



Quinte Health

Making our communities healthier. Together.

BELLEVILLE GENERAL HOSPITAL

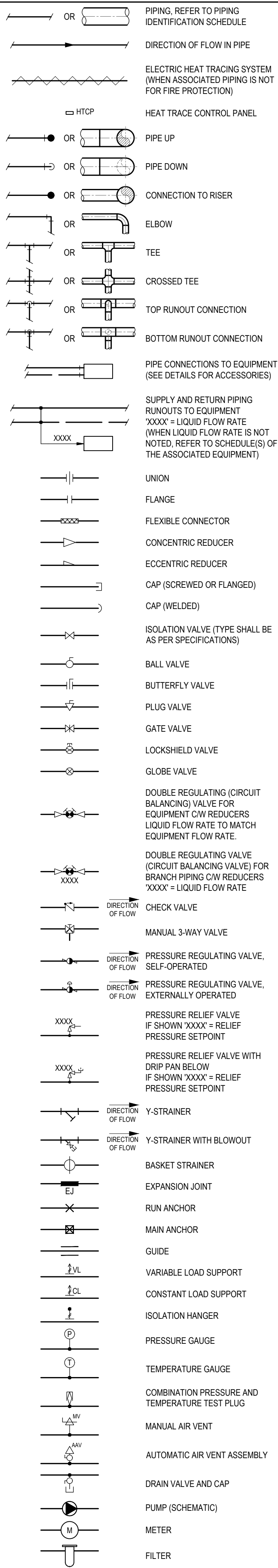
**Phase 2 Work Required for Generator &
Fuel System Replacement Project**

Contract No. CAP24-037-RFP02

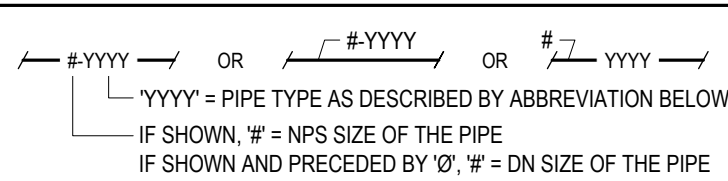
APPENDIX D

IFT Mechanical Package

COMMON PIPING SYSTEM LEGEND

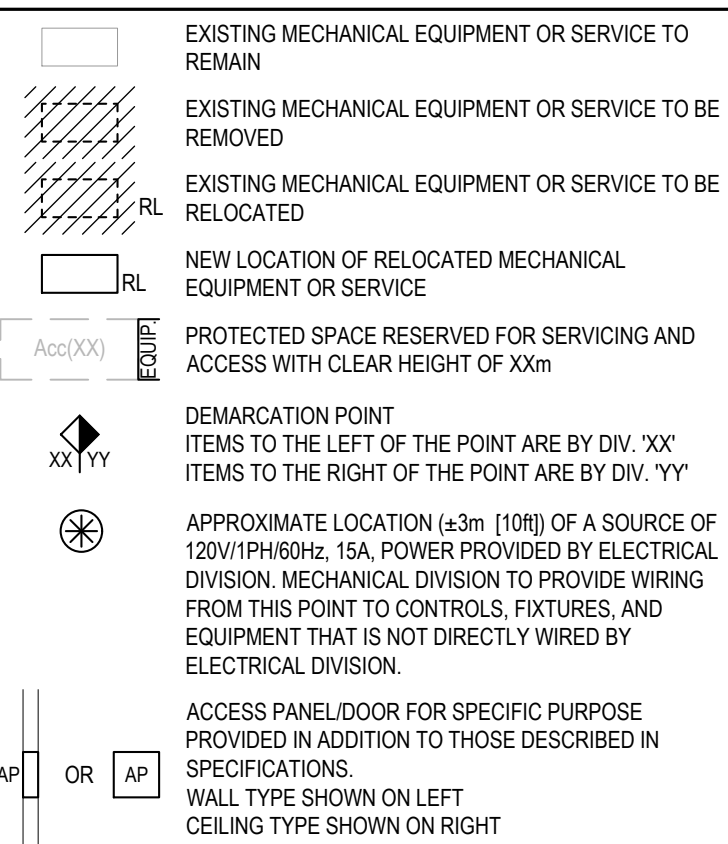


PIPING IDENTIFICATION (1)



ABBREVIATION	PIPE TYPE
FUEL	
NG #	NATURAL GAS IF SHOWN, "F" = NOMINAL PRESSURE
GV	GAS VENT
PG	PROPANE GAS
FOS	FUEL OIL SUPPLY
FOR	FUEL OIL RETURN
FOV	FUEL OIL VENT
PLUMBING	
CA	COMPRESSED AIR
UR	UREA
V	VENT

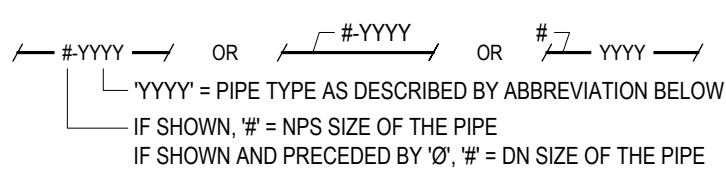
MISCELLANEOUS LEGEND



SENSORS

---	CONTROL LINES (AIR, LIQUID OR WIRING)	(N)	SPACE NITROGEN OXIDE SENSOR
(T)	ROOM TEMPERATURE SENSOR	(CO)	SPACE CARBON MONOXIDE SENSOR
(H)	ROOM HUMIDITY SENSOR	(C)	CARBON DIOXIDE SENSOR
(FS)	FLOW SWITCH	(O ₂)	SPACE OXYGEN SENSOR
(FZ)	FREEZE STAT		DISCONNECT
(T)	TEMPERATURE SENSOR		MOTOR STARTER
(P)	PRESSURE SENSOR		AUDIO ALARM
(DP)	DIFFERENTIAL PRESSURE SENSOR		VISUAL ALARM
(PS)	PRESSURE SWITCH		FIRE DETECTION SENSOR
			EMERGENCY START BUTTON (VENTILATION)

PIPING IDENTIFICATION (2)



LINE TYPE	PIPE TYPE
----	VENT (SEE TEXT ABBREVIATION)
----	SUPPLY LINE (SEE TEXT ABBREVIATION)
----	RETURN LINE (SEE TEXT ABBREVIATION)

ABBREVIATIONS

AFF	ABOVE FINISHED FLOOR
CW	COMPLETE WITH
CTE	CONNECT TO EXISTING
DCW	DOMESTIC COLD WATER
DHW	DOMESTIC HOT WATER
DHWR	DOMESTIC HOT WATER RECIRCULATION
DN	DOWN
EA	EXHAUST OR RELIEF AIR
OA	OUTDOOR AIR
OED	OPEN ENDED DUCT
RA	RETURN AIR
RWL	RAIN WATER LEADER
SA	SUPPLY AIR
(TYP.)	TYPICAL OF MULTIPLE INSTANCES
(TYP. #)	TYPICAL FOR QUANTITY "#"
(TYP. XXX)	TYPICAL FOR 'XXX', WHERE 'XXX' PROVIDES DESCRIPTION
U/C	UNDER CUT
VFD	VARIABLE FREQUENCY DRIVE

NOMINAL SIZES FOR PIPING AND TUBING

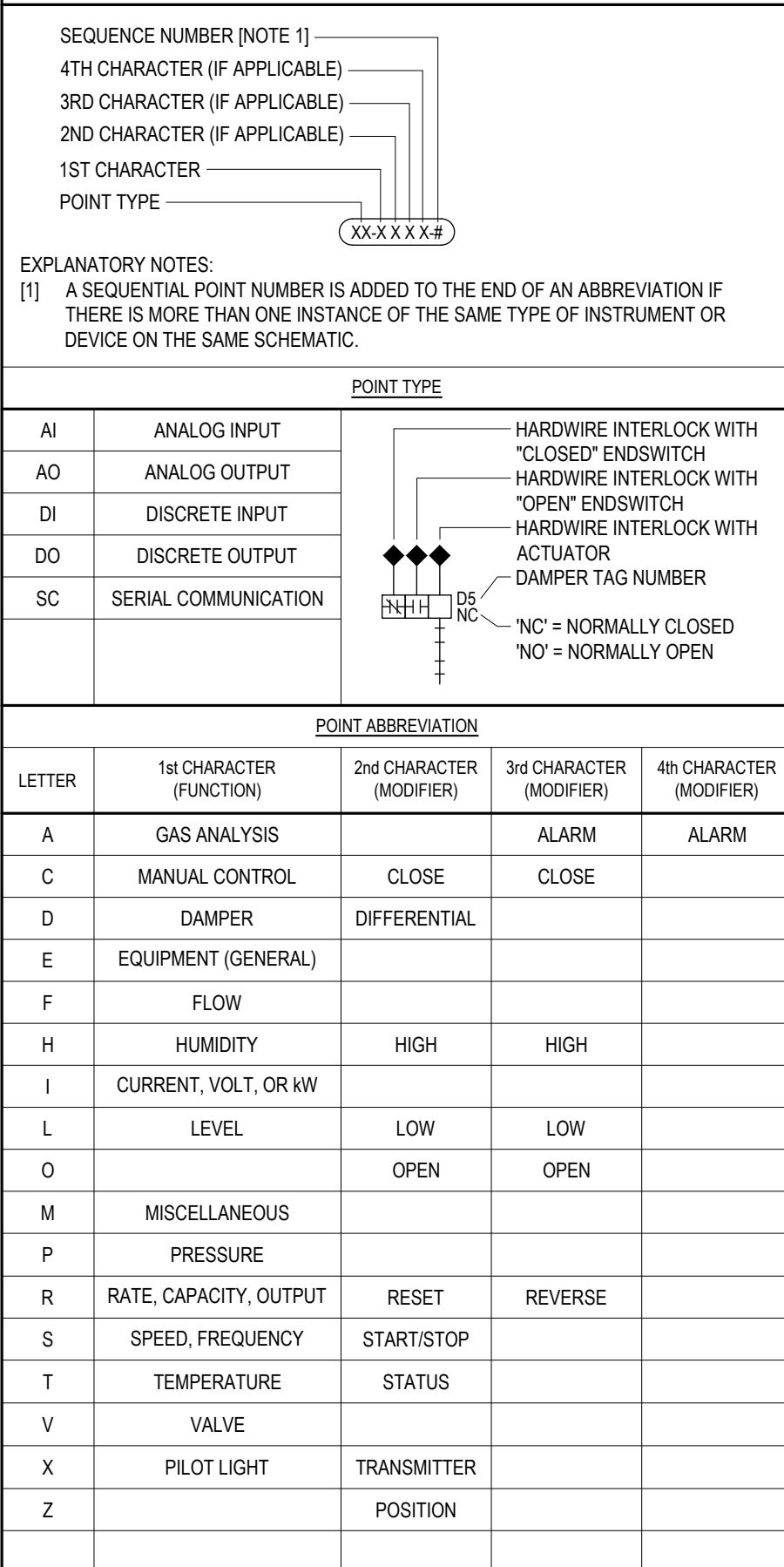
NOMINAL PIPE SIZE (NPS)	DIAMETRE NOMINAL (DN)
1/4	8
1/2	15
5/8	--
3/4	20
1	25
1 1/4	32
1 1/2	40
2	50
2 1/2	65
3	80
4	100
6	150
8	200
10	250
12	300
14	350
16	400
18	450
20	500
24	600

- THE PIPE SIZES SHOWN ARE NOMINAL SIZES.
- MATERIAL OF PIPING/TUBING TO BE AS SHOWN AND AS SPECIFIED.
- REFER TO SPECIFICATIONS FOR ASSOCIATED PIPING/TUBING STANDARDS THAT DEFINE THE DIMENSIONS.

DRAWING LIST

M0-01	MECHANICAL LEGEND AND DRAWING LIST
M0-10	MECHANICAL SITE PLAN
M1-01	SCHEDULES
M1-30	SCHEMATICS - SHEET 1
M1-31	SCHEMATICS - SHEET 2
M1-32	GENERATOR ENCLOSURE SECTION
M3-01	MECHANICAL PLAN - NEW WORK
M9-01	MECHANICAL DEMOLITION PLAN

CONTROL POINT LEGEND



GENERAL

- THIS LEGEND APPLIES TO THE WORK UNDER DIVISIONS 20 TO 25.
- THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATIONS SECTIONS OF DIVISION 20 TO 25 AND THE APPLICABLE SECTIONS OF DIVISION 01.
- ITEMS SHOWN **SCHEMATIC** ARE EXISTING TO REMAIN
- NOT ALL SYMBOLS IN THE LEGENDS ARE PRESENT ON THE DRAWINGS
- ITEMS SHOWN ARE DIAGRAMMATIC AND ILLUSTRATE THE GENERAL LOCATION OF EQUIPMENT AND GENERAL ROUTING OF PIPING AND DUCTWORK. CONTRACTOR SHALL VERIFY ALL ITEMS ON SITE PRIOR TO COMMENCING WORK.
- UNLESS OTHERWISE NOTED, PIPE SIZES ARE SHOWN IN NOMINAL PIPE SIZE (NPS)
- UNLESS OTHERWISE NOTED, DUCT SIZES ARE SHOWN IN MILLIMETRE (mm)
- UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN MILLIMETRE (mm)
- UNLESS OTHERWISE NOTED, ALL AIR FLOW RATES ARE LISTED IN LITRES PER SECOND (L/s)
- UNLESS OTHERWISE NOTED, ALL LIQUID FLOW RATES ARE LISTED IN LITRES PER SECOND (L/s)
- THE EXISTING ITEMS SHOWN HAS BEEN TAKEN FROM BEST AVAILABLE SOURCE AND DOES NOT NECESSARILY CAPTURE ALL AS-BUILT CONDITIONS. CONTRACTOR TO VERIFY & CONFIRM MECHANICAL LAYOUT AND EQUIPMENT PRIOR TO CARRYING OUT ANY PORTION OF MECHANICAL WORK. WORK TO BE COORDINATED WITH ARCHITECTURAL DRAWINGS.

PIPING SYSTEMS:

- FOR WORK IN EXISTING BUILDINGS, CONTRACTOR SHALL ALLOW FOR DRAINING OF THE SYSTEMS AS REQUIRED TO COMPLETE WORK
- FOR WORK IN EXISTING BUILDINGS, ASSUME EXISTING SHUT-OFF VALVES ARE HOLDING
- CAP ALL PIPE ENDS DURING DEMOLITION
- ALL SANITARY PIPING SHOWN TO HAVE A MINIMUM 1% SLOPE UNLESS OTHERWISE INDICATED
- CO-ORDINATE LOCATION OF DEVICES LOCATED IN CEILING REQUIRING ACCESS (VALVES, REGULATORS, ETC.) WITH CEILING ACCESS PANELS
- FOR WORK IN EXISTING BUILDINGS, SIZE AND EXACT LOCATION OF EXISTING RISERS TO BE CONFIRMED ON SITE

VENTILATION SYSTEMS:

- FOR WORK IN EXISTING BUILDINGS, ALL DUCT COLLARS MADE REDUNDANT BY THE PROJECT SHALL BE CAPPED OFF
- FOR WORK IN EXISTING BUILDINGS, DURING CONSTRUCTION, COVER OPEN ENDS OR REGISTERS/GRILLES OF ACTIVE RETURN AND EXHAUST AIR DUCTS WITH FILTER MEDIA SECURED BY METAL BAND PULLED TIGHT AROUND DUCT BY MEANS OF SCREWS. MAINTAIN THIS MEDIA UNTIL WORK IN AREA IS COMPLETED.
- LENGTH OF FLEX DUCT SHALL NOT EXCEED 1800mm (6'-0"). USE RIGID ROUND DUCT IF THE DISTANCE BETWEEN THE AIR TERMINAL AND THE SPIN-ON CONNECTION BRANCH TAP REQUIRES LONGER LENGTHS.
- ALL SUPPLY AIR DUCTWORK INCLUDING FLEX DUCTS SHALL BE INSULATED
- SERVICES ABOVE RETURN GRILLES TO BE PAINTED FLAT BLACK

CONTROLS:

- SPACE TEMPERATURE SENSORS, THERMOSTATS, SPACE HUMIDITY SENSORS, AND HUMIDISTATS TO BE APPROXIMATELY 1200mm (4'-0") AFF AND ALIGNED WITH LIGHT SWITCHES. FINAL LOCATION TO BE REVIEWED WITH THE CONSULTANT PRIOR TO INSTALLATION.
- FOR WORK IN EXISTING BUILDINGS, CONTROLS WORK TO BE CARRIED OUT BY BASE BUILDING CONTROLS CONTRACTOR

DEMOLITION

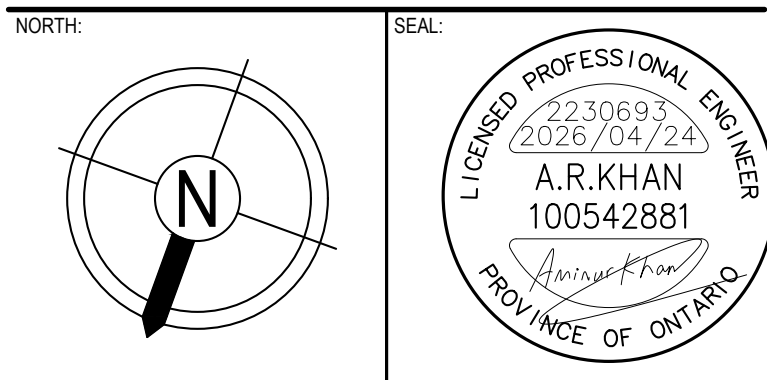
- DEMOLISH SYSTEMS AND EQUIPMENT WHERE SHOWN ON DRAWINGS OR SPECIFICATIONS. OTHERWISE, EXISTING SYSTEMS AND EQUIPMENT ARE TO REMAIN, EVEN IF NOT SHOWN ON THE DRAWINGS.

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DRAWING ISSUE		

KEYPLAN:



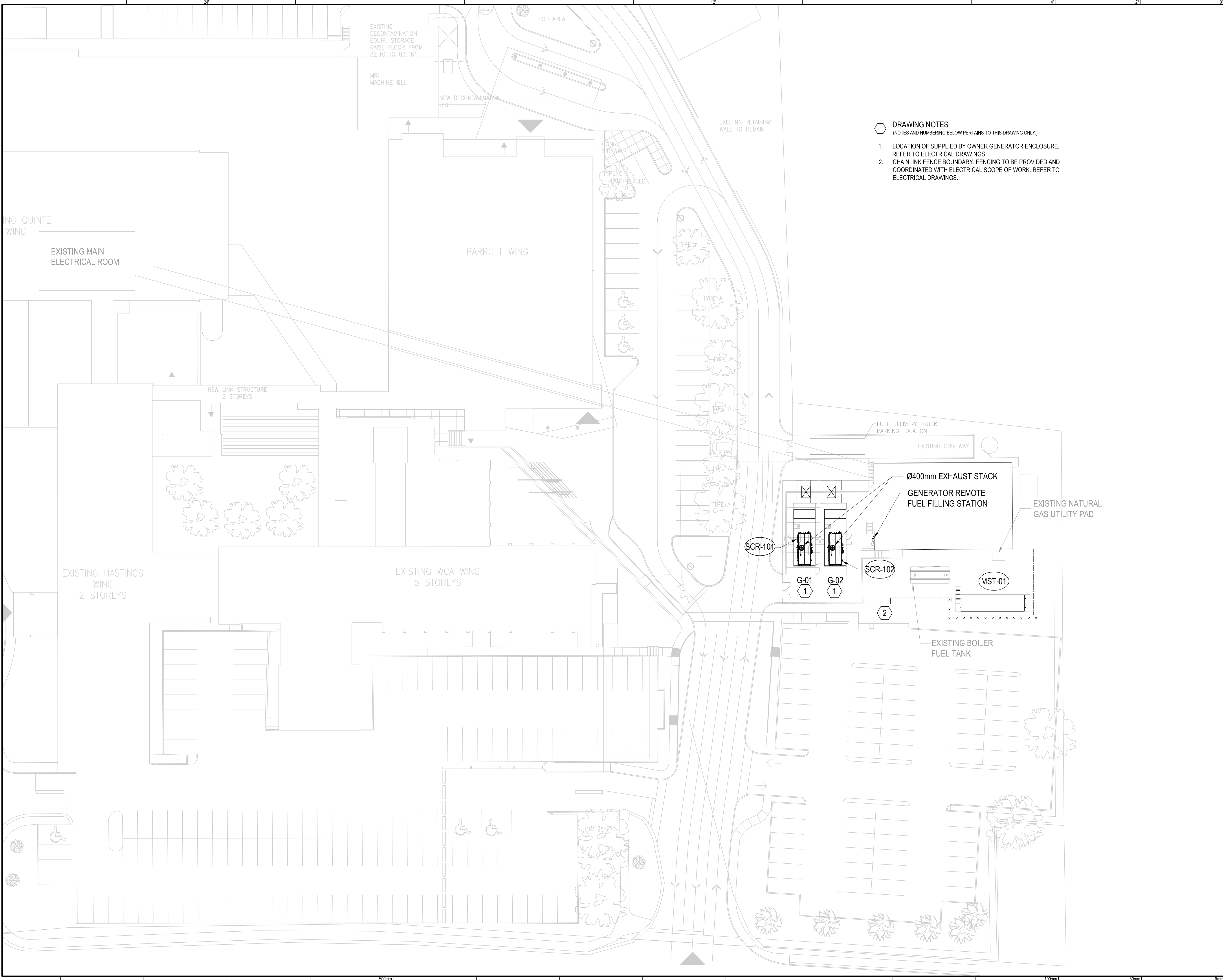
PROJECT:
QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT

HHA PROJECT NUMBER: 2230693

DRAWING TITLE:
MECHANICAL LEGEND AND
DRAWING LIST

PAGE SIZE:	ARCH D	DRAWN BY:	R.N.
SCALE:	N.T.S.	CHECKED BY:	A.K.
DRAWING NUMBER:			

M0-01



- DRAWING NOTES**
(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY.)
1. LOCATION OF SUPPLIED BY OWNER GENERATOR ENCLOSURE. REFER TO ELECTRICAL DRAWINGS.
 2. CHAINLINK FENCE BOUNDARY. FENCING TO BE PROVIDED AND COORDINATED WITH ELECTRICAL SCOPE OF WORK. REFER TO ELECTRICAL DRAWINGS.

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DRAWING ISSUE		

KEYPLAN:

NORTH:

SEAL:

PROJECT:
**QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT**

H/A PROJECT NUMBER: 2230693

DRAWING TITLE:
**MECHANICAL SITE PLAN -
TEMPORARY FUEL STORAGE**

PAGE SIZE:	ARCH D	DRAWN BY:	S.G.
SCALE:	1:300	CHECKED BY:	A.K.
DRAWING NUMBER:			

M0-10

TANK												
No.	DESIGNATION	LOCATION	PERFORMANCE DATA		CONSTRUCTION DATA							REMARKS
			FLUID	CAPACITY LITRES	DIA. mm	LENGTH mm	WIDTH mm	HEIGHT mm	MATERIAL	TYPE	DESIGN PRESS. kPa	
MST-01	DIESEL FUEL MAIN STORAGE TANK	EXTERIOR (NORTH) OF BOILER PLANT	DIESEL	75,000	2921	11,430	-	-	CARBON STEEL	CANULC -S601	35	DOUBLE WALL VACUUM MONITORED,DESIGN BASED ON STEELCRAFT MODEL SCVAF7075000H.
T-01	UREA STORAGE TANK	INSIDE GENERATOR ENCLOSURE G-01	32.5% UREA	450	762	1067	-	-	STAINLESS STEEL	VERTICAL	-	DOUBLE WALL VACUUM MONITORED,DESIGN BASED ON SAFETY POWER MODELS OR EQUAL
T-02	UREA STORAGE TANK	INSIDE GENERATOR ENCLOSURE G-02	32.5% UREA	450	762	1067	-	-	STAINLESS STEEL	VERTICAL	-	DOUBLE WALL VACUUM MONITORED,DESIGN BASED ON SAFETY POWER MODELS OR EQUAL

PUMP												MOTOR		CON- TROLS DIAGRAM	STARTER										FEEDER	REMARKS
No.	DESIGNATION	LOCATION	FLUID	PERFORMANCE DATA				CONSTRUCTION DATA				MIN. KW. [HP]			LOCATION		POWER SOURCE		ACCESSORIES IN COVER							
				CAPACITY L/s [GPM]	TOT. DYN. HEAD kPa	R.P.M.	SUCTION HEAD MPa	C TEMP.	TYPE	DESIGN PRESS kPa.	REFERENCE MODEL	3PH.	1PH.		PANEL	SPLITTER	MCC	E	N	HOA	MSS	P.B	P.L	MTB	BAS	
P-1A	FUEL OIL TRANSFER PUMP FOR GENERATOR G-01	BOILER PLANT	DIESEL FUEL	0.19 [5]	70	1800	36	-22	CAST IRON HELICAL GEAR PUMP OF DUPLEX PUMPSET	345	ALBANY 05G061312	-	0.37 [0.5]	SEE DETAIL 1M1-31	•	-	-	E	-	SEE SPEC			•	SEE ELECTRICAL SLD	C/W PUMP CONTROL PANEL (DPCP-1) FOR P-1A AND P-1B COMPLETE WITH BACHET SERIAL MS/TP OR IP INTEGRATION	
P-1B	FUEL OIL TRANSFER PUMP FOR GENERATOR G-01	BOILER PLANT	DIESEL FUEL	0.19 [5]	70	1800	36	-22	CAST IRON HELICAL GEAR PUMP OF DUPLEX PUMPSET	345	ALBANY 05G061312	-	0.37 [0.5]	SEE DETAIL 1M1-31	•	-	-	E	-	SEE SPEC			•	SEE ELECTRICAL SLD	C/W PUMP CONTROL PANEL (DPCP-1) FOR P-1A AND P-1B COMPLETE WITH BACHET SERIAL MS/TP OR IP INTEGRATION	
P-2A	FUEL OIL TRANSFER PUMP FOR GENERATOR G-02	BOILER PLANT	DIESEL FUEL	0.19 [5]	70	1800	36	-22	CAST IRON HELICAL GEAR PUMP OF DUPLEX PUMPSET	345	ALBANY 05G061312	-	0.37 [0.5]	SEE DETAIL 1M1-31	•	-	-	E	-	SEE SPEC			•	SEE ELECTRICAL SLD	C/W PUMP CONTROL PANEL (DPCP-2) FOR P-2A AND P-2B COMPLETE WITH BACHET SERIAL MS/TP OR IP INTEGRATION	
P-2B	FUEL OIL TRANSFER PUMP FOR GENERATOR G-02	BOILER PLANT	DIESEL FUEL	0.19 [5]	70	1800	36	-22	CAST IRON HELICAL GEAR PUMP OF DUPLEX PUMPSET	345	ALBANY 05G061312	-	0.37 [0.5]	SEE DETAIL 1M1-31	•	-	-	E	-	SEE SPEC			•	SEE ELECTRICAL SLD	C/W PUMP CONTROL PANEL (DPCP-2) FOR P-2A AND P-2B COMPLETE WITH BACHET SERIAL MS/TP OR IP INTEGRATION	

MISCELLANEOUS ELECTRICAL EQUIPMENT							MOTOR		CON- TROLS DIAGRAM	STARTER														FEEDER	REMARKS	
No.	DESIGNATION	LOCATION	PERFORMANCE DATA		CONSTRUCTION DATA		MIN. KW. [HP]			LOCATION		POWER SOURCE		ACCESSORIES IN COVER			CONTROLS		INTERLOCKED MOTOR		BAS	SIZE				
			MAX PRESSURE DROP(kPa)	CAPACITY	TYPE	DESIGN PRESS (kPa.)	3PH.	1PH.		PANEL	SPLITTER	MCC	E	N	HOA	MSS	P.B	P.L	MTB	SAFETY			OPERATING	STARTS		STARTED BY
SCR-101	SELECTIVE CATALYTIC REDUCTION	TOP OF GENERATOR ENCLOSURE	4.73		PACKAGED SCR UNIT FOR KOHLER KD1250 A GENSET G-01 C/W UREA INJECTION SUPPLY AND STORAGE SYSTEM.	-	-	-	SEE DETAIL 3M1-30	•	-	-	E					SEE SPEC			GENSET	•	SEE ELECTRICAL SLD			
SCR-102	SELECTIVE CATALYTIC REDUCTION	TOP OF GENERATOR ENCLOSURE	4.73		PACKAGED SCR UNIT FOR KOHLER KD1250 A GENSET G-02 C/W UREA INJECTION SUPPLY AND STORAGE SYSTEM.	-	-	-	SEE DETAIL 3M1-30	•	-	-	E					SEE SPEC			GENSET	•	SEE ELECTRICAL SLD			
ACS-101	PACKAGED AIR COMPRESSOR	INSIDE GENERATOR ENCLOSURE G-01	-	CAPACITY 204 L/min (7.2 CFM) @ 310 kPa (45 psf)	DUPLEX SCREW COMPRESSOR PACKAGE C/W INTEGRATED STARTER AND CONTROLS	310	-	1.1 [1.5]	SEE DETAIL 3M1-30	•	-	-	E					SEE SPEC			GENSET	-	SEE ELECTRICAL SLD			
ACS-102	PACKAGED AIR COMPRESSOR	INSIDE GENERATOR ENCLOSURE G-02	-	CAPACITY 204 L/min (7.2 CFM) @ 310 kPa (45 psf)	DUPLEX SCREW COMPRESSOR PACKAGE C/W INTEGRATED STARTER AND CONTROLS	310	-	1.1 [1.5]	SEE DETAIL 3M1-30	•	-	-	E					SEE SPEC			GENSET	-	SEE ELECTRICAL SLD			

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KEYPLAN:

NORTH:

SEAL:

2230693
2026/04/24

A.R.KHAN
100542881

Angus & Associates
PROVINCE OF ONTARIO

PROJECT:
QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT

HHA PROJECT NUMBER: 2230693

DRAWING TITLE:
SCHEDULES

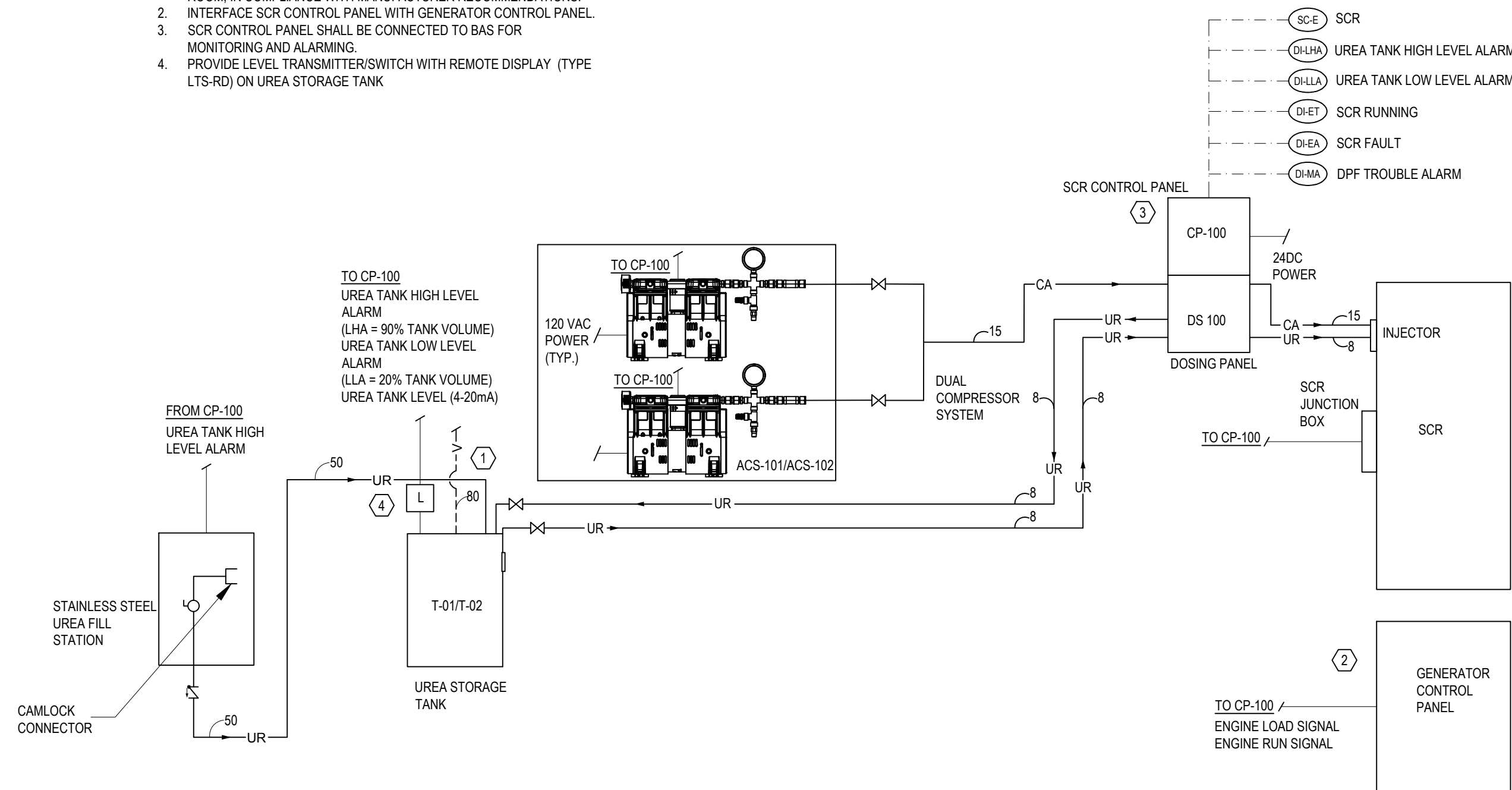
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M1-01

- GENERAL NOTES
(NUMBERING BELOW PERTAINS TO THIS
DRAWING ONLY)
1. PROVIDE SCR FOR KOHLER KD-1250A GENERATOR AS A PACKAGE SYSTEM COMPLETE WITH ALL ASSOCIATED COMPONENTS IN ACCORDANCE WITH SCR MANUFACTURER REQUIREMENTS.
 2. CONTRACTOR SHALL PROVIDE ALL PIPING, VALVES, POWER AND CONTROLS IN ACCORDANCE WITH SCR MANUFACTURER REQUIREMENTS.

DRAWING NOTES:
NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY

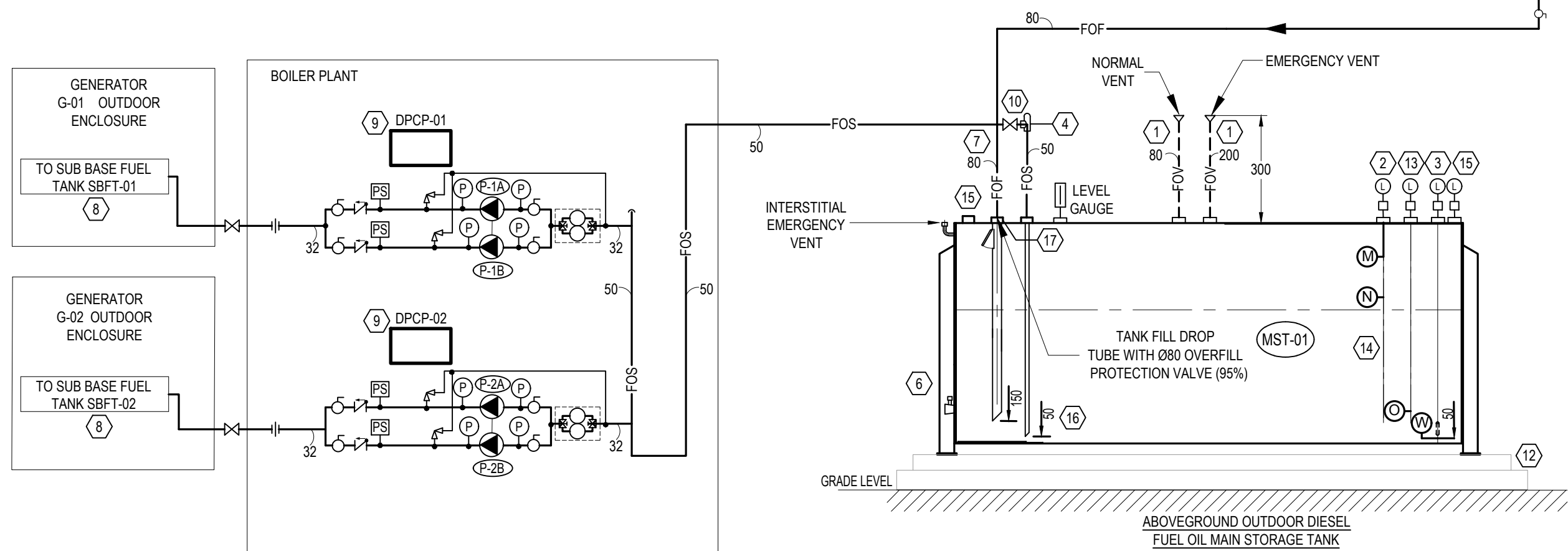
1. UREA TANK VENT SHALL BE ROUTED OUTSIDE THE GENERATOR ENCLOSURE TO PREVENT ACCUMULATION OF FUMES WITHIN THE ROOM, IN COMPLIANCE WITH MANUFACTURER RECOMMENDATIONS.
2. INTERFACE SCR CONTROL PANEL WITH GENERATOR CONTROL PANEL. SCR CONTROL PANEL SHALL BE CONNECTED TO BAS FOR MONITORING AND ALARMING.
4. PROVIDE LEVEL TRANSMITTER/SWITCH WITH REMOTE DISPLAY (TYPE LTS-RD) ON UREA STORAGE TANK



3 SELECTIVE CATALYTIC REACTOR (SCR) SCHEMATIC
M1-30 N.T.S.

DRAWING NOTES:
NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY

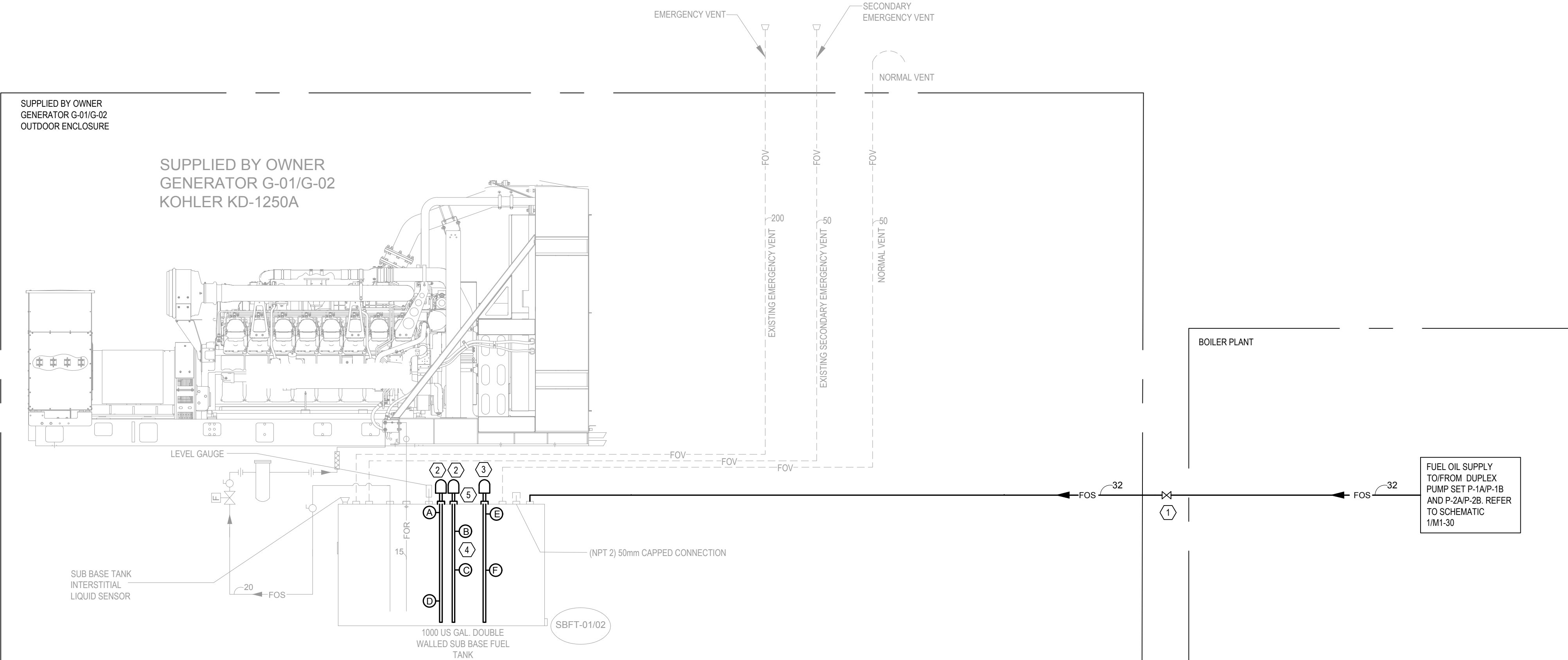
1. TERMINATE NORMAL AND EMERGENCY VENT PIPING 300mm ABOVE THE TOP OF TANK WITH VENT CAP.
2. PROVIDE LEVEL TRANSMITTER/SWITCH (TYPE LTS2) AS PART OF PACKAGED OVERFILL ALARM SYSTEM (OFAS) ON FUEL TANK.
3. PROVIDE WATER LEVEL SENSOR (TYPE LTW) ON FUEL TANK.
4. ANTI-SIPHON VALVE (ASV).
5. PROVIDE UL-C LISTED REMOTE TANK FILL STATION WITH PRESSURIZED TRUCK FILL-HOSE CONNECTION.
6. PROVIDE MAIN TANK INTERSTITIAL SPACE MONITOR ALARM WHICH SHALL BE ACTIVATED IN THE EVENT OF A LEAK IN EITHER THE PRIMARY OR SECONDARY WALL OF THE DOUBLE-WALL TANK.
7. PROVIDE Ø150mm (NPS 6) CONNECTION AT THE TANK TO ACCOMMODATE Ø80mm (NPS 3) OVERFILL PROTECTION VALVE.
8. FOR CONTINUATION OF FUEL OIL PIPING, REFER TO SCHEMATIC 2/M1-30.
9. FUEL PUMP CONTROL PANEL SHALL BE CONNECTED TO BAS FOR MONITORING AND ALARMING.
10. PROVIDE MANUAL SHUT-OFF VALVE WITH SIGNAGE "FUEL SHUT-OFF VALVE LOCATED AT FUEL TANK".
11. PROVIDE ELECTRIC OVERFILL ALARM SYSTEM COMPLETE WITH LEVEL SWITCH (TYPE LTS2) AS A COMPLETE CERTIFIED PACKAGE LISTED TO CANULC-5861.
12. REFER TO STRUCTURAL FOR HOUSEKEEPING PAD DETAILS.
13. PROVIDE LEVEL SWITCH (TYPE LS1) ON ABOVEGROUND FUEL TANK.
14. REFER TO DETAIL 1/M1-31 FOR CONTROL SETPOINT DETAILS.
15. TANK CLEANINGS FITTINGS - NPS 3 NPT WITH CAP.
16. FUEL SUCTION DROP TUBE WITH 45° WHISTLE CUT.



1 DIESEL FUEL OIL SYSTEM SCHEMATIC
M1-30 N.T.S.

DRAWING NOTES:
NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY

1. PROVIDE MANUAL SHUT-OFF VALVE WITH SIGNAGE "EMERGENCY EQUIPMENT DIESEL FUEL SHUT-OFF VALVE".
2. PROVIDE LEVEL SWITCH (TYPE LS2) ON SUB BASE FUEL TANK.
3. PROVIDE LEVEL TRANSMITTER/SWITCH (TYPE LTS2) ON SUB BASE FUEL TANK.
4. REFER TO DETAIL 1 / M1-31 FOR CONTROL SETPOINT DETAILS.
5. EXISTING TANK FITTINGS ARE 50mm (NPT 2).



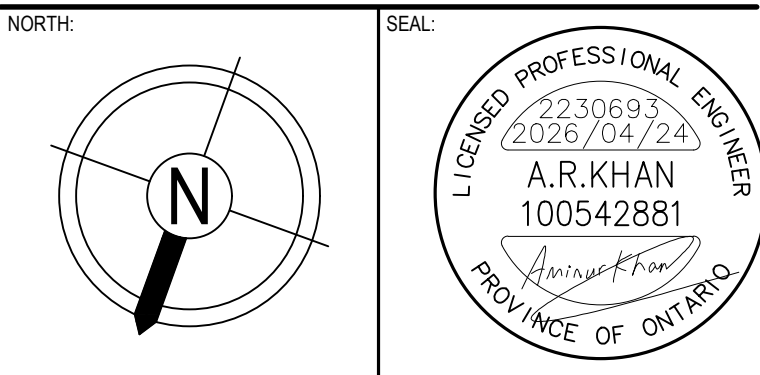
2 GENERATOR ENCLOSURE FUEL OIL SYSTEM SCHEMATIC
M1-30 N.T.S.

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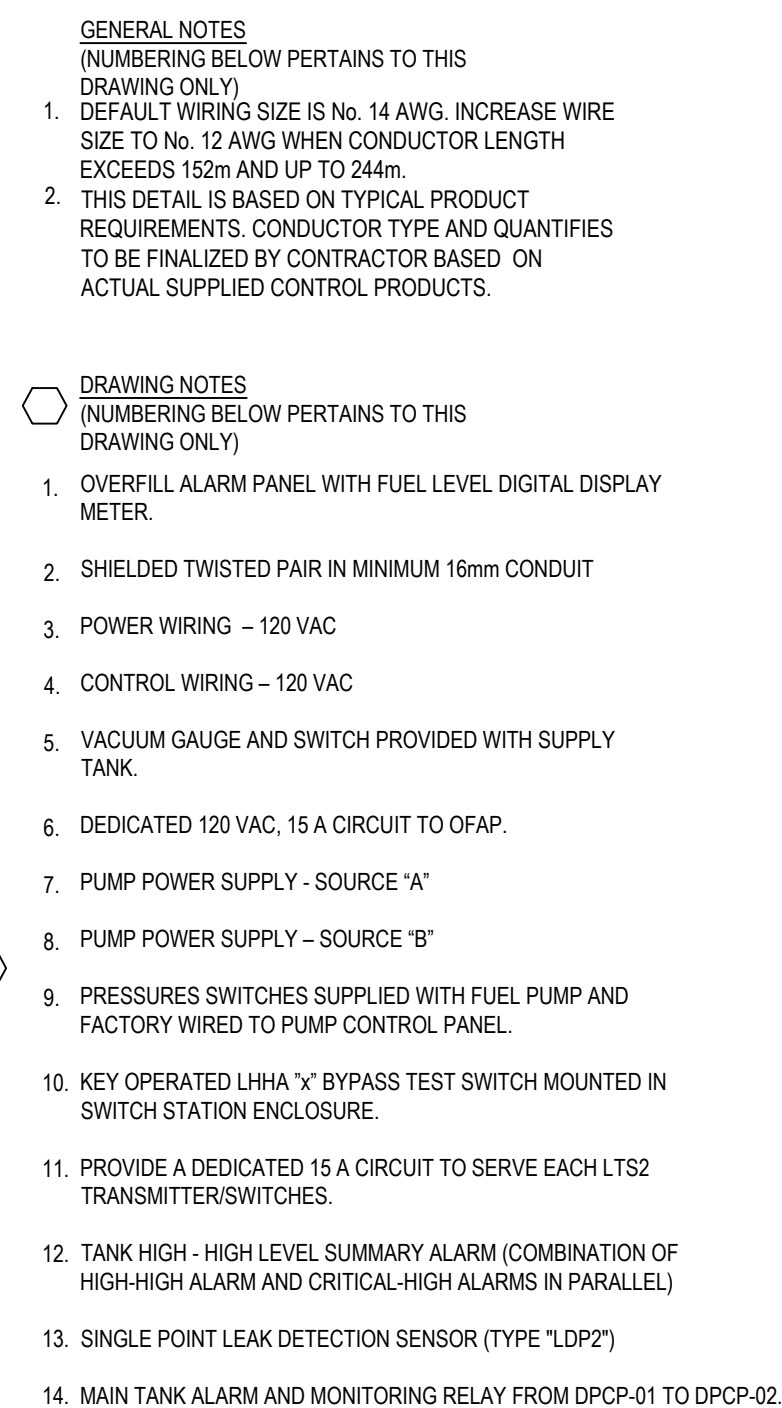
KEYPLAN:



PROJECT:
QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT
HHA PROJECT NUMBER: 2230693
DRAWING TITLE:
SCHEMATICS - SHEET 1

PAGE SIZE: ARCH D	DRAWN BY: R.N.
SCALE: N.T.S.	CHECKED BY: A.K.
DRAWING NUMBER:	

M1-30



AUXILIARY SUPPLY TANK CONTROL LEGEND				
TAG	NO	REF	DESCRIPTION	SETTINGS
UHHA	04 /07	(A)	AUXILIARY SUPPLY TANK LEVEL HIGH-HIGH ALARM	95% TANK VOLUME PUMPS STOP & ALARM
LH	05 /08	(B)	AUXILIARY SUPPLY TANK LEVEL HIGH CONTROL	85% TANK VOLUME PUMPS STOP
LL	05 /08	(C)	AUXILIARY SUPPLY TANK LEVEL LOW CONTROL	50% TANK VOLUME LEAD PUMP STARTS
LLLA	4 /07	(D)	AUXILIARY SUPPLY TANK LEVEL LOW CONTROL	35% TANK VOLUME LAG PUMP STARTS
LOHA	06 /09	(E)	AUXILIARY SUPPLY TANK LEVEL CRITICAL-HIGH ALARM	95% TANK VOLUME PUMPS STOP & ALARM
LLLA	06 /09	(F)	AUXILIARY SUPPLY TANK LEVEL CRITICAL-LOW CONTROL	2 HOUR FUEL REMAINING (APPROXIMATELY 27% TANK VOLUME)
PLA	02 /03		AUXILIARY SUPPLY TANK INTERSTITIAL SPACE ALARM	ALARM
AA	03 /04		OIL LEAK DETECTION	MINIMUM SETTING

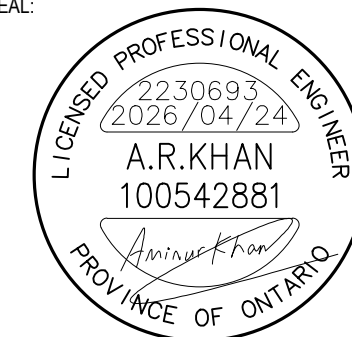
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01	2026-04-24	ISSUED FOR TENDER PHASE 2
NO.	DATE (YYYY-MM-DD)	DESCRIPTION
DRAWING ISSUE		

KEYPLAN

NORTH:



PROJECT

QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT

HHA PROJECT NUMBER: 2230693

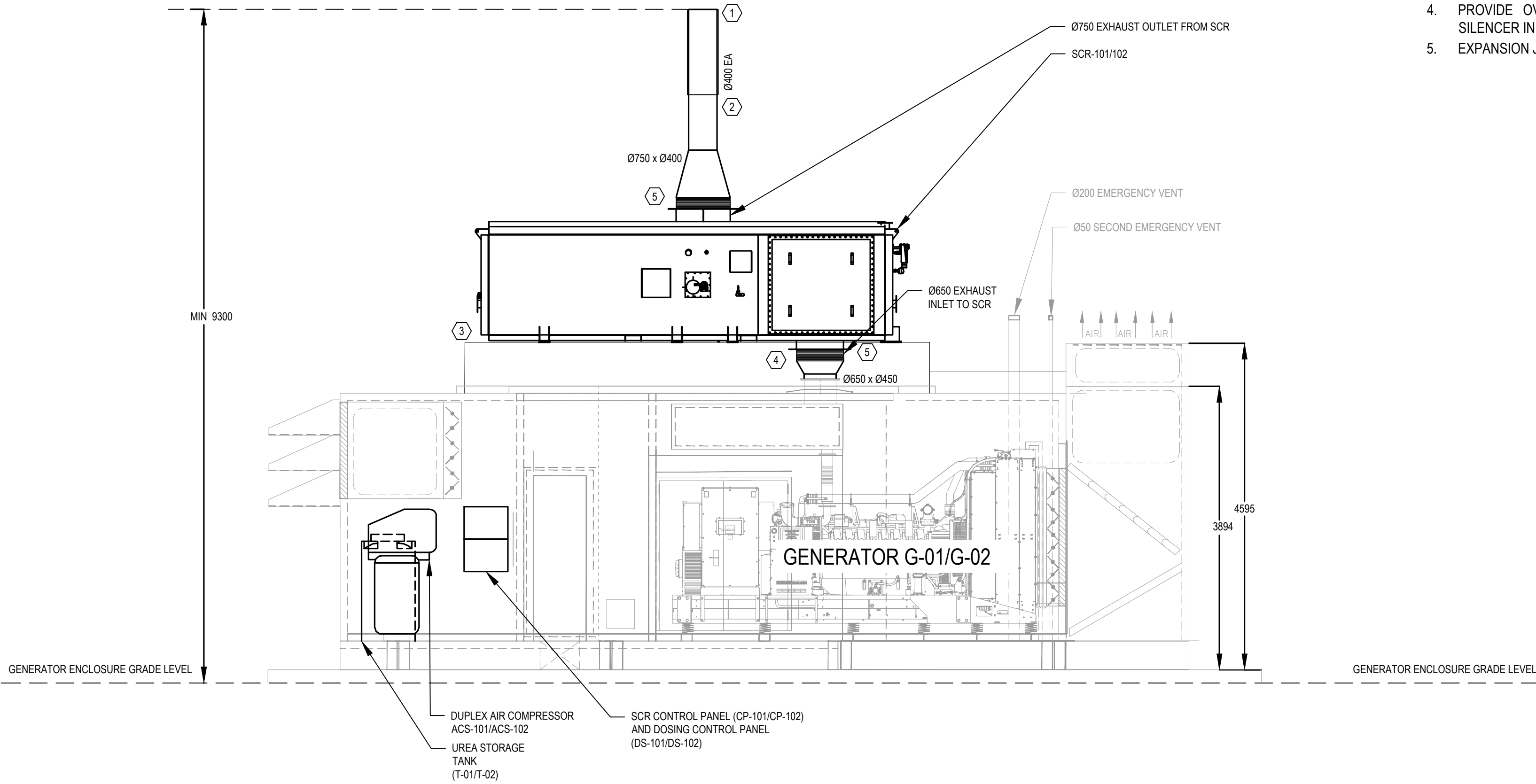
DRAWING TITLE:
SCHEMATICS - SHEET 2

PAGE SIZE:	ARCH D	DRAWN BY:	R.N.
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DRAWING NUMBER:
M1-31

DRAWING NOTES
(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY.)

1. PROVIDE ASHRAE STACKHEAD 450mm x 1800mm LONG.
2. PROVIDE INSULATED SECTIONAL CHIMNEY EXHAUST STACK AS PER SPECIFICATION 23 51 33. TERMINATE 9.3m ABOVE GRADE AT MINIMUM.
3. PROVIDE ENGINEERED STRUCTURAL SUPPORT SYSTEM FOR EXHAUST STACK (APPROXIMATE DEADLOAD = 232 kg), INCLUDING WIND AND SEISMIC LOADS, TO SUPPORT THE STACK ON TOP OF THE SCR, IN COORDINATION WITH SCR AND CHIMNEY MANUFACTURER REQUIREMENTS.
4. PROVIDE ENGINEERED STRUCTURAL SUPPORT SYSTEM TO SUPPORT THE SCR ON TOP OF GENERATOR ENCLOSURE IN COORDINATION WITH MANUFACTURER REQUIREMENTS. REFER TO STRUCTURAL DRAWINGS.
5. PROVIDE OVERPRESSURE RELIEF FITTING AT THE OUTLET OF THE SILENCER IN ACCORDANCE WITH MANUFACTURER REQUIREMENTS.
5. EXPANSION JOINT.



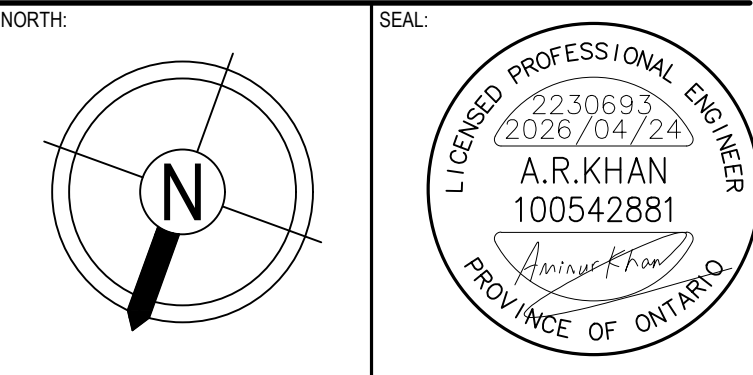
1 GENERATOR ENCLOSURE SECTION
M1-32 N.T.S.

