – Portable Fire Extinguishers.*
 - b. *NFPA 13 – Installation of Sprinkler Systems.*
 - c. *NFPA 14 – Installation of Standpipe and Hose System.*
 - d. *NFPA 90A – Installation of Air Conditioning and Ventilation Systems.*
 - e. *NFPA 96 – Ventilation Control and Fire Protection of Commercial Cooking Operations.*
 - .5 *City of Calgary Bylaws.*
 - .6 *Canadian Standards Association including:*
 - a. *CAN/CSA-B52 – Mechanical Refrigeration Code.*
 - b. *CAN/CSA-B139– Installation Code for Oil Burning Equipment.*
 - c. *CAN/CSA-B149.1 – Natural Gas and Propane Installation Code.*
 - d. *CAN/CSA-B149.2 – Propane Storage and Handling Code.*
 - .7 *Underwriters Laboratories of Canada.*
 - .8 *Alberta Occupational Health and Safety Act:*
 - a. *Ventilation Regulation.*
 - b. *Noise Regulation.*

- .2 *American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standards including:*
 - .1 *ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.*
 - .2 *ASHRAE 55 - Thermal Environmental Conditions for Human Occupancy.*
 - .3 *ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.*
 - .4 *ASHRAE 90.1 - Energy Standard for Buildings Except Low Rise Residential Buildings.*
 - .5 *ASHRAE 129 - Measuring Air Change Effectiveness.*
 - .6 *ASHRAE Handbooks.*
- .3 *Industrial Ventilation: A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists.*
- .4 *Sheet Metal and Air Conditioning Contractors Association (SMACNA) Standards.*
- .5 *Model National Energy Code for Buildings (MNECB).*
- .6 *The City of Calgary – Sustainable Building Policy.*

9.2 General Mechanical Design

- .1 Detailed Procedures to Be Followed By Consultants:
 - .1 At the preliminary design stage the consultant to provide the CFD a schematic design brief as outlined in section 4.3.5 of this guideline. For small projects short descriptions and sketches to be provided indicating:
 - a. Ventilation and air distribution strategy
 - b. Heating / cooling equipment
 - c. Space control strategy
 - d. Equipment locations

- .2 Heating/cooling load calculations and any other relevant design data including energy simulations to be submitted at the request of CFD for any new building construction, major renovations and retrofits.
 - .3 Coordination of Equipment: Ensure adequate clearances are maintained for servicing of all equipment.
- .2 Energy:
- .1 The building design, equipment, and systems to conform to, as a minimum, the mandatory provisions of the *MNECB* and *ASHRAE 90.1*.
- .3 Metering:
- .1 Consultant to discuss with CFD on any additional metering that may be required in addition to the mandatory main utility service meters.
 - .2 Include in contract document specifications, instructions that Contractor to initiate the natural gas, water, sanitary account transfer application to the Project Manager 2 months prior to the expected occupancy date. Contractor to provide all information required for the application to CFD.
- .4 Accessibility to Equipment:
- .1 Provide sufficient access space for servicing, maintaining and removal of equipment and components (coils, exchangers, fans, motors, filters, etc.)
 - .2 Indicate access space required for equipment maintenance on drawings.
 - .3 Coordinate with Architect to provide access doors to concealed mechanical equipment for servicing access. Locate and size access doors such that all concealed items are accessible and so that body or hand entry (as required) is achieved.
- .5 Hazardous Materials:
- .1 Be aware of possible asbestos materials and surfaces and follow regulatory requirements. Refer to Section 12.1 of this guideline.

9.3 Design Criteria

- .1 Design mechanical systems for typical fire hall based on criteria set out below. Special buildings or areas within buildings may require different conditions than those outlined. Document these conditions and make allowances in the system design.
- .2 Base heating design on outdoor ambient temperatures given in the Alberta Building Code. For Calgary the 1% January Outdoor Design Temperature is -33C.
- .3 Base cooling design on outdoor ambient temperatures given in the Alberta Building Code. For Calgary the 2.5% July Outdoor Design temperature is 29C dry bulb, 17C wet bulb.
- .4 Minimum indoor environmental design requirements:

General Office, and Kitchen areas:

- .1 Indoor temperature (heating): 22C
- .2 Indoor temperature (cooling): 25C
- .3 Overall Ventilation Rate: as per *ASHRAE Standard 62* (Relevant Version as noted in *ABC* or as approved by The City of Calgary)
- .4 Humidification; General office, fitness and kitchen areas are not typically provided with central humidification however spaces to adhere to *ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*.

Dorms, Fitness:

- .1 Indoor temperature (heating): 22C
- .2 Indoor temperature (cooling): 20C
- .3 Overall Ventilation Rate: as per *ASHRAE Standard 62* (Relevant Version as noted in *ABC* or as approved by The City of Calgary)
- .4 Humidification; Dorms are not to be humidified however spaces to adhere to *ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*.

Apparatus Bay:

- .1 Indoor temperature (heating): 20C
- .2 Indoor temperature (cooling): Cooling not provided
- .3 Overall Ventilation Rate: as per *ASHRAE Standard 62* (Relevant Version as noted in *ABC* or as approved by The City of Calgary)
- .4 Humidification; Apparatus bays are not humidified however space is to adhere to *ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*. Apparatus bay dehumidification can be controlled hose tower exhaust fan connected on humidity control sensor on apparatus floor.
- .5 Resiliency:
 - i. In the event of a power, gas, and water utility supply failure to the building, the intent is to operate the building for 7 days under normal operating conditions with same internal temperatures, stove usage as experienced during regular operation.

9.4 Plumbing and Drainage

.1 Domestic Water Service:

- .1 Provide domestic hot water re-circulating piping complete with balancing valves where hot water supply length exceeds 15m.
- .2 Provide backflow prevention that conforms to either *The National Plumbing Code of Canada* or the requirements of The City of Calgary, whichever is more stringent.
- .3 Domestic water piping to be type L copper. Solder for fittings to be lead-free.
- .4 Domestic hot water recirculation lines to be type K copper.
- .5 Consider solar water heating technologies. If deployed provide adequate storage and/or provision for heat rejection (via rooftop fin tube radiation or dry cooler bypass) to limit glycol heating medium temperatures at the manifold to below 90C.
- .6 In the event of a natural gas supply pipeline failure, a supplementary connection will be located at the main meter for connection to outside sources (i.e. portable tank). The supplementary connection will be sized to manage to the full load of the CFD portion of the building operating at 100% at design conditions for 7 full days. This includes the following assumptions for operation of gas fired equipment:

Section 9 Mechanical

Equipment	Operating Hours (per day)
1. Infrared Heaters	0
2. Apparatus MUA	8
3. Boilers	24
4. Ventilation AHUs	24
5. Kitchen MUA	6
6. Kitchen Range	6
7. Barbeque	0

This gas consumption is considered conservative, as the outdoor design condition is not likely to persist for a full 7 days, nor is all listed equipment likely to operate at the above listed rates for the full 7 day period. Natural gas load may also be shed, by way of operational shut down, in order to reduce this load.

