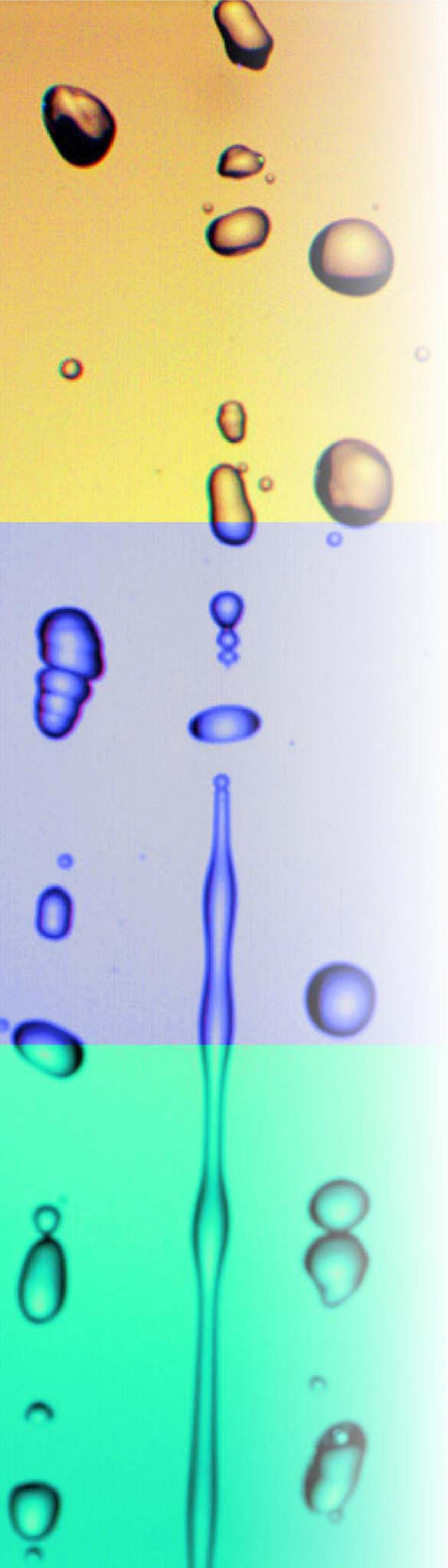
APPENDIX M – DESIGN BASIS MEMORANDUM SAMPLE



THE CITY OF WINNIPEG WATER TREATMENT PLANT

Design Basis Memorandum Draft

Project No. 79538-02

April 26, 2005

Table of Contents

GENERAL

PROJECT TITLE: Winnipeg Water Treatment Program
Design Consultant Services

PROJECT NUMBER: 79538

PROJECT MANAGERS: Doug Taniguchi, P. Eng.
Albert Li, P. Eng.
Ray Bilevicius, P. Eng.

DISCIPLINE LEADS:

CIVIL/SITE:	Jeff Crang, P. Eng.
BUILDING MECHANICAL (HVAC):	Alan Aftanas, P. Eng.
ELECTRICAL:	Petr Stryk, P. Eng.
INSTRUMENTATION & CONTROLS:	Stephen Tormey, P. Eng.
HEAVY STRUCTURAL:	Melvin Klassen, P. Eng.
BUILDING STRUCTURAL:	Dino Kruger, P. Eng.
ARCHITECTURAL:	Bryan Shaw
PROCESS MECHANICAL:	Paul Wobma, P. Eng.

REVISION: **B**

DATE: **April 19, 2005**

CLIENT: City of Winnipeg, Water & Waste Department

LOCATION: Deacon Site, Winnipeg, Manitoba
Adjacent to the existing Deacon Booster Pumping Station.

PROJECT SCOPE: The scope of the work includes the detailed design of the Winnipeg Water Treatment Plant and includes the following plant areas:

Civil/Site: Includes site work, utilities, demolition, access, roads, railway, landscaping, grading, paving & construction, and staging.

Electrical Substation: Design details & information related to electrical substation.

Yard Piping: New yard piping, demolition & yard piping valve chambers and connections.

Main Water Treatment Plant: The main water treatment building incorporates administration component as well as the Raw Water Pumping station and will involve Architecture, Process and Building Mechanical, Electrical, and Instrumentation & Controls. The main plant includes process areas: for DAF and Flocculation, Filtration, Ozonation, Residuals, and Chemical dosing.

Bulk Chemical Storage Building: Architecture, Structural, Building Mechanical, Electrical, Instrumentation & Controls. The Bulk Chemical Storage building is situated to the north of the Main Water Treatment Building. The Aqua-ammonia storage and feed equipment room will be housed inside the Bulk Chemical Storage Building.

Residuals Management: Refers to the freeze-thaw lagoons, associated forcemain and pump station including Structural Building Mechanical, Process Mechanical, Electrical, and Instrumentation & Controls.

Deacon Booster Pumping Station: Modifications to the existing station to receive new pumps, and involves Structural, Process Mechanical, Electrical, and Instrumentation & Controls.

Clearwell: Buried concrete structure for treated water storage including two above grade buildings housed over the inlet and outlet (respectively) portions of the clearwell. Involves Architecture, Structural, Building Mechanical, Process Mechanical, Electrical, Instrumentation & Control.

On-Site Hypochlorite Generation Building: Onsite Hypochlorite Generation Building. is a stand alone building west of the Bulk Chemical Storage Building complete with a outside Transformer Pads on the west side for the 600V Electrical supply to both chemical buildings).

Standby Generator Building: Above-grade facility housing the standby generators, situated to the north of the proposed Water Treatment Plant Building.

The Design Consultant project deliverables include tender-ready drawings and specifications adequate information to enable the Construction Manager (on behalf of the City of Winnipeg) to obtain competitive bids from qualified contractors for the supply and erection of the plant areas and equipment.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS		• During Construction: -35°C to 35°C • Ambient: -35°C to 35°C • Ambient Interior: Refer to each plant area
	SYSTEM OF MEASUREMENT		The accepted system of measurement will be the SI system.

CIVIL/SITEWORKS

DISCIPLINE LEAD STRUCTURAL: Jeff Crang, P. Eng.

ROAD AND RAIL DESIGN: Jeff Crang, P. Eng.

HYDRAULIC DESIGN: Devon Danielson, P. Eng.

MUNICIPAL DESIGN: Greg Karman, C.E.T.

QA AND REVIEW: Todd Smith, P. Eng. (Roads), Mike Eggleston, P. Eng. (Rail), Hydraulics?, Municipal?

INTRODUCTION: The following siteworks design brief for the Winnipeg Water Treatment Plant is based on the scope of work identified in the proposal document and currently referenced in the project plan. This design basis document provides design basis for transportation, municipal and hydraulic aspects for the Winnipeg Water Treatment Plant. Variations, special considerations for specific plant areas shall be identified and appended to this document.

SCOPE AND DESCRIPTION OF CIVIL/SITEWORKS: The civil/siteworks engineer will provide detailed design for all proposed roads, rail, parking lot and site drainage, as presented in the Preliminary Design Report.

.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS	Main Access Road and Truck Loop Service Roads Parking Lot Railway Drainage	
	SYSTEM OF MEASUREMENT	Roadway and Drainage Railway	• Metric • Imperial
	DESIGN REFERENCES (Latest Editions)	Roads	• City of Winnipeg – Transportation Standards Manual • Transportation Association of Canada – Geometric Design Guide for Canadian Roads • Manitoba Transportation and Government Services – Warrants and Standards for Intersection Treatments of Rural Two-Lane Highways • Manitoba Transportation and Government Services –Transportation Planning Manual Manitoba Transportation and Government Services – Highway Design Manual
		Rail	• American Railway Engineering and Maintenance-of-Way Association – Manual for Railway Engineering
REV	**CATEGORIES**	**ITEMS**	**DESCRIPTION**
	DESIGN PARAMETERS - ROADS	Classification Design Speed Design Vehicle Lane and Shoulder Widths Minimum Stopping Site Distance	• Highway No. 207: Collector • Main Access Road: Local Industrial Street • Highway No. 207 = 120 km/h • Main Access Road = 60 km/h • Truck Loop and Service Roads = 40 km/h • WB-20 TAC Tractor Trailer Combination • PTAC (service roads only) • Highway No. 207 – as shown on Drawing No. WM-C007P • Main Access Road 3.75 m lanes, 0.75 m shoulders or curb and gutter • Truck Loop = 3.75 m lanes, 1.5 m shoulders or curb and gutter • Service Roads = 3.0 m lanes, no shoulders • Highway No. 207 = 260 m • Main Access Road = 90 m • Service Roads = 45 m

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS - ROADS (Continued)	Intersection Sight Triangles	Highway No. 207: 450 m at 3 m from edge of roadway
		Vertical Curvature	**<u>CREST CURVE (K)</u>** • Highway No. 207 = 170 • Main Access Road = 20 • Internal Service Roads = 5 **<u>SAG CURVE (K)</u>** • Highway No. 207 = 30 • Main Access Road = 10 • Internal Service Roads = 4
		Horizontal Curvature	• Desirable Radius = 100 m • Minimum Radius = WB-20 turning movement
		Minimum Access Spacing	• Highway No. 207: 200 m to 600 m • Main Access Road: 60 m
		Gradient	• Maximum = 3% • Minimum = 0.5 % Note: A vertical curve is implemented if the following criteria are met: • Crest = 0.8% minimum • Sag = 1.5% minimum
		Height of Embankment (D)	• D = 1.2 m desirable, 0.8 m minimum Note: It is good practice to keep the centreline profile above prairie by 0.8 m
		Sideslope	• All Roads = 4:1
		Backslope	• All Roads = 4:1 up to 2 m cut, 3:1 over 2 m cut
		Cross Fall	• Gravel Surface = 3.5% • Concrete or Asphalt Surface = 2% • Gravel Shoulders = 4%
		Ditch Width	• Swale ditch minimum, 3.0 m desirable
		Sidewalk	• 2.0 m, 2% crossfall, ramp curb for accessibility at Administration Building
		Ditch Grades	• Desirable = 0.3% - 0.5% • Minimum = 0.1%
		Utility Locations	• City standard is to keep communications on the south side of the Main Access Road and electricity and gas on the north side. This standard may be waived due to site constraints.
		Curb and Gutter	• A City mountable curb is preferred.
		Parking Lot	• Slope = 1% - 4% • Stall Width = 2.7 m, 3.0 m handicapped • Stall Length = 6.0 m

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS - RAIL	Gradients and Curvature	• Curvature will not exceed 12 degrees
		Subgrade and Ditches	• Subgrade top width is 24 feet, with 2:1 sideslopes • 8 feet side ditches will be provided as necessary to ensure natural drainage and runoff is maintained
		Culverts	• Culverts will be installed as necessary to maintain natural flows across the right-of-way and would generally be galvanized corrugated metal pipe, designed to meet the 1 in 100 year flood event.
		Sub-ballast	• A minimum of 6 inches (crushed or screened pit run gravel, containing no more than 3% organics by weight) used to below the ballast to distribute the load of the train to subgrade.
		Ballast	• 6 inches of crushed rock ballast under the tie (CN Industrial Specification used throughout.
		Track Structure	• Rail – 100 lb jointed PW (partly worn) (controlled cooled for dangerous commodities • Tie Plates – 7 ½ " x 11" PW • Rail Anchors – Improved Fair • Spikes – 5 ½ " long, minimum two per tie plate, new • Joint Bars – minimum four holes • Ties – 6" x 8" x8'-0", #2 treated softwood new or rehab, 2840 per mile • Turnouts –#8, 100 lb. on GWWD Railway. New ties for all turnouts
	CONSTRUCTABLILITY CONCERNS		•

REV	CATEGORIES	ITEMS	DESCRIPTION
	CONSTRUCTION & DESIGN FEATURES	Ground Water Soil Unloading Docks Future Expansion Site Constrained Site Drainage A-Section Main Aqueduct Spring Weight Restrictions Parking Intersection of Highway No. 207 & Main Access Road Emergency Site Access Roadway Lighting East of WTP Drainage Siding Diversion Hydro Transmission Tower Freeze-Thaw Lagoon Access	• Varies greatly (Spring conditions, floodway operation, holdings cells) • Highly plastic clays over till layer on limestone bedrock • Reinforced concrete pads with spill containment are required at all unloading areas. Unloading pads must be located no further than 6 m from the Camlock. • Road configuration should allow for the building envelope required for a 200 ML/day expansion • Consideration will have to be given to proper road and drainage design in light of the space constraints • Due to the small size of the sight, catchbasins will be used in lieu of ditches • Due to the inadequacy of the aqueduct loading protection will be required. This will be provided with a bridge similar to ones used in the past. • The design engineer will be required to make an application to Manitoba Transportation to have the weight restriction on Highway No. 207 waived during periods of restriction. • The current requirement for parking spots is approximately 25. • It has been determined that the intersection accessing the plant will be required to be widened. • The City wants an emergency access to incorporate into the road design. • Intersection lighting is not required • The site east of the WTP should be re-graded and drained through the tracks, approximately 75 m east of the bulk chemical building. • To make space for the rail car shed adjoining the bulk chemical building the current siding must be moved “south” approximately 1.5 m. • The hydro tower located approximately 500 m west of Highway NO. 207 is required to be moved due to interference with the WTP. Currently it is proposed to relocate this tower approximately 35 m southwest of its current location. • An access will have to be determined for the lagoon. •

REV	CATEGORIES	ITEMS	DESCRIPTION
	SCHEDULING	Bulk Excavation Finalize Preliminary Design Chemical Railway Spur Design Site Utility Design Roads and Parking Lot Design Landscaping and Fencing Design	• January – February 2005 • March 2005 • January 2, 2006 – March 31, 2006 • May 2, 2005 – September 29, 2006 • September 1, 2006 – November 23, 2006 • September 1, 2006 – November 23, 2006
	SPECIFICATIONS	City of Winnipeg Roads Manitoba Transportation Roads	• City of Winnipeg – Standard Construction Specifications • Manitoba Transportation – Standard Construction Specifications
	DRAWINGS	List Standards	• See Master List • See Appendix L of QMP

ARCHITECTURAL

DISCIPLINE LEAD ARCHITECTURAL: Bryan Shaw

ARCHITECT: Neil Cooper, B.E.S., M,Arch, M.A.A.

QA AND REVIEW:

INTRODUCTION: The architectural scope of work includes provisions for code review with respect to exiting, occupancy, and use. Detailing and specifying of the doors, hardware, and all finishes (excluding floor). The architect will also provide design input to the exterior building aesthetic. Special attention will be paid to the building envelope including roof and wall systems. The architect will also provide input to the schematic planning and space programming.

SCOPE AND: DESCRIPTION OF: STRUCTURE: Landscape architecture will incorporate low-maintenance vegetation as much as possible.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN CODES (Latest Editions)	General	• National Building Code of Canada (NBCC) • National Model Energy Code • Supplement to the NBCC
	DESIGN PARAMETERS	Design Temperature Range	• During Construction: -35°C to 35°C • Ambient: -35°C to 35°C
	SPECIAL REQUIREMENTS	Handicap Access	• Provide Administration Building with barrier-free access. The remainder of the plant will not be provided with universal access.
	BUILDING ASSEMBLY	Substructure	• Concrete
		Foundations	• Piling
		Floors	• Concrete
		Walls	• Exterior walls • Masonry enclosures around the electrical generator and auxiliary rooms to underside of the roof • Thermal insulating values of completed wall assemblies to conform to Model National Energy Code • Exterior aesthetic
		Roof	• 2 ply modified bituminous roofing or EPDM roofing system? • Roof parapets
	EXPANSION JOINTS		• Due to the large size of the main water treatment plant roof and wall expansion joints will be incorporated where required.
	OTHER SPECIAL FEATURES (i.e., mech, arch, etc.)	Overhead Doors	• Insulated, roll-up or section doors, electrically operated, sizes to be determined
		Walls	•
		Man Doors	• Insulated, 16 gauge galvanized steel, 45 mm thick. • Heavy duty, corrosion-resistant hardware.
		Interior Doors	• Insulated, hollow steel, painted, 600 mm2 tempered glass lights in upper half except in washroom doors. • Heavy duty, corrosion-resistant hardware.
		Insulation	• Non-combustible and designed so that the completed wall assembly has an insulating value which meets the recommendations of the model National Energy Code for Buildings

REV	CATEGORIES	ITEMS	DESCRIPTION
	OTHER SPECIAL FEATURES (i.e., mech, arch, etc.) (Continued)	Roof	• Maintenance access hatches are required at each roof level; a minimum of 2 for an area of 800 m^2 • Traveled pathways shall be protected by concrete pavers • Insulated membrane roofing system comprised of 2 ply modified bitumen roofing or an optional mechanically fastened EPDM roofing on galvanized steel decking.
	SCHEDULING		•
	UNRESOLVED MAJOR ITEMS		• Building aesthetic • Administration building program, require staffing compliment and review of program requirements to establish final space data and plan.
	SPECIFICATIONS		• City of Winnipeg accepted format
	DRAWINGS	List	• See master list
		Standards	• Refer to Appendix L of QMP
A		Geodetic Elevation	•

STRUCTURAL

DISCIPLINE LEAD STRUCTURAL: Mel Klassen, P. Eng. – ETC
Dino Kruger, P. Eng. – CH2M Hill

STRUCTURAL DESIGN: Fred Kemp, P. Eng./Rados Eric – ETC
Gabe Profeta – ETC
- CH2M Hill

QA AND REVIEW: Ian Shrimpton, P. Eng. – ETC
Kem McWhinnie- CH2M Hill

INTRODUCTION: The following structural design brief for the Winnipeg Water Treatment Plant (WWTP) is based on the scope of work identified in the proposal document and currently referenced in the project plan. This design basis document provides design basis of Electrical Substation, and other ancillary structures (transformer pads, lagoon dewatering pump station, inlet and outlet distribution chambers).r general structural aspects for the Winnipeg Water Treatment Plant. Variations, special considerations for specific plant areas are identified and appended to this document.

SCOPE AND DESCRIPTION OF STRUCTURE: The WWTP structures consist of the Water Treatment Plant, Clearwell, Bulk Chemical Storage Building, Generator Building, Yard Piping Valve Chambers, Electrical Substation, and other ancillary structures (transformer pads, lagoon dewatering pump station, inlet and outlet distribution chambers).

The soil conditions as such that precast concrete piles foundations will be used for most of the structures. The predominant construction material for the substructures will be cast-in-place concrete. The superstructures will be a combination of cast-in-place concrete, concrete masonry, precast concrete, and steel.

Engineering responsibility will be generally as follows:

- Water Treatment Plant (including Main WTP, Raw Water Pumping Station, Administration Building, Enclosed Bridge, Residuals Treatment Area) – CH2M Hill.
- Clearwell, Bulk Chemical Storage Building, Generator Building, Electrical Substation, and other ancillary structures (transformer pads, lagoon dewatering pump station, inlet and outlet distribution chambers) -= ET.
- Yard Piping Valve Chambers – UMA.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS	Soil/Pile Foundation	• Working Stress Design
		Water retaining structure	• ACI 350 (Strength Design Method)
		Non-water retaining Structure	• Limit States Design (steel, concrete, and masonry)
		Climatic	• NBCC 1995 and Supplement
	DESIGN CODES (Latest Editions unless noted otherwise)	General	• National Building Code of Canada 1995 (NBCC) and referenced standards therein • Supplement to the NBCC • National Fire Code of Canada • The Workplace Safety and Health Act • National Sanitation Foundation 61 Standards • Occupational Health and Safety Act and Regulations for Construction Projects
		Cast-in-Place Concrete	CSA Standards: • CSA A23.1-00 Concrete Materials and Methods of Concrete Construction. • CSA A23.2-00 Methods of Test for Concrete • CSA A23.3-94 Design of Concrete Structures (Structures Design) • CSA A23.4-00 Precast Concrete – Materials and Construction • CSA A3001-03, Cementitious Materials for Use in Concrete ACI Standards: • ACI 350 Environmental Engineering Concrete Structures. Design Aids: • “Rectangular Concrete Tanks” 5th edition, Portland Cement Association • Concrete Reinforcing Steel Institute Handbook. CISC Handbook of Steel Construction (7th Edition - 2000)
		Pre-cast Concrete	CSA Standards: • CSA A23.4-00 Precast Concrete – Materials and Construction Design Aids: • “PCI Design Handbook Precast/Prestress Concrete” fourth edition
		Masonry	• CSA-A179 – Mortar and Grout for Unit Masonry • CSA-S304 – Masonry Design for Buildings (Limit States Design) • CSA-A370 – Connectors for Masonry • CSA-A371 – Masonry Construction for Buildings

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN CODES (Latest Editions unless noted otherwise) (Continued)	Wood	• CSA O86-01 – Engineering Design in Wood
		Structural Steel	CSA Standards: • CAN/CSA-S16.1-94 – Limit States Design for Design Structures • CAN/CSA-G40.20 – General Requirements for Rolled or Welded Structural Quality Steels • CAN/CSA-G40.21 – Structural Quality Steels • W47.1 – Certification of Companies for Fusion Welding of Steel Structures • W59 – Welded Steel Construction (Metal Arc Welding) ASTM Standards: • A307 – Specification for Carbon Steel Bolts and Studs • A325 – Specification for High Strength Bolts for Structural Steel Joints • CISC Code of Standard Practice for Structural Steel CISC Handbook of Steel Construction (7th Edition)
		Aluminum	• CSA CAN3-S157.M83 (R2002) – Strength Design in Aluminum
	DESIGN REFERENCES	Cranes	• B167-96 – Safety Standard for maintenance and inspection of overhead cranes, gantry cranes, Monorails, hoists, and trolleys
	DESIGN PARAMETERS	Ground Snow and Rain	• S_s=1.7 kPa • S_r=0.2 kPa
		Wind	• q(1/10)= 0.35 kPa • q(1/30)= 0.42 kPa • q(1/100)= 0.49 kPa
		Seismic	• Z_a=0 • Z_v=0 • Zonal Velocity ratio=0
		Design Temperature Range	• During Construction: -35°C to 35°C • Ambient: -35°C to 35°C
		Design Live Loads	• Electrical and Mechanical Equipment Rooms – equipment weight, but not less than 14.4 kPa plus 9.0 kN point load; loading less than this to be reviewed by associated disciplines. • All equipment loads are to be based on certified data supplied by the equipment manufacturer and will include self-weight and any added items (piping, liquids, curbs, etc.) and impact forces. Operating weight of equipment will be specified on certified shop drawings.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS (Continued)		• Cranes: overhead bridge cranes, monorails and hoists, jib cranes, etc., design loads to be determined on an individual basis • General personnel areas: 4.8 kPa • Stairs and walkways: 4.89 kPa • Basic roof loads: 1.0 kPa • Minimum lateral interior walls: 0.25 kPa • Truck: to be determined on an individual basis, reference CAN/CSA-S6-00, CL-625 Truck (N.B. 62.5 tonne). Concrete truck: 32 tonnes on 4 axles with 8 tonnes each. • Loading restrictions as applicable are identified in the appended descriptions for each structure.
		Lateral Earth Loads	• **Note:** *Refer to geotechnical portion of PDR.* • Pressures due to backfilling at top 2m: 20 kN/m^2 to account for backfilling operations
		Dead Loads	• Concrete: 23.6 kN/m^3 • Steel: 77 kN/m^3 • Aluminum: 25.9 kN/m^3 • *Masonry • *Roofing • *Wall cladding *If not listed use unit weights of construction materials and systems obtained from the appropriate Design Handbook.
	LOAD FACTORS (ACI 350 – Strength Design Method)	Dead Load	• 1.4
		Live Load	• 1.7
		Environmental	• 1.3
	LOAD FACTORS (Limit States)	Dead Load	• 1.25
		Live Load	• 1.5
		Crane Impact	• Per NBCC – 1.25 (powered), 1.10 (manual) • Normal to rails: 20% of weight of lifted load plus crane trolley for powered • Parallel to rails: ≥ 10% of maximum wheel loads for powered • Design references provide more detailed design guidance
		Wind	• 1.5
		Temperature	• 1.25
		Buoyancy, Overturning	• 0.85 for dead loads, 1.5 for live loads

REV	CATEGORIES	ITEMS	DESCRIPTION
	LOAD FACTORS (Limit States) (Continued)	Combination	• 1.0 for any single load • 0.7 for 2 of live, wind, and temperature • 0.6 for all live, wind, and temperature
	LOADS SUPPLIED TO OTHERS		• As required
	SERVICE REQUIREMENTS	Deflection Criteria (live load)	• Floors plates and grating – L/240 or 6 mm maximum • Platforms and walkways – L/240 • Roof structures – L/360 • Floor structures – L/360 • Supports for masonry – L/600 or 6 mm maximum • Monorail and bridge crane supports – L/800
	BUILDING ASSEMBLY	Substructure	• Generally all elements to be reinforced cast-in-place concrete

		Foundations	• Precast concrete hex piles
			  ○ 350 Diameter – 625 kN
			  ○ 400 Diameter – 800 kN

		Floors	• Generally to be reinforced cast-in-place concrete
		Walls	• Requires project Architect input • Generally to be reinforced cast-in-place concrete or reinforced concrete masonry

		Roof	• Requires project Architect input
			• Options:
			  ○ Cast-in-place concrete
			  ○ Precast concrete – double tees, hollowcore
			  ○ Truss/OWSJ/steel deck

	STRUCTURE STABILITY	Structural	• Horizontal and lateral loads will be handled by concrete or masonry shear walls • Roof diaphragm • Cross Bracing for steel structures

REV	CATEGORIES	ITEMS	DESCRIPTION
	CONCRETE WORK	Design parameters	• 28-day concrete strength of 35 MPa for all water retaining structural concrete; other concrete as appropriate for type of usage. • Portland cement type 50 (HS) will be used for concrete in contact with native soil and for water retaining structures. • Portland cement type 10 (GU) will be used for concrete not in contact with native soil. • Water to cement ratio shall be less than 0.42 for all structures. • Reinforcing bars will be specified to conform to CAN/CSA-G30.18-M92.

		Concepts	• Liquid retaining structures shall be designed by working or ultimate design method. See ACI 350. for load factors, allowable stresses, and crack control
			• Remaining structures shall be designed using CSA A23.3-94 (limit states).
			• Special consideration for concrete exposed to water of pH levels as listed below:
			  o For pH above 6.5 – use form liner
			  o For pH 6.3 to 6.5 – use form liner and silica fume in concrete mix
			  o For pH below 6.3 – protective coating
			**NOTE: Process input required for anticipated pH levels for all areas*
			• Special considerations for concrete exposed to ozone are outlined for the specific structures appended to this document
			**NOTE: Process input required for anticipated ozone contact areas.*
			• Special considerations for concrete exposed to corrosive chemicals are outlined for the specific structures appended to this document
			**NOTE: Process input required for anticipated type of corrosive chemicals and areas affected by these chemicals*
			• Crack control and shrinkage resistance measures shall be employed:
			  o W/C 0.42 or less
			  o Aggregates coarse, well rounded, well graded, size to ASTM C33 (Do we have this publication?)
			  o Require test batch with laboratory 21- or 28-day drying age results 0.039% or 0.045% respectively
			  o Meet minimum design strength
			• All water retaining structures will be required to be tested for watertightness per ACI 350.1.