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03	2025-11-07	ISSUED FOR TENDER AND PERMIT
02	2025-09-26	ISSUED FOR FINAL REVIEW
01	2025-09-11	ISSUED FOR BAS COORDINATION
NO.	DATE (YYYY-MM-DD)	DESCRIPTION
DRAWING ISSUE		

KEYPLAN:



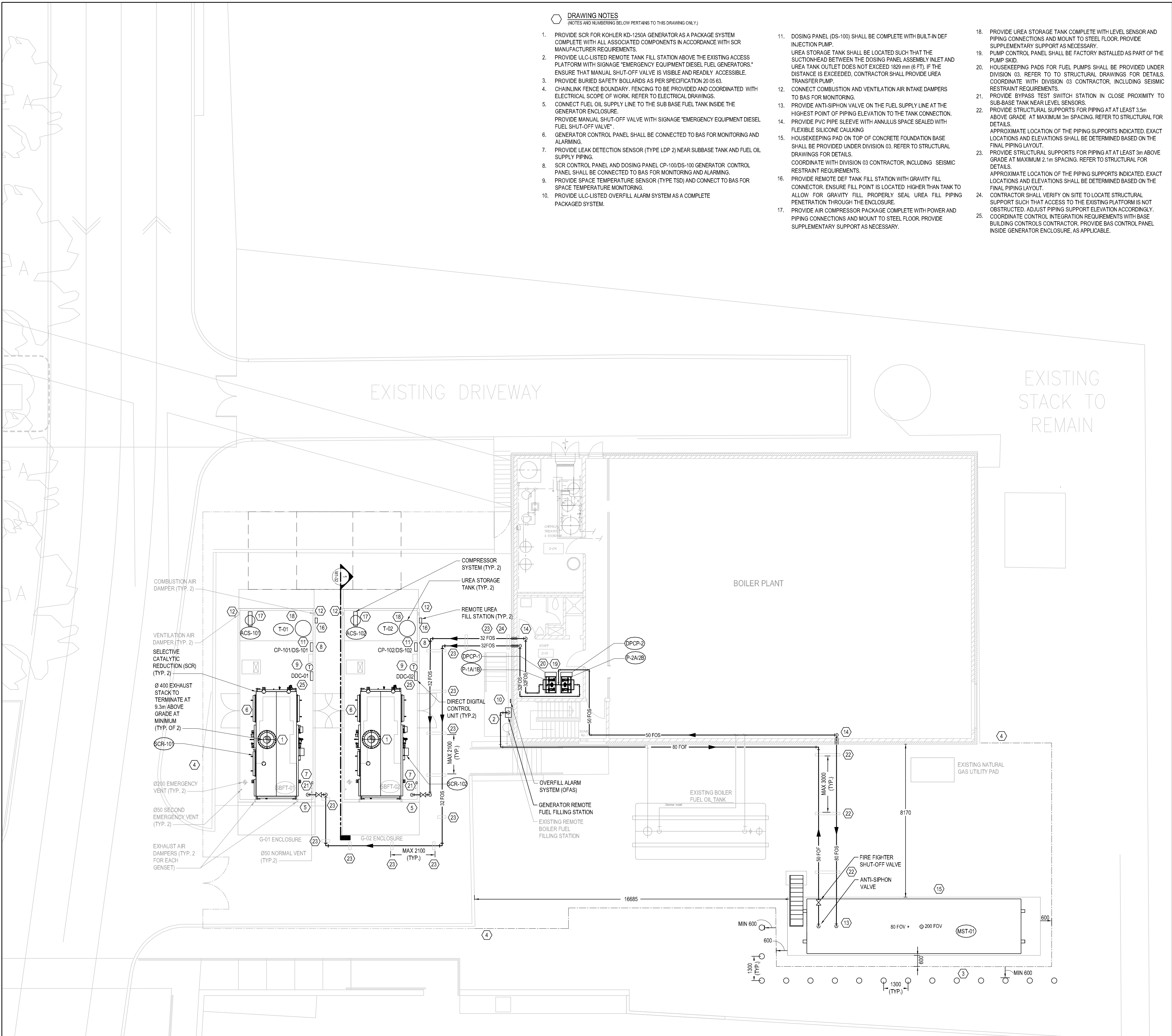
PROJECT:
QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT

HHA PROJECT NUMBER: 2230693
DRAWING TITLE:
GENERATOR ENCLOSURE
SECTION

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M1-32



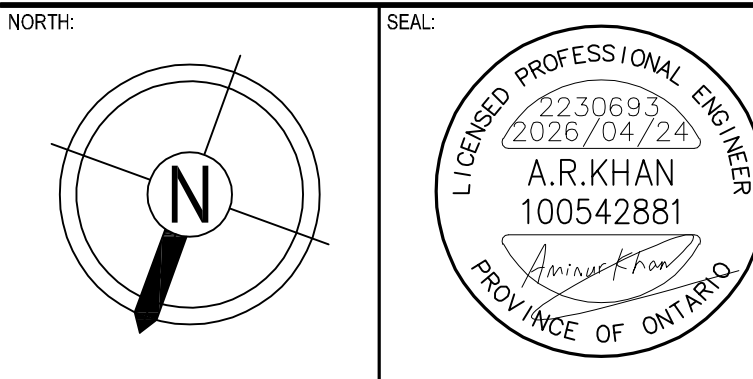
DRAWING NOTES
(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY.)

1. PROVIDE SCR FOR KOHLER KD-1250A GENERATOR AS A PACKAGE SYSTEM COMPLETE WITH ALL ASSOCIATED COMPONENTS IN ACCORDANCE WITH SCR MANUFACTURER REQUIREMENTS.
2. PROVIDE ULC-LISTED REMOTE TANK FILL STATION ABOVE THE EXISTING ACCESS PLATFORM WITH SIGNAGE "EMERGENCY EQUIPMENT DIESEL FUEL GENERATORS." ENSURE THAT MANUAL SHUT-OFF VALVE IS VISIBLE AND READILY ACCESSIBLE.
3. PROVIDE BURIED SAFETY BOLLARDS AS PER SPECIFICATION 20.05.63.
4. CHAINLINK FENCE BOUNDARY. FENCING TO BE PROVIDED AND COORDINATED WITH ELECTRICAL SCOPE OF WORK. REFER TO ELECTRICAL DRAWINGS.
5. CONNECT FUEL OIL SUPPLY LINE TO THE SUB BASE FUEL TANK INSIDE THE GENERATOR ENCLOSURE.
PROVIDE MANUAL SHUT-OFF VALVE WITH SIGNAGE "EMERGENCY EQUIPMENT DIESEL FUEL SHUT-OFF VALVE".
6. GENERATOR CONTROL PANEL SHALL BE CONNECTED TO BAS FOR MONITORING AND ALARMING.
7. PROVIDE LEAK DETECTION SENSOR (TYPE LDP 2) NEAR SUBBASE TANK AND FUEL OIL SUPPLY PIPING.
8. SCR CONTROL PANEL AND DOSING PANEL CP-100/DS-100 GENERATOR CONTROL PANEL SHALL BE CONNECTED TO BAS FOR MONITORING AND ALARMING.
9. PROVIDE SPACE TEMPERATURE SENSOR (TYPE TSD) AND CONNECT TO BAS FOR SPACE TEMPERATURE MONITORING.
10. PROVIDE ULC-LISTED OVERFILL ALARM SYSTEM AS A COMPLETE PACKAGED SYSTEM.
11. DOSING PANEL (DS-100) SHALL BE COMPLETE WITH BUILT-IN DEF INJECTION PUMP.
UREA STORAGE TANK SHALL BE LOCATED SUCH THAT THE SUCTION HEAD BETWEEN THE DOSING PANEL ASSEMBLY INLET AND UREA TANK OUTLET DOES NOT EXCEED 1829 mm (6 FT). IF THE DISTANCE IS EXCEEDED, CONTRACTOR SHALL PROVIDE UREA TRANSFER PUMP.
12. CONNECT COMBUSTION AND VENTILATION AIR INTAKE DAMPERS TO BAS FOR MONITORING.
13. PROVIDE ANTI-SIPHON VALVE ON THE FUEL SUPPLY LINE AT THE HIGHEST POINT OF PIPING ELEVATION TO THE TANK CONNECTION.
14. PROVIDE PVC PIPE SLEEVE WITH ANNULUS SPACE SEALED WITH FLEXIBLE SILICONE CAULKING
15. HOUSEKEEPING PAD ON TOP OF CONCRETE FOUNDATION BASE SHALL BE PROVIDED UNDER DIVISION 03. REFER TO STRUCTURAL DRAWINGS FOR DETAILS.
16. COORDINATE WITH DIVISION 03 CONTRACTOR, INCLUDING SEISMIC RESTRAINT REQUIREMENTS.
PROVIDE REMOTE DEF TANK FILL STATION WITH GRAVITY FILL CONNECTOR. ENSURE FILL POINT IS LOCATED HIGHER THAN TANK TO ALLOW FOR GRAVITY FILL. PROPERLY SEAL UREA FILL PIPING PENETRATION THROUGH THE ENCLOSURE.
17. PROVIDE AIR COMPRESSOR PACKAGE COMPLETE WITH POWER AND PIPING CONNECTIONS AND MOUNT TO STEEL FLOOR. PROVIDE SUPPLEMENTARY SUPPORT AS NECESSARY.
18. PROVIDE UREA STORAGE TANK COMPLETE WITH LEVEL SENSOR AND PIPING CONNECTIONS AND MOUNT TO STEEL FLOOR. PROVIDE SUPPLEMENTARY SUPPORT AS NECESSARY.
19. PUMP CONTROL PANEL SHALL BE FACTORY INSTALLED AS PART OF THE PUMP SKID.
20. HOUSEKEEPING PADS FOR FUEL PUMPS SHALL BE PROVIDED UNDER DIVISION 03. REFER TO TO STRUCTURAL DRAWINGS FOR DETAILS. COORDINATE WITH DIVISION 03 CONTRACTOR, INCLUDING SEISMIC RESTRAINT REQUIREMENTS.
21. PROVIDE BYPASS TEST SWITCH STATION IN CLOSE PROXIMITY TO SUB-BASE TANK NEAR LEVEL SENSORS.
22. PROVIDE STRUCTURAL SUPPORTS FOR PIPING AT AT LEAST 3.5m ABOVE GRADE AT MAXIMUM 3m SPACING. REFER TO STRUCTURAL FOR DETAILS.
APPROXIMATE LOCATION OF THE PIPING SUPPORTS INDICATED. EXACT LOCATIONS AND ELEVATIONS SHALL BE DETERMINED BASED ON THE FINAL PIPING LAYOUT.
23. PROVIDE STRUCTURAL SUPPORTS FOR PIPING AT AT LEAST 3m ABOVE GRADE AT MAXIMUM 2.1m SPACING. REFER TO STRUCTURAL FOR DETAILS.
APPROXIMATE LOCATION OF THE PIPING SUPPORTS INDICATED. EXACT LOCATIONS AND ELEVATIONS SHALL BE DETERMINED BASED ON THE FINAL PIPING LAYOUT.
24. CONTRACTOR SHALL VERIFY ON SITE TO LOCATE STRUCTURAL SUPPORT SUCH THAT ACCESS TO THE EXISTING PLATFORM IS NOT OBSTRUCTED. ADJUST PIPING SUPPORT ELEVATION ACCORDINGLY. COORDINATE CONTROL INTEGRATION REQUIREMENTS WITH BASE BUILDING CONTROLS CONTRACTOR. PROVIDE GAS CONTROL PANEL INSIDE GENERATOR ENCLOSURE, AS APPLICABLE.

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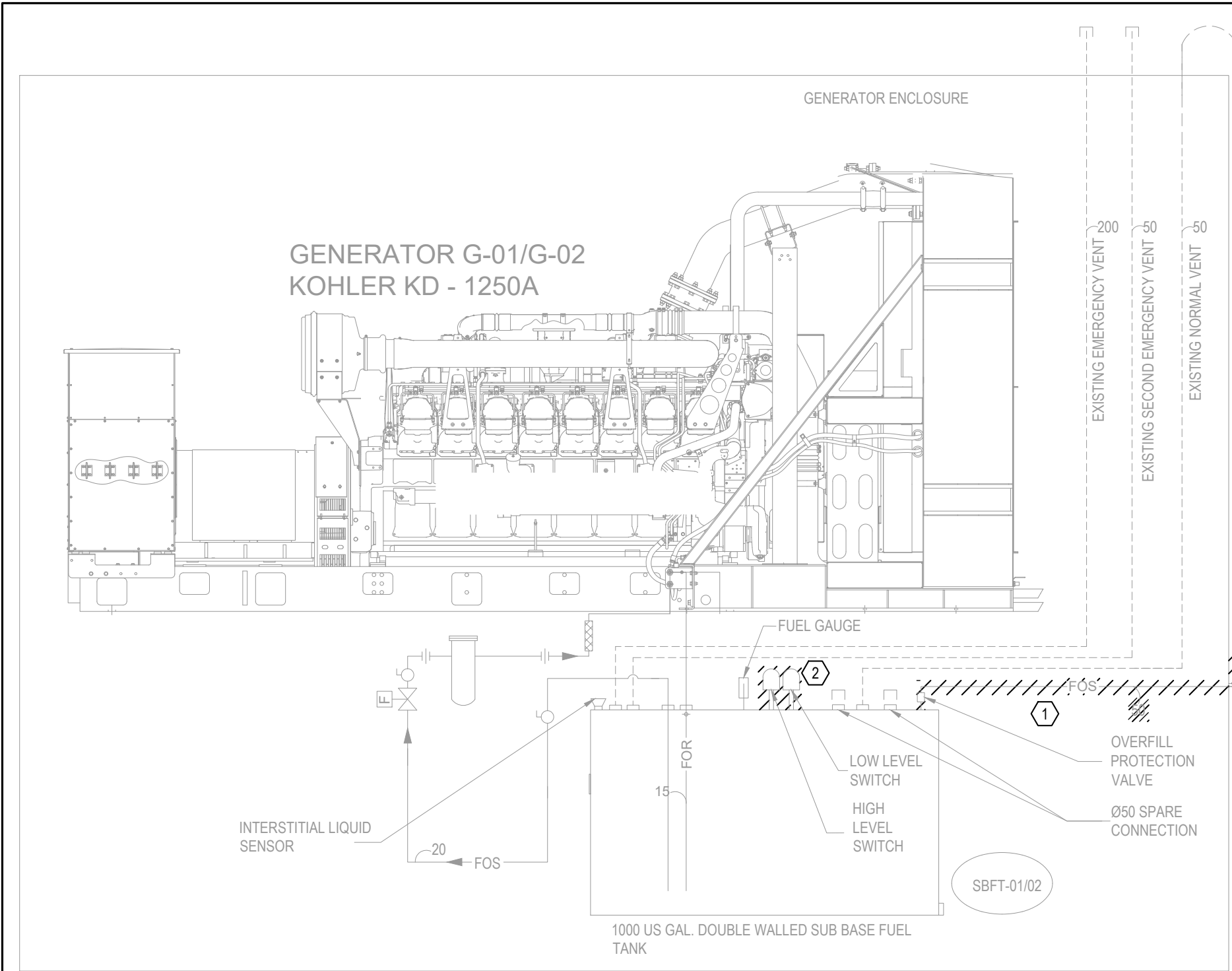


PROJECT:
**QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT**

H/A PROJECT NUMBER: 2230693
DRAWING TITLE:
MECHANICAL PLAN - NEW WORK

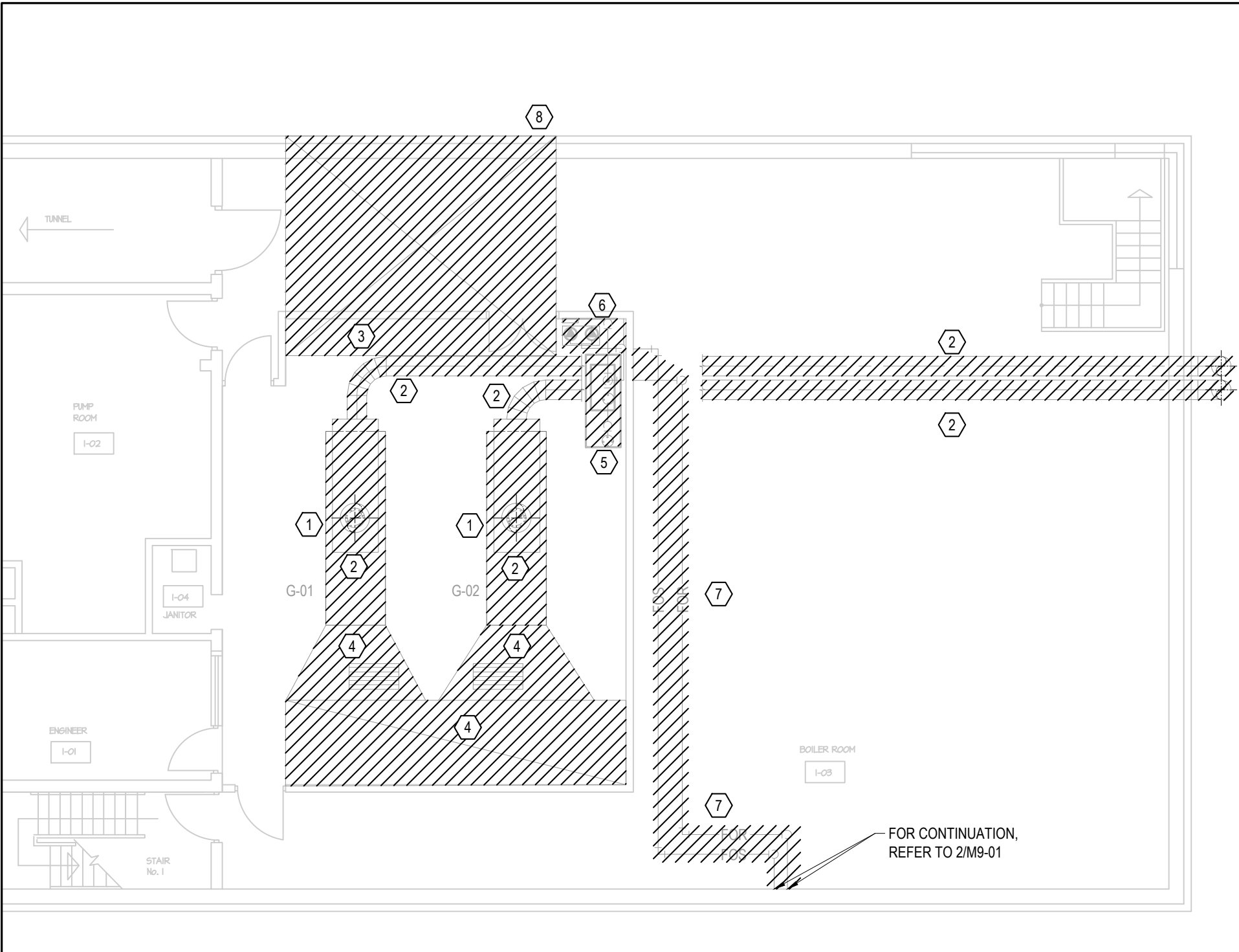
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M3-01



DRAWING NOTES

1. DEMOLISH AND REMOVE EXISTING VENT FUEL OIL SUPPLY PIPING AND ACCESSORIES INCLUDING OVERFILL PROTECTION VALVE AND SPILL CONTAINER IN ITS ENTIRETY BACK TO THE EXISTING CONNECTION AT THE SUB BASE TANK.
2. DEMOLISH AND REMOVE EXISTING HIGH AND LOW LEVEL SWITCHES INCLUDING ANY WIRING CONNECTIONS IN ITS ENTIRETY.



GENERAL NOTES

1. COMPLETELY REMOVE MARKED EXISTING SERVICES, EQUIPMENT, AND DEVICES IN THE AREA TO BE RENOVATED UNLESS NOTED OTHERWISE.
2. FIRESTOP AND CLOSE ALL OR ANY OPENINGS IN WALLS OR CEILINGS (OF THE AREAS TO REMAIN) THAT OCCUR DUE TO THE REMOVAL OF EXISTING SERVICES. FINISH TO MATCH EXISTING CONDITIONS.
3. CONTRACTOR SHALL COORDINATE WITH BGH TO SUBMIT AN ASSESSMENT REPORT TO TSSA THAT DELINEATES THE FULL EXTENT OF ANY PETROLEUM PRODUCT THAT HAS ESCAPED TO THE ENVIRONMENT WHEN A LEAK IS SUSPECTED OR WHERE A SPILL HAS OCCURED AND HAS NOT BEEN PROPERLY REMEDIATED IN ACCORDANCE WITH THE REGULATORY REQUIREMENTS.

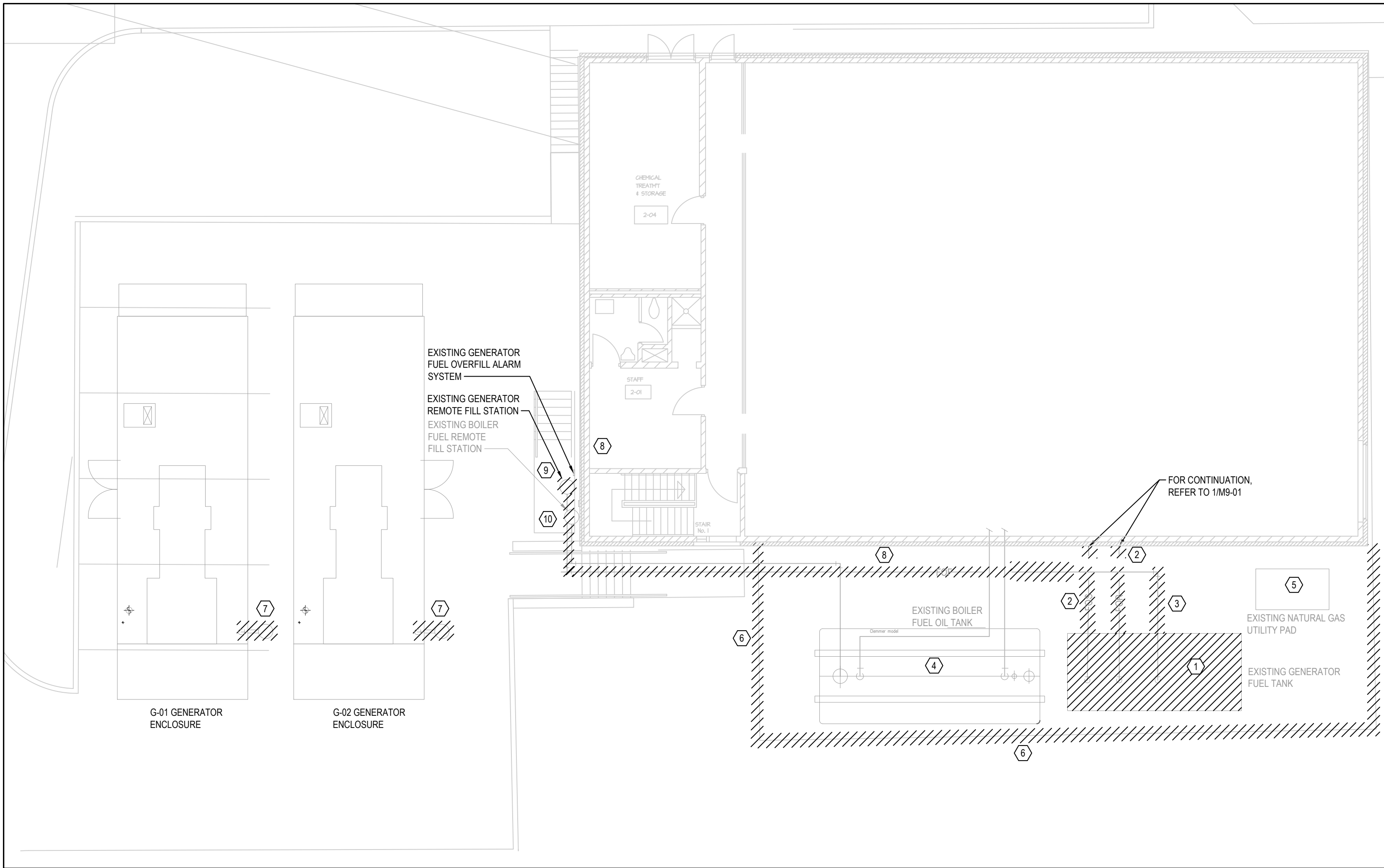
DRAWING NOTES

(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY.)

1. EXISTING GENERATORS G-01 AND G-02 TO BE DEMOLISHED BY ELECTRICAL CONTRACTOR. REFER TO ELECTRICAL DRAWINGS FOR DETAILS.
2. ALL DUCTWORK RELATED TO THE GENERATOR TO BE DEMOLISHED AND REMOVED BY MECHANICAL CONTRACTOR.
3. DEMOLISH AND REMOVE EXISTING GENERATOR EXHAUST SYSTEM IN ITS ENTIRETY, INCLUDING DUCTWORK, SILENCER, OUTDOOR STACK, EXPANSION JOINTS, AND ALL ASSOCIATED COMPONENTS.
4. DEMOLISH AND REMOVE EXISTING AIR INTAKE LOUVRES IN ITS ENTIRETY, INCLUDING DAMPERS, CONTROLS, AND ALL ASSOCIATED COMPONENTS. DEMOLISH APPLICABLE POWER WIRING AND MAKE SAFE.
5. DEMOLISH AND REMOVE EXISTING RADIATOR EXHAUST DUCTWORK AND EXHAUST PLENUM IN ITS ENTIRETY, INCLUDING ANY DAMPERS, CONTROLS AND ALL ASSOCIATED COMPONENTS. DEMOLISH APPLICABLE POWER WIRING AND MAKE SAFE.
6. DEMOLISH AND REMOVE EXISTING DAY TANK IN ITS ENTIRETY, INCLUDING HOUSEKEEPING PAD, CONTAINMENT CURB, FUEL OIL PIPING, LEVEL SWITCHES, SENSORS, AND ALL ASSOCIATED ACCESSORIES. REFER TO SPECIFICATION 23 11 05 FOR DETAILS.
7. DEMOLISH DAY TANK VENT PIPING TERMINATED THROUGH ROOF NEAR THE AIR INTAKE PLENUM.
8. DEMOLISH APPLICABLE POWER WIRING AND MAKE SAFE.
9. DEMOLISH AND REMOVE EXISTING FUEL OIL DUPLEX PUMP, CONTROL PANEL, AND ALL ASSOCIATED PIPING AND ACCESSORIES IN ITS ENTIRETY. DEMOLISH AND REMOVE EXISTING HOUSEKEEPING PAD. DEMOLISH APPLICABLE POWER WIRING AND CONDUIT BACK TO PANEL AND MAKE SAFE.
10. DEMOLISH AND REMOVE EXISTING FUEL OIL SUPPLY PIPING, RETURN PIPING AND ALL ASSOCIATED ACCESSORIES IN ITS ENTIRETY.
11. UPON REMOVAL OF INTAKE LOUVRES, PROVIDE EXTERIOR WALL INFILL AT LOUVRE OPENING TO MATCH EXISTING ADJACENT CLADDING, CONSTRUCTION, AND WEATHERPROOFING.

3 DEMOLITION - GENERATOR ENCLOSURE SCHEMATIC
M9-01 1:100

1 DEMOLITION - BOILER PLANT
M9-01 1:100



GENERAL NOTES

1. COMPLETELY REMOVE MARKED EXISTING SERVICES, EQUIPMENT, AND DEVICES IN THE AREA TO BE RENOVATED UNLESS NOTED OTHERWISE.
2. FIRESTOP AND CLOSE ALL OR ANY OPENINGS IN WALLS OR CEILINGS (OF THE AREAS TO REMAIN) THAT OCCUR DUE TO THE REMOVAL OF EXISTING SERVICES. FINISH TO MATCH EXISTING CONDITIONS.
3. CONTRACTOR SHALL COORDINATE WITH BGH TO SUBMIT AN ASSESSMENT REPORT TO TSSA THAT DELINEATES THE FULL EXTENT OF ANY PETROLEUM PRODUCT THAT HAS ESCAPED TO THE ENVIRONMENT OR INSIDE A BUILDING BOTH ON-SITE AND OFF-SITE.

DRAWING NOTES

(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY.)

1. DEMOLISH AND REMOVE EXISTING GENERATOR ABOVEGROUND FUEL TANK, HOUSEKEEPING PAD, PIPING, ACCESS STAIR AND ALL RELATED ACCESSORIES.
2. REFER TO SPECIFICATION 23 11 05 FOR DETAILS.
3. REMOVE EXISTING FUEL OIL SUPPLY AND RETURN PIPING ALONG WITH ALL ACCESSORIES IN ITS ENTIRETY.
4. DEMOLISH EXISTING FUEL FILL PIPING IN ITS ENTIRETY.
5. EXISTING BOILER FUEL TANK ALONG WITH PIPING AND ACCESSORIES TO REMAIN.
6. EXISTING NATURAL GAS UTILITY PAD TO REMAIN.
7. DEMOLISH AND REMOVE EXISTING 5-GALLON SPILL CONTAINER, FUEL FILL PIPING, AND OVERFILL PROTECTION VALVE INSIDE SUB-BASE TANK.
8. DEMOLISH AND REMOVE EXISTING OVERFILL ALARM SYSTEM ASSOCIATED WITH GENERATOR FILL STATION. CUT BACK POWER WIRING TO SOURCE.
9. DEMOLISH AND REMOVE EXISTING GENERATOR REMOTE FILL STATION IN ITS ENTIRETY AND ADD FILL PIPING TO ABOVEGROUND FUEL OIL TANK.
10. EXISTING BOILER FILL STATION AND OVERFILL ALARM SYSTEM TO REMAIN.

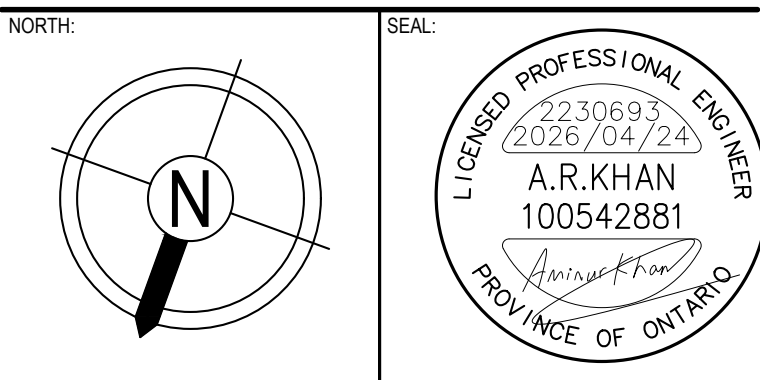
2 DEMOLITION - EXTERIOR
M9-01 1:100

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KEYPLAN:



PROJECT:
QUINTE HEALTH
BELLEVILLE GENERAL HOSPITAL
GENERATOR REPLACEMENT

HHA PROJECT NUMBER: 2230693
DRAWING TITLE:
MECHANICAL DEMOLITION

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M9-01



**Mechanical
Specification**
FOR

BGH GENERATOR REPLACEMENT
Quinte Health

Belleville General Hospital
265 Dundas St E
Belleville, ON K8N 5A9

Issued for Tender Phase 2
04/24/2026

HHA #2230693

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LIST OF SECTIONS - MECHANICAL

20 00 01

DIVISION 20 – COMMON WORKS FOR MECHANICAL

20 00 01	List of Sections
20 01 01	Mechanical General Requirements
20 01 02	Qualifications and Authorities - Ontario
20 01 13	Definitions and Abbreviations - Mechanical
20 05 01	Basic Materials and Methods
20 05 02	Painting for Mechanical Services
20 05 12	Common Electrical Requirements for Mechanical Services
20 05 13	Common Motor Requirements for Mechanical Equipment
20 05 14.13	Constant Speed Motor Controllers
20 05 23	General Requirements for Valves
20 05 24	Welding and Brazing
20 05 29	Common Hanger and Support Requirements for Piping
20 05 48	Vibration Isolation
20 05 49.13	Seismic Restraint for Mechanical Services
20 05 49.23	Seismic Qualification for Mechanical Equipment
20 05 53	Identification for Mechanical Services
20 05 63	Safety Bollards and Equipment Guards
20 08 01	Start-up and Performance Testing Reporting
20 08 11	Testing of Integrated Mechanical Fire Protection and Life Safety Systems
20 08 15	Mechanical Commissioning
20 77 19.20	Closeout Requirements for Mechanical Work

DIVISION 23 – HEATING, VENTILATION AND AIR CONDITIONING

23 11 05	Oil System Demolition
23 11 13.13	Facility Fuel Oil Piping
23 11 13.23	Facility Fuel-oil Controls and Instrumentation Devices
23 12 13.13	Facility Fuel-Oil Pumps and Control Panels
23 13 23	Aboveground Oil Storage Tanks
23 24 17.13	Selective Catalytic Reduction Systems
23 24 19	Diesel Exhaust Fluid Systems
23 26 16	Process Tubing and Accessories – Stainless Steel
23 35 16.13	Engine Exhaust Systems
23 51 33	Insulated Sectional Chimneys

DIVISION 25 – BUILDING AUTOMATION

- 25 05 01 Building Automation Common Work Results
- 25 05 06 Work on Existing Building Automation
- 25 05 12 Building Automation Control Panels and Wiring
- 25 30 16.13 Building Automation Instrumentation

END OF SECTION

MECHANICAL GENERAL REQUIREMENTS 20 01 01

1 GENERAL

1.1 General Contract Documents

- .1 Comply with General Conditions of the Contract, Supplementary Conditions of the Contract, and Division 01 - General Requirements.
- .2 Where content in this Specification section duplicates requirements in various Division 01 Specification sections, this section and the applicable Division 01 sections are to be read together and the most stringent requirements apply.

1.2 Work Included

- .1 Work to be done under Divisions 20, 21, 22, 23 and 25 to include furnishing of labour, materials and equipment required for installation, testing and putting into proper operation complete mechanical systems as shown, as specified, as intended, and as otherwise required. Complete systems to be left ready for continuous and efficient satisfactory operation.
- .2 Read drawings and specifications together as a whole and in conjunction with other such documents included under the Construction Contract.

1.3 Document Organization

- .1 Applicable Divisions for Mechanical Work:
 - .1 Division 20 - Common Work for Mechanical
 - .2 Division 23 - Heating, Ventilation and Air Conditioning (HVAC)
 - .3 Division 25 - Building Automation System
- .2 For clarity, any reference in the Contract Documents to Division 20 includes Divisions 23 and 25.
- .3 The Specifications for these Divisions are arranged in sections for convenience. It is not intended to recognize, set or define limits to any subcontract or to restrict Contractor in letting subcontracts.
- .4 Contractor is responsible for completion of work whether or not portions are sublet.

1.4 Division 20, as it applies to Divisions 23 and 25

- .1 Division 20 contains common work requirements that are applicable as necessary to the Work of Divisions 23 and 25 and apply as if written in full within those Divisions.

1.5 Language

- .1 The specification is written as a series of instructions addressed to the Contractor, and by implication to subcontractors and to suppliers. For clarity and brevity, use is made of numbered lists and bulleted lists. Where a list follows a semi-colon (;) the punctuation is for clarity. Where a list follows a colon (:) the punctuation is to be read as a short-hand form of the verb "to be" or "to have" as context requires.
- .2 It is not intended to debate with the Contractor the reasons for these instructions, and words associated with justification for an instruction or restatement of anticipated performance have been omitted to avoid possible ambiguities.

1.6 Definitions and Abbreviations

- .1 Specification section 20 01 13 *Definitions and Abbreviations – Mechanical* contains general definitions and abbreviations that apply to one or more specification sections of this Division of the Work. Other

specification sections of the mechanical Divisions of the Work may also include additional specific definitions and/or abbreviations that apply to that specification section.

.2 The following general terms apply to Divisions 20 to 25 of the Work:

- .1 The words "indicated", "shown", "noted", "listed" or similar words or phrases used in this Specification, mean that material or item referred to is "indicated", "shown", "listed" or "noted" on Drawings or in Specification.
- .2 Wherever the word "listed" is used in conjunction with a product and a product certification standard (including but not limited to CSA, ULC, CGSB, BNQ, UL), it shall be understood to mean that the product is "listed" by an accredited 3rd party testing laboratory as being certified to the referenced product standard.
- .3 Wherever the words "approved", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides, to mean that material or item referred to shall be "approved by" the Owner.
- .4 Wherever the words "satisfactory", "as directed", "submit", "permitted", "reviewed", or similar words or phrases are used in the Specification they shall be understood, unless the context otherwise provides, to mean that material or item referred to shall be "satisfactory to", "as directed by", "submitted to", "permitted by", or "reviewed by" the Consultant.
- .5 Instructions using any form of the word:
 - (a) "install" means to place in position and activate for service or use,
 - (b) "supply" means to procure and deliver materials to the place of the Work, or to make available labour or services for the stated purpose,
 - (c) "provide" means to supply material, labour and services to install the referenced item.
- .6 The term "building code" means the edition of the applicable building code at the time of obtaining a building permit.
- .7 Wherever manufacturers or manufacturer's products are identified in lists under the phrase "Standard of Acceptance", these are manufacturers and/or products which meet the project standards in regard to performance, quality of material and workmanship.

1.7 Examination

- .1 Examine any existing buildings, local conditions, building site, the specifications and drawings, and report any condition, defect or interference that would prevent execution of the work.
- .2 No allowance will be made for any expense incurred through failure to make these examinations of the site and the documents prior to Tender or on account of any conditions on site or any growth or item existing there which was visible or known to exist at time of Tender.
- .3 Before commencing work under this Division, examine the work of other Divisions of the Work and report any defect or interference.

1.8 Design Services

- .1 Provide specialty design services for elements of the Work where specified in other sections of Division 20. Drawings and specifications prepared by such specialty design service providers shall be sealed by a professional engineer licensed in the jurisdiction of the Work.

1.9 Product Substitutions

- .1 In the absence of requirements concerning product substitution requests in Division 01, Contractor may propose a substitute product to that which is specified in accordance with the following.
- .2 All proposed substitutions shall be submitted using the Consultant's product substitution form and include all information stated therein.

- .3 The use of a substitute article or material which the Contractor represents to be of at least equal quality and of the required characteristics for the purpose intended may be permitted, subject to the following provisions:
 - .1 a substitution will not be considered for reasons of meeting the construction schedule unless the contractor can demonstrate to the satisfaction of the Consultant they made all reasonable efforts to procure the specified product or material in a timely fashion,
 - .2 the manufacturer must advise the Consultant of this intention to use an alternative article or material before doing so,
 - .3 the burden of proof as to the quality and suitability of alternatives to be upon the manufacturer and they shall supply all information necessary as required by the Consultant at no additional costs to the contract,
 - .4 the Consultant shall be the sole judge as to the quality and suitability of alternative materials and their decision to be final,
 - .5 where use of an alternative material involves redesign or changes to other parts of the work, the costs and the time required to effect such redesign or changes will be considered in evaluating the suitability of the alternative materials,
 - .6 no test or action relating to the approval of substitute materials is to be made until the request for substitution has been made in writing by the manufacturer and has been accompanied by complete data as to the quality of the materials proposed. Such request to be made in ample time to permit appropriate review without delaying the work, taking into consideration that such a substitution request may be rejected and require providing the product or material as originally specified,
 - .7 whenever classification, listing, or other certification by a recognized standards body is a part of the specifications for any material, proposals for use of substitute materials is to be accompanied by reports from the equivalent body indicating compliance with the requirements of the specifications,
 - .8 the costs of all testing required to prove equality of the material proposed to be borne by the manufacturer.

2 SHIPPING, HANDLING AND STORAGE

2.1 Shipping

- .1 Provide adequate protection of equipment during shipping and handling so as to provide equipment at the Work site in ex-works condition when handled by commercial carrier systems.
- .2 Provide, as necessary, removable bracing of the internal components in each item of equipment so that the equipment can be moved on its side or back, without sustaining damage.
- .3 Where removeable internal bracing has been provided, the equipment to be provided with warning labels to call for the removal of the shipping bracing prior to energization.
- .4 Any component that is packaged or shipped separately is to be individually crated and tagged with unit number and the equipment number of the assembly to which it belongs.
- .5 Provide each "shipping section" with a permanently-attached, readily-visible identification tag bearing the equipment number of the assembly of which it is a part.

2.2 Storage

- .1 Store equipment and materials at the worksite to protect them from any damage until placed into its final location. Maintain similar protection of installed equipment and materials to protect against damage until they are turned over to the Owner. Make good any damage to equipment or materials up to the time of ready for takeover.

- .2 Store equipment in accordance with the manufacturer's instructions and not less than:
 - .1 stored in a dry, clean location,
 - .2 cover with polyethylene plastic sheeting,
 - .3 include a desiccant material under the protective sheeting to absorb moisture, or provide heated ventilated air
- .3 Provide adequate ventilation and temporary heating to prevent condensation of moisture within the equipment.

2.3 Provisions for Handling and Field Erection

- .1 For equipment that will require hoisting on site, provide removable side panels, lifting angles or lifting plates to accommodate the use of slings or crane hooks, for each shipping section.
- .2 For floor mounted equipment, provide on each shipping section removable steel channel base plates to permit use of pipe rollers or dollies without damaging the equipment.

3 OWNER'S SPECIAL REQUIREMENTS FOR EXISTING SITES

- .1 The following special requirements are in addition to the requirements of Division 01 of the Work.
- .2 Provide a written list of names for employees and sub-trades entering the building, advising which areas they need access to at least 48 hours prior to expected time of arrival. This lead time is required to prearrange security passes.
- .3 Security passes must be visibly worn at all times by all employees.
- .4 Trades people to strictly adhere to owner's building security procedures otherwise entrance into the building will be denied.
- .5 Trades people are to enter the entrance identified by the Owner.
- .6 Park vehicles in designated areas. Do not block driveways.
- .7 Use only the freight elevator to transport tools and material. Freight elevator door must be shut immediately after exiting the cab.
- .8 Do not disable or activate any electrical or mechanical system without prior approval by the Owner's Project Manager. Also, prior to disabling or activation of any electrical or mechanical system, obtain approval from Building Operations and Building Security.
- .9 Submit prior notification to Building Security Staff before any construction activity commences which will result in heat, smoke, dust or fumes, such as welding, saw cutting, soldering, spray painting, which might affect sensitive fire detection and protection equipment.
- .10 Provide at least 48 hours prior notification to Building Operations for any fire system isolation requests.
- .11 Schedule work and meet with sub-trades daily on site, to show trades people the work areas and work to be done.
- .12 Trades-people are to supply and use their own tools. No tools, ladders or equipment, etc. will be loaned by the Owner.
- .13 Provide environmental cleaning of the job site daily during construction and upon completion. This includes above ceilings. Do not store materials or garbage on the loading dock.
- .14 Provide special care, attention and protection when transporting equipment and materials to prevent accidental damage to fire protection equipment, finishes, furnishings and fixtures.
- .15 "No Smoking" – this is a smoke-free building. Violators will be asked to leave and may be denied reentry. Smoking is not allowed on the roof.

- .16 If Building Operations deems that work on a particular system requires security escort, allow 48 hours to make appropriate arrangements.
- .17 For any open flame work, provide fire extinguishers and security fire watch.
- .18 Obtain the approval of the Building Manager for the storage of materials on site.
- .19 Perform a daily cleanup prior to leaving the site.
- .20 Secure oxygen and acetylene cylinders at all times and capped nightly.
- .21 Restore operating and redundant systems to their normal condition at the end of each work day unless otherwise approved by the Owner
- .22 At the conclusion of each work day, the Contractor's superintendent/supervisor is to advise the Building Manager on the day's activities and plans for the next day's work.

4 PROGRESS PAYMENT PROCEDURE

4.1 Schedule of Values

- .1 [Provide schedule(s) of values for progress payments in accordance with this part.
- .2 Prepare and submit a schedule of values ("SOV") for the Division 20 Work.
- .3 Each SOV is to be in the sample format shown in Article "Attachments", specifically that the SOV is to include four sections for:
 - .1 Contract price work element breakdown, which includes:
 - (a) detailed breakdown by work element as agreed with the Consultant,
 - (b) line items for coordination drawings, as-built documents and operating manuals,
 - (c) a summary line item for authorized Cash Allowance disbursements (if applicable),
 - (d) line items for each Itemized Price (if applicable),
 - (e) line items for each Separate Price (if applicable and included in the Contract Price)
 - (f) a line item for the total of the original contract work element values,
 - (g) a summary line item for approved change instructions,
 - .2 Cash Allowance disbursement authorization, with separate work elements for each cash allowance,
 - .3 Approved Change Instructions, with separate work elements for each change instruction,
 - .4 Outstanding Change Instructions which are either not quoted or not yet approved.
- .4 Each work element in the SOV sections (except Outstanding Change Instructions) is to include:
 - .1 the original contract value and the percent of original contract total value (Contract Price section only),
 - .2 the completed to date amount and percent of original work element contract value,
 - .3 the previously billed amount and percent of original work element contract value,
 - .4 the current billing (payment request) amount and percent of original work element contract value, and
 - .5 the balance to complete amount and percentage of original work element contract value.
- .5 The required Contract Price work element breakdown will be determined by the Consultant, with the level of breakdown appropriate to the project such as
 - .1 by trade,
 - .2 by specification section or portion thereof,

- .3 by labour vs material,
- .4 by location in the building,
- .5 or any combination of the above.
- .6 Submit a draft SOV for review and approval by the Consultant at least three weeks before the first request for progress payment. Do not submit requests for progress payments until the SOV has been reviewed and there are no outstanding comments from the Consultant.
- .7 Make requests for progress payments using the values on the reviewed SOV.
- .8 When a change in the Work has been approved by the Owner, include the approved changes on the SOV for the next payment application, whether or not payment is requested in full or in part for that change in that payment request period.

5 CONSTRUCTION CHANGES

5.1 General

- .1 The valuation method to be used for a change instruction to the Work is to be determined by the Consultant from the following methods:
 - .1 by labour and material when the change instruction is by a Change Directive;
 - .2 by unit prices set out in the Contract or subsequently agreed upon for other change instructions;
 - .3 by a detailed quotation for other change instructions; or
 - .4 by a Cash Allowance Disbursement instruction.

5.2 Definitions

- .1 The following definitions apply to this section
 - .1 **Allpricer** – the material pricing guide/service provided by Allpricer Limited.
 - .2 **MCAA manual** – the Mechanical Contractors Association of America publication *Labor Estimating Guide for Service* for labour units.
 - .3 **Base wage rate** – the hourly rate actually paid to the trades person, determined in accordance with applicable collective bargaining agreement, or in their absence the actual gross wages paid to the worker.
 - .4 **Job Site Impact Multiplier** – a multiplier expressed as a decimal number that is included in the Labour Rate to account for special job site conditions that affect labour availability, labour productivity, procurement of materials, and materials management, that are specific to the project and site conditions.
 - .5 **Indirect labour** – any labour that is neither journey person labour that directly performs the work nor labour that directly supervises journey person(s).
 - .6 **Labour Rate** – the actual fully burdened labour cost per hour of labour consumed by a trades person including statutory and regulatory burden, collective bargaining burden, and other project related burden. For greater clarity, the labour rate includes but is not limited to the following:
 - (a) base wage rate,
 - (b) vacation and statutory holiday pay,
 - (c) union deductions and additional union charges,
 - (d) Legislated burdens including EHT, WSIB, EI, CPP, RST on H/W
 - (e) wage-based taxes,
 - (f) job site impact multipliers,

- (g) expendable small tools charge,
 - (h) project insurance,
 - (i) financing of payroll,
 - (j) estimating,
 - (k) rest breaks and idle time,
 - (l) safety including training, safety meetings, WHMIS, fall protection, personnel protection equipment, and safety committees,
 - (m) preparation and handling of shop drawings and other submittals,
 - (n) preparation of as-built documents, including operation and maintenance manuals,
 - (o) labour warranties,
 - (p) site facilities,
 - (q) clean-up,
 - (r) parking.
- .7 **Foreperson** – a first level supervisory position having direct control over the work performed by journeypersons.
- .8 **Journeyperson** – a person working in a skilled construction trade which may be prescribed by regulation, and includes apprentices.
- .9 **Labour Unit** – the number of journeyperson labour hours or part thereof, required to perform a specific construction task, and includes but is not limited to:
- (a) receiving, unloading, stockpiling, distribution and handling of materials and equipment,
 - (b) rigging or erecting of materials or equipment,
 - (c) fitting and joining of materials,
 - (d) pressure testing of piping and ductwork systems,
 - (e) testing of equipment and systems.
- .10 **Line materials** – components that make up a distribution network for fluid, power, or electronic/digital information, and includes:
- (a) piping, pipe fittings, valves (of all kinds), pipe strainers and other pipe mounted equipment,
 - (b) ducting, duct fittings, duct balancing dampers and other duct mounted equipment,
 - (c) conduit, cable tray, cable, conductors, and wiring,
 - (d) supports, hangers and restraints,
 - (e) vibration isolators and seismic restraints associated with line materials,
 - (f) instrumentation including gauges and sensors/transmitters,
 - (g) electrical, pneumatic, and hydraulic actuators for valves and dampers, and
 - (h) any coatings or other protective elements applied thereto including insulation and painting.
- .11 **Overhead** – administrative expenses of the Contractor's business and the project which are not included in a Labour Rate or Labour Unit. For greater clarity, overhead includes but is not limited to the following:
- (a) company office, storage, and fabrication spaces, and associated maintenance, utilities, and expenses,
 - (b) project site office, fabrication and storage spaces, washrooms, break rooms, and associated maintenance, utilities, and expenses,
 - (c) company office equipment, furniture and supplies,
 - (d) project site office equipment, furniture and supplies,

- (e) labour time for project managers and project assistants,
- (f) project site security,
- (g) project site clean-up, recycling and waste disposal,
- (h) materials management,
- (i) property taxes, business licenses, and auto insurance,
- (j) dues and subscriptions,
- (k) postage and courier,
- (l) advertising, telephone, IT services and equipment,
- (m) legal and accounting fees and expenses,
- (n) sales and marketing,
- (o) salaries and benefits for company indirect labour including company management, sales force, dispatchers, estimators, clerical staff, and at-office general (non-trades) labour.
- (p) all other indirect labour.

.12 Senior Foreperson – the second (and subsequent) level supervisory position having direct control over one or more Forepersons, where the number of Forepersons supervised is in accordance with local regulatory requirements or collective bargaining agreements. (“Superintendent” or “Supervisor” has the same meaning.

5.3 Change Directive Method

- .1 Except where otherwise determined in the Construction Contract or Division 01 specification, the valuation of changes by the Change Directive method shall comply with the following:
 - .1 the form of presentation of costs and methods of measurement shall be agreed to by Consultant and Contractor before proceeding with the change,
 - .2 the adjustment in the Contract Price for a change carried out by way of Change Directive shall be determined on the basis of the cost of the Contractor’s actual expenditures and savings attributed to the Change Directive. For clarity and by example, savings for deductions of similar materials, equipment, labour or services shall be valued at the same amount as for expenditures for additions of same.
 - .3 labour costs will be determined based on actual time spent and the agreed labour rate, the actual cost of installed line materials and equipment, and the agreed fee for overhead and profit,
 - .4 if the change results in a net decrease in Contract cost, the contract price will be decreased by the net decrease in the cost, without adjustment for the Contractor’s percentage fee for overhead and profit,
 - .5 the Contractor shall keep accurate records, in an agreed upon form, of time, quantities and invoiced costs and present an account of the cost of the change in the Work, together with vouchers, material receipts and invoices,
 - .6 this time and material method shall be used until such time as a total cost estimate of the change is agreed between the Owner and the Contractor, at which time all payments made under this time and material method will be credited against the agreed total cost for the change.

5.4 Unit Price Method

- .1 Costing of changes by the Unit Price method:
 - .1 Costs for work identified by agreed unit costs shall be charged at those rates, unless the Owner agrees to other rates.

5.5 Proposed Changes; Other Change Instructions Method

- .1 For proposed changes to the Work or other similar instructions, submit a detailed quotation for approval.
- .2 The adjustment in the Contract Price for a change carried out by way of proposed change or other similar instruction shall be determined on the basis of the cost of the Contractor's actual expenditures and savings attributed to the Proposed Change. For clarity and by example, savings for deductions of similar materials, equipment, labour or services shall be valued at the same amount as for expenditures for additions of same.
- .3 Costs are to be approved by the Owner before the proposed change to the Work proceeds. The quotation for the change to the Work is to include a summary of charges made up of three components: labour charges, material costs and fees.
- .4 Labour Charges:
 - .1 The labour unit hour estimates are to be based on the current MCAA estimating manual unless otherwise agreed by the Consultant;
 - .2 The labour cost is to be determined using the agreed labour rates.
 - .3 Labour rates for Foreperson and Senior Foreperson shall be as per agreement, or in absence of such agreement shall be 1.15 times the journeyman labour rate. The maximum allowable labour hours for supervision are not to exceed:
 - (a) for a Foreperson, a maximum of 10% of the total calculated journeyman hours on a change, and
 - (b) for a Senior Foreperson of all levels, a maximum combined amount of 3% of the total calculated journeyman hours on a change.
 - (c) no other supervisory hours will be permitted.
- .5 Material Charges:
 - .1 Material costs for line materials and installed equipment are to be net of trade discounts. The discount to be applied to list prices for items included in Allpricer manual shall not be less than:
 - (a) 20% for line materials, and
 - (b) 10% for equipment that is not line material.
- .6 Fees:
 - .1 The Contractor and any sub-contractor is allowed a combined overhead and profit fee of 15% for work to be performed by their own forces,
 - .2 The Contractor and any sub-contractor is allowed a combined overhead and profit fee of 5% for work performed by a sub-contractor (in the case of the Contractor) or a sub-sub-contractor (in the case of work performed for a sub-contractor),
 - .3 For clarity, the allowable fees on direct work and on sub-contracted work apply to a sub-sub-contractor of any tier.

5.6 Cash Allowances; Contingency Allowances

- .1 Instructions for changes to the Work to be performed under a cash allowance or contingency allowance ("Allowance") included in the contract price shall be authorized by a Cash Allowance Disbursement instruction.
- .2 Except as described below, the determination of costs for Work performed under an Allowance shall be in accordance with the procedure for proposed changes unless otherwise instructed to proceed with the work, in which case the cost of such work shall be valued in accordance with the procedures for Change Directive.
- .3 The contract price, not the Allowance, includes the overhead and profit fee for the value of the Allowance.

- .4 Except where otherwise specified in the Construction Contract, where the cost of the Work performed under a Cash Allowance Authorization;
 - .1 is less than the Allowance value, the contract price includes the overhead and profit for the contractor and any sub-contractors. A change order will be issued for a credit for the balance of the Allowance, but shall not include the associated overhead and profit fee.
 - .2 exceeds the Allowance value, a Change Order will be issued for the amount in excess of the Allowance, and the excess amount is to include the agree fee for overheat and profit.]

6 SUBMITTALS

6.1 Shop Drawings and Product Data Sheets

- .1 Submit shop drawings, manufacturers product data and samples in accordance with the requirements of Specification sections of Division 01, this Part, and as further required in other Specification sections of Division 20.
- .2 Submit shop drawings in the same unit of measure as are used on the drawings. Both metric and U.S. customary units may be included.
- .3 Submit shop drawings by email to: shopdrawings@hhangus.com, except where a project document management web-service is used.
- .4 Include a H.H. Angus shop drawing cover sheet form prepared for this project for each shop drawing submittal (refer to part "Attachments" for an example of this form) , or include the same information on the general or trade contractor's submittal cover sheet;
 - .1 Information required on each submission:
 - (a) Client/Architect name,
 - (b) Project Name,
 - (c) H.H. Angus project number,
 - (d) Date,
 - (e) Contractor name,
 - (f) Contractor reference No.,
 - (g) Manufacturer name,
 - (h) Product type,
 - (i) Specification section number,
 - (j) Contractor trade category: architectural, structural, conveying equipment, user equipment, mechanical, electrical, telecommunications, civil or other.
 - (k) If a re-submission, the Consultant's previous submittal reference number.
- .5 Submit shop drawings in PDF format except as follows;
 - .1 if the Consultant agrees to a shop drawing to be submitted in hardcopy format, submit in 8.5 x 11 or 11 x 17 size, black and white originals of graphic quality suitable for photocopying and digital scanning. Allow one additional week for processing of shop drawings submitted in hardcopy format.
- .6 Manufacturer's letter sized product data sheets for standard items are acceptable in place of shop drawings provided that physical characteristics are identified and are related to specification references.
- .7 Submit with manufacturers data sheets, typed schedules listing manufacturer's and supplier's name and catalogue model number.