.2 DWV (Drain Waste Vent) Piping System:

- .1 All below slab sanitary piping to be minimum 50mm Dia.
- .2 Install trap primers as required by National Plumbing Code.
- .3 Provide the necessary double compartment sumps as required to suit occupancy and use.
- .4 Plumbing vents shall be insulated 2.0m from point of exit at roof.

.3 Storm Drainage System:

- .1 Provide a minimum of two roof drains per contained near-flat roof area, except a single drain may be provided for near flat roof areas not greater than 6 sq. meters, i.e. entrance canopies, elevator penthouses.
- .2 If possible, avoid use of control flow drains. If installed, ensure Structural consultant allows for this load.
- .3 For building surrounded by high foliage, consider 100mm as minimum size of roof drains.
- .4 If possible, route storm drainage internally within the building and connect directly to the City storm sewer system. Avoid discharging flow to grade.
- .5 If discharging storm water to grade, do not allow flow onto pedestrian or vehicle traffic areas where it could freeze and become a safety hazard or onto areas where it could cause erosion damage.
- .6 Explore storm water harvesting opportunities and incorporate if practical and Triple Bottom Line goals are satisfied.

- .7 Storm drainage piping above grade shall be insulated 3.0m downstream of roof drain.
- .4 Plumbing Fixtures:
 - .1 All new plumbing fixtures to adhere to The City of Calgary Low Water Use Fixture Bylaw as a minimum performance requirement.
 - .2 For water closet selection refer to recommendations listed on the Canadian Water and Wastewater Association website:
http://www.cwwa.ca/home_e.asp
 - .3 Consult with CFD as to appropriate locations of non freeze wall hydrants to serve the exterior areas around the perimeter of the building.
 - .4 Provide hose bibs and pressure wash connections in Apparatus Bay.
 - .5 At least one lavatory in each of the CFD fire fighter washrooms and change room to be 102mm centerset single control water faucet lever handle with 135mm integral spout with pop up waste. If more than one lavatory is to be installed per washroom or change room the additional lavatories are to be complete with hardwired hands free faucet. In administration staff and public washrooms, lavatories are to be equipped with hardwired handsfree free faucets.
 - .6 Janitors sink to be moulded composite floor mounted, 900x600x300 deep. To be complete with wall mounted accessories, splash pad, with two handle wall mount faucet.
 - .7 Waterless urinals are not permitted but confirm with CFD on a project per project basis. Consider utilizing high efficiency (0.5 L/flush) hands free flush valves.
 - .8 Waterclosets to be c/w dual capacity (4.2L up/6.0L down) flush valves.
 - .9 Showers to be moulded composite 1050 x 900 with moulded composite surrounding all sides.

9.5 Fire Protection

- .1 General:
 - .1 Where sprinkler system is to be installed, show as a minimum the following on the tender drawings:
 - a. Location and type of sprinkler heads.
 - b. Routing of main lines.

- c. Location of sprinkler tree.
 - d. Location of fire pumps.
 - e. Fire protection system schematic.
 - f. Indication of type of sprinkler head on drawings: upright; pendant; with guard.
- .2 Show location and types of fire extinguishers to be installed.

9.6 Heating

- .1 General: in large mechanical rooms containing natural gas burning equipment, provide ventilation to control the room temperature within the temperature ratings of the equipment.
- .2 Boilers:
- .1 Provide boiler plant that allows for redundancy and extra capacity for future expansion. Typically two boilers, each sized to 60% of total heating design capacity satisfies this requirement however other configurations are acceptable given the proposed strategy is reviewed and approved by CFD.
 - .2 Utilizing alternative boiler setup and /or other heat sources is acceptable as long as the proposed heating strategy is reviewed and approved by CFD.
 - .3 Provide contacts for Building Management System (BMS) control system (if building is BMS controlled) including boiler enable, burner firing rate, and flame failure alarm.
 - .4 Consider installing condensing boilers as appropriate.
 - .5 Establish capacities, arrangement, and number of boilers such that when any one boiler is out of service, the remaining boilers shall be sufficient to offset building transmission heat loss. Note that this may exclude heat for ventilation.
 - .6 Boilers to have fully modulating burner controls with high turn-down ratios.
 - .7 Boilers other than condensing boilers shall incorporate means for preventing heat losses through the boilers when they are not in operation, such as 3-way bypass valves or check valves that prevent the flow of heat carrying fluid through boilers that are not operating.
- .3 Heating Distribution:

- .1 Terminal units including reheat coils, fin tube radiation, and radiant heating panels to circulate hot water.
 - .2 Provide a separate propylene glycol loop for the air handling system coil loop (if applicable) and solar heating loop (if applicable), separate from water loop supplying fin tube radiation, radiant panels, and terminal reheat coils.
 - .3 Two pipe reverse return system preferred for heating water piping.
 - .4 Grooved fittings are not permitted on heating water piping.
 - .5 Provide a minimum of two primary circulation pumps, sized for duty/standby operation.
 - .6 Include provisions for water treatment.
- .4 Heating Terminal Units:
- .1 Where perimeter radiation and reheat coil serve the same space, radiation to operate initially and in sequence to reheat coil.
 - .2 Each perimeter fin radiation zone to have isolating valves and control valves on supply side. On return side install balancing valve and isolating valve. Install air vents on high side of return. Provide access to all valves and accessories associated with the terminals.
 - .3 Provide means of isolation, balancing and flow measurement for equipment and major loop circuits.
 - .4 Terminal heating units with quick response time for heating and cooling is required for the non apparatus bay spaces (including dorms and offices). Radiant floor heating discouraged for these spaces due to the slower response time compared with other terminal unit types.
 - .5 Apparatus Bays; The primary source of heating for the apparatus bays is to be provided via in slab hydronic radiant floor heating. A series of overhead radiant tube heaters will be used to for de-icing of the fire apparatus and or vehicles with in the apparatus bays. Overhead radiant heaters are activated via a pushbutton and to run for a preset time. A high limit normally closed thermostat (Div 16) to shut off the radiant heater in the event a high space temperature is achieved. Refer to controls section and Div 16.

9.7 Cooling

- .1 General:
 - .1 Cooling system guidelines:
 - a. Direct expansion refrigeration recommended when the cooling load is 80 tons or less. Provide hot gas bypass control on first compressor.