REV	CATEGORIES	ITEMS	DESCRIPTION
	CONCRETE WORK (Continued)	Detailing Concepts	• Walls over 3 meters high should not be less than 300 mm thick. • Walls less than 250 mm thick are to be detailed with a single layer of reinforcing steel. • Walls 250 mm or thicker shall be detailed using two layers of reinforcing steel. • Slabs less than 200 mm thick are to be detailed with a single layer of reinforcing steel. • Slabs 200 mm or thicker shall be detailed using two layers of reinforcing steel. • Water retaining structures - maximum stresses for steel reinforcing and minimum reinforcing per to conform to ACI 318 and ACI 350.
		Concrete Finishes	• Concrete finishes and type of forming will be coordinated with the architectural room finish schedules • Exposed exterior formed concrete or formed concrete to receive coatings shall have a smooth-form finish. Other exterior concrete to receive rough-form finish. • Exposed interior formed concrete shall have a smooth-rubbed finish. Other interior concrete to receive smooth-formed finish. • Water retaining interior formed concrete walls to receive formliner surface.
		Expansion and Construction Joints	• Expansion joint locations will be determined by the engineer and shall consider shape and behaviour of the structure resulting from shrinkage, temperature changes, and foundation conditions • Maximum expansion joint spacing to be 30 m; however, greater spacing may be achieved with adequate reinforcing spacing • Construction and control joints locations may be suggested on the drawings; however, the contractor may have input into the locations to suit his construction methods, but must be reviewed by the engineer • Maximum spacing of construction and control joints shall be +/-14 m • Provide waterstop in wall and slab expansion and construction joints separating dry areas from earth or liquid, in exterior walls and slabs of liquid holding tanks • PVC waterstop minimum widths to be 150 mm for construction and control joints and 225 mm for expansion joints • Stainless steel waterstop will be used for ozone contact areas.

REV	CATEGORIES	ITEMS	DESCRIPTION
	STRUCTURAL PRECAST CONCRETE	Design Concepts	• Precast manufacturer shall be responsible for structural design of individual precast prestressed components, connections between components, and components connections to cast-in-place concrete. • Design, reinforce, and prestress units as required by CSA A23.4, and PCI Design Handbook. • There shall be no tension under superimposed live load of 0.72 kPa in bottom of precast units used over water holding structures. • Provide minimum of 38 mm of cover for tendons in precast units when located over water.
	MASONRY	Design Concepts	• Design based on CSA S304.1 Masonry Design for Buildings. • Construction and design shall meet the requirements of CSA A371. • Masonry walls shall be laid in a running bond pattern. • Masonry walls shall be used as bearing and shear walls for the structures as required. • Space control joints at two times the height of wall, but not more than 7.6 meters. • Provide joint reinforcement at 400 mm on centers. • Provide structural bond beams at connections to roof and floor diaphragms and at top of walls. Bond beams minimum reinforcement of 2-15M bars. • Provide minimum vertical reinforcement in the masonry wall of one 15M bar at 600 mm on center. Additional bars to be provided as required by structural analysis, at all corners, wall intersections, and at edges of all openings. • Masonry unit cores with bars shall be solid grouted.
		Material	• Block to CSA A165 Series, H/15/A/M. • Mortar and grout to CSA A179.

REV	CATEGORIES	ITEMS	DESCRIPTION
	METAL DECKING	Design and Detailing	• Shall conform to the requirements of CSA S136 with reference to the "Steel Deck Institute (SDI) Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Metal Floor Deck with Electrical Distribution". • Roofs to perform as diaphragms shall conform to the requirements of "SDI Diaphragm Design Manual". • Deck shall be designed to generally span over three supports wherever possible. • No permanent loads shall be suspended from roof deck. • Decking shall have a minimum bearing length of 38 mm at supports. • Drawings shall include deck type, thickness in mm or gauge, minimum moment of inertia, minimum section modulus, depth and fastening requirements.
		Material	• Steel used in decks shall have a minimum yield strength of 228 MPa. • Maximum working stress under full live and dead loads is not to exceed 138 MPa. • Steel decks shall be galvanized to ASTM A446. • Roof deck shall be a minimum of 0.76 mm thick.
	STEEL JOISTS	Design and Detailing	• Shall conform to the requirements of the CSA S16.1, CSA S136, Canadian Institute of Steel Construction, (CISC) "Code of Standard Practice for Buildings" and "Steel Joist Facts". • The effects of ponding shall be investigated. • Span of steel joist shall not exceed 24 times its depth. • Size and spacing of joists should be kept uniform whenever possible. If loading increases, maintain the same size joist and reduce spacing. • Drawings shall show required joist, or joist girder, designation, spacing, bridging, and applied live load. • Concentrated loads and specified area loads due to equipment shall be noted on the drawings. • Effects of wind uplift shall be considered for joists supporting roofs. • Joists are to be designed by a registered Professional Structural Engineer registered in the Province of Manitoba.

REV	CATEGORIES	ITEMS	DESCRIPTION
	METALS	Connections	• Generally design loading shall be provided on the drawings for the fabricator to design the connections. However, where loads are not specified the fabricator will be designing connections to minimums as per specifications o Shear – 60% of beam shear resistance o Bracing – 50% of member tensile resistance o Connection bolts for metal-to-metal connections shall be to ASTM A325 for steel members; to ASTM A325 galvanized or stainless steel for galvanized steel members; and stainless steel for aluminum or stainless steel members. Minimum of two bolts per connections. Cast-in-placed anchor bolts or concrete adhesive anchors shall be used for dynamic loading or anchors close to concrete edges.
		Floor and Plate Grating	• Floor plates and grating generally to be constructed of aluminum. • Design floor plates and grating for same live load as floor. Limit deflection to the lesser of L/240 or 6 mm under design load of 4.8 kPa. • Floor plates shall have raised checker pattern or be grit surface.
		Stairs	• Stairs generally to be constructed of aluminum. • Stairs and landings shall be designed to support dead loads and a uniform live load of 4.8 kPa or a concentrated moving load of 4.5 kN. • Stringers should be 300 mm minimum depth channel or tubes to allow for installation of prefabricated treads. Smaller sections may be used for ships ladders.
		Ladders	• Ladders generally to be constructed of aluminum. • Ladder rungs shall be designed to support a 1.3 kN concentrated load applied in any direction. • Each pair of ladder support brackets shall be designed to support a 2.2 kN vertical load combined with a 2.2 kN pullout load. • Provide safety cage or climbing device when required by OSHA or owner safety requirements.
		Grating Support	• Design to support applied loads. Deflection of support shall not exceed the lesser of 12 mm or L/360. • Steel members supporting aluminum grating shall be stainless steel or hot dip galvanized. • Minimum thickness of support member at wet or exterior locations shall be 6 mm.

REV	CATEGORIES	ITEMS	DESCRIPTION

	METALS
	(Continued)
		Materials	• Structural steel - CSA G40.21, minimum 350 MPa
			• Miscellaneous steel - CSA G40.21, minimum 300 MPa
			• Round structural tubing and steel pipe - ASTM A53, grade 240, Type S, Grade B, standard wall thickness
			• Square and Rectangular Hollow Structural Shapes - CSA G40.21, minimum 350 MPa
			• Stainless Steel
			  o Exterior, submerged, and industrial uses - ISI, Type 316
			  o Interior and architectural use - AISI, Type 304
			  o Bolts and anchors - AISI, Type 304
			• Aluminum, structural shapes and plates - Alloy 6061-T6 or 6351-T6
			• Bolted connections for steel - ASTM A325
			• Anchor bolts, submerged - Stainless steel
			• Anchor bolts, non-submerged - Galvanized steel
			• Connection bolts for aluminum - Stainless steel
			• Guardrail – Aluminum
			• Grating - Aluminum or galvanized steel
			• Generally, City preference for miscellaneous items is aluminum or stainless steel versus FRP materials

	VIBRATIONS		• To avoid resonance, the natural frequency of the structure should be either less than half or greater than one and a half of the frequency of the machinery • Where possible, provide a concrete base on grade with a mass equal to ten times the rotating mass of the equipment or a minimum of three times the gross mass of the machine, whichever is greater. Where this is not possible perform dynamic analysis and design of the foundation • Large equipment bases such as pumps/ couplers/ motors will be filled with epoxy grout • Where possible isolate vibrating equipment from the structure • Recommend use of vibration isolators or dampers where appropriate • In walkway framing, use steel support beam depths greater than or equal to 1/20th of the span to minimize perceptible transient vibrations.

NOTE: Special features shall be prepared for each structure by the lead structural engineer – see following pages.

CLEARWELL – ETC – ***REVISION 0***			
REV	**CATEGORIES**	**ITEMS**	**DESCRIPTION**
	SPECIAL FEATURES *(i.e. mech, arch, etc.)*	Clearwell Roof	• Clearwell roof covered in waterproof membrane, insulation, granular drainage layer, and soil, total ~600 mm thick • Roof slopes east and west for surface drainage • Granular drainage "tunnels" to exit from perimeter slopes to be spaced at +/-5 meters all around.
		Expansion joints	• The structure will require expansion joints, quantity and locations to suit the structure configuration and overall dimensions
		Permanent underslab drainage	• Permanent perimeter weeping tile to be installed to drain to collection pits and pumped to site drainage system • A layer of granular will be placed under the base on a layer of 10 mil poly and woven geotexile.
		Cell drainage	• The Clearwell floor will be sloped from the inlet walls to the outlet corner • baffle wall will have appropriate openings to accommodate drainage
		Weir	• The inlet chamber features a weir that requires precise contouring *Note: process to provide precise contouring information*
		Emergency exits	• Each cell requires two emergency outlets which will consist of structures on top of the Clearwell roof with exit hatches and aluminum exit ladders; the structures will also feature louvers for additional air relief venting.
		Inlet Building	• The inlet corner will feature a concrete building to accommodate the operation of the gates • Building interior vertical clearance will be set at a meter above the gate operator height requirements; this has been determined to be 5 m • Boat launches: one for each of two cells is required; openings through the floor will have insulated aluminum covers • Jib crane for boat launches – two required, one for each cell • Overhead doors openings - two required. *Note: Architect input required for door size, type, operation, and specifications* • Insulated floor: mechanical recommends an insulated floor; this requires a concrete sandwich floor construction with a 100 mm (or as per mechanical requirements) and a 100 mm concrete topping

REV	CATEGORIES	ITEMS	DESCRIPTION
	SPECIAL FEATURES *(i.e. mech, arch, etc.)* (Continued)		• Gate openings: the gates will require openings directly above each one through the floor and roof for removal by mobile crane; each opening will require an insulated aluminum cover or hatch
			• Ventilation: ventilation openings and shafts are required for each cell and for the inlet chamber; shafts are to be configured with trap walls to prevent debris falling through openings into the Clearwell • Clearwell Access: each cell and the inlet chamber requires a stair access complete with insulated aluminum covers (in sections to be manually removable); stairs and landings to be constructed of aluminum
		Outlet Structure	• Sump: the outlet structure features a sump approximately 2.7 m below the main base slab and accommodates a series of outlet gates; the sump lip must have guardrailing • Each side of the sump will require shallow floor depressions for clean out pumping
			• Insulated floor: due to rapid and frequent air changes mechanical recommends an insulated floor; this requires a concrete sandwich floor construction with a 100 mm (as per mechanical requirements) and a 100 mm concrete topping
			• Gate openings: the gates will require openings directly above each one through the floor and roof for removal by mobile crane; each opening will require an insulated aluminum cover or hatch
			• Ventilation: ventilation shafts and openings are required for each cell
	CONSTRUCTION & DESIGN FEATURES	Ground Water	• Varies greatly (Spring conditions, floodway operation, holdings cells)
		Soil	• Highly plastic clays over till layer on limestone bedrock
		Temporary drainage	• Temporary drainage will be required during construction to direct water to collection system at the SW corner; slopes and ditching will need to covered with impermeable lining
		Working base	• A granular working base will be required for the installation of the piles; an impermeable liner and a geotexile will be installed under the working base
		Monorail	• City says "no"
		Crane	• See note above for Outlet Building
		Adjacent structures	• Railway to north and west, water treatment plant to east

REV	CATEGORIES	ITEMS	DESCRIPTION
	SCHEDULING	Design schedule	• 75% by April 3, done (85%) by April 18/05
		Watertightness testing	• The exterior and dividing walls will be designed as cantilever walls so that watertightness testing or backfilling can be performed before construction of the roof slab.
	UNRESOLVED MAJOR ITEMS		• Final architectural features for walls and roofs
	SPECIFICATIONS		• Specification Sections required: ○ 02223 Excavation and Backfilling for Structures ○ 02451 Pile Foundation, General (Done) ○ 02468 Precast Concrete Piles (Done) ○ 03100 Concrete Formwork ○ 03200 Concrete Reinforcement ○ 03250 Concrete Accessories ○ 03300 Cast-In-Place Concrete ○ 03345 Concrete Floor Finishes ○ 03411 Precast Concrete Wall Panels (by Architect?) ○ 03600 Grout ○ 05500 Metal Fabrications (by Architect) ○ 05530 Aluminum Fabrications (by Architect) ○ 07??? Waterproofing Membrane (Clearwell roof) ○ 146?? Jib Crane
	DRAWINGS	List	• See Master List
		Standards	• See Appendix L of QMP
		Geodetic Elevation	• Geodetic @ DBPS • Nominal base slab elevation = 230.600
WATER TREATMENT PLANT – CH2M Hill - *PRELIMINARY*			
	OTHER SPECIAL FEATURES *(i.e. process, mech, arch, etc.)*	Gates	•
		Overhead doors	•
		Ozone production	•
		Low pH levels	•

REV	CATEGORIES	ITEMS	DESCRIPTION
	CONSTRUCTION & DESIGN FEATURES	Ground Water	•
		Soil	•
		Monorail	•
		Crane	•
		Adjacent Structures	•
	SCHEDULING		•
	UNRESOLVED MAJOR ITEMS		•
	SPECIFICATIONS		• Specification sections required: ○
	DRAWINGS	List	• See Master List
		Standards	• See Appendix L of QMP
		Geodetic Elevation	• Geodetic @ DBPS
BULK CHEMICAL STORAGE BUILDING – ETC - *PRELIMINARY*			
	SPECIAL FEATURES *(i.e. mech, arch, etc.)*		•
			•
			•
	CONSTRUCTION & DESIGN FEATURES	Ground Water	• Varies greatly (Spring conditions, floodway operation, holdings cells)
		Soil	• Highly plastic clays over till layer on limestone bedrock
		Temporary drainage	•
		Working base	•
		Monorail	•
		Crane	•
		Adjacent structures	• Railway to north, water treatment plant to south
	SCHEDULING	Design schedule	•
			•

REV	CATEGORIES	ITEMS	DESCRIPTION
	UNRESOLVED MAJOR ITEMS		•
			•
	SPECIFICATIONS		• Specification Sections required:
			•
	DRAWINGS	List	• See Master List
		Standards	• See Appendix L of QMP
		Geodetic Elevation	• Geodetic @ DBPS • Nominal base slab elevation =

BUILDING MECHANICAL (HVAC)

MECHANICAL DISCIPLINE LEAD:	Alan M. Aftanas, P. Eng.
MECHANICAL DESIGN:	Dave Cuddington, P.Eng. Peter Tataryn, P.Eng. Pertti Laitinen, P.Eng.
QA and REVIEW:	John Munroe (Alternate: Chris Himsl) Formal Work Product Quality Reviewer

INTRODUCTION:

The mechanical scope of work includes the provision of mechanical building systems for the Winnipeg Water Treatment Plant. The scope of work includes the following major components:

Excluded from the mechanical scope of work are process-related mechanical systems, which will be designed by the Process Mechanical Discipline.

SCOPE AND DESCRIPTION OF STRUCTURE:

The following distinctions of work are defined for the Plumbing and Drainage Systems:

Building Mechanical Discipline to include:

- Plumbing associated with washrooms, sinks, lavatories, eyewash stations, etc. (i.e. domestic hot and cold water distribution, sanitary drainage pipes to nearest sump pit and vent piping).
- All sub-floor or sub-slab drainage piping, including floor drains (i.e. run to nearest sump pit).
- Roof drainage
- Utility water distribution for wash-down, including hose reels.

Process Mechanical Discipline to include:

- All above floor process drainage piping (e.g. drainage from a sample station to a floor drain, back-wash drains, etc.).
- Sump pumps and force-drain piping to main lift station.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS	Mechanical Bldg. Systems	• HVAC, Plumbing, Roof Drainage and Fire Protection Systems • Our intention is to build an energy efficient (Power Smart) water efficient facility. • However, this will not be a LEED registered building.
	DESIGN CODES	General	• 1995 National Building Code • 1995 National Fire Code • 1998 Manitoba Plumbing Code Regulation 161/98 • 2000 Natural Gas Installation Code CAN/CGA-B149.1-00 with Manitoba Gas Notices (Sept. 2000) • ASME Boiler and Pressure Vessel Code • Manitoba Steam and Pressure Plants Act (S210) • Manitoba Power Plants Act (P95) • Model National Energy Code for Buildings
	DESIGN REFERENCES (Standards)	General	• ASHRAE Standard 62-2004 – Ventilation for Acceptable Indoor Air Quality • ACGIH-Industrial Ventilation –Manual of Recommended Practices – 19th Edition • National Fire Protection Association (NFPA) Standards • Sheet Metal and Air Conditioning Contractor's Association (SMACNA) – Duct Construction Standards • ANSI/ISA Standard S71.04 – Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants
	OUTDOOR DESIGN PARAMETERS (for Winnipeg)	Winter	• T_{db}= -35°C (January 1%) • $T_{db\ extreme}$ = - 40°C
		Summer	• T_{db}= 31°C T_{wb}= 22°C (July 2.5%)
		Rainfall	• D= 28 mm based on 15 minute rainfall
A	**INDOOR DESIGN PARAMETERS**	WTP – Process Areas	• $T_{db\ Min.}$ = 15° C • $T_{db\ Max}$ = 30° C • Certain areas may have additional temperature constraints based on process and chemical storage requirements (e.g. chemical storage areas)

REV	CATEGORIES	ITEMS	DESCRIPTION
	INDOOR DESIGN PARAMETERS (Continued)		• RH: control to prevent condensation on pipes, insulation, equipment and building surfaces. Humidity control must address evaporation loads from open process water (require annual temperature profile for process water for design). Note: it may be difficult to prevent condensation on process water pipes under all conditions, unless the piping is insulated. For example, there may be warm humid days in the springtime when the process water is still very cold and the piping surface is below the dewpoint temperature. • Ventilation: as required by Code and as required for a) heat removal b) humidity control c) control of air contaminants.. • Space Pressure: negative relative to outdoors (2 Pa to minimize potential for migration of moisture into building envelope). • Mechanical Filtration: Remove 85% of particles larger than 1 micron.
		WTP – Pump Rooms	• $T_{db\ Min.}$ = 15°C • $T_{db\ Max}$ = 37°C • RH: control to prevent condensation on pipes, insulation, equipment and building surfaces. • Ventilation: as required to dissipate heat when pumps are running. • Space Pressure: Neutral • Mechanical Filtration: Remove 85% of particles larger than 1 micron.
		WTP – Control Room	• $T_{db\ Min.}$ = 20°C • $T_{db\ Max}$ = 24°C • $RH_{Min.}$ = 30% • $RH_{Max.}$ = 60% • Ventilation: Per code. Provide minimum 20 cfm per person in accordance with ASHRAE standard 62 and maintain CO2 levels below 800 ppm. • Space pressure: Positive relative to process spaces. • Mechanical Filtration: Remove 95% of particulates larger than 1 micron.
		WTP – Administration Areas	• $T_{db\ Min.}$ = 20°C • $T_{db\ Max}$ = 24°C • $RH_{Min.}$ = 30% • $RH_{Max.}$ = 60% • Ventilation: Per Code. Provide minimum 20 cfm per person (in accordance with ASHRAE standard 62) and maintain CO2 levels below 800 ppm. • Space Pressure: Positive relative to process spaces. • Mechanical Filtration: Remove 95% of particulates larger than 1 micron.

REV	CATEGORIES	ITEMS	DESCRIPTION
	INDOOR DESIGN PARAMETERS (Continued)	WTP - Electrical Rooms	• $T_{db\ Min.}$ = 15° C • $T_{db\ Max}$ = 26° C • $RH_{Min.}$ = 30% • $RH_{Max.}$ = 60% • Ventilation: as required to dissipate heat (utilize free cooling). • Space Pressure: Neutral • Mechanical Filtration: Remove 85% of particles larger than 1 micron.
		WTP - Mechanical Rooms	• $T_{db\ Min.}$ = 20° C • $T_{db\ Max}$ = 30° C • $RH_{Min.}$ = 30% • $RH_{Max.}$ = 50% • Ventilation: Per code. Provide combustion air and vent for rooms with gas fired equipment in accordance with Gas Code. Provide ventilation as required to dissipate heat (utilize free cooling). • Space Pressure: Neutral • Mechanical Filtration: Remove 85% of particles larger than 1 micron.
		Bulk Chemical Storage Building	• Winter: $T_{db\ Min.}$ = 20° C • Summer: $T_{db\ Max}$ = 30° C (or as required to maintain stability of chemicals) • RH = control to prevent condensation on pipes, insulation, equipment and surfaces. • Ventilation: as required by Code. Provide capability for at least 6 ACPH of outside ventilation air. • Need to determine nature of chemicals to determine ventilation and containment (drain) requirements. • Space Pressure: Slight negative relative to outdoors (2 Pa). • Mechanical Filtration: Remove 85% of particles larger than 1 micron.
		Valve Chambers	• Winter: $T_{db\ Min.}$ = 10° C • Summer: $T_{db\ Max}$ = 38° C • Ventilation: These spaces will require "confined space entry" procedures. Provide ventilation to dissipate heat.
A	**HVAC STRATEGIES**	WTP – Process Areas	• Natural gas fired air handling equipment with capabilities to provide outdoor air for humidity control. • Separated combustion natural gas fired unit heaters for perimeter heating, as required (Evaluate if hydronic system makes sense). • Direct air flow from grilles away from open water

REV	CATEGORIES	ITEMS	DESCRIPTION
			surfaces to minimize evaporation.
	HVAC STRATEGIES (Continued)	WTP – Pump Rooms	• Natural gas fired air handling equipment with capabilities to provide outdoor air for ventilation and heat dissipation. • Separated combustion natural gas fired unit heaters for perimeter heating, as required.
		WTP – Control Room	• Water to air heat pump system using process water as energy source/sink. Provide secondary loop to eliminate potential for cross-contamination. • Fresh outdoor air to be provided via make-up air system. One make-up air system may be able to supply the Control Room and the Administration areas. • Provide natural gas boiler and fluid cooler as back-up. Possibly locate the boiler in central mechanical room. • Variable air volume air distribution to reduce fan energy consumption. • Provide CO2 control systems.
		WTP – Administration Areas	• Water to air heat pump system using process water as energy source/sink. Provide secondary loop to eliminate potential for cross-contamination. • Fresh outdoor air to be provided via make-up air system. One make-up air system may be able to supply the Control Room and the Administration areas. • Provide individual heat pump for each zone. • Provide natural gas boiler and fluid cooler as back-up. • Variable air volume air distribution to reduce fan energy consumption. • Provide CO2 control systems.
		WTP - Electrical Rooms	• Water to air heat pump system using process water as energy source/sink. Provide secondary loop to eliminate potential for cross-contamination. Use heat exchanger with process water circulating on one side of the HX and the heat pump loop on the other side. • Heat pump loop connected to administration/control room system to provide heat recovery from electrical rooms.
		WTP - Mechanical Rooms	• Provide combustion air and vent ducts per Gas Code. • Provide ventilation as required to dissipate heat (utilize free cooling). • Separated combustion natural gas fired unit heaters for perimeter heating, as required.

REV	CATEGORIES	ITEMS	DESCRIPTION
	HVAC STRATEGIES (Continued)	Bulk Chemical Storage Building	• Provide steam boiler for steam cleaning chemical rail cars. • Steam or natural gas fired air handling equipment with capabilities to provide outdoor air for humidity control. • Separated combustion natural gas fired unit heaters for perimeter heating, as required.
		Valve Chambers	• These spaces will require "confined space entry" procedures. Provide ventilation to dissipate heat only (if required). • Provide electric heater for temperature control.
A	**BUILDING ASSEMBLY**	HVAC Equipment	• Robust/Industrial Components • Natural Gas Fired Equipment – indirect fired • Mechanical Cooling • No R-22 refrigerant. • No canvas recovery jacketing (PVC or Aluminum only)
		HVAC Control System	• HVAC systems to be controlled by plant SCADA system with HMI located in Control Room. • HVAC systems to have their own graphics. • Instrumentation and controls to be commercial grade (e.g. Belimo), and compatible to SCADA I/O protocols (e.g. 4-20 mA). • Develop HVAC P&ID's for SCADA system tie-ins with I&C group.

		Additional HVAC Suggestions for Consideration	• The following concepts to be considered:
			    ○ Central Plant to service WTP Process area air handling equipment
			    ○ Condensing boilers
			    ○ Heat Recovery from Ozonation Equipment
			    ○ Heat Recovery from Electrical Rooms
			    ○ LEED Registration.

		Fire Protection	• Sprinklers and standpipe system as required by Code review. • Sprinkler and standpipe systems to operate on raw water. Suitable pressures to be provided via Fire Pumps. • Provide Siamese connection for Fire Department Connection to yard hydrant system. • Provide Fire extinguishers as required.