- .8 For plumbing fixtures and other permeant fixtures, submit fixture sheets with catalogue numbers. Identify and arrange fixture sheets in the same sequence and using the same identification number as shown in specification fixture lists.
- .9 Shop drawings and/or product data sheets to show;
 - (a) dimensioned outlines of equipment and construction details,
 - (b) equipment weights and center of gravity,
 - (c) performance ratings,
 - (d) dimensioned details showing service connection points,
 - (e) elevations illustrating locations of visible equipment such as gauges, pilot lights, breakers and their trip settings, windows, meters, and access doors,
 - (f) description of operation,
 - (g) single line diagrams,
 - (h) general routing of bus ducts and connecting services,
 - (i) mounting and fixing arrangements,
 - (j) operating and maintenance clearances,
 - (k) access door swing spaces, and
 - (l) where products are required to be certified to a published standard, the mark of the testing organization who certified the product and the standard reference number to which it is certified.
- .10 Shop drawings and product data to be accompanied by;
 - (a) detailed drawings of bases, supports and anchor bolts,
 - (b) sound power data, where applicable, and
 - (c) performance curve for each piece of equipment marked with point of operation.
- .11 Shop drawing and data sheet submission is taken as certification that the products are;
 - .1 from the manufacturer's current production, and
 - .2 in compliance with applicable codes, standards, and regulations.
- .12 For standard catalogued (non-custom) products, do not submit drawings showing internal construction details, component assemblies or interior piping and wiring diagrams. Such information may be necessary to understand correct functioning of equipment and are to be submitted with operating and maintenance data.
- .13 Check and stamp each shop drawing as being correct before submission. Shop drawings without such stamps will be rejected and returned.
- .14 Keep one copy of each reviewed shop drawing and product data sheet on site and have them available for reference purposes.
- .15 Where equipment is delivered without reviewed shop drawings, equipment will be condemned and is to be removed from site and replaced with new equipment after shop drawings have been submitted and reviewed.

6.2 Coordination, Fabrication, or Installation Drawings

- .1 Contractor coordination, fabrication, installation and/or sleeving drawings are to be provided in accordance with specification Section 20 01 03 *Mechanical Coordination and Installation Design Services*.
- .2 Contractor's coordination, fabrication, installation, and/or sleeving drawings will not be reviewed as shop drawings. If submitted as a shop drawing, a transmittal only will be returned identifying the submitted drawings have not been reviewed as a shop drawing.

- .3 Maintain a copy on site of such drawings for reference by the Consultant.
- .4 The Consultant reserves the right to request selected Contractor's coordination, fabrication, or installation drawings for review.

6.3 Effect of Consultants Review of Submittals

- .1 Consultant's review of shop drawings is performed on a sampling basis only, to confirm to Consultant's satisfaction that the Contractor understands the Work to be performed and is interpreting the design documents correctly, and such reviews are performed for the benefit of the Owner.
- .2 For greater certainty, the review of shop drawings by Consultant does not constitute a quality control function for the benefit of Contractor, nor does such a review relieve Contractor of their responsibility for complying with the Contract documents.

7 APPLICABLE CODES, STANDARDS AND REGULATIONS; PERMITS

7.1 Codes, Standards and Regulations

- .1 Where a published product standard or installation code is adopted by statute or regulation by an applicable AHJ, the applicable edition of the standard or code is the one that has been adopted
 - .1 at the time of obtaining a permit for the applicable portion of the Work, or
 - .2 in the absence of a requirement for a permit, the start date of construction.
- .2 Where a published product standard or installation code is not adopted by statute or regulation, then the most current edition of that standard or code at the start date of construction applies.
- .3 Install mechanical and electrical systems in accordance with the applicable requirements adopted by the AHJ in the jurisdiction of the Work.
- .4 Where requirements of the Specifications exceed those of applicable codes, standards, and regulations the requirements of the Specifications is to govern.
- .5 In the event of a conflict between codes, bulletins, regulations, or standards, or where work shown is in conflict with these documents, obtain interpretation before proceeding. Failure to clarify any ambiguity will result in an interpretation requiring application of the most demanding requirements.

7.2 Confined Spaces

- .1 Unless otherwise prescribed by the Constructor's / Owner's workplace safety program, treat spaces not designed and constructed for continuous human occupancy as confined spaces in accordance with applicable health and safety legislation, including but not limited to:
 - .1 horizontal and vertical service spaces, shafts, and tunnels,
 - .2 inside of equipment which permits entry of the head and/or whole body, and
 - .3 ceiling spaces which are identified as containing a hazardous substance.

7.3 Permits, Tests and Certificates

- .1 Arrange and pay for permits, tests, and Certificates of Inspection required by the AHJ applicable to the element of the Work.
- .2 Submit applications requiring Owner's signature before commencing work.
- .3 Obtain and submit applicable AHJ Inspection certificates or reports including but not limited to:
 - (a) Electrical inspection,
 - (b) Plumbing and drainage inspection,
 - (c) HVAC inspection,

- (d) Pressure Vessel Inspection.
- (e) Piping and Boiler Inspection.
- (f) Fuel safety Inspection.
- .2 Renew certificates or reports so as to remain in force through the warranty period.
- .4 Co-ordinate and perform testing required by an AHJ in accordance with the Part on Testing in this Section.

8 COMMON PRODUCT REQUIREMENTS

8.1 Standard of Material and Equipment

- .1 Provide materials and equipment in accordance the requirements of Specification section of Division 01 and as follows.
- .2 Materials and equipment:
 - .1 new and of uniform pattern throughout work,
 - .2 of Canadian manufacture where obtainable,
 - .3 standard products of approved manufacture,
 - .4 labeled or listed (certified) to applicable standards in accordance with Specification sections of the Work and as required by authorities having jurisdiction,
 - .5 registered in accordance with the requirements of the applicable provincial pressure vessels regulation and registered in accordance with CSA B51 for Canadian Registration Numbers, as applicable,
 - .6 in compliance with Standards and Regulations including but not limited to;
 - (a) chemical and physical properties of materials,
 - (b) design,
 - (c) performance characteristics, and
 - (d) methods of construction and installation.
 - .7 identical units of equipment to be by the same manufacturer. ,
 - .8 identical component parts of same manufacturer in similar units of equipment, but various component parts of each unit need not be from one manufacturer.
- .3 Materials and equipment are described to establish standards of construction and workmanship. Where manufacturers and/or products are listed under "Standard of Acceptance", select manufacturers and or products from these lists. Use of manufacturers or products other than as listed are subject to specification requirements concerning requests for substitution.
- .4 Include items of material and equipment not specifically noted on Drawings or mentioned in Specifications but which are required to make a complete and operating system.
- .5 Confirm capacity or ratings of equipment being provided, when based on ratings of equipment being provided under other trade Sections, before such items are purchased.
- .6 Factory fabricated control panels and component assemblies are to be listed for electrical safety requirements.
- .7 Select materials and equipment in accordance with manufacturer's recommendations and these Specifications, and install same in accordance with manufacturer's instructions and these Specifications.
- .8 Materials and equipment not satisfying these selection criteria will be condemned. Remove condemned materials from job site and provide properly selected and approved materials.

8.2 Manufacturers Nameplates

- .1 Provide manufactured equipment with metal nameplate with raised or recessed lettering, mounted on each piece of equipment. On insulated equipment, mechanically fasten plates on metal stand-off bracket arranged to clear insulation.
- .2 Manufacturer's nameplate to indicate equipment size, capacity, model designation, manufacturer's name, serial number, voltage, cycle, phase and power rating of motors, and approval listings.
- .3 Certified products are to clearly show the mark of the certification agency when in the final installed state.

8.3 Factory Applied Painting

- .1 Protect factory finished equipment during construction, and clean at completion of work.
- .2 Touch-up factory painted prime and/or final coats damaged during construction, with colour matching paint recommended by the equipment manufacturer.
- .3 Use heat resistant paint where conditions require.

8.4 Factory Applied Prime Painting

- .1 Factory-prime paint other equipment fabricated from iron or steel, including equipment supports and hangers, access platforms, access doors, registers, grilles, diffusers, dampers, metal radiation enclosures and fire hose cabinets where separate product specifications do not require a factory applied final coat.

8.5 Field Painting

- .1 After equipment has been installed and piping and insulation is completed, clean rust and oil from exposed iron and steel work provided under this Division, whether or not it has been factory prime painted.
- .2 In "occupied" areas of building touch up any damage to prime coat resulting from shipping or installation and leave ready for final decorative painting under Finishes, Division 9.
- .3 In "un-occupied" areas of the building such as mechanical equipment rooms, boiler rooms, fan rooms, crawl spaces, pipe tunnels and penthouses, provide corrosion coatings and floor sealers in accordance with specification section 20 05 02 *Painting for Mechanical Services*.
- .4 In addition, apply prime and/or final paint coats to equipment and materials where specifically detailed in other Sections of these Divisions.

8.6 Provision for Future

- .1 Where space is indicated as reserved for future equipment or for future extension to building, leave such space clear and install piping, raceways and equipment so that connections can be made to future apparatus or building.
- .2 Identify provisions and service terminations for future on Record Drawings.

8.7 Maintenance of Bearings

- .1 Turn-over rotating equipment at least once a month from delivery to site until start-up.
- .2 Run-in sleeve type bearings in accordance with manufacturer's written recommendation. After "run-in", drain, flush out and refill with new charge of oil or grease.
- .3 Protect bearings, shafts and sheaves against damage, corrosion and dust accumulation during building construction.

8.8 Pre-purchased Equipment; Damage and Ownership

- .1 At time of receipt of pre-purchased or pre-tendered equipment at the job site by the installing mechanical contractor, provide the services of the manufacturer/distributor/supplier's technical representative to:
 - .1 inspect the equipment prior to unloading,
 - .2 witness the unloading and advise the contractor on the appropriate method for handling the equipment in order to avoid damage during the unloading, moving and setting in place phase of the equipment, and
 - .3 report any damage to the Consultant.
- .2 In the event the equipment has been found to be damaged before unloading, it is to be returned immediately to the factory for repairs and/or replacement by the manufacturer/supplier.
- .3 In the event of damage occurring at any time during unloading and until the equipment is accepted by the Owner, the installing contractor is responsible for repairs and/or replacement of the damaged equipment to the satisfaction of the Owner.

9 OFFICE AND STORAGE; TOOLS

9.1 Office and Storage

- .1 Provide temporary office, washroom and lunchroom facilities, workshop, and tools and material storage space in accordance with Division 01.

9.2 Tools, Temporary Equipment and Materials

- .1 Provide tools, equipment, scaffolding, extension cords, lamps and miscellaneous consumable materials, required to carry out the Work.

10 COORDINATION; INSTALLATION DRAWINGS

10.1 Coordination

- .1 Consultant drawings are diagrammatic and illustrate the general location of equipment, and intended routing of ductwork, piping, etc. and do not show every structural detail. In congested areas drawings at greater scale may be provided to improve interpretation of the Work. Where equipment or systems are shown as "double line", they are done so either to improve understanding of the Work, or simply as a result of the use of a CAD drawing tool, and in either case such drawings are not represented as fabrication or installation drawings.
- .2 Lay out and coordinate Work to avoid conflict with work under other Divisions.
- .3 Make good damage to Owner's property or to other trade's work caused by inaccurate layout or careless performance of work of this Division.
- .4 When equipment provided under other Sections connects with material or equipment supplied under this Section, confirm capacity and ratings of equipment being provided.
- .5 Take information involving accurate measurements from dimensioned Architectural Drawings or at building.
- .6 Install services and equipment which are to be concealed, close to building structure so that furring is kept to minimum dimensions.
- .7 Location of pipes, ductwork, raceways and equipment may be altered without extra cost provided instruction is given or approval is obtained, in advance of installation of items involved. Changes will be authorized by site instructions and are to be shown on Record Drawings.

- .8 Location of floor drains, hub drains, combination drains, plumbing fixtures, convectors, unit heaters, diffuser, registers grilles and other similar items may be altered without extra cost provided instruction is given prior to roughing in. No claim will be paid for extra labour and materials for relocating items up to 3 m (10 ft) from original location nor will credits be anticipated where relocation up to 3 m (10 ft) reduces material and labour.
- .9 Include incidental material and equipment not specifically noted on Drawings or mentioned in Specifications but which is needed to complete the work as an operating installation.

10.2 Field, Fabrication, and Installation Drawings

- .1 Prepare field, fabrication, and/or installation drawings to show location of equipment and relative position of services, and to demonstrate coordination with the work of other trades;
 - .1 drawing scale: minimum 1:50 (1/4"=1'-0")
 - .2 use information from manufacturer's shop drawings for each trade and figured dimensions from latest Architectural and Structural Drawings,
 - .3 layout equipment and services to provide access for repair and maintenance,
- .2 Circulate drawings to other trades involved in each area, and conduct coordination meetings with those trades.

11 ANCHORS AND INSERTS

- .1 Supply anchor bolts and locating templates for installation in advance of concrete pouring.

12 CUTTING, PATCHING AND REMEDIAL WORK

12.1 General

- .1 Assume responsibility for prompt installation of work in advance of concrete pouring, masonry, roofing, finishing trades and similar work. Should any cutting or repairing of either unfinished or finished work be required because such installation was not done, employ the particular trade whose work is involved to do such cutting and patching and pay for any resulting costs.
- .2 Neatly cut or drill holes required in existing building elements to accommodate building services including ductwork, piping, cable, raceways, bus duct or cable tray.
- .3 Arrange and pay for all cutting and patching as required for the Work. Before cutting, drilling, or sleeving structural load bearing elements, obtain the Consultant's approval of location and methods in writing. Employ original installer or expert in the finishing of material required to perform cutting or patching for weather-exposed, moisture-resistant elements or sight-exposed surfaces.

12.2 Structure Scanning and Cutting

- .1 Layout cutting of structural elements, such as floors slabs, walls, columns or beams and obtain approval before starting work. Conduct an initial electromagnetic scan of reinforcing rods and electrical conduit, and review with structural engineering Consultant.

Standard of Acceptance

- Hilti - fig. PS 300 Ferrosan

- .1 Based on the preceding results, arrange and pay for supplemental radiographic examination where necessary to improve on locating concrete reinforcement, conduits and other embedment's.
 - .1 submit radiographic results to the structural engineer and obtain comments before starting work,

- .2 the use of radiographic imaging methods is subject to approval by the Owner on a case by case basis.
- .2 As an alternative to radiographic examination for areas where the Owner does not permit radiographic examination, based on the preceding results, provide two-dimensional ground penetrating radar scans to locate concrete reinforcement, conduits and other embedment's. Scanners to be operated by personnel trained by the measurement device manufacturer.

Standard of Acceptance

- ° Hilti PS1000 X-SCAN
- .3 Relocate core drilling location if steel or conduit is found in the proposed location and repeat procedure. Reroute any circuits damaged by core drilling.
- .4 Scan for all shots and anchors in floors, walls, and ceilings.

13 PROTECTION OF PERSONNEL, WORK, AND PROPERTY

13.1 Personnel Protection

- .1 Without limiting the Contractor's responsibilities regarding occupational health and safety requirements at the construction site, provide specific personnel protection as follows:
 - .1 protect exposed live equipment during construction for personnel safety,
 - .2 shield and mark live parts "LIVE 120 VOLTS", or with appropriate voltage,
 - .3 arrange for installation of temporary doors for rooms containing electrical distribution equipment. Keep these doors locked except when under direct supervision of electrician,
 - .4 do not leave conduit, wires, cables, tools, equipment or materials in such a way that they constitute a hazard,
 - .5 provide toe guards around openings in the roof or floor to prevent materials or debris from dropping down to a lower level,
 - .6 remove loose equipment and tools from overhead areas before leaving each day,
 - .7 cut off bolts at floor level to eliminate a possible tripping hazard.

13.2 Protection During Construction

- .1 Provide protection required to enable existing building and equipment to remain in continuous and normal operation.
- .2 Take the necessary precautions to protect equipment, existing building and service from damage during the Work. Accept responsibility for any damage and make good without cost to the Owner.
- .3 Protect existing surfaces and items so that they are not damaged in any way whatsoever by the work of all trades. Take precautions as necessary to prevent damage to walls, floors, ceilings, windows, doors, door frames, moldings, finishes, piping, ductwork, light fixtures, etc. Provide protection, hoarding, tarpaulins, dust sleeves etc., as required. Any damage caused because of lack of adequate protection to be made good at no cost to the Owner.
- .4 Take care when working above or around equipment that must remain in service.
- .5 Take care to eliminate dust in equipment areas.
- .6 Protect switchgear fronts from accidental breaker trips when working around or above them. Provide an extended shield constructed of 12 mm (½") fire retardant plywood a minimum of 450 mm (18") from board front to allow access to board.

13.3 Core Drilling

- .1 Wherever core drilling is required, provide temporary dust proof screens.
- .2 In areas where core drilling through a slab in an operating facility is necessary, clearly mark out the areas to be drilled on the underside of slab. Owner's representative to be notified at least 1 week prior to core drilling operation. Provide tarping of equipment supervised by the Owner.
- .3 During core drilling operations, station at least one person directly below the area of drilling with a large plastic container pressed to underside of slab to capture and hold core and water upon completion of operations.
- .4 Continuously use a wet/dry commercial quality vacuum at location of drilling operation to remove all excess water from the area.

13.4 Temporary Dust Proof Screens

13.5 Provide temporary dust proof screens in accordance with Division 01. Protection of Floors During Equipment Installation

- .1 Provide protection of floor finishes during installation or removal of equipment, and at any other time when moving or installing heavy equipment.
- .2 Install 19mm (¾") plywood over 6 mil plastic over finished floor areas when moving heavy equipment that could damage floor finish, or when installing equipment or line materials overhead.
- .3 Repaint or re-tile any floors or walls damaged or scratched during construction.

13.6 Housekeeping

- .1 Maintain a high level of cleanliness.
- .2 Remove scrap and refuse from the work area daily.
- .3 Whenever possible, clean up immediately following completion of work.
- .4 Deposit oily and waste solvent rags in approved containers to minimize the fire hazard.
- .5 Sweep and damp mop daily.

14 WORK IN EXISTING BUILDING

14.1 General

- .1 Comply with Specification section of Division 01 for restrictions on working in existing occupied buildings and as follows.
- .2 During the tender period, the Contractor shall perform a site inspection of the place of work and surroundings including the accessible ceiling spaces and other areas where access could be considered reasonable. Make a thorough investigation of as-built conditions to determine scope of renovation or demolition work required prior to submitting tender.
- .3 The Work includes changes to existing building and changes at junction of old and new construction. Route pipes, ducts, conduits and other services to avoid interference with existing installation.
- .4 Perform core drilling at a time coordinated with the Owner.

- .5 Relocate existing pipes, ducts, conduits, bus ducts and any other equipment or services required for proper installation of new work, including as required for temporary removal and re-installation to suit new installation work.
- .6 Remove existing plumbing fixtures, lighting fixtures, piping, ductwork, wiring, and equipment to suit new construction. Cut back and cap drain, vent and water outlets, conduits and electrical outlets, not being used.
- .7 Unless noted otherwise removed materials and equipment become the property of the Contractor and are to be taken from the site and disposed of appropriately.
- .8 On completion of relocations, confirm relocated equipment are in proper working order.
- .9 Where Owner wishes to take over renovated areas ahead of project completion date and these areas are to be fed from new distribution systems, make temporary connections to existing services in these areas. Reconnect to permanent services, at later date, when new distribution systems are available.

14.2 Continuity of Services

- .1 Keep existing buildings in operation with minimum length of shutdown periods.
- .2 Make connections to existing systems at approved times.
- .3 Obtain written approval recording times when connections can be made.
- .4 Arrange work so that physical access to existing buildings is not unduly interrupted.
- .5 Be responsible for and make good any damages caused to existing systems when making connections.
- .6 Provide premium time labour to tie-in to services at night or on weekends.
- .7 For piping systems, make connections to existing piping by draining down the existing piping system. Use of hot-tapping or freezing of piping is only permitted where approved by the Owner and a specification section for such work has been included in the project specifications.
- .8 Provide temporary services to drain down existing piping systems which convey liquids or steam condensate, including provision of temporary hoses, etc., and provide services to perform the drain down of these systems, except where the Owner elects to perform such drain-downs.
- .9 For piping systems conveying liquids, after completion of new work to existing piping systems, refill the existing and new piping systems including provision of cleaning of new piping and addition of chemical treatments, as applicable, in accordance with the requirements of other sections of Division 20. Include for addition of replenishing chemical treatment for existing piping systems in accordance with the Owner's existing chemical treatment program, or in the absence of such, in accordance with the chemical water treatment requirements specified in other Sections of Division 20.

15 MOVING AND SETTING IN PLACE OF OWNER-SUPPLIED PRODUCTS

15.1 General

- .1 The requirements of this Part applies to;
 - .1 Division 20 equipment that has been directly purchased by the Owner, and
 - .2 other Owner-supplied products or equipment (i.e. process equipment) that has building services requirements.
- .2 Comply with the requirements of Division 01 and as specified herein.

15.2 Owner-Supplied Products (Supplied by Owner Equipment – “SBO”)

- .1 Items marked SBO on drawings are to be;
 - .1 purchased by the Owner,

- .2 received, checked, and stored by the Contractor, and
 - .3 subsequently unpacked, uncrated, assembled and located in its final location by the Contractor, and installed in accordance with the manufacturer instructions,
 - .4 participate in the start-up and testing of the equipment and placing into service.
- .2 Provide mechanical and electrical services to SBO equipment in accordance with the SBO equipment manufacturer's instructions and as otherwise shown.

15.3 Existing Owners Equipment to be Relocated (E.R. or Ex. Rel.)

- .1 Applies to owners existing equipment which has mechanical and electrical services, and marked on the drawings as E.R. Ex.Rel. or otherwise so identified.
- .2 Items so marked on drawings are to be moved from their present location and reinstalled by the Contractor.
- .3 Disconnect and reconnect mechanical and electrical services to accommodate this equipment relocation.

16 TEMPORARY HEATING

16.1 During Construction

- .1 Temporary heating required while building is under construction will be provided under Division 01.
- .2 Permanent heating system may be used for temporary heating, when this equipment is installed in its permanent location and the building is closed-in and Contractor under Division 1 provides staff for operation and maintenance whenever permanent heating system is being used for temporary heating.
- .3 Hot water boilers may not be used unless heating units, radiation, pumps and piping are complete, the piping system has been pressure tested, cleaned, and final chemical water treatment is in operation.
- .4 Permanent heating equipment used for temporary heating to be thoroughly cleaned and put in first class operating condition and appearance at completion of the Work, as approved by the Owner.

17 FINAL CLEANING AND ADJUSTMENTS

17.1 Final Cleaning

- .1 Conduct final cleaning in accordance with Division [01 74 00] requirements and as specified herein.
- .2 Perform final cleaning after construction activities that create dust have been completed.
- .3 Thoroughly clean exterior surface of exposed piping, and vacuum external surfaces of exposed ducts and interior surfaces of air handling units. Clean strainers in piping systems and install clean filters in air handling systems immediately prior to handover of the building to the Owner.
- .4 HEPA vacuum the top and interiors of motor controllers, VFDs, control panels, and control cabinets followed by a thorough HEPA vacuuming of the service room floors. Thoroughly wash floors with wet mop and clean water. Control access to the room after cleaning. Provide temporary filter media on air supply ducts to these rooms to prevent re-contamination from other areas of construction.
- .5 Remove tools and waste materials on completion of work and leave work in clean and perfect condition.

17.2 Final Adjustments

- .1 Calibrate components and controls and check function and sequencing of systems under operating conditions.

- .2 Supply lubricating oils and greases for proper operation of equipment and systems until work has been accepted.

18 RECORD DRAWINGS

18.1 Record Drawings

- .1 Maintain record drawings in accordance with Division 01 during the course of the Work and as follows.
- .2 A set of design drawings in AutoCad, Revit, or PDF format (as determined by the Consultant) will be provided by the Consultant. Record changes in actual installation as the Work progresses by the following method:
 - .1 make sets of white prints for each phase of Work and mark-up the print drawings, or
 - .2 revise the AutoCad or Revit file directly, and identify all changes made.
- .3 Mark-up these record drawings to provide dimensioned locations of drains, pipes, ductwork, conduit, manholes, foundations and similar buried items within the building, with respect to building column centres. Mark level with respect to an elevation which will be provided.
- .4 Retain on-site the survey information from excavation and backfill of site services, and after approval, transfer this information to the record documents.
- .5 Retain these drawings and make available to Consultant for periodic review.
- .6 At 50%, 75% and 90% project completion, scan marked-up drawings to PDF format and submit copy to the Consultant, or to the project on-line document management service if one is used.

18.2 As-Built Drawings

- .1 Prior to testing, balancing and adjusting, transfer site record drawing information to a copy of the computer aided drafting/design program ("CAD") files, in the same software format used for the Consultants design drawings, to record final as-built condition.
- .2 Obtain a current set of CAD files from the Consultant. The Consultant's CAD files may not reflect all or any construction changes.
- .3 Drawings are to remain set to and follow Consultants CAD Standards - do not alter drawing scales, reference files, colours, layers or text styles,
- .4 Where items have been deleted, moved, renumbered or otherwise changed from contract drawings, revise the CAD files to record these changes. "Bubble" these revisions, and place these annotations on a separate and easily identified drawing layer.
- .5 Show on mechanical as-built drawings final location of piping, ductwork, switches, starters, Motor Control Centres, thermostats, and equipment.
- .6 Show on site services as-built drawings survey information provided by an accredited land surveying service.
- .7 Identify each drawing in lower right hand corner in letters at least 12 mm (½ in) high with a note as follows:

AS-BUILT DRAWINGS.
This drawing has been revised to
show systems as installed
(Signature of Contractor) (Date).

- .8 The site services drawings are to include the signature and stamp of the accredited surveyor adjacent to the note.
- .9 Submit one (1) set of white prints of the draft as-built CAD files for Consultant's review.

- .10 Once "AS BUILT DRAWINGS" white prints are reviewed, transfer Consultant's comments to the CAD files. Return CAD files modified to "As Built" condition to Consultants electronically by removable mass storage device or by electronic file transfer as designed by the Consultant.
- .11 Submit three (3) sets of white prints and one (1) electronic copy of CAD files with Operating and Maintenance Manuals to the Owner.

19 OPERATING AND MAINTENANCE INSTRUCTIONS

19.1 Operating and Maintenance Manuals

- .1 Provide operating and maintenance manuals in accordance with Section [01 78 00 *Closeout Submittals*] and as follows.
- .2 Provide operation and maintenance data bound in vinyl covered, hard back, three-ring covers, nominally 50 mm (2 in) thick, suitable for paper size of 210 mm x 300 mm (8½ in x 11 in);
 - .1 organize material in volumes, generally grouped by Trade section;
 - (a) Table of Contents,
 - (b) General Information,
 - (c) Sub-contractors (list),
 - (d) Site services,
 - (e) Fire Protection,
 - (f) Plumbing,
 - (g) Heating and Cooling Plant and Distribution,
 - (h) Air Handling Equipment and Distribution,
 - (i) Building automation, Controls and Instrumentation,
 - (j) Testing Reports,
 - (k) As-Built Drawings,
 - (l) Warranties.
 - .2 Title sheet in each volume to be labeled "Operating and Maintenance Manual" and to bear;
 - (a) Project Name,
 - (b) Project Number,
 - (c) Date,
 - (d) Trade Section,
 - (e) List of Contents.
 - .3 Provide three hard-copies to Owner.
- .3 In addition, provide PDF files for each document, produced from original direct-to-digital file creations;
 - .1 organize documents into separate PDF files for each Trade Section identified above, and apply PDF Bookmarks to create a Table of Contents for each file.
- .4 Operating data to include;
 - .1 control schematics for each system,
 - .2 description of each system and associated control elements,
 - .3 control operating sequences at various load conditions, reset schedules and anticipated seasonal variances,
 - .4 operating instructions for each system and each component,

- .5 description of actions to be taken in event of equipment failure,
- .6 valve schedules and flow diagrams,
- .7 service piping identification charts.
- .5 Maintenance data to include;
 - .1 manufacturer's literature covering servicing, maintenance, operating and trouble-shooting instructions for each item of equipment,
 - .2 fault locating guide,
 - .3 manufacturer's parts list,
 - .4 reviewed shop drawings,
 - .5 equipment manufacturer's performance sheets,
 - .6 equipment performance verification test results,
 - .7 voltage and ampere rating for each item of electrical equipment,
 - .8 spare parts list and an itemized cost,
 - .9 name and telephone numbers of service organization and technical staff that will provide warranty service on the various items of equipment.
- .6 Approval procedure;
 - .1 submit one set of first draft of Operating and Maintenance Manuals for approval at least one month prior to planned substantial performance date,
 - .2 make corrections and resubmit for a final review,
 - .3 review contents of Operating and Maintenance Manuals with Owner's operating staff or representative to ensure thorough understanding of each item of equipment and its operation.
 - .4 hand-over two (2) hard-copies and one (1) PDF copy on removable storage device of the Operating and Maintenance Manuals to the Owner's operating staff and obtain written confirmation of delivery. Provide a copy of the delivery record to the Consultant.

19.2 Operating and Maintenance Training

- .1 Provide operating and maintenance training in accordance with Division 01 and as follows.
- .2 Provide training to Owners operations staff to thoroughly explain operation and maintenance of each system, incorporating specialized instruction by manufacturers as described under other Sections in these Divisions. Include classroom instruction and hands-on instruction, delivered by competent instructors.
- .3 Develop the proposed training plan, and submit an outline of the training program for review, adjustment and approval by the Owner.
- .4 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, utilizing the services of the manufacturers' representative as required.
- .5 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each training topic, separated by approximately one week each. Develop the proposed training plan and obtain approval from the Owner before commencing training.
- .6 All training to be scheduled and provided between the hours of 7 am to 5 pm, Monday to Friday. Where training is required to be performed outside of these hours due to availability of Owners operations personnel, if the trainers are paid for overtime outside of these hours, the overtime portion only is eligible to be paid by the Owner as an extra cost.

- .7 Complete the training as close to Substantial Performance as possible, so that the operations staff are prepared to operate the systems after Substantial Performance is certified.
- .8 Organize each training sessions as follows:
 - .1 HVAC – Division 23
 - .2 Building Management System – Division 25
- .9 Keep records of date and duration of each instruction period together with names of persons attending. Submit signed records at completion of instruction.
- .10 For each training session, include the following topics;
 - .1 general purpose of system (design intent),
 - .2 use of O&M manuals,
 - .3 review of control drawings and schematics,
 - .4 start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, control set-up and programming troubleshooting, and alarms,
 - .5 interaction with other systems,
 - .6 adjustments and optimizing methods for energy conservation,
 - .7 health and safety issues,
 - .8 special maintenance and replacement sources,
 - .9 occupancy interaction issues, and
 - .10 system response to different operating conditions.
- .11 Develop and provide training material, including printed documents and electronic presentation aids (e.g. MS PowerPoint) for each session. Submit three (3) copies of materials in both hardcopy and PDF format, in accordance with article on Operating and Maintenance Manuals.
- .12 Sessions may be video recorded by the Owner as an aid to ongoing training of Owners staff.

20 CARE, OPERATION AND START-UP

- .1 Provide all labour and materials as necessary to perform start-up and testing of equipment and systems.
- .2 Arrange and pay for services of manufacturer's factory service technician to supervise start-up of the installation, check, adjust, balance and calibrate components and equipment as specified in the specification sections of Division 20.
- .3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with every aspect of the operation, care and maintenance thereof.
- .4 Arrange and pay for services of applicable manufacturer's factory service engineer or certified independent testing organization to supervise initial start-up of specialized portions of installation and to check, adjust, balance and calibrate components including related wiring and controls. Provide these services for such periods, and for as many visits as may be necessary to put applicable portion of the installation in complete working order. Provide a certificate indicating that the equipment is free and clear of deficiencies.

21 TESTING

21.1 General

- .1 The following describes the general requirements for testing of mechanical systems; refer to additional testing requirements in applicable sections of Division 20 of the Work.
- .2 Conduct tests during progress of Work and at its completion to verify equipment and systems meet the contract documents. Submit details of test methods in writing and obtain approval before commencing work.
- .3 Supply test equipment, apparatus, gauges, meters and data recorders, together with skilled personnel to perform tests and log results.
- .4 Submit written notice 24 hours in advance of each test series, setting out the time, place and nature of the tests, to the Inspection Authority and personnel witnessing tests.
- .5 The Owner reserves the right to witness any test; any such witnessing activity shall not be construed as acceptance of the system or equipment by the Owner.
- .6 Conduct tests before application of external insulation and before any portion of pipes, ducts or equipment is concealed.
- .7 Do not subject expansion joints, flexible pipe connections, meters, control valves, convertors, and fixtures, to test pressures greater than the stated working pressure of equipment. Isolate or remove equipment or devices during tests when prescribed test pressure is greater than working pressure of any piece of equipment or device.
- .8 Should section of pipe, duct, or electrical cable fail under test, replace faulty piping, duct, or cable with new fittings, pipe, duct or cable and then retest. Do not repair threaded pipe joints by caulking nor welded joints by peening. Repeat tests until results are satisfactory.
- .9 Where it is necessary to test portions of piping, ductwork or electrical cable system before system is complete, overlap successive tests so that no joint or section of duct or pipe is missed in testing.
- .10 Upon completion of work and testing of same, submit logs to demonstrate that tests have been carried out satisfactorily. Repeat any tests if requested.

21.2 Testing of Integrated Life Safety and Fire Protections Systems

- .1 Conduct testing of integrated life safety and fire protection systems in accordance with specification Section 20 08 11 *Testing of Integrated Electrical Life Safety and Fire Protection Systems*.

21.3 Testing - Piping

- .1 Test fuel oil systems in accordance with CSA B139 *Installation Code for Oil Burning Equipment*.
- .2 Test drainage, waste and vent piping for tightness and grade as required by the plumbing code in effect at the location of the Work.
- .3 Test special service piping as detailed in other sections of Divisions 21, 22 and 23.

21.4 Testing - Electrical

- .1 Make tests of equipment and wiring. Test wiring systems in accordance with section 20 05 12 *Wiring Requirements for Mechanical*.
- .2 Replace defective equipment and wiring with new material.

22 COMMISSIONING

- .1 Participate in commissioning of equipment and systems in accordance with Section 20 08 15 *Mechanical Commissioning*.

- .2 Equipment supplied on this project will be subject to detailed factory inspection and/or on-site testing and commissioning prior to being placed in service. The electrical contractor, their major system and equipment suppliers, and the Independent Testing Agent (ITA) will be required to participate in special commissioning meetings to review progress and status of the commissioning program.
- .3 Include in Bid amount for licensed electricians to participate in the commissioning program, to undertake temporary power connections, operation of equipment, opening and closing of panel boards and switchboards, testing of power and control wiring, and assisting the ITA and the equipment suppliers' field personnel in the startup and testing of the equipment.
- .4 The contractor and equipment suppliers to include in the Bid amount the costs to accommodate and undertake factory and site testing.

23 TEMPORARY AND TRIAL USAGE

- .1 Temporary and trial usage by Owner of any mechanical or electrical device, machinery, apparatus, equipment or any other work or materials before final completion and written acceptance is not to be construed as evidence of acceptance by Owner.
- .2 Owner to have privilege of such temporary and trial usage, as soon as that said work is claimed to be completed and in accordance with Contract Documents, for such reasonable length of time as is sufficient for making complete and thorough test of same.
- .3 No claims will be considered for damage to or failure of any parts of such work so used which may be discovered during temporary and trial usage, whether caused by weakness or inaccuracy of structural parts or by defective materials or workmanship of any kind whatsoever.
- .4 Defects in workmanship and materials identified during temporary and trial usage are to be rectified under warranty.

24 SPECIAL TOOLS AND SPARE PARTS

24.1 Spare Parts

- .1 Prior to application for Substantial Performance, furnish spare parts as follows;
 - .1 one set of mechanical seals for one pump of each model size,
 - .2 one pump casing joint gasket for each model size,
 - .3 one head gasket for each shell-and-tube heat exchanger with removable heads,
 - .4 one glass for each gauge glass,
 - .5 one set of V-belts for each drive of the same model size,
 - .6 one set of filter cartridges for each filter or filter bank installed.
- .2 Maintain an inventory record and delivery receipt record of spare parts delivered to the Owner, and include them in the Operating and Maintenance manuals.

25 CONSULTANT REVIEWS

25.1 General

- .1 Consultant's attendance at site including but not limited to site meetings, demonstrations, site reviews and any resulting reports are for the sole benefit of the Owner and as required by the local authority have jurisdiction. It is the Contractor's responsibility to ensure that the Work is complete and constructed in accordance with the design documents.

25.2 Site Reviews

- .1 General reviews and progress reviews do not record deficiencies during the course of the Work until such time as a portion or all of the work is declared complete. In some instances, before the work is completed, readily noticeable deficiencies may be recorded by the Consultant where the deficient item is indicative of issues such as poor workmanship, incorrect materials or installation methods, or may be difficult to correct at a later date. Any such reported items, or lack thereof, shall not be relied on in any way as part of the Contractors quality assurance program nor relieve the Contractor in the performance of the Work, specifically in identification and rectification of deficiencies or incomplete Work.
- .2 Deficiency reviews conducted by the Consultant are performed on a sampling basis, and any deficiency item is to be interpreted as being indicative of similar locations elsewhere in the Work, unless otherwise shown.

25.3 Milestone Reviews

- .1 Specific milestone reviews may be conducted at key stages by the Consultant, including;
 - .1 before backfilling of buried drainage,
 - .2 before closing of shafts,
 - .3 before closing of ceilings,
 - .4 before closing of walls,
 - .5 equipment demonstration,
 - .6 Substantial Performance deficiency review,
 - .7 Total Performance deficiency review.
- .2 Coordinate with the Consultant the type and quantity of milestone reviews required by the Consultant and incorporate these requirements in the construction schedule.
- .3 Notify the Consultant in writing seven (7) calendar days in advance of work to be concealed to arrange a site review prior to the Work being concealed where required by the Consultant. Any noted deficiencies are to be corrected before being concealed. Failure to provide notification can result in the Work being exposed for review at the Contractor's cost.

25.4 Partial Occupancy Reviews

- .1 Where the Work is planned to include occupancy by the Owner of a part of the Work but not the entire Work ("partial occupancy"), the procedures specified for Substantial Performance Review will apply to the portion of the Work being considered for partial occupancy.

25.5 Substantial Performance Review

- .1 At the time of applying for project Substantial Performance, submit to Consultant a comprehensive list of items to be completed or corrected.

25.6 Final Review

- .1 At project completion submit written request for final review of mechanical and electrical systems. Refer to section 20 08 19 *Project Close-Out*.
- .2 Include with the request a written certification that:
 - .1 reported deficiencies have been completed,
 - .2 systems have been balanced and tested and are ready for operation,
 - .3 completed maintenance and operating data have been submitted and approved,

- .4 equipment/line material tags are in place and equipment identification is completed,
- .5 cleaning is finished in every respect,
- .6 all mechanical equipment surfaces have been touched up with matching paint, or re-finished as required,
- .7 spare parts and replacement parts specified have been provided and receipt acknowledged,
- .8 As-built and Record drawings are completed and approved,
- .9 Owner's operating personnel have been instructed in operation and maintenance of systems,
- .10 fire protection verification is 100% completed and Verification Certificates have been submitted and accepted.

26 CONTRACTOR INSPECTIONS

26.1 General

- .1 The Division 20 contractor shall assign one person responsible for ensuring that Work from all mechanical trades is complete prior to;
 - .1 closing in wall, ceilings or burying of services,
 - .2 partial-occupancy reviews, and
 - .3 substantial performance reviews.
- .2 In conjunction with the Contractor's Mechanical and Electrical sub-contractors, the Contractor shall walk the site and thoroughly inspect that the work is complete, in good workmanship and installed according to the contract documents and derived documents therefrom. The Contractor shall then submit a report attesting to the completed state of the Work (the "Statement of Completion" report, as detailed later in this part).
- .3 In the case of Contractor inspections for partial-occupancy or substantial performance, submit the Statement of Completion report at least 24 hours prior to the scheduled review by the Consultant.

26.2 Contractor Inspections for Partial Occupancy and Substantial Performance

- .1 In preparation for the Consultants general review for partial-occupancy and/or substantial performance of the Work, the Contractor shall perform a comprehensive inspection of the Work to ensure that their contractual obligations are met before requesting a Consultant's review of the Work. In performing this inspection, the Contractor shall create a Statement of Completion report which is to include;
 - .1 date and time of the Contractor's inspection, signed by the person who conducted the inspection,
 - .2 names of the mechanical contractor's personnel who participated in the inspection,
 - .3 confirmation that previously noted deficiencies have been completed,
 - .4 confirmation that the work is 100% complete, tested, balanced and free of deficiencies, or include a list of outstanding deficiencies and incomplete Work with;
 - (a) a reason why the Work has not been completed (i.e. another trade has to complete their work)
 - (b) a plan of action to complete the Work, and
 - (c) a commitment date for completion of the Work including rectification of all deficiencies.
- .2 The format of the Statement of Completion shall be approved by the Consultant.
- .3 The Consultant shall review and sign-off the Statement of Completion Report and return a copy to the Contractor. The Contractor shall retain on-site a log of all signed off Statement of Completion reports.

- .4 If a required Statement of Completion report is not received, the Consultant reserves the right to withhold conducting a review for partial-occupancy or substantial performance.
- .5 After receipt of the Contractor's Statement of Completion report, if upon entering an area of the work covered by the Statement of Completion report the Consultant determines, in its sole opinion, that the applicable Work is not ready for review, the Consultant may elect to cancel the review of the Work or the affected portion of the Work, and shall assume no responsibility for any damages or losses as a result of cancellation of the review. The Contractor shall remedy the incomplete work and request another review with 72 hours prior written notice, and shall resubmit the revised Statement of Completion at least 24 hours prior to the new review.

27 CORRECTION AFTER COMPLETION

- .1 At completion, submit a written warranty undertaking to remedy defects in work for a period of one year from date of substantial performance of the Work. This warranty is not to supplant other warranties of longer period called for on certain equipment or materials.
- .2 Warranties are to encompass replacement of defective parts, materials or equipment, and to include incidental fluids, gaskets, lubricants, supplies, and labour for removal and reinstallation of the corrected Work.
- .3 Submit similar warranties for one year from date of acceptance for any part of work accepted by Owner, before completion of the whole Work.

28 ATTACHMENTS

28.1 Schedule of Values Form

- .1 Attached sample of the Schedule of Values form layout.

28.2 Shop Drawing Submittal Form

- .1 Attached sample of shop drawings submittal form.

SCHEDULE OF VALUES

Project Name: <<name of project>>
Owner Name: <<owner name>>
Contractor Name: <<name of trade contractor: mechanical, electrical, etc>>
Division(s) of the Work: <<i.e. 20, 21, 22...>>
For the billing period ending: dd-mmm-yyy

This sheet is an example of a required schedule of values to be developed by the Contractor, to be submitted with each progress payment request.
Specific level of detail for each work element to be approved by the Consultant.

Item	Base Contract Element	Contract Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$	%	\$	%	\$	%	\$	%	\$	%
1.1	<<work element>>	1,000,000.00	65.9%	400,000.00	40.0%	225,000.00	22.5%	175,000.00	17.5%	600,000.00	60.0%
1.2	<<work element>>	250,000.00	16.5%	30,000.00	12.0%	5,000.00	2.0%	25,000.00	10.0%	220,000.00	88.0%
1.3	<<work element>>	125,000.00	8.2%	50,000.00	40.0%	22,000.00	17.6%	28,000.00	22.4%	75,000.00	60.0%
X.X	Itemized Price No. 1	25,000.00	1.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%	25,000.00	100.0%
X.X	Separate Price No. 1	12,500.00	0.8%	5,000.00	40.0%	0.00	0.0%	5,000.00	40.0%	7,500.00	60.0%
CCA.1	Cash Allowance Disbursements Summary	75,000.00	4.9%	34,000.00	0.0%	8,000.00	0.0%	26,000.00	0.0%	41,000.00	0.0%
X.X	Coordination drawings	15,000.00	1.0%								
X.X	As-built documents and operating manuals	15,000.00	1.0%								
Original Contract Values		1,517,500.00	100.0%	519,000.00	34.2%	260,000.00	17.1%	259,000.00	17.1%	968,500.00	63.8%
CO.1	Approved Changes Summary	13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%
Total Current Contract Values		1,530,900.00		524,200.00	34.2%	262,000.00	17.1%	262,200.00	17.1%	976,700.00	63.8%

Reference	Cash Allowance Disbursement	CA Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$		\$	%	\$	%	\$	%	\$	%
CAA_1	<<description of cash allowance>>	20,000.00		20,000.00	100.0%	8,000.00	40.0%	12,000.00	60.0%	0.00	0.0%
CAA_2	<<description of cash allowance>>	55,000.00		14,000.00	25.5%	-	0.0%	14,000.00	25.5%	41,000.00	74.5%
					0.0%		0.0%	0.00	0.0%	0.00	0.0%
Total		75,000.00		34,000.00	45.3%	8,000.00	10.7%	26,000.00	34.7%	41,000.00	54.7%

Reference	Approved Changes	Change Value		Complete to Date		Previously Billed		This Billing		Balance to Complete	
		\$		\$	%	\$	%	\$	%	\$	%
CO_01	<<description of change of work>>	5,800.00		-	0.0%	-	0.0%	0.00	0.0%	5,800.00	100.0%
CD-01	<<description of change of work>>	7,600.00		5,200.00	68.4%	2,000.00	26.3%	3,200.00	42.1%	2,400.00	31.6%
					0.0%		0.0%	0.00	0.0%	0.00	0.0%
Total		13,400.00		5,200.00	38.8%	2,000.00	14.9%	3,200.00	23.9%	8,200.00	61.2%

Reference	Unquoted/Unapproved Changes	Status	Quotation	
			\$	
CCN-01	<<description of change of work>>	Waiting for approval	12,000.00	
CCN-02	<<description of change of work>>	Unquoted		
Total			12,000.00	



Toronto Montreal Vancouver Dallas Chicago

SHOP DRAWING SUBMITTAL

***Include this cover page with each shop drawing submission.
Submissions without this form will be returned without review.
Submit one submittal form per shop drawing; do not group under one submittal sheet***

Client/Architect: Click or tap here to enter text.

Project Name: Click or tap here to enter text.

HHA Project No: Click or tap here to enter text.

Contractor to complete the following for each submission.

Date: _____

Contractor Name: _____ Ref. No: _____

Manufacturer Name: _____

Product Type/Description: _____

Specification section number: _____

Contractor Trade Category:

☐ Architectural	☐ Structural	☐ Conveying Equipment	☐ User Equipment
☐ Mechanical	☐ Electrical	☐ Telecommunications	☐ Civil
☐ Other			

If this is a resubmission, check here: ☐

Previous submission HHA reference no.: _____

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END OF SECTION

QUALIFICATIONS AND AUTHORITIES - ONTARIO

20 01 02

1 GENERAL

1.1 Scope

- .1 This specification section:
 - .1 describes the qualification requirements for tradesmen in the province of Ontario;
 - .2 defines the applicable authorities having jurisdiction related to construction in Ontario; and
 - .3 describes the responsibilities of the contractor and/or Owner for registration and inspection of systems and application for construction or installation permits.

1.2 Definitions

- .1 **TSSA:** Technical Standards and Safety Authority
- .2 **ESA:** Electrical Safety Authority

2 QUALIFICATIONS

2.1 Trades Qualification and Apprenticeship

- .1 Tradesmen to hold a a certificate of qualification or be an apprentice in accordance with the *Building Opportunities in the Skilled Trade Act*, 2021, S.O. 2021, c. 28, including but not limited to the following prescribed trades in accordance with the *Prescribed Trades and Related Matters* regulation O.Reg. 876/21:
 - .1 Construction Millwright,
 - .2 Electrician – construction and maintenance,
 - .3 Fuel and electrical systems technician,
 - .4 Heat and frost insulator,
 - .5 Information technology – hardware technician,
 - .6 Information technology – network technician,
 - .7 Network cabling specialist,
 - .8 Instrumentation and control technician,
 - .9 Plumber,
 - .10 Refrigeration and air-conditioning systems mechanic,
 - .11 Sheet metal worker,
 - .12 Sprinkler and fire protection installer,
 - .13 Steamfitter,

2.2 Work-Specific Qualification Licenses

- .1 Fabricators and installers of pressure piping and equipment which are subject to O.Reg. 220/01 *Boilers and Pressure Vessels* regulation shall hold the required license for performing such work, unless otherwise exempt by the regulation.
- .2 Contractors performing work on liquid or gaseous fuel piping systems and related equipment shall hold certificates of authorization made under O.Reg. 215/01 *Fuel Industry Certificates* to perform work within the scope of the following regulations;;

- .1 Gaseous Fuels, O.Reg. 212/01
- .2 Propane Storage and Handling, O.Reg. 211/01
- .3 Fuel Oil, O.Reg. 213/01
- .4 Compressed Natural Gas, O.Reg. 214/01

3 AUTHOURITIES

3.1 Authorities having Jurisdiction

- .1 When referenced in specification sections in Division 20 to 25, the authority-having-jurisdiction ("AHJ") over regulated portions of the work are identified in the following table.

Work Element	Authority	AHJ Abbreviation
Fire Protection	Municipal Building Department or Fire Department	None
Plumbing	Municipal Building Department	None
HVAC	Municipal Building Department	None
Flammable and Combustible Liquids	Fire Department	None
Liquid fuels (for vehicle refueling)	Technical Standards and Safety Authority	TSSA
Heating Oil and Diesel Fuel	Technical Standards and Safety Authority	TSSA
Propane	Technical Standards and Safety Authority	TSSA
Pressure Piping	Technical Standards and Safety Authority	TSSA
Refrigeration	Technical Standards and Safety Authority	TSSA
Licensed Plant Operators	Technical Standards and Safety Authority	TSSA
Electrical	Electrical Safety Authority	ESA

4 PERMITS, REGISTRATION AND INSPECTION

4.1 Building Code Permits

- .1
- .2 Application for Building Permit including plumbing and HVAC has been made by the Owner. Arrange and coordinate for municipal inspections as required under the Ontario Building Code.

4.2 Other Work Permits, Registration and Inspection

- .1 Arrange, provide documentation, and pay for permits, registration, and inspection of the following work elements:
 - .1 Electrical work performed under Division 20 to 25, and
 - .2 Where described elsewhere in Division 20 to 25.

- .2 Arrange, provide documentation, and pay for variance approvals and field inspections where specified elsewhere in Division 20 to 25.

END OF SECTION

DEFINITIONS AND ABBREVIATIONS - MECHANICAL 20 01 13

1 GENERAL

1.1 Scope

- .1 This specification provides definitions and abbreviations of terms which may apply to one or more specification sections under Division 20, 21, 22, 23 and 25.
- .2 Additional definitions and/or abbreviations may also be included in other specification sections where they apply only to one specification section.

1.2 Definitions

- .1 General definitions:

Authority having Jurisdiction ("AHJ"): the designated government body or regulatory agency responsible for enforcement of applicable statute.

Bronze: a copper alloy with a minimum copper content of 84%.

Building Automation System ("BAS"): the building control systems as specified in Division 25.

Class XXX: a numerical pressure-temperature designation "XXX" in accordance with ANSI/ASME B16 series of standards.

Canadian Registration Number ("CRN"): as defined in accordance with CSA B51.

Certificate of competency: a license, certificate or other document which attests to the qualifications of a construction tradesperson and which is recognized and/or required under prevailing provincial, territorial or federal statutes in the location of the project as an authorization to perform such work.

Cold Working Pressure ("CWP"): the maximum non-shock cold working pressure at temperatures as stated in a MSS valve standard.

Design Criteria: criteria that states the required performance of equipment or a system, and is also the minimum design basis for equipment, systems and contractor's design responsibilities.

Design Pressure: (in reference to a pressure piping system) - the maximum allowable internal pressure in a piping system at the indicated coincident Design Temperature that the piping system may be subjected under normal operating conditions and is the basis for determining the piping system hydrostatic or pneumatic test pressure requirements.

Design Temperature: (in reference to a pressure piping system) – the maximum allowable in-service temperature of the piping system.

Double Regulating Valve ("DRV"): a calibrated manual flow balancing valves with pressure test ports (also referred to as circuit balancing valve),

Dezincification Resistant ("DZR"): a brass copper alloy which by means of its alloy and method of manufacture is certified as being resistant to the process of dezincification.

Flow Limiting Regulating Valve ("FLRV"): an automatic calibrated flow control device which limits the maximum flow to a branch piping network.

Minimum Component Pressure Rating (“MCPR”): the minimum pressure at the indicated coincident temperature at which the component must be capable of withstanding, remain functional and not exceed its maximum allowable stress in accordance with its referenced standard.

National Pipe Taper (“NPT”): a pipe thread in accordance with ANSI/ASME B1.21.1

Operating Pressure: the estimated maximum expected internal operating pressure of a fluid in a pipe or equipment for the purpose of establishing a piping system Design Pressure; actual in-service gauge pressures may be lower. The operating pressure may be specified as a single value, or it may vary by location in the system. “Working pressure” has the same meaning.

Operating Temperature: the estimated maximum normal temperature of the fluid in a piping system

Potable water: has the same meaning as defined in the applicable plumbing code or building code in the jurisdiction of the project. “Domestic water” has the same meaning.

Steam Working Pressure (“SWP”): the maximum steam pressure at the indicated maximum steam temperature or it is the saturated steam pressure if a coincident temperature is not specified.

Service rooms: means a room provided in a building to contain equipment associated with building services, and which includes but is not limited to: boiler rooms; furnace rooms; incinerator rooms; garbage handling rooms; rooms to accommodate HVAC appliances, pumps, compressors and other related equipment; rooms containing electrical distribution equipment; and rooms containing telecommunications and data equipment.

Service space: means space provided in a building to facilitate or conceal the installation of building service facilities such as chutes, ducts, pipes, shafts or wires.

1.3 Abbreviations

AMCA	Air Movement and Control Association International
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineers
ASTM	ASTM International (formerly American Society for Testing and Materials)
CSA	Canadian Standards Association
FM	Factory Mutual Approvals
MCAA	Mechanical Contractors Association of America
MCAC	Mechanical Contractors Association of Canada
MSS	Manufacturers Standardization Society
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association

NFPA	National Fire Protection Association
NSF	NSF International (formerly National Sanitary Foundation)
SMACNA	Sheetmetal and Air Conditioning Contractors' National Association
UL	Underwriters Laboratory (USA)
ULC	Underwriters Laboratory Canada

End of Section

BASIC MATERIALS AND METHODS

20 05 01

1 GENERAL

1.1 Scope

- .1 Articles that are of a general nature, and applicable to each Section of Division 20 to 25.

2 ACCESSIBILITY FOR BUILDING CONTROL DEVICES

- .1 Mount control devices, intended to be adjusted or to otherwise be operated by the occupant for the operation of building services or safety devices, as follows:
 - .1 room environmental controls, including thermostats/adjustable room temperature sensors: at 1200 (47 in) above the finished floor,
 - .2 all other controls: between 900 and 1100 mm (36 in. and 43 in.) above the finished floor.
 - .3 be positioned to have a clear space in front of and centered on the control device, of 810 x 375 mm (32 x 15 in).
 - .4 be operable using a closed fist and with a force not exceeding 22.2 N (5 lbf).
- .2 The above requirements do not apply to control devices that are solely located and used by the building operations staff.

3 ACCESS PANELS / DOORS

3.1 General

- .1 Provide access doors to be installed at locations where equipment requiring inspection, service, maintenance or adjustment is "built-in" to work of other trades.

Standard of Acceptance

- Williams Brothers – fig. GP
- Elmdor/Acorn - fig. DW
- Mifab - fig. UA

3.2 Applicable Product Standards

- .1 CAN/ULC-S104 Standard Method for Fire Testing of Door Assemblies

3.3 Construction:

- .1 Standard access door:
 - .1 1.6 mm (16 ga) carbon steel door and door-frame with white satin coat prime coat finish, with door edges turned back to frame for rigidity,
 - .2 flush mounted with 180° opening door, round safety corners, concealed hinges, plaster lock and anchor straps,
 - .3 latch: screw driver operated,
 - .4 access doors in ceilings, where acoustic tile is applied to plaster or gypsum board, to be dish type designed to receive tile insert.
 - .5 size:
 - (a) 600 mm x 600 mm (24 in x 24 in) for personnel entry,
 - (b) 300 mm x 450 mm (12 in x 18 in) for hand entry,

.2 Variations:

- .1 stainless steel variant:
 - (a) Type 304 stainless steel with No. 4 brush satin finish.
- .2 waterproof variant:
 - (a) Type 304 stainless steel with No. 4 brush satin finish, with neoprene gasketed door.
- .3 security access variant:
 - (a) keyed cylinder, with all cylinders keyed alike,
- .4 fire rated variant:
 - (a) where access door is located in a horizontal or vertical fire separation that has a fire resistance rating of 2 hours or less,
 - (b) insulated door with 50 mm (2 in) fire retardant mineral wool insulation, and 0.95 mm (20 ga.) back liner,
 - (c) heavy duty spring for self-closing door action,
 - (d) rated for installation in masonry walls and fire rated shaft wall construction, or fire rated ceiling construction as applicable to the installation,
 - (e) listed to CAN/ULC-S104 for minimum 1.5 hour closure ratings.
- .5 Submit shop drawings showing access door size, type and location.