- b. Consider air cooled chiller, or evaporative cooling tower when cooling load is 80 tons and above. KW/ton and EER ratings of various cooling equipment options to be evaluated when making a decision on system selected.
- .2 Provide chillers that allow supply water to be reset electronically.
- .3 Consider variable flow pumping to conserve energy use.
- .4 Include provisions to water treatment.
- .5 Use outdoor air for free cooling when ambient temperature conditions permit.
- .2 Sizing
 - .1 Air Conditioning equipment to be sized based on the calculated block cooling load requirements and diversity.
 - .2 Do not apply any safety factor when sizing cooling equipment.
- .3 Refrigeration Equipment
 - .1 Design refrigeration systems in conformance with *CSA/CAN-B52 Mechanical Refrigeration Code*.
 - .2 HFC refrigerants to be utilized.
 - .3 Refrigerant piping shall be rigid ACR copper. Suction lines shall be insulated. Suction and discharge lines susceptible to damage (Such as roof installations) will be insulated and aluminum wrapped.
 - .4 Compressors to have minimum 5 year warranty.
- .4 Cooling Distribution: two pipe reverse return system preferred for cooling water piping. Grooved fittings are not permitted for cooling water piping.
- .5 Air and water side economizer strategies are to be employed where possible.

9.8 Ventilation

- .1 General ventilation system philosophy: Ventilation air will be supplied via a dedicated Outdoor Air System (DOAS). Each occupied space in the fire hall shall have ducted supply and ducted return with all return air being exhausted and not mixed with the supply ventilation air. Each occupied space shall have individual heating and cooling temperature control via dedicated sensor or thermostat.

.2 Apparatus Bay.

- i. Ventilation typically supplied by make up air unit interlocked with the general exhaust CO NOX removal system and the dedicated vehicle exhaust system. Deploy either 2 speed makeup air unit with general exhaust and vehicle exhaust operating individually (MUA at low speed) or simultaneously (MUA at high speed) OR single speed make up air unit with coordinated general exhaust and vehicle exhaust sequence with necessary interlocks so that only one exhaust system is operating at any given time.
- ii. General exhaust to be initiated by the CO or NOX sensors and to shut off when contaminant levels below that stipulated by code. General exhaust and interlocked make up air unit to operate only when CO and/or NOX concentrations exceed preset levels. A manual pushbutton override is also to be provided to allow system to operate for a preset time.
- iii. Vehicle Exhaust ; If the bay door opens the vehicle exhaust fan and the make up air unit are to operate on a timed cycle. A manual pushbutton override is also to be provided to allow system to operate for a preset time. New vehicle exhaust system installations to be compatible with CFD vehicle exhaust systems installed at other CFD facilities to allow exhaust tailpipe connection to any CFD vehicle.
- iv. Apparatus bay is to be under negative pressure relative to the rest of the facility.
- v. Coordinate with controls section and Div. 16.

.3 Kitchen Ventilation.

- i. Kitchen exhaust is to meet the requirements of NFPA 96. A dedicated make up air unit is to be interlocked with the kitchen exhaust fan. Provide a lag time for the kitchen makeup air unit to start after kitchen exhaust is initiated. Ensure building ventilation system is balanced to eliminate back drafting of kitchen exhaust when exhaust fan is not running.
- ii. The gas service to the stove and barbecue require a remote two position solenoid valve(24V by Div 15) for gas shut off that is connected to the alerting system headend and reset button (Hardware and wiring by Div 16). Additionally a two position normally closed solenoid valve (24V by Div 15) will be installed in the gas supply to the kitchen range which will only open upon activation of the kitchen exhaust hood via a wall switch (hardware and wiring by Div15). The range cannot operate without the hood exhaust fan being on. These two solenoid valve are independent of the solenoid valve in the gas line serving the range associated with the NFPA 96 fire protection system. Coordinate with controls section and Div. 16.

.4 Generator Room Ventilation.

- i. Generator room will be ventilated with necessary proportions of outside air and return air entering a mixing box in order to control room temperature during generator operation.

.5 Air Handling Equipment:

- .1 Provide air plenums with hinged, sealed access doors and lighting for inspection of each chamber. Access doors to be complete with lockable lever handles operable from both sides.
- .2 As a minimum provide air filters with minimum dust spot efficiency of 30% (MERV 8) based on *ASHRAE 52.1*. For hydronic systems provide summer/winter position filters. Consider MERV 13 filtration depending on the occupancy and /or if designated as an owner priority.
- .3 Do not utilize mechanical rooms as air plenums.
- .4 Cabinet panels to be: 18 gauge for air handlers supplying less than 10,000 L/S; 16 gauge for air handlers supplying more than 10,000 L/S.
- .5 Cabinet floor panels to be 16 gauge. Floor panels next to potentially wet areas to be non-slip.
- .6 Panels to be complete with 50mm thick insulation.
- .7 Consider Heat Recovery Ventilation equipment as suitable for the application.
- .8 Refrigerant coils with multiple compressors shall be alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions.
- .9 Bearings to be anti-friction ball, roller, self –aligning pillow block type bearings with heavy clamp lock as opposed to set screws. Bearings are to be selected for minimum L10 bearing life of 40,000 hours when operating at maximum catalogued class conditions. Consider L10 of 200,000hr bearings for critical and 24/7 applications.
- .10 Fan shafts: solid AISI C-1040, or C-1045 hot rolled steel accurately turned, ground and polished, and ring gauged for accuracy. All shafts must be dial indicated for straightness after the keyways are cut and straight as required. Shafts shall be sized for first critical speeds at least 1.43 times the maximum speeds of the fan.

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- .11 Fan wheels: blades shall be true lined, statically and dynamically balanced on precision electronic balancers. Each fan assembly shall be designed for critical speeds of at least 1.35 times the maximum speed of the fan.
- .12 DX coil section, filter section, mixing section, heating coil section shall be provided with 22 gauge solid galvanized steel liner over insulated areas.
- .13 Fan section to have 24 gauge perforated galvanized steel liner over insulated areas.
- .14 For outdoor and exhaust air dampers utilize aluminum thermally insulated dampers with leakage characteristics of 25 L/s/m² at 1 KPa differential static pressure at -40C. For return air dampers utilize non-insulated aluminum airfoil dampers with leakage characteristics of 52 L/s/m² at 1 KPa differential static pressure at -40C.
- .15 Disconnect switch enclosure for outdoor units shall be NEMA 4.
- .16 Extended grease lines to be primed with grease at the factory.
- .17 On large systems consider providing return fan in lieu of gravity relief.
- .18 Provide 25mm birdscreen mesh for air openings at the air handling unit.
- .19 Power cable within the air handling unit serving fan motors to be liquid tight.
- .6 Humidification: Not provided however occupied spaces to adhere to *ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy*.
- .7 Natural Ventilation: consider natural ventilation strategies as deemed applicable and practical.
- .8 Zoning: match areas to appropriate heating and cooling zones.
- .9 Distribution:
 - .1 Ensure that proper air distribution is achieved through correct diffuser application, selection, and location in the ceiling grid.
 - .2 Take into account variable air volumes and tenant requirements so that adequate air circulation is achieved under all conditions.
- .10 Rooftop Units:
 - .1 If at all possible, air handling units to be installed in interior dedicated mechanical service rooms.
 - .2 Rooftop units to be installed on a roof curb that has a minimum 350mm height. For large units where an open structural frame support is required, provide a

minimum of 1.0m clearance from the top of roof level to the underside of the equipment.