REV	CATEGORIES	ITEMS	DESCRIPTION
	BUILDING ASSEMBLY (Continued)	Plumbing	• Low flow fixtures • Dual Flush Toilets • Wall hung flush valve urinals. If approved by COW use waterless urinals to conserve water.
		Potable Water	• Supply from Deacon Booster Pumping Station after final UV treatment.
		Utility Water	• Utility water system shall be separated by back-flow preventer from potable water systems.
		Sanitary Drainage System	• Sanitary wastes to be gravity fed to sump pits. • Sump pits will be pumped by force mains into the central lift station (design by Process Mechanical). • Sump pumps in the gallery areas for drainage, connected to the sanitary system. • May need sewage tanks with grinder type lift pumps for washrooms (gravity flow is better if we can make it work). • Heavy duty floor drains. Floor drain system to connect to sanitary system. • Funnel floor drains to be connected to sanitary system.
		Process Drains (and floor drains)	• Process drains to be designed by Process Mechanical Discipline. • Process drains for sampling stations to return to Residuals Management Area.
		Roof Drainage	• Internal roof drainage discharge to rainwater leaders discharging to grade.
	MAJOR UNRESOLVED ISSUES		• Electrical clarification in Chemical Building. Need MSDS sheets for chemicals stored. • Need to resolve locations of sump pits.
	APPROVED SUPPLIERS		• Pumps: ? • Valves: ? • Air Handling Units: ?
	ELECTRICAL LOADS SUPPLIED TO OTHERS		• To be supplied to Electrical
	WEIGHT LOADS SUPPLIED TO OTHERS		• To be supplied to Structural

REV	CATEGORIES	ITEMS	DESCRIPTION
	SCHEDULING		• Refer to CM Issue
	DRAWINGS	Refer to Master List	• Legend Page • HVAC Schematics • HVAC Plans & Sections • Hydronic Plans & Sections • Plumbing Plans & Sections • Roof Plan • Details

PROCESS MECHANICAL

LEAD DISCIPLINE PROCESS MECHANICAL:

PROCESS MECHANICAL DESIGN:

QA and REVIEW:

INTRODUCTION:

SCOPE AND DESCRIPTION OF SYSTEMS:

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS		
	SYSTEM OF MEASUREMENT		
	DESIGN CODES		
	DESIGN REFERENCES		
	DESIGN PARAMETERS		
	SERVICE REQUIREMENTS		
	CONSTRUCTABILITY CONCERNS		
	CONSTRUCTION & DESIGN FEATURES		
	SCHEDULING		
	UNRESOLVED MAJOR ITEMS		
	SPECIFICATIONS		
	DRAWINGS		

DESIGN BASIS
ELECTRICAL

REVISION 0

DISCIPLINE LEAD ELECTRICAL:	Petr Stryk, P. Eng. - ETC
ELECTRICAL DESIGN:	Garrett Norsworthy/Shirley Xue Chen – ETC James Thannickal /Larry Llewellyn – CH2M Hill
QA AND REVIEW:	Brian Lockhart, P. Eng. – ETC Lyle Taylor – ETC XXX XXXX – CH2M Hill

INTRODUCTION:

The following electrical design brief for the Winnipeg Water Treatment Plant (WWTP) is based on the scope of work identified in the proposal document and currently referenced in the project plan. This document provides design basis for major electrical design aspects for the Winnipeg Water Treatment Plant.

SCOPE AND DESCRIPTION OF ELECTRICAL SERVICE AND SITE DISTRIBUTION:

The WWTP facilities are the Water Treatment Plant, Clearwell, Bulk Chemical Storage Building, Generator Building, Yard Piping Valve Chambers, Electrical Substation, and other ancillary structures (transformer pads, lagoon dewatering pump station, inlet and outlet distribution chambers).

The main 66 kV supply voltage from Manitoba Hydro will be transformed to 4160 V and then distributed throughout the (WWTP) site, including the existing Deacon Booster Pumping Station (DBPS). Two new service transformers and a main 5 kV electrical room will be located northwest of the proposed clearwell and the proposed WTP. From the 5 kV electrical room, the 4160 V power will be distributed to the Administration Building electrical room, to another electrical room in the Hypochlorite generation building, and to the existing DBPS.

Several 5kV/600V transformers will be installed through the site to provide 600 Vac for most of the process loads and for the building mechanical loads. Small equipment, instruments, lighting and the control system will be powered from 600/120/208 transformers and corresponding distribution system.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS	Main Service Capacity	• 400 MLD, provisions for 600 MLD
		System Reliability and Redundancy	• All major components shall be 100% redundant and shall be sized to carry normal load and the load of failed counterpart.
		On site power generation capacity	• One process train (200MLD) to be on standby power; no separate standby power distribution; control system will lock-out certain loads during a power failure.
		Recovery after a failure	• Closed transition; bump-less re-transfer after a failure.
	DESIGN STANDARDS AND CODES (Latest Editions unless noted otherwise)	General	• Canadian Electrical Code (CEC) and all local amendments. • Canadian Standards Association (CSA) • CSA C22.1-02 Safety Standard for Electrical Installations • Electrical and Electronic Manufacturers of Canada (EEMAC) • Institute of Electrical and Electronics Engineers (IEEE) • Insulated Cable Engineer's Association (ICEA) • American National Standards Institute (ANSI) • Illuminating Engineering Society (IES) • National Electrical Manufacturers (NEMA) • American Society for Testing and Materials (ASTM) • National Fire Code of Canada (TBConfirmed) • Underwriters Laboratories of Canada (ULC)
		Hazardous locations (if applicable, i.e. chemical building) Fire Alarm System (if required)	• NFPA XXX? • CAN/ULC Standards
		Harmonic Control	• IEEE 519
			•
			•
			•
			•

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS	Electrical System Capacity, future considerations	• 400 MLD, provisions for future 600MLD
		Equipment sizing and feeder capacity	• Dual feed to all major distribution centers • All components sized to carry normal load and load of failed counterpart • Split bus with tie breaker normally open •
		System flexibility, ease of maintenance	• Switching scheme to isolate faults. • Switching scheme to isolate equipment for regular maintenance • TBC
		Service Ground	• Resistance Grounding with monitoring instruments
		Voltages	• Utility 66kV • Site Distribution 4160 V • Motors above 350HP 4160V • Motors ¾ - 350 HP, building and process loads 600 V • Motors up to ½ HP 120 V • Transformers 5 kV/600 V/347 3 phase, 4 wire; transformer secondary neutral points shall be solidly grounded wye • 120/208V 3 phase, 4 wire; transformer secondary neutral points shall be solidly grounded wye • Fluorescent, metal halide, high-pressure sodium, and incandescent lighting shall be 120-volt, for **specific** situation 347V. • Heaters up to 1,500 W, convenience outlets, motor controls, and motors less than 3/4 horsepower (hp) 120-volt. • Heaters above 1,500 W 600V • No single phase L-N loads to be supplied directly from secondary of 600V transformers; - **to be discussed.**
			•
			•
	DRAWINGS	Legend Sheet	• symbol/legend sheet to contain symbols and abbreviations used in the drawing set • TBC
		Site Plans	• Will show the location of all facilities and major equipment, duct banks routes and manholes

REV	CATEGORIES	ITEMS	DESCRIPTION
	DRAWINGS (Continued)	Single Line Diagrams	• Will show distribution system from its point of service to 600V utilization devices and 120/208V panelboards. Circuiting of 600V panelboards for major loads shall be shown on the single line diagram; circuiting of 600V, 120/208V panelboards will be shown on drawings in the typical 3-line format. • Included will be bus capacity, short circuit fault ratings (kA), overcurrent device types and ratings, breaker frame and trip ratings, protective relay types and ratings, metering and load ratings (kilowatt).
		Elevations	• Will shown medium voltage switchgear, low voltage switchgear, and 600V motor control centers. It will show locations of starters or breakers within an MCC or panel, door mounted relay devices, metering, and conductor entrances. Show MCC units with extra height where required for relays
		Motor control schematic diagram (MCSD)	• Will show control circuit devices. Motor Schedule with a table listing control devices can be used • Momentary or maintained control to be considered with process engineer – main issue is restart after a power failure. • The following control devices shall be shown on the MCSDs o HOA switch (where required) o START/STOP Push Buttons (where required) o ETM o Ground fault relays o Metering o Motor thermal devices o ON/OFF and ALARM status lights o Motor CT's o Ground fault CT's o ESD o Line disconnect • Control devices 1 through 9 as listed above to be located in motor controller (i.e motor starter, soft starter, VFD) • Control devices 10 (ESD) and 11 (Line disconnect) as listed above shall be located in the field by the process equipment. • HVAC equipment control will be provided by Div. 15

REV	CATEGORIES	ITEMS	DESCRIPTION
	DRAWINGS (Continued)	Schedules to be provided	• Luminaire Schedule for 1. Process areas 2. Corridors 3. Offices areas 4. Any other? • Panel Schedules; in a 3-line format. A separate panel will be provided for each facility for the power supply to process related instruments and equipment. In smaller facilities, this panel may be subfed from the lighting panel but in larger facilities it shall be fed from a transformer that is separated from the building facilities power supply. Where sensitive instruments need to be powered from facilities that also contain variable frequency drive systems, a shielded transformer shall be provided to power them. In other facilities the panel may be subfed from the lighting panel.
		Details	• Details will be numbered. A preliminary set of design details will be selected and a copy of each will be provided to each design team member. All detail that are being used will be in the book. Details will be the ET-CH2M standard details. To be discussed.
		Process and Facility Plans	• Will show the location of and connection to all equipment, which require raceway or conductors. A separate connection point shall be shown for each device located within a process area even if they are all supplied as part of the same package unless the specifications clearly require that all of the devices are to be wired to a single panel or TJB by the supplier of the equipment. Spare raceway for future equipment shall also be shown and clearly labelled, where appropriate. On the facility plan show receptacles, lights, water heaters, HVAC equipment and other non-process loads.
		Connection to I&C Provided Equipment	• All instruments individually fused (breakers or Weidmuller knife-style fused terminals) • All control loops individually fused (Weidmuller knife-style fused terminals) • All I/O points (Weidmuller knife-style fused terminals) • 24 VDC power supplies to be fully redundant; if one unit fails it shall not effect the operation of the redundant unit; power supply failure shall be alarmed and operator shall be notified. • Final connection to all I&C supplied equipment will be shown on the drawings as being made by the electrical subcontractor; to be coordinated with I&C Division.

REV	CATEGORIES	ITEMS	DESCRIPTION
	ELECTRICAL EQUIPMENT CONSIDERATION	Equipment identification	• The following equipment will be identified 1. Motor control centers 2. Panelboards 3. Distribution panelboards 4. Switchgear 5. Terminal junction boxes **6.** Cables to be identified with cable #; and with “from” (power source; panel & circuit #) “to” (power destination; panel & circuit #) information. **Information to be provided on Cable Schedule).** • Use mechanically attached Lamacoids • Use encircled wire markers for cable identification. • Other equipment may be identified if identification is required for other purposes
		As built Single Line Diagram	• As built Single Line Diagram shall be provided as full size drawing in each electrical room.
		Distribution System Protection	• The following types of protective devices shall be used 1. 66 kV main switchgear assembly- Fused load break switches 2. 4,160 volt motor control--drawout type vacuum contactors in NEMA 1 gasketed enclosure, one-high construction 3. 600V main, tie, and feeder circuit breakers in new switchgear assemblies, 100% rated power circuit breakers with solid state trip units 4. 600V motor control center main circuit breakers--moulded case thermal magnetic breakers 5. 600V motor control center tie breakers – moulded case circuit breakers 6. 600V motor control center branch circuit and breakers (other than combination motor starters)--moulded case thermal magnetic • Equipment shall have adequate momentary and interrupting capacity to withstand fault currents that may occur at the point in the system where the equipment shall be applied • Main breakers and tie breakers (moulded case circuit breakers) on MCC’s shall be 100% rated breakers. These shall still be represented with a frame and trip rating. If the trip rating does not match the size of a frame rating, then the breaker shall still be a 100% rated breaker, however, with a smaller trip unit • Each circuit breaker that is located immediately downstream from the secondary main on a 600V secondary transformer shall be equipped with ground fault protection unless that circuit is rated 1000A or less

REV	CATEGORIES	ITEMS	DESCRIPTION
	ELECTRICAL EQUIPMENT CONSIDERATION (Continued)		• Each circuit breaker protecting a motor of 100 horsepower or more shall be equipped with ground fault protection • Ground fault protection on motors shall be instantaneous type and ground fault protection on main breakers and feeder breakers shall be equipped with time delay setting and restraint systems • Coordination Study shall be provided. • Any other?
		Motor Protection and Control	• Magnetic only circuit breakers shall be provided as a branch circuit protection in motor starters for all motors 50 hp and smaller. Branch circuit protection for larger motors shall be provided by thermal magnetic breakers with adjustable magnetic trips • Each motor shall be provided with thermal overload protection in all ungrounded phases. Controller-mounted relays shall have external manual reset. For motors with motor starters, the overload protection will be in the motor starter. For fractional horsepower equipment not normally requiring motor starters, manual motor starters with overload protection will be added. Some small equipment such as ceiling fans will have overload protection integral with the motors • Internal temperature detectors embedded in motor windings shall be specified for motors of 50 hp and larger including motors that are powered by a variable frequency drive. Temperature detectors in motors shall be equipped with thermistors, motors larger than 300HP shall be equipped with RTDs. Multi-function protective relays, GE Multilin SR469, for overload, phase protection, and ground fault protection shall also be provided on 4160 volt motors • All motor control circuits shall operate at 120 volts and shall be supplied by individual control power transformers fused both phases in the primary and one phase on the secondary side. Secondary neutral tied to ground • Electrical motor starter control shall normally consist of indicating lights, pushbuttons, or switches. Devices connected with process controls, such as timers and auxiliary relays, shall be provided in instrumentation and control panels or operated by a programmable logic controller as part of its internal control logic. This will be coordinated with I&C for each item • Indicating lights shall be push to test style • Starter control will be typically "HOA" "Start/Stop". Momentary or Maintained type of control needs to be determined on individual basis, depending on the application. • All Motor Starters shall be NEMA rated

REV	CATEGORIES	ITEMS	DESCRIPTION
	ELECTRICAL EQUIPMENT CONSIDERATION (Continued)	Motor Control Center	• MCCs will use design around Square-D or approved equal, but use the same manufacturer for all designs. • Vacuum breakers shall be used in 5kV distribution, (i.e.5 kV motor starters) – to be finalized • Spares and spaces should be allowed – to be determined - to the identifiable spares required for known future equipment. Allow space for at least one future section at each MCC. • Include digital Power Monitoring Instrument capable of measuring, calculating and displaying V, I, Fr, PF, kVA, kVAR, kW, tot kWh, kW demand, I demand, kVA demand. • Other??
		Equipment Disconnects	• Provide disconnects where required at process equipment. • Disconnects for motor-operated valves and gates will be specified as integral disconnects • Integral disconnects shall be provided with process equipment as a standard option where available. • Provide disconnect switches for all HVAC equipment that has any integral controls (i.e. unit heaters, compressors, duct heaters, air handlers, etc.). • Provide a local disconnect for all hoisting equipment overhead cranes, and motor operated rollup doors • For VFD's fed from MCC's, the lockable disconnect at the VFD is adequate • Motor rated toggle switches shall be used for small motors; Regular disconnect switches shall be shown for larger pieces of equipment • Disconnects for HVAC equipment that requires HACR rated devices shall be fused safety switches
		Panel boards	• Generally, provide a separate circuit breaker for each instrument or control element • Where multiple instruments or control elements are connected to a single-branch circuit, a fused disconnect switch shall be provided for each instrument / control element. • Identify all branch circuits or feeders on the drawings • Lighting panel boards shall be surface-mounted, 120/208V, 3 Ph, 4-W type with the main circuit breaker sized to match the lighting transformer capacity. • Separate panel boards shall be provided to supply power to instruments and control panels where the equipment to be supplied requires a conditioned power supply. **UPS shall be considered as power conditioner**. • Each panel board shall be with a minimum of 20 percent spare breakers, spaces, bus work, and terminations.

REV	CATEGORIES	ITEMS	DESCRIPTION
	ELECTRICAL EQUIPMENT CONSIDERATION (Continued)		• Panel board schedules shall show the circuit description, protective device trip rating, number of poles, rating of main lugs or main circuit breaker, neutral bus size, ground bus size, and interrupting rating of breakers. Computer-generated panel board schedules shall be included in the drawings
		Convenience Receptacles	• Shall be spaced not more than 15m apart inside all process building and 20m apart in outside process areas and shall be located on the surface of walls or columns • Shall be located as needed in office/corridor areas – generally 15 m O.C. in corridors and as required in offices. • Shall have separate neutral conductor for all non-linear loads (computers, lighting using ballasts.) • Washroom and outdoors receptacles shall be ground fault protected • Receptacles in washdown area – shall be 1.5 m AFF mounted in angled device boxes with WP covers and GFI breakers.
		Welding Receptacles	• Welding Receptacles shall be in all process areas • The Receptacles shall be **XXX** m apart – to be discussed • The Receptacles shall be Crouse Hinds – model number to be finalized •
		Variable Frequency Drives	• Variable frequency drives will be standard 6 pulse units to 75hp, 75hp and greater to be minimum 12 pulse. • VFDs shall be supplied with minimum 3 % line reactor, Mirus filter or phase shifting transformer for 12 or higher pulse system. • VFDs shall be ABB ACS drives – client preference. • VFDs shall be supplied with process equipment where practical. Equipment supplier shall be responsible for matching the VFD with motor, including dV/dT filters and inverter duty motors. • VFDs smaller than 40HP will be located within the MCC and 40HP and above will be located outside the MCC in its own cabinet
		Soft Starters	• Generally for motor loads 200 HP and above, soft starters to be used – subject to further discussion. • Soft Starters shall be supplied with bypass contactor and with a contactor for a power factor correction capacitor. • Design around Benshaw – client preference • Use of soft starters may not be suited for all applications; individual evaluation and justification will be required. – Comments?

REV	CATEGORIES	ITEMS	DESCRIPTION
	ELECTRICAL EQUIPMENT CONSIDERATION (Continued)	Harmonic Control and Power Factor Correction	• Filters, line reactors shall be specified and supplied with VFDs • Harmonic Analysis shall be done after the electrical system has been commissioned • Based on the Harmonic Analysis a Detuned Power Factor Correction System with Harmonic Filters may be provided.
	STANDBY POWER		• Standby power capacity for one process train (app. 5MW) • Generator voltage 4160 V; generators will be connected to the main 5 kV bus • Generators will be synchronized with each other and with the utility • No separate standby power distribution on site. The entire plant could be powered form the generators. • Control system will lockout pre-selected el. loads when utility power fails and generators provide power to the plant.
			•
	UPS POWER		• One UPS unit per Electrical/Control room or process area; exact location to be discussed; • No single UPS unit for the entire plant. • No single UPS unit per control panel. • Each UPS shall be true-online with static and maintenance bypass. • Distribution panel shall be provided with each UPS
			•
	POWER SMART	Motors	• High efficiency motors •
		Lighting	• High efficiency electronic ballasts • Occupancy sensors and control – motion detectors to be finalized
		Feeder Size	• Minimize losses, increase size of long feeders
		Other?	•
			•

REV	CATEGORIES	ITEMS	DESCRIPTION
	WIRING METHODS	Raceways: general guidelines for sizing, selection, and installation	• Cable tray the preferred raceway method • Cable tray shall be rigid Aluminum ladder type in process areas; follow installation guidelines, no contact with concrete. • If conduit is used: 1. In process areas, it shall be rigid aluminum; follow installation guidelines, no contact with concrete. 2. In non-process (i.e. office) areas: Concealed conduit shall be EMT. Exposed conduit shall be rigid steel up to 1.5 m above finished floor in dry areas, otherwise EMT. • Exposed raceways shall be installed in process areas. • Concealed raceways in walls and ceilings shall be installed in control rooms, offices, and all areas with finished interiors • Exterior, underground, concrete-encased, direct-buried conduit shall be schedule 40 PVC • The minimum diameter of exposed conduit in all areas shall be 19mm. Raceways in duct banks shall not be smaller than 52mm • Embedded and buried nonmetallic conduits shall be converted to metallic conduit before existing from masonry or earth and galvanized steel shall be used at all bends greater than 30 degrees; **All embedded and buried nonmetallic conduits shall be accurately documented and shown on as-built drawings; All stub-ups shall be identified with "From" "To" information**. • Duct banks shall include a minimum of two spares. In all cases, provide duct bank sections • The number of conduit bends shall be limited to an equivalent of 270 degrees on long runs • Conduit runs, junction boxes, and exposed wall penetrations should not be used on building exteriors
		Wire and Cable	• Copper conductors shall be used for all lighting, power and control wiring. • Minimum No. 12 AWG for power, minimum No. 14 AWG for control. • The current carrying capacity of conductors shall be based on 90°C insulation ratings for all circuits • Insulation shall be chemically cross-linked, thermosetting polyethylene, and, unless otherwise specified, rated RW90, or RWU 90, 1000 V.

REV	CATEGORIES	ITEMS	DESCRIPTION
	WIRING METHODS (Continued)		• Cable shall be Teck 90; if Teck cable is not installed in cable tray, then it shall be properly supported – **to be finalized.** • Power conductors will typically be 3C cable. Unless absolutely necessary, the largest 3C cable will be 500MCM and the largest 1c cable will be 750MCM. • Bonding and Grounding conductors shall be insulated, minimum #12 AWG; No conduit shall be used for bonding / grounding. • Any other?
		Neutral Sizing and Wiring	• All 120 VAC circuits shall use dedicated neutral • Any neutral size reduction to **be discussed** – harmonic control
	LIGHTING	Lighting levels	• Lighting levels in various areas shall be calculated as recommended in the Illumination Engineering Society (IES) handbook. • The following minimum foot-candle level shall be provided: 1. Office 70 2. Process, inside 30 3. Process, outside 5 4. Storage, inside 10 5. Walkway, corridor 10 6. Walkway, outside 2 7. General site 1 • The following general types of light source shall be used to provide the proposed foot-candle levels: 1. Office Fluorescent 2. Process, inside to 3.5 m Fluorescent 3. Process, above 3.5 m Metal Halide 4. Storage, inside Fluorescent 5. Walkway, corridor Fluorescent 6. Walkway, outside Metal Halide 7. General site Metal Halide • Lighting controls for areas that require more that 3 switching location shall be low voltage remote control wiring system type • All luminaries in indoor non-process areas shall be accessible by step ladder – **to be finalized for process areas.**
		Battery packs	• In all electrical rooms • As required by code – to be finalized
		Exit lights	• As required by codes - to be finalized • Exit lighting to be self powered

REV	CATEGORIES	ITEMS	DESCRIPTION
	SURGE PROTECTION	General	• Shall utilize non-linear voltage dependent metal oxide varistors or selenium cells • Shall not utilize gas tubes, spark gaps, or silicon avalanche diodes
		Protection levels	• Main panel • MCC • Branch panel • Individual Equipment/ UPS shall be used for instruments. • To be finalized
	FIRE ALARM		• Shall be installed in accordance with CAN/ULC S524 Standard for Installation of Fire Alarm Systems
			•
	SECURITY SYSTEM		• To be finalized
			•
	TELEPHONE SYSTEM		• To be finalized • CAT 5E based • BL to discuss
			•
	LAN FIBER OPTIC	Division 17 to address	•
			•
	TBD		•
			•
NOTE:			

INSTRUMENTATION AND CONTROLS

DISCIPLINE LEAD I&C: Stephen Tormey, P. Eng.

I&C DESIGN: **Blair Moore, P. Eng., Brian Larson, Neal Toulson**

QA AND REVIEW: **Mike Sell?**

INTRODUCTION: The design of the instrumentation and controls systems encompasses the selection and installation guidelines for all instrumentation required to monitor the water treatment process, the design of the plant control system and the design of the operator interface to the plant control system. Instrumentation and Controls design will proceed according to the parameters laid out in the Automation Guidance Document (AGD) while incorporating basic I&C philosophies to produce a design that provides functionality, reliability, modularity (ability to expand) and ease of maintenance.

SCOPE AND DESCRIPTION OF THE CONTROL SYSTEM: The water treatment plant control system will actually consist of two networks: a control network and an operator interface network. Each network will be a fully redundant Ethernet based network. Data will flow from one network to the other via redundant server computers that collect data from the plant control network and serve it to the Human Machine Interface (HMI) computers on the operator interface network. Modicon based PLCs will be utilized as the primary process controllers and will reside on the plant control network. Local HMI computers will be provided in each process area and will reside on the operator interface network. By segregating the two networks, we believe that inter device communication and resulting plant control can be achieved in a more efficient manner.

A third device level network is currently being considered. This network would interface between intelligent end devices and PLCs. The addition of such a device network would make more end device information available to the control system than traditional hard-wiring. At this point in time, Modbus/TCP and Profibus-DP protocols are being considered because these protocols are more widely accepted at the device level than the other protocols that Modicon offers interface modules for. The device level network will probably be limited to electric actuators, variable speed drives and power metering.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN BASIS	Operator Interface Network	• Ethernet. Modbus/TCP protocol. • OPC if and when required. • Windows Operating System. • Hot Standby • Redundant Server machines
		Control Network	• Ethernet. Modbus/TCP protocol. • Modicon PLC based. • Hot/Standby Processors • Remote I/O • Redundant communication cabling.
		Level of Automation	• Remote plant control/monitoring from a centralized control room will be the norm. As such, all parameters necessary for complete plant control/monitoring will be available on the operator interface network. • Local motor control will also be available. • Smart devices will be used where appropriate
		Interface to other Networks	• Firewall between the Regional Water Distribution SCADA and the Operator Interface Network. • Institute a Demilitarized Zone (DMZ). Both networks can read/write to DMZ but do not have direct access to each other.
		Automation Guidance Document (AGD)	• Remote Control/Monitoring of all parameters required for plant operation. • Flow pacing and flow metering of chemical feed systems. • Automatic filter backwash and backwash timing logic. • Extensive use of online analyzers. Analyzers to be specified with fault detection. Prudent use of redundant analyzers. • UPS for main shutdown valves, critical sensors and transmitters, control system. • Automatic shutdown systems • Self-healing network (redundant paths) with fibre optics between network switches. • Virus Protection Software • 21 Steps to Improve Cyber Security of SCADA Networks. • Room for a Test Lab along side the engineering workstation(s) will be provided in the programming/configuration office. • Redundant Data Centers – preferably in two separate buildings.