3.4 Installation:

- .1 Access doors are required at;
 - .1 expansion joints,
 - .2 dampers,
 - .3 fire dampers,
 - .4 air valves,
 - .5 air terminal units,
 - .6 isolation and control valves ,
 - .7 pressure reducing valves,
 - .8 heating or cooling coils,
 - .9 control wiring junction boxes.
- .2 Supply access doors and make arrangements and pay for installation by Division in whose work they occur.
- .3 Supply access doors with the required variations in accordance with the following table:

Space Type	Wall or Ceiling Finish	Variants		
		Stainless Steel	Water-proof	Key lock
Service rooms, Service corridors,	Drywall	---	---	---

Space Type	Wall or Ceiling Finish	Variants		
		Stainless Steel	Water-proof	Key lock
Public spaces and corridors - more than 2.4 m (8 ft) above the floor, Private spaces, washrooms	Tile or other hard finished surfaces	Yes	---	---
Public spaces and corridors - 2.4 m (8 ft) or less above the floor, Mental health patient areas, Public washrooms	Drywall	---	---	Yes
	Tile or other Hard Surfaces	Yes	---	Yes
Shower rooms, bathtub rooms, Pools, saunas, Kitchens, laundries, Other damp, washdown or high humidity spaces	All	Yes	Yes	Yes

- .4 Provide fire rated variant in addition to the above table variants, as applicable to the wall or ceiling construction.
- .5 Size and locate access doors in applied tile, block or in glazed or unglazed structural tile to suit joint patterns.
- .6 Access doors are not required in removable ceilings. Provide coloured marking devices after completion of ceilings, at four corners of each panel below point requiring access. Colour code markers to show service or device above.
- .7 At time of instruction of owners operating staff, hand-over and obtain signed receipt for 4 sets of each type of key used for access doors with key-lock cylinders.

4 DIELECTRIC FITTINGS

4.1 General

- .1 Provide dielectric fittings for connection between carbon/galvanized steel piping and either copper tube or stainless steel tube/piping in the following pipe systems:
 - .1 Non-Potable Water (NPW) piping systems which do not have any chemical treatment,
 - .2 Domestic hot water systems where galvanized steel pipe is used, including at connections to hot water heating equipment.

4.2 Products

- .1 Dielectric unions – NPS 2 and under:
 - .1 body and union nut material selected to suit connecting piping materials, including carbon steel/copper, carbon steel/stainless steel, and copper/stainless steel,
 - .2 flat-face union design,
 - .3 tail-piece with NFPT ends with thermobaked epoxy coating, and Teflon shoulder gasket,
 - .4 head-piece with integral O-ring, with threaded or sweat pipe ends.

- .5 union nut,
- .6 pressure rating: Class 3000.
- .7 dielectric coating resistance rating: minimum 500 V/mil thickness.

Standard of Acceptance

- Hart Industrial Unions - fig. D-3136 series

.2 Dielectric nipples – NPS 3 and smaller:

- .1 for connecting copper to carbon steel piping,
- .2 fitting body: Zinc-plated carbon steel tube to ASTM A513,
- .3 liner: polypropylene covering entire inner surface of fitting body,
- .4 fitting ends: threaded to ASME B1.20.1.
- .5 design pressure: 2000 kPa (300 psi) at design temperature,
- .6 design temperature: -40 to +110°C (-40 to +230°F)

Standard of Acceptance

- ASC - fig. 7090

.3 Dielectric insulating flanges – NPS 2-1/2 to NPS 4;

- .1 For connecting copper to carbon steel piping.
- .2 Ductile iron flanges, Class 125 to ANSI B16.42.
- .3 Copper tailpiece for soldered joint,
- .4 NFPT thread to AMSE B1.20.1 x copper solder joint,
- .5 BUNA-N gasket,
- .6 lead free materials to NSF 61+G.
- .7 maximum design pressure: 1200 kPa (175 psi)
- .8 maximum operating temperature: 82°C (180°F)

Standard of Acceptance

- Watts No. LF3100

.4 Dielectric insulated flange – single face with copper tube tailpiece – NPS 2-1/2 to NPS 4;

- .1 For connecting copper to carbon steel piping.
- .2 Van Stone style carbon steel flange with copper tailpiece with flared flaired end,
- .3 carbon steel flange, Class 150 to ANSI B16.5, with powder coated finish.
- .4 copper tailpiece with rolled flange face-end, and EPDM insulating gasket isolating the copper tube from the steel flange.

Standard of Acceptance

- CTS Flange Canada - fig. CTS Copper Flange Adaptor

.5 Dielectric Insulating gaskets for flanges NPS 6 and over:

- .1 for use with ASME Class 150 and 300 dimensional flanges.
- .2 suitable for connecting dissimilar piping materials, including carbon steel/copper, carbon steel/stainless steel, and copper/stainless steel,
- .3 compatible with pressure and temperature service,
- .4 BUNA-N or EPDM gasket seals compatible with potable water
- .5 flange bolts run in insulating sleeves with insulating washers under nuts.

Standard of Acceptance

- Advance Products and Systems

4.3 Installation

- .1 Provide dielectric isolation on specified piping systems between pipes of dissimilar metals with suitable insulating dielectric unions, dielectric nipples, insulating flanges, or insulating gaskets between flanges;
 - .1 place dielectric isolation between steel piping and bronze or brass valves,
- .2 Do not use bronze or brass valves as dielectric fittings.

◦

5 DRAIN VALVES

- .1 Provide drain points with drain valves at low points of piping systems and at section isolating valves.
- .2 Drain valves:
 - .1 NPS ¾ drain and valve for service pipes NPS 2-1/2 and smaller, complete with hose end male thread, cap and chain,
 - .2 NPS 2 drain and valve for services pipes NPS 3 and larger, complete with female Camlock coupling and dustcap.
- .3 Where mechanical-compression fittings are used in the piping system, use only threaded fittings for the construction of the drain piping.

6 V-BELT DRIVES

6.1 Products

- .1 Provide V-belt drive for each motor driven device which is not directly connected to the motor. Keep overhung loads on prime mover shafts within manufacturer's design guidelines.
- .2 Sheaves for motors 7.5 kW (10 hp) and less, with not more than two belts:
 - .1 cast iron or steel secured to shafts with removable keys.
 - .2 adjustable pitch on motor, fixed pitch on driven device, giving plus or minus 10% speed range,
 - .3 selected to meet specified operating condition at mid position in pitch adjustment.
- .3 Sheaves for motors greater than 7.5 kW (10 hp) or drives with three or more belts:
 - .1 cast iron or steel with split tapered bushing and keyway.
 - .2 fixed pitch.
- .4 Belts:
 - .1 matched sets of 'B' section, selected for service factor of 2.0 times installed motor horsepower.
 - .2 capable of carrying load with one belt broken.

- .5 Motor slide rails:
 - .1 adjustment plates for centre line alignment
 - .2 belt tension adjusting screws.

6.2 Installation

- .1 Tension belts to manufacturer's recommendations before start-up and after first 100 hr of operation using calibrated belt tensioning gauge.
- .2 Provide replacement pulleys and belts during start-up and balancing to suit field operating conditions.

7 DRIVE AND COUPLING GUARDS

7.1 Products

- .1 Provide guards to protect belt drives, flywheels, rotating couplings on equipment and fan inlet and outlets.
- .2 Guards:
 - .1 removable for servicing,
 - .2 arranged to permit lubrication with guards in place.
- .3 Guards for belt drives:
 - .1 expanded metal screen welded to steel bar stock or angle frame,
 - .2 minimum 1.2 mm (18 ga) thick galvanized sheet metal tops and bottoms,
 - .3 40 mm (1½") diameter holes at both shaft centres for insertion of tachometer.
- .4 Flexible coupling and flywheel guards:
 - .1 Removable "U" shaped, minimum 1.6 mm (16 ga) thick galvanized mild steel or expanded metal mesh on substantial welded angle iron or round barstock frame.
- .5 Guards on unprotected fan inlets and outlets:
 - .1 Minimum 20 mm (¾ in) galvanized wire mesh or expanded metal screen with net free area of guard not less than 80% of fan opening.

7.2 Installation

- .1 Belt guards to accommodate movement of motors for belt tension adjustment.
- .2 Where equipment is installed on resiliently mounted base frame or pad, attach belt guard to this base
- .3 Belt guards and fan inlet guards may be omitted where fan and motor is installed in plenum less than 1.4 m (4 ft) high and disconnect for fan motor is mounted adjacent to and outside access door to plenum.
- .4 Fan inlet guards may be omitted where fan is fitted with inlet guide vanes.

8 SLEEVES

8.1 General

- .1 Provided sleeves for pipes, ducts and conduits passing through walls, floors and roofs.
- .2 Maintain fire-resistance integrity where pipes and ducts pass through walls, floors and partitions which are or form part of a fire separation.

- .3 Manufactured sleeves and integral sleeves with firestopping may be used provided they meet the same performance requirements as specified for fabricated sleeves.

Standard of Acceptance

- Hilti
- 3M
- Marfab Metal Products

8.2 Floor and Wall Sleeves – Dry Locations (“Standard Sleeves”)

- .1 Sleeve dimensions in floor and wall fire separations having a fire-resistance rating:
 - .1 For piping, insulated piping, and conduit:
 - (a) opening sized to suit fire stopping methods employed but in no case having an inside dimension more than 50 mm (2 in.) larger than the outside dimension of the service.
 - (b) sleeves may be permanent or only provided as formwork in concrete and masonry construction,
 - .2 For ductwork:
 - (a) opening sized to suit duct fire damper and/or smoke damper with clearance required for thermal expansion between the wall/floor opening and the fire/smoke damper sleeve in accordance with the fire/smoke damper manufacturer installation instructions.
 - (b) opening sleeves may be permanent or only provided as formwork in concrete and masonry construction,
 - (c) in gypsum-board construction provide permanent opening sleeves or ensure that steel-stud framing is provided to line the opening in the construction.
 - .3 Sleeve length – permanent type:
 - (a) piping: extend 25 mm (1 in.) past each face of fire separation.
 - (b) ductwork fire damper sleeve: as required to allow for installation of retaining angles and installation of required access door.
- .2 Sleeve dimensions for all other wall and floor types (except waterproof floors):
 - .1 For all services:
 - (a) opening sized to suit the outside dimension of the service, but in no case having an inside dimension of not less than 12 mm (1/2 in.) and not more than 50 mm (2 in.) larger than the outside dimension of the service.
 - (b) for clarity, for insulated pipes and insulated ducts the outside dimension of the service includes the insulation thickness.
 - .2 Sleeve length:
 - (a) flush to wall/floor construction or not to extend more than 25 mm (1 in.) past each face of wall or floor construction.
- .3 Sleeve construction for pipes and conduits:
 - .1 for all types of floor and wall construction:
 - (a) minimum schedule 10 steel pipe,
 - (b) fabricated carbon steel sheet of same thickness as schedule 10 pipe, rolled to dimension, lapped and spot welded, or
 - (c) as required by specific firestop system listing requirements.
 - .4 Sleeve construction for ducts smaller than 0.4 m² (4 sq ft) cross sectional area including insulation:
 - .1 for wall construction other than as fire separations having a fire-resistance rating:

- (a) 1 mm (20 ga) minimum sheet metal, lapped and spot welded with 20 mm ($\frac{3}{4}$ in) lip flange at one, or
 - (b) sleeves are not required where wall openings are coordinated wall construction trades which includes any duct insulation.
- .2 for floors and walls that are fire separations with required fire-resistance rating:
 - (a) as required by fire and/or smoke damper listing.
- .5 Sleeve construction for ducts of 0.4 m² (4 sq ft) and larger cross sectional area including insulation through walls and floors:
 - .1 for wall construction other than fire separations having a fire-resistance rating:
 - (a) 1.6 mm (16 ga) minimum sheet metal, lapped and spot welded with 20 mm ($\frac{3}{4}$ in) lip flange at one end.
 - .2 for floors and walls that are fire separations with required fire-resistance rating:
 - (a) as required by fire and/or smoke damper listing.
- .6 Manufactured floor sleeves with integral fire stopping:
 - .1 floor sleeve with integrated firestopping, for insulated and non-insulated metal pipes, and plastic pipes,
 - .2 for installation in concrete floors and metal deck/concrete floors,
 - .3 adaptors for support or pipe riser clamps,
 - .4 listed to CAN/ULC-S115.

Standard of Acceptance

- Hilti - fig. CP 680 series

8.3 Slot Sleeves

- .1 Application:
 - .1 where multiple pipes or conduits are grouped together in a linear arrangement to pass through a concrete floor or wall, or masonry wall, a common slot sleeve may be used,
 - .2 where slot openings are not shown on structural drawings, Contractor may propose location and sizes of slot openings for approval by the structural engineer. Where such approval is denied, use individual sleeves for each pipe or conduit.
- .2 Formwork:
 - .1 provide removable formwork or instruct the contractor under Division 03 of the Work to set formwork for the required slot dimensions prior to pouring concrete or setting of masonry units.
- .3 Slot dimensions:
 - .1 slot sleeve dimensions, pipe and conduit sizes, and location of services within the slot are subject to firestopping listing requirements.

8.4 Waterproof Floor Sleeves - Indoors

- .1 Applications:
 - .1 where pipes, conduits and ducts pass through floors in areas subject to water, in building service rooms, in kitchens, in washing areas and in slabs over electric and telephone rooms.
- .2 Fabricated waterproof sleeves for pipes and conduits, :
 - .1 minimum schedule 10 carbon steel pipe with either:

- (a) hot dip galvanized to ASTM A123 after fabrication, or
 - (b) internally and externally painted with industrial anti-corrosion paint in accordance with Specification section 20 05 02 *Painting for Mechanical Services*, or
- .2 schedule 10 stainless steel pipe,
- .3 provided with water bars: 75 mm (3 in.) wide annular water bar flange continuously welded to sleeve.
- .3 Fabricated waterproof sleeves for ducts:
 - .1 fabricated carbon steel sheet sleeve, continuously welded seams and joints, with angle-channel water bar welded to side of sleeve,
 - (a) 1 mm (20 ga) thick for ducts of less than 0.4 m² (4 sq ft) cross-section area including insulation,
 - (b) 1.6 mm (16 ga) thick for ducts 0.4 m² (4 sq ft) and larger cross-section area including insulation, and for openings with multiple ducts:
 - .2 sleeves internally and externally painted with industrial anti-corrosion paint in accordance with Specification section 20 05 02 *Painting for Mechanical Services*,
 - .3 water bars:
 - (a) new construction, embedded into floor concrete: 75 x 75 mm (3 x 3 in.) galvanized-steel angle channel continuously welded to sleeve,
 - (b) existing or new construction, surface mounted: 75 x 50 mm (3 x 2 in.) carbon steel angle channel, surface mounted to top of concrete housekeeping curb.
- .4 Location of water bars:
 - .1 placed at mid-height of floor construction thickness in new floor construction,
 - .2 surface mounted on and fastened to top of concrete housekeeping curb in existing buildings or in new floor construction.

8.5 Foundation Wall Sleeves

- .1 For installation in poured concrete foundation walls.
- .2 Manufactured foundation wall sleeves:
 - .1 PVC wall sleeve with 50 mm (2 in) wide water bar,
 - .2 sized to suit pipe OD and pipe link-seal.

Standard of Acceptance

- Metraflex

- .3 Fabricated wall sleeve:
 - .1 Method 1:
 - (a) schedule 10 Type 304 stainless steel pipe with 75 mm (3 in) wide water bar welded to mid-point of sleeve,
 - .2 Method 2:
 - (a) schedule 40 carbon steel pipe with 75 mm (3 in) wide water bar welded to mid-point of sleeve,
 - (b) sleeves internally and externally painted with industrial anti-corrosion paint in accordance with Specification section 20 05 02 *Painting for Mechanical Services*,
 - .3 sized to suit pipe OD and pipe link-seal.

8.6 Roof Sleeves for Pipe and Conduit

.1 Manufactured roof sleeves:

- .1 one-piece spun aluminium sleeve, minimum 1.6 mm (0.064 in) wall thickness, with integral continuous welded flashing,
- .2 insulated with polyurethane insulation for hot and cold piping,
- .3 with 135° gooseneck for flexible electrical conduit, with minimum clearance from gooseneck outlet to flashing flange of:
 - (a) minimum 300 mm (12 in) for installation on conventional roofs,
 - (b) minimum 450 mm (18 in) for installation on inverted roofs.
- .4 with vented flashing insert and flashing cap for hot piping,
- .5 with ventilation perforations at top of sleeve and a flashing cap for natural gas piping,
- .6 stainless steel fasteners,
- .7 EPDM base seal between conduit or pipe and bottom of sleeve,
- .8 EPDM top seal, with triple pressure seal, either integral to the sleeve or as a two-piece sleeve and flashing cap,
- .9 sleeve height: 300 mm (12 in),
- .10 suitable for hot and cold piping, with or without pipe insulation, and rigid and flexible electrical conduit.

Standard of Acceptance

- Thaler – fig. MEF series

Application	Thaler Model
Hot piping	MEF-3A
Cold piping	MEF-3A
Natural gas piping	MEF-9
Rigid electrical conduit	MEF-1
Flexible electrical conduit	MEF-2A

8.7 Installation

- .1 Provide sleeves for the passage of services through walls, floors and roofs in accordance with the following table:

Construction Element	Fire Resistance Rating	Element Construction	Mechanical Service	Opening Sleeve Required
Roof	Any or none	All	All	Yes
Walls	>0 hrs		Pipe and Conduit	As required for formwork

		Concrete, Masonry Units	Ductwork	As required for formwork
		Gypsum Board	Pipe and Conduit	Yes
			Ductwork	As required by fire or smoke damper listing
Wall (smoke barrier)	0 hrs	All	All	Yes, or wall tightly finished to sides of service
Acoustic Isolation Walls	None [1]	All	All	Yes
All other walls	None [1]	All	All	None unless otherwise shown
Floors	>0 hrs	Concrete	Pipe and Conduit	As required for formwork
			Ductwork	As required by fire or smoke damper listing
Waterproof Floors	Any or none	Concrete	Pipe and Conduit	Yes
			Ductwork	Yes or Curb

Notes:

[1] Walls are not fire separations of any type.

- .2 Place and secure sleeves in concrete form work for floors, walls and roofs.
- .3 Supply sleeves to be set in masonry walls with installation detail drawings setting out locations of sleeves.
- .4 Standard sleeves:
 - .1 terminate flush with surfaces of concrete and masonry walls.
 - .2 standard sleeves may be omitted where the services pass through walls which are not fire-separations and are concealed above opaque ceilings.
- .5 Waterproof sleeves in new construction:
 - .1 extend sleeves 50 mm (2 in.) above top of housekeeping curbs,
 - .2 extend sleeves 150 mm (6 in.) above finished floors where housekeeping curbs are not used,
 - .3 install sleeves with water bar embedded within the concrete floor or with water bar sitting on top of concrete housekeeping curb. Where mounted on top of housekeeping pad, mechanically fasten sleeve and water bar to concrete housekeeping curb.
 - .4 where water bars are exposed, grind smooth any edges to allow application and adhesion of floor/curb paint finishes.
- .6 Waterproof sleeves in existing concrete buildings:
 - .1 install sleeves in neatly cut or drilled holes in existing construction,
 - .2 carry out cutting and drilling of structural elements, such as floors, slabs, and walls in accordance with procedure set out in Article "Cutting and Patching".
 - .3 provide 150 wide x 150 high mm (6 x 6 in.) housekeeping curb for each penetration.

- .4 extend sleeves 50 mm (2 in.) above top of housekeeping curbs, with water bar mechanically fastened to curb,
- .7 Seal the void between sleeve and service:
 - .1 except for sleeves for fire dampers and smoke dampers, fill void between sleeve and pipe, conduit or duct in accordance with Article "Fire Stopping and Smoke Seals" in this Section for sleeves located in fire separations,
 - (a) for waterproof sleeves, use firestopping material which is also suitable for exposure to water under normal operating conditions.
 - .2 at other locations, pack the void between sleeve and pipe, conduit or duct for full depth of sleeve, with mineral wool insulation and seal both ends with silicone-free caulking compound.
- .8 Roof sleeves for pipe and conduit:
 - .1 install manufactured roof flashing sleeves in accordance with manufacturer instructions, specifically in accordance with requirements applicable to the type of roofing membrane requirements,
 - .2 where limestone ballast is used, apply asphalt or similar protective coating onto flashing sleeve to a height of 50 mm (2 in) above ballast layer.
- .9 Where shown, provide floor, wall or roof sleeves for future use. Coordinate with trade contractor under Division 03 of the Work to have such sleeves filled with light weight concrete.

9 LINK SEALS

9.1 General

- .1 Fit each pipe passing through floor slab in contact with ground or basement walls below grade with link seal between sleeve and bare pipe.
- .2 Submit manufacturer's literature and schedule showing location, service, inside diameter of wall opening, sleeve length and pipe outside diameter.
- .3 Link seal:
 - .1 Manufactured from modular synthetic rubber links with stainless steel hardware.
 - .2 Loosely assembled with bolts to form continuous rubber belt around pipe, with pressure plate under each bolt head and nut.
 - .3 Constructed to provide electrical insulation between pipe and sleeve.

Standard of Acceptance

- Power Plant Supply – fig. Thunderline Linkseal
- Advance Products & Systems – fig. Innerlynx
- Metraflex - fig. MetraSeal

9.2 Installation

- .1 Determine inside diameter of each wall opening or sleeve before ordering seal.
- .2 Position seal in sleeve around pipe and tighten bolts to expand rubber links until watertight seal is obtained.

10 FIRE STOPPING AND SMOKE SEALS

10.1 General

- .1 Provide fire stopping and smoke seals where ducts, pipes or conduits penetrate fire separations.
- .2 Fire stop materials to be impervious to water when installed in a horizontal separation, including waterproof service sleeves.
- .3 Firestop material manufacturer or their designated service representative to provide the following services:
 - .1 selection of listed fire stopping assemblies for each applicable service penetration and fire separation assembly/rating,
 - .2 provide training of contractor's staff for proper installation of fire stopping assembly; create and maintain a log of those personnel who obtain training,
 - .3 inspect the completed installation of all penetrations and submit a written report to the Consultant, including photo record of randomly selected instances of each fire stopping method. Where deficiencies are discovered, note the deficiencies in the report and provide remedial instructions to the contractor to correct the deficiency. After deficiencies are corrected, re-inspect the deficiencies to conform their correction, update and resubmit the report to the Consultant.
- .4 Submit a complete fire stopping and smoke seal shop drawing schedule to the Consultant for review. Include details, cut sheets, system description and location for each proposed fire stopping and smoke sealing application.

10.2 Products

- .1 Materials and firestopping system to be listed for conformance with CAN/ULC-S115 "*Standard Method of Fire Tests of Firestop Systems*".
- .2 Firestop systems to have F duration rating equal to the fire resistance rating of the applicable fire separation. In addition, where required by the applicable building code for the specific service penetration, the fire stop assembly shall:
 - .1 have a F rating equal to the fire resistance rating of the applicable fire separation with a pressure differential of 50 Pa (0.2 in.w.c.) between exposed and unexposed side with the highest pressure on the exposed side, and
 - .2 have an FT rating equal to the fire resistance rating of the applicable fire separation,

Standard of Acceptance

- Hilti Firestop Systems
 - 3M
 - Nelson Firestop Products
 - Eastern Wire + Conduit (Royal Quickstop)
- .3 Other manufacturers having products with explicitly similar characteristics, listings or classifications and approvals are acceptable.

10.3 Installation

- .1 Install firestopping and smoke seals in accordance with the manufacturer's recommendations and in accordance with its listing.
- .2 Firestopping and smoke seals to be installed only by personnel trained by the manufacturer on the installation of such systems.
- .3 Seal space between penetrating service and sleeve or opening in in fire rated floors and walls with a firestop and smoke sealing system.

- .4 Select thickness and arrangement of back-up materials to suit size of service, length of sleeve and anticipated movement.
- .5 At time of application of materials, surfaces to be clean, dry and free from dust, oil, grease, loose or flaking paint and foreign materials.
- .6 Select firestopping system to allow insulation and vapour barrier to pass un-broken through assembly.
- .7 Do not apply fire stopping materials to fire or smoke dampers.

11 WALL AND FLOOR PLATES

11.1 General

- .1 Provide finishing plates fitted to ducts, pipes, and electrical services provided under Division 20 of the Work which pass through walls, floors and ceilings in finished areas.

11.2 Products

- .1 Escutcheons for small diameter piping and small diameter electrical conduit:
 - .1 manufactured chrome plated two-piece split type with hinge and set-screw.
- .2 Finishing plates for ducts, larger pipes, larger electrical conduits and electrical cables:
 - .1 finishing plate (ring) fabricated from minimum 0.9 mm (20 ga) thick T304 stainless steel with No. 4 brushed finish, with minimum 25 mm (1 in) high collar ring,
 - .2 mounting holes drilled at not less than three (3) symmetrically location positions around the ring to allow mechanical fastening,
 - .3 plate diameter to be sufficiently sized to overlap the wall, floor or ceiling opening by not less than 25 mm (1 in) all around the opening.

11.3 Installation

- .1 Escutcheons;
 - .1 secure escutcheons to pipe and electrical conduit with mechanical fastener.
- .2 Finishing plates:
 - .1 set finishing plates flat against the finished surfaces, and secure to the surface with stainless steel pan-head mechanical fasteners. Provide insert anchor plugs in the finished surface as necessary to secure the fasteners.

12 PIPE SUPPORTS, EQUIPMENT SUPPORTS, AND TRENCH COVERS

12.1 General

- .1 Design and fabricate supplementary supporting steel for piping, ductwork and equipment supports, and trench and pit covers, from steel plate and sections. For clarity, the contractor under these Division 20 to 25 of the Work is responsible for design, fabrication and installation of such materials.
- .2 Concrete housekeeping bases for mechanical and electrical equipment which are in direct contact with floor slab, are to be provided by this Division 20.
- .3 Concrete for equipment supported on vibration isolated inertia bases is to be provided by this Division 20.
- .4 Work to be done by firms specializing in these fields.
- .5 Submit shop drawings for steel and concrete work, prepared by Professional Engineers licensed in the jurisdiction of the Work

12.2 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Building Code,
 - .2 R.R.O. 1990, Reg. 851 Industrial Establishments
- .2 Installation codes and standards:
 - .1 CAN/CSA-S16.1 Limit States Design of Steel Structures.
 - .2 CSA W59 Welded Steel Construction (Metal Arc Welding).
- .3 Product standards:
 - .1 ASTM A36 Standard Specification for Carbon Structural Steel
 - .2 ASTM A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - .3 ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - .4 ASTM A 307 Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .5 CAN/CSA G40.20/G40.21 General Requirements for Rolled or Welded Structural Quality Steel.

12.3 Supplementary Supports and Support Brackets

- .1 Provide supplement supports and brackets for the support of equipment, piping and ductwork.
- .2 Fabricate supports from structural grade steel with anchor bolts and fastenings, so that horizontal supporting beam deflections do not exceed 1/360 for the span, and not exceed an absolute deflection of 5 mm (0.20 in), with a safety factor of 1:4 to the ultimate strength of the material
- .3 Design the supports in consultation with the building structural Consultant, to transfer live loads and dead loads to the building structural elements,
- .4 Construct the supports as frames bracketed from walls, and/or supported from building structure above, and/or floor below.

12.4 Slide Pads for Equipment Support

- .1 General:
 - .1 slide pads for equipment supports for equipment subject to thermal expansion,
 - .2 designed for continuous-weld and/or tack-welding of backing plate to the equipment support,
 - .3 assembled in pairs per load point.

Standard of Acceptance

- ° Piping Technologies & Products Inc.
- .2 Composite 25% glass-filled PTFE bearing plate bonded to carbon steel backing plate:
 - .1 PTFE thickness: 0.1 mm (3/32 in.)
 - .2 backing plate: 3 mm (1/8 in.) thick carbon steel plate,
 - .3 compressive strength: 19.3 MPa (2800 psi)
 - .4 temperature rating: -45 to +260°C (-50 to +500°F)
 - .5 coefficient of friction: 0.15

- .3 Graphite bearing plate bonded to carbon steel backing plate:
 - .1 graphite thickness: 13mm & 6mm (1/2 in & 1/4 in.)
 - .2 backing plate: 6 mm (1/4 in.) thick carbon steel plate,
 - .3 compressive strength: 19.3 MPa (2800 psi)
 - .4 temperature rating: -45 to +537°C (-50 to +1000°F)
 - .5 coefficient of friction: 0.15.

12.5 Trench Covers, and Pit Covers

- .1 Fabricated with:
 - .1 75 mm x 75 mm x 9.5 mm (3 in x 3 in x 3/8 in) welded angle frame with anchor bars,
 - .2 25 mm x 9.5 mm (1 in x 3/8 in) trim bar to fit concrete pit, and with matching checker-plate cover,
 - .3 hot dip galvanized after fabrication

12.6 Installation - General

- .1 Locate supporting steel to permit removal of parts for service or repair, and to allow clear access to valves, fittings, and equipment,
- .2 Set equipment on supporting frames and brackets and install hangers, anchor bolts, vibration mountings and snubbers.
- .3 Set equipment base plates on housekeeping pads on minimum 13 mm (1/2 in) epoxy grout and fill hollow portion of base with concrete.
- .4 Install anchor bolts, vibration mountings and snubbers between equipment and housekeeping pad, or inertia pad and housekeeping pad.
- .5 Provide anchorage, dowels, anchor clips, bar anchors, expansion bolts and shields, and toggles.
- .6 Make field connections with bolts to CAN/CSA-S16.1, or by welding.
- .7 Supply items for casting into concrete or building into masonry to appropriate trades together with setting templates.
- .8 Touch-up field welds, bolts and burnt or scratched surfaces after completion of erection with primer.
- .9 Where trench covers are cut in field or damaged, touch up with zinc rich paint.

13 HOUSEKEEPING PADS AND CURBS

13.1 General

- .1 Housekeeping pads and containment curbs are to be provided under Division 03 of the Work with details of construction by the project structural engineer.
- .2 Be responsible for coordinating with the trade contractor under Division 03 of the Work for construction of the housekeeping pads and curbs, including but not limited to laying out of these pads and curbs, location dimensions relative to the building structure, and identifying pad/curb heights based on supported equipment type
- .3 Provide equipment anchors for embedment in concrete floors, pads and curbs, and place and secure in required position.
- .4 Inspect the pads and curbs during construction and verify pads and curbs are level and true.

13.2 Housekeeping Pads for Seismically-Restrained Equipment

- .1 Refer to Specification section 20 05 49 for additional requirements for housekeeping pads which support equipment requiring seismic restraint.

13.3 Housekeeping Pad Dimensions

- .1 Seismic applications: outside dimensions of pads to conform to Specification section 20 05 49.
- .2 Plan dimensions of housekeeping pads for large equipment that has a non-continuous base, including fuel storage tanks:
 - .1 curb width for equipment requiring seismic restraint:
 - (a) extending a minimum of 200 mm (8 in.) outwards from the outside edge of the equipment base frame channel or anchor bracket whichever is greater, and
 - (b) extending 100 mm (4 in.) inwards from the inside face of the equipment base frame channel.
- .3 Housekeeping pad height for all other equipment: in accordance with the following table based on equipment type, location and vibration isolation condition:

Equipment Type	Floor Type	Vibration Isolation	Thickness of Housekeeping Pad mm (in)
Stationary, not motorized	All	All	100 (4)
Fans	All	Yes	150 (6)
Motorized, up to 7.5kW (10 HP)	All	Yes or No	150 (6)
Motorized, 11 to 19kW (15 to 25 HP)	Slab on Grade	No	250 (10)
	Slab on Grade	Yes	150 (6)
	Suspended Slab	Yes	150 (6)
Motorized, 22kW (30 HP) and over	Slab on Grade	No	300 (12)
	Slab on Grade	Yes	150 (6)
	Suspended Slab	Yes	150 (6)

13.4 Concrete Curb Dimensions

- .1 Dimensions for containment curbs: 150 mm wide x 150 mm high (6 in. x 6 in.) and length as shown, unless otherwise shown.

14 INSTALLATION OF EQUIPMENT SUBJECT TO THERMAL EXPANSION

- .1 The following specific installation requirements apply to hot equipment which is not supported on spring vibration isolators, including but not limited to:
 - .1 diesel exhaust SCR emission control units.
- .2 Fasten equipment to building structure to accommodate thermal expansion in accordance with manufacturer's instructions. In the absence of such instructions, fasten equipment support legs as follows unless otherwise shown;

- .1 rigidly mechanically-fasten one fixed support point which is closest to the inlet exhaust piping connections,
 - .2 for supports located on the same transverse or longitudinal axis as the fixed support point, provide slide guides with lateral limit-stops (lateral to the direction of thermal movement) with a lateral clearance gap not exceeding:
 - (a) 6 mm (1/4 in.) lateral movement for outdoor equipment and/or equipment subject to seismic restraint,
 - (b) 12 mm (1/2 in.) total movement otherwise.
 - .3 for other support points, provide guides with two-axis horizontal limit-stops to allow free movement under thermal conditions,
 - .4 when installed outdoors, or where subject to seismic restraint, or both, provide vertical movement limit stops to limit free movement due to wind loading or seismic forces to not more than 6 mm (1/4 in.).
- .3 Provide support slide pads beneath each support leg other than the fixed support;
- .1 use PTFE slide pads for equipment with an operating temperature less than 260°C (500°F),
 - .2 use graphite slide pads for equipment with an operating temperature greater than 260°C (500°F).

END OF SECTION

PAINTING FOR MECHANICAL SERVICES

20 05 02

1 GENERAL

1.1 Scope

- .1 Provide industrial sealer and anti-corrosion coatings for mechanical and electrical building services and related construction elements including:
 - .1 mechanical and electrical services and supporting elements as specified under other sections of Divisions 20 to 25

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 01 01 Mechanical General Requirements
 - .2 20 05 01 Mechanical Basic Materials and Methods
 - .3 23 11 13 Fuel Oil Piping and Accessories
- .2 In addition to building elements to be painted as specified herein, refer to other Specification sections of Division 20 to 25 for other mechanical equipment to be painted.

1.3 Submittals

- .1 Submit product data sheets which demonstrate compliance with LEED VOC requirements.

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 SOR/2009-264 Canadian Environmental Protection Act, *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*
- .2 Installation standards and codes:
 - .1 LEED v4 New Construction, credit EQ Cr 4.2
 - .2 SSPC-SP1 Solvent Cleaning
 - .3 SSPC-SP2 Hand Tool Cleaning
 - .4 SSPC-SP11 Bare Metal Power Tool Cleaning
 - .5 SSPC-SP13 Surface Preparation of Concrete
- .3 Product standards:
 - .1 Green Guard GC-03 Green Seal Environmental Criteria for Anti-Corrosion Paints

2 PRODUCTS

2.1 Industrial Anti-Corrosion Coatings – Carbon Steel Materials

- .1 Outdoor applications:
 - .1 For carbon steel materials and structural steel support components.

- .2 Top coat: Industrial urethane alkyd enamel top coat, or single compound 100% acrylic coating.
- .3 Primer coat: as per manufacturers' recommendation for coating of steel piping.
- .4 Colour: Sherwin Williams No. SW4027 (Galvano), unless specified elsewhere.
- .5 VOC limit: 340 g/L of product less water and excluded compounds.

Standard of Acceptance

- Sherwin Williams – Pro Industrial Urethane Alkyd Enamel
- Sherwin Williams – Pro Industrial Acrylic

.2 Indoor applications:

- .1 For carbon steel materials and structural steel support components.
- .2 Top coat: single compound 100% acrylic coating.
- .3 Primer coat: as per manufacturers' recommendation for coating of steel piping.
- .4 Colour: Sherwin Williams No. SW4027 (Galvano), unless specified elsewhere.
- .5 LEED: certified to Green Guard standard GC-03 for anti-corrosion coatings.
- .6 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Pro Industrial Acrylic

.3 Zinc rich primer applications:

- .1 For field painting of carbon steel material, or touch-up of galvanized steel material.
- .2 Top coat: as specified for interior or exterior applications.
- .3 Primer: single or multi-part zinc rich coating.
- .4 Colour: gray-green.
- .5 LEED: certified to Green Guard standard GC-03 for anti-corrosion coatings.
- .6 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Zinc Clad III HS 100

2.2 Industrial Coatings – Poured Concrete

.1 For field painting of concrete safety bollards.

- .1 Resistant to fuel oil, general solvents and water.
- .2 Top coat: water based urethane floor enamel
- .3 Primer: water based epoxy
- .4 Colour: Sherwin Williams Deck Gray
- .5 Colour: Sherwin Williams Safety Yellow where shown.
- .6 VOC limit: 250 g/L of product less water, U.S. EPA method 24.

Standard of Acceptance

- Sherwin Williams – Armorseal Floor Plex 7100 Primer / Amorseal 1K Topcoat

3 EXECUTION

3.1 General

- .1 Refer to requirements for services to be painted in the relevant sections of Division 20 to 25 and as specified herein, including but not limited to:
 - .1 general requirements for painting in accordance with Specification section 20 01 01,
 - .2 painting of pipe sleeves in accordance with Specification section 20 05 01,
 - .3 painting of fuel oil piping in accordance with Specification section 23 11 13,

3.2 Repair of Factory Coatings

- .1 Touch up any damage to factory prime coat finishes resulting from shipping or installation with appropriate primer for indoor/outdoor installation followed by an appropriate top-coat colour to match existing. Materials to be compatible with the original factory finish.
- .2 Touch up any damage to factory galvanized finish resulting from site welding, shipping or installation with zinc rich primer.

3.3 Paint Installation

- .1 Surface preparation and protection:
 - .1 Clean surfaces to be painted in accordance with paint manufacturer recommendations and as follows.
 - .2 Surfaces to be clean, dry and free from dust, oil, grease, loose or flaking paint and foreign materials at time of application of paint materials.
 - .3 For carbon steel materials, remove all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter by hand chipping, scraping, sanding, and wire brushing in accordance with SSPC-SP2 or use power tool cleaning in accordance with SSPC-SP11
 - .4 For galvanized steel material, solvent clean to SSPC-SP1. If galvanized surface is already rusty, remove loose rust and dirt in accordance with SSPC-SP2 or SSPC-SP11 and prime the exposed metal the same day as being cleaned.
 - .5 For concrete materials, clean surfaces to SSPC-SP13 / NACE 13 by mechanical, chemical or thermal methods.
 - .6 Tape-off adjacent materials which are not to be painted.
 - .7 Provide drop sheets to protect other material from falling paint or over-spray.
- .2 Application - General:
 - .1 Apply one coat of primer to carbon steel items.
 - .2 Use primer unadulterated, as prepared by manufacturer.
 - .3 Apply top coat in the number of coats recommended by the manufacturer, to obtain 100% coverage to the minimum recommended thickness, free of streaks, drips and sags.
 - .4 Do not paint when temperature is lower than 7°C.
- .3 Application – Galvanized base metal finish:

- .1 Where material is galvanized, touch up welded sections or other locations where protective galvanized surface has been damaged, with zinc rich primer.
- .2 Apply a top coat to match base material colour.
- .4 Application – Concrete safety bollards
 - .1 Apply one coat of primer and two top-coats.
 - .2 Seal joints between floors and curbs or housekeeping pads, and between floors and walls , with a silicone based industrial caulking in matching colour after paint has dried.

End of Section

COMMON ELECTRICAL REQUIREMENTS FOR MECHANICAL SERVICES

20 05 12

1 GENERAL

1.1 Scope

- .1 Provide wiring, conduit, fittings, supports, disconnect switches, service lights, and related devices and equipment for mechanical trades work, at voltages of 600V and less and to the extent specified herein.
- .2 Pre-installation survey of SCCR values for equipment supplied under Divisions 20 to 25 which requires power wiring supply, to verify nameplate SCCR is equal to or greater than the minimum specified SCCR values.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Hangers and Supports
 - .2 20 05 49 Seismic Restraint.
 - .3 20 05 14.13 Constant Speed Motor Controllers

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section and referenced sections:
 - .1 **Control panels** – an electrical device that controls or monitors mechanical equipment, or that interfaces with instrumentation devices.
 - .2 **Control wiring** - wiring for the purpose of communication or control of equipment and instrumentation.
 - .3 **Electrical safety code** - the edition with amendments of CSA C22.1 as adopted by applicable legislation at the location of the Work.
 - .4 **Mechanical breaker panel (MBP)** means a 120/208 V mechanical power panel with overcurrent protection circuit breakers provided as part of an MCC.
 - .5 **Mechanical service panel (MSP)** - panelboard with branch circuit overcurrent protection devices provided by Division 26, and dedicated to supply power for equipment provided by mechanical trades work.
 - .6 **Mechanical trades work** - equipment and systems provided under Divisions 20 to 25.
 - .7 **Motor controllers** - constant speed motor controllers of the manual, magnetic or solid-state type in accordance with specification section 20 05 14.13.
 - .8 **Motor Control Center** – has the meaning as specified in section 20 05 14.13.
 - .9 **Packaged equipment** - equipment containing some or all of: motor(s), controls and/or other electrically powered equipment, such as but not limited to: electric heating equipment, water treatment equipment, packaged HVAC equipment, electric boiler, electric domestic water heaters, etc.)
 - .10 **Power Panel (PP)**: 208 up to 600 V, 3 phase, panelboard with branch circuit overcurrent protection devices provided by Division 26, which serves general building loads and may also serve equipment provided by mechanical trades work.
 - .11 **Power wiring** means wiring that provides electrical power to equipment including to control panels, including BAS panels, that are not integral to the controlled equipment.

- .12 **Receptacle panel (RP)** - a 120/208 V panelboard with branch circuit breakers, provided by Division 26.
- .13 **SCCR**: the RMS symmetrical short-circuit current rating of the equipment or motor controller, measured at the input to the motor or controlled equipment (short-circuit withstand rating has the same meaning).
- .14 **VFD**: variable frequency drives in accordance with specification section 20 05 14.16.
- .15 **Wiring** means conductors, cable, conduit, fittings, supports and accessories.
- .2 With respect to these definitions, for equipment provided by Division 26 the actual terminology used in the Division 26 drawings and specification may differ but the intent remains the same.
- .3 For clarity, any reference herein to Division 20 means Divisions 20 to 25 inclusive.

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 Electrical safety legislation in the jurisdiction of the Work.
 - .2 For clarity, on Federal Government projects, comply with the provincial or territorial legislation at the place of the Work which adopts the applicable edition of CSA 22.1 with any amendments
- .2 Installation standards and codes:
 - .1 CSA C22.1 Canadian Electrical Code Part 1, as amended and adopted by the AHJ for electrical safety in the province or territory at the place of the Work.
- .3 Product standards:
 - .1 CSA C22.2 No. 4 Enclosed and Dead-Front Switches
 - .2 CSA C22.2 No. 38 Thermoset-Insulated Wires and Cables
 - .3 CSA C22.2 No. 39 Fuseholder Assemblies
 - .4 CSA C22.2 No.94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .5 CSA C22.2 No. 106 HRC – Miscellaneous Fuses
 - .6 CSA C22.2 No. 124 Mineral Insulated Cable
 - .7 CSA C22.2 No. 131 Type TECK 90 Cable
 - .8 CSA C22.2 No. 208 Fire Alarm and Signal Cable
 - .9 CSA C22.2 No. 230 Tray Cable
 - .10 CSA C22.2 No. 239 Control and Instrumentation Cables

1.5 Quality Control

- .1 Electrical wiring for mechanical trades work to be performed by a specialist electrical contractor firm with an established reputation in the field of wiring of mechanical equipment and controls.

1.6 Short Circuit Current Ratings (SCCR) and Markings

- .1 Except where another Specification section requires a SCCR of a different value, equipment provided under Division 20 to 25 which is supplied electrical power in accordance with CSA C22.1 shall have a short circuit capacity rating (SCCR) of not less than [10][25] kAIC RMS symmetrical.
- .2 The SCCR value is to be marked on all equipment provide with power wiring in accordance with CSA C22.1. Where the SCCR nameplate rating references an instruction manual, provide a separate label that states the SCCR value.

1.7 Permits, Fees and Inspections

- .1 Arrange and pay for electrical permits and any required inspections for electrical work for mechanical equipment and systems.
- .2 Submit to the electrical safety authority the required number of drawings and specifications for examination and approval prior to commencement of work.
- .3 Notify Consultant of changes required by the electrical safety authority prior to making changes.
- .4 On completion of the Work, furnish certificates of acceptance (or similar report) from the electrical safety authority to the Consultant.

1.8 Standard Details

- .1 Device legend with list of abbreviations and schematic wiring diagrams are included at the end of this section that delineate the scope of work between Division 20 and Division 26 and as further specified herein.
- .2 This material is to be used in the interpretation of specification requirements for power wiring and control wiring of Division 20 to 25 equipment.

1.9 Submittals

- .1 Submit manufacturer catalogue cut-sheets for the following materials;
 - .1 VFD Inverter Duty cable,
 - .2 service lights.

1.10 Storage of Materials

- .1 Store wire and cable in a clean, dry, well-ventilated area.
- .2 Protect white insulated wire from exposure to NOx gas (e.g.: exhaust from propane fueled equipment) by wrapping with shrink wrap, by locating away from sources of NOx and by maintaining adequate ventilation to minimize NOx levels.
- .3 Where white insulated wire has discoloured:
 - .1 do not install,
 - .2 dispose of the wire,
 - .3 remove and replace wire that has been installed.

2 PRODUCTS

2.1 Motor Feeder and Control Wiring ("Building Wires")

- .1 Application:
 - .1 motor and equipment power feeders controlled by constant speed motor controllers;
 - (a) do not use for motors controlled by variable frequency drives,
 - .2 control wiring including control valves and damper actuators, panel control wiring, motor controller interlock wiring, BAS control wiring, and switch-type instrumentation,
 - .3 convenience power outlets and service lights.
- .2 Conductors:
 - .1 solid copper for No. 12 and 14 AWG,
 - .2 stranded conductors for 10 AWG and larger.

- .3 Minimum wire size:
 - .1 No. 12 AWG for equipment power,
 - .2 No. 14 AWG, for control wiring at 120 VAC or lower.
- .4 Insulation:
 - .1 chemically cross-linked thermosetting polyethylene (XLPE) material, RW90 or RWU90,
 - .2 1000 V insulation for 600 V systems,
 - .3 600 V insulation for 100 VAC to 480 VAC systems.
 - .4 300 V insulation for systems less than 100 VAC, and for systems 24 VDC and less.
- .5 Colour coded conductors:
 - .1 colour impregnated into insulation at time of manufacture,
 - .2 phase conductors No. 8 AWG and larger with black insulation, may be colour coded with adhesive colour coding tape.
- .6 Listed to CSA C22.2 No. 38.
 - Standard of Acceptance*
 - Aetna Insulated Wire
 - General Cable
 - Nexans Canada Inc.
 - Prysmian Cables & Systems Ltd.
 - Southwire

2.2 Extra-Low Voltage Power Wiring – 24 VAC, 24 VDC

- .1 Application: power wiring to 24 VAC or 24 VDC electrically commutated motors.
- .2 Type: ACIC,
- .3 Cable:
 - .1 insulated solid or stranded copper conductors,
 - .2 insulation: XLPE, colour coded or numbered wires,
 - .3 minimum wire size: 16 AWG,
 - .4 voltage rating: 600 V.
- .4 Armour:
 - .1 aluminium interlocked armour.
- .5 Jacket:
 - .1 FT4 flame retardant,
 - .2 FT6 when installed in raised floors, or in ceiling spaces that are used as return air plenums.
- .6 Listed to CSA C22.2 N0. 239,
 - Standard of Acceptance*
 - General Cable (Carol)
 - Belden
 - Nexans Canada Inc.

2.3 Instrumentation Cabling

- .1 Application: instrumentation and control wire suitable for analogue 4-20 mA and 0-10 VDC signaling.
- .2 Cable:
 - .1 insulated solid-copper twisted-multipair conductors, shielded cables with individually shielded pairs, 100% coverage overall shield, drain wires and overall rated jacket,
 - .2 insulation: XLPE, colour coded or numbered wires,
 - .3 minimum wire size: as specified by equipment manufacturer or controls vendor, but not less than 18 AWG,
- .3 Armour:
 - .1 corrugated steel, or
 - .2 none required if installed in conduit or approved wireway.
- .4 Jacket:
 - .1 FT4 flame retardant,
 - .2 FT6 when installed in open style cable trays in ceiling spaces that are used as return air plenums.
- .5 Listed to CSA C22.2 No. 239,
 - Standard of Acceptance*
 - General Cable (Carol)
 - Belden
 - Nexans Canada Inc.

2.4 Conduits and Fittings

- .1 Conduits:
 - .1 rigid hot dipped galvanized steel threaded conduit,
 - .2 electrical metallic tubing (EMT), hot dipped galvanized with couplings,
 - .3 PVC coated hot dipped galvanized rigid steel conduit: with 40 mil PVC exterior coating, 2 mil urethane interior and thread coating,
 - .4 flexible metal conduit and liquid-tight flexible metal conduit.
- .2 Conduit fastenings:
 - .1 single hole steel straps to secure surface conduits 50 mm (2") and smaller,
 - .2 two hole steel straps for conduits larger than 50 mm (2"),
 - .3 beam clamps to secure conduits to exposed steel work,
 - .4 channel type supports for two or more conduits,
 - .5 Ø6 mm threaded rods to support suspended channels.
- .3 Conduit fittings:
 - .1 manufactured for use with conduit specified including coatings,
 - .2 factory "ells" where 90° bends are required for 25 mm (1in.) and larger conduits,
 - .3 insulated throat steel set screw or raintight insulated throat steel compression connectors and couplings for EMT,
 - .4 threaded or compression type raintight/concrete tight insulated throat zinc plated steel connectors and couplings for rigid steel conduit,

- .5 raintight insulated throat steel connectors at all surface equipment enclosures and other electrical equipment in sprinklered areas for all conduit terminations.

2.5 Outlet Boxes

- .1 Construction:
 - .1 hot dipped galvanized steel single and multi-gang flush device boxes for flush installation,
- .2 Size:
 - .1 76 mm x 50 mm x 38 mm (3" x 2" x 1½") or as indicated,
 - .2 102 mm (4") square outlet boxes when more than one conduit enters one side with extension and plaster rings as required.

2.6 Disconnect Switches

- .1 Construction:
 - .1 listed to CSA C22.2 No. 4,
 - .2 enclosure type:
 - (a) painted metal with hinged door,
 - (b) indoors: type 1, 3R, 4 or 12, unless otherwise specifically shown,
 - (c) outdoors: type 3R.
 - .3 fuseholder assemblies listed to CSA C22.2 No. 39,
 - .4 include fuses unless shown as unfused,
 - .5 fuseholders suitable for Class J fuses, sized to suit the fuse sizes without the use of adaptors,
 - .6 horsepower rated,
 - .7 one, two or three pole as required for single phase or polyphase circuits,
 - .8 two pole with solid neutral or three pole with solid neutral for three wire and four wire circuits with neutral,
 - .9 six pole for two speed motor applications,
 - .10 provision for padlocking in the Off switch position,
 - .11 mechanically interlocked door to prevent opening when handle is in the ON position,
 - .12 heavy duty, quick-make, quick-break action,
 - .13 ON-OFF switch position indication on switch enclosure cover.
- .2 Fuses:
 - .1 HRCI-J time delay up to 600A,
 - .2 HRCI-L for ratings above 600A,
 - .3 minimum interrupting capacity: 200 kAIC
 - .4 product of one manufacturer,
 - .5 ampere rating as indicated, where not indicated, the maximum rating permitted by the electrical code.
- .3 Special requirements for disconnect switch located upstream of harmonic filters:
 - .1 double break contacts per pole, to isolate fuses on both the line and load side,

- .2 14 AWG power taps on both line and load sides for control power transformers.
- .4 Special requirements for disconnect switch located between a VFD and the controlled equipment:
 - .1 auxiliary switch position status switch;
 - (a) rating: 10 A at 120 VAC,
 - (b) switch contacts open when disconnect switch is Not-Closed.
- .5 Ratings:
 - .1 IEC 90 rotary switch for motors up to 18.6 kW (25 HP),
 - .2 NEMA flange mount switch-handle for all ratings.

Standard of Acceptance

- Square "D"/Schneider Electric Company (Canada) Ltd.
- Eaton
- Siemens Canada Ltd.
- Klockner Moeller/Eaton

2.7 Equipment Service Lights

- .1 Protected globe light fixture ("Marine light"):
 - .1 die-cast aluminium housing and cage, frosted glass lens, stainless steel hardware, suitable for wall and ceiling mounting,
 - .2 enclosure rating: NEMA 4X or IP 65, vapourtight,
 - .3 listed and fixture marked for use in wet locations,
 - .4 bulb: LED with electronic driver, minimum life of 50,000 hours at L70 lumen level,
 - .5 optics: 3500 to 4000 K light, nominally 1400 lumens,
 - .6 operating temperature: -20 to +40°C (-4 to +104°F),
 - .7 operating humidity: up to 100% relative humidity at operating temperatures between 0 and +40°C (32 to 104°F),
 - .8 power: 120 VAC.

Standard of Acceptance

- Cooper - fig. LVL20UG

- .2 Area light fixture ("Area light"):
 - .1 reinforced-polyester fiberglass housing, stainless steel hardware, with lens gasket, suitable for wall and ceiling surface-mounting,
 - .2 fixture length: 600 mm (24 in),
 - .3 lens: low profile, high impact 50% DR acrylic lens, for wide distribution,
 - .4 enclosure rating: NEMA 4X or IP 65, vapourtight,
 - .5 listed and fixture marked for use in wet locations,
 - .6 bulb: LED with electronic driver, minimum life of 60,000 hours at L80 lumen level,
 - .7 optics: 3500 to 4000 K light, nominally 3000 lumens,
 - .8 operating temperature: -20 to +40°C (-4 to +104°F),

- .9 operating humidity: up to 100% relative humidity at operating temperatures between 0 and +40°C (32 to 104°F),
- .10 power: 120 VAC.

Standard of Acceptance

- Cooper - fig. 2VT3
- Lithonia - fig. FEM LED

2.8 Switches

- .1 Toggle switch, with neon pilot light – light is On when switch is Off.
- .2 Rating: 20 A at 120 Vac.
- .3 Switch cover: weatherproof with silicone rubber gasket, and clear bubble over toggle.

Standard of Acceptance

- Hubbell - HBL1795

2.9 Receptacles

- .1 Class A GFCI type, 15 A at 120 VAC indoors, and 20 A T-slot for outdoors.
- .2 Receptacle outlet hood:
 - .1 in-use weatherproof, for both indoor and outdoor locations,
 - .2 die cast aluminum base and cover with gasket,
 - .3 vertical mount.
 - .4 self-closing lift cover.
 - .5 CSA 3R rated.

Standard of Acceptance

- Bryant Electric – WPB26EH

2.10 Conduit and Equipment Supports

- .1 General:
 - .1 supports for conduit may conform to Specification section 20 05 29 except/and as specified herein.
 - .2 Materials: carbon steel supports, hot dipped galvanized after fabrication.
 - .3 manufacturer standard products suitable for support load rating of conduit and conductors:

Standard of Acceptance

- Burndy Canada Ltd.
- Canstrut
- Electrovert Ltd.
- E. Myatt & Co. Ltd
- Steel City Electric Ltd.
- Pilgrim Technical Products Ltd.

- .2 Upper attachment – concrete inserts
 - .1 galvanized wedge inserts to MSS SP-58 type 18.
 - .2 maximum tension load rating: 4.4 kN (1000 lbs),

Standard of Acceptance

- Anvil - fig. 281
- Unistrut - fig. P-3245

.3 Upper attachment – existing concrete:

- .1 conform to Specification section 20 05 29.

.4 Upper attachment – steel beams:

- .1 carbon steel beam clamp (top flange), hook rod with locking jaw, fasteners and lockwashers, to MSS SP-58, type 25,

Standard of Acceptance

- Anvil - fig. 227
- Myatt - fig. 504, 505

.5 Upper attachment - steel joists:

- .1 for installation of support rod in the interstice space of double-ell steel joists and open-web steel joists for support on the lower chord,
- .2 carbon steel washer plate with double locking nuts on top-side of washer,
- .3 second steel washer plate on underside of joist with nut where supported equipment is subject to vibration.

Standard of Acceptance

- Anvil - fig. 60
- Myatt - fig. 545

.6 Hanger rods:

- .1 continuous threaded rod, carbon steel, USS national course thread,
- .2 minimum rod size: Ø6 mm (1/4 in. dia.),
- .3 tension load ratings to MSS SP-58,

Standard of Acceptance

- Anvil - fig. 146
- Myatt - fig. 434

.7 Horizontal Pipe Support – Swivel Ring Hanger

- .1 swivel ring hangers, carbon steel ring strap, zinc plated, adjustable knurled swivel nut, to MSS SP-58 Type 10,
- .2 nominal conduit size: 12mmC to 100 mmC.

Standard of Acceptance

- Anvil - fig. 69, CT-69
- Myatt - fig. 41, 42, 43
- Unistrut

.8 Support channels:

- .1 U shape, minimum size 41 mm x 41 mm x 2.5 mm (1-1/2" x 1-1/2" x 1/10") thick, surface mounted, suspended or set in poured concrete walls and ceilings.

- .2 channel size selected for total supported loads,
- .3 conduit attachments: one-piece or two piece conduit clamps suitable for suspended loads and bottom supported conduit loads.
- .9 J Hooks:
 - .1 galvanized steel open-style J hooks with rolled edges for fastening direct to building structure or hanger rods.

2.11 Wire Markers

- .1 Printed, self-laminating vinyl wire and cable labels and sleeve-labels.