.11 Noise and Vibration Control:

- .1 Do not locate rooftop equipment over dorm areas.
- .2 Provide acoustic and vibration isolation to all mechanical equipment.

9.9 Insulation

1. Domestic water piping, hot water heating, chilled water, ductwork shall be insulated to minimum standards noted in *MNECB*.
2. Emergency Generator tail pipe wall or roof penetration thimble to be complete calcium silicate insulation.

9.10 Motors

1. Equipment motors 1Hp and larger shall be NEMA “premium” efficient design.
2. Equipment motors 3/4Hp and less shall be 1 phase and 1Hp and more to be 3 phase.

9.11 Controls

- .1 Provide a complete system of automatic controls for HVAC equipment.
- .2 All requirements of the Energy Management Control Systems (EMCS) to be provided by a single control contractor.
- .3 Systems shall be based upon DDC/SAC with electrical devices where specified.
- .4 Mechanical equipment is to be controlled by a local Stand Alone Controller (SAC) which will interface to the central Direct Digital Control (DDC) panel. The central DDC system shall monitor and control each system controller as well as other miscellaneous mechanical equipment. The DDC system will not be networked at this time to allow remote access, however coordinate with electrical to allow for data port in proximity of the panel in the event that the EMCS will be networked.
- .5 The following systems will be complete with local application specific controllers (ASC) which will interface with the main panel.

1. Heating plant including pumps
 2. Ventilation Air handling Unit
 3. Radiant slab heating for Apparatus Bays
- .6 The following miscellaneous mechanical equipment will be controlled by dedicated SAC with status and alarms relayed to the ECMS:
1. General, Washroom, Kitchen exhaust fans
 2. Sump pumps
 3. Generator Ventilation
 4. IT Rooms; Temperature monitoring and Alarm
 5. Kitchen Make Up Air Unit;
 6. Apparatus Make Up Air Units;
 7. Apparatus general exhaust and vehicle exhaust;
- .7 Terminal units shall be controlled by electronic thermostats that have occupied/unoccupied temperature setpoint capability. Space thermostats will not be connected to EMCS.
- .8 The following mechanical equipment will be under local electrical control. Contract documents to clearly delineate between Div. 15 and Div. 16 scope of work.
1. Apparatus Bay gas fired infrared heaters; high limit normally closed thermostat only – on/off controlled by pushbutton control which is part of Div. 16 PLC. The overheat heaters and the radiant floor slab are to be controlled independently. Mechanical consultant to provide control sequence and electrical consultant shall specify and include layout of PLC control cabinets to be installed by Div 16.
 2. Apparatus Makeup Air unit ;on/off only - temperature control via air handling unit manufacturer supplied discharge air controller. Mechanical consultant to provide control sequence and electrical consultant shall specify and include layout of PLC control cabinets to be installed by Div 16.
 3. Unit and Cabinet Heaters ;line voltage thermostat with no connection to EMCS.
 4. Kitchen exhaust and make up air unit ;Local switch with direct interlock to the dedicated makeup air unit. No software interlock via BMS. Mechanical consultant to provide control sequence and electrical consultant shall specify and include layout of PLC control cabinets to be installed by Div 16.
 5. Electrical room exhaust – Local reverse acting line voltage thermostat. No connection to EMCS
 6. Hose tower exhaust; Local humidistat control with no connection to EMCS.
- .8 Develop control strategies that minimize energy consumption.
- .9 The EMCS specification to be based on BACnet open protocol system. User operator interface shall be web based. Specification to include software access via CFD supplied laptop

9.12 Start-up and Testing

- .1 Include a complete list and test report forms for all tests required in the specification. Identify which test needs the consultant engineer to witness and those by the commissioning agent if applicable.
- .2 Contractor to conduct operating start-up to confirm that equipment and systems meet specified requirements after mechanical installations are completed and pressure tested and all systems are operational.
 - .1 Start-up of air systems
 - a. Start-up fans, coils circulators, humidifiers, exhaust air systems and interlocked cooling systems.
 - b. Balance in accordance to testing , adjusting , and balancing requirements.
 - .2 Start-up of hydronic systems
 - a. Pressure test piping systems
 - b. Start-up pumps, boilers, chillers, and all ancillary equipment.
 - c. Balance in accordance to testing , adjusting , and balancing requirements.
 - d. Check distribution system for fluid noise and pump noise.
 - .3 Start-up of plumbing systems
 - a. Pressure test
 - b. Flushing and Cleaning: Flush entire system for 8 hrs. Ensure outlets flushed for 2 hrs. Let stand for 24hrs, then draw one sample off longest run. Submit to testing laboratory to verify system is clean. Let system flush for additional 2hrs, then draw another sample for testing.
 - c. Disinfection:

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- Supply materials and test kit to carry out disinfection as follows:
 - Fill piping system and tanks with chlorine/water solution with a strength of at least 50 mg/L . Ensure pipe is full and no air pockets remain.
 - Leave solution in piping system for 24 hours, while maintaining a pressure of 175 kPa.
 - After 24 hours sample and test the chlorine solution. If the chlorine residual is at least at 25 mg/L, the disinfection will be considered successful. Flush chlorine solution from the system. Protect against contamination of the disinfected system.
 - If the chlorine residual is less than 25mg/L, flush the system, clean any deleterious material, re-flush and disinfect again. Repeat until satisfactory.
 - If in the opinion of the mechanical consultant any component of the potable water system becomes contaminated after disinfection, it shall be flushed and disinfected again at no additional cost.
 - Obtain water sample off longest run. Test in approved laboratory for bacteriological analysis and provide certification that all samples are suitable for human consumption prior to interim-occupancy inspection.
 - Upon completion provide laboratory test reports on water quality for mechanical consultant approval.
- .4 Manufacturer Start-up: include for and coordinate manufacturer start-up of boilers, air handling units, chillers, cooling towers, and condensing units, water chemical treatment.
- .3 All tests forms required as per specifications to be recorded on the test report forms and submitted to the consultant.

END OF SECTION

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10.1 Codes and Standards

- .1 New design, additions, upgrades and repairs to conform to or exceed the latest edition of the following codes and standards generally, plus those specifically referenced in following clauses:
 - .1 *Canadian Electrical Code Part 1.*
 - .2 *Alberta Building Code.*
 - .3 *National Fire Code.*
 - .4 *National Fire Alarm Code.*
 - .5 *Underwriters Laboratories of Canada*
 - a. *Installation of Fire Alarm System.*
 - b. *Standard for the Inspection and Testing of Fire Alarm Systems.*
 - c. *Standard for the Verification of Fire Alarm Systems.*
 - .6 *Canadian Standard Association*
 - a. *Installation Code for Lightning Protection Systems.*
 - b. *Emergency Electrical Power Supply for Buildings.*
 - .7 *Illuminating Engineering Society of North America.*
 - .8 *Institute of Electrical and Electronics Engineers.*
 - .9 *Model National Energy Code for Buildings (MNECB).*
 - .10 *The City of Calgary – Sustainable Building Policy.*
 - .11 *Fire Station Design Standards*
 - .12 *Calgary Fire Department Electrical Design Schematics*
 - .13 *The City of Calgary – Communications Infrastructure Standards*