REV	CATEGORIES	ITEMS	DESCRIPTION
	SYSTEM OF MEASUREMENT	Metric	• Level: mm, m • Flow: l/s, Ml/day • Pressure: kPa • Valve, Gate Position: % Open • Speed, Frequency: % Max. • Temperature: Deg C. • Power: kW
	DESIGN CODES		• **C22.1-02**: Canadian Electrical Code, Part I • Local Amendments to the Canadian Electrical Code. • Canadian Standards Association (CSA)
	DESIGN REFERENCES		• **IEEE 100-88:** Dictionary of Electrical and Electronic Terms • **ISA RP12.6-87:** Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations • **ISA-S5.1-1984(R1992)**: Instrumentation Symbols and Identification. • **ISA S5.4-76:** Instrument Loop Diagrams • **ISA S51.1-79:** Process Instrumentation Terminology • **NEMA 250-85:** Enclosures for Industrial Controls and System • **NEMA ICS 1-88:** General Standards for Industrial Control and Systems • **NEMA ICS 2-88:** Industrial Control Devices, Controllers, and Assemblies • **NFPA 70-1999:** National Electrical Code (NEC) • **SAMA PMC 17-10-63:** Bushings and Wells for Temperature Sensing Elements • **UL 1012-89:** Power Supplies • **Marshall, Perry S. & Rinaldi, John S.:** Industrial Ethernet 2nd Edition, ISA, 2005
	DESIGN PARAMETERS	Operator Interface Network	• Enterprise class Historian • Redundant Application Servers • Redundant Terminal servers hosting centralized operator interface. • Engineering workstation. • Local HMI's resident in each process area. • HMI Monitors: 20" LCD • Network Switches: Industrial Grade • Password determines Levels of Access • Fibre optic communication between buildings
		Firewalls	• Intrusion Detection Systems

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS (Continued)	Control Network	• Will attempt to segregate duty/standby systems so that the duty I/O resides on a separate module from the standby I/O. • Fibre optic communication between buildings
		I/O Types	• Motor Discrete I/O: Isolated 120 VAC inputs and outputs. • Other Discrete I/O: Non-isolated 120 VAC Inputs and outputs. • Hard wired Analog I/O: 4-20 mA
		Typical I/O	• 4160 V Motor Starters: Start Command, Stop Command, Running Status, Stopped Status, Computer (Auto) status, Motor Tripped Status, 4-20 mA Current feedback. • FVNR Motor Starters, 600 V and below: Start command, Run status, Computer (Auto) status, Ready status • Variable Speed Drives: 4-20 mA Speed control, 4-20 mA Speed feedback, 4-20 mA Current feedback, Start command, Run status, Computer (Auto) status, Ready status • Electric Actuators, non-modulating: Open command, Close command, Computer (Auto) status, Open status, Closed status • Electric Actuators, modulating: Computer (Auto) status, Open status, Closed status , 4-20 mA Position control, 4-20 mA Position feedback, • Transformers: Winding temperature high alarm and trip status, Oil temperature high alarm, Oil level low alarm, Vacuum pressure high alarm, Grounding resistor circuit open alarm. • Generator Sets: Engine Running Status, Radiator fan Running Status, Computer (Auto) status, Generator Alarm status, Generator Fault status, Radiator fan Fault Status, Transfer Switch in Generator Position Status, Transfer Switch in manual bypass position Status. Building/Enclosure temperature and ventilation I/O TBA. • Transmitters: 4-20 mA process feedback, Fault status • Unmanned buildings: Motion detected alarm, Door switch operated alarm. • Fire Alarm Panel: Fault status, fire detected status. • Power Meters: Volts, Amps, kW, kVA, kVAR, Hz, Harmonic Distortion - All via Modbus/TCP interface. Fault Status hardwired. • UPS: System normal status, Bypass not available status, On Battery status, On Bypass status, Shutdown Imminent Alarm. • TVSS: Surge Protection Device Fault status.

REV	CATEGORIES	ITEMS	DESCRIPTION
	DESIGN PARAMETERS (Continued)	I/O monitored via proposed device level network	• 4160 V Motor Starter motor management relay (Multilin): Type of trip and bearing temperature alarms. • Variable Speed Drives: Control and Statuses as outlined above. • Electric Actuators, modulating: Control and Statuses as outlined above. • Generator Sets: Status' outlined above. Individual alarm and fault statuses such as low oil level, low fuel level, etc. instead of Common Fault & Alarm statuses. • Power Meters: Status' outlined above. • UPS: Status' outlined above.
		PID's	• Follow standards generated at pre-design stage. • ISA standards for instrument device identification will be followed.
	SERVICE REQUIREMENTS		• Modicon PLC's will be hard-specified.
	CONSTRUCTABILITY CONCERNS		• Interface between Regional Water Supply SCADA and WTP interface network must address security concerns.
	CONSTRUCTION & DESIGN FEATURES	Control System	• The control system will be split into 2 networks: An operator interface network and a control network. The interface between the two networks will consist of a pair of server computers that will provide real time fail-over in the case of a fault on the primary server. • Communication redundancy will be provided for both networks in the form of redundant cables, network switches and interface modules. • Local HMI and controllers will be provided at each primary process area.
	SCHEDULING	Control System Network Design	• Commences Immediately
		Generation of Templates for Lists, ILD's etc.	• Commences Immediately
		Instrumentation Design, wiring and Interface to control system.	• Commences at 70-80 % completion of process design.

REV	CATEGORIES	ITEMS	DESCRIPTION
	UNRESOLVED MAJOR ITEMS		• Regional Water Supply SCADA control room relocation. • Would like direction from the City regarding requirement for redundant data centers and need for these centers to be located in separate buildings. Due to the required speed of communication between main and backup servers, do not believe the infrastructure is in place to locate backup server at McPhillips. • Need to coordinate with electrical regarding UPS. Central UPS is preferable. UPS in each process area? • Interface with City of Winnipeg corporate network. Firewall(s) must be installed. Currently out of scope however must interface with City IT staff to ensure the interface to the corporate LAN is not restricted by WTP control system design.
	SPECIFICATIONS		• A preferred Instrument supplier list will be developed. • A Standard Specification template has been created.
	DRAWINGS	Refer to the master list	• Legend Sheet • Network Architecture • Interface to DBPS – Firewall & Connection Details • Typical Instrument Loop Diagrams • Instrumentation Location Drawings • Instrument installation details • I/O Lists • Instrument Index • Instrument Cable lists • Marshalling/Control Panel Interconnection Diagrams

PROCESS MECHANICAL

LEAD DISCIPLINE PROCESS MECHANICAL: Paul Wobma, P.Eng.

PROCESS MECHANICAL DESIGN: Ray Bilevicius, P.Eng., Albert Li, P.Eng., David Pernitsky, P.Eng., Simon Breese, P.Eng., Toby Brodkorb, P.Eng., Jason Sinclair, P.Eng., Sunny Mangat, P.Eng., Barry Williamson, P.Eng. Kim Schurtz, C.E.T.

QA and REVIEW: Bill Bellamy, P.E., Ken Mains, P.Eng., Mike Adkins, P.Eng., Russell Ford, P.E., Ed. Minchew, P.E., Steve Lavinder, P.E. Linda Ferguson, P.Eng., Nol Wenneker, P.Eng., Norm Newman, P.Eng.

INTRODUCTION:

This memorandum will guide engineers and designers during the detailed design phase of the Winnipeg Water Treatment Plant. The process mechanical design basis will streamline engineering effort by presenting information common to most unit processes, and provide design uniformity regardless of which firm or office completes the design of a particular unit process. The purpose of this memorandum is to present the general design philosophies and considerations for the mechanical systems located throughout the plant.

SCOPE AND DESCRIPTION OF SYSTEMS:

The process mechanical scope of work includes provision for hydraulic and process sizing of the water retaining structures, conduits and piping systems. Detailing and specifying of process equipment and related piping and valving systems will be core functions of the process mechanical design team. The process designers will also have input into the instrumentation and controls design to preserve the design intent and functionality. Special attention will be given to equipment layout and support/restraint of major piping systems to support the structural design.

REV	CATEGORIES	ITEMS	DESCRIPTION
1	**DESIGN BASIS**		Refer to Section 2 of the PDR for a Summary of the Unit Process Design Basis
1	**CALCULATIONS & SYSTEM OF MEASUREMENT**		**<u>General</u>** • Describe all documentation in Metric (SI) units • Equipment and piping calculations are to be prepared and reviewed in accordance with this design basis. • This document describes calculations and/or support data required as part of the detailed design phase. Other calculations not listed may also be needed for specific facilities or systems. • All calculations are to be checked by the Discipline Lead (or designee) as defined in the QMP QA/QC procedures. • Computer calculations are acceptable provided the programs used are accepted by the firm leading that portion of the design, the calculation and method are easily traceable, and the final calculations are checked by the Discipline Lead. • Calculations are also required to estimate emissions from certain combustion equipment (where applicable). **<u>Typical Calculations Performed by Mechanical Designers</u>** • Pressure piping thrust calculations, as described under Plant Piping below. • Piping thermal expansion calculations for piping systems operating above 65°C. • Control valve sizing calculations, as described under Valves, Gates and Actuators. • Compressed air system calculations supporting compressor and receiver selection for process equipment air and control valve actuation • Heat exchanger sizing calculations. • Calculations supporting selections of all process mechanical equipment based on detention time, overflow rate, solids loading, gas transfer, mixing energy etc. Selection of equipment shall be accompanied by completed copies of equipment data sheet. • Calculations for heating and ventilation air systems and odour control (if applicable) shall be conducted using the methods presented in the Winnipeg WTP Building Mechanical (HVAC) Design Basis**.**
1	**DESIGN CODES AND STANDARDS (Latest Editions)**	**General**	• CSA - Canadian Standards Association • ASTM – American Society for Testing and Materials • ANSI – American National Standards Institute • ASME – American Society of Mechanical Engineers • ABMA – American Bearing Manufacturers Association (formerly AFBMA) • AWWA – American Water Works Association • ISA **–** Instrument Society of America • SSPC – Society of Protective Coatings

	DESIGN CODES AND STANDARDS (Latest Editions) (Continued	**General (Continued)**	• NSF/ANSI Standard 61 – Drinking Water System Components • Design Standards for Waterworks (10-State Standards) • Manitoba Building Code • Manitoba Fire Code • National Building Code of Canada • Manitoba Workplace Safety and Health Act and regulations, guidelines and code • NFPA - National Fire Protection Association codes for area classification will be adopted. • The codes and standards listed in the sections below are for guidance to the Engineers and Designers only, and are not intended to be a complete list of the applicable manufacturing and construction standards for the WTP. For more complete listings of the applicable codes and standards refer to the Project Standard Specifications
1		**Plant Piping Systems**	• Provincial and local codes governing water piping systems, flammable and combustible liquids, flammable gases, and hazardous chemicals are frequently in place. Acquaint yourself with these requirements before starting design work. • Fabricated (welded) steel piping should be designed in accordance with AWWA Manual M11, *Steel Pipe – A Guide for Design and Installation.* • ANSI/AWWA C200-97: *Steel Water Pipe-6 In. (150 mm) and Larger* • ANSI/AWWA C208-01: *Dimensions for Fabricated Steel Water Pipe Fittings* • ANSI/AWWA C207-01: *Steel Pipe Flanges for Waterworks Service - Sizes 100 mm through 3,600 mm* • ANSI/AWWA C213-01: *Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines* • ANSI/AWWA C220-98: *Stainless-Steel Pipe, 100 mm and Larger* • AWWA C220a-99: *Amendment 1 - Stainless-Steel Pipe, 100mm and Larger* • ANSI/ASME B31.3 – Process Piping Ductile iron piping systems wall thickness should be designed in accordance with AWWA C150, *Thickness Design of Ductile Iron-Pipe.* AWWA Manual M41, *Manual of Water Supply Practices – Ductile Iron Pipe and Fittings*, provides design guidance on

	DESIGN CODES AND STANDARDS (Latest Editions) (Continued)	**Plant Piping Systems (Continued)**	buried ductile iron piping design for pressure class and thrust restraint. • Pipe manufacturers and fabricators also provide much design information and they should be consulted early in the project. • ANSI Z53.1 - *Safety Color Code for Marking Physical Hazards* • NFPA 30, Vol. 3 – *Flammable and Combustible Liquids Code* • CSA B149.1 – Natural Gas and Propane Installation Code. • Piping is furnished in varying chemical compositions and manufactured by a variety of processes. These factors cause pipe within a generic group to have different physical characteristics such as tensile and yield strengths, creep resistance, resistance to heat, cold, and fatigue, etc. • The codes should be checked carefully before choosing piping types and grades for design or specifying them. For example, stainless steel piping manufactured under ASTM A778 and fittings manufactured under ASTM A774 are not recognized in the codes for use in systems which must meet ANSI/ASME B31.3 code requirements. • Special service stainless steel must be used for code applications. Check code limitations/restrictions on piping and components and the notes and footnotes applicable to the tables of allowable stresses in these codes relative to the standards for piping in the project specifications.
1		**Valves, Gates and Actuators**	• ANSI/AWWA C504-00 – *Rubber Sealed Butterfly Valves* • AWWA C507-99: *Ball Valves*, 150 mm through 1200 mm. • ANSI/AWWA C509-01: *Resilient-Seated Gate Valves for Water-Supply Service* • ANSI/AWWA C500-02: *Metal-Seated Gate Valves for Water Supply Service* • ANSI/AWWA C508-01: *Swing-Check Valves for Waterworks Service, 50 mm through 600 mm* • AWWA valve standards do not include 350 and 450 mm sizes • ANSI/AWWA C560-00: *Cast-Iron Slide Gates* • ANSI/AWWA C561-04 – *Fabricated Stainless Steel Slide Gates* • ANSI Standards B16.1 and B16.5 cover gate, globe, check, and ball valves up to approximately 400 mm for general water, air, steam, oil, and gas services • ANSI/ISA Standard S75.01.01 – *Flow Equations for Sizing Control Valves* (formerly ISA S75.01-1985 (R1995))
1		**Pumping Systems**	• Hydraulic Institute Standard ANSI/HI 9.8 (M123), Centrifugal and Vertical Pump Intake Design

1	**DESIGN CODES AND STANDARDS (Latest Editions) (Continued**	**Storage Tanks & Pressure Vessels**	Standards for tanks can be found in the many sources. The most common include: • American Water Works Association (AWWA) – standards for steel tanks for water storage • American Society of Mechanical Engineers (ASME) – boiler and pressure vessel (B&PV) codes for metal tanks (Section VIII) • American Society of Mechanical Engineers B&PV code for fiberglass tanks (Section X) • National Institute of Standards and Technology (NIST) – Voluntary Product Standard PS 15 for fiberglass reinforced tanks • American Petroleum Institute (API) – field-erected, shop-erected tank standards for a variety of tank types <<do we have any of these tanks?>> • National Fire Protection Association (NFPA) – standards for flammable liquids and gases, as required by fire and safety codes
	DESIGN CODES AND STANDARDS (Latest Editions) (Continued	**Lifting Equipment**	• The Crane Manufacturers Association of America (CMAA) specifications list design aspects of various types of bridge cranes. • ANSI MH 27.1 - *Specifications for Underhung Cranes and Monorail Systems* • ANSI/ASME HST 4M - *Performance Standard for Overhead Electric Wire Rope Hoists* • Hoist Manufacturer's Institute Standard Specification for Electric Wire Rope Hoists. • ANSI/ASME B30.10: *Hooks.* • ANSI/ASME B30.11: *Safety Standards for Monorails and Underhung Cranes.* • ANSI/ASME B30.16*: Safety Standard for Overhead Hoists (Underhung).*
1	**DESIGN REFERENCES AND RESOURCES**	**Manuals and Design Guides**	• AWWA M-11 – Steel Pipe – A Guide for Design and Installation • *Flow of Fluids through Valves, Fittings, and Pipe*, Crane Co. (Crane Technical Paper 410) • *Hydraulic Institute Engineering Data Book*, Hydraulic Institute 1990 • *Pumping Station Design*, Sanks, et al., 1998. • Fisher Controls and Regulators (Emerson) *Control Valve Handbook,* 3rd Edition • ISA *Handbook of Control Valves* • *Instrument Engineer's Handbook, Volume II, Process Control,* Bela G. Liptak, Editor, Chilton Book Company • CH2M HILL Design Guide for Ozone Systems© • CH2M HILL Design Guide for Granular Filtration Systems©

1	**DESIGN REFERENCES AND RESOURCES (Continued)**	**Hydraulic Modeling Tools**	• CH2M HILL's WinHydro© will be used to calculate general plant hydraulics and determine pipe and channel sizing. WinHydro is a steady-state model that describes systems that are downstream controlled. This model is utilized to determine water surface elevations for the main process tanks and channels and to verify that gravity flow can be accomplished through the plant at the maximum design flowrate. Minimum and average design flowrate scenarios will also be checked. • Applied Flow Technology (AFT) Fathom may also be used to determine pipe sizing. AFT Fathom is a software package that performs steady-state, incompressible, Newtonian fluid flow and energy analysis in an easy-to-use graphical environment for most piping systems (such as simple to complex networks, recirculating loops, heat transfer pipes and heat exchanges). Multiple- or single-pump systems can be modeled by assigning the required flows or pump curves for the pumps. Fathom can model control valves such as pressure control on either side of the valve, flow and pressure drop controls, and check valves. Fathom's built-in databases include many common liquids and gases, pipes, and many standard loss models for fittings, etc. In addition, Fathom can model sludges, utilizing coefficients from the Bingham Plastic flow model. Common applications include pipe sizing, pump selection, system operation, and control valve selection. • The Raw Water Pump Station (RWPS) and Deacon Booster Pump Station (DBPS) hydraulics will be modeled by Earth Tech. using their standard in-house programs.
1	**DESIGN PARAMETERS**		**<u>Unit Process Design Parameters</u>** • Refer to the respective Sections of the PDR **<u>Test Pressures for Plant Piping Systems</u>** • Raw water piping <> kPa • Filtered water piping <> kPa • Sludge transfer piping <> kPa **<u>Hydraulic Factors of Safety</u>** • In-plant concrete conduits – 1.5 • Process tanks – 1.5 • In-plant piping (RW, FE, SL etc.) – 1.0 • Non-structural process elements e.g. baffle walls, level control weirs – 1.0 • Process pumps – largest unit out of service for design flow (install additional pumps for Phase 2 capacity upgrades) • Process Overflows – 1.5 (each to be risk assessed)
1	**SERVICE CONDITIONS**	**General**	• Raw water pH 7.0 to 9.0 • Coagulation pH 5.5 to 6.0 • Finished water pH 7.5 to 8.0. • Post coagulation chloride levels < 50 mg/L

1	**SERVICE CONDITIONS (Continued)**	**Raw Water Pump Station**	• pH 7.0 to 9.0 • Chloride levels <50 mg/L
1		**Raw Water Header Piping**	• pH 7.0 to 9.0 • Chloride levels < 50 mg/L
1		**Flocculation & DAF**	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L
1		**Ozone Contactors**	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L • Ozone residual entering last cell of 0.5 to 1.0 mg/L • Intermittent hydrogen peroxide residual of 0.25 to 0.5 mg/L • Sulphate residual at outlet of 0.1 to 0.3 mg/L
1		**BAC Filters**	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L • Sulphate residual of 0.1 to 0.3 mg/L
1		**Chlorine Contact Conduit (CCC)**	• pH 5.5 to 8.0 • Chloride levels < 50 mg/L • Continuous Free Chlorine residual at outlet of 0.25 to 1.0 mg/L
1		**Piping between CCC and Clearwell**	• pH 5.5 to 8.0 • Chloride levels < 50 mg/L • Continuous Free Chlorine residuals of 1.5 to 3.0 mg/L • Continuous Combined Chlorine (Chloramine) residual of 1.5 to 3.0 mg/L
1		**Clearwell, DBPS and UV Disinfection Facility**	• pH 7.5 to 8.0 • Chloride levels < 50 mg/L • Continuous Combined Chlorine (Chloramine) residual of 1.5 to 3.0 mg/L • Sulphate residual of 0.1 to 0.3 mg/L
1		**Washwater Recovery Tanks & Decant Pump Station**	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L • Intermittent Free Chlorine residual of <> to <> mg/L • Sulphate residual of 0.1 to 0.3 mg/L
1		**Gravity Thickeners & Thickened Sludge Storage Tank**	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L • Intermittent Free Chlorine residual of <> to <> mg/L • Sulphate residual of 0.1 to 0.3 mg/L
		Freeze-Thaw Lagoons and Lift Station	• pH 5.5 to 6.0 • Chloride levels < 50 mg/L • Intermittent Free Chlorine residual of <> to <> mg/L • Sulphate residual of 0.1 to 0.3 mg/L
		Sanitary Lift Station and Force Main	• pH 5.5 to 9.0 • Chloride levels < 50 mg/L • Intermittent Free Chlorine residual of <> to <> mg/L • Sulphate residual 0.1 to 0.3 mg/L

1	**CONSTRUCTABILITY CONCERNS**		• Installation and retro-fitting of large dia. piping into the Raw Water Piping and Filter Effluent galleries at a later stage if dual lines are required in future (but not installed initially). •
1	**CLIENT EQUIPMENT PREFERENCES AND ACCEPTABLE SUPPLIERS**	**Equipment Procurement**	Isolation and Control Valves • Automated and Manual Actuators (Rotork, pneumatic, chainwheels) • Pipe Coupling Systems (Victaulic, Dresser, Depend-O-Lok, Straube) • Flow Measurement (large and small dia pipes, open channel) • Coating and Lining of Piping and Fittings (dry and wetted) • Fusion-bonded epoxy Wall penetration/seal systems (e.g. link seals v.s. seal plates) • Large Submersible Centrifugal Pumps • Chemical Feed Pumps and Preparation Systems • Large Horizontal Centrifugal Pumps • Large Vertical Turbine Pumps • Process Blowers • Process and Instrumentation Air Compressors • Ozone Equipment (incl. LOX system/supply) • Gravity Filter Equipment (underdrains, troughs) • Large Chemical Storage Tanks (FRP, SST) • Gravity Thickener Equipment • Solids Handling Pumps • Onsite Sodium Hypochlorite Generation Equipment (Chlortec or WT) • DAF Equipment (Pre-purchase Bid) •

1	**LAYOUT & ACCESS**	**General**	• Designers should ask the following questions when developing layout drawings: ➢ Can the facility be built as shown? ➢ Is the facility easy and accessible to operate? ➢ Is the facility crowded? ➢ Can the facility be maintained conveniently? ➢ Is there a better way to lay out the facility? ➢ Can major equipment be easily accessed and removed if required? ➢ Can frequently removed equipment be easily moved through the plant? ➢ Can complete isolation of each process train be achieved? ➢ Are bypasses, parallel flow paths, and isolation provisions included for all unit processes and sub-systems? • Plant and area layouts were derived during the pre-design phase of the Winnipeg WTP, but require refinement during detailed design phase. • The major purpose of layout development is to ensure the efficient flow of materials, people, and vehicles around the site and within the buildings. All disciplines have input on the layouts, but the Area Lead Engineer has the primary authority. • Gallery layout is another important feature. Generous space allowances should be provided at major corridor junctions to minimize conflicts between crossing piping, trays, and

	LAYOUT & ACCESS (Continued)	**General (Continued)**	conduits. The gallery structure has a significant footprint that must be factored into the building layout. • The type and size of vehicles that require access for maintenance reasons must be determined. This information is required to allow design of the site roadway geometry and the bridges over channels. A functional site arrangement should be developed in which each building's function and the access requirements for maintenance vehicles are defined. Based on the functional arrangement, the ingress and egress of vehicles can be planned and the roadway system thereby developed by the Civil Discipline. • Pathways should be functionally planned in the same manner as the roadways. Above-ground pedestrian traffic should be considered with respect to an Operator's normal rounds and to pedestrian traffic between buildings. This assessment would account for instrument layout and above-ground equipment arrangement. Walkway planning would be integrated with structures that are provided as part of an operating piece of equipment (DAF clarifier basins, etc.) and those that are planned for pedestrian traffic between parallel tanks (i.e., Filters). Planning will minimize conflicts between vehicle and pedestrian traffic. In most case, pedestrian traffic would take precedence. Coordinate with Civil and Architectural Disciplines. • Emergency access planning must be performed. Ingress and egress routes for ambulances, fire trucks, etc., must be factored into the roadway and pathway design to ensure that the distance is not excessive between any point where accidents or fires could occur and a roadway accessible to the appropriate emergency vehicle. It is important get input on the layout from Fire Commissioner early in the design. Similarly, the authority having jurisdiction for the application of the building code should be brought into the discussion to ensure that the understanding of the code is not in question. Coordinate with Architectural and Building Services Disciplines. • In addition, building codes generally stipulate the maximum spacing between access points between the surface and the below grade structures such as tunnels, pipe galleries and chases. These access points must be factored into the walkway and roadway layout. Coordinate with the Architectural Discipline

1	**LAYOUT & ACCESS (Continued)**	**Process Equipment and Tanks**	• Typically, one type of equipment will be chosen as the basis of design. This 'make' or 'model' is referred to as the "design standard". Layout should be based on this selection. Where other manufacturer's products are also suitable, the layout should be checked to ensure that the arrangement does not preclude the use of the alternatives. • All required space and routes of equipment removal/replacement/maintenance shall be provided for in the layout drawings. • Mount equipment and panels upon equipment house-keeping pads to protect them from wash down. • The minimum clearance on all sides around rotating equipment over 10 hp (7.5 kW) should be 1.2 metres. • Leave at least 1.2 metres of clearance between the outermost extremities of adjacent pieces of equipment or between a wall and a piece of equipment. • Clearance in front of any other equipment face or panel requiring maintenance should be at least 1.2 metres. • Pressure vessels should be at least 0.6 metres from the back wall and 1.0 metres apart. Sufficient space in front of the vessel should be provided for the face piping plus 1.2 metres. • For pumps, compressors, and other rotating equipment where parallel units are provided, the orientation of the drive and the rotation should be identical. • Pumps used for sludge/solids pumping should be arranged to minimize the distance and number of bends through which the liquid must be conveyed to the pump suction. • Provide adequate headroom for removal of vertical turbine pumps, and/or specify shafts, shaft enclosure tubes (where applicable), and columns in specific length sections that are removable within the building/lifting equipment constraints. • Provide ladders and hatches to access and remove equipment. • 'Motorized' hoists, monorails, or cranes should be provided where equipment component weights exceed 900 kg (2000 lb) and/or when frequent lifting for maintenance is necessary. • Provide adequate lifting headroom for all equipment. An allowance for sling length or lifting (spreader) beams between equipment lift points and crane or hoist hook also needs to be included (consult equipment manufacturers). • Provide lifting eyes, in accordance with the Standard Details, above all equipment not otherwise provided with lifting means. • Place wash-down drain points in logical areas to facilitate clean-up and pipe flushing. Provide PSW hose bibs so that the maximum length of hose required is 15 metres.
1		**Piping and Valves**	• Locate piping so that it is not a tripping hazard, a head-banger, or a barrier to equipment access. • Minimal piping should be located above blowers, compressors, or pumps to facilitate lifting/removal. • In general, lay out piping close to walls where it can be supported easily, particularly in spaces with high ceilings.