Standard of Acceptance

- ° Brady BMP21 Plus series

3 EXECUTION

3.1 Pre-Installation Survey for Short Circuit Current Ratings

- .1 Prior to installation of power wiring to mechanical equipment provided under Division 20 to 25, conduct a survey of such mechanical equipment's' SCCR values. Verify that the equipment nameplate SCCR rating is equal to or greater than:
 - .1 the general value specified in this section, or
 - .2 the specific value specified in the relevant Specification section for the equipment.
- .2 Where the nameplate SCCR is less than the specified minimum SCCR required value, provide a fused disconnect switch as specified herein ahead of the equipment, even if the equipment already has an integral disconnect switch. The cost for the provision of such disconnect switches shall be borne by the trade contractor supplying the mechanical equipment, at no cost to the Owner.
- .3 For clarity, this survey also applies to existing mechanical equipment where the Work includes replacement of the power wiring supplying the equipment.

3.2 General Installation Requirements

- .1 Install electrical wiring work under this specification section in accordance with the applicable electrical safety code and regulations applicable at the location of the Work.
- .2 In other than service rooms, run conduit and cable concealed within walls or above ceilings.
 - .1 for open-cell concrete block walls, install conduit during wall construction with openings for outlet boxes,
 - .2 for solid concrete walls, rough-in conduit and outlet boxes supported from structural reinforcing bars prior to pouring of concrete,
 - .3 where walls or ceiling structures are exposed, such as steel or finished concrete, arrange conduit neatly on the supporting surface, avoid the use of elbows to the greatest extent possible, and locate conduit as close as possible to the building structure.
- .3 In service rooms, run conduit and cables exposed.

3.3 Conduit Support and Hanger Installation

- .1 As an alternative to the materials specified herein, specification section 20 05 29 may also be used for support of conduits.
- .2 Support conduit from building structure in accordance with specification section 20 05 29.

- .3 Support conduit directly from or on structural building elements. Do not support conduit directly from other services.
- .4 Provide all miscellaneous materials including nuts, washers, and backing plates to make a complete support installation.
- .5 Where wall brackets are used, select brackets and size mounting bolts and backing plates to suit the supported load, allowing for a safety factor by not loading the bracket more than 80% of its published load rating.
- .6 In steel framed construction, support conduit from structural members. Where structural members are not suitably located for upper hanger attachment locations, and where inserts of adequate capacity cannot be installed in concrete slabs, provide supplementary steel framing members;
 - .1 fabricate supplementary steel from standard HSS sections, single EL section, double C “strongback” sections, or pipe rolls,
 - .2 size supporting steel to limit span deflection to 1/250 (0.4%) between support points,
- .7 Support horizontal conduit at intervals not exceeding 3 m (6 ft).
- .8 Support vertical conduit at intervals not exceeding 3 m (6 ft).
- .9 Where trapeze hangers are used, secure conduit to trapeze with U-bolts or conduit clamps.
- .10 Mechanically fasten supplementary steel to structural steel.

3.4 Armoured Cable Support

- .1 Support armoured cable VFD cables on 300 mm (12 in.) centres on channel supports and secured with conduit clamps. Do not use nylon or wire lashing or perforated strap to support or secure cables.
- .2 Support instrumentation armoured cables horizontally in cable trays or with J-hooks on 300 mm (12 in.) centres.
- .3 Support instrumentation armoured cables vertically by securing to building structure or secondary framing with perforated straps with 3 mm (1/8 in.) thick EPDM protective strip between the strap and cable.

3.5 Plenum-Rated Control and Instrumentation Cables Support

- .1 Support plenum-rated instrumentation and control cables in cable trays or with J-hooks on 300 mm (12 in.) centres. Support vertical cable drops to controls instrumentation, controlled devices or related equipment by use of vinyl tie-wraps fastened to building structure, supplementary steel, or equipment hanger rods. Do not support cables on piping or ductwork.

3.6 Installation of Power and Control Wiring – General Requirements

- .1 Wiring methods and standards to conform with those specified in Electrical Division 26 for the area of building in which installation is to be made, except as otherwise specified in this section.
- .2 Except where fire rated cables or VFD Inverter duty cables are required, use building wire for:
 - .1 power wiring for motors and packaged equipment,
 - .2 power wiring to control panels, heat tracing and other non-motorized packaged equipment, and
 - .3 non-analog control wiring at 120 VAC or less, and 24 VDC or less.
- .3 Provided polyphase motor and equipment power conductors with the following colour coding:
 - .1 Phase A – Red,
 - .2 Phase B – Black,
 - .3 Phase C – Blue ,

- .4 Neutral - White,
- .5 Ground - Green,
- .6 Control - Orange.
- .7 Where colour coded tape is utilized, apply at least 50 mm (2") at terminations, junction boxes and pull boxes. Do not paint conductors.
- .4 Provide single-phase motor and control wiring conductors with the following colour coding:
 - .1 Line – Red,
 - .2 Neutral – White,
 - .3 Ground – Green.
- .5 Install all wiring in conduit or approved raceway.
- .6 Use conduit type as follows:
 - .1 EMT: use thin wall conduit up to and including 32 mm (1 ¼ in) size for wiring in ceilings, furred spaces, in hollow walls and partitions and where not exposed to mechanical injury, and as otherwise shown.
 - .2 Rigid : use rigid galvanized steel conduit for wiring in poured concrete, where exposed, and for conduit 40 mm (1½ in) size and larger.
 - .3 Liquid-tight flexible: use only for the last 1000 mm (3 ft) of motor feeder at connection to motor, and for instrumentation wiring to equipment subject to vibration.
 - .4 select conduit size to be of sufficient size to allow easy removal of conductors at any time. Conduit sizes, where shown, are minimum and shall not be reduced.
- .7 Provide separate conduit for power wiring for each motor or starter. Except for motor temperature transducer wiring, do not install control wiring in the same conduit as power wiring.
 - .1 exception: motor temperature transducer wiring between motor and associated motor controller may be run in the same conduit as the associated motor feeder provided the conduit is sized for the additional wire pair.

3.7 Installation of Instrumentation, Communications and Control Cabling

- .1 Install wiring in conduit.
- .2 Neatly train circuit wiring in cabinets, panels, pullboxes and junction boxes and hold with nylon cable ties.
- .3 Run instrumentation, communication and control cabling point to point and terminate on terminal strips. Do not splice communication or control cabling. Where long runs make a continuous point to point installation impractical, make splices on labelled terminal blocks in an accessible labelled terminal cabinet, installed at 1200 mm (48") above floor, and indicate cabinet location, terminal and wire numbers on the As-built drawings.
- .4 Terminate control cables in equipment with suitable connectors.
- .5 Clearly identify cables/conductors at both ends, with permanent wire markers, indicating device/panel identification and terminal numbers on the device/panel (refer to standard detail 20 15 12-021 at the end of this specification section):
 - .1 Use applicable reference name or ID tag for the device or control panel.
 - .2 Print the labels such that the applicable panel/device identification is closest to the end of the cable.

- .3 Where individual wires are run in conduit, collect wires associated to the same control panel/device and apply a label to the group of wires inside each control panel/device. Where there is insufficient space inside a device (such as a transmitter), the label may be applied to the conduit at the point of connection to the device.
- .4 Where there are multiple conductors, individually identify each wire by its termination reference on the panel or device to which it connects.
- .5 Where there are only two wires and it is readily understood where each wire is to be terminated (i.e. white neutral, green ground), individually marking of the wires is not required.

3.8 Grounding

- .1 Ground electrical equipment and wiring in accordance with the applicable electrical safety code and regulations applicable at the location of the Work except where greater requirements are specified herein.
- .2 Provide insulated green bonding conductor in each power and control conduit sized per Table 16 of the Electrical Safety Code. Minimum bonding conductor size #12AWG copper.
- .3 Install grounding conductors, outside electrical rooms and electrical closets, in conduit.
- .4 Make connections to neutral and equipment with brass, copper or bronze bolts, star-washers, and connectors.
- .5 Except for VFD Inverter Duty cables, ground all motors with separate green insulated copper ground conductor installed in power feeder conduit, wired from ground terminal in the motor controller to a ground lug bolted directly to the motor frame, located inside the motor terminal box. Size the ground conductor per Table 16 of the electrical safety code except that the smallest conductor size to be #12 AWG.
- .6 Ground VFD inverter duty cables using all three integral ground conductors, from the ground terminal in the VFD enclosure to the ground lug bolted directly to motor frame inside the motor terminal box.
- .7 For VFDs, bond both ends of the VFD inverter duty cable as previously specified herein.

3.9 Disconnect Switches

- .1 Provide a disconnect switch for each piece of mechanical equipment provided under Division 20 to 25 which requires a power supply. This requirement is to be met by the following methods as applicable to each piece of equipment:
 - .1 as an integral factory-installed component of the equipment, or
 - .2 as a field-installed switch where;
 - (a) the equipment does not have an integral disconnect switch, or
 - (b) the equipment includes a factory installed disconnect switch but the equipment as a whole does not have a SCCR rating which meets or exceeds the required minimum SCCR rating specified herein or as specified in the applicable equipment Specification section.
- .2 For clarity, provide a disconnect switch upstream of harmonic filters provided for VFDs.
- .3 Locate the disconnect switches as follows;
 - .1 within 9 m (29 ft) and in the line-of-site of motors serving non-refrigeration motorized equipment, and within 9 m (29 ft) of the motor controller or VFD controlling the equipment,
 - .2 within 3 m (9.5 ft) and in the line-of-site of equipment containing refrigeration compressors and related motorized equipment that forms part of a refrigerant circuit,
 - .3 at cooling towers and other outdoor equipment where the motor controller is located indoors, and
 - .4 within 1 m (3 ft) of non-motorized equipment,

- .5 within 1 m (3 ft) of harmonic filters for VFDs.
- .4 Disconnect switch types for motorized equipment:
 - .1 fused type for motor controllers and VFD's, including harmonic filters.
 - .2 fused type for motorized packaged equipment,
 - .3 unfused for non-motorized equipment,
 - .4 unfused type at the controlled equipment for:
 - (a) cooling towers and other outdoor equipment where the motor controller is located indoors, or
 - (b) where the motor controller is in excess of the distance specified above or is not in line of site of the controlled equipment.
- .5 Disconnect switches on load side of VFD:
 - .1 where a disconnect switch is required between a VFD and the driven motor due to excess distance or lack of line-of-site requirements, provide an unfused disconnect switch with integral disconnect status position switch, as close as possible to the motor,
 - .2 wire the status switch back to the VFD input for drive output protection.
- .6 Disconnect switches for non-motorized equipment:
 - .1 provide unfused disconnect switch for non-motorized mechanical equipment.
- .7 Where the nameplate SCCR value of a mechanical equipment is less than the specified minimum SCCR value required, provide a fused disconnect switch to isolate the mechanical equipment, even if the equipment has an integral disconnect switch.
- .8 Where fuse protection is specified, install fuses of the correct overcurrent rating as specified by the mechanical equipment installation instructions.
- .9 Where fuse protection is specified, provide a set of six spare fuses of each size used in the disconnect switches. Turn spare fuses over to the Owner and submit a copy of the receipt signed by the Owner.
- .10 Provide power wiring between the field-installed disconnect switch and the associated equipment, with the conductors of the same wire gauge as the branch circuit conductors.

3.10 Outlet Boxes

- .1 Size boxes in accordance with CSA C22.1. Use 102 mm (4") square or larger outlet boxes as required for special devices.
- .2 Gang boxes where wiring devices are grouped. Use combination boxes with barriers where outlets for more than one system are grouped.
- .3 Provide blank cover plates for boxes without wiring devices.

3.11 Service Lights, Switches and Receptacle

- .1 Provide service light in the following locations, with the type and spacing as indicated.

Location	Condition	Fixture Type	Fixture Spacing
Under service catwalks in mechanical rooms (if shown on drawings)	All	Area	As shown.
Other location as shown on drawings	All	As shown	As shown.

- .2 Provide one receptacle wired ahead of each service light switch, located between 300 mm (12 in) and 1200 mm (4 ft) above the floor.

3.12 Seismic Restraint

- .1 Provide seismic restraints for electrical conduit in accordance with specification section 20 05 49.

3.13 Coordination and Division of Responsibility – Division 20 and Division 26

- .1 Schedule A at the end of this Specification section specifies the division of responsibility between Division 20 and Division 26 for provision of electrical work for mechanical equipment, including termination of conductors.
- .2 For clarity;
 - .1 the Division 20 electrical Work may be performed by the Division 26 contractor, but the work is managed and paid for by the Division 20 contractor.
 - .2 related work performed under Division 26 is listed in Schedule A for reference.
- .3 Coordinate power requirements for mechanical trades equipment with the contractor under Division 26 of the work, including;
 - .1 provide a list of all planned and ordered mechanical trades equipment with motor horsepower ratings and electrical power requirements, prior to the Division 26 contractor procuring their power distribution equipment,
 - .2 periodically update this power requirements list as mechanical trades equipment is ordered, and review with the Division 26 contractor to allow them to revise breaker ratings in a timely manner,
- .4 Where the branch circuit breaker rating requirements change as a result of the actual ordered mechanical trades equipment, coordinate and pay for any breaker and feeder changes required whether the affected work is in Division 20 or Division 26 scope of work.

3.14 Wiring Diagrams

- .1 The following wiring diagrams are included at the end of this section:
 - .1 20 05 12 - 001 Mechanical – Electrical Coordination (Sheet 1 of 3)
 - .2 20 05 12 - 002 Mechanical – Electrical Coordination (Sheet 2 of 3)
 - .3 20 05 12 - 003 Mechanical – Electrical Coordination (Sheet 3 of 3)

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
All	Motor Control Centers, motor controller racks, motor controllers, VFDs, Mechanical Breaker Panels (MBP), and disconnect switches	●	
Mechanical Equipment at voltage > 600 VAC	Power wiring from Division 26 switchgear to: - motor controller, - between motor controller and the mechanical equipment (where motor controller is free-standing separate from the mechanical equipment) - field-installed disconnect switches, and wiring between the disconnect switch and the mechanical equipment		●
	Field-installed disconnect switches.		●
General Mechanical Equipment fed from Dedicated Power Panels for Mechanical Equipment (Note 1)	Mechanical Service Panels (MSP), including branch overcurrent protection devices.		●
	Power wiring from MSPs and/or MCCs to: - motors, including between motors and motor controllers, VFDs and/or disconnect switches as applicable, - packaged equipment, including disconnect switches as applicable, - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.)	●	
	Power wiring from RP and/or MBP to: - motors, including between motors and motor controllers, - packaged equipment, including disconnect switches as applicable, - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.)	●	
General Mechanical Equipment fed from Non-dedicated Power Panels (Note 2)	Non-dedicated Power Panels (PP) and receptacle panels (RP), including branch overcurrent protection devices.		●
	Distribution splitters		●
	Power wiring from PPs and/or distribution splitters to: - motor controller, - disconnect switch ahead of VFD, - disconnect switch for package equipment, - packaged equipment (with integral disconnect switch) - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.)		●
	Power wiring from RP to: - motor controller or disconnect switch, - disconnect switch for package equipment, - packaged equipment (with integral disconnect switch), - equipment not requiring motor controllers or disconnect switches (control panels, heat tracing, etc.)		●

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
	Power wiring from: - disconnect switch to a VFD, - motor controller or VFD to the motor, - disconnect switch to packaged equipment	●	
BAS Controls and OEM Controls	In service rooms: provision of 120/208 VAC mechanical service panels (MSP) complete with 15 A breakers in service rooms for use by Division 20 to 25.		●
	Power wiring for controls in service rooms: wiring from MSP or BP to the BAS and OEM control equipment.	●	
	Other than service rooms: Dedicated 120V 15A normal and emergency branch circuit breakers as indicated on the receptacle panel schedules.		●
	Power wiring for controls other than in service rooms: wiring from dedicated circuits in receptacle panels to control equipment.	●	
	120 V, single phase power supply with a junction box at specific control devices as shown.		●
	Breaker tamper-protection locks.	●	
	Instrumentation and actuator power and control wiring, for both BAS controls and OEM controls.	●	
	Control wiring to interlock motor controllers and to connect safety and operating controls.	●	
Plumbing Fixtures	120 V, single phase power supply with a junction box with sufficient wiring to terminate at plumbing fixtures requiring control power		●
	Conduit from adjacent junction box or pull box to plumbing fixtures requiring control power, pulling of wiring to the plumbing fixture and termination of wiring to the fixture or primary side of control transformer.	●	
	Control transformers and extra-low voltage wiring	●	
Equipment Service Lights	120 VAC, 15A power circuits for equipment service lights, terminated in the equipment service light.		●
	120 VAC, 15A power circuits for equipment convenience receptacles, terminated in the receptacle.		●
	Power wiring from adjacent junction boxes to light switches/service convenience receptacles and fixtures	●	
	Equipment service lights, switches and convenience receptacles.	●	
Fire and Smoke Dampers	Power wiring to damper interlock control panels for smoke dampers, motorized fire dampers, and combination smoke/fire dampers.		●

Schedule A – Coordination of Division 20 and 26 Scope of Work			
Reference	Work Element	Div. 20	Div. 26
	Wiring between damper interlock control panels (for smoke dampers, motorized fire dampers, and combination smoke/fire dampers), to their associated dampers.	●	
Life Safety Interface	Fire Alarm System (“FAS”) control and monitoring modules located at BAS control interface panel. Fire Alarm System (“FAS”) control and monitoring modules located at/near fan starter or damper actuator, and wiring between control module and damper motor and fan starter.		●
	FAS control and monitoring modules located at/near sprinkler and standpipe supervised valves and flow switches including wiring between each module and the respective valve/flow switch.		●
	Wiring between FAS control and monitoring modules, and smoke control and smoke venting fans and dampers.		●
	Termination of FAS control and monitoring wiring in BAS panels	●	

Notes:

[1] MPP and MBP will be located in mechanical services rooms.

[2] PP and RP are not dedicated for mechanical equipment and may be located in any type of service room or space.

LEGEND

	CONSTANT SPEED MOTOR CONTROLLER		SCOPE OF WORK: DIVISION "A" / DIVISION "B" BOUNDARY
	VARIABLE FREQUENCY DRIVE		WIRING AND/OR EQUIPMENT BY DIVISIONS 20-25
	UNFUSED SERVICE DISCONNECT SWITCH		
	FUSED SERVICE DISCONNECT SWITCH		WIRING AND/OR EQUIPMENT BY DIVISION 26
	TRANSFORMER		
	120 VAC/ XX VDC POWER SUPPLY, CLASS AS SHOWN		
	120/208 VAC MECHANICAL BREAKER PANEL		
	MECHANICAL SERVICE PANEL (DIV 26)		
	POWER PANEL (DIV 26)		
	JUNCTION BOX		
	MOTOR		
	ELECTRIC HEAT TRACING		
	PACKAGED EQUIPEMENT WITH MOTORS AND INTEGRAL MOTOR CONTROLLERS		
	CONTROL PANELS, TERMINAL UNIT CONTROLLERS, AND OTHER NON- MOTORIZED EQUIPMENT		
	FUSE		
	LIGHT SWITCH (FOR SERVICE LIGHTS) - FLOOR PLAN		
	POWER SWITCH (SINGLE-LINE)		
	SERVICE LIGHT		
	ALARM BEACON		

General Notes

1. This drawing indicates general coordination of mechanical and electrical work. Refer to plan and riser drawings and specifications for project specific requirements, which take precedence over this drawing.

 **HHA Angus**

Sheet Title:
**MECHANICAL – ELECTRICAL
COORDINATION BLOCK DIAGRAM
(SHEET 1 OF 3)**

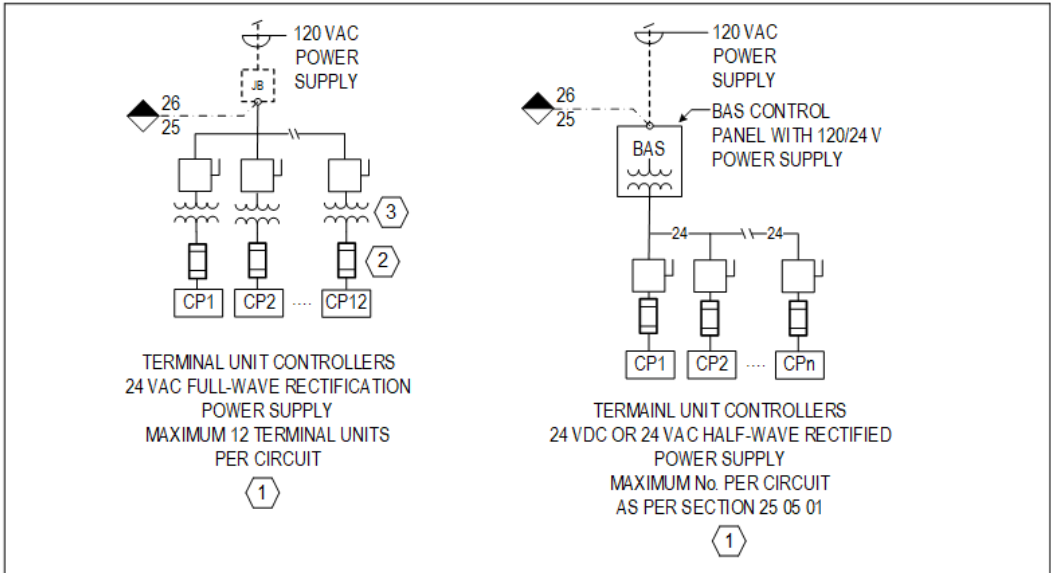
Date:
21 JUNE 2023

Rev. No.:
03

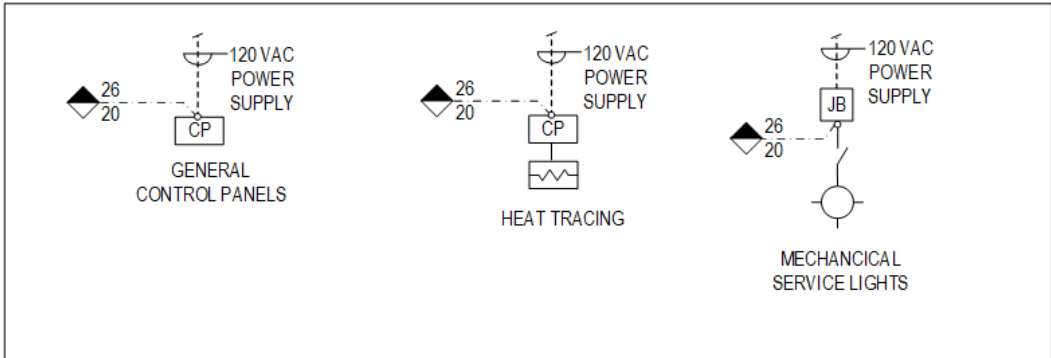
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PS

Standard Detail No.

20 05 12 - 001



TERMINAL UNITS



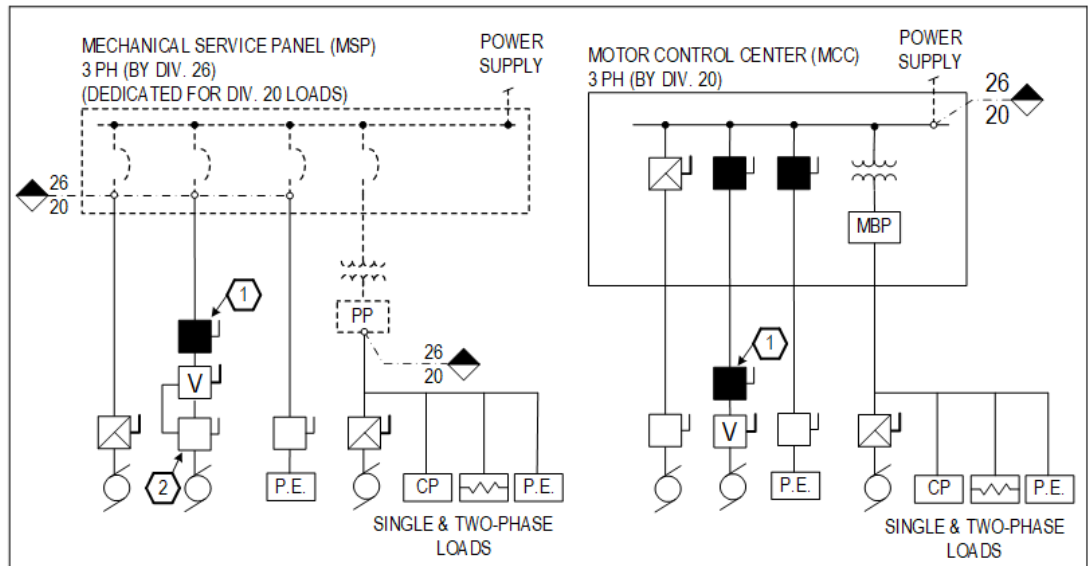
MISCELLANEOUS EQUIPMENT

- DRAWING NOTES**
(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY)
1. REFET TO SPECIFICATION SECTION 25 05 01 FOR APPLICABLE WIRING METHODS.
 2. PROVIDE FUSE PROTECTION IF TRANSFORMER DOES NOT HAVE INTEGRAL CIRCUIT BREAKER.
 3. PROVIDE DEDICATED TRANSFORMER FOR FULL-WAVE RECTIFIED 24 VAC CONTROL DEVICES.

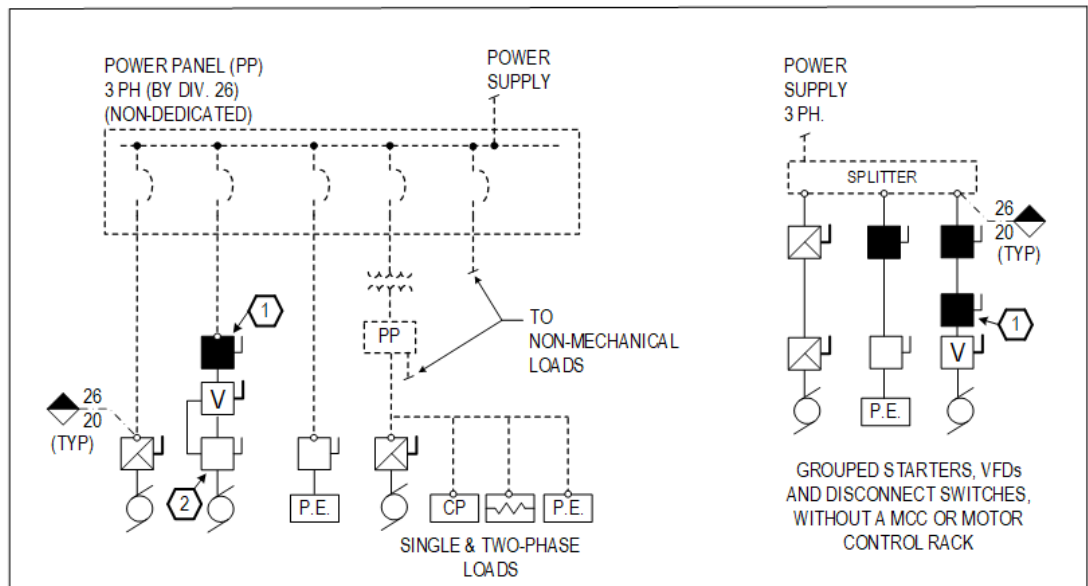


Sheet Title:
MECHANICAL – ELECTRICAL
COORDINATION BLOCK DIAGRAM
(SHEET 2 OF 3)

Date: 21 JUNE 2023	Rev. No.: 03	Checked: PS
Standard Detail No. 20 05 12-002		



DEDICATED POWER DISTRIBUTION EQUIPMENT



NON-DEDICATED POWER DISTRIBUTED EQUIPMENT

DRAWING NOTES
(NOTES AND NUMBERING BELOW PERTAINS TO THIS DRAWING ONLY)

1. SEPARATE FUSED DISCONNECT WHEN REQUIRED TO MEET SPECIFIED SCCR VALUES. (TYP).
2. SEPARATE UNFUSED DISCONNECT WHERE V.F.D. IS REMOTE FROM THE MOTOR. PROVIDE DISCONNECT SWITCH POSITION INDICATOR WITH INTERLOCK WIRING TO THE V.F.D. (TYP).

General Notes

1. This drawing indicates general coordination of mechanical and electrical work. Refer to plan and riser drawings and specifications for project specific requirements, which take precedence over this drawing.
2. Dedicated power distribution equipment is only located in mechanical service rooms.



Sheet Title
**MECHANICAL – ELECTRICAL
COORDINATION BLOCK DIAGRAM
(SHEET 3 OF 3)**

Date: 21 JUNE 2023	Rev. No.: 04	Checked: PS
Standard Detail No. 20 05 12 – 003		

END OF SECTION

COMMON MOTOR REQUIREMENTS FOR MECHANICAL EQUIPMENT 20 05 13

1 GENERAL

1.1 Scope

- .1 Provide single phase and three-phase low-voltage AC induction motors from fractional horsepower to 200 horsepower, and brushless DC ECM motors.
- .2 This specification section applies to general purpose motors and inverter duty motors, except where otherwise specified by other specification sections of Divisions 20 to 25.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 14.13 Motor Controllers

1.3 Definitions

- .1 The following definitions apply to this section and referenced sections:
 - .1 **ECM**: electrically commutated motor (AC supply, brushless DC motor).
 - .2 **ODP**: open drip proof (motor enclosure).
 - .3 **Soft-start motor controller**: a solid-state electronic motor controller that regulates output current and voltage during motor starting.
 - .4 **FEFC**: totally enclosed non-ventilated (motor enclosure without motor driven cooling fan).
 - .5 **TEFC**: totally enclosed fan cooled (motor enclosure with motor driven cooling fan).

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 O.Reg. 509/18 Energy and Water Efficiency – Appliances and Products
- .2 U.S. DOE 10 CFR 431 Code of Federal Regulations Part 431 (to the extent adopted in O.Reg. 509/18)Product standards:
 - .1 CSA C22.2 No. 100 Motors and Generators
 - .2 CSA C390-10 Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-phase Induction Motors
 - .3 CSA C747-09 Energy Efficiency Test Method for Small Motors
 - .4 IEEE 85-1973 Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
 - .5 IEEE 112-2004 Standard Test Procedure for Polyphase Induction Motors and Generators
 - .6 IEEE 114-2010 Standard Test Procedure for Single-Phase Induction Motors
 - .7 NEMA MG1-2016 Motors and Generators

1.5 Submittals

- .1 Submit manufacturer data sheets with the following information for motors 50 HP and smaller:

- .1 motor model/catalogue numbers,
- .2 motor full load ratings: current, speed, voltage, horsepower, efficiency, and KVAR.
- .2 Submit manufacturer data sheets with the following information for motors greater than 50 HP:
 - .1 associated driven equipment identification tag,
 - .2 motor model/catalogue numbers,
 - .3 motor full load ratings: current, speed, voltage, horsepower, efficiency, and KVAR,
 - .4 bearing data,
 - .5 acceleration time at maximum inertia,
 - .6 guaranteed efficiency and power factor at full load, 75% load, 50% load, and 25% load,
 - .7 dBA scale sound power levels.
- .3 For inverter duty motors 5 HP and larger, submit manufacturer data sheets or similar documentation for the following information:
 - .1 confirmation of compliance to NEMA MG-1 for inverter duty,
 - .2 protection method for grounding of stray motor currents,
 - .3 motor frequency operating range (minimum to maximum),
 - .4 insulation winding class,
 - .5 details of motor bearing construction.

1.6 Shipping and Storage

- .1 Ship motors from factory;
 - .1 packed in impact-absorbing material, or fastened to hardwood skid or pallet for fork truck handling. Do not use Styrofoam or similar plastic-based materials,
 - .2 protected against dirt and moisture during transit and outdoor storage,
 - .3 clearly identified with permanent ink marking on packing,
- .2 Protect motors attached to equipment against dirt and moisture during transit and outdoor storage.

1.7 Operating and Maintenance Manuals

- .1 Include in the operating and maintenance manuals the following data for all motors supplied to the project:
 - .1 shop drawing data as specified herein,
 - .2 motor weight,
 - .3 sliding base dimensioned drawings,
 - .4 internal winding connection diagram,
 - .5 speed torque performance data for across line start, from stand-still to synchronous speed,
 - .6 installation and maintenance instructions.

2 PRODUCTS

2.1 Motors - General Requirements

- .1 Listed to CSA C22.2 No.100.

- .2 Listed to CSA C390 for NEMA MG-1 Premium efficiency ratings (three phase, 1 – 200 HP)
- .3 Motors selected and marked with a power rating that is the greater of:
 - .1 not less than the input brake horsepower of driven equipment at both the specified operating condition and at maximum run-out conditions at design driven equipment operating speed, without operation in the motor service factor, and
 - .2 not less than the minimum horsepower rating as shown.
- .4 Common motor characteristics:
 - .1 frequency: 60Hz.
 - .2 voltage:
 - (a) 115 and 220 volt, for single phase motors as shown,
 - (b) 575 and 208 volt, for three phase motors, as shown.
 - .3 nominal rated-load speed: 1750 RPM unless otherwise shown,
 - .4 minimum ambient operating temperature at nameplate power rating: 40°C (104°F),
 - .5 vibration velocity: not to exceed 2.0 mm/s (0.08 inches/second) measured at bearing housing,
 - .6 motor generated noise, 10 HP and larger: not to exceed 85 dBA, measured at 3 m (10 ft) in accordance with IEEE 85.
- .5 Permanently lubricated ball bearing rotor supports.
- .6 Motor enclosure:
 - .1 cast iron, aluminum, or rolled steel construction,
 - .2 drain openings,
 - .3 shouldered lifting eye bolts (three phase TEFC motors),
 - .4 bi-directional, spark-proof, abrasion and corrosive resistant cooling fan keyed to shaft (three phase TEFC motors),
 - .5 compression type grounding lug or double ended cap screw of silicon bronze, mounted in conduit box by drilling and tapping into motor frame.
- .7 Motor nameplate:
 - .1 stainless steel plate mounted on enclosure with stainless steel fastening pins,
 - .2 information as described in NEMA MG-1 including motor efficiency rating,
 - .3 motor bearing part numbers and motor wiring diagram instructions,
- .8 Protective coating, TEFC motors:
 - .1 primer and 4 to 5 mils epoxy overcoat on external surfaces, and corrosion resistant coating of epoxy paint on internal surfaces, shaft, rotor, stator iron, and end bells,
 - .2 shaft extension protected with rust preventive strippable coating capable of being peeled off or unwrapped.
- .9 Motor termination junction boxes and motor leads:
 - .1 cast iron or sheet steel diagonally split, tapped for conduit, and attached to motor frame with cadmium plated hex head cap screws,
 - .2 arranged for conduit entry from either side or bottom,
 - .3 gaskets between box and motor frame and between halves of box, with cover secured with cadmium plated hex head cap screws,

- .4 motor leads in conduit box;
 - (a) identified in accordance with ANSI C6.1,
 - (b) with the same insulation class as windings,
 - (c) sized in accordance with EASA recommended minimum ampacity values,
- .5 motor leads between motor frame and termination box to pass through tight fitting neoprene rubber seals.

2.2 Motor Efficiency

- .1 Motor efficiency test method:
 - .1 CSA C747 or IEEE 114 for single phase ECM and AC motors,
 - .2 CSA C747 or IEEE 112 for polyphaser motors up to 3 HP, and.
 - .3 CSA C390 or IEEE 112 for three-phase motors 1 to 200 HP.
- .2 Motor efficiency ratings:
 - .1 Minimum motor efficiency to be not less than the greater of the following:
 - (a) applicable legislation for energy efficiency,
 - (b) NEMA Premium® for three-phase integral horsepower motors, and
 - (c) as specified in the Schedules appended at the end of this specification section.
- .3 These motor efficiency ratings do not apply to electric motor-driven fire pumps.

2.3 Single Phase Motors

- .1 Single phase motor rating less than 375 W (1/2 hp):
- .2 Types:
 - .1 PSC motor:
 - (a) permanent split capacitor type for AC power supply,
 - (b) suitable for variable speed applications.
- .3 ECM motor:
 - .1 brushless DC electrically commutated motor with integral microprocessor based inverter and controller, for AC power supply,
 - .2 factory programmed or field programmable for specific application,
 - .3 capable of accepting an external 0-20 mA or 0-10 V signal for remote variable speed operation including fan On/Off control.
- .4 Winding insulation: Class B.
- .5 Suitable for mounting in the horizontal or vertical orientation.
- .6 Continuous duty rating with 1.35 service factor.
- .7 ODP or TEFC enclosure, resilient mounts.
- .8 Built-in overload protection.
- .9 Motor over-temperature protection as specified herein.

2.4 Three Phase Motors, Fractional Horsepower

- .1 Motors of 375 W (1/2 HP) and 560 W (3/4 HP).

- .2 For use with magnetic motor controllers.
- .3 Three phase squirrel cage induction type, NEMA T frame, general purpose type, to NEMA MG-1.
- .4 NEMA B design.
- .5 Winding insulation: Class F, with a rated motor winding temperature rise of not more than 90°C above an ambient temperature of 40°C at full motor load,
- .6 Continuous duty rating with minimum 1.15 service factor.
- .7 ODP or TENV enclosure.
- .8 Motor over-temperature protection as specified herein.

2.5 Three Phase Motors, Integral Horsepower

- .1 Motors 745 W (1 hp) to 150 kW (200 hp).
- .2 For use with constant speed magnetic motor controllers.
- .3 Three phase squirrel cage induction type, NEMA T frame, general purpose type.
- .4 NEMA design:
 - .1 Type B for centrifugal fans and pumps,
 - .2 Type C for positive displacement pumps and compressors.
- .5 Winding insulation: Class F, with a rated motor winding temperature rise of not more than 90°C above an ambient temperature of 40°C at full motor load,
- .6 Continuous duty rating with minimum 1.15 service factor.
- .7 TEFC enclosure.
- .8 Suitable for horizontal, vertical or belt-driven mounting.
- .9 Motor over-temperature protection as specified herein.
- .10 Motor winding leads:
 - .1 three (3) leads for single speed operation,
 - .2 six (6) leads for two-speed operation (five lead two-speed motors are not acceptable).

2.6 Three Phase Motors – Inverter Duty

- .1 Application: motors 745 W (1 hp) to 150 kW (200 hp) operating on power supply controlled by a variable frequency drive (inverter) motor controllers and soft-start constant speed motor controllers.
- .2 General requirements:
 - .1 three phase squirrel cage induction type, NEMA T frame, general purpose type, suitable for pulse width modulated wave form,
 - .2 winding insulation: Class F insulation, with a rated motor winding temperature rise of not more than 90°C above an ambient temperature of 40°C at full motor load (i.e. Class B temperature rise),
 - .3 continuous duty rating and rated for 200% of full load starting torque,
 - .4 service factor: 1.15 on Sine Wave and 1.0 on pulse-width modulated power supply,
 - .5 TEFC enclosure,
 - .6 suitable for horizontal, vertical or belt-driven mounting,
 - .7 motor over-temperature protection as specified herein,
 - .8 motor winding leads: three (3) leads,

- .9 motor over-temperature protection as specified herein except where the protection function is provided by the variable frequency drive.

.3 Special requirements:

- .1 motors rated for inverter duty in accordance with NEMA MG-1 Part 31,

(a) stator winding insulation ratings:

- i) peak voltage and partial discharge-free voltages:

Rated Voltage V RMS	Withstand Voltage Zero-to-Peak (Line-to-Line) V	Partial Discharge-Free Zero-to-Peak (Line-to-Line) V
208, 3 phase	645	513
575, 3 phase	1782	1281

- .2 speed range: minimum 10:1 (6 to 60 Hz) for variable torque applications,

- .3 provided with stray rotor current grounding system consisting of;

(a) 3 HP and smaller: electrically conductive bearing grease for motors,

(b) all HP ratings: rotor shaft grounding system at the drive-end bearing, either integral to the bearing construction or externally mounted to the motor frame.

Standard of Acceptance

- ° AEGIS - fig. SGR series

- .4 for motors 100 HP and larger, provide insulated bearings on the non-drive end.

- .5 motor to be compatible with type of soft-start motor controller or variable frequency drive supplied under other specification sections, and that the starter/motor system will be capable of providing rated torque over a frequency range from 15 to 60 hz while operating within motor temperature rise specification,

- .6 motor to be capable of operating between 60 Hz and 90 Hz with torque reducing at drive frequency above 60 Hz,

- .7 ball bearing rotor supports suitable for continuous low speed operation at minimum motor speed.

- .8 drive end face drilled and tapped (4 places) for mounting of auxiliary devices.

.4 Motor stator winding:

- .1 made up with copper magnet wire coated with moisture resistant triple-build Class F insulation, non-hygroscopic varnish, phase paper insulation, and with thermal rating of not less than 150°C for 30,000 hours life when tested in accordance with IEEE No. 57,

- .2 insulation resistance greater than 100 megohms when measured at 25°C with 1000-volt direct current mega-ohm bridge,

- .3 slot-wound installation, held in stator slots that have had sharp edges and burs removed prior to winding insertion,

- .4 connection leads mechanically secured and silver soldered,

- .5 designed for operation in either direction of rotation.

.5 Motor bearings:

- .1 anti-friction single shield, vacuum-degassed steel ball bearings,

- .2 lubricated bearings; extended pipe zerk fitting, and ½-lb relief fitting for external lubrication while machine is in operation, bearing seal, lubricated at factory after assembly,
- .3 bearing shield on motor winding side of bearing,
- .4 rated fatigue life of L'-10 (B-10) 150,000 hours for direct coupled applications and 50,000 hours for belted applications,
- .5 belt drive-set rating based on radial loads and pulley sizes from NEMA MG1-14.43.
- .6 Motor junction box sized and provided with at least two (2) conduit connection points, one for motor feeder cable and one for motor thermal sensor control wiring.

2.7 Motor Over-Temperature Protection

- .1 Motor thermal protection for single phase motors mounted in air ducts, plenum chambers or in air stream inside air handling equipment:
 - .1 motor winding thermostats, normally closed contact, phenolic snap-acting disc thermal switch, temperature calibrated,
 - .2 automatic reset type.

Standard of Acceptance

- Texas Instruments - Klixon Phenolic Motor Protectors

- .2 Motor thermal protection for three phase motors less than 37 kW (50 HP) that are mounted in air ducts, plenum chambers or in air stream inside air handling equipment:
 - .1 Winding sensors;
 - (a) three (3) Positive Temperature Coefficient (PTC) temperature sensors, one in each motor winding, wired in series, and compatible with Texas Instruments - Klixon model 42AA100E control unit,
 - (b) control unit provided under section 20 05 14.13 or 20 05 14.16.
- .3 Motor thermal protection for three phase motors 37 kW (50 HP) and larger:
 - .1 Winding sensors;
 - (a) three (3) Positive Temperature Coefficient (PTC) temperature sensors, one in each motor winding, wired in series, and compatible with Siemens model 3RN10 12 control unit,
 - (b) control unit provided under section 20 05 14.13 or 20 05 14.16.

2.8 Sliding Base for Motors with V-belt Drives

- .1 Construction:
 - .1 fabricated from steel as a single unit with double supported slide and two adjusting bolts,
 - .2 finished with coating as specified above for motor exterior.

3 EXECUTION

3.1 Application

- .1 Refer to other specification sections for motor style requirements for single phase motors and fractional horsepower polyphase phase motors (ODP, TENV or TEFC).
- .2 Where motors are provided with internal thermistors for motor overtemperature protection, run thermistor control wiring:
 - .1 in the same conduit as the motor power conductors for constant speed motor controllers,

- .2 in a separate conduit from the motor power conductors for variable frequency drive motor controllers.

3.2 Field Applied Rotor Grounding System

- .1 Install shaft-grounding system on motors operating on variable speed drives and not provided with OEM rotor grounding systems.

3.3 Maintenance During Construction

- .1 Rotate motors by hand at one month intervals while at the project site.

3.4 Schedules

- .1 The following schedules of motor minimum electrical efficiency ratings apply:
 - .1 Schedule A – Single Phase Electric Motor Efficiency, 0.25 to 0.5 HP,
 - .2 Schedule B – Two-phase Electric Motor Efficiency 0.25 to 3 HP, and Three-phase Electric motor Efficiency 0.25 to 0.75 HP,
 - .3 Schedule C – Three Phase Electric Motor Efficiency, 1 to 200 HP.

Schedule A - Single Phase Electric Motor Efficiency, 0.25 to 0.5 HP

Motor HP (kW)	Single Phase, Permanent-Split Capacitor 0.25 to 0.5 HP Nominal Full-Load Efficiency (%) [Note 1]		
	Open Motors		
	6 Pole 1200 RPM	4 Pole 1800 RPM	2 Pole 3600 RPM
0.25 (0.18)	62.2	68.5	66.6
0.33 (0.25)	66.6	72.4	70.5
0.5 (0.37)	76.2	76.2	72.4

Notes:

[1] From U.S. DOE 10 CFR Part 431, SubPart X, §431.446(a)

Schedule B – Polyphase Electric Motor Efficiency, 0.25 to 3 HP

Motor HP (kW)	Polyphase Induction Motors 0.25 to 3 HP Nominal Full-Load Efficiency (%) [Note 2]			Remarks
	Open Motors			
	6 Pole	4 Pole	2 Pole	
0.25 (0.18)	67.5	69.5	65.6	2 Phase & 3 Phase
0.33 (0.25)	71.4	73.4	69.5	2 Phase & 3 Phase
0.5 (0.37)	75.3	78.2	73.4	2 Phase & 3 Phase
0.75 (0.55)	81.7	81.1	76.8	2 Phase & 3 Phase
1 (0.75)	82.5	83.5	77.0	2 Phase only
1.5 (1.1)	83.8	86.5	84.0	2 Phase only
2 (1.5)	---	86.5	85.5	2 Phase only
3(2.2)	---	86.9	85.5	2 Phase only

Notes:

[2] From U.S. DOE 10 CFR Part 431, SubPart X, §431.446(a)

Schedule C – Three-Phase Electric Motor Efficiency, NEMA Premium, 1 to 200 HP

Motor HP (kW)	Three-Phase Induction Motors 1 to 200 HP Nominal Full-Load NEMA Premium Efficiency (%) [Note 3]							
	2 Pole 3600 RPM		4 Pole 1800 RPM		6 Pole 1200 RPM		8 Pole 900 RPM	
	Encl.	Open	Encl.	Open	Encl.	Open	Encl.	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1

Notes:

[3] From U.S. DOE 10 CFR Part 431, SubPart B, §431.25(h), Table 5, and NEMA MG-1 Table 12-12.

END OF SECTION

CONSTANT SPEED MOTOR CONTROLLERS 20 05 14.13

1 GENERAL

1.1 Scope

- .1 Provide constant speed motor controllers including magnetic, manual, reduced voltage and solid-state motor controllers, for electric motor-driven equipment provided under mechanical trades work.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections;
 - .1 20 05 12 Wiring Requirements for Mechanical Services
 - .2 20 05 13 Common Motors Requirements for Mechanical Equipment
 - .3 20 05 49.23 Seismic Qualification for Mechanical Equipment
 - .4 20 05 53 Identification

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Constant speed motor controllers** – a motor controller/starter other than VFDs, for operating control of single speed, multi-speed, and/or reversing operation as specified, consisting of a disconnecting means, a short-circuit protection device, a motor-starter contactor, a motor overload protection device, and a control circuit.
 - .2 **Mechanical breaker panel (MBP)** means a 120/208 V mechanical power panel with overcurrent protection circuit breakers provided as part of an MCC.
 - .3 **SCCR**: the RMS symmetrical short-circuit current rating of the motor controller, measured at the output of the controller (short-circuit withstand rating has the same meaning).
- .2 For other definitions, refer to definitions in specification section 20 05 12.

1.4 Applicable Codes and Standards

- .1 Product standards:
 - .1 IEEE 315 Standard for Graphical Symbols for Electrical and Electronic Diagrams
 - .2 CSA C9 Dry-Type Transformers
 - .3 CSA C22.2 No. 5 Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
 - .4 CSA C22.2 No. 14 Industrial Control Equipment
 - .5 CSA C22.2 No. 29 Panelboards and Enclosed Panelboards
 - .6 CSA C22.2 No. 39 Fuseholder Assemblies
 - .7 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-environmental Considerations
 - .8 CSA C22.2 No. 94.2 Enclosures for Electrical Equipment, Environmental Considerations
 - .9 CSA C22.2 No. 106 HRC – Miscellaneous Fuses
 - .10 CSA C22.2 No. 248.8 Low-voltage Fuses – Part 8: Class J Fuses
 - .11 CSA C22.2 No. 254 Motor Control Centres

1.5 Design Criteria

- .1 Device legend with list of abbreviations, general schematic wiring diagrams for single and three phase motor controllers, are included at the end of this Specification section. This material is to be used in interpretation of specification and equipment schedule requirements for motor controllers and accessories within motor controller enclosures, motor and wiring protection components, and ancillary devices.

1.6 Seismic Qualification

- .1 Seismically qualify (certify) the following equipment specified herein:
 - .1 constant speed motor controllers,
- .2 The seismic qualification of the above-listed equipment is to conform to Specification section 20 05 49.23 for the following seismic qualification level and certification method:
 - .1 Functional seismic qualification (Level III) for motor control equipment: by shake table testing,
- .3 The following equipment specific seismic force parameters are to be used:

C _p	A _r	R _p	h _x /h _n
1.00	1.00	1.25	1.0

1.7 Submittals

- .1 Submit motor controller wiring diagrams that are specifically prepared for the project. The use of standard manufacturer wiring diagrams are permitted provided they clearly identify any included options that are required to meet these specifications.
- .2 Wiring diagrams format:
 - .1 ladder diagram form with energized conductor on the left and grounded conductor on the right,
 - .2 IEEE 315 graphic symbols with individual horizontal lines numbered sequentially and every conductor terminal matching identifying terminal numbers.

2 PRODUCTS

2.1 General – Short Circuit Current Rating

- .1 Short circuit protection rating (SCCR) for motor controllers:
 - .1 motor controller minimum SCCR value: [25 kAIC RMS symmetrical,
 - .2 SCCR value to be marked on the motor controller nameplate. Where the SCCR nameplate rating references an instruction manual, provide a separate label that states the SCCR value.

2.2 Motor Controllers - General Requirements

- .1 General;
 - .1 These general requirements apply to all constant speed motor controllers unless otherwise specified.
 - .2 Motor controllers listed to CSA C22.2 No. 14.
 - .3 Size motor controllers for rated motor load and contactor coil load.
 - .4 Operating voltage: as shown on drawings.
 - .5 Engraved Lamacoid nameplate identifying load served.
 - .6 Supply motor controllers from one manufacturer.

Standard of Acceptance

- ABB
- Allen Bradley
- Baldor
- Benshaw
- Cutler Hammer
- Graham (Danfoss)
- Klockner Moeller
- Siemens
- Square D
- Toshiba
- WEG
- Yaskawa

- .2 Electrical enclosure:
 - .1 painted metal construction, hinged door with screwdriver-operated latches,
 - .2 conforming to CSA C22.2 No. 94.1 /UL 50E and of the following types unless otherwise specified herein or in other specification sections of mechanical trades work;
 - (a) indoor installation, general use: Type 1 or 12
 - (b) outdoor installation: Type 3, 3R or 4.
 - .3 allow for additional space inside of enclosure to allow installation of motor current transducers/transmitters (provided under Division 25).
- .3 Disconnecting means:
 - .1 interlocked to disconnect all input power to the motor controller, and lockable in the open position,
 - .2 door mounted or enclosure-flange mounted operating handle.
- .4 Overcurrent protection – fuses:
 - .1 HRC current and energy limiting, type “J” time-delay, with NEMA Class “J” rejection type mountings,
 - .2 minimum interrupting capacity: 200 kAIC.

Standard of Acceptance

- Ferraz Shawmut - Amp-Trap 2000-AJT
- Littelfuse-JTD_ID Series
- Bussmann-LPJ-SPI
- .3 size fuses installed in motor controllers, or in disconnect switches used in conjunction with motor controllers, for branch circuits to the maximum value permitted for motor overcurrent protection in accordance with CSA C22. 1.
- .4 provide one spare set of three fuses for each rating and type of fuse used.]
- .5 Contactor and motor overloads:
 - .1 NEMA magnetic contactor, with 120 VAC, 60 Hz control coil.
 - .2 integral or bolt-on overload relay with monitoring of each phase:
 - (a) solid state, adjustable setting,
 - (b) manual reset button,
 - (c) sized and set to suit characteristics of motor,
 - (d) Form C overload status contacts.

- .6 Control transformer:
 - .1 120 VAC with fused primary and secondary circuits, sized for starter requirements plus an additional 50 VA for remote damper or valve actuator.
- .7 Operating controls:
 - .1 door panel mounted, momentary push-buttons (Start-Stop) or three-position selector switch (Hand-Off-Auto) as shown,
 - .2 Hand-Off-Auto selector switches provided with additional contact block to allow remote monitoring when selector switch is in the Auto position.
- .8 Pilot lights:
 - .1 type: 120 VAC, push-to-test LED with lamp transformer,
 - .2 quantity: three cover mounted pilot lights arranged for Fault (red), Ready (amber), and Running (green)].
- .9 Accessories:
 - .1 numbered terminal strips and function identification for field-connected control devices,
 - .2 auxiliary contacts and/or auxiliary relays to satisfy interlocking and automatic control requirements.
- .10 Control units for motor winding over-temperature sensors:
 - .1 control unit as specified herein, compatible with PTC sensors provided in applicable motors.

2.3 Single Phase Manual Motor Controllers

- .1 Single pole manual type with interchangeable and adjustable overload heaters.
- .2 Rating: motor rated up to ½ HP at 120 VAC and 1 hp at 240 VAC.
- .3 Enclosure:
 - .1 complete with mechanically fastened steel cover plate, pilot light and handle guard with standard junction box,
 - .2 flush-mounted in all indoor spaces except in mechanical service rooms, electrical service rooms, vehicle garages, or where the finished wall is poured concrete:
 - .3 surface mounted in mechanical service rooms, electrical service rooms, vehicle garages, or where the finished wall is poured concrete.
 - .4 surface mounted for outdoor installations.

2.4 Full-Voltage Magnetic Motor Controllers ("FVNR")

- .1 Type:
 - .1 full-voltage across-the-line combination motor starter and disconnect switch,
 - .2 for three phase motors, and for single phase motors requiring remote operating control,
 - .3 non-reversing, single speed operation.
- .2 For single phase motors;
 - .1 less control transformer for 120 V motors,
 - .2 single-pole, single phase motor contactors, or three-pole three-phase motor contactors with power wiring arranged to feed through all three contacts.

2.5 Two-speed and Reversing Motor Controllers ("FVTS", "FVR", "FVTSR")

- .1 Type:

- .1 full-voltage across-the-line combination motor starter and disconnect switch,
- .2 additional contactors and control circuits to perform required operating function:
 - (a) two speed operation ("FVTS"),
 - (b) reversing operation ("FVR"), and/or
 - (c) two-speed forward, single low-speed reversing ("FVTSR").
- .3 control interlocking to prevent simultaneous operation in multi-speeds or bi-directionally,
- .4 adjustable time delay relays minimum 0-60 seconds on change of motor speed or motor direction, for operation in both BAS-Auto mode and local-Hand mode,
- .5 suitable for two-speed AC motors with two-windings (6 leads).

2.6 Motor Thermal (over-temperature) Protection

- .1 Single phase motors:
 - .1 Not applicable: thermal motor protection provided with motor under Section 20 05 13.
- .2 Three phase motors - less than 37 kW (50 HP):
 - .1 Application:
 - (a) constant speed motors less than 37 kW (50 HP) that are mounted in air ducts, plenum chambers or in air stream inside air handling equipment.
 - .2 Winding sensors:
 - (a) winding sensors provided in motors under Section 20 05 13.
 - .3 Control unit:
 - (a) compatible with three (3) Positive Temperature Coefficient ("PTC") temperature sensors, one in each motor winding, wired in series,
 - (b) electronic motor protection module, single channel, 3 sensors per channel,
 - (c) 120 VAC line power,
 - (d) manual reset.

Standard of Acceptance

- Texas Instruments - Klixon model 42AA100E

- .3 Three phase motors - 37 kW (50 HP) and larger:
 - .1 Application:
 - (a) constant speed motors 37 kW (50 HP) and larger.
 - .2 Winding sensors:
 - (a) winding sensors provided in motors under Section 20 05 13.
 - .3 Control unit:
 - (a) compatible with three (3) Positive Temperature Coefficient ("PTC") temperature sensors, one in each motor winding, wired in series,
 - (b) temperature monitoring relay, single channel, 3 sensors per channel,
 - (c) 120 VAC line power,
 - (d) unit holds relay contacts on power supply failure,
 - (e) automatic/manual reset, with remote reset.

Standard of Acceptance

- Siemens - 3RN2

- .4 Additional requirements for three phase motor thermal protection:
 - .1 control unit mounted inside motor controller enclosure,
 - .2 120 VAC power to control unit fed from motor controller,
 - .3 a momentary normally-closed Reset push-button located on front of starter enclosure door,
 - .4 test and test-reset push-buttons located on front of starter enclosure door,
 - .5 auxiliary output relay for safety interlock to motor contactor,
 - .6 red pilot light indicating high-winding temperature,
 - .7 1 N.O. contact for remote alarm monitoring. []

3 EXECUTION

3.1 General

- .1 Coordinate location of motor controllers [][and motor control centers] with the trade contractors under Division 25 and 26, specifically but not exclusively for termination requirements for power and control wiring.
- .2 Provide each controlled motor with a dedicated VFD, unless otherwise shown to group motors on a common VFD on a special case basis.