10.2 Site Electrical Services

- .1 Consultant to coordinate with the electrical, cable, fibre, and telephone utilities providers for location and routing of these services to the facility. Contractor to coordinate all utilities into demarcation room within the facility.
- .2 Avoid crossing any utility service lines unless absolutely deemed necessary.
- .3 Consultant to contact electrical service provider to determine service availability, connection costs (to be included in a cash allowance), and date that permanent service can be made available.
- .4 Contractor to provide temporary power and absorb all electrical utilities costs until project is turned over to the Owner.
- .5 Contractor to initiate the electricity account transfer application 2 months prior to the expected occupancy date. Contractor to provide all necessary information required for the application to Calgary Fire Department.
- .6 Power, telephone and cable television services to, unless impractical, be routed underground from the Utility connection point to the building service equipment.
- .7 Provide one (1) spare 100mm secondary feeder conduit from the exterior pad-mount transformer to the electrical room inside the facility, capped off.
- .8 Provide one (1) spare 100mm conduit for future communications service provider.
- .9 Select service voltage according to the majority of load requirements, 120/208 volt or 347/600 volt, 3 phase, 4 wire.

10.3 Service Distribution, Sub-Distribution and Panelboards

- .1 Size the main distribution panel 25% above the combined current and anticipated future expansion design ampacity.
- .2 Provide for a maximum utilization of 60% for main and sub-distribution circuit breakers to total panel spaces available.
- .3 Use circuit breakers for all main and branch circuit protective devices.
- .4 Ensure adequate fault duty ratings of all switchgear, panels, MCC's and overcurrent devices, verified by fault calculations.
- .5 Ensure coordination of overcurrent and ground fault devices:
 - .1 Conduct preliminary coordination analysis complete with consolidated time-current characteristic curves and single line diagram showing utility fault level and protection, main incoming and feeder devices.

- .2 Provide final coordination analysis documents before completion of construction to ensure proper functional coordination of all devices and include the final coordination documents to the O&M Manual
- .6 For new as well as modification and addition of CFD facilities, specification shall call for Arc Flash Hazard Analysis based on CSAZ462 and IEEE 1584 for all new and existing distribution equipment at the facilities. When performing the Arc Flash Analysis and the warning labelling, the following rules to be followed,
 - .1 The Arc Flash Analysis shall be done by the manufacture of the power distribution system, any other third party firm is not acceptable.
 - .2 For modification and addition projects, the analysis shall be based on current power distribution configuration of the whole facility.
 - .3 The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts;
 - .4 The Arc Flash Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 KVA where work could be performed on energized parts;
 - .5 Based on Arc Flash Analysis, a 3.5 in. X 5 in. thermal transfer type warning label of high adhesion polyester to be provided and installed for each work location analyzed ;
 - .6 All labels shall be based on recommended or existing overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system;
 - .7 The label shall include the following information, at a minimum:
 - Location designation
 - Nominal voltage
 - Flash protection boundary
 - Hazard risk category
 - Incident energy
 - Working distance

 - PPE category and description including glove rating

- Limited approach distance
 - Restricted approach distance
 - Prohibited approach distance
 - Engineering report number, revision number and issue date
- .8 The manufacture shall provide one day of Arc Flash Safety training which shall include
- Proper use of the system analysis data
 - Interpretation of hazard labels
 - Selection and utilization of personal protective equipment
 - Safety work practices and procedures
- .7 City of Calgary Corporate Engineering to be consulted for electricity metering and/or submetering requirement for corporate owned and operated infrastructures. Consider providing panel-mounted microprocessor-based digital AC metering device for all services 400 Amperes and over, with:
- .1 meter to display true RMS values for phase voltage (line to line and line to neutral), phase currents, kVA, kVAR, kW, PF, Hz, KWhr, kWd and kVAd.
 - .2 metering to be field programmable via front key pad and RS232 and RS485 port.
 - .3 meter to have two programmable dry contacts.
 - .4 output and interface software for tie to building automation system; capacity for recording, load shed and alarm set points.
 - .5 sizing of instrument transformers such that the initial design full load is approximately 60% of rating.
 - .6 provision of PT test blocks, if required, and CT test blocks for each meter.
- .8 Provide a customer service utility meter in a separate cabinet.
- .9 Provide lifting equipment for all industrial-type air circuit breakers and high voltage switches.

- .10 Provide all floor-mounted equipment with a housekeeping pad except for roll-out style switchgear.
- .11 Locate main electrical distribution equipment in a separate room. The room to be large enough to accommodate electrical equipment and have space to accommodate future needs. The room to be adequately ventilated and illuminated and located as close as practical to major electrical loads. Provide legible single line diagram which shall be approved by the design Engineer prior to installation in glass frame in main electrical room and generator room is applicable.
- .12 Do not locate main service and distribution equipment in mechanical, storage or janitor rooms except for MCC's in mechanical rooms.
- .13 Do not locate distribution transformers in ceiling spaces.
- .14 Coordinate transformer heat removal with mechanical consultant.
- .15 To limit fault current available on the secondary side, maximum transformer size not to exceed 1000 kVA.
- .16 Select low temperature rise transformers, using high temperature insulating materials to achieve long life and low losses (e.g., Class 220°C, 150°C temperature rise over a 40°C ambient). Provide three phase transformers with delta-wye connection and accessible voltage taps. Rate transformers to accommodate the harmonic currents and voltages present for the loads being supplied. Transformers may be K factor rated or may be of the phase shifting type designed to mitigate harmonics.
- .17 Provide flexible conduit for final connection to transformer. Provide vibration isolators for transformers located on floors or suspended from upper floors.
- .18 Make provisions for fan cooling on dry type transformers in excess of 750 kVA. Size transformers for calculated capacity without fan-cooling.
- .19 Panelboards to be distributed uniformly about the facility sized on the basis of the known and anticipated loads in each area of the facility.
- .20 Panelboards to be located in storage rooms, mechanical rooms and electrical rooms. Where these rooms are not available locate panelboards in corridors and provide with a lockable cover. Do not locate panels behind doors that open in the direction of the panels.
- .21 Correct power factor to at least 95% where normal loading yields a power factor of less than 90%.