	LAYOUT & ACCESS (Continued)	**Piping and Valves (Contintued)**	• If piping must be run close to a wall, but not supported from it, leave at least 0.6 metres of clearance between the outermost pipe flange and the wall. • To permit purging of air from the pipeline while it is being filled with water, locate a manual vent valve on the highest point of every pipeline to be filled with liquid or which is to be hydrostatically tested. • To permit water drainage, locate a manual drain valve on the lowest point of every pipeline. • Pipe supports and seismic bracing are generally not shown on the layout drawings. Verify, however, that adequate space is available for installation of these supports. • Provide flexible connections/couplings to permit easy assembly and disassembly of piping and connections to equipment. • When laying out piping, keep the placement of anchors and expansion joints in mind. These must be located on the drawings. • If piping reducers are required on the suction side of a pump, provide eccentric reducers that are flat on top (FOT). • Wall penetrations should be perpendicular to the wall. • Make an effort to keep valves within operator reach (below 2.4 metres). For any valve over 2.4 metres above the operating floor, provide a chain operator or actuator. • Do not place swing check valves in vertical piping runs. • Install an easy disassembly coupling or pipe joint within four diameters of all valves. • Provide thrust restraint for sleeve and other couplings that are not capable of internal thrust restraint. • Allow ample space for valve and gate actuators. • Provide adequate clearances for rising stem valves and gates. • Provide sufficient straight runs for flow meters and other I&C elements sensitive to flow patterns. •
1	**PUMPING EQUIPMENT**	**Pumping Equipment Selection <<Acceptable vendors to be deleted if WWD have preferred manufactuers /suppliers for specific equipment, as listed above>>**	**<u>Centrifugal Pumps</u>** Centrifugal pumps are best used to move large flows at low to moderate heads. Depending upon the impeller configuration, centrifugal pumps can move liquids containing a variety of solid material. Centrifugal pumps, however, do not pump viscous fluids very well. Also, flow from a centrifugal pump is strongly affected by the system pressure (suction and discharge), making it a poor selection where a precise flow rate is required (without flow control) • **Non-Clog Dry Pit Centrifugal** Use non-clog dry pit centrifugal pumps for pumping sludges and for dewatering. These pumps shall handle solids up to a sphere size of 75 mm. • **Non-Clog Submersible Centrifugal** Includes recessed impeller, screw centrifugal and chopper styles. Typically used for standard sumps, or low-head sludge and slurry transfer. Minimum sphere passage is 100 mm. Acceptable

	PUMPING EQUIPMENT (Continued)	**Pumping Equipment Selection (Continued)**	vendors include Flygt, Flowserve, KSB and Cornell. • **Horizontal End Suction Centrifugal** Use horizontal end suction centrifugal pumps for pumping or circulating clear or reasonably clear water, such as process samples. Non-metallic (FRP) versions are used to transfer chemical solutions and other clear corrosive liquids. Acceptable vendors include Goulds and Fybroc (non-metallic). • **Horizontal Split-Case** Use for pumping or circulating clear or reasonably clear water. Use only where an end suction centrifugal pump is not adequate, as the cost of split-case pumps is higher. Acceptable vendors include Flowserve and Aurora. • **Vertical Wet Pit Centrifugal** Typically used as sump pumps for pumping mild slurries and clear or reasonably clear liquids. Also used for pumping chemical solutions from storage tanks or secondary containment sumps. • **Non-Metallic Vertical** Typically used for chemical or corrosive sump applications, constructed of FRP. Acceptable vendors include Goulds and Fybroc. • **Vertical Turbine** Also includes vertical mixed-flow and axial-flow pumps. Typically used for pumping clear or reasonably clear water such as; raw water (low lift), BWS, filter influent, surface wash pumping; and for plant service water supply and fire pumps. • **Magnetic Drive Centrifugal** Typically only used for chemical transfer pumps. To prevent leakage, magnetic drive pumps have no shafts (or seals), resulting in low efficiencies and higher horsepower requirements. **<u>Positive Displacement Pumps</u>** Positive displacement pumps are used for low to medium flow rates at low to high heads. Positive displacement pumps handle viscous fluids well, but can be susceptible to abrasion. Flow from a positive displacement pump is essentially independent of system pressure, making it a good choice when a precise flow rate is required. Coupled with a variable speed drive, some positive displacement pumps can handle a much wider pressure/flow range than any centrifugal pump. Positive displacement pumps tend to be more expensive than centrifugal pumps, and usually have higher maintenance requirements. • **Progressive Cavity** Typically used for non-abrasive sludges, slurries and viscous liquids such as liquid polymer transfer and metering. For sludge pumping applications the maximum speed should be limited to 150 rpm. PC pumps shall be complete with stator over-temperature sensor/switch. Acceptable vendors include Moyno and Seepex. • **Chemical Metering Gear Pumps** Typically used for chemical metering where either high accuracy,

	PUMPING EQUIPMENT (Continued)	**Pumping Equipment Selection (Continued)**	off-gassing or significant flow turn-down are issues. While they are more robust than diaphragm and peristaltic styles they have higher capital costs. Specify as magnetically coupled and driven to prevent leakage. Ensure to check wetted part material compatibility against pumped fluid. Acceptable vendors include Micropump, Pulsafeeder or Tuthill. • **Peristaltic** Typically used for chemical metering. More robust than solenoid or diaphragm metering pumps. Consider for use on the hydrogen peroxide system due to them having a range of compatible non-metallic wetted parts (tubes). Acceptable vendors include Watson-Marlow-Bredel, and.Verderflex. • **Rotary Lobe** Typically used for same applications as progressive cavity. Rotary lobes consume less footprint and can be less expensive compared with progressive cavity in terms of maintenance. Acceptable vendors include Vogelsang and Boeger.
1	**PUMPING EQUIPMENT**	**Pumping Equipment Specification** **Pumping Equipment**	**<u>Pump Speeds</u>** • Centrifugal pump speeds should not, as a rule, exceed 1,750 rpm in water and waste pumping applications. Exceptions are services such as single-stage pumping against very high heads (90 to 150 m). • Slower speeds are desirable where non-clog centrifugal, vertical turbine, mixed-flow, and axial-flow pumps are used, particularly for 100 hp sizes or larger. Speeds of 1,170 rpm, 870 rpm, and lower are not unusual for large diameter pumps. Slower speed pumps are usually larger than pumps operated at 1,750 rpm, however, and therefore cost more. • Where slow speed (580 and 700 rpm) or medium speed (1,170 and 1,750 rpm) horizontal mixed-flow and axial-flow pumps do not provide the head required, vertical multistage units of the same types shall be considered. Two- and three-stage units are available in vertical mixed-flow and. axial-flow pumps. • Operating speeds for positive displacement pumps vary depending on the pump type and fluid being pumped. Check with pump manufacturers for recommended maximum pump speeds for specific services. **<u>Pump Shaft Seals and Packing</u>** • Generally, pumps should be furnished with mechanical seals. • Single seals will suffice for most applications. Consider double seals for sludge and chemical services, however magnetic drives are preferred for chemical services. • Packing may be considered for a few applications (not common). • External flushing with seal water is required for all services other than clean water. • **Mechanical Seals** Seals will be high quality, split mechanical, cartridge (refer to standard specifications). • **Packed Stuffing Boxes** Specify five rows (minimum) of graphite-impregnated braided

	(Continued) **PUMPING EQUIPMENT**	**Specification (Continued)** **Pumping Equipment**	non-asbestos packing and split glands. If external flushing is required to flush abrasives into the pump, specify lantern ring. Consider packed stuffing boxes only when all the following conditions are met: - Pump discharge pressure less than 50 psig. - Pump speed less than 1,750 rpm. - Pump shaft diameter of less than 1-1/2 inches. • **Seal Water Pressure** Seal water pressure, whether for mechanical seals or packed stuffing boxes, shall be approximately 3 to 5 psig higher than the stuffing box pressure. Consult pump manufacturer for specific stuffing box pressure. For a rough approximation of stuffing box pressure, use a minimum of one-half the pump differential pressure plus the pump suction pressure. A CH2M HILL standard detail is available for the seal water connection to a pump. **<u>Bearing Life Ratings</u>** • Bearing Life Rating (B-10 or L-10) is defined as the number of hours that 90 percent of a group of bearing will complete or exceed, at a rated speed and loading, before the first evidence of fatigue develops. Average life is statistically five times the rating life. • The minimum anti-friction (rolling element) bearing rating life (ABMA L-10) for this project is to be specified as 100,000 hours for 24-hour continuous duty and maximum reliability. • Rating life is not defined for plain journal type bearings. **<u>Bearing Lubrication</u>** • Specify grease lubrication for ball and roller bearings, both guide and thrust. • Grease-lubricated bearings shall be fitted with addition and relief fittings. • Consult the manufacturers for details of lubrication systems for large rotating equipment. **<u>Couplings</u>** • Couplings shall either be Falk, Fast spring-grid, or gear type flexible coupling with coupling guard for horizontal pumps and close-coupled vertical pumps. • Spacer couplings shall be used for back pullout-type pumps and pumps with mechanical seals. • Vertical turbine pumps with hollow shaft motors shall be furnished with “non-reverse couplings” to protect the pump and motor against backspin during shutdown and power failure. • Pumps with adjustable-speed drives which have solid shafts should be furnished with a flanged, adjustable coupling. **<u>Shaft Guards</u>** • Shaft guards shall be provided on vertical non-clog pumps around any exposed intermediate shafting that presents a safety hazard to operating personnel. • The shaft guard shall cover the shafting from the top of the pump to a minimum height of 2.1 metres above the floor or other working surface, or as otherwise required by local

	(Continued)	**Specification (Continued)**	safety codes. • Two-piece cage guards, split for easy disassembly, shall be provided. **<u>Materials of Construction</u>** • Pump materials shall generally be iron construction with bronze fittings. • There may be certain installations that require selection of corrosion or abrasion resistant materials, such as chemical feed or sludge pumping. Designers shall refer to and <u>review</u> the PDR in making material selections. **<u>Sump and Wet Well Design</u>** • The Hydraulic Institute Standard ANSI/HI 9.8 shall be utilized as a reference and guide in the design of sumps and wet wells. Adequate pump suction approach velocities and submergence shall be provided. • Sufficient wet well volume to provide system control stability is required for all pump installations. Improper wet well sizing can result in serious control problems. Consider the following: ➢ Wet well surface area should be sized to prevent excessively rapid motion (rising or falling) where continuous level control is being considered. Under any viable loading changes, a speed of less than 75 mm per second is recommended. ➢ Another rule of thumb recommended by the Hydraulics Institute is to design the wet well so that the usable control volume (in litres, volume between top and bottom of the control) is at least two times the maximum station pumping capacity (in lpm). ➢ If it is desired to crowd either of these two criteria, a dynamic analysis is recommended. ➢ Wet well volume for constant speed pumps should be sized to prevent pump cycling (starting) more frequently than can be facilitated by its drive motor. Refer to the Electrical Discipline Design Basis for appropriate minimum cycle times (start to start). ➢ The level measurement location point should be chosen to be in a region of low turbulence, wave action, or vortexing, or provided with a stilling well, to avoid a widely fluctuating or unstable level signal.
1	**PUMPING EQUIPMENT (Continued)**	**Pumping Equipment Hydraulic Design** **Pumping Equipment Hydraulic**	• Hydraulic calculations shall be prepared for all pump applications. • Prepare single-line isometric schematics from pump suction piping origin to the point of system discharge for development of the calculations. This schematic shall show line sizes, dimensions, fittings, and piping materials. • Prepare plots of system curve from the system information and impose pump curves on these plots indicating pump operating points for various pump speeds and system head conditions. Indicate on these plots the design operating points and envelope for possible inclusion in the pump specification. • Conversion of pump operating performance for fluids having viscosities different than water shall be determined by the

		Design (Continued)	pump manufacturer. • Selected pump operating points shall be centered near the pump best efficiency point at the design condition. A rating point selected to the right of best efficiency flow will allow higher efficiency at reduced flow and speed. Caution shall be exercised in selecting pump operating points at the extremes of the pump operating curve due to possible excessive pump shaft radial loading and reduced bearing life and possible shaft failure. • Care shall be exercised in providing adequate overlap of pump performance when multiple parallel pump installations are provided. Proper pump sequencing requires that pumps have sufficient performance overlap to allow transition adding or dropping pumps in operation. • Net positive suction head available (NPSHA) is the system energy available to drive flow into the pump suction at the impeller eye. Specific design characteristics determine the net positive suction head required (NPSHR) by a given manufacturer's pump. NPSHA must exceed the NPSHR of the pump(s) under consideration. • Keep suction lines short and straight. Check the NPSHR of several pump manufacturers. Design engineer must provide adequate NPSHA plus a margin of safety because most pump manufacturer's NPSHR curves are based on the pump operation at 3-percent deterioration in head when operating on clean, clear water at the NPSHR value. This is the basis of pump testing for NPSHR in Hydraulic Institute standards. • NPSH calculations for centrifugal and vertical pumps must comply with ANSI/HI 9.6.1, *American National Standard for Centrifugal and Vertical Pumps for NPSH Margin*. The standard provides calculation methods and safety factors. The minimum safety factor for positive displacement pumps such Gear Pumps and Progressive Cavity is 30 percent (i.e., NPSHA/NPHSR =1.3).
1	**AIR COMPRESSORS**	**General**	• The information below is presented to serve as a guide in selecting compressors. • In this Design Basis, only compressors in the size ranges commonly used for plant air requirements are discussed. • Pressure ranges commonly used vary from 550 to 860 kPag..
	AIR COMPRESSORS (Continued)	**Compressor Selection** **Compressor Selection**	**<u>Reciprocating Compressors</u>** • Reciprocating compressors commonly used for plant air generation cover an approximate range from 0.2 kW (0.25 hp) with an output of 1.7 m3/h (1 cfm) to 1,119 kW (1,500 hp) at an output of 10194 m3/h (6,000 cfm) for a 69 0kPag (100 psig) discharge pressure. • Reciprocating units are positive displacement compressors. The reciprocating compressor accomplishes this by using a piston within a cylinder as the compressing and displacing element. • The compressor is considered single acting when the compression is accomplished using only one side of the piston. This type of compressor is normally air-cooled.

	AIR COMPRESSORS (Continued)	**(Continued)** **Compressor Selection**	• A compressor unit using both sides of the piston is called double acting. This type of compressor is normally water-cooled. • The compressor uses a number of automatic spring-loaded valves in each cylinder that open only when the proper differential pressure exists across the valves. Inlet valves open when the pressure in the cylinder is slightly below the intake pressure. Discharge valves open when the pressure in the cylinder is slightly above the discharge pressure. • A unit is considered to be single stage when the entire compression is accomplished with a single cylinder or a group of cylinders in parallel. • Many applications involve conditions beyond the practical capability of a single compression stage. Therefore, for practical purposes, most plant air reciprocating compressors over 100 hp are built as multistage units in which two or more steps of compression are grouped in series. • The air is normally cooled between the stages, with a water-cooled heat exchanger, to reduce the temperature and volume entering the following stage. • Advantages: ➢ Proven dependability ➢ Most efficient at full load ➢ Best part load efficiency ➢ Largest size range (capacities and pressures) • Disadvantages: ➢ Unbalanced forces ➢ Highest first cost ➢ May require air dryers and oil removal filters ➢ High foundation cost to isolate reciprocating forces ➢ Greatest installation cost ➢ Large number of maintenance parts ➢ High maintenance cost **Rotary Compressors** • Rotary compressors commonly used for plant air production cover an approximate size range of 7-1/2 hp @ 30 cfm to 500 hp @ 2,500 cfm for a 100 psig discharge pressure. • The most common unit is the helical or spiral lobe screw compressor, which is a positive displacement, oil-flooded, single-stage compressor. These units consist of two rotors within a casing where the rotors compress the air internally. There are no valves. These units are basically oil-cooled (with air- or water-cooled oil coolers) where the oil seals the internal clearances. • The most efficient units limit the rotor tip speed to about 20 to 30 m/s (4,000 to 6,000 feet per minute) and use unsymmetrical rotor profiles. To achieve this optimum rotor tip speed, built-in speed-increasing or speed-reducing gears are used sometimes to achieve the most efficient rotor speed for a given rotor diameter. • Other designs provide for direct drive of the rotors with 1,750- or 3,500-rpm motors, achieving lower manufacturing costs at some sacrifice of efficiency.

	AIR COMPRESSORS (Continued)	**(Continued)** **Compressor Selection**	• The rotary compressor is a very simple compressor with few moving parts. It operates in the following way: ➢ Air passes through an air intake filter and across the intake throttle valve into the compressor. ➢ Oil is injected into the casing to seal the air passage and cool the air. The air-oil mixture is compressed to about 100 psig and travels to an air receiver/oil separator where almost all of the oil is removed. ➢ The air then passes through a built-in air- or water-cooled after cooler and check valve into the plant. The recovered oil is cooled, filtered, and returned to the compressor. • Advantages: ➢ Lowest first cost ➢ Lowest installation cost ➢ No unbalanced forces ➢ Few maintenance parts ➢ Easy to relocate ➢ Low foundation cost • Disadvantages: ➢ Least efficient at partial load ➢ Oil must be changed frequently ➢ Noise on some units ➢ May require air dryers and oil removal filters ➢ Relatively high maintenance cost **<u>Centrifugal Compressors</u>** • Centrifugal compressors used for plant air production range in size from approximately 300 hp with a capacity of 1,250 cfm, to 3,500 hp with a capacity of 15,000 cfm for a 100 psig discharge pressure. • The centrifugal compressor is a dynamic unit that depends on the transfer of energy from a rotating impeller to the air. The rotor accomplishes this by changing the momentum and pressure of the air. This momentum is converted to useful pressure energy by slowing the air down in a stationary diffuser. • This is an oil-free compressor. The oil-lubricated running gear is separated from the air by shaft seals and atmospheric vents. • All modern centrifugal plant air compressors use a bull gear that, in turn, drives three or four impellers or stages. They work basically as follows: ➢ Air passes across a built-in throttle valve or inlet turning vanes to the first-stage impeller. The impeller imparts velocity, which is converted to pressure by a built-in diffuser. ➢ The air then passes through a built-in water-cooled intercooler where it is cooled to within 15 degrees of the cooling water inlet temperature. The moisture is removed in a moisture separator and drained through a trap. ➢ The compressed air then repeats the same process through the second, third, and fourth stages. The air

		(Continued)	leaving the fourth-stage after-cooler passes across a built-in check valve and into the plant. ➢ If the plant demand is less than the surge capacity, the unused air passes through a blow-off valve and a silencer to the atmosphere. • Advantages: ➢ Lowest cost large compressor greater than 2,500 cfm ➢ Oil-free air ➢ Packaged designs common at low installation cost ➢ No unbalanced forces ➢ Minimal maintenance ➢ Low foundation cost • Disadvantages: ➢ More complex control system ➢ Additional protective devices advisable **<u>Recommendations</u>** • Before selection of a compressor or compressors can be made, several basic decisions must be made. These include: ➢ A determination of air capacity and pressure requirements ➢ The increments of compressor size to be added ➢ The type of compressor: • Reciprocating, rotary helical lobe screw, or centrifugal • Air-cooled or water-cooled • Lubricated or non-lubricated cylinders • To narrow the field of choice, only air-cooled reciprocating and rotary units generally are considered under 1,000 cfm. • For heavy-duty continuous operation, crosshead-type reciprocating compressors should be reviewed in this range. • Above 2,000 cfm, centrifugal compressors should be included in a review. In making a selection, careful analysis should include: ➢ First cost ➢ Installed cost ➢ Cost of required accessories ➢ Space requirements ➢ Foundation requirements ➢ Power consumption, at both full and partial load ➢ Availability and cost of cooling water ➢ Oil-free air requirements ➢ Oil consumption ➢ Duty cycle ➢ Local or central location ➢ Caliber of maintenance and operating personnel ➢ Carbon or Teflon dust-free air requirements
1	**PROCESS AIR BLOWERS** **PROCESS AIR**	**General** **General**	• Low-pressure compressors used for granular filter air scour are commonly called blowers. • Acceptable blowers for Winnipeg WTP are limited to two-centrifugal blowers or lobed rotary units, preference being depending on the application.

	BLOWERS (Continued)	**(Continued)**	• Consider multistage blowers for use in filter air-scour. Acceptable vendors include Lamson and Hoffman • HVAC and Odour Control System (if applicable) blowers are covered by the Building Mechanical Design Basis
	PROCESS AIR	**Blower Selection**	**<u>Centrifugal Blowers</u>** • Centrifugal compressors are the most important of the dynamic machines, having an impeller similar to a centrifugal pump. • Impellers can be arranged singly or in multiple units for higher discharge pressures. • Centrifugal blowers usually take in air at the impeller eye and accelerate it radially. • At a constant speed, a centrifugal compressor delivers practically constant discharge pressure over a considerable range of inlet capacities. • If demand decreases below rated flow, the compressor continues to deliver compressed gas at about the same pressure until a point is reached where surge occurs. • Surge is an unstable condition, occurring usually at about 50 percent of rated flow. The surge point is sometimes called the stability limit. As demand decreases, a point is reached where backpressure temporarily exceeds the pressure ratio developed by the compressor, and a breakdown in flow results. This immediately allows backpressure to go down, regular compression is resumed, and the cycle is repeated. • Varying the speed will permit lowering the surge point at reduced output pressures, or use of adjustable inlet guide vanes will further reduce the surge point. • Also, to ensure stable operation, a minimum pressure rise (normally 0.5 psig) from design point to surge point should be specified. • Advantages: ➢ Lowest maintenance cost ➢ Low installation cost ➢ No inertia forces, small foundation ➢ Less noisy operation ➢ Oil-free air ➢ Low foundation cost • Disadvantages: ➢ Limited stable operating range ➢ High vibration may require rebalancing of wheel ➢ Reduced volume will result from excessive backpressure buildup due to a decrease in permeability filter media **<u>Rotary Blowers (not used for filter air-scour)</u>** • Lobed-rotor compressors have two rotating elements that revolve in opposite directions in a chamber. Usually, the lobed rotating elements have two projecting lobes, but some have more. • Ideally, the impellers do not touch one another, a small amount of clearance being maintained by timing gears. The clearances allow some air to escape back to the suction side of the compressor.

	BLOWERS (Continued)		• Defined as "slip," this leakage is a constant for any given compressor at a given pressure. It is expressed in revolutions per minute since it is found by dividing leakage volume per minute by the displacement per revolution. • Because slip is constant, these compressors should be operated at the highest recommended speeds to obtain maximum volumetric efficiency. • Advantages: ➢ Lowest first cost ➢ Lowest installation cost ➢ Oil-free air ➢ Constant pressure with varying speed ➢ Easy metering by rpm count • Disadvantages: ➢ Higher maintenance ➢ Noisy operation
1	**STORAGE TANKS & VESSELS**	**Materials of Construction**	• Typical tank materials for WTPs include concrete, stainless steel, steel (rubber lined, plastic lined), aluminum, plastics (PVC, FRP, PVDF, PP), and ductile-iron (cement lined, glass lined) for process areas and mild steel, copper, cast iron, and plastics for non-process areas. • General guidance on selection of piping and compatible tank materials for the chemicals proposed for the Winnipeg WTP are discussed in the PDR Section 20. • The storage tank material is determined based upon the characteristics of the liquid or gas that is to be stored. The liquid or gas that is stored should not corrode or deteriorate the storage tank over time.
1	**STORAGE TANKS &**	**Tank Features** **Tank**	**<u>General</u>** There are a number features that should be considered when designing/specifying tanks. The codes and standards listed above provide guidance in tank design & construction, often including tank features. The information presented below is to supplement what is available in these documents. **<u>Nameplates and Code Data Plates</u>** • ASME codes require application of a data plate to a pressure vessel. This specifies code information such as the appropriate code symbol, name of manufacturer, working pressure, design temperature, serial number, and year built. API (and the other standards) provides similar requirements. • In addition, a nameplate should be provided on each tank with the following information: ➢ Equipment number ➢ Process liquid or gas ➢ Contract number or purchase order number ➢ Capacity of vessel ➢ Pressure/temperature rating (if not provided on other data plates) • Nameplates should be made from 16-gauge stainless steel or aluminum, with 1/4-inch die-stamped lettering.