3.2 Motor Controller Selection and Installation

- .1 Except where equipment is otherwise specified or shown to be provided with a variable speed drive motor controller, provide constant-speed motor controllers of the applicable type listed in the following table, unless otherwise shown in other Specification sections.

Equipment Type	Phase	HHA Controller Diagram Type	Motor Controller Type HP Rating		
			FVNR, FVR, FVMS FVMS-R	RVSS	RVAT
			Motor HP	Motor HP	Motor HP
Pumps	1	L	≤ 0.5	---	---
	3	A, B	≤ 25	>10 and ≤ 50	> 50
Pumps, Duplex	3	C	≤ 25	>10 and ≤ 50	> 50
Fans	1	K, L, LF	≤ 0.5	---	---
	3	A, B, BF	≤ 50	≤ 50	> 50
Packaged Equipment	3	(Note 1)	≤ 50	≤ 50	> 50

Notes:

- (1) Control type as specified in separate equipment specification sections.
- .2 Where motor controllers are not located in an MCC, install motor controllers adjacent to controlled equipment or as otherwise shown. Position the motor controller so that:
 - .1 the door front is readily visible and accessible from the work space,
 - .2 for wall-hung motor controllers: with the top of the motor controls located between 1700 and 1800 mm above the local work surface and all adjacent motor controllers aligned to the same height,

- .3 with a minimum clear space of 1000 mm (40 in.) in front of the motor controller.
- .3 Mount motor controllers to building walls or structure, on Unistrut or similar mounting rails; do not weld miscellaneous support steel to building structure. Secure with seismic-rated fasteners where seismic restraint is required in accordance with specification section 20 05 49.
- .4 Where there is no adjacent or insufficient wall space or building structure upon which to mount the motor controller, provide a floor-mounted fabricated support assembly to mount the motor controller. Design the support assembly to:
 - .1 support the dead-weight of the motor controller,
 - .2 withstand a 220 N (50 lbf) horizontal force from any direction applied to the starter enclosure, with a maximum deflection of 3 mm (1/8 in).
 - .3 resist seismic movement where seismic restraint is required in accordance with specification section 20 05 49.
- .5 Adjust motor circuit breakers equipped with adjustable trip settings as required to suit each motor in-rush current requirement.
- .6 Adjust motor overload protection devices equipped with adjustable trip settings to not exceed;
 - .1 125% of motor full load current rating, for motors marked with a 1.15 or higher service factor, and
 - .2 115% of motor full load current rating, for motors marked with a service factor less than 1.15, and for motors that are not marked with a service factor.

3.3 Motor Winding Over-Temperature Protection

- .1 Coordinate with motor suppliers that the motor winding temperature sensors provided by the motor supplier is compatible with the thermal protection control units, as applicable.
- .2 Provide control wiring between PTC sensors in three phase motors and the over-temperature control units located in motor controllers.

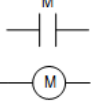
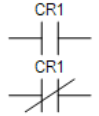
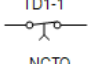
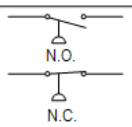
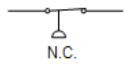
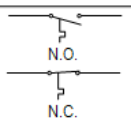
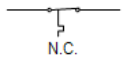
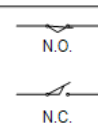
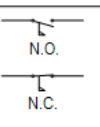
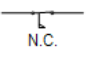
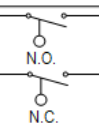
3.4 Identification

- .1 Provide identification nameplates for motor controllers [][and MCC's] in accordance with Section 20 05 53.

3.5 Wiring Diagrams

- .1 The included device legend and motor controller wiring diagrams are to be read in conjunction with equipment specifications, control sequences, and motor/starter schedules for implementation of control sequences and identification of components required in each in each motor controller.
- .2 In the following standard details, motor overcurrent protection is shown as a circuit breaker for illustration purposes. Refer to this specification section and other mechanical trades work equipment specification sections for requirements for the use of circuit breakers or fuses.
- .3 The following standard details provide indicative wiring requirements for motor controllers.
 - .1 20 05 14 – 000 Device Legend
 - .2 20 05 14 – 001 Type "A", 3 Phase - Start/Stop
 - .3 20 05 14 – 002 Type "B", 3 Phase - Hand-Off-Auto
 - .4 20 05 14 – 004 Type "C", 3 Phase - Hand-Off-Auto - Duplex Lead-Lag Starters
 - .5 20 05 14 – 009 Motor Winding Temperature Protection (3 Phase)
 - .6 20 05 14 – 011 Type "K", 1 Phase - On/Off
 - .7 20 05 14 – 012 Type "L", 1 Phase - Hand-Off-Auto

DEVICE SYMBOLS

DISCONNECT 	FUSE 	MOTOR CIRCUIT PROTECTOR MCP 	STARTER 	OVERLOADS 	MOTOR 
TRANSFORMER 	GROUND 	CONDUCTORS NOT CONNECTED  CONNECTED 	TERMINALS  LABELLED TERMINALS ON TERMINAL STRIP	SOLENOID  (VALVE OR DAMPER)	
RELAY COIL 	RELAY CONTACTS 	TIME DELAY: ON-DELAY TD1-1 NOTC 	TIME DELAY: OFF-DELAY TD1-1 NCTO 	TIME DELAY: OFF-DELAY TD1-1 NCTC 	TIME DELAY: OFF-DELAY TD1-1 NOTO 
CONTROL SWITCHES			PILOT LIGHTS		
 MAINTAINED	 MAINTAINED/ SPRING TO OFF	 MOMENTARY		 PUSH-TO-TEST	R: RED A: AMBER G: GREEN W: WHITE B: BLUE
PRESS. SWITCH  N.O.  N.C.	TEMP. SWITCH  N.O.  N.C.	LIMIT SWITCH  N.O.  N.C.	FLOW SWITCH  N.O.  N.C.	LEVEL SWITCH  N.O.  N.C.	METERS  VOLT  HOUR  AMPS  RPM

ABBREVIATIONS

AR	ALARM RELAY	HOA	HAND-OFF-AUTO
CCT	CONTROL CIRCUIT	LS	LIMIT SWITCH
CR	CONTROL RELAY	M	MOTOR
DISC	DISCONNECT SWITCH	MTB	MOMENTARY TEST BUTTON
DPS	DIFFERENTIAL PRESSURE SWITCH	NC	NORMALLY CLOSED
DVR	DOUBLE VOLTAGE RELAY	NO	NORMALLY OPEN
F	FIRESTAT	OL	OVERLOAD
FAS	FIRE ALARM	PB	PUSHBUTTON
FMA	FLOAT MECHANICAL	PE	PRESSURE ELECTRIC SWITCH
FR	FALUT RELAY	PS	PRESSURE SWITCH
FS	FLOW SWITCH	T	THERMOSTAT
FTS	FLOAT SWITCH	TD	TIME DELAY (RELAY)
FZ	FREEZESTAT		

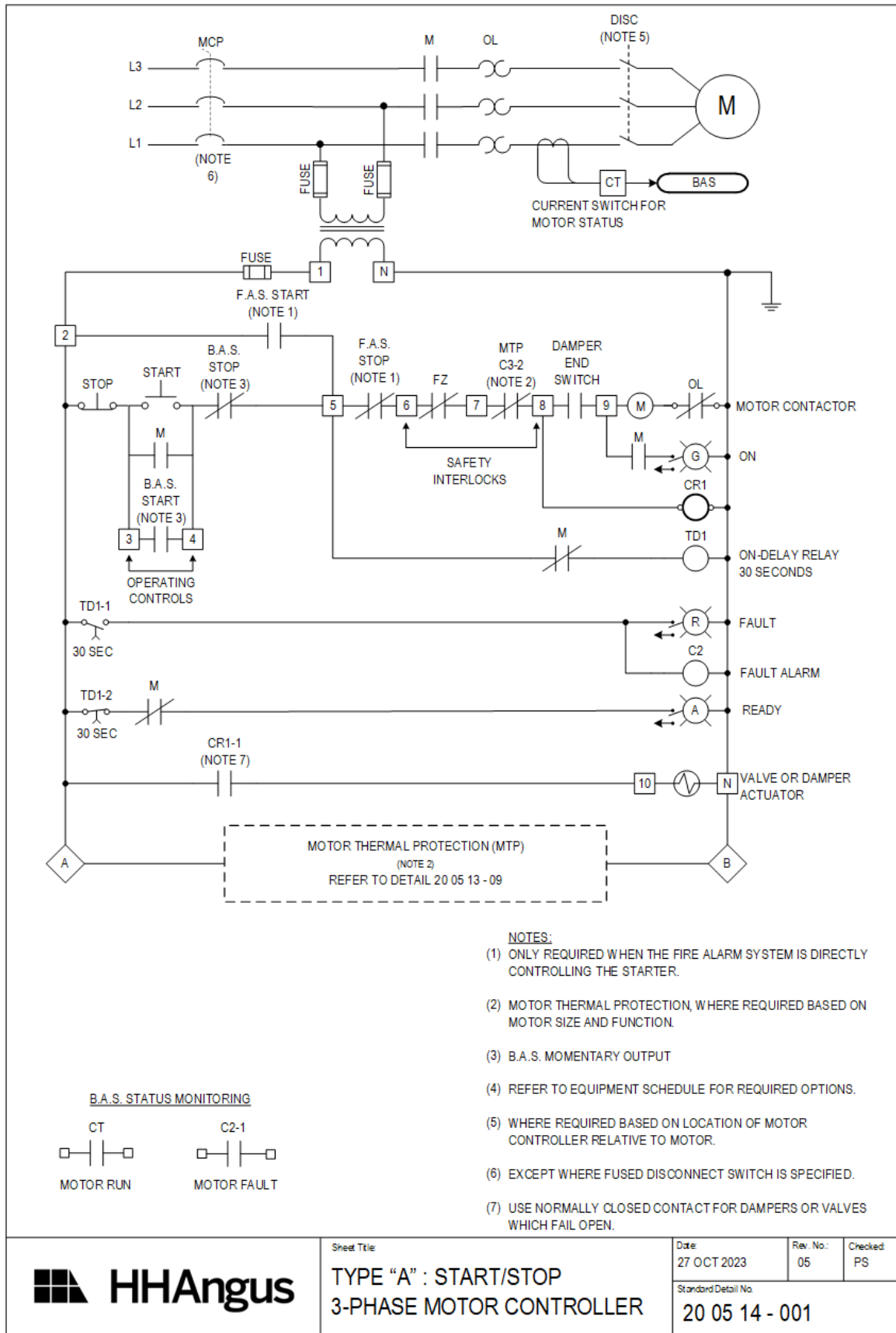
LEGEND

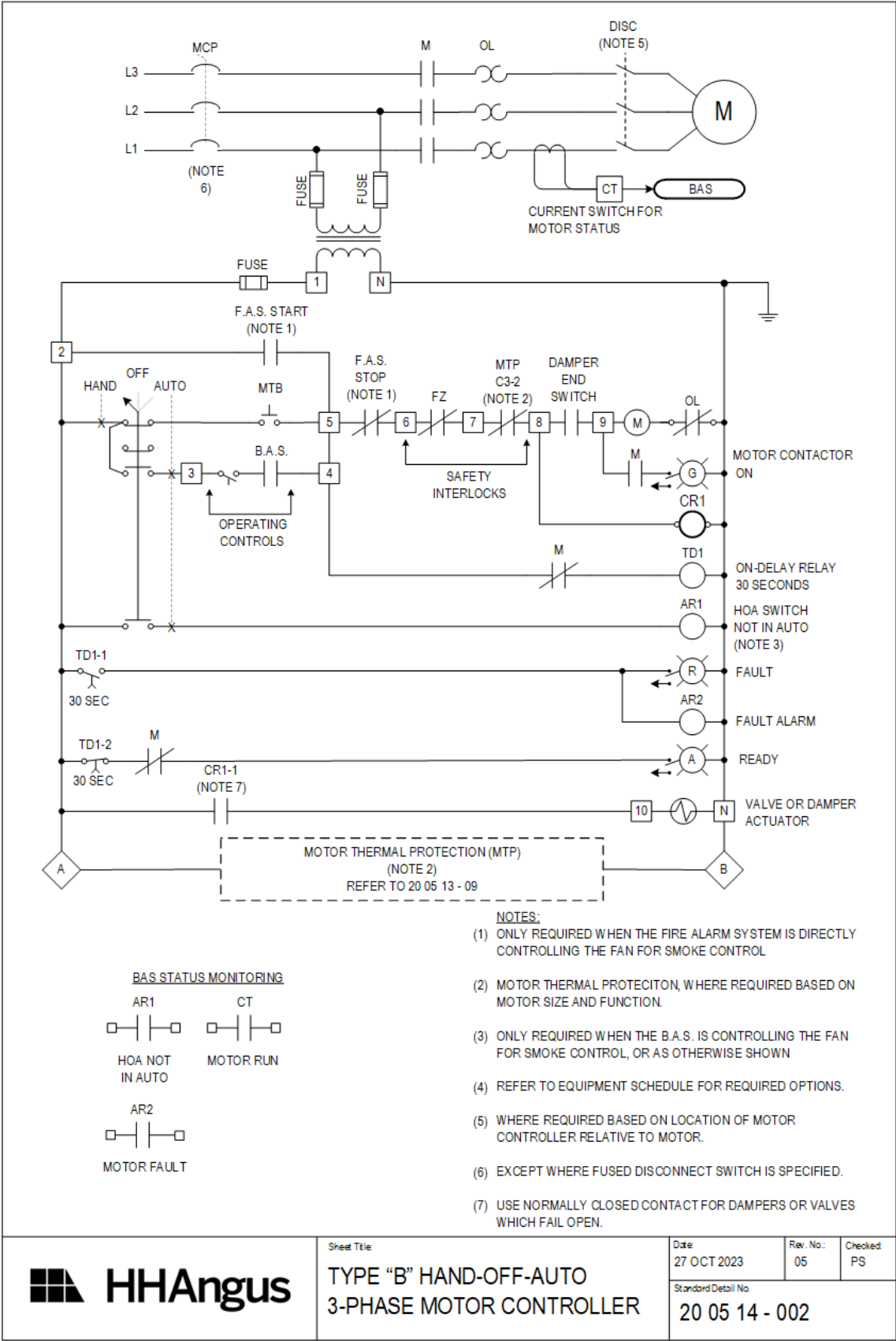
A | B SCOPE OF WORK:
 DIVISION "A" / DIVISION "B"
 BOUNDARY

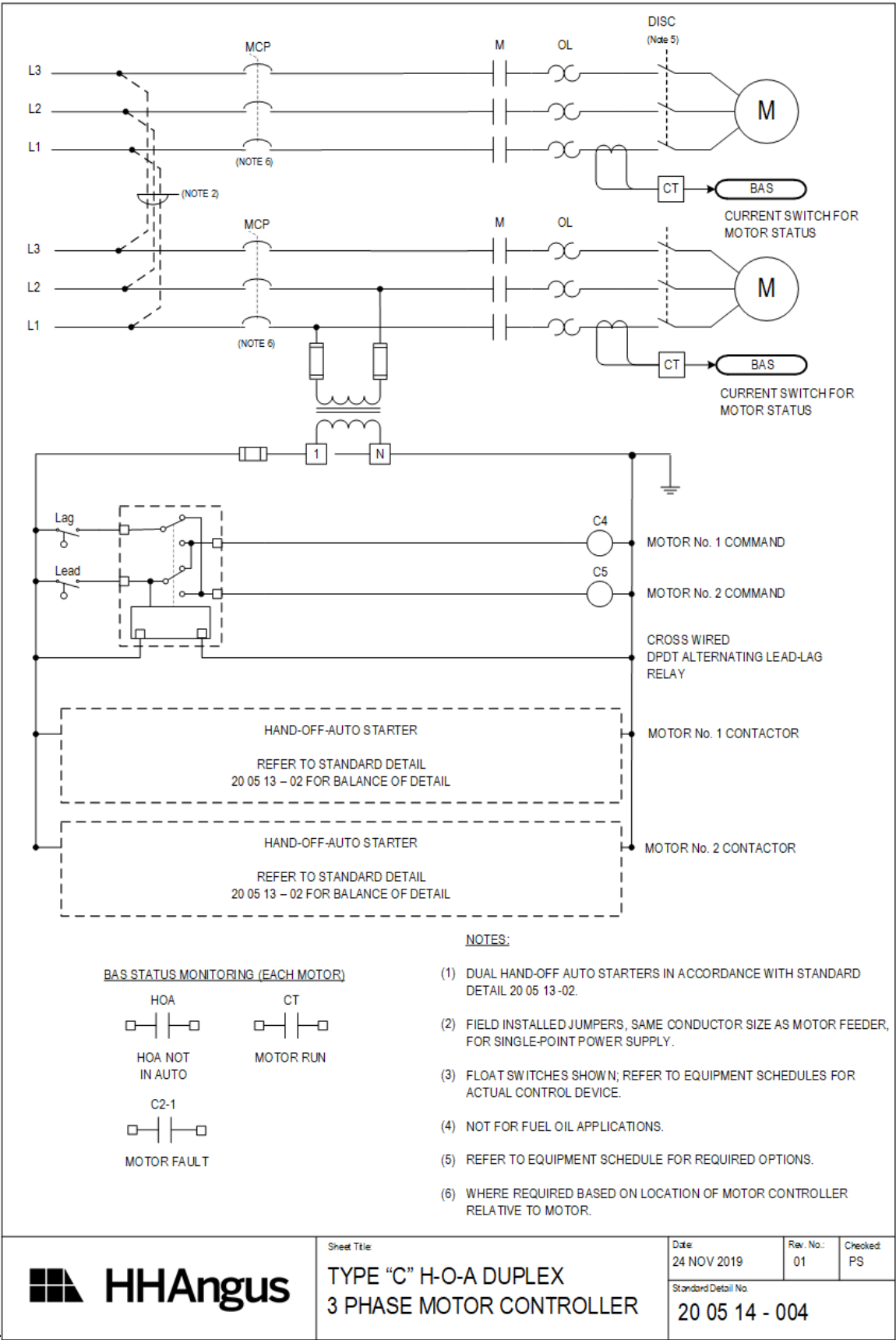


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 DEVICE LEGEND**

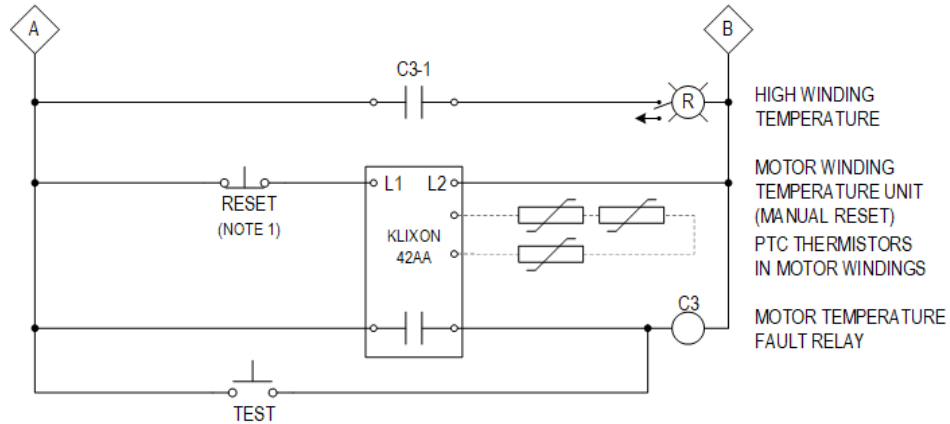
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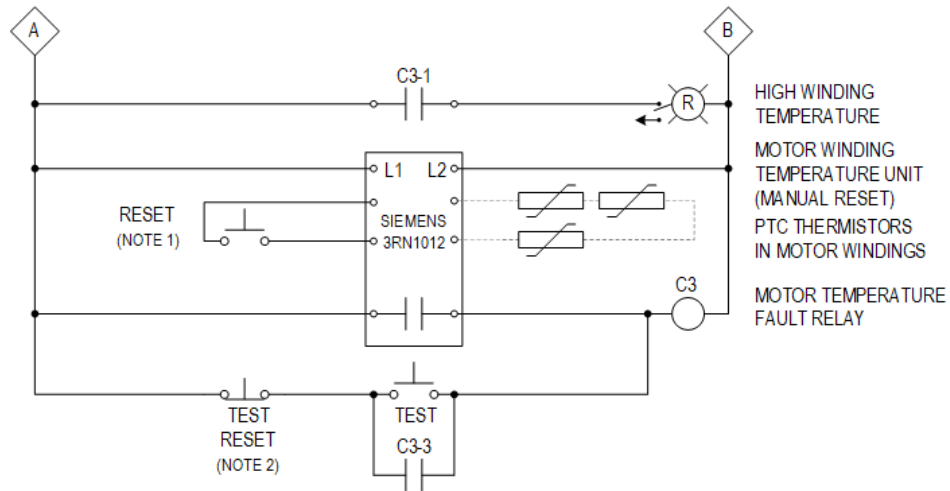




MOTOR WINDING TEMPERATURE PROTECTION
< 50 HP, MOTOR LOCATED IN AIRSTREAM



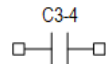
MOTOR WINDING TEMPERATURE PROTECTION
50 HP AND LARGER



NOTES

- (1.) RESET SWITCH LOCATED ON FRONT OF STARTER ENCLOSURE
- (2.) TEST AND TEST-RESET SWITCH LOCATED ON FRONT OF STARTER ENCLOSURE
- (3.) REFER TO SEPARATE STANDARD DETAILS FOR MOTOR CONTROL REQUIREMENTS
- (4.) FOR THREE PHASE MOTORS ONLY. REFER TO SPECIFICATION FOR TYPES OF APPLICABLE INSTALLATIONS

BAS STATUS MONITORING



MOTOR THERMAL
FAULT



Sheet Title

MOTOR THERMAL PROTECTION
3-PHASE MOTOR CONTROLLERS

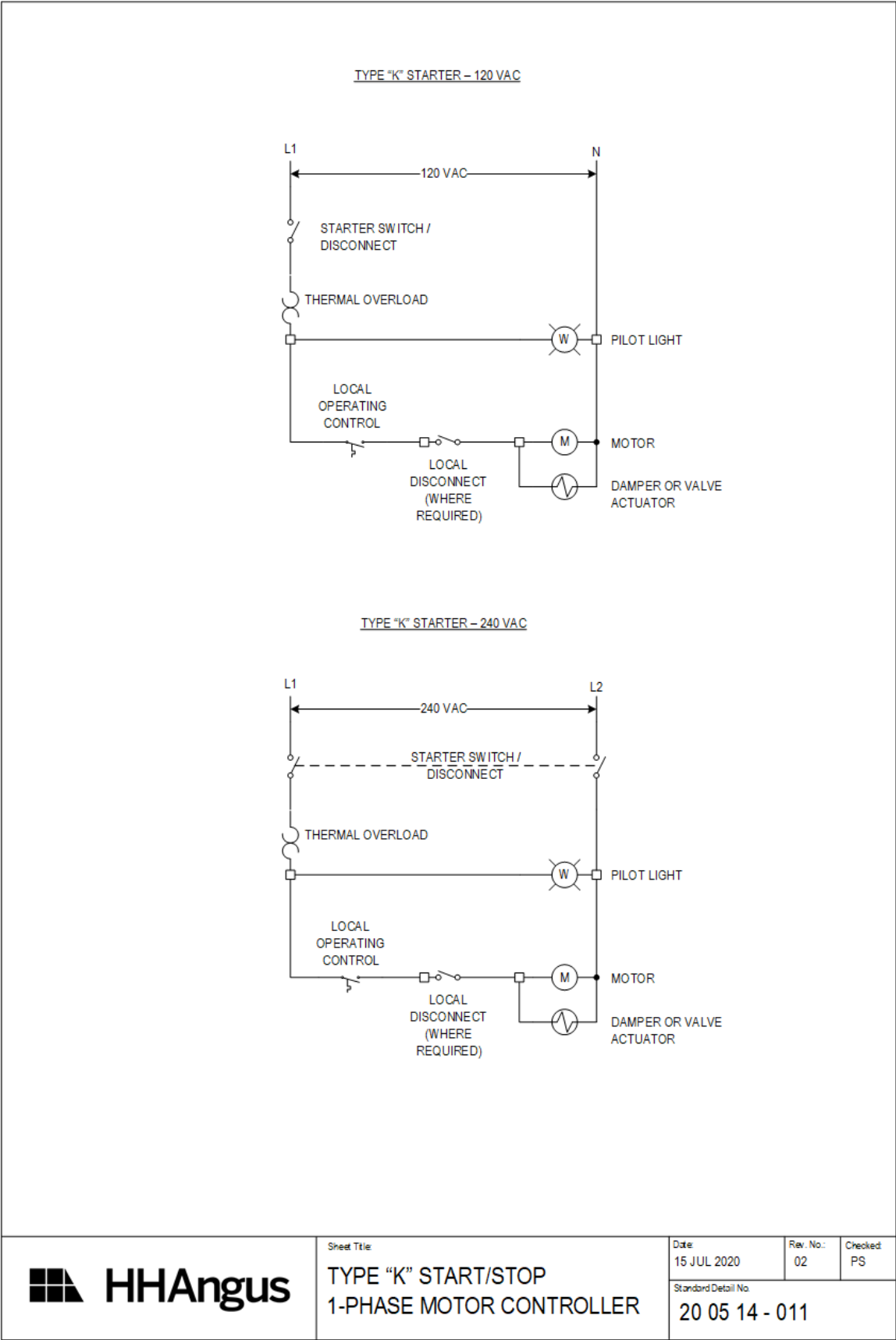
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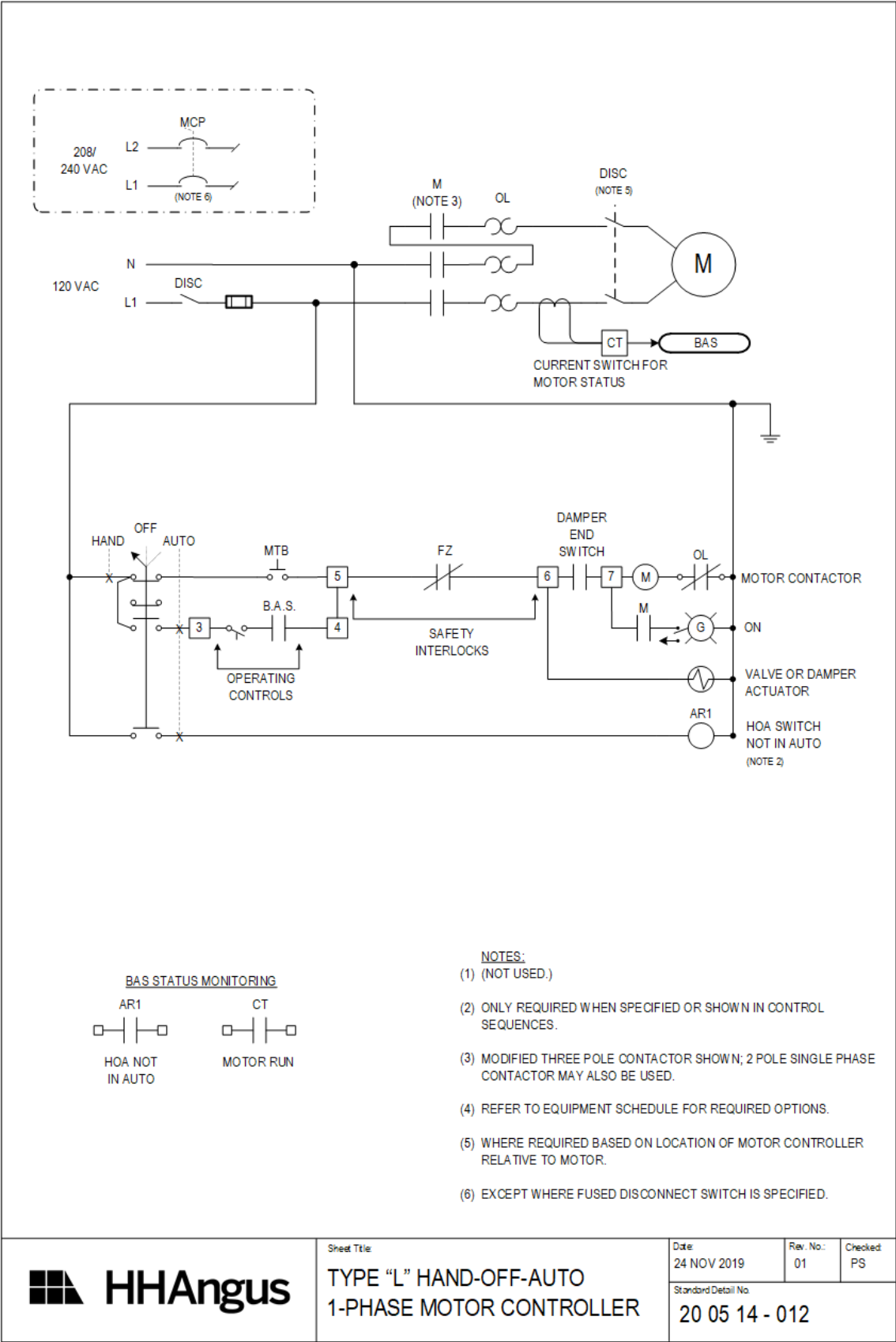
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END OF SECTION

GENERAL REQUIREMENTS FOR VALVES

20 05 23

1 GENERAL

1.1 Scope

- .1 Provide valves in piping systems for shut-off service, manual flow balancing, check-stops and valve bodies for automatic flow control.
- .2 This specification section provides general requirements for valves.

1.2 Related Sections

- .1 Refer to the following specifications sections for requirements for specific-duty valves in addition to the general requirements specified herein.
 - 23 11 13 Facility Fuel Oil Piping and Accessories
 - 23 24 17.16 Services for Selective Catalytic Reduction System
 - 23 24 19 Diesel Exhaust Fluid Systems
 - 23 26 16 Process Tubing and Accessories – Stainless Steel

1.3 Submittals

- .1 Submit manufacturer product data-sheets for valves, including pressure-temperature ratings with confirmation that the valve meets the required MCPR rating specified for each valve.
- .2 Where valves are specified to be listed (certified) to a standard, include the following information for each affected product:
 - .1 applicable standard by name and reference number,
 - .2 name of accredited testing organization or their mark who certified the product, and
 - .3 the testing organization file reference number.
- .3 Where valves are required to have a CRN, include the CRN and its expiry date on each valve submittal.
- .4 Where manufacturer pre-printed data-sheets do not include this information, a schedule may be submitted which includes the manufacturers name, model number and the required listing and/or CRN information described above. Where the product is name-branded for a manufacturer, include the name of the source manufacturer.

1.4 Applicable codes and standards

- .1 Legislation:
 - .1 Valves installed in piping systems which are subject to provincial or federal pressure piping legislation shall have current Canadian Registration Numbers ("CRN") in accordance with CSA B51.
- .2 Installation standards, codes and guidelines:
 - .1 CSA B51 Boiler and Pressure Vessel Code.
 - .2 Refer to applicable piping specification sections for any other specific requirements.
- .3 Product standards:
 - .1 ANSI/ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings

.3	ASME B16.5	Pipe Flanges and Flanged Fittings
.4	ASME B16.10	Face-to-Face and End-to-End Dimensions of Valves
.5	ASME B156.24	Cast Copper Alloy Pipe Flanges and Flanged Fittings
.6	ASME B16.34	Valves Flanged, Threaded and Welding Ends
.7	ASME B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60
.8	ISO 5211	Industrial Valves – Part-turn Actuator Attachments
.9	MSS SP-25	Standard Marking System for Valves, Fittings, Flanges, and Unions
.10	MSS SP-42	Corrosion-Resistant Gate, Globe, Angle, and Check Valves with Flanged and Butt Weld Ends (Classes 150, 300, & 600)
.11	MSS SP-67	Butterfly Valves
.12	MSS SP-68	High Pressure Butterfly Valves with Offset Design
.13	MSS SP-70	Cast Iron Gate Valves, Flanged and Threaded Ends
.14	MSS SP-71	Cast Iron Swing Check Valves, Flanged and Threaded Ends
.15	MSS SP-72	Ball valves with Flanged or Butt-Welding ends for General Service
.16	MSS SP-78	Cast Iron Plug Valves
.17	MSS SP-80	Bronze Gate, Globe Angle and Check Valves
.18	MSS SP-85	Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
.19	MSS SP-110	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
.20	MSS SP-125	Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves
.21	MSS SP-126	In-Line, Spring-Assisted, Center-Guided Check Valves (Carbon, Alloy Steel, Stainless Steel, & Nickel Alloys)
.22	MSS SP-136	Ductile Iron Swing Check Valves
.23	MSS SP-139	Copper Alloy Gate, Globe, Angle, and Check Valves for Low Pressure/Low Temperature Plumbing Applications
.24	NSF/ANSI 61	Drinking Water System Components – Health Effects
.25	NSF/ANSI 372	Drinking Water System Components – Lead Content (formerly NSF/ANSI 61- Annex G).

1.5 Quality and Equivalence

- .1 Valve selections are in general identified by model designations taken from manufacturers catalogues to indicate physical properties and quality requirements not otherwise described.

2 PRODUCTS

2.1 General

- .1 Refer to related specification sections.
- .2 Manufactures and/or trade names listed in Table 1 are acceptable for various indicated valve types, where products offered are essentially similar to those identified by manufacturer or model number under “Standard of Acceptance” designation in the related specification sections.

- .1 Refer to the General-duty valve specification sections and specific-duty valve requirements contained in the related piping system specification sections.
- .2 Additional specification requirements and/or certification requirements may be required by those sections.

Manufacturer	Gate, Globe, Angle, Check	Silent Check	DRV	Butterfly	Plug	Ball
A-Chem Valves & Controls	•			•		•
American Valve						•
APCO		•				
Apollo				•		•
Bonney Forge	•					
Beric	•					
Bray				•		•
Canadian Worchester Controls						•
Challenger				•		
Couplox				•		
Crane	•			•		•
Crane Centreline				•		
Crane Flowseal				•		
Dahl Bros	•					•
Demco				•		
DeZurik				!		
Durabla		•				
Grinnell				•		
Gruvlok				•		•
Hattersley Milliken (Crane)					•	
Jenkins	•			•		•
Keystone				•		
Kitz	•			•		•
MA Stewart (MAS)	•					•
Milwaukee Valve				•		•
Mueller		•		•	•	
Neo Valves	•					•
Nibco	•	•		•		•
Nordstrom					•	
Powell	•					
Preso			•			
S.A. Armstrong	•		•			
Shurjoint				•		•
Sure Seal				•		

Manufacturer	Gate, Globe, Angle, Check	Silent Check	DRV	Butterfly	Plug	Ball
Tour & Anderson			•			
Toyo Valve (Red & White)	•					•
Triad				•		
Trueline	•					•
Valmatic		•				
Velan	•			•		•
Victaulic				•		•
Watts	•			•		•
WKM				•		

3 EXECUTION

3.1 Valve Selection Criteria

- .1 Select valves in accordance with function criteria as shown in Table 2.

Table 2: Valve Function Selection						
Function	Gate	Butterfly	Ball	Globe	Plug	DRV
Shut-Off	•	•	•		•	
Flow balancing and shut-off					• [1] [2]	•
Flow Balancing only (excluding pumps)				•		•
Pump Balancing		• [1] [3]		•		•

Notes:

- [1] Gear operator with position limit memory stops.
[2] Non-lubricated plug valve designed for flow balancing.
[3] Sized one (1) NPS line size smaller than pipe line size (not pump discharge size).

3.2 Piping System Drain Valves

- .1 Provide drain valves on piping and at equipment as follows unless otherwise shown on drawings:
- .1 On pipe mains and branches NPS 3 and under, and for equipment with pipe connections NPS 4 and smaller:
 - (a) NPS ¾ ball valve in accordance with pipe system specification with integral NPSH ¾ hose end with cap and chain.
 - .2 On pipe mains NPS 4 to NPS 6, and for equipment with pipe connections NPS 6 and larger:
 - (a) NPS 1 ball valve, with a NPT threaded brass Cam and Groove female coupler fitting with dust-plug

- .3 On pipe mains NPS 8 and larger:
 - (a) NPS 2 ball valve, with a NPT threaded brass Cam and Groove female coupler fitting with dust-plug.

3.3 Valve Installation - General

- .1 Install shut off valves at:
 - .1 branch take-offs,
 - .2 to isolate piping to each piece of equipment, and
 - .3 in locations shown.
- .2 Remove internal parts of valves before soldering, welding or brazing pipe to valve body.
 - .1 Exception: where valve is provided with tube end extensions to allow soldering or brazing without removal of internal parts.
 - .2 For valves which do not permit disassembly including ball valves and inline check valves, comply with valve manufacturer instructions to protect valve internal components during soldering, brazing or welding.
- .3 Install triple duty or throttling valves where shown in pump discharge piping with ten pipe diameters of straight pipe on the inlet side and two pipe diameters on outlet side.
- .4 Install butterfly valves between weldneck or slip-on flanges.

3.4 Valve Orientation and Accessibility

- .1 Arrange valve hand-wheels and operating levers to be accessible.
- .2 In equipment rooms and service spaces provide chain operators for valves mounted more than 2m (6 ft) above floor or access platform. Provide sufficient chain length to extend to 1.5m (4 ft-6 in) above floor or platform and to be hooked on clips secured to building structure, clear of walking aisles.
- .3 In horizontal piping (see figure 1);
 - .1 For OS&R valves, install the valve with stem vertical where the valve centerline is not more than 1200 mm above the adjacent floor or access platform. For greater heights, install the valve with stem horizontal. Where space is restricted, the valve may be installed with the valve spindle at a 45° angle from the vertical where the valve centerline is not more than 1500 mm above the floor or access platform.
 - .2 For gear operated valves, install with gear-box on top of the valve and hand-wheel shaft in the horizontal position.
 - .3 For lever operated valves, install with handle on top of valves where the valve centerline is not more than 1500 mm above the floor or access platform. Where spaces is restricted, the valve may be positioned with the lever handle shaft in the horizontal position. For greater heights, install valves with handle shaft in the horizontal position.

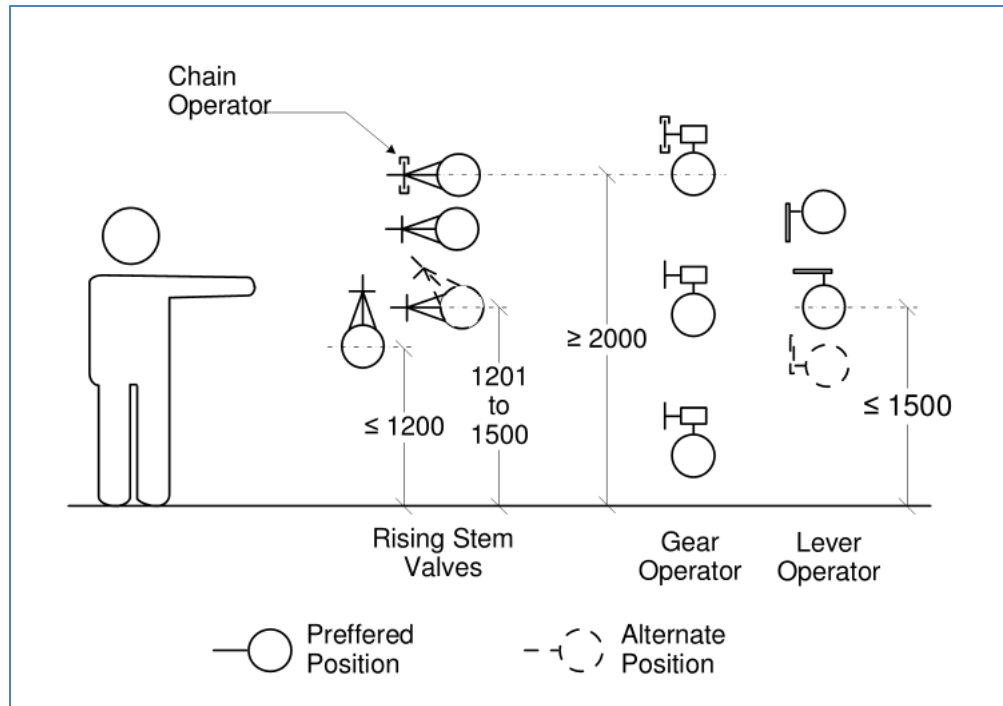


Figure 1: Valve Spindle Arrangement

- .4 In vertical piping, install with valve stem facing directly towards the means of access. Where access space in front of the valve is less than 900 mm (36 in), rotate the valve 45° from the straight forward position.

END OF SECTION

WELDING AND BRAZING

20 05 24

1 GENERAL

1.1 Scope

- .1 Weld or braze pipe and fittings for work of Division 20.

1.2 Definitions

- .1 The following definitions apply to this specification section:

AHJ (BPV): *the authority having jurisdiction which is responsible for boiler, pressure vessel and pressure piping safety in the province of the project.*

- .2 In this specification,
 - .1 the word “piping” also includes tubing as the case applies.
 - .2 the words “welding” or “welder” shall be read as to also refer to “brazing” or “brazer” unless the context otherwise dictates one or the other.

1.3 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASME B31.1 Pressure Piping
 - .2 ASME B31.3 Process Piping
 - .3 ASME B31.9 Building Services Piping
 - .4 ASME BPVC Section V Nondestructive Examination
 - .5 ASME BPVC Section IX Welding and Brazing Qualifications
 - .6 CSA B51. Boiler, Pressure Vessel, and Pressure Piping Code

1.4 Quality Control

- .1 Welding of piping systems which have specified design pressures greater than 100 kPa (15 psi) to be carried out using approved welding procedures by welders certified for pressure piping by the AHJ (BPV), whether or not the piping system is subject to registration as pressure piping.
- .2 Welding procedures shall be registered with the AHJ (BPV), in accordance with CSA B51 and as qualified in accordance with ASME BPVC Section IX.
- .3 Welders shall be certified for welding of pressure piping in accordance with the requirements of the AHJ (BPV). Welders shall be qualified by their employer on the employers welding procedures.
- .4 For piping systems which have specified design pressure of 100 kPa (15 psi) or less, welding procedures and welders shall be qualified by the Contractor in accordance with the requirements of ASME B31.9.

2 PRODUCTS

2.1 Not used

3 EXECUTION

3.1 Welding Method and Quality

- .1 Welding, both shop and field, to be electric arc in accordance with recommendations of Canadian Welding Bureau unless other welding methods are specified in the piping specification sections.
- .2 Welds to be solid homogeneous part of metals joined and free from pits, slag-inclusions, and scale.
- .3 Weld surfaces to be smooth and regular and weld metal deposition to achieve full penetration groove weld fused to the base metal throughout joint thickness. Fillet welds, where permitted or required by applicable piping codes, shall achieve adequate depth of fusion of the base metal as required by those codes.
- .4 Brazed joints to use brazing filler and fluxes as specified for each applicable piping system. For socket joints, the tube and joint are to overlapped not less than four times the thickness of the thinner base material, with filter material penetrating to this full depth and finished with well-developed fillet.

3.2 Welded Connections to Existing Pressure Piping Systems

- .1 At the commencement of the Work, where registration and/or inspection of the piping system is required in accordance with provincial boiler and pressure vessel regulations, review with the AHJ (BPV) inspector to determine their weld testing requirements to validate the proposed welding procedures for connecting to existing piping, including but not limited to:
 - .1 acceptable dimensional misalignment between old and new pipe;
 - .2 requirements, if any, for metallurgical analysis of exiting piping;
 - .3 sample butt weld guided-bend test; and
 - .4 sample fillet weld test.
- .2 After testing requirements are determined, provide a proposed schedule for tie-in connections and required existing service shut-down periods, for approval prior to commencing work.
- .3 Prior to shut-down of existing piping systems for tie-ins, inspect the existing pipe O.D. dimensions to confirm their suitability for pipe attachment. Specifically, where the work requires a complete transection of an existing pipe, check the existing pipe for excessive out-of-roundness which would otherwise exceed the allowable misalignment as defined in the applicable ASME piping code. Where necessary, trim the pipe ends in accordance with the referenced piping code.

3.3 Welding Examination

- .1 For piping systems which are specified to be constructed to ASME B31.1 or ASME B31.3, examination of pipe welds, including both visual and other nondestructive examination performed in accordance with those piping codes shall be arranged and paid for by the Contractor, and are to be performed by a specialist testing company whose personnel are qualified to perform such examinations in accordance with ASME BPVC Section V.
- .2 For piping systems which are specified to be constructed to ASME B31.9, examination of pipe welds in accordance with that piping code shall be performed by the Contractor using personnel who are suitably experienced for such examinations.
- .3 Acceptance criteria for weld examination shall be in accordance with the specified ASME piping code applicable to each piping system and as may be specified in other Specification sections of Division 21 to 23.

- .1 for clarity, where ASME B31.9 code applies to a piping system, the weld examinations and weld defect acceptance criteria are summarized in the following table.
- (a) Notwithstanding the listed weld defect criteria, the overall quality of the weld shall also be able to meet the requirements for incomplete weld penetration and weld root concavity. However, examination of the interior surface of the weld is not required.

Table 1: Weld Defect Acceptance Criteria – ASME B31.9		
Type of Weld	Weld Defect	Acceptance Criteria
Girth (butt) weld, Groove weld, Fillet weld, Socket weld, Seal weld	Cracks	None
	Lack of fusion	Length of unfused areas $\leq$ 20% of pipe circumference or total length of weld, and not more than 25% in any 150 mm (6 in.) of weld
	Undercut	Not exceed the lessor of 1 mm (1/32 in.) or 12.5% of wall thickness.
	Weld surface	Weld reinforcement not to exceed 4.8 mm (3/16 in.)

3.4 Welding Inspection

- .1 Arrange and pay for any required inspection of welds by the AHJ (BPV).
- .2 Welders certificates and welding procedures used for the Work to be made available for inspection by the AHJ (BPV) on demand. Provide traceability of welders work by either stamping each weld with the welder's identifying number, or maintain a record log to record and identify each welders work.

END OF SECTION

COMMON HANGER AND SUPPORT REQUIREMENTS FOR PIPING

20 05 29

1 GENERAL

1.1 Scope

- .1 Provide hangers and supports for piping, including insulation protection devices.
- .2 The requirements of this specification section apply to all piping systems, except where required otherwise by specific piping specification sections including:
 - .1 23 11 13 Facility Fuel Oil Piping and Accessories
 - .2 Applicable sections of Division 22 sections for plumbing and drainage piping,
- .3 Provide engineering services associated with the design, analysis, and selection of custom piping supports, including pipe riser supports.

1.2 Related Work

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 48 Vibration Isolation
 - .2 20 05 49 Seismic Restraints for Mechanical Services
 - .3 20 07 19 Piping Insulation

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section:
 - .1 **Ambient piping:** piping with a fluid temperature greater than 16°C (61°F) and up to and including 40°C (104°F).
 - .2 **Cold piping:** piping with a fluid temperature greater than 4°C (39°F) and up to and including 16°C (61°F).
 - .3 **Dual temperature piping:** piping which operates non-simultaneously as both cold piping and hot piping depending on the season.
 - .4 **Hot piping:** piping with a fluid temperature greater than 60°C (140°F).
 - .5 **Low temperature piping:** piping with a fluid temperature greater than 40°C (104°F) and up to and including 60°C (140°F)

1.4 Applicable Codes and Standards

- .1 Product and installation codes and standards:
 - .1 ANSI/MSS SP-58 Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation
 - .2 CAN/UL 203 Standard for Pipe Hanger Equipment for Fire Protection Service
- .2 Refer to each applicable piping specification section for supplemental requirements for pipe supports.

1.5 Analysis, Design, and Inspection Services

- .1 Where custom fabricated pipe and equipment supports are proposed to be used, provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in the design of piping and equipment supports (the "Specialty Engineer"), for the design of piping and equipment support systems and to provide inspection services of the completed installation.

- .2 Provide services of a Specialty Engineer for the design and selection of constant-load and variable-load hanger supports. Where a manufacturer of such equipment provides this design service, this is deemed to meet this requirement.
- .3 Specialty Engineer design services to include;
 - .1 provide the design of the piping support system, including anchors, guides, expansion joints, and shall include seismic restraints where applicable,
 - .2 analysis of dead loads, thermal expansion loads, wind load, static seismic loads (where applicable) and capacity of materials utilized for connections to equipment and structure.
 - .3 provide design drawings showing locations of supports, restraints and details of construction and attachment of supports and restraints,
 - .4 seismic design to conform to Specification section 20 05 49 where applicable.
- .4 Specialty Engineer inspection services to include:
 - .1 at periods during installation and at completion of the installation of the piping supports and anchor devices, the Specialty Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected,
 - .2 Specialty Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation. Include in the final report site photographs of the complete installation prior to covering with insulation, with specific photos at pipe anchors, guides, and expansion joints.
- .5 Provide shop drawings of custom supports, which shall be sealed by the Specialty Engineer.
- .6 Provide signed declarations for commitment for general review and final review letters of conformity as required by applicable legislation at the place of the Work.

1.6 Design Criteria

- .1 The support spacing and hanger rod size specified herein is based on supporting a single pipe directly from the structure in accordance with MSS SP-58. If multiple pipes are supported from trapeze hangers (or similar), or from common hanger rods supporting a tier of multiple piping, then;
 - .1 the total load on the support rods or similar elements shall not exceed published tension load rating data in accordance with Table 2 of MSS SP-58.
 - .2 design of custom trapeze hangers shall meet the design criteria as specified in Part 2 of this section.
- .2 Provide complete custom engineered design services in accordance with the requirements of MSS SP-58 for support of vertical piping for the following portions of the Work:
 - .1 vertical piping located in vertical services spaces (shafts) where any of the following criteria apply;
 - (a) piping is NPS 8 and larger,
 - (b) the vertical pipe length exceeds 25 m (82 ft),
 - (c) pipe expansion joints are shown, or
 - (d) vibration isolated supports, variable spring supports or constant load supports are shown.
 - .2 where horizontal piping is supported on;
 - (a) trapeze hangers or supported on/suspended from horizontal structural elements, or
 - (b) pipe racks.

- .3 Where the mechanical system are required to have seismic restraints, this section is to be read in conjunction with the requirements of Specification section 20 05 49.
- .4 Pipe support spacing and/or selection of pipe support types may be other than as specified herein provided the pipe supports are determined by a completely custom engineered system in accordance with the requirements of MSS SP-58 and as follows:
 - .1 all loads used for designing of supports are concurrent static and dynamic loads including vibration, seismic (where applicable to the project), and where applicable wind and snow loads in outdoor installations,
 - (a) for clarity, the design does not need to consider seismic loads concurrently with wind or snow loads.
 - .2 horizontal pipe vertical deflection at midpoint in the pipe span while in operation not to exceed 2.5 mm (0.10 in.),
 - .3 deflections of horizontal supporting elements does not exceed $1/240^{\text{th}}$ of the span,
 - .4 design load for carbon steel materials: not to exceed 28% of minimum tensile strength nor exceed 50% of minimum yield strength in combined tension/compression and bending,
 - .5 design load for stainless steel and low alloy steel materials: not to exceed 20% of minimum tensile strength and 45% of minimum yield strength in tension/compression and bending.
 - .6 rod hanger loads are not to exceed 90% of the table 2 values in MSS SP-58.
 - .7 maximum single point suspended tension load in concrete not to exceed 20.5 kN (4600 lbs.),
 - .8 operating pipe stress not to exceed the maximum allowable stress in accordance with the requirements of the piping code specified for the piping system.
- .5 Where custom engineered support systems are used, submit shop drawings designed and sealed by a professional engineer licensed in the province of the Work, and include details for each support system including imposed load calculations.]

1.7 Submittals

- .1 Submit manufacturer product data sheets for hanger components, and include:
 - .1 load ratings,
 - .2 typical composite detail drawings for complete hanger assembly, including upper attachment, hanger rods, hanger rod swivels, pipe attachments, shields and saddles, and load ratings, for each pipe condition and size.
- .2 Submit support details for glass, fibre-reinforced plastic, and other plastic piping systems which are coordinated with the piping material manufacturer installation instructions.
- .3 Where variable spring supports or constant load supports are shown, provide completely engineered design and fabrication drawings, including any supplementary steel requirements, and loads transferred to the building structure.
- .4 Submit engineered design drawings for fabricated trapeze hangers and completely engineered support systems, including
 - .1 construction detail drawings for each loading condition,
 - .2 span deflection calculations,
 - .3 building attachment load calculations and type.
 - .4 shop drawings to be sealed by a professional engineer licensed in the project location jurisdiction.
- .5 Where custom designed supports are proposed, shop drawings are to be sealed by a professional engineer licensed in the place of the Work.

1.8 Quality Control

- .1 Where custom engineered supports are used, provide the services of a specialist professional engineer licensed in the location of the Work, to design the support systems and to conduct an inspection of the completed installation that it is in general conformance with the sealed shop drawing requirements, and submit an inspection report to the Owner and the Consultant.

2 PRODUCTS

2.1 General

- .1 Fabricate pipe hangers, supports, sway braces and associated components from stock or production parts, manufactured and fabricated in conformance with MSS SP-58, and the requirements of the piping code specified for each piping system.
- .2 Pipe hangers and supports for fire protection systems to be listed to CAN/UL 203, except where such listing requirement is excluded under applicable NFPA standards.
- .3 Select elements of pipe support systems to provide adequate factors of safety under loads applied by gravity, by temperature induced expansion and contraction, by internal pressure in mechanically jointed plain end pipe, and by fluid flow pressure thrust.
- .4 Where specified products define the applicable pipe size NPS range (notwithstanding that the product may be available for larger pipe sizes), the maximum specified pipe size is limited to not exceed the load rating of the specified product under maximum allowable pipe spans as defined in MSS SP-58 for insulated pipe filled with water.
- .5 Product finishes (unless otherwise specified for each product):
 - .1 outdoors: hot dipped galvanized,
 - .2 in mechanical service rooms, pipe tunnels and pipe trenches: zinc-plated or hot-dipped galvanized,
 - .3 within data server and switch equipment rooms: plain carbon or hot-dipped galvanized,
 - .4 all other indoor locations: plain carbon steel or zinc-plated steel.
- .6 Select pipe support products from manufacturers standard product line.

Standard of Acceptance

- Anvil
- Unistrut
- Taylor
- Acrow Richmond
- Portable Pipe Hangers
- Hilti
- nVent Caddy
- Pipe Shields
- Buckaroos

2.2 Upper Attachments – Inserts for New Concrete

- .1 General:
 - .1 upper hanger attachment for casting into new cast-in-place concrete decks, for piping or equipment supports,
 - .2 for attachment to formwork prior to concrete pour,
 - .3 designed to receive USS coarse thread hanger rods.

- .4 in the following tables, pipe size limit is based on insulated pipe filled with water at the maximum allowable span in accordance with Schedules A1(a), A2(a), and A3 at the end of this section. Larger pipe sizes may apply where reduced spans are used in accordance with the alternate rod size and support span limits in accordance with Schedules A1(b) and A2(b) as the end of this section.
- .2 Fixed rod position:
 - .1 fixed position type,
 - .2 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
 - .3 materials: malleable iron, or zinc-plated carbon-steel with plastic form, with nailing feature,
 - .4 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	5.0 (1130)	3
Ø5/8	5.6 (1260)	4
Ø3/4	11.1 (2500)	8

Standard of Acceptance

- Anvil - fig. 152
- Hilti - fig. KCM

- .3 Fixed rod position – high capacity:
 - .1 fixed position type,
 - .2 stainless steel insert body, with two (2) fibreglass and concrete barrier disc for attachment to concrete rebar,
 - .3 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/4	14.4 (2500)	8
Ø7/8	19.9 (4480)	12
Ø1	26.2 (5900)	18
Ø1-1/4	42.2 (9500)	20
Ø1-1/2	61.4 (13,800)	30

Standard of Acceptance

- Anvil - fig. 286

- .4 Single-direction adjustable rod position:
 - .1 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8.
 - .2 galvanized wedge inserts to MSS SP-58 type 18, with single-direction adjustment of rod position,

- .3 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	5.0 (1130)	3
Ø5/8	5.6 (1200)	4
Ø3/4	11.1 (1200)	8

Standard of Acceptance

- Anvil - fig. 281
- Unistrut - fig. P-3245

- .5 Concrete inserts – channel type;

- .1 single hanger or multiple hangers support,
- .2 2.75 mm (12 Ga) thick channels, hot-dipped galvanized, with concrete embedment tabs, open bottom channel allowing multiple support points and lateral position adjustment,
- .3 with back plates, end caps and closure strips to prevent concrete spillage into channel space,
- .4 minimum point load spacing: 300 mm (12 in.)
- .5 maximum tension load rating for single hanger support:

Channel Length mm (in.)	Tension Load kN (lbf)	Tension Load kN/m (lbf/ft)	Single Pipe Size Limit NPS
200 (8)	4.4 (1000)	---	6
300 (12)	6.6 (1500)	---	8
450 (18)	17.8 (4000)	23.8 (2000)	12

Standard of Acceptance

- Unistrut - fig. P-3249 to P-3270 series.