- .22 Consider correction capacitors for motors 10 kW and larger and group motors smaller than 10 kW where total motor load is 50 kW or larger.
 - .1 Locate capacitors close to the motor or group of motors, preferably downstream of starters.
 - .2 Where switchable capacitor banks are used, take the following precautions:
 - a. First in, first out switching.
 - b. Provide time delay between switch steps.
 - c. Prevent overcorrecting and cycling.
- .23 Conduct harmonic analysis and, where necessary, provide harmonic detuning.
- .24 Identify non-linear loads including: pulse mode power supplies (typically found in personal computers, photocopiers, fax machines, printers, etc.), UPS, rectifiers, variable frequency drives and electronic ballasts. Determine the effects of these loads on the power distribution system.
- .25 Provide harmonic filtration, either integral with the equipment or separately, to limit total current harmonic distortion from each piece of equipment to less than 15%. Limit the harmonic distortions to comply with the current edition of *IEEE 519*.
- .26 Provide transformer isolation between large harmonic generating loads and the balance of the distribution system.
- .27 Provide surge protection in the following manners:
 - .1 Install surge suppression on utility incoming mains.
 - .2 For areas containing a large group of electronically sensitive loads, provide surge protection on panelboards serving the area.
 - .3 Coordinate surge protection devices within the same power distribution system.
- .28 Provide modular group assembly motor control centres (MCC's) for three phase motor starters.
 - .1 Motor control centres to be complete with:
 - a. Standardized central wiring extended to terminal strips in control terminal section.
 - b. Copper bussing.

- c. Combination magnetic starters, minimum size 1.
 - d. 20% spare spaces.
 - e. Adjustable time delay relays for start-up on motors 5kW and larger where this feature is not available through building automation system.
 - f. Individual control transformers in each starter cell.
 - g. Auxiliary contacts for interlocking controls.
- .2 Do not use fuses for individual motor overcurrent protection.
 - .3 Provide three phase motor starters with three overload protection elements.
 - .4 Provide single phase protection for all three phase motors either by relaying, differential overloads or Building Automation shutdown.
 - .5 Provide time delay on speed change for 2 speed starters.
 - .6 Provide space on back panel in starter for Building Automation current sensors.
- .29 Where there is a three phase service, provide motors larger than 0.37 kW as three phase units, and motors 0.37 kW and smaller as single phase 120 volt units.
- .30 Provide control relays in MCC control terminal section for automated control of single phase motors where required.
- .31 Coordinate motor sequential starting with building automation or controls.
- .32 Variable Frequency Drives to be of pulse width modulation type. Provide VFD's complete with harmonic distortion line filters with limit total harmonic current distortion to less than *IEEE 519* Standard requirements where the drive terminals are the point of common coupling, but in no case more than 15%. Select drives with proven maintenance capabilities. Coordinate motor selection with mechanical to ensure inverter duty motors are provided. Provide output reactor to limit rise time to suit motor type and lead length. Locate drives within 7 meters of load.
- .33 Provide car plug control equal to AC Dandy ACRT20K 5 Series and locate the car plug controller in a lockable room, such as electrical room, IT/Communication room.
- .34 Electrical consultant shall specify and include layout of control cabinets with PLC control for Infrared heaters in apparatus bay and kitchen exhaust. Mechanical engineer provide control sequence based on section 9.6 if this guideline. Include coordination note at control cabinet layout plan to direct electrical contractor to control sequence provided by Mechanical engineer.

- .35 Provide electrical single line *diagrams*, as part of the Contract Documents, indicating the following:
 - .1 *Configuration, type, voltage and current ratings* of switchgear, transformers,
 - .2 Panelboards and motor control centres (MCC's).
 - .3 Type, size, amperage ratings of services and feeders.
 - .4 Type, frame size, trip size, interrupting rating of all overcurrent protective devices.
 - .5 Available fault current at all switchgear, switchboards, panelboards, transformers secondary, MCC's and overcurrent devices.
 - .6 Type, size and current ratings of services and feeders.
 - .7 Connected load at all switchgear, switchboards, panelboards and MCC's.
 - .8 Anticipated demand load at all switchgear, switchboards, panelboards and MCC's.
 - .9 Service and distribution grounding.
- .36 Provide copies of "as-built" single line diagrams as part of the Operating and Maintenance Manuals.
- .37 Provide two framed copies of "as-built" single line diagrams to CFD so they for hanging in main electrical room and generator room.

10.4 Emergency Power

- .1 Batteries shall be used as the emergency power source for all life safety loads.

10.5 Backup Power

- .1 For fire hall, provide bi-fuel (diesel/ natural gas) generator to back up the entire building load to meet CFD resiliency requirement. The size of the generator will be based on existing similar fire hall. Consult Corporate Engineering for electricity demand data for an existing fire hall. The backup generator will be a bi-fuel generator (diesel/ natural gas). Specify the tank size to 24 hours at rate of full load. the following requirements apply:
 - .1 Comply *CAN/CSA C282 Standard, Emergency Electrical Power Supply for Buildings*. The main difference will be that the generator will not be monitored by the fire alarm system.

- .2 Provide dedicated indoor, climate-controlled, fire-rated room. Locate generator room away from noise sensitive areas and preferably at grade level. Do not locate room below grade or where access for the removal of equipment is impeded.
 - .3 Exclude unrelated electrical and mechanical equipment from generator room.
 - .4 Provide vibration isolation for generator control panel or remote mount from generator set skid.
 - .5 Locate transfer equipment and main emergency distribution in close proximity to (but not within) emergency generator room.
 - .6 Where feasible, provide wired glass view between switchgear and generator room.
- .2 .7 Make provisions for connection to load bank to facilitate annual full load testing; size only for additional required load. Provide automatic transfer switch. Provide time delay or in-phase monitoring in transfer scheme to prevent motor damage upon transfer to utility power. Provide time delay between start-up of each motor over 5 kW on emergency power after transfer to emergency power, starting largest motor first.
- .3 For non-fire hall CFD facility, Consult CFD for back up generator requirement.
 - .4 Provide UPS for backup power to receptacles in IT/Communication room and alarm room.

10.6 Conduit & Wiring

- .1 Provide underground service entrance in duct bank with steel reinforced concrete encased PVC or FRE duct. Provide transition at foundation wall, manholes, etc., with rigid steel conduit.
- .2 Specify all A.C. and D.C. wiring to be installed in conduit or wireway (except where NMD90 and AC90 cables are used). Refer to the *City of Calgary Information Technology Communications Infrastructure Standards* for cabling/conduits requirement for Network, security, and telephone. Refer to CFD *Electrical Design Standard* for alerting system wiring requirement.
- .3 Exposed conduit not accepted. All conduits must be concealed except in service areas where otherwise approved by the owner.
- .4 Provide conduit systems (power, communications, network, etc.) to a point of anticipated future expansion when applicable. Label the purpose of conduit at junction box where conduit terminates.