	VESSELS (Continued) **STORAGE TANKS &**	**Features (Continued)** **Tank**	**Manways** • Every tank should have a way to enter the vessel for periodic inspection, unless the vessel is quite small (less than 450 mm dia. typically) when hand holes are acceptable for inspection and cleaning. • Depending on dimensions of the tank, manways to be provided at the top of the tank and the side of the tank near the base. • Manways should meet the applicable OH&S standards for size and function. In a practical sense, this means round manways of at least 500 mm in diameter, and oval manways of at least 300- by 400-mm. A commonly used manway size is a circular 600-mm-diameter unit with a bolted cover and gasket. • Many manways have davits or hinges provided, especially if the pressure rating of the vessel dictates a heavy flange, or if the flange is located such that it is inconvenient to unbolt and bolt up the cover each time. • Most manways have flat covers, but hemispherical heads are used for high pressure situations. **Support Saddles** • Horizontal tanks require some means of support, and support saddles are commonly used to provide this function. Often, the saddles are formed out of concrete and provided as part of the foundation. In other cases, the saddles are furnished with the tank itself and have bearing pads to match with the foundation. • In either case, protection must be provided to the tank wall. With either welded saddles or concrete saddles, wear plates (or doubler plates) should be provided on the tank. The advantage to these wear plates is twofold. First, welding and/or support contact does not interfere with the tank wall material, or compromise the pressure design. Second, the material choice for the saddle system does not need to be the same as the tank wall, and the transition between dissimilar metals can take place at the wear plate. • Concrete saddles usually have arc-shaped inserts provided to mate with the wear plate on the tank. Coordination of the radii of the wear plate and the saddle dimensions is important to avoid poor fit of the final assembly. **Vent Lines and Overflows** • All atmospheric tanks should have vent lines provided, often with some kind of insect screen or desiccant breather to protect tank contents. Tanks containing fuels often have flame arresters provided on the vent connection. • The vent line should run outside, or into a suitable ventilation system for exhausting fumes and moisture. Vent lines should be sized to prevent collapsing (imploding) the tank during pump out or drainage activities. • Just as important for most tanks is the overflow line. The overflow line should prevent surcharging of the tank contents out of the vent line or other nozzles if and when the tank is over-filled. The overflow line is usually routed to a

	VESSELS (Continued)	**Features (Continued)**	drain sump or secondary containment system, where the contents can be safely and efficiently handled. • Where two or more tanks are used for storage of a single chemical, the overflow lines will be combined such that one tank will first overflow into the next tank before it overflows into the secondary containment system. • Overflow lines should be fitted with fume traps (where applicable) to prevent venting off-gases into the room. **<u>Ladders and Platforms</u>** • Storage tanks and silos need methods of access to the tank manways, inspection doors, top-mounted relief valves and level sensing instrumentation, and other tank accessories. This often requires the use of platforms and ladders on tanks. • Platforms and ladders should be designed to meet the applicable OH&S standards, and should be suitably sized for the work activity they support. Attachments should be made to the tank to securely hold platforms and ladders in place. These attachments should be made using doubler plates on the tank, to avoid direct connection of support steel to the tank wall. **<u>Safety and Relief Valves</u>** • ASME defines safety valves as a pressure relief device that opens rapidly by inlet static pressure. The common application of safety valves is on steam and air service, where a large volume of gas is vented to effect a reduction in pressure. Air saturator vessels would be such an application. • A relief valve is defined as a pressure relief device that opens in proportion to the internal pressure. Relief valves are used on liquid systems, where a small amount of liquid will generally effect a reduction in pressure. • ASME requires some form of pressure relief device on a code certified tank properly selected for the service. An alternative to a safety or relief valve is a rupture disc (or blast gate), which also responds to internal pressure, and rapidly releases pressure (without re-closing). • Connection(s) on tanks for these devices should consider the following: ➢ Relief valves/rupture discs should be as close as possible to the vessel to maintain the relief pressure set point. ➢ Pressure reaction at the valve should be anticipated, especially with discharge piping connections. Often the slip-fit, "umbrella" type discharge connection is appropriate. ➢ Discharges of rupture discs can be dangerous and should be situated to avoid contact with personnel. Also, some form of protection should be given the rupture disc element (from the outside) to avoid accidental puncture or damage. ➢ Sulfuric acid storage tanks will include low-pressure "conservation" vents to allow air into the tank at vacuum conditions of approximately 300 mm water column and allow air to discharge at approximately 500 mm water column. This will minimize the respiration
	STORAGE TANKS &	**Tank**	

	VESSELS (Continued)	**Features (Continued)**	of air during periodic temperature changes and between tank filling and drawing down. The vacuum vent will be fitted with a desiccant air dryer to remove much of the atmospheric air moisture entering the tank to reduce the potential for weak acid corrosion in the gas space above the liquid surface.
1	**PLANT PIPING SYSTEMS**	**General**	• Plant piping includes yard piping, which may be entirely designed and specified outside of the mechanical discipline. • Yard piping of site-related utilities such as drainage systems and water distribution is discussed in the Civil Discipline Design Basis. • Plant piping of process services and mechanical utilities in the yard also requires Civil Discipline coordination and consideration for earth loads and traffic loads.
1		**Pipe Materials and Applications**	• A preliminary Piping Schedule indicating piping services planned for the Winnipeg WTP can be found in Section 20 of the PDR. • The schedule will be updated as the Detailed Design progresses to include identifying symbols (abbreviations) for service/commodity, material of construction, coatings, linings, and test pressures to be used for these services. • The finalized schedule will ultimately become the Piping Schedule included in the construction specification documents. • Polyvinyl Chloride (PVC) piping shall not be used where it may be subject to mechanical impact damage, buried services or where heat tracing is required. Also note that PVC piping is very brittle at low temperatures. • For Hazardous Chemical Piping; piping, labeling, personnel protection, and pipe location; shall conform to Provincial and local codes. • Hazardous Chemical piping and tubing between structures and building areas shall be run in containment piping (double walled) with leakage monitoring wells formed by a containment tee branch and drip-leg below the low point of piping runs.
1		**Pipe Joints and Couplings**	The following types of pipe joints and coupling systems shall be shown on the drawings and specified in order to provide design uniformity. **<u>Black Steel Pipe (Epoxy Lined/Coated)</u>** • < 50 mm – screwed or socket-welded • > 65 mm – grooved end, butt-welded, or flanged **<u>Stainless Steel Pipe</u>** • **<u>Stainless Steel Tubing</u>** • **<u>Ductile Iron Pipe</u>** • > 100 mm: grooved end, flanged, mechanical joint, or proprietary restrained joint **<u>Galvanized Steel Pipe</u>**

	PLANT PIPING SYSTEMS (Continued)	**Pipe Joints and Couplings (Continued)**	• < 50 mm – screwed • > 65 mm – grooved end or flanged **<u>Copper Pipe and Tubing</u>** • general service **-** socket joint with 95-5 wire solder **<u>Polyvinyl Chloride Pipe</u>** • solvent welded, screwed, or flanged **<u>Buried and Submerged Piping Joints</u>** • Do not use grooved end joints on any type of buried or submerged piping • Buried ductile iron pipe – mechanical joint, push-on joint, or proprietary restrained joint ends • Buried ductile iron pressure piping – thrust blocked, if practical, or proprietary restrained joint ends • Buried steel piping – coupled with flexible sleeve-type mechanical couplings, bell and spigot joints with retained rubber gaskets, or welded joints. Mechanical couplings and bell and spigot joints in pressure piping shall be provided with thrust ties unless thrust-blocked. • Buried joints on ferrous metal piping – bonded for cathodic protection application, as indicated in the Civil Design Basis. **<u>Grooved End Piping Joints</u>** • Grooved end joints (Victaulic or Anvil International, Inc., Gruvlok) are to be shown for all exposed piping 4 inches and larger in ductile iron systems • Grooved end joints (Victaulic or Anvil International, Inc., Gruvlok) are to be shown for all exposed steel piping larger than 2 inches, except fuel oil, propane, natural gas, compressed air and carbon dioxide shall be screwed, butt-welded, or flanged. • For those services that exclude grooved end joints, the specific type of joint to be used shall be specified in the piping specification data sheet and shown/noted on the drawings.
1	**PLANT PIPING**	**Piping System Hydraulics**	**<u>Modeling and Calculations</u>** • Refer to Hydraulic Modeling Tools above, for methods/software to be used for calculating energy gradeline and losses for process 'water' piping. • Fluids other than water (s.g. 1.0) must use a hydraulic loss calculation method, which considers the fluid properties of specific gravity and viscosity. These parameters are used to determine the Reynolds Number of the flow and the appropriate Darcy friction factor for the type of pipe and the pipe size. • A good resource for these methods is the *Crane Technical Paper No. 410*. The Crane Technical Paper includes methods for calculating fitting and valve losses and for compressible fluids. The AFT Fathom software includes fluid properties for many common fluids other than water and the user may define properties for specific aqueous solutions of chemicals used in this project (e.g. polymers). • Sludge flows with solids concentrations < 2% can be

	SYSTEMS (Continued)	**System Hydraulics (Continued)**	adequately modeled as water using the Darcy or Hazen-Williams equations. • Due to the complex and varying rheological properties of sludge with solids concentrations > 2%, calculating pressure drop is more challenging than for Newtonian liquids like water. Sludge piping calculations should be supervised by persons experienced in designing sludge conveyance systems. The reader is refered to Chapter 19 of *Pumping Station Design*, Sanks, et al., 1998, for discussion on determining friction losses in sludge piping. • Designers are cautioned to use actual pipe inside diameters, especially for small piping and tubing. Different pipe materials in the same nominal size usually have different actual inside diameters. The effect of pipe aging should also be accounted for in the calculation as well (aged C factor). **<u>Pipeline Velocities</u>** • **Gravity Pipelines and Channels** ➢ Normal: 1.0 to 1.5 m/s ➢ Maximum velocity: 2.5 to 2.8 m/s ➢ Minimum velocity: 0.5 m/s (where floc present) • **Pressure Pipelines** ➢ Normal: 1.5 to 2.5 m/s ➢ Maximum: 3.0 to 3.5 m/s ➢ Minimum liquid velocity: 0.5 to 1.0 m/s • The maximum and minimum liquid velocities noted above may be exceeded occasionally. However, this is the design range to be used for normal maximum and minimum flows. • Absolute minimum and maximum liquid line velocities seldom should be less than 0.2 m/s or more than 4.5 m/s. **<u>Hydraulic Surges (Transients or Water Hammer)</u>** Hydraulic surge, commonly called “water hammer,” is a change in fluid pressure due to an increase or decrease in the flow velocity within a piping system. The fundamental formula is: $$\Delta H = \frac{a}{g}\Delta V$$ where: ΔH = change in head, in metres ΔV = change in velocity from V_o (steady state), in m/s g = gravitational acceleration constant = 9.81 m/s^2 a = speed of sound in the fluid pipe system, in m/s The value of a/g usually falls between 100 and 140. Thus a sudden change in velocity of an amount ΔV = 1 m/s causes a transient pressure change ΔH = 100 to 140 metres, approximately. This is true for all cases that satisfy the equation, $$T = \frac{2L}{a}$$ where: T = time interval, in seconds, during the velocity change ΔV
	PLANT PIPING	**Piping**	

	SYSTEMS (Continued)	**System Hydraulics (Continued)**	L = line length, in metres Thus, any time a piping system is relatively long (300 metres or more) and the flow velocities are above 1.0 m/s, due consideration should be given to the potential for "Water hammer" under the following conditions: • If valves in the system are opened or closed rapidly, i.e., more rapidly than the time interval T above • If the system flow rate is subject to rapid acceleration or deceleration due to pump starting, stopping, or power failure As a general rule, the time required for valve closure should equal or, exceed 15 time intervals (T) in the formula above to prevent water hammer. If a piping system design fits the above criteria, or if you are uncertain as to the potential for damaging water hammer, a piping model view or plan and profile sketch of the proposed system should be prepared and sent to a hydraulic transient analysis specialist for further study. The sketch should show: • Pipeline locations, sizes, lengths, wall thicknesses and materials. • Valve sizes, locations, types, and proposed speeds of operation. • Pump locations, sizes, speeds, and characteristic curves. • Design average and maximum system flows. The pipeline profile should show: • Approximate pipeline elevations. • Pump locations, together with minimum and maximum pump suction elevations. • Reservoir locations, together with minimum and maximum water surface elevations. If further analysis is required, a computational transient analysis should be performed.
1	**PLANT PIPING**	**Piping Wall Thicknesses & Pressure Ratings** **Piping Wall**	• Wall thickness of mill-type steel and stainless steel plant piping should be determined in accordance with the ANSI/ASME B31.3 code for process piping. • Except for thin walled stainless steel piping, where corrosion naturally is less, standard wall or Schedule 40 pipe generally will be suitable for use in steel piping systems up through 300 mm nominal size. Above that size, walls thicker than 9.5 mm or thinner than 6 mm are seldom used for treatment plant steel piping. • Thickness of ductile iron pipe generally will be the pressure class above the design pressure. Of course, if the ductile iron pipe is buried, then the external loads due to soil pressure and traffic must be taken into account. • ANSI B36.10 and the ASTM material specifications state the manufacturing tolerance of thickness. For example, ASTM steel pipe specifications customarily allow a manufacturing tolerance of 12.5 percent. • Corrosion allowances should be determined on the basis of experience for the type of fluid being handled. Yearly corrosion rates for a given pipe material may be found in the

	SYSTEMS (Continued)	**Thicknesses & Pressure Ratings (Continued)**	*Chemical Engineering Handbook*. Generally speaking, the corrosion allowance should not be less than 1.5 mm, and more often 3 mm is used. • In addition to the Design Codes and Standards listed above for the more common piping materials, proprietary design information is usually available upon request from the manufacturers of reinforced concrete and concrete cylinder pipe, polyvinyl chloride (PVC) pipe, high density polyethylene (HDPE) pipe, and fiberglass reinforced plastic (FRP) pipe.
1	**PLANT PIPING**	**Piping System Thermal Expansion and Flexibility** **Piping**	• Unlike pipe support systems, thermal expansion provisions cannot be left to the contractor for design when they are required. Once piping is laid out, the potential expansion movement must be calculated with consideration for the pipe length, material, and the range of temperature the piping may experience. • Where the expansion is within the allowable flexure and allowable pipe wall stress for the particular pipe material and where the support system does not hinder movement, then it is best to avoid the use of expansion joints, compensators, or flexible metal hose. • All piping systems must be reviewed for thermal expansion needs. Details regarding piping expansion and flexibility are to be developed during detailed design. • The allowable flexure and expansion stress range for piping systems must be determined in accordance with the requirements of the ANSI codes listed under the Piping Design Codes and Standards above. This calculation is independent of that used to determine pipe wall thickness. However, pipe wall thickness must be determined <u>before</u> the stress range caused by temperature expansion of the piping can be calculated. The thermal expansion is then kept within allowable limits by use of selective piping configurations that allow for expansion, or by the use of expansion joints. • In the case of plastic piping, the manufacturers generally provide formulas for calculating the geometry of expansion offsets and loops. • Where expansion provisions are part of the piping system design, the pipe support system must be designed and detailed as necessary to include pipe guides adjacent to expansion joints, pipe anchors to direct the expansion and rolling or sliding supports to carry moving piping. • Anchor loads for piping with expansion joints must be calculated to determine if special structural design is required for the structural attachment or if a special design is required for the anchor attachment to the pipe. The anchor load is caused by the system pressure acting on the expansion joint inside cross-sectional area plus the joint resistance to compression. • Expansion joints should never be applied using more than half of their rated deflections at normal operating temperatures. • The contractor should also be directed as to the initial installation condition of expansion joints; whether they are to

	SYSTEMS (Continued)	**System Thermal Expansion and Flexibility (Continued)**	be compressed, extended, or left at their neutral length, or with length set according to ambient temperature at the time of piping length closure. • Where anchor loads would be excessive with expansion joints, flexible metal hose may be considered in a piping offset to eliminate the thrust load due to pressure and joint compression. The flexible metal hose specified has a braided thrust restraining jacket. • As the piping moves to offset the hose ends, the only anchor load is the pipe weight friction component at the hangers and supports. • In long, straight piping runs, thermal expansion may be a problem even though the fluid carried is at moderate temperature, depending upon the difference between installation and operating temperatures. • Even for smaller temperature differences, thermal expansion can be a problem when a pipeline is relatively long (50 to 100 m).
1		**Piping System Supports**	• All piping larger than 600 mm must be shown with specific details indicated, and all supports located on the drawings. • Supports must be provided at changes in direction and adjacent to or under flanges of heavy valve bodies and flowmeter bodies. • Future maintenance operations, requiring removal and replacement of piping and valves, need to be considered for selection of appropriate supports and their locations. • The pipe support specifications require the contractor to design all pipe supports and seismic bracing for piping through 600 mm in diameter. • Locations for rigid pipe anchorage for thermal expansion control, however, must be shown regardless of diameter. • Contract drawings should illustrate typical support types in appropriate views, for the purpose of indicating a general approach to piping support; for example, a drawing may show piping being supported from the floor rather than from the overhead structure. • Pipe support materials and component manufacturer model numbers will not be shown on standard details, but will be referenced to the specifications. • The designer should refer to Specification Section 15060, PIPING SUPPORTS, for the types of systems available already specified. • Standard details also are available for many common support and hanger arrangements. The contractor will be able to obtain support and hanger shop drawings from pipe support fabricators and subcontractors. These fabricators and subcontractors also offer design service to provide load rated components in accordance with the specifications. • Piping 750 mm and larger and all piping where the designer requires specific supports at specific locations shall include the detail design of supports and hangers. • Channel-type support systems such as Anvil International Powerstrut and Unistrut are good systems for runs of several different pipes through galleries and chemical tank farms.

	PLANT PIPING SYSTEMS (Continued)	**Piping System Supports (Continued)**	Corrosion resistant alloy and FRP versions are also available. • There are limitations to the use of these channel systems though. The load-carrying capacity of long spans of channel may not be adequate where several large ductile iron services are run. Channel moments and stresses must be checked for the worst case to be sure you are not asking a contractor to design a system for which members are not available to meet all conditions. Channel framing supports offer little resistance in the pipe axis direction and therefore are not to be used for anchors except for only the smaller piping and lower pressures. Again, always calculate the loads to determine the limiting size and pressure. • Another limitation of the channel framing systems is that many of the common catalog pipe support items such as pipe rolls and pipe guides require some adaptation to the channels and these should be detailed. • Duct support design is covered separately by the Building Mechanical Design Basis Memorandum.
1		**Piping System Hydraulic Thrust Restraint**	• Hydraulic thrust is produced wherever a flexible joint occurs, such as at flanged coupling adapters, flexible sleeve couplings (Dresser type), rubber-ring sealed buried pipe joints, and at expansion joints. • The thrust is the system pressure acting on the area of the outside diameter of the pipe, or in the case of the expansion joint, the cross-section area of the inside of the bellows arch. • Elastomer bellow expansion joints are provided with extension-limiting rods to protect the bellows from over extension, but these are normally unloaded if the joint is functioning properly. • Dynamic thrust of fluid flow through a bend is usually of much lower magnitude and is a function of the fluid-specific weight and velocity. • Hydraulic thrust must be restrained to keep pipe joints together when pressurized. • Thrust tie and welded lug assemblies for steel pipe are covered by a standard detail. • Ductile iron pipe 300 mm and smaller can be restrained at flanged coupling adapters with anchor studs provided in the coupling by the manufacturer. The anchor studs engage holes drilled through the end of the pipe. • Flanged dismantling joints are also available for restrained final closure pieces in ductile iron and steel piping systems beyond the size range covered by flanged coupling adapters with anchor studs. • Thrust tie rods may also be attached to piping with socket clamps. The socket clamps must engage a flange or grooved joint coupling between the clamp and the flexible joint. Socket clamps are available up to 600 mm, but pressure ratings are low in the larger sizes. • Buried pipe thrust restraint may be provided by joints individually restrained with thrust tie rod assemblies or proprietary restrained joints for ductile iron pipe.

	PLANT PIPING SYSTEMS (Continued)	**Piping System Hydraulic Thrust Restraint (Continued)**	• Buried pipe thrust restraint may also be carried by concrete thrust blocks where adequate soil-bearing pressure is available. • Additional information and guidance on thrust restraint for buried piping is covered by the Civil Discipline Design Basis Memorandum.
1		**Piping System Accessories & Specialties**	**General** • Various piping components that are occasionally required for certain systems could be sight flow indicators (rotameters), safety heads, rupture discs, hose and couplings, strainers, and swivel joints. These types of items are to be specified within Specification Section 15205, PROCESS PIPING SPECIALTIES. **Pipe Coatings and Linings** • Corrosion protection by coating and lining is to be covered by the detailed piping specifications. For coatings and linings requirement for specific services see Sections 19, and 22 of the PDR. **Thermal Insulation** • The common insulations to be considered for application to water treatment works piping are fiberglass, calcium silicate, and foamed glass. • Fiberglass is by far the most commonly used and although rated to 450°C, it is generally not applied above 230°C. • Calcium silicate is generally not applied below 230°C or above 530°C. • Foamed glass insulation can be rated to 650°C, but would be recommended in water treatment works as an underground insulation, subject to freezing and thawing. • Foamed glass (Pittsburgh Corning Foamglas), has low water permeability, low water absorption, low coefficient of thermal expansion, and a high compressive strength. • Insulation thickness should be selected for economy, and this can be done for a given insulation type of evaluating the present worth of energy loss over a period of time compared to the present worth of the insulation system over the same period of time. • Insulation of hot piping for the safe surface temperature to which people may come in contact shall be selected to provide not more than 49°C surface temperature. • The various manufacturers should be consulted for recommended vapor barriers, jackets, and finishes. • Buried insulated steel and copper piping should be the pre-insulated type with an outer protective conduit. These piping systems are available in many multiple pipe configurations within a single conduit. **Heat Tracing** • Heat tracing of piping will be required for freeze protection or to maintain the temperature of certain fluids that would become too viscous or may crystallize upon loss of heat. Examples of the later would be heavy fuel oil and saturated

	PLANT PIPING SYSTEMS (Continued)	**Piping System Accessories & Specialties (Continued)**	solution of sodium hydroxide (caustic), respectively. • The specification Section 16055, PIPE HEAT TRACING, includes electric heat tracing of the self-limiting cable type. The manufacturer's literature includes all of the necessary information for design. • Heat tracing is primarily electrical work and the selection of voltage and thermostats must be coordinated with the Electrical Discipline work on the project. **<u>Freeze Protection</u>** • Outdoor piping and tubing for water services and instrumentation are subject to the design minimum ambient temperature of -26 ºC (-15 ºF). This temperature is based on the mean low temperature minus one standard deviation from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 2001 Fundamentals Handbook, Chapter 27. • Freezing temperature periods are long enough to be a risk to small diameter exposed piping, especially those with no flow or very low flow. • The ASHRAE Fundamentals Handbook, Chapter 24, Thermal and Moisture Control in Insulated Assemblies—Applications, describes the calculation of insulation thickness and time to freeze for varying temperature conditions and pipe sizes. • It is assumed that the maintenance temperature for the process piping is 5 ºC for all cases except sodium hydroxide (caustic) and sodium bisulphate (SBS). • Sodium hydroxide (50% concentration) requires a maintenance temperature of 12 ºC to prevent freezing. • SBS (38% concentration) requires a maintenance temperature of 6 ºC to prevent freezing. • For freeze protection at the Winnipeg WTP, minimum insulation thickness will be 25 mm with a protective aluminum jacket. Pre-formed sectional fiberglass insulation is recommended. **<u>Pipeline Pigging</u>** • Pigging facilities should be designed into all pipelines subject to sludge or scale accumulations. This includes, but is not limited to: ➢ DAF sludge ➢ Washwater sludge ➢ Thickened sludge transfer ➢ Sanitary • Pigs can negotiate short-radius bends, tees, laterals, and pipe reductions as small as 65 percent of the main line size. However, pigs can hang up on rectangular-ported valves. • Use only round-ported eccentric plug valves in lines to be pigged. Consult both the pig manufacturer (Girrard-confirmation required) and King County for additional design criteria.

<table>
<tr><th></th><th></th><th></th><th></th></tr>
<tr><td>1</td><td>VALVES, GATES & ACTUATORS</td><td>General</td><td>To provide uniformity for design and maintenance at the Winnipeg WTP, the valve coupling configurations that shall be used are as follows:
<table>
<tr><th colspan="3">Valve Coupling Configurations</th></tr>
<tr><th>Type</th><th>Size</th><th>Configuration</th></tr>
<tr><td>Gate</td><td>≤ 50 mm</td><td>Screwed</td></tr>
<tr><td></td><td>≥ 65 mm</td><td>Flanged</td></tr>
<tr><td>Butterfly</td><td>75 to 500 mm</td><td>Flanged and Wafer Pattern</td></tr>
<tr><td></td><td>≥ 600 mm</td><td>Flanged</td></tr>
<tr><td>Plug, Globe, and Ball</td><td>≤ 50 mm</td><td>Screwed</td></tr>
<tr><td></td><td>≥ 65 mm</td><td>Flanged</td></tr>
<tr><td>Check</td><td>≤ 50 mm</td><td>Screwed</td></tr>
<tr><td></td><td>65 to 500 mm</td><td>Flanged and Wafer Pattern</td></tr>
<tr><td></td><td>≥ 600 mm</td><td>Flanged</td></tr>
<tr><td>Diaphragm</td><td>≤ 50 mm</td><td>Solvent socked weld solid plastic body and flanged, lined metal body</td></tr>
<tr><td></td><td>≥ 65 mm</td><td>Flanged</td></tr>
<tr><td>Pinch</td><td>≥ 65 mm</td><td>Flanged</td></tr>
</table>

Spring assisted closure may be recommended for larger swing check valves, depending on system static head and configuration. A transient analysis specialist can assist in making this determination.
Where flanged ends are specified, valves with rigid grooved ends are also acceptable for general water and air services, provided they meet valve specifications in all other respects, and are supported to prevent rotation in the grooves.
</td></tr>
<tr><td>1</td><td></td><td>Valve Types</td><td>
Valve types to be used for various process services are presented in the tables below. The recommended valve type shall be used unless the specific application requires another type for throttling applications.
Knife gate valves inherently exhibit leakage problems at the sealing surfaces of their gate slides. This is particularly true for very large gates. The use of knife gates should be avoided where the valves must be operated frequently. They are satisfactory, however, for isolation valves operated only occasionally. Resilient seated designs are preferred.
If large knife gate valves are required, larger than 900 mm, bonneted knife gates having a better seal design are available at a cost premium. It is better to use a sluice gate or butterfly valve larger than 900 mm if location or fluid properties permit.
</td></tr>
</table>

<table>
<tr>
<td></td>
<td>VALVES, GATES & ACTUATORS (Continued)</td>
<td>Valve Types (Continued)</td>
<td>
Valves for Process Water and Sludge Services
<table>
<tr><th>Size</th><th>Isolation</th><th>Throttling</th></tr>
<tr><td colspan="3">Water Streams with No Stringy Materials</td></tr>
<tr><td>≤ 75 mm</td><td>Gate</td><td>Eccentric plug</td></tr>
<tr><td>≥ 100 mm</td><td>Butterfly</td><td>Butterfly and MWD multi jet sleeve</td></tr>
<tr><td colspan="3">Sludges and Streams with Stringy Materials</td></tr>
<tr><td>≤ 300 mm</td><td>Eccentric plug</td><td>Eccentric plug</td></tr>
<tr><td>≥ 350 mm</td><td>Knife gate</td><td>Diamond port knife gate or slide gate</td></tr>
</table>
Valves for Clean Water and Air Services
<table>
<tr><th>Size</th><th>Isolation</th><th>Throttling</th></tr>
<tr><td>≤ 50 mm</td><td>Ball</td><td>Globe</td></tr>
<tr><td>65 and 75 mm</td><td>Gate</td><td>Globe</td></tr>
<tr><td>≥ 100 mm</td><td>Butterfly</td><td>Butterfly</td></tr>
</table>
Valves for Fuel Oils and Gaseous Fuels
<table>
<tr><th>Size</th><th>Isolation</th><th>Throttling</th></tr>
<tr><td>≤ 50 mm</td><td>Lubricated plug</td><td>Globe</td></tr>
<tr><td>≥ 65 mm</td><td>Lubricated plug</td><td>Globe</td></tr>
</table>
Valves for Chemical Service
<table>
<tr><th>Size</th><th>Isolation</th><th>Throttling</th></tr>
<tr><td>≤ 50 mm</td><td>Ball and Diaphragm</td><td>Diaphragm</td></tr>
<tr><td>≥ 65 mm</td><td>Diaphragm</td><td>Diaphragm</td></tr>
</table>
Valves for Slurries (abrasive)
<table>
<tr><th>Size</th><th>Isolation</th><th>Throttling</th></tr>
<tr><td>All Sizes</td><td>Pinch</td><td>Pinch</td></tr>
</table>
</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Valve Materials of Constructio n</td>
<td>• As a general rule, the materials presented in the table below shall be used for valve bodies. Specific recommendations must be developed after the process services are identified. These recommendations may differ from the general rules below.</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>VALVES, GATES & ACTUATORS (Continued)</td>
<td>Valve Materials of Construction (Continued)</td>
<td>
Valve Material Overview
<table>
<tr><th></th><th colspan="2">Size and Body Material</th></tr>
<tr><th>Valve Type</th><th>≤ 50 mm</th><th>≥ 60 mm</th></tr>
<tr><td>Gate</td><td>Bronze</td><td>Iron</td></tr>
<tr><td>Knife Gate</td><td>---</td><td>Steel, w/316 SS wetted parts</td></tr>
<tr><td>Butterfly</td><td>---</td><td>Iron</td></tr>
<tr><td>Eccentric Plug</td><td>Iron</td><td>Iron</td></tr>
<tr><td>Lubricated Plug</td><td>Iron, Steel</td><td>Iron, Steel</td></tr>
<tr><td>Globe</td><td>Bronze</td><td>Iron</td></tr>
<tr><td>Globe Type Plug</td><td>Bronze</td><td>Iron</td></tr>
<tr><td>Ball - Noncorrosive</td><td>Bronze</td><td>---</td></tr>
<tr><td>Ball - Corrosive</td><td>PVC, CPVC, or Alloy</td><td>---</td></tr>
<tr><td>Check</td><td>Bronze</td><td>Iron</td></tr>
<tr><td>Diaphragm</td><td>Solid Plastic or Alloy</td><td>Plastic or elastomer-lined iron or steel</td></tr>
<tr><td>Pinch</td><td>---</td><td>Iron w/elastomer sleeve</td></tr>
</table>
</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Valve Pressure Ratings</td>
<td>