2.3 Upper Attachments – Anchors for Existing Concrete

- .1 General:

- .1 upper hanger attachment for anchoring into existing concrete decks, for piping or equipment supports,
- .2 designed to receive USS coarse thread hanger rods.

- .2 Drop-in anchors:

- .1 zinc-plated carbon steel drop-in friction anchor design, with matched drill bit and setting tool,
- .2 not to be used for seismic restraints or hanger rods at pipe hangers having seismic restraint,
- .3 rated for uncracked concrete,
- .4 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
- .5 capacity rating with 4:1 safety factor to ultimate load,

- .6 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	2.82 (635)	2
Ø1/2	4.2 (945)	3
Ø5/8	8.34 (1875)	4
Ø3/4	11.1 (2500)	8

Standard of Acceptance

- Hilti - fig. HDI, HDI+, HDI-L+

- .3 Wedge anchors:

- .1 anchor-end wedging action on concrete, and not relying on friction between side of bolt and concrete hole wall,
- .2 zinc-plated carbon steel wedge anchor design with load washer and nut,
- .3 wedge anchor capacity as specified herein to be rated for cracked concrete having not less than 20 MPa (2900 psi) strength.
- .4 rated for cracked and uncracked concrete,
- .5 listed for seismic tension and shear loads in accordance with ACI 355.2 and ICC-ES AC193.
- .6 listed to CAN/UL 203 for fire protection piping, for pipe NPS ¾ through NPS 8,
- .7 extra-long bolt length to allow attachment of hanger rod coupling with full thread engagement in the coupling, while providing required load engagement length,
- .8 standard rating: minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	4.85 (1090)	2
Ø1/2	7.52 (1690)	3
Ø5/8	12.1 (2715)	4
Ø3/4	15.5 (3495)	8

Standard of Acceptance

- Hilti - fig. Kwick Bolt series

- .9 high-capacity rating: minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)
Ø3/8	14.0 (3150)
Ø1/2	20.8 (4675)
Ø5/8	29.1 (6535)

Rod Nominal Size	Tension Load kN (lbf)
Ø3/4	40.6 (9135)
Ø7/8	53.4 (12,000)

Standard of Acceptance

- Hilti - fig. HSL-3 series

2.4 Upper Attachment – Mounting Plates

- .1 Surface mounting plates to underside of concrete decks:
 - .1 for installation post concrete pour with either concrete inserts or drilled anchors,
 - .2 surface mount carbon steel plate, with either clevis hanger with pin (for use with hanging rod-eye) or for attachment of hanger rod and load nut,
 - .3 mounting holes in four corners of plate, sized for fastening bolts to achieve rated capacity,
 - .4 minimum load rating in tension based on connected rod size:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.25 (730)	2
Ø1/2	6.0 (1350)	3
Ø5/8	9.6 (2160)	4
Ø3/4	14.4 (3230)	8
Ø7/8	19.9 (4480)	12
Ø1	26.2 (5900)	18
Ø1-1/4	42.3 (9500)	20
Ø1-1/2	61.4 (13,800)	30

Standard of Acceptance

- Anvil - fig. 49 clevis plate,
- Anvil - fig. 52 load nut,
- Taylor - fig. 166 clevis plate,
- Taylor - fig. 167 load nut

2.5 Upper Attachments – Steel Structure

- .1 Steel beam clamp (bottom flange), pipe size NPS 8 and smaller:
 - .1 hanger clamp attachment to beam or joist bottom flange, applying concentric loading to the beam/joist web,
 - .2 for hanger rod sizes Ø3/8 to Ø7/8 in.,
 - .3 malleable iron or carbon steel, symmetrically loading beam clamp to MSS SP-58, type 30,
 - .4 listed to CAN/UL 203 for fire protection piping,
 - .5 minimum load rating in tension: 6.1 kN (1365 lbf)

- .6 with extension piece swivel attachment to receive hanger rod.

Standard of Acceptance

- Anvil - fig. 218 with fig. 157 extension swivel.
- Taylor - fig. 410 with fig. 411 extension swivel.

- .2 Steel beam clamp (bottom flange), pipe size NPS 2½ to 24:

- .1 hanger clamp attachment to beam or joist bottom flange, applying concentric loading to the beam/joist web,
- .2 for hanger rod sizes Ø5/8 to Ø1-1/2 in.,
- .3 forged steel, symmetrically loading heavy duty beam clamp, to MSS SP-58, type 28 or 29.
- .4 load rating based on standard hanger rod load capacities in accordance with MSS SP-58,
- .5 with weldless eye nut.
 - Anvil - fig. 228
 - Taylor - fig. 450

- .3 Steel beam (top flange) - for conduit, piping NPS 6 and smaller, and ductwork:

- .1 hanger clamp attachment to the top flange of beam or joist, applying an eccentric loading to the beam/joist,
- .2 carbon steel, hook rod with locking jaw, fasteners and lock washers, to MSS SP-58, type 25,
- .3 for hanger rod sizes Ø3/8 to Ø3/4 in.,
- .4 minimum load rating in tension:

Rod Nominal Size	Tension Load kN (lbf)	Single Pipe Size Limit NPS
Ø3/8	3.2 (730)	2
Ø1/2 to Ø3/4	4.2 (940)	6

- .5 listed to CAN/UL 203 for fire protection piping (rod size Ø3/8 and Ø1/2 in.)

Standard of Acceptance

- Anvil - fig. 227

- .4 Steel joists (joist bottom chord) – for piping NPS 2 and smaller:

- .1 steel washer plates for installation of support rod within the interstice space of double-channel steel joists and open-web steel joints, installed on top and bottom surface of the joist and secured with load nut (top washer plate) and locking nut (bottom washer plate).
- .2 load rating based on standard hanger rod load capacities in accordance with MSS SP-58,
- .3 carbon steel washer plates with locking nuts,

Standard of Acceptance

- Anvil - fig. 60
- Taylor - fig. 80

2.6 Upper Attachments – Wall Brackets

- .1 Medium and heavy-duty wall mounting brackets:
 - .1 welded carbon steel plate or channel assembly, designed to allow at least 75 mm (3 in.) of horizontal adjustment of hanger rod position, to MSS SP-58, Types 32 and 33,
 - .2 carbon steel backplates for through bolting of concrete walls where required by supported load and wall material,
 - .3 for bolting into concrete wall, concrete block, or welding to building structure (where permitted by structural engineer),
 - .4 minimum load rating:
 - (a) medium duty: 6.7 kN (1500 lbs).
 - (b) heavy duty: 13.4 kN (3000 lbs).

Standard of Acceptance

- Anvil - fig. 195 and 199
- Taylor - fig. 801 and 802.

- .2 Light-duty wall mounting brackets:
 - .1 welded carbon steel plate or channel assembly, single point rod support, to MSS SP-58, Types 31,
 - .2 with carbon steel backplates for through bolting of concrete walls where required by supported load,
 - .3 FM approved,
 - .4 for bolting into concrete wall, concrete block, or welding to building structure,
 - .5 minimum load rating: 3.35 kN (750 lbs).

Standard of Acceptance

- Anvil - fig. 194

2.7 Upper Attachment - Swivels

- .1 Clevis swivel:
 - .1 to allow rotation movement of suspended clevis hangers,
 - .2 forged steel clevis with hanger pin, threaded rod socket, to MSS SP-58 type 14,
 - .3 tension load capacity not less than the connected rod load capacity,
 - .4 threaded end connected to concrete insert, with clevis end connected to weldless eye nut or welded eye rod.

Standard of Acceptance

- Anvil - fig. 299
- Taylor - fig. 63

- .2 Weldless eye nut swivel:
 - .1 to allow rotation movement of suspended clevis hangers,
 - .2 forged steel eye nut, threaded rod socket, to MSS SP-58 type 17,

- .3 tension load capacity not less than the connected rod load capacity.
- .4 for connection to top of rod hanger, suspended from a clevis.

Standard of Acceptance

- Anvil - fig. 290
- Taylor – fig. 64

2.8 Hanger Rod

- .1 Continuous threaded rod:
 - .1 carbon steel, USS course thread,
 - .2 tension load ratings to meet or exceed MSS SP-58.

Standard of Acceptance

- Anvil - fig. 146
- Taylor – fig. 54

- .2 Welded eye rod:
 - .1 carbon steel, USS course thread,
 - .2 tension load ratings to MSS SP-58,
 - .3 tension load ratings to meet or exceed MSS SP-58 for hanger rod.

Standard of Acceptance

- Anvil - fig. 278
- Taylor - fig. 53

- .3 Rod connectors:
 - .1 carbon steel, USS course thread,
 - .2 with mid-point site hole,
 - .3 tension load ratings to meet or exceed MSS SP-58.

Standard of Acceptance

- Anvil - fig. 135i
- Taylor - fig. 62S

2.9 Horizontal Pipe Support - Clevis

- .1 Clevis support:
 - .1 applicable piping materials:
 - (a) carbon steel and stainless steel pipe, schedule 10 to 80,
 - (b) cast iron DWV piping,
 - .2 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,
 - .3 adjustable hanger height while under load,
 - .4 listed to CAN/UL 203 for fire protection piping,
 - .5 applicable pipe size:
 - (a) steel pipe: NPS ½ to NPS 16

- (b) ductile or cast iron drainage pipe: NPS 3 to 24

Standard of Acceptance

- Anvil - fig. 260
- Anvil - fig. 590 (for ductile or cast iron drainage pipe)
- Taylor – fig. 24
- Taylor – fig. 27AC (for ductile or cast iron pipe)

- .2 Clevis support with extended yoke for where yoke is located inside of pipe insulation:

- .1 applicable piping materials:

- (a) carbon steel and stainless steel pipe, schedule 10 to 80,
- (b) cast iron DWV piping,

- .2 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,

- .3 adjustable hanger height while under load,

- .4 yoke sized for outside dimension of pipe only, with extended yoke to clear pipe insulation,

- .5 applicable pipe size:

- (a) steel pipe: NPS ¾ to NPS 12

Standard of Acceptance

- Anvil - fig. 300
- Taylor – fig. 24L

- .3 Clevis support with integral non-metallic insulation saddle:

- .1 alternate to using standard clevis hanger specified above with separate high density insulation inserts or pipe insulation saddles,

- .2 applicable piping materials:

- (a) insulated carbon steel and stainless steel pipe, schedule 10 to 80,
- (b) insulated cast iron drainage piping.

- .3 carbon steel, adjustable clevis, with clevis bolt reinforcing tube, to MSS SP-58 Type 1,

- .4 adjustable hanger height while under load,

- .5 listed to CAN/UL 203 for fire protection piping,

- .6 with glass-reinforced polypropylene saddle, sized to allow up to 50 mm (2 in.) insulation thickness,

- .7 yoke and clevis sized for outside dimension of pipe and insulation,

- .8 applicable pipe size:

- (a) steel pipe: NPS ½ to NPS 8,
- (b) copper tube: NPS ½ to NPS 8.

- .9 piping system design temperature limits: 4.4 to 100°C (40 to 212°F).

Standard of Acceptance

- Anvil - fig. 260 ISS

- .4 Clevis support for copper pipe and tube:

- .1 for copper tube, NPS ½ to 4,

- .2 zinc-plated carbon steel yoke and clevis, adjustable clevis to MSS SP-58, type 1, copper plated or felt lined finish,
- .3 applicable tube size: NPS ½ to NPS 4,
- .4 sized for outside dimension of pipe/tube, or outside diameter of pipe and insulation as applicable.

Standard of Acceptance

- Anvil - fig. CT-65 or 260F
- Taylor – fig. 52

2.10 Horizontal Pipe Support – Swivel Ring Hanger

- .1 For non-insulated drain-waste-vent piping, gas piping, and chemical piping.
- .2 Pipe swivel ring hangers:
 - .1 carbon steel ring strap, zinc plated, adjustable knurled swivel nut, to MSS SP-58 Type 10,
 - .2 copper plated or epoxy-coated for use on copper tubing,
 - .3 listed to ULC/ORD-C203 or UL 203 for fire protection piping,
 - .4 nominal pipe size: NPS ½ to NPS 4.

Standard of Acceptance

- Anvil - fig. 69, CT-69
- Taylor – fig. 41, 43

2.11 Pipe Straps

- .1 General:
 - .1 for non-insulated drain-waste-vent piping, gas piping, and chemical piping.
 - .2 pipe size: NPS 4 and smaller.
- .2 Zinc plated carbon steel U-loop straps for mechanical fastening to structure.

Standard of Acceptance

- Anvil - fig. 262

- .3 Hot-dipped galvanized carbon steel U-loop with clip-in or bolt-on attachment to modular channel supports.

Standard of Acceptance

- Unistrut

2.12 Horizontal Pipe Support – Pipe Roller (Type 41, 43, 44)

- .1 Suspended support pipe roller – trapeze hanger style:
 - .1 adjustable height, pipe roller support for overhead support, to MSS SP-58 type 41,
 - .2 dual-hanger rod trapeze style,
 - .3 pipe size range: NPS ½ to NPS 16, with or without insulation.

Standard of Acceptance

- Anvil - fig. 171
- Taylor – fig. 95

.2 Suspended support pipe roller – clevis hanger style:

- .1 adjustable height, pipe roller support for overhead support, to MSS SP-58 type 43,
- .2 single rod clevis style,
- .3 pipe size range: NPS ½ to NPS 8, with or without insulation.

Standard of Acceptance

- Anvil - fig. 181
- Taylor – fig. 93

.3 Bottom support pipe roller:

- .1 adjustable height, pipe roller with bottom support rods, to MSS SP-58 type 41,
- .2 for bottom support of piping,
- .3 with mounting rods and upper/lower retention nuts at both ends,
- .4 pipe size range: NPS ½ to NPS 16, with or without insulation.

Standard of Acceptance

- Anvil - fig. 177
- Taylor – fig. 95S

.4 Bottom support pipe roller with stand:

- .1 pipe roller with cast iron support stand, to MSS SP-58 type 44,
- .2 for bottom support of piping,
- .3 fixed height and adjustable height variants,
- .4 base drilled for fastening to supporting element,
- .5 pipe size range: NPS ½ to NPS 18, with or without insulation.

Standard of Acceptance

- Anvil - fig. 271 (fixed), fig. 274 (adjustable)
- Taylor – fig. 279S (fixed), fig. 280S (adjustable)

2.13 Horizontal Pipe Support – Slides**.1 Structural slide bases – welded attachment:**

- .1 Tee or H shaped pipe support for welding to pipe, to allow axial and lateral movements,
- .2 carbon steel, structural shape or fabricated, to ANSI/MSS SP-58 Type 35,
- .3 operating temperature range: -28 to 200°C (-20 to 400°F),
- .4 pipe insulation thickness clearance: up to 75 mm (3 in.),
- .5 pipe size and load rating in accordance with the following table:

Slide Base Type	Vertical Support Load Rating kN (lbf)	Lateral Restraint Load Rating kN (lbf)	Uplift Restraint Load Rating kN (lbf)	Pipe Size Range NPS	
				Water	Steam, Gas
T	35.0	9.0	3.6	½ to 18	½ to 30

	(8000)	(2000)	(800)		
H	53.0 (12,000)	13.0 (3000)	5.3 (1200)	6 to 8	½ to 30
	53.0 (12,000)	18.8 (4000)	7.1 (1600)	10 to 20	
	107 (24,000)	26.0 (6000)	10.7 (2400)	24 to 30	

Standard of Acceptance

- Anvil - figs. 257A, 436A, 439A
- Taylor – figs. 257A

.2 Structural slide base assemblies with PTFE pads – welded attachment:

- .1 for piping with design temperatures greater than 121°C (250°F), including steam at pressures greater than 103 kPa (15 psig),
 - (a) may also be used for lower temperatures,
- .2 as specified above for slide bases and as follows,
- .3 PTFE bonded to underside of slide,
- .4 matching lower steel plates with bonded PTFE element (for fastening to structural support beam),

Standard of Acceptance

- Anvil - figs. 257, 436, 439
- Taylor – figs. 257

.3 Restraint variants for slides:

- .1 lug restraints to limit lateral movement due to thermal expansion of between 6 mm to 25 mm (1/4 to 1 in.),
- .2 where seismic restraint is required, lug restraints designed to limit lateral and vertical uplift movement to not more than 6 mm (1/4 in.),
 - (a) exception: if lateral movement of greater than 6 mm (1/4 in.) is shown, then the seismic design load is to be two (2) times the seismic load as shown in Specification section 20 05 49.

.4 Clamp for T and H slides supporting cold piping:

- .1 galvanized steel clamp for insulated cold piping, sized for outside dimension of insulated pipe,
- .2 rolled from structural plate steel with bolting flanges,
- .3 continuous single clamp for length of slide, or two (2) individual clamps at each end of the slide,
- .4 bottom half of clamp welded to T or H slides,
- .5 top half of clamp mechanically fastened to bottom half.

Standard of Acceptance

- Anvil - fig. 212 (2 clamp) 432 (continuous clamp)

2.14 Horizontal Pipe Support – Trapeze

.1 Manufactured trapeze support:

- .1 load ratings as per manufacturers data sheets,

- .2 carbon steel, double-C channel (strong-backs), HSS shape and equal-leg angles.

Standard of Acceptance

- Anvil - fig. 45, 46, and 50
- Taylor – fig. 170

.2 Fabricated trapeze support:

- .1 custom designed trapeze hangers of either hollow structural sections, double C channels (strongbacks), single C channel or unequal lengths angle channels, to support one or more pipes, conduits or ducts,
- .2 design of custom trapeze supports to conform to the requirements of MSS SP-58,
- .3 designed and sealed by a professional engineer licensed in the jurisdiction of the work.
- .4 design criteria:
 - (a) static design load: deadweight of supported services plus 1.5 kN (250 lbf) point load at the mid-span,
 - (b) dynamic loads: include for seismic loads where system is subject to seismic restraint, and for wind and snow loads where located outdoors, superimposed on static design load,
 - (c) maximum trapeze deflection at any point: 1/250 (0.4%) of trapeze span,
 - (d) design load for carbon steel materials: not to exceed 28% of minimum tensile strength nor exceed 50% of minimum yield strength in tension/compression and bending,
 - (e) design load for stainless steel and low alloy steel materials: not to exceed 20% of minimum tensile strength and 45% of minimum yield strength in tension/compression and bending.
- .5 for concurrent tension/compression loads and bending loads, the sum of the ratio of the stresses to allowable stress shall not exceed 1.0.

$$\frac{\text{Stress in Tension or Compression}}{\text{Allowable Tension or Compression Stress}} + \frac{\text{Stress in Bending}}{\text{Allowable Bending Stress}} \leq 1.0$$

.3 Hanger rods:

- .1 minimum of two support rods per trapeze,
- .2 rod size selected not to exceed 80% of the allowable maximum rod tensile load rating in accordance with MSS SP-58,

.4 Pipe restraint:

- .1 restrain pipes from lateral movement with:
 - (a) bolt-on angle brackets or pipe U-bolts for manufactured hangers, or
 - (b) welded-on angles for fabricated hangers,
- .2 restraints to permit axial linear movement and axial-rotation, except where otherwise shown to be an anchor.

2.15 Vertical Pipe Stanchions

.1 Pipe support stanchion, with welded attachment:

- .1 fixed height, or telescoping two-piece design with height adjustment, field-welded to pipe elbow or horizontal pipe,
- .2 carbon steel, structural cylinder shape,

- .3 designed for static loads of pipe and contents, as well as dynamic loads and anchor loads as shown,
- .4 nominal pipe size: NPS 2 to NPS 18.

Standard of Acceptance

- Anvil - fig. 62

2.16 Vertical Pipe Riser Clamps

- .1 Steel pipe, cast iron pipe:
 - .1 carbon steel clamps for carbon steel piping and cast iron piping,
 - .2 stainless steel clamps for stainless steel piping,
 - .3 listed to ULC/ORD-C203 or UL 203 for fire protection piping,
 - .4 supplied with field-welded pipe support lugs of same material as supported steel pipe (not including cast iron pipe).
 - .5 floor supported pipe riser clamps, to ANSI/MSS SP-58, type 8,

Standard of Acceptance

- Anvil - fig. 261
- Taylor – fig. 82

- .6 suspended pipe riser clamps, 4 or 6 bolt patterns, to ANSI/MSS SP-58, type 42,

Standard of Acceptance

- Anvil - fig. 40, 40SS
- Taylor – fig. 82HCopper pipe and tube:

- .7 floor supported pipe riser clamps, carbon steel with copper plated finish, to ANSI/MSS SP-58, type 8,

Standard of Acceptance

- Anvil - fig. CT-121
- Taylor – fig. 85

2.17 Vibration Isolation Supports

- .1 Refer to specification section 20 05 48.

2.18 Cast Iron Pipe Joint Restraint

- .1 Joint restraint rodding assembly for cast iron and asbestos cement drain waste and vent pipe, for each branch, tee, wye and clean-out fittings on drainage piping NPS 5 and over.
- .2 Clamp and rod joint restraint:
 - .1 carbon steel pipe clamps with four bolt fasteners and rod washers, plain finish, to MSS SP-58, Type 8,
 - .2 carbon steel threaded rods and load nuts,
 - .3 two pipe clamps and two restraint rods required for each joint.

Standard of Acceptance

- Taylor – fig. 35

2.19 Insulation Shields

.1 Insulation shields:

- .1 galvanized steel protection shield, thickness and length as applicable to pipe size, to MSS SP-58 type 40
- .2 designed to meet MSS SP-58 maximum support spans with insulation inserts having a compressive strength of 620 kPa (90 psi).
- .3 pipe size: NPS ½ to 24,
- .4 insulation thickness: 12 mm to 50 mm (1/2 in. to 2 in.).
- .5 gauge: minimum 18 ga.
- .6 sleeve width: minimum 180 degree arc of insulation exterior surface
- .7 minimum sleeve length:
 - (a) pipe NPS ½ to 4: 300 mm (12 in.)
 - (b) pipe NPS 6: 450 mm (18 in.)
 - (c) pipe NPS 8 to 24: 600 mm (24 in.)

Standard of Acceptance

- Anvil - fig. 167 (up to NPS 24)
 - Anvil - fig. 168 (up to NPS 8)
 - Taylor – fig. 69H
- .8 sleeve length exemption: sleeve lengths may be reduced where shield is supplied as an integrated part of a high density insulation insert system. – refer to Specification section 20 07 19.
- ### **.2 Heavy-duty insulation shield:**
- .1 for piping NPS 18 and larger installed on roller hangers and trapeze hangers,
 - .2 insulation shield as specified above plus a heavy duty support plate as follows,
 - .3 support plate fabrication: 6 mm (1/4 in.) thick ASTM A36 galvanized steel rolled plate, inside diameter to fit outer radius of insulation shield,
 - .4 size:
 - (a) width: minimum 120 degrees arc of mating insulation shield,
 - (b) length: not more than 100 mm (4 in.) shorter than the primary shield.
 - .5 Support plate tack welded to the insulation shield.

2.20 Insulation Pipe Saddles

- .1 Carbon steel or stainless steel (to match pipe material) saddle welded to pipe with insulation inserted between saddle and pipe, to MSS SP-58 type 39.
- .2 For pipe sizes NPS ¾ to 36.
- .3 Insulation thickness range: 25 to 140 mm (1 to 5.5 in.)

Standard of Acceptance

- Anvil - fig. 160 to 166
- Taylor – fig. 70 to 77

3 EXECUTION

3.1 General

- .1 Where the specific requirements for pipe supports are specified in other sections of Division 20 to 23, the requirements of those sections take precedence over the requirements of this specification section.

3.2 Coordination with Concrete Work

- .1 Supply, deliver and install concrete inserts in ample time to be built into the work of Division 03.
- .2 Correctly position and set concrete inserts onto concrete formwork for pipes and equipment hangers. Secure inserts firmly to formwork before concrete is poured.
- .3 Do not use explosive drive pins in any section of the Work without obtaining prior approval from the Consultant.

3.3 Support and Hanger Installation – General Requirements

- .1 Support piping directly on or from structural building elements. Do not support pipe directly from other services. Multiple piping services may be supported on a common trapeze support.
- .2 Provide all miscellaneous materials including nuts, washers, and backing plates to make a complete installation.
- .3 Where wall brackets are used, select brackets and size mounting bolts and backing plates to suit the supported load, allowing for a safety factor by not loading the bracket more than 80% of its published load rating.
- .4 Do not support piping or tubing in direct contact with hangers or supports of dissimilar metallic material. Select hangers to include an electrical insulating material between the hanger and the pipe, or provide electrical insulating material.
- .5 Coordinate location of pipe supports with pipe flexible connectors, pipe guides and pipe anchors provided under specification section 20 05 16.
- .6 In steel framed construction, support piping from structural members. Where structural members are not suitably located for upper hanger attachment locations, and where inserts of adequate capacity cannot be installed in concrete slabs, provide supplementary steel framing members;
 - .1 fabricate supplementary steel from standard HSS sections, single EL section, double C “strongback” sections, or pipe lengths,
 - .2 size supporting steel to limit horizontal span deflection to 1/250 (0.4%) between connecting points to the structure,
 - .3 mechanically fasten supplementary steel to structural steel to prevent axial and transverse displacement, and rotation.
- .7 It is permissible to offset hangers and displace the hanging rod so that in the final operating position, the hanging rods are within 4° of vertical.
- .8 Provide a pipe support within 300 mm (12 in.) of;
 - .1 an elbow or tee,
 - .2 a concentrated load, including but not limited to valves, strainers and flanges,
 - .3 a connection to equipment.
- .9 Where hanger rods are used, provide load nuts on top and load nuts on the underside of attachment to the pipe support, including clevis hangers, roll supports, roll yoke hangers, and trapeze hangers.

3.4 Horizontal Pipe Support Spacing and Hanger Rod Size

- .1 Provide horizontal pipe supports at the spacing as detailed in the Schedule "A" included at the end of this Specification section, unless specified otherwise in other sections of Division 20 to 23.
 - .1 Schedule "A" includes alternate hanger rod size and support spans for reduced rod sizes.
- .2 Use threaded rod of the size based on pipe type and horizontal pipe hanger spacing as stated in the Schedule "A" for single rod hangers. Where the pipe hanger type requires two rods, the rod size may be reduced by one trade size but shall not be less than Ø3/8 in.
- .3 For piping using flexible roll-groove joints, there shall be not less than one hanger between pairs of joints.
- .4 Support plastic and other special piping, including anchors and guides, in accordance with the pipe manufacturer's requirements.

3.5 Horizontal Pipe Hanger and Support Selection

- .1 Select horizontal pipe hanger and support type based on pipe size and fluid service temperature in accordance with Schedules "B(1)" and "B(2)" at the end of this section.
- .2 For fire protection piping;
 - .1 use clevis hangers for all pipe sizes,
 - .2 swivel ring pipe hangers may be used for fire protection piping NPS 4 and smaller.
- .3 Swivel ring pipe hangers may only be used for;
 - .1 drain waste and vent (DWV) piping and tubing, NPS 4 and smaller,
 - .2 medical gas piping and laboratory gas piping, NPS 4 and smaller,
 - .3 compressed air piping and tubing located downstream of a refrigerated dryer, NPS 2 and smaller,
 - .4 chemical treatment piping NPS 2 and smaller.
- .4 For cast iron drainage and vent piping;
 - .1 use clevis hangers for suspended supports,
 - .2 drainage MJ type hangers may be used on hub-less cast iron piping,
 - .3 use roller or slide type supports for bottom supported piping. For slide supports, use a variant incorporating pipe band clamps in lieu of welded attachment.
- .5 For other piping, select pipe support types in accordance with Schedule B at the end of this section.
- .6 For pipe size NPS 16 to 24, a clevis hanger may be used to support a concentrated load, provided it is used only to locally support the concentrated load and there is a separate pipe run support within one-third of the maximum allowable span on each side of the concentrated load.
- .7 The use of a half-section of a suspended pipe clamp to support a horizontal pipe using two threaded rods is prohibited unless the manufacturer has written installation instructions permitting such use. The use of a pipe riser clamp for this purpose is prohibited.

3.6 Clevis Hangers

- .1 Where clevis hangers are used for cold piping, select clevis to fit the outside dimension of pipe and associated insulation.
- .2 Where clevis hangers are used for heating piping;
 - .1 select clevis to fit the pipe diameter only (clevis located inside of insulation) for small diameter piping in accordance with Schedule "C" at the end of this section,

- .2 for larger diameter piping, select clevis to fit the outside dimensions of pipe and insulation – refer to Schedule “C” at the end of this section,
- .3 where the distance from the building support element to the clevis pin is less than the value shown in the standard details at the end of this section, use an alternative method of support;
 - (a) exception: where the pipe is installed tight to the structure, the exposed length between the structural attachment and the top of the clevis shall not exceed 25 mm (1 in.).
- .3 Where clevis hangers are used for stainless steel pipe or tube and for copper tube;
 - .1 use copper or epoxy finished carbon steel clevis hangers for copper pipe/tube,
 - .2 use stainless steel or alloyed steel clevis hangers (for stainless steel pipe/tube), or
 - .3 use a standard clevis hanger with integral non-metallic insulation saddles, and select hanger size for outside of the pipe and insulation.
- .4 Adjust clevis hangers to provide the required drainage slope and direction for each pipe.
- .5 Where the project requires seismic bracing of piping systems, add a Schedule 40 pipe over the clevis bolt, sized to provide at least 6 mm (1/4 in.) inside diameter clearance to the clevis bolt. This applies only where a transverse or longitudinal brace is attached to the clevis hanger.

3.7 Roll Hangers and Supports

- .1 For roll hangers, provide load and lock nuts to allow final adjustment of roll hanger to allow pipe drainage.
- .2 For roll supports supported above the structure element, the length of exposed threaded pipe between the roll support and the structural element shall not exceed 10 times the outside diameter of the rod.

3.8 Trapeze Hangers

- .1 Provide U-bolts or fabricated angles to restrict lateral pipe movement, while allowing pipe thermal axial motion and rotation;
 - .1 fasten U-bolts or angles to the trapeze hanger with top and bottom nuts,
 - .2 fabricated retention angles to extend vertically at least one-quarter the outside pipe/insulation diameter, and mechanically fasten to the trapeze,
 - .3 where seismic restraint is required, only use U-bolts.
- .2 Adjust trapeze hangers to provide the required drainage slope and direction for each pipe. If the trapeze serves multiple pipes having different drainage slopes or directions, provide shims under each pipe as necessary to provide required slope. Mechanically fasten or tack-weld the shim plates to the trapeze.

3.9 Slide Supports

- .1 For cold piping, weld the T or H slide to the bottom half of a carbon steel clamp assembly.
- .2 Use slides with integral lateral movement limit lugs at pipe supports required to function as a guide. Movement clearance to be between 6 mm and 25 mm (1/4 to 1 in.).
- .3 Where seismic restraint is required, use slides with integral lateral and vertical-up movement limit lugs so that the maximum allowable movement does not exceed 6 mm (1/4 in.).
- .4 For fluid service temperatures of 121°C (250°F) and less, apply grease with a service temperature of not less than 200°C (392°F) over the entire bottom of the T or H slide.
- .5 For fluid service temperatures greater than 121°C (250°F) use a PTFE slide pad bonded to the underside of the slide and a matching PTFE slide pad bonded to the top of the structural steel support.

3.10 Vertical Pipe Supports

- .1 Pipe riser clamps:
 - .1 provide pipe riser clamps for non-insulated pipes NPS 4 and smaller at every second floor level for vertical pipe risers passing through two or more floors, unless other vertical pipe support types are shown,
 - .2 for steel pipe, provide support lugs welded to steel piping so that pipe lugs bear on the top-surface of the riser clamp,
 - .3 for copper tube and pipe, arrange vertical piping so that a pipe joint bears on the top-surface of the riser clamp.
- .2 Fabricated pipe riser supports:
 - .1 support piping NPS 6 and larger, using fabricated riser support brackets complete with reinforcing gusset plates welded or clamped to piping, designed not to exceed the maximum allowable local pipe stress at a load of not less than 200% of the supported load of:
 - (a) for the lowest support point of the riser, the supported pipe plus insulation weight for the lowest support interval plus the total water weight of the entire riser.
 - (b) except at the lowest support point of the riser, the pipe plus insulation weight for each support interval (except at the bottom of the riser).
- .3 Support vertical cold piping and hot piping for riser heights that are 25 m (82 ft) or less in height as follows:
 - .1 provide spring vibration isolators in accordance with specification section 20 05 48, attached to pipe riser supports at intervals of every 2nd storey or 10 m (32 ft), whichever is less,
 - .2 provide a pipe anchor at the base of the riser or the mid-height of the riser.
- .4 Support vertical cold piping and hot piping for riser heights that are greater than 25 m (82 ft) but do not exceed 50 m (165 ft) in height as follows:
 - .1 provide a custom engineered support system utilizing variable spring isolators,
 - .2 provide pipe anchors at the mid-point of the riser, and
 - .3 provide at least one spring support per riser section above and below the anchor point.
- .5 Support vertical cold piping and hot piping for riser heights greater than 50 m (165 ft) as follows:
 - .1 provide a custom engineered support system utilizing constant load supports for each pipe section located between expansion joints,
 - .2 variable spring supports may be used at intermediate locations between main constant load supports,
 - .3 provide pipe anchor supports at the base of the riser, and at intermediate locations along riser length at locations as shown,
 - .4 provide in-line expansion joints between each pair of pipe anchors on the same riser in accordance with Specification section 20 05 16,
 - .5 design pipe anchors to withstand pressure thrust created by the expansion joints, unless pressure-balanced expansion joints are used,
- .6 Design riser anchors to support the deadweight of the riser pipe, fluid contents and insulation. Where seismic restraint is required, the anchors may also be designed to resist the seismic horizontal and vertical loads.
- .7 Where custom engineering riser supports are required, they are to be designed to meet the following criteria:

- .1 the maximum vertical movement of a horizontal branch pipe is not to exceed 20 mm (0.75 in) from its installation temperature to its in-service temperature,
- .2 the maximum vertical movement of the horizontal mains pipe at the base or top of the riser is not to exceed 40 mm (1.5 in.) from its installation temperature to its in-service temperature, provided that the horizontal piping adjacent to the riser are also supported on variable spring supports for the first three horizontal support points.

3.11 Pipe Saddles and Shields

- .1 Provide pipe saddles and shields for insulated piping in accordance with Schedule "C" at the end of this section.
- .2 Provide pipe shields for uninsulated glass and plastic piping NPS 1-1/2 and larger.
- .3 Where piping is insulated and requires pipe shields, install the shields between pipe insulation and pipe support. Provide high-density insulation insert between pipe and insulation shields of the designation type as shown in Schedule "C" and as specified in accordance with specification section 20 07 19.
- .4 Where piping is not insulated and requires a pipe shield, install the shields between the pipe and the pipe support.
- .5 Where clevis hangers with integral insulation saddles are used, apply insulation sealant to the polypropylene saddle in accordance with the pipe hanger manufacturer's instructions;
 - .1 for cold piping, seal the saddle's pipe contact surfaces with vapour-barrier sealant before the piping is installed. Finish sealing the remainder of the saddles' exposed faces when pipe insulation is installed.

3.12 Vibration Isolation Supports

- .1 Provide vibration isolators at pipe supports for horizontal piping in accordance with specification section 23 05 48.
- .2 Provide vibration isolators at vertical pipe (riser) supports in accordance with specification section 20 05 48.
- .3 When installed with clevis hangers, install the vibration isolators below the top surface of the clevis; do not attached the vibration isolator to the structural element.

3.13 Variable Load Supports

- .1 Provide variable load supports on piping connections NPS 10 or larger at motorized equipment as follows:
 - .1 locate the support as close as possible to the equipment connection, and beyond any flexible connector (where required),
 - .2 select the support to have a static displacement to be equal to the static displacement of the equipment vibration isolator, but not less than 20 mm (0.75 in),
 - .3 set the support load so that the total pipe weight imposed on the equipment connection does not exceed the maximum allowable load as defined by the equipment manufacturer.
- .2 Provide variable load supports for vertical pipe supports as shown.
- .3 Provide variable load supports in mechanical rooms where piping transitions from horizontal to vertical where it enters a vertical service shaft. Provide vibration isolation hangers for other locations in accordance with Section 20 05 48 Vibration Isolation.

3.14 Set-up After Installation

- .1 Adjust hangers to equalize hanger loads, to support piping true to line and grade, and to minimize loads transferred through connections to equipment and outlets.

3.15 Schedules

- .1 The following appended schedules form part of this Specification section.
 - .1 Schedule A1(a) Horizontal Pipe Support Loads and Support Spans – Schedule 20 to 80 Pipe
 - .2 Schedule A1(b) Alternate Hanging Rod Sizes and Support Spans for Schedule 20 to 80 Pipe
 - .3 Schedule A2(a) Horizontal Pipe Support Loads and Spans – Schedule 10/10S Stainless Steel Pipe
 - .4 Schedule A2(b) Alternate Hanging Rod Sizes and Support Spans for Schedule 10/10S Stainless-steel Pipe
 - .5 Schedule A3 Horizontal Pipe Support Loads and Spans – Copper and Stainless Steel Tube
 - .6 Schedule B Pipe Support Type Selection Requirements

3.16 Standard Details

- .1 The following standard details are appended to the end of this Specification section.
 - .1 20 05 29-010 Cold Piping and Dual-Temperature Piping – Clevis Hanger Detail
 - .2 20 05 29-011 Cold Piping and Dual-Temperature Piping – Roll Hanger Detail
 - .3 20 05 29-012 Cold Piping and Dual-Temperature Piping – Trapeze Hanger Detail
 - .4 20 05 29-013 Cold Piping and Dual-Temperature Piping – Slide Support Detail
 - .5

Schedule A1(a)

**Horizontal Pipe Support Spacing
for
Carbon Steel, Galvanized Steel, Stainless-steel Piping
Schedule 20 to 80 Inclusive**

Notes for Schedule A1(a) and A1(b):

[1] Hanging rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than Ø3/8 in..

[2] Subject to load capacity of hanger components other than the hanging rod.

[3] Where piping is hydrostatically tested with water, temporary pipe supports are required to limit pipe span to the "liquids" values.

[4] For trapeze hangers only.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Support Spacing, Liquids [Note 2] m (ft)	Maximum Support Spacing Steam, Gases [Note 2, 3] m (ft)
½	Ø 3/8	1.8 (6)	1.8 (6)
¾ to 1¼	Ø 3/8	2.1 (7)	2.1 (7)
1½	Ø 3/8	2.7 (9)	2.7 (9)
2	Ø 3/8	3.0 (10)	4.0 (13)
2½	Ø ½	3.3 (11)	4.3 (14)
3	Ø ½	3.3 (12)	4.6 (15)
4	Ø 5/8	4.2 (14)	5.2 (17)
6	Ø ¾	5.1 (17)	6.4 (21)
8	Ø ¾	5.7 (19)	7.3 (24)
10	Ø 7/8	6.7 (22)	7.9 (26)
12	Ø 7/8	7.0 (23)	9.1 (30)
14	Ø 1	7.5 (25)	9.8 (32)
16	Ø 1	8.0 (27)	10.7 (35)
18	Ø 1 [Note 4]	8.4 (28)	11.3 (37)
20	Ø 1-1/4 [Note 4]	9.0 (30)	11.9 (39.0)
24	Ø 1-1/2 [Note 4]	9.6 (32)	12.8 (42.0)
30	Ø 1-1/2 [Note 4]	10.0 (33)	13.4 (44.0)

Schedule A1(b)

**Alternate Rod Sizes and Pipe Spans
For Pipe Sizes NPS 10 to 16
Carbon Steel, Galvanized Steel, Stainless-steel Piping
Schedule 20 to 80 Inclusive**

The following table provides alternate combinations of rod hanger size and associated support spacing for select pipe sizes.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Support Spacing, Liquids [Note 2] m (ft)	Maximum Support Spacing Steam, Gases [Note 2, 3] m (ft)
10	Ø 3/4	4.0 (13)	6.7 (22)
12	Ø 3/4	3.0 (10)	5.8 (19)
14	Ø 3/4	2.7 (9)	5.2 (17)
	Ø 7/8	5.8 (19)	9.1 (30)
16	Ø 3/4	2.1 (7)	4.6 (15)
	Ø 7/8	4.9 (16)	7.9 (26)

Schedule A2(a)

**Horizontal Pipe Support Spacing
For
Stainless-steel Pipe
Schedule 10/10S**

Notes for Schedule A2(a) and A2(b):

[1] Rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than Ø3/8 in..

[2] Subject to load capacity of hanger components other than the hanging rod.

[3] Where piping is hydrostatically tested with water, temporary pipe supports are required to limit pipe span to the "liquids" values.

[4] For trapeze hangers only.

Pipe Size NPS	Rod Diameter Single Support [Note 1]	Maximum Spacing, Liquids [Note 2] m (ft)	Maximum Spacing Steam, Gases [Note 2, 3] m (ft)
½	Ø 3/8	1.83 (6)	2.45 (8)
¾	Ø 3/8	2.1 (7)	2.75 (9)
1	Ø 3/8	2.45 (8)	2.75 (9)
1¼	Ø 3/8	2.75 (9)	2.75(9)
1½	Ø 3/8	2.75 (9)	3.65 (12)
2	Ø 3/8	3.10 (10)	4.0 (13)
2½	Ø 1/2	3.35 (11)	4.3 (14)
3	Ø 1/2	3.65 (12)	4.6 (15)
4	Ø 5/8	4.25 (14)	5.2 (17)
6	Ø 3/4	4.9 (16)	6.4 (21)
8	Ø 3/4	5.5 (18)	7.3 (24)
10	Ø 7/8	5.8 (19)	7.9 (26)
12	Ø 7/8	6.1 (20)	9.2 (30)
14	Ø 1	7.0 (23)	9.7 (32)
16	Ø 1	7.3 (24)	10.7 (35)
18	Ø 1 [Note 4]	7.3 (24)	11.3 (37)
20	Ø 1-1/4 [Note 4]	7.6 (25)	11.9 (39)
24	Ø 1-1/2 [Note 4]	7.3 (25)	11.9 (42)
30	Ø 1-1/2 [Note 4]	8.5 (28)	12.8 (44)

Schedule A2(b)

**Alternate Rod Sizes and Pipe Spans
For Pips Sizes NPS 10 to 16
Stainless-steel Pipe
Schedule 10/10S**

The following table provides alternate combinations of rod hanger size and associated support spacing for select pipe sizes.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Spacing, Liquids [Note 2] m (ft)	Maximum Spacing Steam, Gases [Note 2, 3] m (ft)
10	Ø 3/4	4.9 (16)	4.9 (16)
12	Ø 3/4	3.7 (12)	3.7 (12)
14	Ø 3/4	2.7 (9)	2.7 (9)
	Ø 7/8	5.2 (17)	6.1 (20)
16	Ø 3/4	2.4 (8)	2.4 (8)
	Ø 7/8	4.3 (14)	5.2 (17)

Schedule A3

**Horizontal Pipe Support Spacing
For
Copper Tube and Stainless-steel Tube**

Notes for Schedule A3:

[1] Rod size for single support. Where two supports are used, the rod size may be reduced by one size but not less than M10 (3/8 in.).

[2] Subject to load capacity of hanger components other than the hanging rod.

Pipe Size NPS	Rod Diameter Single Support [Note 1] Inches	Maximum Spacing, Liquids and Gases [Note 2] m (ft)
½	Ø 3/8	1.5 m (5 ft)
¾ to 1¼	Ø 3/8	1.8 m (6 ft)
1½	Ø 3/8	2.4 m (8 ft)
2	Ø 3/8	2.4 m (8 ft)
2½	Ø 1/2	3.0 m (10 ft)
3	Ø 1/2	3.0 m (10 ft)
4	Ø 5/8	3.0 m (10 ft)
6	Ø ¾	4.3 (14)
8	Ø ¾	4.9 (16)

Schedule B

Pipe Support Type Selection Requirements

The following tables B(1) and B(2) lists hanger types which are to be used based on pipe size and service temperature. Refer to Schedule C for additional requirements concerning insulation protection.

Pipe Support Type Legend

CL	Clevis hanger
CL(EY)	Clevis hanger with extended yoke for installation under pipe insulation
CL(IS)	Clevis hanger with integral insulation saddle
CL(LD)	Clevis hanger, light duty
SW	Swivel hanger
RS	Roll support
RH	Roll hanger with clevis
RB	Roll support with integral base
TS	T slide
HS	H slide
TZ	Trapeze

Application Legend

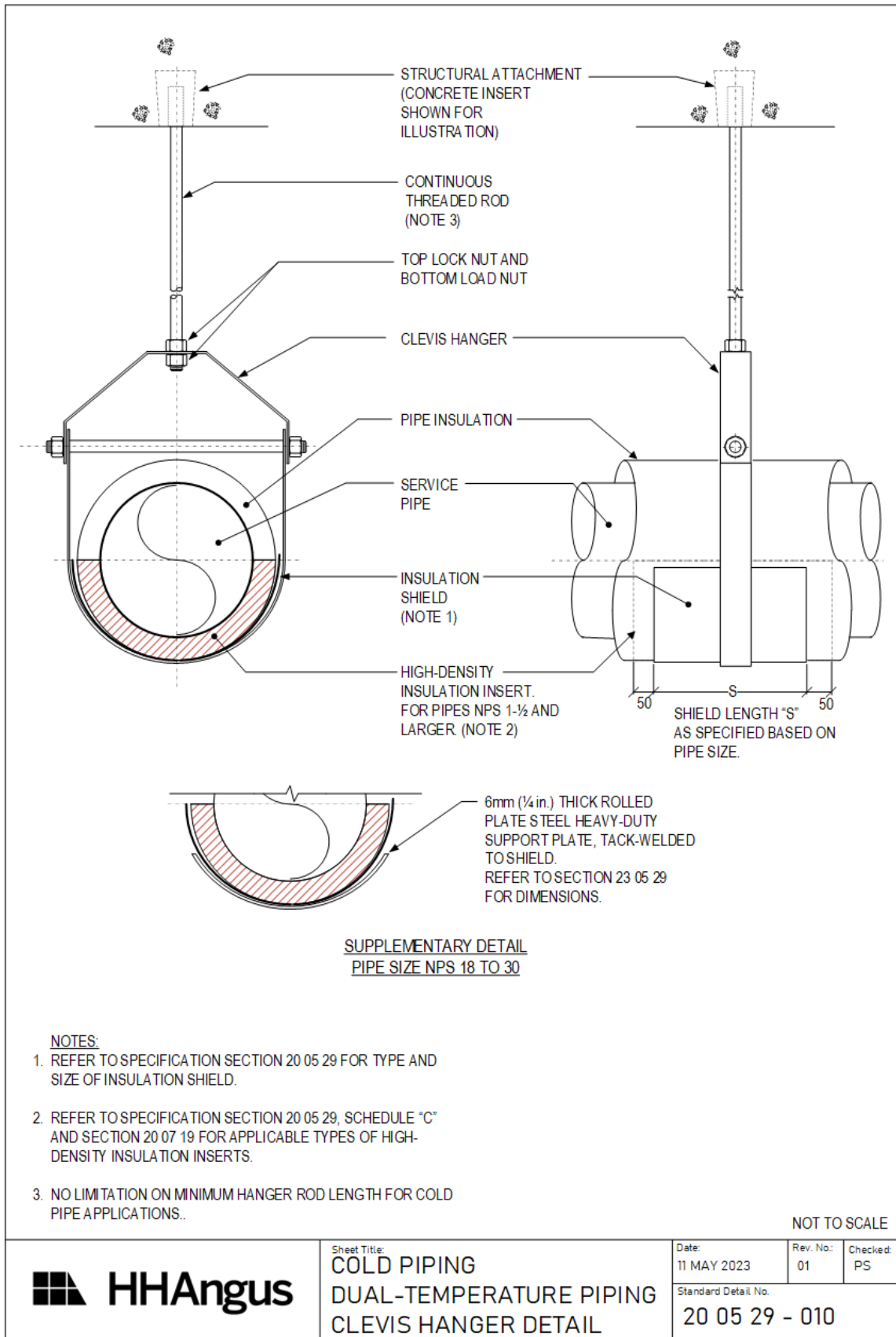
A	Acceptable
---	Not permitted

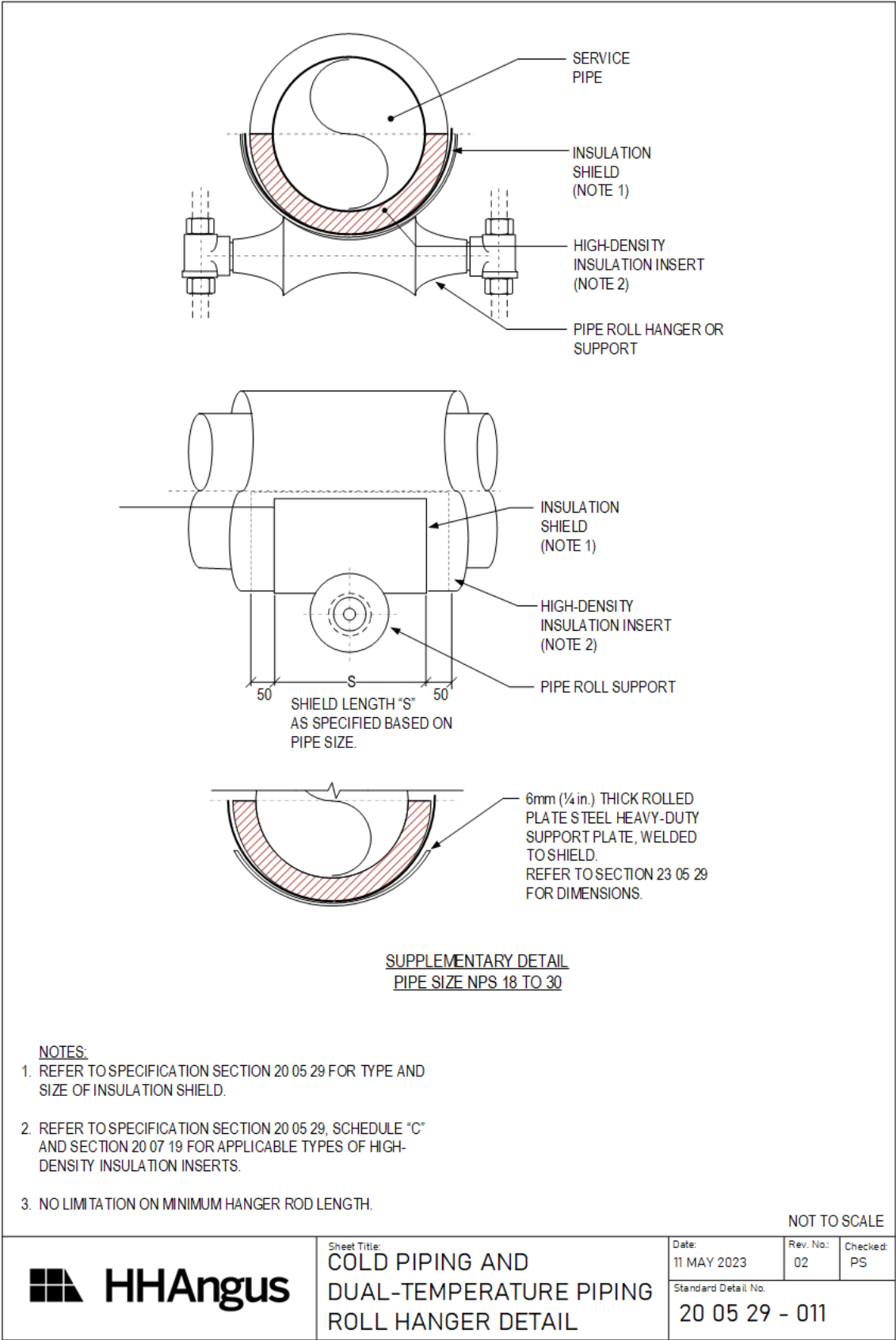
Table B(1):
Pipe Support Type Selection Requirements
For Fluid Service Temperatures up to 100°C (212°F) or Less

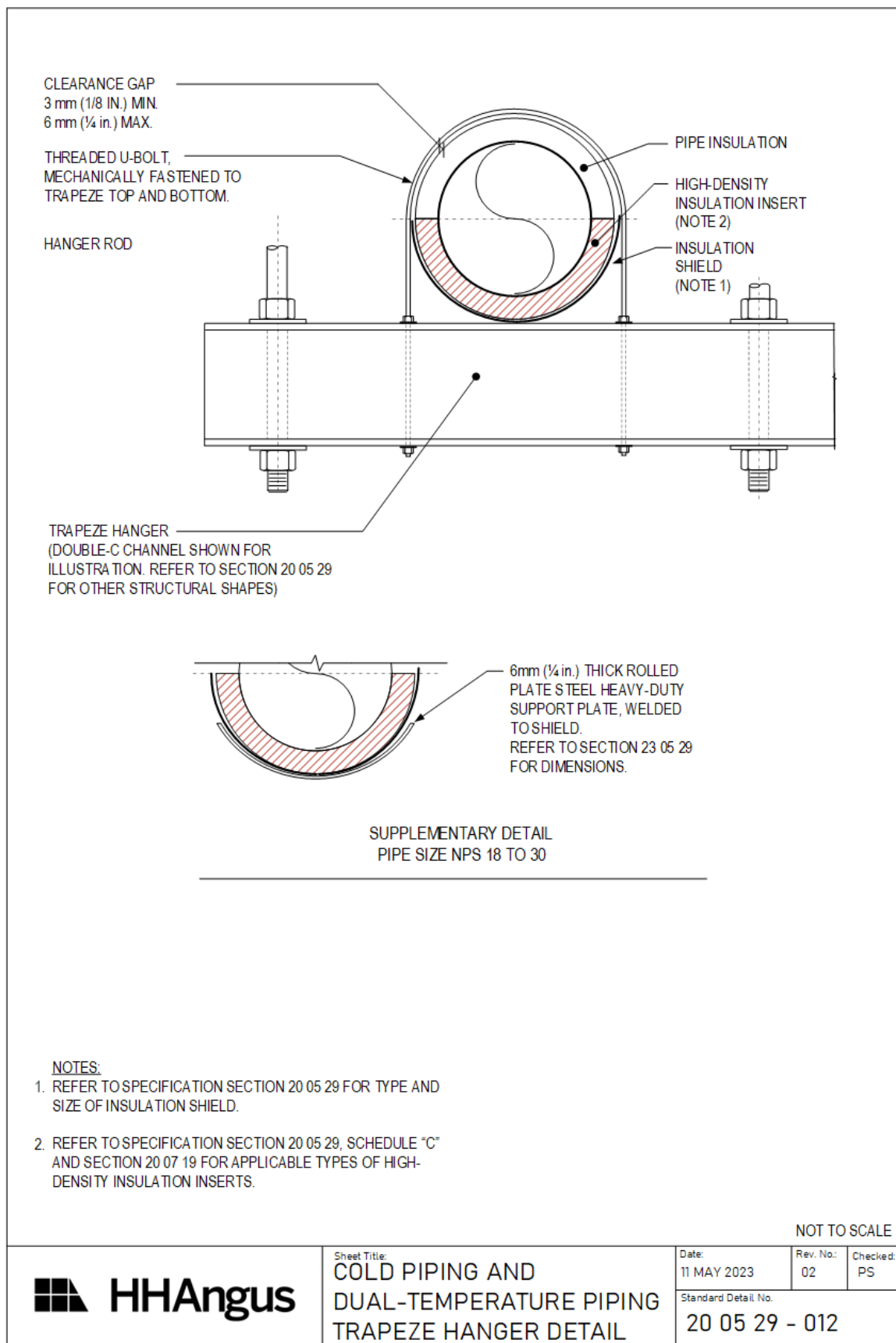
Pipe/Tube Size NPS	CL	CL (EY)	CL (IS)	CL (LD)	SW [Note 1]	RS	RH	RB	TS	HS	TZ
½ - ¾	A	A	A	A	A	---	---	---	---	---	A
1 - 4	A	A	A	A	A	A	A	A	A	---	A
6	A	A	A	---	---	A	A	A	A	A	A
8	A	A	A	---	---	---	A	A	A	A	A
10	A	A	---	---	---	---	A	A	A	A	A
12	A	A	---	---	---	---	A	A	A	A	A
14	A	---	---	---	---	---	A	A	A	A	A
16	A	---	---	---	---	---	---	A	A	A	A
18	---	---	---	---	---	---	---	A	A	A	A
20	---	---	---	---	---	---	---	---	A	A	A
24	---	---	---	---	---	---	---	---	---	A	A
30	---	---	---	---	---	---	---	---	---	A	A

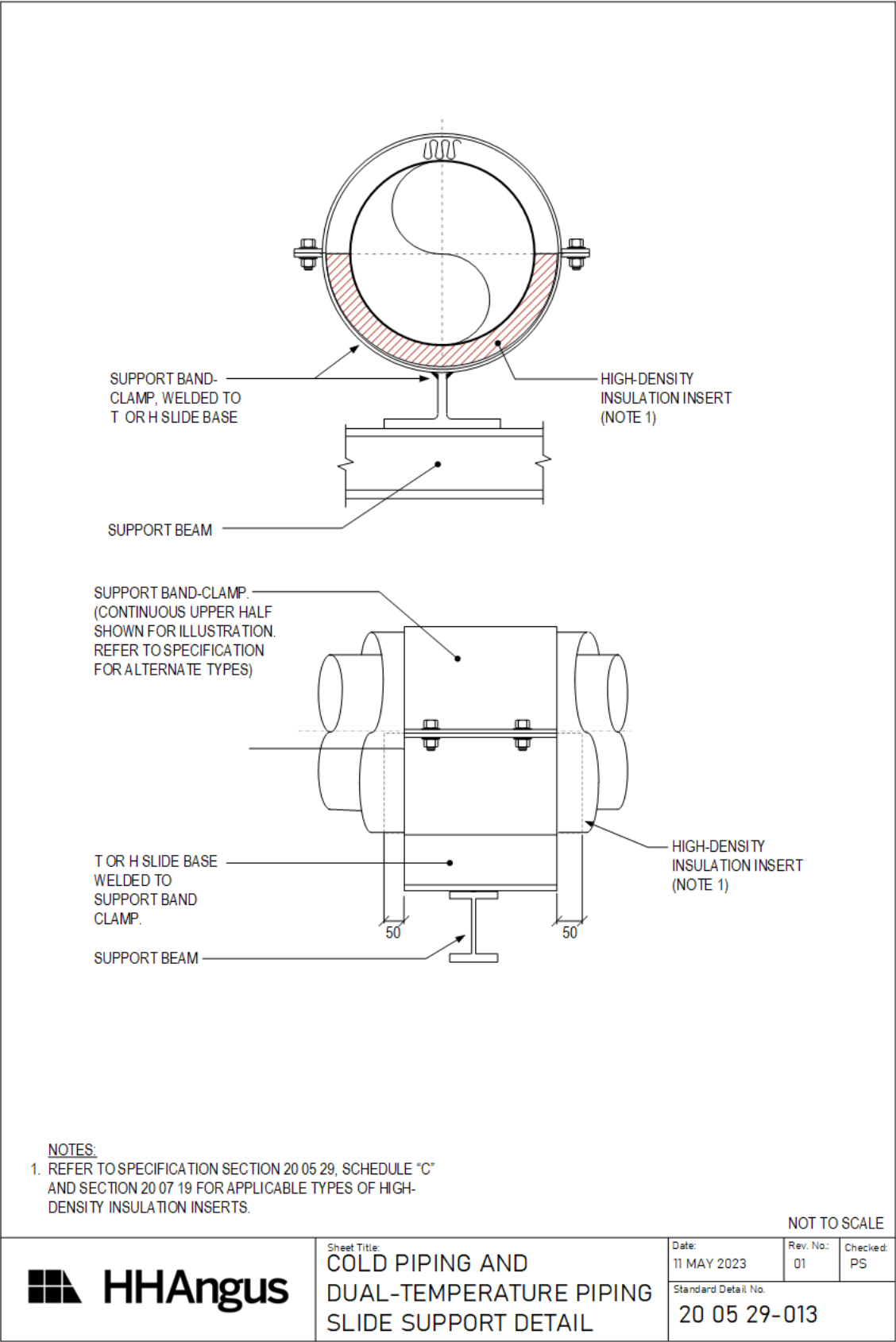
Notes:

[1] For uninsulated ambient piping/tubing only.