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- .5 Provide three (3) 27mm conduit stub-outs from all power, communication and protection systems recessed panels to junction boxes just above ceiling level for future use.
- .6 Record exact routing of conduit runs in floor slabs. Do not loop through to downstream outlets.
- .7 Where conduit is used in ceiling plenums, use steel EMT: do not use FT4 low spread rated PVC conduit.
- .8 Provide ventilated cable tray for low tension systems, Class C1, ladder type. Tray to consist of open top cable tray with minimum dimensions of 450 mm wide x 100 mm deep galvanized steel. Support cable tray from the building structure at 3 meters on centre. Where cable tray passes through fire rated walls, provide totally enclosed tray for a distance of 600 mm on each side of the wall.
- .9 For low tension systems, provide conduit for final drops in finished walls from cable tray in ceiling space.
- .10 Size feeders for a maximum 2% voltage drop from main distribution to branch circuit panelboards under rated full loads.
- .11 Generally, use copper conductors for feeders and branch circuits. Panelboard, MCC and Distribution Board feeders larger than #4/0 may be aluminium alloy. Use copper conductors with RW90 X-Link or THNN insulation. Minimum size of branch circuit wire to be #12 AWG. Minimum size of parallel conductors shall be #1/0. Conductor length for parallel conductors to be identical.
- .12 Provide a 100% rated neutral and bonding conductor with all feeders.
- .13 Use separate neutrals or increase size of neutral of branch circuits where circuits are dedicated for computer equipment loads including office personal computers.
- .14 Avoid the use of non-metallic sheathed cables, except for buildings entirely of combustible construction.
- .15 Use AC-90 cable only in short lengths for final connections to luminaires and similar equipment. Provide sufficient length of flexible drop to luminaires to enable unit relocation 2 meters in any direction. Drops are to occur from junction box on structure to each luminaire.
- .16 Size branch circuit conductors to avoid excessive voltage drops. Indicate conductor sizing in design documents.
- .17 Wiring of power and low voltage devices, even in an existing building, are under no circumstances to be installed or remain in the same conduit.
- .18 For all major equipment such as power panels, use continuous feeder runs (i.e. no spliced sections). For existing installations with upgrades, prior approval required from the owner if non-adherence is necessary.

- .19 Use Liquid-tight Flexible Conduit as raceway for final connection to all motor terminal boxes, pipe mounted and other devices subject to movement or water, minimum length to be 460mm plus 4 times and conduit diameter. Provide a separate ground wire within conduit, bond to motor frames and system ground.

10.7 Wiring Devices & Boxes

- .1 Provide 20/15 amp service outlets in the corridors at approximately 15m intervals.
- .2 Use 15A, 125V, duplex, grounding type, specification grade receptacles for all convenience receptacles except for special equipment use ones. Receptacles to be Decora style for office areas and general purpose style for service areas.
- .3 Use 20A, 120V, quiet type specification grade, Decora type switches for office areas and general purpose type for service areas.
- .4 Identify all receptacles as to panel and circuit number on clear plastic background with black lettering affixed to top of device cover plate.
- .5 Determine the extent and severity of electrical service disturbances including voltage sags, surges, short term and long term transients and outages. Consult with the Utility to determine the likely incidence of these disturbances.
- .6 Identify electronic equipment and systems likely to be affected by these disturbances and the extent of protection necessary for normal operation.

10.8 Lighting

- .1 Lighting design levels to be per latest IES standards.
- .2 Design to maximize the energy efficiency of lighting systems. Design in accordance with the *Model National Energy Code of Canada for Buildings*.
- .3 Design to minimize direct and reflected glare.
- .4 Fluorescent lights to be the standard in most interior areas except where otherwise specified.
- .5 Provide a design report which includes a schedule describing each typical area, luminaire, lighting source, load (W/m^2) and design lighting levels. Upon project completion add field measured levels to the report.
- .6 Interior lighting control shall comprise of simple distributed systems. Do not utilize LV control cabinet for lighting control. The general principle is to provide a minimum level of lighting within the building that will turn on automatically at night and off at dusk.

- .7 Provide manual on/ auto off in areas with daylight contribution and auto on/ auto off in other interior spaces. Override switches will be provided to assist with maintenance. These switches will be located in the electrical room.
- .8 Exterior lightings will only be controlled by an exterior photocell and will be on at dusk and off at dawn. Provide a keyed maintenance switch in electrical room to bypass the photocell.

There will be fixtures within the building designated to be low level lighting. These lights will be controlled by an exterior photocell(s). These lights will be coordinated with the emergency and egress lighting. If required in interior dark spaces, some of these lights may be on continuously.

Large service spaces and critical spaces such as electrical /mechanical room and apparatus floor the lights will be controlled by occupancy sensor(s) with an electronic interval timer override that allows the user to turn the lights on for a maximum of 6 hours.

Dorm washrooms will have low level lighting controlled by occupancy sensor(s). Other lights will be controlled by an electronic interval timer.

Provide ceiling mounted occupancy sensors at washrooms, change rooms, meeting rooms, fitness rooms for energy conservation.

Provide all mount occupancy sensor for small spaces such as IT room and rooms in office style areas.

Provide manual switch in electrical room and generator room.

Dorms: 3 way switch for general lighting (one by the door and the other by the bed). Reading light will be controlled by a wall switch by the bed.

Do not use breaker switching.

- .9 Minimize voltage drop for low voltage lighting system:
 - a. Using heavier gauge cable;
 - b. Shorten cable runs;
 - c. Use lower wattage lamps;
 - d. Use fewer luminaries on each run;
 - e. Use multiple transformer;

10.9 Emergency & Exit Lights

- .1 Provide emergency and exit lights as required by code in all egress paths, stairwells, mechanical rooms, washrooms, and electrical rooms.
- .2 Use high brightness LED type exit lights.

10.10 Fire Alarm System

- .1 Design and install the system to latest *CAN/ULC-S524 Standard for Installation of Fire Alarm Systems*.
- .2 Verify system to latest *CAN/ULC-S527 Standard for Verification of Fire Alarm Systems*.
- .3 Review design of fire alarm system with local authority.
- .4 Select system vendors with local support. Do not use proprietary equipment.
- .5 Provide a programmable intelligent fully addressable supervised single stage; class 'A' fire alarm system for all facilities. Provide two-stage system for facilities that require voice evacuation system in accordance with the *Alberta Building Code*.
- .6 Provide fire alarm system as a stand-alone system, independent of building control or security systems.
- .7 Provide magnetic door hold-open devices on circulation doors where smoke or fire separations are required.
- .8 Provide fire-rated wiring installation for system communications trunks where they are used.
- .9 Provide wiring diagram on inside of each fire alarm control panel door. Clearly identify wiring at all panels and junction boxes identifying initiating loops, addresses and signal circuits.
- .10 Coordinate duct detectors with mechanical to ensure air velocities are compatible with detectors.

10.11 Security System

- .1 Provide electronic security systems as required by building owner to enhance physical and dynamic security.

10.12 Public Address System

- .1 Provide a public address system capable of communicating throughout the facility for emergency and other purposes using telephones and the public address speaker system.

10.13 Telephone System

- .1 Provide conduit and raceway as per City of Calgary IT communication infrastructure guidelines.

10.14 Computer Network System

- .1 Provide conduit and raceway as per City of Calgary IT communication infrastructure guidelines.

10.15 Cable Television System

- .1 Design cable television distribution system for signal strength 6 dB mV to 14 dB mV at each outlet.
- .2 Connect utility cable television service to cable television distribution system. If cable television service is not available at present, ensure that it can be connected when service is available.