Screwed end bronze valves through 75 mm are available in all of the common ratings except 250 pound SWP.
Flanged cast iron valves, 50 mm and larger are available in the 125 and 250 pound SWP ratings only.
For very high pressure and temperature applications, the above valves are available in cast steel and alloys in ANSI B16.5 pressure classes of 600, 900, 1,500, and 2,000 pound.
There is some compatibility of mating cast iron and ductile iron flanges to steel flanges. 125 pound and 150 pound flanges may be mated although the 150 pound flange has a raised face. Where possible, the joint should be bolted as specified in the piping specification with bolts of specific strength to afford some protection against breaking the cast iron flange. 250 pound and 300 pound flanges may also be mated. Both of these flanges have a raised face and the raised face diameter differs slightly.
Under the AWWA standards, valve manufacturers offer valves generally corresponding to the ANSI B16.1 standard for cast iron pipe flanges. Although most manufacturers offer valves in all sizes included in the ANSI standard, the AWWA standards do not include the 350 mm and 450 mm sizes.
The important AWWA standards and the corresponding pressure ratings are presented in the table below:

</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>VALVES, GATES & ACTUATORS (Continued)</td>
<td>Valve Pressure Ratings (Continued)</td>
<td>
AWWA Standards for Valves
<table>
<tr><th>AWWA Standard</th><th>Rating and Size</th><th>ANSI B16.1 Flange</th></tr>
<tr><td>C500 Gate Valves</td><td>200 psi/≤ 300 mm
150 psi/≥ 350 mm</td><td>125 pound flat-face</td></tr>
<tr><td>C504 Rubber-Seated Butterfly Valves</td><td>150 psi/≤ 500 mm
25, 75, 150 psi/≥ 600 mm</td><td>125 pound flat-face</td></tr>
<tr><td>C507 Ball Valves</td><td>150 psi/150 thru 1200 mm
250 and 300 psi/150 thru 1200 mm</td><td>125 pound flat-face
250 pound raised-face</td></tr>
</table>
Many of the manufacturers of AWWA valves also offer 250 and 300 psi rated versions of the AWWA gate valves and butterfly valves although the higher pressure ratings are not included in the AWWA standards for these valves.
</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Manual Valve Operators</td>
<td>
In general, the following types of manual valve operators shall be specified. Final selection will depend upon the differential pressure across the valve when closed, or the operating line pressure.
Valve Operators
<table>
<tr><th>Valve Type</th><th>Size</th><th>Operator</th></tr>
<tr><td>Gate</td><td>≤ 350 mm
≥ 400 mm</td><td>Geared Handwheel</td></tr>
<tr><td>Knife Gate</td><td>≤ 500 mm
≥ 600 mm</td><td>Geared Handwheel</td></tr>
<tr><td>Butterfly</td><td>≤ 200 mm
≥ 250 mm</td><td>Locking lever
Geared handwheel w/horizontal disc shaft</td></tr>
<tr><td>Eccentric Plug</td><td>≤ 150 mm
≥ 200 mm</td><td>Wrench lever
Geared handwheel</td></tr>
<tr><td>Lubricated Plug</td><td>≤ 150 mm
≥ 200 mm</td><td>Wrench lever
Geared handwheel</td></tr>
<tr><td>Globe</td><td>≤ 150 mm
≥ 200 mm</td><td>Handwheel
Geared handwheel</td></tr>
<tr><td>Ball</td><td>All sizes specified</td><td>Lever</td></tr>
<tr><td>Diaphragm</td><td>All sizes specified</td><td>Handwheel</td></tr>
<tr><td>Pinch</td><td>All sizes specified</td><td>Handwheel</td></tr>
</table>
Valves shall be installed with operating mechanisms vertically upward or horizontal, never vertically downward.
Installation at an inclined angle above the horizontal is also permissible, but for appearance should be limited to situations where interference must be avoided.
</td>
</tr>
</table>

	VALVES, GATES & ACTUATORS (Continued)	**Manual Valve Operators (Continued)**	• Valves installed horizontally with stem, centerlines more than 2.0 m above the operating floor or grade shall be furnished with chain wheel operators. Chains shall extend to within 1.2`m of the floor or grade. Nested valves with chains shall have staggered operators. • Within certain size ranges and pressure ratings, gate valves can be obtained with inside-screw non-rising stem, inside-screw rising stem, or outside screw rising stem. • Globe valves are available with either an inside or outside-screw rising stem. • The valve stem packing of outside-screw and yoke (OS&Y) valves is between the thread and the process fluid. Since the threads do not contact the fluid, these valves are recommended for corrosive and high temperature applications. • The position of the stem gives an indication of the amount of valve opening, but adequate headroom must be provided for the rise of the stem when the valve is opened. The outside screw also permits easy lubrication of the thread. However, care must be taken to protect the exposed threads from damage. • The stem thread of inside-screw valves is within the valve and thus exposed to the process fluid. The rising-stem gate and globe valves of this type give an indication of plug or disc position, but adequate headroom must be available the rise of the stem. • The non-rising stem gate valve should be used where headroom is limited. They should be used for buried service and in environments where exterior threads would be subject to corrosion or damage. • Buried valves shall be equipped with square-head operating nuts and tee-wrenches in place of handwheels. Some buried valves with enclosed, geared operators are available with a ground level position indicator and this should be specified where desired.
1		**Automated & Control Valves**	**<u>General</u>** • In most cases the need for automated (power-actuated) valves shall be determined by process requirements. In addition to the process requirements, power actuators shall be provided for the following applications: ➢ Where valve operation is required at least once per shift ➢ Where quick valve operation may be required because of an emergency condition ➢ For very large valves where manual operation is cumbersome or a H&S risk ➢ Where slow valve operation is required to control water hammer • All power-actuated valves shall be provided with manual over-ride operators (i.e. hand wheels, levers etc). Refer to Manual Valve Operators above, for additional guidance. **<u>Solenoid Valves</u>** • Solenoid valves larger than a 40 mm size are not to be used for OPEN/CLOSE process control.

	VALVES, GATES & ACTUATORS (Continued)	**Automated & Control Valves (Continued)**	• In detailing solenoid valves on drawings, show a ball valve and union upstream of the solenoid valve, so that the line may be isolated for solenoid valve replacement. **<u>Valve Bypasses and Isolation</u>** • The choice of whether to provide a bypass around a control valve is governed by the importance of the process or stream being controlled. • If the stream can be shut down long enough to replace the control valve without upsetting a critical process, no bypass is required. • If the process is critical and can't be controlled by manual throttling, a redundant control valve must be provided. • Regardless of whether or not a bypass is provided, manually operated isolation valves will usually be required on either one side or both sides of the control valve to facilitate its removal and replacement.
		Flow Characteristics of Control Valves	**<u>General</u>** • The flow characteristic of a control valve is the relationship between the flow rate through the valve and the valve travel as the travel is varied from 0 to 100 percent. • "Inherent flow characteristic" refers to the characteristic observed with a constant pressure drop across the valve. • "Installed flow characteristic" means the one obtained in service, where the pressure drop varies with flow and other changes in the system. • The purpose of characterizing control valves is to provide control loop stability over the expected range of system operating conditions. • To establish the flow characteristic needed to best control a given process requires a dynamic analysis of the control loop. However, analyses of the more common processes have been performed, so some useful guidelines for the selection of the proper flow characteristic are already established from experience. Typical inherent flow characteristic curves are also available in valve manufacturer's literature. **<u>Quick-Opening</u>** • The quick-opening characteristic is one normally limited to globe-style valve bodies. • A valve with a quick-opening flow characteristic provides a maximum change in flow rate at low travels, when the valve is near the closed position. The curve is basically linear through the first 40 percent of valve plug travel, and then flattens out noticeably to indicate little increase in flow rate as travel approaches the wide open position. • Control valves with quick-opening flow characteristics are to be used for OPEN/CLOSE applications only, where a significant flow rate must be established quickly as the valve begins to open. Consequently, they are often used in relief valve applications. • Quick-opening valves can also be selected for many of the same applications for which linear flow characteristics are recommended, since the quick-opening characteristic is linear up to about 70 percent of maximum flow rate. Linearity

	VALVES, GATES & ACTUATORS (Continued)	**Flow Characteristics of Control Valves (Continued)**	decreases sharply after the flow area generated by valve plug travel equals the flow area of the port. For a typical quick-opening valve, this occurs when valve plug travel equals one-fourth of the seat diameter. **<u>Linear</u>** • The linear flow characteristic curve shows that the flow rate is directly proportional to the valve travel, throughout the travel range. For instance, at 50 percent of rated travel, flow rate is 50 percent of maximum flow; at 80 percent of rated travel, flow rate is 80 percent of maximum; etc. • Change in flow rate is constant with respect to valve travel. This proportional relationship produces a characteristic with a constant slope so that with constant pressure drop, the valve gain will be the same at all flows. (Valve gain is the ratio of an incremental change in flow rate to an incremental change in valve plug, disc, or ball position. Gain is a function of valve size and configuration, system operating conditions, and valve flow characteristic.) • Valves with a linear characteristic are commonly specified for liquid level control and for certain flow control applications requiring constant gain. The linear flow characteristic shall be applied where the control valve pressure drop is 60 percent or more of the total pressure drop at all flowing conditions. **<u>Equal Percentage</u>** • In the equal percentage flow characteristic, equal increments of valve travel produce equal percentage changes in the flow. The change in flow rate is always proportional to the flow rate just before the change in valve plug, disc, or ball position is made. • When the valve plug, disc, or ball is near its seat and the flow is small, the change in flow rate will be small; with a large flow rate, the change in flow rate will be large. • Valves with an equal percentage flow characteristic are generally used on pressure control applications. The equal percentage flow characteristic shall be used if the major portion of the system pressure drop is not available across the valve. What constitutes a major portion of the system varies with each application. • Valves with an equal percentage characteristic should also be considered where highly varying pressure drop conditions can be expected. **<u>Modified Parabolic</u>** • The modified parabolic characteristic is not in widespread use today. Although seldom designed into a valve intentionally, it is, nonetheless, one that is inherent in many valve shapes. • Its use is dictated more often by the type of valve that must be used in a given service (e.g., with slurries or stringy solid-laden fluids) than by a specific control application. • At small valve openings the valve characteristic is somewhat similar to that of equal percentage valves. After about the first 40 percent of valve travel, the characteristic approaches a linear characteristic. **<u>Selection of Flow Characteristic</u>**

VALVES, GATES & ACTUATORS (Continued)

Flow Characteristics of Control Valves (Continued)

- Experience shows that when in doubt, it is better to pick an equal percentage characteristic. Using a linear characteristic where an equal percentage characteristic would be better often leads to an unstable system. However, the reverse situation seldom causes instability.
- It should be noted that where a linear characteristic is recommended, a quick-opening valve plug could also be used; although the controller will have to operate on a wider proportional band setting, the same degree of control accuracy may be expected.
- If a good dynamic analysis of the system is available, or if there is sufficient time to make one, the valve flow characteristic that is best suited in a particular control loop can be selected without reliance on the guidelines listed above. However, without a dynamic analysis, trouble can usually be avoided by following the suggestions above, although optimum control may not be reached.
- The Fisher Controls *Control Valve Handbook* lists some guidelines that will help in the selection of the proper flow characteristic. Remember, however, that there will be occasional exceptions to most of these "rules of thumb," and that a positive recommendation is possible only by means of a complete dynamic analysis.
- The table below shows characteristics of valves commonly used in water treatment and solids handling service.

Valve Characteristics of Common Valve Types

Valve Type	Typical Model or Manufacturer	Characteristic
Butterfly	Fisher Fishtail	Equal Percentage
Eccentric Plug	Homestead Ballcentric Dezurik Fig. 100	Modified Linear
Vee-Ball	Fisher Design "U"	Equal Percentage
V-Port	Dezurlik	Modified Linear to Linear
Ball	Neles-Jamesbury McCanna	Equal Percentage
Saunders Diaphragm	Grinnell McCanna	Modified Parabolic
Globe Body	Fisher Masoneilan Neles-Jamesbury	Quick Opening Linear Equal Percentage
Pinch	Red Valve Co. RKL Controls	Modified Parabolic

- The tables below provide generally recommended characteristics of valve characteristics for typical applications.

Flow Control Processes

		Best Inherent Characteristics	
Flow Measurement Signal to	**Location of Control Valve in**	**Wide Range of Flow Set**	**Small Range of Flow but Large ∆ P Change at**

VALVES, GATES & ACTUATORS (Continued)

Flow Characteristics of Control Valves (Continued)

Controller	Relation to Measuring Element	Point	Valve with Increasing Load
Proportional to Flow	In Series	Linear	Equal Percentage
	In Bypass[1]	Linear	Equal Percentage
Proportional to Flow Squared	In Series	Linear	Equal Percentage
	In Bypass[1]	Equal Percentage	Equal Percentage

[1]When control valve closes, flow rate increases in measuring element

Pressure Control Systems

Application	Best Inherent Characteristic
Liquid Process	Equal Percentage
Gas Process. Small Volume, Less Then 3 metres of Pipe Between Control Valve and Load Valve	Equal Percentage
Gas Process. Large Volume /Process has a receiver, distribution system or transmission line exceeding 30 metres of nominal pipe volume decreasing ΔP with increasing Load, ΔP at Maximum Load > 20°6 of Minimum Load ΔP	Linear
Gas Process. Large Volume. Decreasing ΔP with Increasing Load. ΔP at Maximum Load < 20% of Minimum Load ΔP	Equal Percentage

Liquid Level Systems

Control Valve Pressure Drop	Best Inherent Characteristic
Constant ΔP	Linear

	VALVES, GATES & ACTUATORS (Continued)	**Flow Characteristics of Control Valves (Continued)**	Decreasing ΔP with Increasing Load. ΔP at Maximum Load > 20% of Minimum Load ΔP — Linear Decreasing ΔP with Increasing Load. ΔP at Maximum Load < 20% of Minimum Load ΔP — Equal Percentage Decreasing ΔP with Increasing Load. ΔP at Maximum Load < 200% of Minimum Load ΔP — Linear Decreasing ΔP with Increasing Load. ΔP at Maximum Load > 200% of Minimum Load ΔP — Quick Opening
	VALVES, GATES & ACTUATORS (Continued)	**Control Valve Sizing** **Control Valve Sizing (Continued)**	**General** • Once the valve configuration and flow characteristic are selected, the control valve can be sized for the capacity best suited to control the process. • The main challenge in sizing control valves is turndown, i.e., the ratio of maximum to minimum flow. As a "rule of thumb," a turndown ratio of 5:1 should not be exceeded, although in steam applications turndown ratios of 10:1 are sometimes required. • The C_v method of sizing shall be used. Valve sizing equations such as those given in ANSI/ISA Standard S75.01.01 shall be used. These equations include correction factors for non-turbulent flow conditions, pipe reducer effects, compressibility factor for gases, and specific heat ratio compensation. • Valve position should be maintained so that the valve operates in the more linear portion of the flow coefficient (C_v) curve (between approximately 20 to 70 percent) for optimum control. **Pressure Drop (ΔP)** • The required valve size is calculated after determining the maximum and minimum flow rates of the system and the pressure drops (ΔP) at each flow rate, including the average. The following guidelines shall be followed for allocating ΔP and sizing valves for various applications: • Valves shall be sized to pass the maximum flow at minimum ΔP with the valve operating at not more than 80 percent of maximum capacity. • In a pumped system, the ΔP across the control valve at maximum flow should be: ➢ Forty percent of the system total frictional losses (including the control valve) when the static head exceeds 75% of the total dynamic head (TDH) ➢ Thirty percent of the system total frictional losses (including the control valve) when the static head is between 50 and 70% of TDH ➢ Twenty percent of the system total frictional losses (including the control valve) when the static head is less than 50% of TDH ➢ In all cases, the valve: closure must be checked at the maximum throttling (minimum opening) position. If it is not at least 10 percent open, a smaller valve or a valve

			with a different characteristic must be used. The preferred minimum opening is 15%. • In a system where static pressure moves liquid from one pressure vessel to another, the pressure drop allocated to the control valve should be 10% of the static pressure or 40% of the system total frictional losses (including control valve) at maximum flow, whichever is greater. As before, the minimum valve opening must be at least 15%. • The above ΔP allocations may be reduced with proper care and attention for systems where the dynamic losses are well defined and load changes are minimal. • Control valve ΔP cannot be determined independently of other system components. Control valve ΔP must be calculated taking into account pump curves, line losses, elevation differences, and static heads, at maximum flow, average flow, and minimum flow conditions. **Flow Sizing Coefficients (C_V and Cg)** • Control valve capacities are listed in terms of sizing coefficients in all manufacturer's literature. They are expressed in USgpm at 1 psi differential pressure liquids, or in standard cubic feet per hour at 1 psi differential pressure for gases. Metric equivalents may be available. • The sizing coefficient is expressed as C_v for liquids and Cg for gases. Some manufacturers do not use a specific coefficient for gases. Instead, they employ a conversion method to handle compressible fluids using the liquid flow sizing coefficient, C_v. • Using the manufacturer's published techniques, it takes only a few minutes to select a valve with the proper capacity from a sizing chart and check for flashing or cavitating conditions. • Best control will come with a valve that is neither oversized nor undersized, and most manufacturers supply a logical progression of capacities in their ranges to aid in selecting optimal valve sizes. • Restricted trim is also available for applications where future demands for capacities might be greater than today's, or where the designer wishes to avoid a situation where a 200 mm line was sized down to handle a 50 mm valve.
1	**VALVES, GATES & ACTUATORS (Continued)**	**Control Valve Cavitation Control** **Control Valve Cavitation Control (Continued)**	• Cavitation occurs in a fluid when the fluid forms vapor bubbles at low pressure; then, upon an increase in pressure the vapor bubbles collapse and release acoustic energy, which can damage adjacent materials. • The best method of cavitation control is to prevent the low pressure condition that forms the vapor bubbles. This can often be accomplished by installing the control valve where static head is maximized or by providing adequate downstream head with system friction loss. • Many control valves are characterized with regard to their incipient cavitation. The cavitation index is the absolute downstream pressure divided by the pressure drop across the valve at incipient cavitation. • Many control valve manufacturers offer special valve trim and materials to resist cavitation damage. • Some situations may be best handled with control valves in

			series.
1	**VALVES, GATES & ACTUATORS (Continued)**	**Valve Torque, Thrust and Actuators**	**<u>General</u>** Actuators are either a sliding stem or rotary type. Within these two general categories there are five basic actuator types. A description of each type and its application follows. **<u>Electric Motors</u>** • Electric actuators usually consist of motors with gear trains to provide a wide range of torque outputs. A prime advantage is their use in remote installations where no instrument air source is available. • Electric actuators are normally economical only in relatively small thrust (600 to 1,000 pound, or 2.7 to 4.5 kN) ranges. • Large units with high thrust generally operate slowly and weigh considerably more than their pneumatic counterparts. • At this time, there are no electric actuators economically available with fail-position action other than lock-in-last-position. • Throttling-control designs are somewhat limited in capability, however designs are improving. In continuous, closed-loop throttling applications, where very frequent changes are made to control valve position, the electric actuator may be unsatisfactory due to limited duty cycles and slow response. **<u>Spring and Diaphragm</u>** • The pneumatic spring-and-diaphragm actuator offers high reliability at low cost. It is also fast-acting. • The principle advantage of the spring-and-diaphragm actuator is its fail-safe action upon loss of actuation pressure. As air is loaded on the diaphragm casing, the diaphragm moves the valve and compresses the spring. Energy stored in the spring moves the valve back to its original position as air is removed from the casing. • Where the diaphragm is actuated directly by an instrument output signal, signal pressure loss to either the instrument or the actuator will cause the spring to move the valve to its initial (fail-safe) position. • Spring and diaphragm actuators are available for either fail-open or fail-closed action. • Diaphragm actuators normally operate using air signal ranges of 3 to 15 psig or 6 to 30 psig. Because of this, they can often provide throttling control (continuous, proportional pressure control) while operating directly from instrument air-pressure signals. • However, without positioners valves may be sensitive to line pressure. • Since diaphragm actuators have few moving parts, they are extremely reliable and easy to maintain. • The primary drawback of spring-and-diaphragm actuators is their relatively limited thrust capability. Much of the force created by the diaphragm is absorbed by the spring and does not result in thrust output. The spring-and diaphragm actuator ceases to be cost-effective for thrust requirements in excess of about 2,000 pounds (9 kN) or torque requirement over 5,000
		Valve Torque, Thrust and Actuators (Continued)	

	VALVES, GATES & ACTUATORS (Continued)	**Valve Torque, Thrust and Actuators (Continued)**	inch-pounds (565 N.m). • Therefore, as a rule of thumb, spring-and-diaphragm actuators may be considered to be limited to valves 200 mm and smaller. However, they are an excellent application in this size range. **<u>Pneumatic Piston</u>** • Pneumatic piston actuators are an economical choice when thrust and torque requirements exceed the capability of diaphragm actuators. • Piston actuators normally work with supply pressures from 60 to 150 psig. • They are also an excellent choice when compact, high-thrust actuators are required. • They can also be used very effectively where varying service conditions require a wide range of output forces, and, therefore, a fast-acting unit. • Piston actuators used for throttling control require a double-acting positioner that will simultaneously load and unload opposite sides of the piston. The differential pressure created across the piston causes travel toward the lower pressure side. The positioner senses this piston motion and, when the required position is reached, the positioner equalizes the pressure on both sides of the piston, preventing further piston motion. • Positioners are required in throttling applications to isolate valve position from line pressure. • The main disadvantages of piston actuators are the high air-supply pressures required, the need for positioners during throttling service, and the lack of built-in fail-safe systems. • The basic failure mode of a pneumatic piston is the fail-last position. The options for piston actuators include spring return, but the addition of springs limits the construction to much the same force outputs as the diaphragm actuator. The only alternatives to springs are pneumatic trip systems, which move the piston actuator to its fail-safe position. These consist of an air volume tank and trip valve which, though quite reliable, add to the overall system complexity, maintenance, and cost. • Pneumatic piston actuators should be considered where high valve forces, torques, or thrusts exist, where long valve strokes are required, or where valves are large. If a valve is 200 mm or larger, it may require a pneumatic piston. **<u>Hydraulic</u>** • Hydraulic actuators are powered by an external pumping unit. High-pressure hydraulic fluid, sometimes up to 3,000 psig, can be supplied from a central hydraulic pumping unit. • Actuator control is accomplished through a servo-amplifier and a system of hydraulic valves. This system can provide the ultimate in actuator performance, i.e., exceptional stiffness, fast stroking speeds, very high thrust (sometimes up to 50,000 pounds, or 220 kN). However, the price tag for this performance is quite high. • Gas- or spring-charged hydraulic accumulators are also

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>available that have the advantage of releasing stored energy in the even of power failure.

<u>Recommendations</u>
• In summary, the choice of an actuator depends upon the application requirements.
• Sometimes the selection is made automatically, depending upon the type of control signal, the power source available, the torque or thrust required, the manual operator requirements, the need for a specific fail-safe mode, or client preference.
• The relative values of actuator simplicity, maintenance, and economy must be considered.
• If a spring-and-diaphragm actuator suits the application, it should be considered first because of its simplicity, reliability, and economy.
• If it is not possible to use a diaphragm actuator, the next best choice may be a pneumatic piston actuator. The piston offers the desirable combination of high thrust and relatively low initial cost. Further, it is simple and easy to maintain, which is characteristic of pneumatic actuators.
• Because of their cost and complexity, electric and hydraulic actuators should be considered only when compressed air isn't readily available, or where extremes of performance are required (as discussed under these units above).
• Actuators shall be factory mounted and tested before coming to site. The matching of actuator size to the valve body is best left to the control valve manufacturer.
• Although actuator sizing is not difficult, the great variety of actuator designs available complicates the task. Further, the access to manufacturer expertise through suppliers makes it unnecessary for process designers to acquire detailed knowledge of actuator sizing procedures.</td>
</tr>
<tr>
<td>1</td>
<td>VALVES, GATES & ACTUATORS (Continued)</td>
<td>Control Valve Accessories & Hydraulic Power Units

Control Valve Accessories & Hydraulic Power Units (Continued)</td>
<td><u>Position Indicators</u>
• Position indication shall be provided locally on all control valves by mechanical attachment or linkage to either the valve stem or valve actuator.

<u>Positioners and Boosters</u>
• In many control systems, a properly sized spring-and-diaphragm actuator will do an excellent job without the use of either a positioner or a booster. In other systems, a booster (pneumatic amplifier) or positioner is mandatory. A booster amplifies an instrument signal pressure or volume. A positioner isolates valve position from the influences of line pressure or flow. Pneumatic valve positioners transduce an instrument air signal to a valve position; the air signal does not control the actuator directly.
• There are three principal reasons for selecting a positioner or a booster: 1) to obtain split operating ranges for two control valves, 2) to obtain a loading pressure greater than the maximum instrument signal, and 3) to obtain a finer degree of control. Examples might include rapid adjustment of a valve plug to recover quickly from process disturbances, or minimization of valve overshoot during actuation. Some</td>
</tr>
</table>

			positioners include standard and custom characterizing cams. • Proper selection of a positioner or booster is loosely related to process dynamics, but not to valve size, valve plug unbalance, packing friction, or transmission line length. The selection of either a positioner or a booster depends mainly on whether the process is classified as "slow" or "fast." • If the system is relatively fast, such as is typical of liquid pressure control loops, some gas pressure control loops, and most flow control loops, the proper choice is a booster. If the system is relatively slow, such as is typical of liquid level, blending, temperature, and some reactor control loops, the proper choice is a positioner. Fortunately, for those in-between cases when it is difficult to determine if a system is fast or slow, the choice has little effect on performance. **<u>Solenoid Pilot Valves</u>** • Where solenoid pilot valves are specified as a part of the control loop, they shall be provided with the main control valve. Solenoid valves shall be line size and soft-seated, with brass bodies and 120-Vac solenoid coils. **<u>Air Exhaust Mufflers</u>** • Mufflers shall be provided in the exhaust port of all actuator solenoid pilot valves.
1	**VALVES, GATES & ACTUATORS (Continued)**	**Slide Gates, Sluice Gates, Weir Gates & and Stop Logs** **Slide Gates, Sluice Gates, Weir Gates & and Stop Logs (Continued)**	**<u>General</u>** • Slide gates will be used to isolate flow in basins and channels in the Winnipeg WTP. **<u>Slide Gates</u>** • Slide gates will meet AWWA C561, *Standard for Fabricated Stainless Steel Slide Gates*. • It is expected that slide gates will leak, however sound fabrication can minimize this leakage. • The slide gate operator is often mounted to the gate frame to form a self-contained unit. • Slide gates shall be used only for isolation service, not for throttling. Unlike sluice gates, the slide gate can be installed in a channel without a concrete wall for the thimble. • The slide gate guides may be embedded in a grouting blockout leaving the full channel width equal to the gate. • Because the gate runs on a bearing surface throughout the travel, slide gates should not be installed in the process where abrasive grit could accumulate and wear the gate at these surfaces. • Slide gates should not be applied in unseating head installations. • Power operators shall be provided for any of the following situations: ➢ The total gate lift is 72 inches or greater ➢ The nominal gate cross sectional area is 36 square feet or more ➢ The gate is anticipated to be operated more frequently than once a week ➢ The slide gate may require rapid response to some condition

	VALVES, GATES & ACTUATORS (Continued)	**Slide Gates, Sluice Gates, Weir Gates & and Stop Logs (Continued)**	➢ The gate requires remote operation **<u>Sluice Gates</u>** • Wedges: ➢ Sluice gates shall have wedges only for seating head conditions. ➢ All gates 600 mm and wider subject to unseating heads of 1.5 m or more shall be equipped with side, top, and bottom (full) wedges. • Wall Thimbles: ➢ All sluice gates shall be mounted on wall thimbles. ➢ Normally, gates shall be furnished with F-section wall thimbles. However, E-section thimbles shall be considered when unseating heads are more than 7.6 metres. ➢ Also, large gates installed in thin walls often require E-section thimbles. Consult the manufacturer in such cases. ➢ When gates are in channels, the gates shall be of the “flush bottom” design. • Frames: ➢ Frames shall be the flanged type unless frame clearances preclude their use. ➢ Flanged frames require 200 to 250 mm clearance, sides and bottom, for bolt attachment during gate installation. ➢ If clearances are a problem, flat frames require only 25 mm clearance on the sides and 40 to 50 mm clearance at the bottom for installation on the thimble. ➢ Clearance differences stated are dependent upon the specific gate manufacturer. ➢ Flanged frames shall be used for all round openings provided with wall thimbles. • Stems: ➢ See Gate Operator section below. **<u>Gate Operators</u>** • Operators normally shall be the rising stem type to permit visual determination of gate position. • Gates 600 mm by 600 mm or smaller, or larger gates operating with less than 1 metre of unbalanced head, may have bench stand or floor-stand hand wheel operators. • All other sluice gates shall be provided with enclosed, geared-type bench stand or floor-stand operators. Consider size, unbalanced head, speed of gate travel, and frequency of operation in making the selection. Use bench stands only if they can be installed at convenient operating heights. Non-rising stem operators are available for use where needed. • All manual, geared floor-stand gate hoists should be capable of portable electric operator attachment by replacement of the crank operator with an adapter. • Electric motors for gate operator service are normally of the totally enclosed, non-ventilated type with intermittent duty ratings depending on the running torque and time required as well as the motor rated temperature rise. • Most gate operators should be capable of a 3-stroke operation, open-close-open, at the maximum ambient temperature. In

			some cases, this will require a larger motor just to obtain the thermal rating, but where the gate is in a critical service, where maximum reliability is required, the specification requirements for the critical operators must be clear on the sizing requirements. • The maximum gate operating thrust must be calculated for proper structural design of gate hoist installations. • Hydraulic fluid power operation of gates should generally be avoided where there is any possibility of contaminating the process water with a spill or leak of hydraulic fluid. • Cylinder operators utilizing water power have been used in water treatment works where the operator is continually submerged. • The slide gate specifications and the manufacturer's literature should be reviewed for limitations of size, operating leads, and physical installation. • The table below presents a general schedule for fabricated slide gates to be used at the Winnipeg WTP.

Winnipeg WTP Fabricated Slide Gate Schedule

Size	**Number**	**Location**	**Use**
	1	Main WTP Building – DAF Effluent Channel	Isolation of DAF treatment trains
	2	Main WTP Building – Ozone Contactors Inlets	Isolation of Ozone treatment trains
	4	Main WTP Building – Ozone Contactors Outlets	Isolation of Ozone treatment trains
	1	Main WTP Building – Filter Influent Channel	Isolation of Filter treatment trains
	8	Main WTP Building – Filter Influent/WW Gullets	Isolation of Individual Filter Units (influent)
	8	Main WTP Building – Filter Influent/WW Gullets	Isolation of Individual Filter Units (Washwater)
	4	Washwater Recovery Basins	Isolation of Individual Recovery Basins
		Freeze-thaw Lagoons	Removal of decant water

* Indicates a weir gate

1	**HOISTING AND CONVEYING EQUIPMENT**	**General**	• This section covers criteria for two varieties of hoisting equipment: bridge cranes and monorail cranes. • Hoists themselves will also be discussed, as well as electrification, controls, and variable-speed drive systems. • A list of the cranes and hoists identified for the Winnipeg WTP are described in the table below:

Crane and Hoist Schedule

Description	Capacity	No.	Location	Use
Bridge Crane/Travelling Monorail	<> tonnes	1	Main WTP Building – Maintenance Workshop	Loading and unloading of equipment
Travelling Monorail and Hoist	<> tonnes	2	Main WTP Building – Residuals Area	Maintenance of gates, valves, pumps, and thickener drives
Monorail and Hoist	<> tonnes	1	Main WTP Building – Raw Water Pumping Station	Maintenance of valves and pumps
Traveling Monorail and Hoist	<> tonnes	<>	Main WTP Building – Rapid Mix Area	Maintenance of valves and mixing pumps
Traveling Monorail and Hoist	<> tonnes	<>	Main WTP Building – Floc/DAF Operating Floor	Maintenance of mechanical mixers
Traveling Monorail and Hoist	<> tonnes	1	Main WTP Building – DAF Service Gallery/BWS Pumps	Maintenance of valves and BWS Pumps
Monorail and Hoist	<> tonnes	2	Main WTP Building – Filter Operating Floor	Maintenance of slide gates, and mechanical mixers

		Bridge Cranes and Traveling Molnorails	**General** • There are two basic types of bridge cranes: ➢ Top running, dual girder or single girder cranes ➢ Under running (or underhung), dual girder or single girder cranes • While modifications to these two basic types exist (e.g., floor supported gantry cranes, etc.) these are the most common types of crane systems.

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Bridge Cranes and Traveling Molnorails (Continued)**	• Dual girder cranes provide greater load carrying capacity than single girder cranes, and are more stable in support of the hoist (by using a trolley system, mounted on the dual girders) than a single girder design. • Usually very small cranes (1 or 2 tonne) will be configured as single girder, while most others are dual girder. **<u>Classes</u>** • CMAA provides various service categories for cranes, which must be considered and specified prior to purchase and fabrication. • For the bridge system and trolley, the following service categories are provided. ➢ Class A – standby or infrequent use ➢ Class B – light service (2 to 5 lifts per hour, 10-foot lift) ➢ Class C – moderate service (5 to 10 lifts per hour, less than 50 percent capacity lifts not over 15 feet) ➢ Class D – heavy service (10 to 20 lifts per hour, 50 percent capacity lifts averaging 15 feet) ➢ Class E--severe service (20 or more lifts per hour, at or near rated capacity) ➢ Class F--continuous severe service (critical work tasks) • Most maintenance cranes can be considered Class A, since they are not in service most of the time. • A process crane (such as fuel loader on a garbage plant) would range from Class C to Class F. • This project will require Class A cranes only. • Hoists are given a separate service classification, and is covered below. **<u>Rails and Drive Systems</u>** • Bridge cranes run on railway type steel rails, supported by structural members. These members are held up on the building columns, with sufficient c1earance to allow the crane end trucks to pass by without striking the columns. • The support steel must be quite stiff and straight, with loads and stresses as specified in CMAA. • Crane support steel has a much lower tolerance for sag between supports than normal ASCE standards require, since crane movement and precision will be affected. ➢ A1 drive – motor and gearbox on center of bridge ➢ A2 drive – motor on center of bridge, with output shafts provided for dual end truck gearboxes ➢ A3 drive – motor on center of bridge, twin output shafts to dual gear boxes ➢ A4 drive – motor and gearbox located at each end truck ➢ A5 drive – same as A3 drive, but with one motor shaft and additional gear box ➢ A6 drive – same as A3 drive, but twin motors used, connected via a torque shaft • The most common drive system is either the Al or A4 system. The Al system provides the best control of crane movement, and is especially useful on short spans (< 15 metres) and difficult installations (old construction, dirty environments). The A4 drive works well on longer spans, clean environments, and new construction.

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Bridge Cranes and Traveling Molnorails (Continued)**	• Trolley drive systems can be 1) electric motor, 2) chain drive, or 3) hand operation. The drive can be direct drive or geared to drive wheels. **Speeds** • Suggested operating speeds are specified in CMAA, including design factors (e.g., wheel speed, load factors), and hoist/trolley/bridge speeds. • Speeds are a function of the distance to travel and the service. Maintenance cranes are usually slow speed to facilitate assembly and disassembly of machines and equipment. Heavy duty cranes are usually higher speed, to optimize duty cycles. • Bridge and trolley drives are often provided with "soft-start" capability to allow slow starts and "inching" movements. • Also, variable speed drives are used in this application, to allow high traverse speeds and slow speeds on pickup and delivery. **Accessories** • Provisions must be made for the following items on bridge cranes: ➢ Central lubrication points should be provided, to allow maintenance. Usually three points are established – one at each end truck and one at the trolley area lubrication point. Grease tubing is run from these - points to individual bearings and sliding surfaces. ➢ Walkways, toe guards, and handrails should be provided, both on top of the crane girders as well as adjacent to the festoon or cable drum areas (if provided). ➢ Also, some form of access door should be provided on cranes that are accessed from below. This door should be designed to provide spring closure, and not interfere with crane operation. ➢ Provide instructions on how to load test cranes prior to service, as well as providing guidelines for safe operation of cranes. Load test weights shall be provided and maintained onsite for periodic testing. The ANSI standards B30.11, 16, and 17 also provide general safety standards for cranes and monorails. **Data Sheets** • CMAA provides recommended crane inquiry sheets, including clearance diagrams, as part of the specification. • Data should be provided, as part of the supplementary specifications, on the following items of information: ➢ Number, of cranes ➢ Capacity ➢ Required hook lift ➢ CMAA class ➢ Service information (duty cycle, lifts per hour, material handled, indoor/outdoor location, etc.) ➢ Method of control (cab, floor, radio, pendant, etc.) ➢ Electrification (busbar, festoon, reel) • In addition, a clearance diagram is usually provided. CMAA provides recommended types of diagrams, as do most crane suppliers.

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Monorails**	**General** • The other kind of hoisting equipment is the simple monorail. This system involves a single girder supporting a driven or push hoist support trolley, and is often supplied with a stabilizing roller (which resists tipping if the load is lifted to the side of the hoist vertical axis). • Monorails are limited by the load they can support, as well as the load the building steel can support. In contrast to bridge cranes, which spread the load across the girders, twin bridge trucks and twin runway rails, monorails concentrate the load on a few support rollers and a single beam, which doubles as the "runway rail." Often a special rail is utilized to meet the shape and load reactions of the hoist. **Classes** • Monorails are classified by ANSI MH 27.1 much the same as bridge cranes: ➢ Class A – standby or infrequent use ➢ Class B – light service (2 to 5 lifts per hour, 3 metre lift) ➢ Class C – moderate service (5 to 10 lifts per hour, less than 50 percent capacity lifts not over 4.5 metre) ➢ Class D – heavy service (10 to 20 lifts per hour, 50 percent capacity lifts averaging 4.5 metre) • There are no severe service monorail classes in the revised CMAA specifications. OSHA provides instructions on how to load test cranes prior to service, as well as providing guidelines for safe operation of cranes. The ANSI standards B30.11, 16, and 17 also provide general safety standards for cranes and monorails. **Speeds** • Operating speeds for motor driven monorails are provided by CMAA, including design factors (e.g., wheel speed, load factors) and hoist/trolley speeds. • Speeds are a function of the distance to travel and the service provided. • Maintenance cranes are usually slow speed to facilitate assembly and disassembly of machines and equipment. Heavy duty cranes are usually higher speed to optimize duty cycles. The Winnipeg WTP will use only slow speed cranes and hoists as they will be infrequently used. **Data Sheets** • CMAA provides recommended crane inquiry sheets, including clearance diagrams, as part of the specification. • Data should be provided, as part of the supplementary specifications, on the following items of information: ➢ Number of monorail systems ➢ Capacity ➢ Required hook lift ➢ Monorail length ➢ CMAA class ➢ Service information (duty cycle, lifts per hour, material handled, indoor/outdoor location, etc.) ➢ Method of control (floor, radio, pendant, etc.) ➢ Electrification (busbar, festoon, reel)

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Hoists**	**General** • Hoists are provided in a number of configurations, suited for a variety of services. • Hoists can be classified as parallel mount or cross mount, which refers to the location of the cable drum to the monorail or trolley axis. • Drum configurations can be made, to avoid "walking" the hook during raise and lower operations, by winding the cable on both ends of the drum to counteract movement. • There are various types of hoists as well, such as: ➢ Chain hoists – usually used on slow speed and low capacity applications ➢ Wire rope hoists – usually used on high speed and high capacity applications ➢ Electric motor drive – most common ➢ Chain wheel drive – for low-use hoists or low capacity units • Electric driven, wire rope hoists are recommended for most applications. **Service Groups** • Hoists are classified into service groups by ANSI HST 4M as follows: ➢ Class H1 – infrequent use ➢ Class H2 – light use, running time 12.5 percent of work period ➢ Class H3 – general use, running time not over 25 percent of work period ➢ Class H4 – high volume handling, running time not over 50 percent of work period ➢ Class H5 – bulk material handling, continuous duty cycle • Hoists used in the Winnipeg WTP will be used for maintenance service and will be H1 or H2 class. **Speeds** • Hoist speeds are specified in ANSI HST 4M as a function of rated load. • The speeds listed in ANSI HST 4M should be compared to ratings provided by CMAA, which are generally more conservative than HST 4M. • Hoist speeds should also be analyzed in relation to the lift distance – a longer lift distance could warrant higher speed. **Brakes** • Hoists are normally supplied with one of two types of load brakes. These brakes function to assist dynamic braking (by the motor, if provided) and act as a safety system upon loss of power. • The first type, electric release brake, is installed with the drive motor, and releases when power is applied to the motor itself. • The second type, latch pawl mechanical brake, is part of the hoisting mechanism, and is integrated into the hoist function of mechanical hoists (such as chain hoists). **Hooks and Cable**

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Hoists (Continued)**	• Hooks are specified in ANSI specification B30.10 for safety and function. Hooks should have sufficient ductility to noticeably open or crack before failure.
			• Hooks should be provided with a safety latch, which can be either a spring-loaded flap or an interlocking mechanism that closes the hook opening.
			• Hoist cable should be suitable for hoisting service, chosen for the service class and duty of the hoist itself. Chain should be alloy steel, close link coil type, suitable for the service class and duty of the hoist.
			<u>Electrification</u>
			• Hoisting electrification systems include:
			  ➢ Busbar – most common, especially for bridge crane main electrical feed
			  ➢ Festoon – also common, especially for trolley and monorail main electrical feed
			  ➢ Cable reel – not as common, used in corrosive environments in place of busbar, and occasionally in place of festoons on trolleys or monorails
			• Busbar can be provided as standard galvanized strip enclosed in nonconducting plastic cover, or with a stainless steel covered strip for corrosive environments.
			• Festoon cable must be measured to fit the travel of the crane, trolley or monorail, and should be supported with a high quality heavy duty roller system. To ensure safety and reliability, festoon cable should be supplied with extra conductors (recommend 20 percent) to allow repair of cable damage without replacing the entire festoon. Because of the room required to fold festoon cable, crane travel is often hampered with this system.
			• Cable reel should have high quality cable suitable for this service, of suitable length (similar to festoon). Cable reel systems can be higher maintenance than busbar or festoons, and should be given more attention.
			• It is common for large bridge cranes to carry their own lighting system on the bridge steel. These lights should be coordinated with the building to be as compatible as possible. Lights that swivel up for bulb change and cleaning are especially good on bridge cranes. Power for the lights should be on a circuit separate from other crane functions.
			<u>Control Systems</u>
			• Hoisting systems should always be furnished with a pendant control system, which is a hanging control box with several push buttons. This can be either the primary or secondary control system for the crane.
			• Most new cranes are now being furnished with some form of remote control system, in addition to the pendant control box. There are two common varieties of remote control systems for bridge cranes and monorails:
			  ➢ Infrared, line-of-sight transmitters – usually used on small cranes and monorails where distance between the transmitter and the crane is held to within 100 feet
			  ➢ FM radio transmitters – used on larger crane systems,

	HOISTING AND CONVEYING EQUIPMENT (Continued)	**Hoists (Continued)**	supports several crane functions (e.g., bridge, trolley, hoist, lights, horn, etc.) and has greater distance capability • Both types of remote control can be hand held or belt mounted. • Remote control systems are also used on pit cranes and similar applications with stationary control cab to reduce the amount of wiring required between the crane and the control booth. • Remote control systems should be designed to fail in a safe position to stop crane movements if out of range, to have a logical arrangement of switches, and to include emergency stop and power off capability. • Large crane installations can be provided with a control cab, which allows for controls, closed circuit TV, operator seating and controlled environment (e.g., air conditioning). This cab can be stationary or travel with the crane. **Motor Drive Systems** • Motors on cranes are often specially designed, specially wound rotor motors for conventional step switching control schemes. Variable speed motors (usually variable frequency types) can utilize conventional motor designs, but the VS unit should be specifically designed for crane duty. This should include slow speed pickup and delivery, torque limiting circuits, and high speed travel capability. • Soft-start capability can be added to fixed speed motor systems, including two speed motor systems. Used like a reduced voltage starter, this system allows a regulated acceleration of the motor at startup, which is useful with both bridge and trolley drives. • Grounding provisions are required for cranes, as per all electrical equipment covered by the NEC. Cabinets on cranes need to be sealed in dusty or dirty environments, and ventilated or cooled (if sealed) to control heat buildup.
1	**NOISE & VIBRATION**		**Noise** • Designers should collect noise information for each major equipment piece. When possible, discuss noise with equipment manufacturers. Do not settle for manufacturers' ratings of A-weighted sound power or sound pressure levels (dBA). This information is inadequate for noise modeling. • Request from each equipment manufacturer the following: ➢ Noise levels in decibels (dB) for each octave band in addition to dBA ratings. Preferred data are sound pressure levels at 1 m (3 ft) and 15 m (50 ft). Second choice is sound power levels (no reference distance is needed). ➢ Directivity effects of the specific equipment. ➢ Presence of dominant 1/3-octave bands or pure tones. Be sure to obtain sound power or pressure levels and frequency of any dominant tones. ➢ Availability of manufacturer-supplied noise attenuation packages. If available, request all noise data and additional costs associated noise attenuation as the

	NOISE & VIBRATION (Continued)		equipment quotation. • This information will be used as input to the noise model to estimate off-site noise levels and to identify equipment that would exceed permit levels. Noise reduction will be addressed during the detail design with input from the Architectural Discipline. **<u>Vibration</u>** • Vibration deteriorates equipment and building components, and can create excessive noise. • Vibration isolation should be addressed according to the requirements outlined in Project Master Specifications, equipment manufacturer's requirements and structural requirements.
1	**SCHEDULING**	**Equipment Procurement Packages**	• Pre-purchase significant process equipment that has either long lead times, or impacts building/room layout design, not necessarily determined by cost of package (refer to Procurement Schedule) • Timing of Equipment Procurement Packages worked back from WTP Construction/Installation Contracts (refer to Procurement Schedule)
1		**Construction and Installation Contracts**	• Identify Process components/requirements of WTP Substructure Construction Contract • Identify Process components/requirements of WTP Superstructure Construction Contract • General Process & Mechanical Installation Contract • Refer to Procurement Schedule and Master Schedule
1	**UNRESOLVED MAJOR ITEMS**	**Building Footprint and Layouts**	• DAF equipment supply contract award impacts the Main WTP footprint, layout of surrounding rooms and facilities (e.g. Electrical Room, RWPS), wall locations and therefore the piling configuration. • Plant overflow collection piping and discharge/disposal route, with consideration of regulations on quality and quantity, effects placement of process overflow points, overflow level set points and flood protection. • Onsite Hypochlorite Generation Building placement on the site, will effect it's building/room layout • WTP maintenance workshop and Technician's shop areas require further definition and development • Administration Area functionality and space requirements require definition to maintain the procurement schedule
1		**Piping and System Redundancy**	• Raw Water plant piping twinning of line needs to be finalized • Raw water lines – entry level into RW Pipe gallery needs to be finalized • Chlorine Contact Tank (CCT) – chemical dose points and minimum (limiting) volume. • CCT to Clearwell underground piping – twinning, access, and future UV connections • Sodium hydroxide application points/diffusers and potential freezing due to low temperatures

1	**UNRESOLVED MAJOR ITEMS (Continued)**	**Equipment Procurement**	• What equipment will be required to be pre-purchased for design or construction schedule purposes? • Scope of supply and timing of Equipment Procurement (Pre-purchase) Packages.
1		**Project Standards & Instructions**	• Standard scales for P. Mech drawings and the official IFT & IFC drawing paper sizes. • Standard Project Specifications for Div 11, 13 & 15, for use by all DC partners
1		**Engineering Discipline Standards & Instructions**	• Consistent materials of construction selection for chemical storage tanks • Materials of construction for large diameter plant piping (1800, 2100 mm etc.). • Materials of construction for general plant process piping (e.g. epoxy lined and coated steel or stainless steel) • Plant piping test pressures, standardized for entire plant, specific to system/service, or specific to piping material? • Piping insulation requirements for condensation control • Use of double walled Piping for hazardous chemical piping outside of secondary containment areas. • Client equipment preferences, in particular method of automated valve actuation, as it impacts fail modes and UPS requirements • Limitations to the general application of the 1.5 hydraulic factor of safety (i.e. fixed orifice size baffle walls, filter effluent piping)
1	**SPECIFICATIONS**	**Project Master Specification List**	• Refer to Project Standard Specifications for Div. 11 & 15 • Master piping specifications have been developed for the Winnipeg WTP project, based on previous projects. The current specification is available on the e-room project website • Engineers and Designers should familiarize themselves with these piping specifications in order to determine pipe materials and valves for use in piping calculations, as well as to properly depict piping and valving on the drawings.
1	**PROCESS MECHANICAL EQUIPMENT DATA SHEETS**		• Data sheets are used to coordinate work between disciplines during the detailed design, as well as specification of technical data in the Construction documents • The Process Mechanical Engineers and Designers will either complete, or have input into the development of an equipment data sheet for equipment defined below: ➢ Process Equipment (e.g., DAF clarifier mechanisms, thickener mechanisms, pumps, blowers etc.) ➢ HVAC Equipment (e.g., fans, motorized louvers, condensers, etc.) ➢ Control Valves and Primary Elements ➢ Devices requiring electrical connections ➢ Devices with instrumentation and control interfaces

1	**DRAWINGS**	**General**	• Work from the current Project Master Drawing List for drawing naming and numbers • Refer to Appendix L of the Quality Management Plan (QMP) for the complete CADD Standards and conventions • Geodetic datum is to be taken @ Deacon Booster Pumping Station (DBPS) • PFD drawings will be developed by the Process Mechanical Discipline to the extent that they indicate the intent and functional requirements of the process. At this point the Instrumentation and Control Discipline will assume ownership of the PFD drawings to complete them as P&IDs.
1		**Discipline Specific Standards for Layouts and Sections**	**<u>General</u>** • Show all piping reducers and couplings required to connect piping to equipment, valves, tanks etc. • Properly reference the Standard Details. Only create custom details when absolutely necessary. • Ensure that drawing notes and naming are clear and concise and that terms and names used on the drawings agree exactly with the terms used in the general abbreviation sheets, legends and the Project Standard Specifications. **<u>Dimensioning</u>** • Locate equipment and piping centerlines as required, using a minimum of two dimensions. • Dimension from interior wall surfaces or from exterior wall surfaces. **<u>Pipe Elevation Notation</u>** • When indicating pipe elevations, use the following conventions: ➢ Centerline for all pressure pipes except when two or more pipes rest on a common support. ➢ Invert elevation (IE) for all gravity-flow pipes (including gravity-flow pipes through walls) except when two or more pipes rest on a common support. ➢ Bottom-of-line (BOL) elevation when two or more pipes rest on a common support. **<u>Equipment Elevation Notation</u>** • Be aware of differences in equipment dimensions among manufacturers. Ensure that a satisfactory installation will result for any probable equipment. A pump, for example, should normally be set by indicating inlet or outlet piping elevations.
1		**Standard Detail Application**	**<u>General</u>** • In general, CH2M HILL standard details will be used for Process Mechanical equipment at the Winnipeg WTP, with the exception of City of Winnipeg standard details, the Raw Water Pumping, Flocculation & DAF, and the Residuals Areas. Where the same detail is common to several areas, the Process Mechanical Lead will select the detail that will be commonly used. • The application of some of these standard details are outlined below

	DRAWINGS (Continued)	**Standard Detail Application (Continued)**	**<u>Chemical Injection Points and Diffusers</u>** • Installation of chemical injection points will be based upon the CH2M HILL standard detail 15957. • It is not generally recommended that chemical injection pipes (or diffusers) be removed while the main process pipe is under pressure. This could cause the chemical injection pipe to be blown out, spraying chemical and/or process water before the ball valve can be closed. • Where there is a requirement to remove the chemical injection pipe while the process pipe is under pressure an additional detail (CH2M HILL Standard Detail XXXXX) will be used. • Larger chemical injection points and diffusers tend to leak more easily, therefore adherence to specifications and standard details will be important. **<u>Seal Water Supplies</u>** • Installation of single mechanical seals for seal water supplies will be based upon the CH2M HILL standard detail 15186.