10.16 Lightning Protection System

- .1 Provide lightning arrestors on all services supplied from an overhead line.
- .2 As a guideline, provide lightning protection as determined by the latest *CAN/CSA-B72-M87– Installation Code for Lightning Protection System* standard.
- .3 Do not provide protection for adequately grounded metal buildings.
- .4 Ensure adequate treatment for all envelope penetrations such as generator exhaust piping, lightning down conductors and points and service masts.

10.17 Electrical Start-up and Testing

- .1 Include a complete list and test report forms for all tests required in the specification. Identify which test needs the consultant engineer's to witness.
- .2 Basic electrical start-up and testing:
 - .1 Test and check all portions of the electrical systems for satisfactory operation.
 - .2 Before energizing any portion of the electrical systems :
 - a. Perform megger tests on all feeder conductors.
 - b. Torque all bus connections to manufacturer's requirements and seal with red lacquer.
 - c. Measure ground resistance of ground grids and wiring devices with earth test megger to verify compliance with CSA C22.2 No. 0.4-M1982 and Canadian Electrical Code, and submit test results to Consultant.
 - d. After energizing as many loads as possible, test load balance on all feeders at distribution centres, motor control centres and panelboards. If load unbalance exceeds 15%, reconnect circuits to balance loads and revise panelboard directories and wiring identification accordingly.
 - e. Test and calibrate all protective devices on site prior to energizing to ensure proper operation as determined by final coordination studies.

- f. Prior to starting motors, confirm motor nameplate data with motor starter heater overloads, verify rotation, ensure disconnect switches are installed and confirm labelling of motors, disconnects and starters.
 - g. Functional test of all lighting switches, luminaires, dimmers and lighting control equipment such as photocells and time clock settings.
 - h. Check operation of all battery operated emergency lighting units, exit lights and connection of exit lights to emergency lighting units as specified.
 - i. Test operation of UPS.
 - j. Factory and field test standby power generation systems.
 - k. Complete fire alarm verification as per current addition of CAN/ULC-S527 Standard for Verification of Fire Alarm System.
 - l. Test signal strength at each cable television outlet and provide verification that signal levels meet specified requirements.
- .3 All tests to be recorded on the test report forms and submitted to the consultant.

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11.1 Codes and Standards

- .1 New design, additions, upgrades and repairs to conform to or exceed the latest edition of the following codes and standards generally, plus those specifically referenced in following clauses:
 - .1 *ASHRAE; Applications Handbook*; Sound and Vibration Control Chapter
 - .2 *CISC Handbook of Steel Construction – Appendix G, Guide for Floor Vibrations.*

11.2 Architectural

- .1 Consult with CFD on rooms where speech privacy, sound isolation, background noise, or reverberation noise is critical.
- .2 Develop a floor plan so that noise-sensitive spaces are not next to high noise generating areas. Consider both vertical and horizontal adjacencies.

11.3 Mechanical

- .1 Design mechanical systems to provide background Room Criterion (RC) noise levels as follows.
 - .1 Enclosed office: 30-35.
 - .2 Open-plan areas, reception: 35-40.
 - .3 Kitchen: 45 maximum
 - .4 Dorms : 25 maximum
 - .5 Apparatus Bay: 40 maximum
 - .6 Conference room: 25 maximum
 - .7 Mechanical, Electrical, IT rooms: 40 maximum

Section 11 Acoustics and Vibration

.2 Ducts, Terminal Units, Silencers:

- .1 Whenever possible, design the mechanical duct system such that main high and medium velocity ductwork is located above low occupancy areas such as corridors and service spaces.
- .2 Do not locate exhaust fans or fan coils directly above meeting rooms or sound-sensitive areas. Provide acoustic lined duct as required.
- .3 Avoid placing rooftop equipment over noise-sensitive areas. Provide details describing acoustic treatment, duct configuration and roof penetration seals for any rooftop installations.
- .4 Select duct silencers with low static pressure losses.
- .5 Locate balancing damper as close to branch takeoff from main as possible.
- .6 Use flexible connections between fans, plenums, and all related ductwork.
- .7 Select grilles and diffusers such that the combined noise from all devices in a room meets the design criteria.

.3 Plumbing Noise:

- .1 Ensure sleeves are provided for piping that penetrates walls. Seal space between pipe and sleeve with caulking.
- .2 Install water hammer arrestors adjacent to quick acting solenoid valves.

.4 Vibration Isolation:

- .1 Use the latest *ASHRAE Application Handbook* as a guide for selecting vibration isolation of mechanical equipment.
- .2 Provide vibration isolators for all pipe hangers.
- .3 Use flexible connectors on pumps that require isolation from piping or as recommended by the pump manufacturer.
- .4 Use flexible connections between fans, plenums, and all related ductwork.

11.4 Electrical

- .1 Transformers:
 - .1 Avoid locating transformers within or above noise-sensitive areas.
 - .2 Provide vibration isolators for transformers located near occupied spaces.
 - .3 Provide flexible conduit for connections to the transformer.

11.5 Structural

- .1 Mechanical room floors to be minimum 130mm thick concrete, to minimize structural vibration problems.
- .2 Provide 100mm thick concrete housekeeping pad for major mechanical equipment.
- .3 Design structural steel framed floors to prevent transient footstep-induced vibration from exceeding the annoyance threshold. Refer to *CISC Handbook for Steel Construction – Appendix G Guide for Floor Vibration*.
- .4 Ensure rooftop mechanical equipment is located on a stiff portion of roof structure to avoid resonance problems.
- .5 Isolate Dormitory floor structure from adjacent vibration-producing areas such as Mechanical Room and Exercise floor structure.

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12.1 Environmental / Hazardous Materials

- .1 Where a hazardous materials audit is not available or does not exist, contact CFD prior to starting detail design or any destructive investigation.
- .2 Where any existing hazardous materials are not normally accessible by staff or public, and where they are undamaged and not friable, they are to be recorded and left in place. If they are accessible, damaged or friable, CFD may decide to encapsulate them. Where they will be disturbed during an upgrade or renovation, or where they may pose a hazard to staff or trades performing normal operating maintenance, those materials are to be removed in accordance with regulations and recognized safe practices: coordinate with CFD as to whether to include removal in project scope.

END OF SECTION

Section 13 Architectural and Interior Space Planning

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Section 13 Architectural and Interior Space Planning

13.1 Architectural And Interior Space Planning

- .1 A Building Code Analysis is to be included on design drawings, including classifications and fire separations.
- .2 Fall Protection: coordinate with the client and building operator on whether there is a preference for interior (e.g. hatch) versus exterior (e.g. ladder) roof access, and whether tie-off points will be required.
- .3 Follow City of Calgary “*Access Design Guidelines*” where designated by CFD.
- .4 Protect steel components exposed to the exterior (e.g. roof screens, handrails) or to frequent washdowns (e.g. in Apparatus Bays) against corrosion by galvanizing or powder-coating, with those finishes uncompromised by site welding.

END OF SECTION

Questions and comments on these guidelines are welcome and should be referred to:

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END