END OF SECTION

VIBRATION ISOLATION

20 05 48

1 GENERAL

1.1 Scope

- .1 Provide vibration isolation equipment for;
 - .1 vibration control for motor-driven mechanical equipment,
 - .2 vibration control for piping connected to motor drive equipment,
 - .3 movement control for piping due to thermal movement, and
 - .4 movement control for piping due to building movement.
- .2 Provide engineering services associated with the design, analysis and selection of vibration isolation supports, including pipe riser supports.
- .3 Refer to specification section 20 05 29 for installation requirements for variable and constant load supports for pipe riser in excess of 25 m (82 ft) in height.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Wiring Requirements for Mechanical Services
 - .2 20 05 29 Common Hanger and Support Requirements for Piping
 - .3 20 05 49 Seismic Restraint

1.3 Applicable Codes and Standards

- .1 Product standards:
 - .1 ASTM A653-19 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - .2 ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus

1.4 Design Criteria

- .1 Isolator and base type designations are taken from the current ASHRAE Applications Handbook.
- .2 Base type, isolator type and minimum static deflection are shown in equipment schedules and/or equipment selection sheets.
- .3 Information shown in equipment schedules is to establish minimum standards and vibration isolation equipment to be selected to maintain noise levels in building below RC levels in following schedule.

AREA	NOISE CRITERIA (NC level)
Offices - private	32 to 34
-open plan	36 to 38
-business machine areas	40 to 42
-conference/boardrooms	30 to 32
Operating Rooms	25 to 27
Private Bedrooms	26 to 28
Hospital Wards	30 to 32
Public Areas	38 to 40

- .1 Provide a completely engineered design of pipe riser vibration isolated supports to minimize the pipe anchor loads under normal operating conditions, with engineering documents sealed by a professional engineer licensed in the jurisdiction of the Work.

1.5 Submittals

- .1 Submit shop drawings consisting of;
 - .1 product data sheets for isolation components,
 - .2 a schedule (or similar document) of vibration isolators selected for each piece of equipment, including equipment weight and isolator static deflection;

- (a) where a common selection is used for multiple instances of the same equipment type, a single submission identifying all applicable equipment units is sufficient,
- .3 drawing details for equipment bases, specific to each piece of equipment,
- .4 fabrication details, location and size of anchor bolts and concrete requirements for inertia bases.
- .2 Submit shop drawings for the completely engineered pipe riser vibration isolation supports and pipe anchors;
 - .1 for each isolator, identify the estimated supported static loads, estimated supported operating loads (at temperature), spring deflections at static and operating conditions, spring deflections at static and operating condition, spring selections, and riser anchor design, including anchor loads at static and operating conditions,
 - .2 shop drawings to be sealed by a professional engineer licensed in the jurisdiction of the Work.

2 PRODUCTS

2.1 General Requirements

- .1 Provide vibration isolation equipment by one manufacturer.

Standard of Acceptance

- Vibro-Acoustics (Swegon NA)
- Kinetics
- BVA
- Korfund Mason
- Tecoustics

2.2 Resilient Isolator Pads – Type P1

- .1 Elastomer-in-shear pads:
 - .1 rubber waffle or ribbed pads:
 - (a) 45 or 60 durometer neoprene depending on loading, minimum of 22 mm (7/8 in) thick,
 - (b) load rating: up to 5 mm (0.19 in) static deflection and up to nominally 4400 kg (9700 lbs.) load,
 - .2 rubber-steel-rubber pads:
 - (a) two layers of rubber waffle or ribbed pad, 13 mm (½ in) thick, as specified above,
 - (b) bonded to 6 mm (¼ in) steel plate, with holes sleeved and fitted with isolation washers.
 - .3 Neoprene jacketed pre-compressed moulded fiberglass pads.

2.3 Elastomeric Mounts – Type M1

- .1 Molded neoprene mount:
 - .1 one piece, molded neoprene mount, with cast-in-top threaded steel load insert, and two hold down bolt openings on the bottom plate,
 - .2 load rating: up to 13 mm (0.5 in) static deflection and up to nominally 1800 kg (3960 lbs.) load,

2.4 Isolator Springs – Type S1

- .1 Open spring isolator:
 - .1 free-standing, open (un-enclosed) spring isolator, selected for static deflections as shown,

- .2 upper load plate and leveling assembly, and bottom load plate with non-skid noise isolation pad and bolt holes for fastening to the floor,
- .3 load rating: up to 50 mm (2 in) static deflection and up to nominally 8000 kg (17,600 lbs.) load,
- .4 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
- .5 overload capacity: 50% minimum,
- .6 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.5 Isolator Springs – Type S2

- .1 Enclosed spring isolator:
 - .1 free-standing, enclosed (housed) spring isolator, selected for static deflections as shown,
 - .2 suitable for equipment subject to wind loads, large changes in mass due to change in water content, torque loads, and/or seismic loads,
 - .3 load rating: up to 100 mm (4 in) static deflection and up to nominally 8000 kg (17,600 lbs.) load,
 - .4 housing: fabricated and welded steel members, hot-dipped galvanized after fabrication, with;
 - (a) top load plate with adjusting and leveling bolts,
 - (b) vertical restraints with isolation washers,
 - (c) bottom plate with non-skid noise isolation pads and bolt holes for fastening to the floor,
 - .5 ratio of lateral spring stiffness to vertical spring stiffness:
 - (a) 1.2 or greater for equipment installed outdoors,
 - (b) 1.0 or greater for equipment installed indoors,
 - .6 overload capacity: 50% minimum,
 - .7 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.6 Isolation Springs - Type S3

- .1 Restrained open spring isolator:
 - .1 free-standing, open (un-enclosed) spring isolator, with vertical limit stops, selected for static deflections as shown,
 - .2 suitable for equipment subject to changes in mass due to change in water content,
 - .3 load rating: up to 50 mm (2 in) static deflection and nominally 1500 kg (3300 lbs.) load,
 - .4 spring assembly:
 - (a) top load plate with adjusting and leveling nut and bolt,
 - (b) integral vertical restraint limit with elastomeric washer,
 - (c) bottom fastening plate with noise isolation pad and mounting holes.
 - .5 ratio of lateral spring stiffness to vertical spring stiffness: 0.8 or greater.
 - .6 overload capacity: 50% minimum,
 - .7 springs coated in a colour-coded corrosion protection finish and tested with a 1000 hour salt spray rating to ASTM B117.

2.7 Isolator Springs – Type S4

- .1 Open spring thrust restraint isolators:
 - .1 horizontal arrangement, with equipment and structure mounting plates,
 - .2 open spring, with load plate and isolator bushing,
 - .3 static deflection to match equipment isolator.

2.8 Isolation Hangers – Type H1

- .1 Spring isolation hanger:
 - .1 open (un-enclosed) spring isolator for connection to upper and lower hanger rods, selected for static deflections as shown,
 - .2 a stamped or welded hanger bracket mount with elastomeric washer isolating the spring,
 - .3 bracket and spring: polyester powder coat finish,
 - .4 swivel arrangement to permit hanger box or rod to move through 30° of arc without metal to metal contact,
 - .5 load rating: 10 mm (0.4 in) to 50 mm (2 in) static deflection and up to nominally 1450 kg (3190 lbs.) load,
 - .6 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
 - .7 overload capacity: 50% minimum.,

2.9 Isolation Hangers – Type H2

- .1 Spring isolation hanger with elastomer-in-shear insert:
 - .1 Same as type H1 except as follows.
 - .2 includes a neoprene elastomer-in-shear insert on the upper load connection, in series to the spring,
 - .3 load rating: up to 100 mm (4 in) static deflection and up to nominally 1700 kg (3740 lbs.) load,

2.10 Isolation Hangers – Type H3

- .1 Neoprene isolation hanger:
 - .1 neoprene isolator for connection to upper and lower hanger rods,
 - .2 a stamped hanger bracket mount with isolator and load washer, with galvanized steel finish
 - .3 bracket and spring: polyester powder coat finish,
 - .4 swivel arrangement to permit hanger box or rod to move through 30° of arc without metal to metal contact,
 - .5 load rating: up to 15 mm (0.57 in) static deflection and up to nominally 900 kg (1980 lbs.) load,
 - .6 ratio of lateral spring stiffness to vertical spring stiffness: 1.0 or greater,
 - .7 overload capacity: 50% minimum.

2.11 Equipment Base – Type A

- .1 Vibration isolators attached directly to equipment,
- .2 No supplementary base required.

2.12 Equipment Base – Type B

- .1 Fabricated steel frame or rails (except cooling towers, evaporative fluid coolers, and evaporative condensers):
 - .1 prefabricated steel base for fans and other equipment requiring motor support,
 - .2 welded assemblies from structural sections,
 - .3 reinforced for motor and drive with;
 - (a) isolation elements attached to base brackets and
 - (b) adjustable motor slide rails.
 - .4 use height-saver isolator mounting brackets wherever possible,
 - .5 minimum vertical section of base selected on basis of motor size from following;

Motor Size Horsepower	Motor Size kW	Vertical Side mm (in)
up to 3	up to 2.2	75 (3)
7.5	5.5	100 (4)
20	15	150 (6)
50	37	200 (8)
over 50	37	250 (10)

2.13 Equipment Base – Type C

- .1 Concrete filled inertia base:
 - .1 Type B base and as follows,
 - .2 full depth perimeter structural section or formed plate channel frame with;
 - (a) welded in place reinforcing rods running in both directions and
 - (b) 1 mm (20 ga) metal pans,
 - (c) base section filled with concrete, vibrated into place.
 - .3 spring mount units carried by height-saver gusseted brackets welded to frame and
 - .4 'T' shaped bases to support horizontal pump elbows.

2.14 Acoustic Barriers for Anchors and Guides

- .1 Manufactured from 25 mm (1 in) thick neoprene isolation with ductile reinforcing material.

3 EXECUTION

3.1 General

- .1 Install vibration isolation equipment in accordance with manufacturer's instructions and locate isolation for equipment to provide stable support under saddles, frames and projections of equipment.
- .2 Select thrust restraints for equipment mounted on vibration isolation to limit movement during start-up and normal operation.

3.2 Equipment Bases

- .1 Provide equipment bases for equipment as shown on equipment schedule drawings.
- .2 Block and shim bases level at correct operating height. Set the bottom of bases to clear housekeeping pads under full static load conditions by:
 - .1 25 mm (1 in) minimum for type C bases, and
 - .2 50 mm (2 in) minimum for type A and B bases.

3.3 Equipment Vibration Isolation

- .1 Provide vibration isolators with required static deflection for motorized equipment as shown on equipment schedule drawings, except as otherwise specified herein.
- .2 Provide Type S4 horizontal thrust restraints for horizontal discharge fans developing over 1.5 kPa (6 in wg) total static pressure, arranged symmetrically on either side of unit and attached at the center-line of thrust.
- .3 Provide vibration isolation rubber washers where isolator is bolted to floors, housekeeping pads or overhead structure.

3.4 Vibration Isolation for Service Connections to Vibration Isolated Equipment

- .1 Make ductwork connections to vibration isolated air handling equipment with flexible connections in accordance with specification section 23 33 05.
- .2 Make electrical connections to vibration isolated equipment with flexible liquid tight conduit in accordance with specification section 20 05 12.
- .3 Make pipe connections to vibration isolated equipment in accordance with specification section 20 05 16.

3.5 Vibration Isolation Piping Supports – General Requirements

- .1 Provide vibration isolators on pipe supports where piping is connected to motorized equipment that is supported on vibration isolators of any type, in accordance with the following table.

Location	Pipe Size NPS	Isolator Type	Static Deflection mm (in)
The first two pipe supports adjacent to the vibration isolated equipment	≥ 10	Variable support hanger to section 20 05 29	Equal to the equipment isolator static deflection, but not less than 20 (0.75)
	< 10	S1 or H2 [Note 1]	
The third pipe support adjacent to the vibration isolated equipment	All	S1 or H2	Equal to the equipment isolator static deflection, but not less than 20 (0.75)
The 4 th and 5 th support point from the vibration isolated equipment	≥ 6	S1 or H2	20 (0.75)
The 6 th support point from the vibration isolated equipment	≥ 10	S1 or H2	20 (0.75)

Location	Pipe Size NPS	Isolator Type	Static Deflection mm (in)
Within 15 m (50 ft) pipe-run distance of outdoor equipment	All	S1 or H2	20 (0.75)

Notes:

[1] Order springs pre-compress to suit the installed weight of the pipe filled with the operating fluid.

- .2 Provide acoustic barrier materials at pipe anchors and guides, located within pipe shafts, duct shafts, equipment and fan rooms, and up to the first anchor outside of these rooms or areas.

3.6 Thermal Expansion Supports for Pipe Risers

- .1 Unless otherwise shown for pipe riser supports to use variable or constant load pipe hangers in accordance with section 20 05 29, provide spring isolators for pipe supports to accommodate pipe thermal movement for vertical pipe (risers) as follows.
- .2 Support vertical cold- and hot-piping for riser heights that are 25 m(82 ft) or less in height on spring isolators attached to the pipe riser supports;
 - .1 select springs so that the initial spring deflection is at least four (4) times the expected thermal movement at each support point,
 - .2 provide the design and fabrication of brackets at the riser spring mount as well as at the pipe attachment where standard riser clamps are not sufficient, and
 - .3 in accordance with specification section 20 05 29.
- .3 For support of vertical cold- and hot-piping for riser heights greater than 25 m (82 ft), refer to specification section 20 05 29.
- .4 Provide spring isolators on horizontal branch piping or the horizontal pipe mains connecting to the riser as follows:
 - .1 type S2 or H2 isolators on the first three supports on horizontal piping connecting to the pipe risers,
 - .2 spring isolators on the horizontal piping is not required where the horizontal pipe connection is within 4 m (13 ft) of a pipe riser anchor or fixed riser base support.
 - .3 select spring isolators with a static deflection of that is four (4) times the expected thermal movement of the riser pipe at the location of the horizontal pipe connection.

3.7 Pipe Movement Isolation Supports at Building Expansion Joints

- .1 Where piping crosses building expansion joint, provide spring hangers at first two support locations of piping at either side of the construction joint line.

3.8 Start-up and Set-up

- .1 After installation of connections to resiliently mounted equipment;
 - .1 remove shims and blocking and adjust mountings to level equipment,
 - .2 adjust connections, hangers, snubbers, and restraints,
 - .3 ensure that there is no physical contact between isolated equipment and building structure.
- .2 On completion of installation and start-up of equipment;

- .1 make arrangements for manufacturer/supplier of vibration isolation equipment to visit site, check the performance of the vibration isolation systems, inspect their installation, and submit written report,
- .2 make corrections to installation in accordance with manufacturer/suppliers recommendations,
- .3 provide notice 24 hours in advance of this site visit.

END OF SECTION

SEISMIC RESTRAINT FOR MECHANICAL SERVICES 20 05 49.13

1 GENERAL

1.1 Scope

- .1 Provide restraint devices to limit movement of piping, conduits, and equipment under seismic force and movement conditions and, where applicable, wind loads.
- .2 Provide engineering services for the design, selection of materials, installation instructions, and inspection of seismic restraint devices.
- .3 The requirements under this Specification section are in addition to the requirements for equipment, piping and vibration isolation specified in other sections of Division 20.
- .4 Where specifications of materials of this section differ from those in other sections of Division 20, this section governs.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Common Hanger and Support Requirements
 - .2 20 05 48 Vibration Isolation
 - .3 20 05 49.23 Seismic Qualifications for Mechanical Equipment
 - .4 26 05 49 Seismic Restraints for Electrical Services

1.3 Definitions

- .1 The following definitions apply for the purpose of this section.

Transverse restraint – means restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

Longitudinal restraint – means restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

Restraint: means a device which limits movement of an object due to imposed seismic forces acting on the object.

Brace: a restraint directly connected to an object that reacts against both tension and compression seismic loads.

Cable restraint: a restraint consisting of cables that reacts against only tension seismic forces, and that may have a small amount of slack to prevent vibration isolation short-circuiting during normal operation.

Snubber (restraint): a restraint that does not come into contact with the object under normal operating conditions.

[[Seismically qualify (seismically qualified): Refer to specification section 20 05 49.23.]

- .2 The following abbreviations apply to this section:

“C_p” the horizontal seismic force coefficient as defined in NFPA 13.

" K_s " horizontal seismic force coefficient equal to $0.3 S(0.2) I_E S_p$, as defined in the 2020 National Building Code of Canada and represents a multiply of gravitational acceleration.

" K_v " vertical seismic force coefficient and represents a multiple of gravitational acceleration.

" W_p " the weight of the component subject to a seismic force.

.3 Interpretation:

- .1 In this specification, the parameter " S_s " (spectral response acceleration at 5 Hz) in NFPA 13, ASHRAE, SMACNA and MSS SP-127 used for estimating the horizontal seismic force, has the same meaning as the parameter " $S(0.2)$ " for the Project site-specific design spectral response acceleration value at 0.2 seconds as defined in article 4.1.8.18 of the 2020 National Building Code of Canada.

1.4 Applicable Codes and Standards

.1 Legislation

- .1 2020 National Building Code of Canada, as adopted in the jurisdiction of the Project.

.2 Installation standards and codes:

.1	ASHRAE D-90316	Practical Guide to Seismic Restraint
.2	ANSI/SMACNA	Seismic Restraint Manual Guidelines for Mechanical Systems, 3 rd edition.
.3	MSS SP-127	Bracing for Piping Systems: Seismic - Wind - Dynamic Design, Selection,
.4	NFPA 13	Installation of Sprinkler Systems

.3 Product standards:

.1	ACI 355.2	Qualification of Post-Installed Mechanical Anchors in Concrete
.2	ASHRAE 171	Method of Testing Seismic Restraint Devices for HVAC&R Equipment
.3	ASTM A492	Standard Specification for Stainless Steel Rope Wire
.4	ASTM A1023	Standard Specification for Stranded Carbon Steel Wire Ropes for General Purpose
.5	ICC-ES AC01	Expansion Anchors in Masonry Elements
.6	ICC-ES AC106	Predrilled Fasteners (Screws) in Masonry
.7	ICC-ES AC156	Acceptance Criteria for Seismic Certification by Shake-Table Testing of Non-structural Components
.8	ICC-ES AC193	Mechanical Anchors in Concrete Elements
.9	ICC-ES AC308	Post-Installed Adhesive Anchors in Concrete Elements
.10	MSS SP-58	Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation

.4 Other documents:

.1	ASCE 7	American Society of Civil Engineers, Minimum Design Loads and Associated Criteria for Buildings and Other Structures

1.5 Seismic Analysis, Design and Inspection Services

- .1 Provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in seismic restraint of building services and equipment (the "Seismic Engineer"), for the design of seismic restraints and to provide inspection services of the completed installation.

- .2 Seismic Engineer design services;
 - .1 Provide the design of seismic restraint systems, including seismic restraint calculations for all connections of equipment to the structure.
 - .2 Provide design drawings showing locations of restraints and details of construction and attachment of restraints. Mark-ups of Consultant drawing or Contractor installation drawings may be used for this purpose.
 - .3 Analysis of dead loads, seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis to detail anchoring methods, bolt diameter, embedment and/or welded length. Design seismic restraint devices to accept, without failure, the seismic forces acting on the equipment or components and their support and restraint attachments to the building structure.
- .3 Seismic Engineer inspection services;
 - .1 At periods during installation and at completion of the installation of the seismic restraint devices, the Seismic Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected.
 - .2 Seismic Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the seismic design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation.
- .4 Shop drawings of custom restraints, supporting calculations, and reports shall be sealed by the Seismic Engineer.
- .5 Prepare and submit reports of inspections of the installation and a final general review report of the completed seismic installation.

1.6 Manufacturer's Services – Seismic Restraints

- .1 Manufacturer of seismic control equipment are responsible for:
 - .1 determining seismic restraint sizes and locations,
 - .2 provide calculations and supply materials for restraint of vibration isolated and non-isolated equipment,
 - .3 provide installation instructions, drawings and trained field supervision to ensure proper installation and performance including welding details,
 - .4 field inspection of manufactured support systems including roof curbs and other rooftop equipment supports at time of installation.

1.7 Contractor Design Services – Pipe Risers

- .1 Notwithstanding the requirements of section 20 05 29, engineered design services for pipe riser supports are required for all pipe risers. These design services may be provided by the Contractor, the Seismic Engineer, or by a seismic restraint manufacturer.
- .2 Pipe riser supports design responsibilities include:
 - .1 complete engineering design of pipe riser support system including design and selection of pipe riser anchors, riser guides and riser isolators,
 - .2 provide calculations and supply materials for support of pipe risers to accommodate dead loads, dynamic loads and static seismic loads.
 - .3 provide installation instructions, drawings and trained field supervision to ensure proper installation and performance including welding details.

1.8 Design Criteria

- .1 Design seismic restraint systems to conform to the provincial or territorial building code requirements for seismic forces and movement as applicable for the place of the Work. Seismic restraint methods as described in ASHRAE D-90316, SMACNA seismic guideline and MSS SP-127 are acceptable as the baseline requirement.
- .2 Base the design of seismic restraints on actual equipment data (dimensions, weight, center of gravity, etc.,) obtained from submittals or the manufacturers of the equipment.
- .3 Testing and calculations of seismic restraints shall include both shear and tensile loads as well as one test or analysis at 45° to the weakest mode.
- .4 Site design parameters:

Item	Description	Abbrev.	Value
1	Site Class	--	C
2	Building Category	---	Post-Disaster
3	Building Importance Factor	I _E	1.5
4	Design Spectral Response acceleration factor	S(0.2)	0.309
6	Interstorey displacement factor	---	0.01

- .5 Building seismic force coefficient data;
 - .1 seismic horizontal force coefficients “K_s” and seismic vertical uplift force coefficient “K_v” for building service are listed in Schedule A attached to the end of this Section. These coefficients are the maximum values independent of the type of equipment or service being restrained. It is permitted to calculate a lower K_s coefficient where the C_p, A_r and R_p values, as defined in the building code specific to the actual equipment or service being restrained, are used.
 - .2 seismic force coefficient “C_p” for fire protection piping is listed in Table 3 of Schedule A attached to the end of this Section.
- .6 Seismic force calculation (except fire protection piping);
 - .1 the horizontal seismic force “V_p” applied to a component is:
$$V_p = K_s \times W_p,$$
 - .2 the vertical seismic force “V_{pV}” applied to a component is:
$$V_{pv} = K_v \times W_p$$
- .7 Seismic force calculation for fire protection piping, including automatic sprinklers constructed in accordance with NFPA 13 and fire standpipes constructed in accordance with NFPA 14;
 - .1 the horizontal seismic force applied to a component is
$$F_p = C_p \times W_p \times 1.15,$$
 - .2 the vertical seismic force applied to a component is equal to 15% of the horizontal seismic force F_p.
- .8 For suspended equipment, the building elevation height is measured to the level of the floor above the suspended equipment.

- .9 For vibration isolated equipment, where the clearance distance (air gap) between the equipment support frame and the restraint (e.g. snubber or integral limit stop) exceeds 6 mm (1/4 in.), the seismic horizontal force V_p is to be increased by 100%.
- .10 Where adhesive anchors for concrete are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section by the " R_p " equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained.

$$K_{s,adhesives} = K_s \times R_{p,applicable\ equipment}$$

- .11 Where concrete inserts are used, the seismic force for the restrained equipment is to be increased by multiplying the horizontal seismic force coefficient specified in Schedule A of this Specification section by the " R_p " equipment category as defined in article 4.1.8.18 of the National Building Code of Canada specific to the equipment being restrained and divided by the value of 1.5.

$$K_{s,inserts} = K_s \times \frac{R_{p,applicable\ equipment}}{1.5}$$

1.9 Seismic Qualification of Equipment

- .1 Refer to Specification section 20 05 49.23.

1.10 Submittals

- .1 Submit shop drawings in accordance with Division 1 and as follows.
- .2 Submittals for design of seismic restraint systems shall be sealed by a Professional Engineer licensed in the province or territory of the jurisdiction of the Project.
- .3 Seismic restraints:
- .1 Provide test certificates for each seismic restraint device, identifying maximum tested load capacities.
 - .2 Provide calculations for each piece of restrained equipment, lengths of braced piping, ductwork and conduit, including seismic forces, restraint selection, and selection data.
 - .3 Provide seismic data in spreadsheet format for each piece of equipment and include the following information:
 - (a) Equipment ID,
 - (b) Building floor level,
 - (c) Horizontal seismic force factor K_v ,
 - (d) Equipment weight,
 - (e) Horizontal seismic force,-
 - (f) Vertical uplift seismic force (where applicable),
 - (g) Design condition (worst case) overturning moment,
 - (h) Number of restraint fastenings,
 - (i) Pull-out tension for worst case restraint,
 - (j) Compression for worst case restraint (vibration isolated equipment),
 - (k) Horizontal shear load per fastener,
 - (l) Worst case simultaneous tension and shear loads at each restraint and snubber,
 - (m) Pull-out tension load rating per fastener,

- (n) Horizontal shear rating per fastener.
- .4 Provide drawings for each type of restraint assembly, including details for connections to building structure, and associated bill of materials, and (where applicable) full welding details of field welds to structural elements.
- .5 For building connections in concrete, provide concrete anchor sizes and nominal and effective embedment depth.
- .6 Provide floorplan layout drawings indicating location of each restraint, identifying each restraint type in a manner to identify the restraint detail.
- .7 Provide layout and construction details for reinforced housekeeping pads based on actual equipment to be restrained and selected concrete anchors. Shop drawings to include:
 - (a) minimum housekeeping pad plan dimensions and height, including reinforcement,
 - (b) details for securing the housekeeping pad to the structural floor slab,
 - (c) dimensioned position of restraint devices or combination isolator/restraint devices,
 - (d) minimum distance from concrete anchors to edge of housekeeping pad.
- .4 Calculations and designs shall be sealed by a Professional Engineer licensed in the province or territory of the jurisdiction of the project.
- .5 Pipe riser support system:
 - .1 Provide engineered layout drawings of pipe supports including anchors, guides, and isolators, with supporting load calculation including dead loads, dynamic loads and static seismic loads, and reaction loads at building connection.
 - .2 Include:
 - (a) riser drawing indicating location of each support element for each for each piping system,
 - (b) installation instructions for presetting of pipe guides and isolators,
 - (c) riser clamp products or fabrication details of pipe brackets,
 - (d) riser clamping details as applicable for each riser pipe material.

1.11 Quality Assurance

- .1 Without limiting Contractors responsibility for quality assurance of the Work, the following minimum quality control processes are required.
- .2 Pre-Construction meeting;
 - .1 Request and arrange a meeting with the Seismic Engineer and Consultant to review seismic restraint approach, prior to any restraint installation. Obtain approval from the Consultant before commencing work.
- .3 Initial installation and review;
 - .1 Install the first three transverse and three longitudinal braces for one (1) building service piping system.
 - .2 Request and arrange for a review of the installation by the Seismic Engineer and Consultant. Obtain approval of the installation before commencing remainder of the work.
- .4 Provide services of the manufacturer's technical representative to conduct site inspections of the Work in progress, and to conduct a final inspection of the Work. Provide a copy of the final inspection report to the Consultant for review. For clarity, these inspections are separate from those performed by the Seismic Engineer.

- .5 Provide services by the Seismic Engineer to conduct periodic reviews of the work in progress, and final review of the completed seismic restraint installation, before any ceilings are installed or work is otherwise concealed.
- .6 All deficiencies identified by the Seismic Engineer, manufacturer, or Consultant are to be rectified before equipment or services are concealed.

2 PRODUCTS

2.1 General

- .1 Seismic restraint materials to be provided by manufacturers specializing in the field of seismic restraint.

Standard of Acceptance

- Vibro-Acoustics (Swegon North America)
 - Kinetics Noise Control Inc.
 - B.V.A. Systems
 - Korfund (VMC)
 - Tecoustics
 - Hilti
 - nVent
- .2 Manufactured seismic restraints, anchors and related materials to be tested in accordance with ICC ES AC156 for loads meeting or exceeding the applied seismic forces of the Work.
 - .3 Demonstrate conformity of seismic restraint products by:
 - .1 approved by a government agency and indicate maximum restraint ratings, or
 - .2 provided with test results verified by an independent testing laboratory which state the maximum restraint ratings.
 - .4 Seismic restraints for equipment supported by vibration isolators to be either:
 - .1 vibration isolators as specified in section 20 05 48 and provided with separate seismic snubbers, or
 - .2 combination vibration isolators with integral seismic snubbers.
 - .5 The following product articles describe the more common type of restraint devices. Other restraint devices are permissible provided they are qualified by 3rd party testing laboratories for seismic force restraint.

2.2 Seismic Snubbers

- .1 Type "SS1" – Single-Axis/Single Direction Snubbers:
 - .1 ASHRAE Type "I", designed to restrict movement in one axis,
 - .2 carbon steel construction with epoxy or electrostatic paint finish, attached to floor or housekeeping pad with minimum of two bolts, faced with minimum 6.4 mm (1/4 in.) thick neoprene pad of compounded to bridge bearing quality,
- .2 Type "SS2 / SS3" – Multi-Axis/Multi-Direction Snubber Assemblies:
 - .1 ASHRAE Type "G" and "F", designed to restrict movement in two (2) lateral ("SS2") or three (3) axis ("SS3"),
 - .2 interlocking steel construction, attached to equipment structure and equipment, maximum of 6 mm (1/4 in) seismic movement,
 - .3 minimum 6 mm (1/4 in) thick resilient neoprene pads compounded to bridge bearing specifications, to prevent metal-to-metal impact,

- .4 minimum two bolt attachments to the floor,

2.3 Seismic Restraint Brackets

- .1 Type "SRB" – Rigid Equipment Restraint Brackets:
 - .1 suitable for connection to equipment bases and tank bases,
 - .2 carbon steel "L" sections with epoxy or electrostatic paint finish, for fastening to both the floor structure/housekeeping pad and the equipment base,
 - .3 structure bolt opening equipped with neoprene bushing, compounded to bridge bearing quality,
 - .4 minimum two bolt fastening to equipment base using screws,
 - .5 suitable for equipment direct contact to floor with or without isolation pads,

2.4 Seismic Vibration Isolators

- .1 Type "2-S" – All Direction Neoprene Isolator:
 - .1 ASHRAE Type "E", designed to restrict movement in all directions with no metal-to-metal contact.
 - .2 molded, oil resistant neoprene compounded to bridge bearing quality, with encapsulated cast-in-place top steel load plate, and steel base plate with anchor holes,
- .2 Type "3-S" – Restrained Spring Isolator – Constant Load:
 - .1 ASHRAE Type "B", designed to restrict movement in all directions,
 - .2 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (¼ in.) neoprene pad,
 - .3 removable coil spring element without having to disturb supported equipment,
 - .4 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .5 minimum 50% overload capacity,
 - .6 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .7 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .8 neoprene snubber, to limit maximum equipment movement in any direction to 6 mm (¼ in.),
 - .9 location of snubbers designed to minimize prying action on floor bolts,
 - .10 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.
- .3 Type "4-S" – Restrained Spring Isolator – Variable Load:
 - .1 colour coded seismic-controlled spring isolator, single or multiple spring coils, with minimum 6 mm (¼ in) neoprene pad mounted under spring(s),
 - .2 removable coil spring element without having to disturb supported equipment,
 - .3 lateral stiffness greater than 1.2 times rated vertical stiffness,
 - .4 minimum 50% overload capacity,
 - .5 non-welded spring elements: epoxy coated, with a minimum 1000-hour rating when tested in accordance with ASTM B-117,
 - .6 steel housing design to limit lateral and vertical movement of the supported equipment,
 - .7 top load plate with adjustable and leveling bolts,
 - .8 adjustable vertical restraints to allow unloading of water-bearing equipment,

- .9 isolation washers,
- .10 bottom load plate with anchor holes,
- .11 hot dipped galvanized for outdoor installations,
- .12 neoprene snubber compounded to bridge veering quality, to limit maximum equipment movement in any direction to 6 mm (¼ in),
- .13 adaptor base suitable sized for larger anchors, when required to suit anchorage capacity.

2.5 Restraints and Braces for Distribution Services

.1 Type "SCR" – Cable Restraints:

- .1 manufactured system consisting of cable, building attachment, and vertical hanger rod reinforcement assembly,
- .2 field-built assemblies are not acceptable,
- .3 steel wire strand cables:
 - (a) galvanized steel aircraft cable to ASTM A1023, or stainless steel to ASTM A492
 - (b) sized for seismic load with a safety factor of 2,
 - (c) arranged for restraint in both longitudinal and transverse directions under tension loads only,
 - (d) connector strength rating equal to 90% of cable breaking strength rating.
- .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) protective loop thimbles at contact with connectors,
 - (c) rope connections: overlap wire "U" clips with at least two (2) bolt fasteners, or, tool-less wedge insert lock connectors,
 - (d) selected to exceed the cable working design load by 50%,
 - (e) single sided "C" beam clamps are not acceptable.
 - (f) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.

.2 Type "SSB" – Solid Braces:

- .1 factory-built or field assembled solid braces, consisting of structural-shapes, building attachment, and vertical hanger rod reinforcement assembly.
- .2 sized for seismic load with a safety factor of 2,
- .3 arranged for restraint in both longitudinal and transverse directions.
- .4 building and equipment attachment brackets:
 - (a) carbon steel assemblies, designed to permit rotation to the final installation angle, or 45° bent steel plates with holes to allow attachment of cable loops,
 - (b) selected to exceed the working design load by 50%,
 - (c) single sided "C" beam clamps are not acceptable.
 - (d) fasteners to building structure designed to withstand simultaneous shear and tension loads, including prying action due to the bracket.

.3 Vibration isolators for suspended pipes:

- .1 applies where vibration isolators are specified for pipes in Specification section 20 05 48.

- .2 type "H2" spring hanger in accordance with Specification section 20 05 48 and with two (2) travel-limit stops of neoprene washers with integral steel inserts which are located:
 - (a) on the top of the isolator housing, with an air gap of 6 mm (1/4 in.) between the neoprene washer and the structure connection point,
 - (b) on the underside of the isolator housing, supported by a nut on the hanger rod, and provided with an air gap of 6 mm (1/4 in.) between the underside of the isolator housing and the top of the neoprene washer.
- .4 Bracing of vertical hanger rods for SCR restraints and SRB braces:
 - .1 hanger rods braced to avoid potential for buckling;
 - (a) structural steel angle or formed channel brace selected to prevent support rod buckling,
 - (b) brace attached to support rod with a series of adjustable clips, without the use of hand-tools.
 - .2 hanger rods are not required where two SRB braces are provided at each seismic restraint location, and are installed at 180° opposition to each other.

2.6 Seismic Pipe Riser Supports – Piping not Subject to Thermal Expansion

- .1 Use pipe riser clamps and guides in accordance with Specification section 20 05 29, except select components to have a load capacity equal to at least two times the combined dead weight, dynamic load and seismic load.

2.7 Mechanical Anchors

- .1 General:
 - .1 Post-installed mechanical anchors in concrete to be seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC193, and qualified by an ICC-ES seismic evaluation report.
 - .2 Anchors installed in concrete masonry units to be seismically qualified in accordance with TMS 402/602 by testing for seismic tension and shear loads in accordance with ICC-ES AC01 or AC106, and be qualified by an ICC-ES seismic evaluation report.
 - .3 Anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.
- .2 Undercut anchors for post-concrete installation:
 - .1 zinc-plated carbon steel bolt, nut, washer and cone-shape bearing-bell, with tungsten-tipped cutting radial edges, to create bearing force by keying into concrete,
 - (a) for outdoor use, all materials are to be stainless steel.
 - .2 special undercut stop-drill bit and installation setting tool,
 - .3 marking system to indicate when the anchor is completely installed,
 - .4 designed for pre-setting of anchors and/or fastening of anchors through the equipment attachment opening,

Standard of Acceptance

- Hilti - fig. HDA (indoor), HDA-R (outdoor)
- .3 Expansion wedge anchors for post-concrete or masonry unit installation:
 - .1 zinc-plated carbon steel bolt, nut, washer, expanding segments and wedge mandrel, to create restraint force by friction and keying against/into adjacent concrete,
 - (a) for outdoor use, all materials are to be stainless steel.

- .2 torque- loading to determine complete installation,

Standard of Acceptance

- Hilti - fig. KB-TZ2 (concrete and masonry)
- Hilti - fig. HSL-3 (concrete only)

- .4 Screw anchors for masonry units:

- .1 Zine-plated carbon steel masonry screw with hex washer head, to create restraint force by keying into concrete masonry units.

(a) for outdoor use, all materials to be stainless steel.

Standard of Acceptance

- Hilti - fig. KH-EZ series.

- .5 Housekeeping pad anchors:

- .1 for installation prior to pouring of the housekeeping pad and post-installation of the structural floor,
- .2 tapered ductile iron body, with openings sized for two runs of Ø10mm (#3) reinforcing bar, and body NC threaded receiver for connection to undercut or expanding wedge anchors,
- .3 two pieces of Ø10mm (#3) reinforcing bar, of sufficient length to tie into housekeeping pad reinforcement,
- .4 undercut or expanding wedge anchor for connection to the structural floor slab.

Standard of Acceptance

- Mason Industries - fig. HPA

2.8 Adhesive Anchors

- .1 Adhesive anchors for post-concrete installation:

- .1 seismically qualified for installation in cracked concrete in accordance with ACI 355.2 by testing for seismic tension and shear loads in cracked concrete in accordance with ICC-EC AC308.
- .2 to have an ICC-ES seismic evaluation report, and be suitable for installation in cracked and uncracked normal- and light-weight concrete.
- .3 anchors to be selected for concurrent shear and tension loads with a safety factor not less than 2.0 times estimated load.
- .4 injectable, two-component hybrid adhesive, matching threaded rod and accessories.

Standard of Acceptance

- Hilti - fig. HIT-HY 200

3 EXECUTION

3.1 General Requirements

- .1 Design and construct seismic restraints to;
 - .1 keep equipment and distribution services in place during and following seismic events,
 - .2 resist vertical loading simultaneously with transverse or longitudinal seismic loading.
- .2 Give special consideration to design for adjacent connections, insulation treatment, thermal movement, vibration isolation, and relation to building seismic joints.

- .3 Select restraint fastening systems so that full restraint will be provided assuming one failed fastener.
- .4 Install seismic restraint devices in accordance with manufacturer's instructions and Seismic Engineer's installation shop drawings.
- .5 Secure each transverse or longitudinal brace to the building structure, and not any other building service.
- .6 Restraint installation:
 - .1 install cable restraints with slack not exceeding a deflection of 12 mm (1/2 in.) measured at its midpoint, where equipment being restrained is supported on/by vibration isolators or for piping which is subject to thermal expansion,
 - .2 install cable restraints snug in all other applications,
 - .3 use solid braces only in rigidly supported situations,
 - .4 brace hanger rods forming a part of a seismic restraint to accept resulting compressive loads,
 - .5 install transverse and longitudinal braces at angles between 45 and 60° measured from the horizontal, unless the seismic bracing details by the Seismic Engineer states otherwise.
- .7 Concrete or masonry walls may be used as transverse duct restraints (but not pipe restraints), provide the wall is not a fire separation requiring the duct to be installed with a fire damper, and the annual space on any side of the duct does not exceed 12 mm (1/2 in.). Where the annual space exceeds this value, provide separate braces or use angle channels to secure the duct to the wall.
 - .1 drywall partitions, including demountable partitions, are not to be used for restraint.
- .8 Trapeze support and racks piping systems may have the rack braced (transverse and longitudinally) provided each pipe supported by the rack is restrained to the rack, while allowing thermal expansion as necessary.

3.2 Use of Pre-Engineered Bracing Details for Distribution Services

- .1 Use of pre-engineered restraint and bracing details in accordance with SMACNA (for ducts, piping and conduit) or MSS-SP-127 (for piping) is permitted. Where the installation of these services exceeds the limits of these documents, provide specific engineering restraint devices and systems.
 - .1 for SMACNA details, refer to the seismic hazard level ("SHL") by floor level in Schedule A of this Specification Section.
- .2 Restrain fire protection automatic sprinkler systems and fire standpipe systems in accordance with NFPA 13.
- .3 Provide cable restraints or bracing for transverse and longitudinal seismic restraints at spacing and locations as specified in the above referenced standards.
- .4 Exemptions for seismic restraints for distribution services (pipes, ducts, conduit) described in ASHRAE, SMACNA or MSS SP-127 are limited to the explicit exemptions described herein.

3.3 Exemptions for Pipe Seismic Restraints

- .1 Except as required in paragraph .2 below, the following piping is not required to have seismic restraints where all the following conditions are met;
 - .1 the pipe is supported by hangers where the support height measured from the structural support to the top of the pipe is 305 mm (12 in.) or less along the continuous length of the pipe,
 - .2 piping is supported on a trapeze where the support height measured from the structural support to the top surface of the trapeze is 305 mm (12 in.) or less along the continuous length of the pipe,
 - .3 the rod hanger at the connection to the support structure is provided with a swivel in accordance with Specification section 20 05 29 to prevent bending of the hanger rod. Where such a device

only provides rotation of the hanger rod in one plane, it shall be installed to allow transverse movement of the hanger rod, and

- .4 the extent of the free movement of the piping under seismic forces will not cause the pipe to come into contact with other building services or building elements.
- .2 The above exemptions do not apply to fire protection piping and piping conveying fuel oil, natural gas, propane gas and liquid, medical gases and compressed gases.

3.4 Building Structural Connections

- .1 Select building connection devices based on seismic loads for actual provided equipment.
- .2 For connection to concrete structures;
 - .1 Select building structure anchors as follows:
 - (a) post-installed undercut anchors or wedge-expansion anchors,
 - (b) concrete inserts may be used in new construction but only where complete seismic design is completed and seismic forces are adjusted to suit,
 - .2 Spacing between anchors: not less than 3 x the effective embedment of the greatest embedment length.
- .3 Where adhesive anchors or concrete inserts are used, the anchors are sized for an increased seismic force as described in article "Design Criteria".
- .4 For connection to steel structures:
 - .1 use double sided beam clamp, loaded to the centerline of the beam web, or
 - .2 where permitted by the building structural engineer, specifically designed welded or bolted connection may be used.
 - .3 the use of single sided "C" type beam clamps is not permitted for the connection to the building steel structure for hanger rods and seismic restraints.

3.5 Construction of Housekeeping Pads

- .1 Do not construct housekeeping pads until equipment restraint and anchors are designed and selected by the Seismic Engineer and/or seismic restraint manufacturer, and housekeeping pads detailed design are provided by the Seismic Engineer.
- .2 Provide housekeeping pads with integral reinforcement and structural anchors to the floor slab to withstand applied shear loads and anchor pull-out tension loads.
 - .1 provide reinforcing bar both directions on equal centers, and interior and perimeter floor anchors,
 - .2 in pre-installation construction, "Z-bar" shapes may only be used when housekeeping pad layouts are known prior to construction of the structural floor slab,
 - .3 in post-installations, use tapered housekeeping pad anchor assemblies,
 - .4 in post-installations, "L-rebar" shapes with adhesive anchors may be used, except the seismic forces in Schedule A of this Specification section must be increased as described above for adhesive anchors.
- .3 Pre-engineered details of construction for housekeeping pads as shown in chapter 6 of ASHRAE *Practical Guide to Seismic Restraint* may be used within its defined limits of application including but not limited to:
 - .1 housekeeping pad sizes are limited to 37 m² (400 ft²) or less,
 - .2 equipment center of gravity height does not exceed the width of the housekeeping pad,

- .3 the ASHRAE maximum load rating includes the weight of the restrained equipment, vibration isolation equipment, support rails and bases, and the housekeeping pads,
- .4 for values of “Fp” in ASHRAE, substitute the horizontal seismic force “Vp” as defined in the National Building Code of Canada for non-structural components (based on the seismic force coefficient “Ks” in Schedule A of this Specification section).
- .4 Size the housekeeping pad so that the distance from the equipment anchors to the edge of the pad is not less than 1.5 times the effective embedment depth of the equipment anchor, unless the anchor manufacturer requires greater separation distance.

3.6 Piping Restraints General Requirements

- .1 Use cable restraints for piping subject to thermal expansion, including but not limited to chilled water, heating water, steam and glycol heating/cooling water.
- .2 Use cable restraints for piping supported on vibration isolation hangers or supports.
- .3 Use cable restraints or braces for all other piping.
- .4 Thermal expansion pipe anchors and guides on piping systems may be used as both a transverse and longitudinal seismic restraint where they are designed for concurrent thermal and seismic loadings.
- .5 Provide reinforcement of hanging rods to prevent buckling of the rod.
- .6 Where clevis hangers are used, provide a brace for the clevis cross bolt consisting of Schedule 40 pipe of the smallest size to fit over the clevis cross bolt, of a length to provide a 6 mm (1/4 in.) total gap between the reinforcement and the clevis frame.
- .7 For trapeze hangers, provide U-bolts over piping to limit lateral and vertical movement, but allow approximately 6 mm (1/4 in.) total clearance to allow pipe thermal expansion movement.
- .8 Attach restraints to pipe hangers and trapezes. For existing piping, restraints may be attached to the pipe using pipe clamp assemblies manufactured for this purpose.
- .9 Where pre-engineering restraints in accordance with SMACNA or MSS SP-127 are used, the spacing for transverse and longitudinal restraints are to be reduced to 50% of the stated spans in these documents for the following piping systems:
 - .1 steel piping with threaded joints,
 - .2 plastic piping including but not limited to PVC, CPVC, PP, and PVDF,
 - .3 fiberglass-reinforced pipe,
 - .4 cast iron drainage piping with no-hub connectors,
 - .5 glass drainage piping.

3.7 Piping Movement Control at Equipment Connections

- .1 Provide flexible connectors at piping connections to equipment in accordance with Specification section 20 05 16 except/and as follows.
 - .1 The following table for pump connectors takes precedence over the requirements of Specification section 20 05 16.

Service	Pump Type	Limits	Connector Type
Fuel pumps	All	All	Flexible Metal Hose

- .1 The following table for equipment connectors takes precedence over the requirements of Specification section 20 05 16.

Equipment Type	Limits	Connector Type
Air compressors, Compressed gas cylinders	All	Flexible Metal Hose
Other equipment not specifically listed	NPS 2 and smaller	Flexible Metal Hose
	NPS 2-1/2 and larger	Corrugated Connector

- .2 Provide seismic restraints at ends of piping where connected to equipment, to limit pipe movement so that it does not cause the flexible connector devices at the equipment to exceed their lateral movement rating;
- .1 For pipe drops to equipment, provide a pipe guide on the pipe immediately above the flexible connector device, with clearance of not more than the lateral deflection rating of the flexible connector. Line the pipe guide with 6 mm (1/4 in.) neoprene pads of bridge bearing quality. Support the guide from the floor level,
- .2 this requirement applies to piping that is otherwise exempt from seismic restraints.

3.8 Piping Risers Restraints

- .1 Use pipe anchors and guides for seismic restraints of vertical pipe risers. Do not use separate cable restraints or braces.
- .2 For horizontal seismic forces acting on vertical pipe risers, use the seismic force coefficient "Ks" value at the floor location of the pipe anchor or guide (as applicable), and the restrained weight is to include 50% of the pipe and fluid content weight between the anchor or guide and the next anchor or guide, in both vertical directions.
- .3 For piping subject to thermal expansion:
- .1 provide fully engineered pipe riser support system,
- .2 for steel pipe;
- (a) provide an anchor at the location shown,
- (b) construct the anchor assembly using heavy-duty pipe riser clamps or pipe brackets with full-welded connections to the pipe, and full-welded or bolted connections to the anchor. Use mechanical anchors to bolt the pipe anchor to concrete floor, and weld pipe anchors to steel framing.
- (c) unless otherwise shown, use a heavy-duty pipe riser clamp with a load capacity not less than two times the combined dead weight of pipe and water, dynamic load and seismic loads.
- .3 for copper tube,
- (a) attach a copper sleeve that matches the OD of the tube and fully braze the sleeve to the tube.
- (b) alternatively, use a slip-on flange over the tube and fully-braze the flange to the tube,
- (c) position the sleeve or flange immediately above and bearing on a pipe riser clamp, which is bolted to the riser anchor.
- .4 based on engineered support design, provide intermediate isolator supports.
- .4 For piping not subject to thermal expansion;
- .1 provide pipe guides and riser clamps for piping not subject to thermal expansion in accordance with Specification section 20 05 29,

- .5 For all piping;
 - .1 for cast iron DWV pipe, plastic DWV pipe, and glass DWV pipe, provide a guide at each floor level.
 - .2 for all other piping, provide guide or riser clamp at every other floor but not to exceed 7.6 m (25 ft) spacing, unless engineering design determines other spacing dimensions,

3.9 Conduit Restraints

- .1 Conduits for mechanical wiring are to be restrained in accordance with the requirements of section 26 05 49.

3.10 Floor Mounted Equipment Restraints

- .1 Anchor floor mounted equipment with anchor bolts, minimum four bolts for rectangular equipment bases, and three bolts for circular equipment bases.
 - .1 friction due to gravity loads shall not be considered to provide resistance to seismic forces.
- .2 For non-isolated equipment, secure equipment directly using equipment base supports or use SRB brackets. Alternatively, use type SS1 or SS2 snubbers where equipment is not subject to overturning moments. Use type SS3 snubbers where equipment is subject to overturning moments;
 - .1 for type SS1 snubbers, provide a minimum of eight (8) snubbers for each piece of equipment, with two units placed on each corner of the equipment base frame.
 - .2 for type SS2 and SS3 snubbers, provide a minimum of four (4) snubbers for each piece of equipment, with one unit placed on each face of the equipment base frame.
- .3 For round equipment bases, such as expansion tanks with floor-support ring without mounting flanges, use type SS3 snubbers or purpose-constructed clamps to positively attach to the equipment base and anchored to the floor. Welding to the equipment base is permitted only where the equipment manufacturer information permits this method of attachment.
- .4 Provide resilient neoprene bushings and washers between equipment and anchor bolts where equipment is secured rigidly to floor or housekeeping pad.
- .5 Install snubber devices only after equipment is installed and operating, to ensure no metal-to-metal contact. Adjust snubbers so that any clearance gaps do not exceed 6 mm (1/4 in.).
- .6 For floor mounted equipment with vibration isolators;
 - .1 select basic vibration isolator in accordance with Section 20 05 48.
 - .2 select seismic restraint for each piece of equipment of either:
 - (a) integrated seismic vibration restraint type 2-S, 3-S or 4-S, or
 - (b) vibration isolator in accordance with Section 20 05 48 combined with seismic snubbers SS1, SS2 or SS3 as applicable to suit overturning moment.
 - .3 Do not mix type of restraint on the same piece of equipment.
 - .4 Where the equipment is not provided with a structural base to transfer seismic forces, provide a structural-shape or formed steel channel base or a Type C inertia base as a complete steel frames suitably cross braced in both horizontal directions to withstand seismic induced shear force and bending moments.

3.11 Suspended Equipment Restraints

- .1 For isolated equipment, select basic vibration isolator in accordance with Section 20 05 48.
- .2 Provide restraints for equipment independent of restraints provided on connecting ductwork or piping.
- .3 Provide reinforcement of hanger rods to prevent buckling.

- .4 Provide SCR type longitudinal and transverse restraints at each corner of the equipment (total of eight (8) cables). Alternatively, a single SCR cable can be installed at each corner of the equipment, positioned at 45° to both transverse and longitudinal direction and sized for concurrent transverse and longitudinal loads.

3.12 Equipment Restraints - Surface Wall-Mounted Equipment and Panels

- .1 Application: for non-rotating mechanical equipment, electrical panels, control panels, motor controllers, and other electrical distribution equipment.
- .2 Attach equipment to horizontal galvanized steel channels and fasten with bolts equipped with neoprene isolation grommet washers. Channels to extend past the side of the equipment to allow anchoring to wall. Select bolts for concurrent shear dead-weight without deduction for uplift load, and tension restraint load.
- .3 Attach channels to concrete or masonry walls with not less than four (4) anchors with each anchor having a not less than a 1.5 safety factor.

3.13 Equipment Restraints - Recessed Wall-Mounted Equipment

- .1 Application: for non-rotating mechanical equipment, electrical panels, control panels, motor controllers, and other electrical distribution equipment.
- .2 Mount recessed equipment through the top, bottom and sides of the equipment housing to adjacent block wall or wall studs.

3.14 Inspection, Testing, Adjustment and Reporting

- .1 For equipment supported on vibration isolators, field measure air gaps on each restraint and if necessary adjust the restraint so that the clearance air gap does not exceed 6 mm (1/4 in.). Provide a written report identifying the results of each test and adjustment, to the Seismic Engineer and Consultant for review.
- .2 Arrange for the seismic restraint manufacturer to inspect and report on the installation at completion of the work. Make corrections of deficiencies identified by the manufacturer. This work is to be performed prior to the final field review by the Seismic Engineer.
- .3 Arrange for Seismic Engineer to conduct a final inspection prior to substantial performance of the Work. Make corrections of deficiencies identified by Seismic Engineer. This work is to be performed prior to the final field review by Consultant.
- .4 Make corrections of deficiencies identified by Consultant.
- .5 Submit the following reports prior to application for substantial performance of the Work, or where applicable, ready-for-takeover of the Work:
 - .1 Seismic Engineer periodic and final inspection reports,
 - .2 seismic restraint manufacturer inspection reports,
 - .3 Seismic Engineer declaration of general review.

3.15 Schedules

- .1 The following schedules are attached to and form part of this Specification section.
 - .1 Schedule A Seismic Force Coefficients and SMACNA SHL Class
 - (a) Table 1 Horizontal Seismic Force Factor, K_s
 - (b) Table 2 Vertical Seismic Force Factor, K_v

Schedule A –Seismic Force Coefficients and SMACNA SHL Class

Table 1 – Horizontal Seismic Force Coefficient (except fire protection piping)		
Building Level	Horizontal Seismic Force Coefficient (except fire protection)	SMACNA SHL Class
	K_s	---
Ground Floor	0.1	D
Basement	0.1	D

Table 2 – Vertical Seismic Force Coefficient (except fire protection piping)	
Building Level	Vertical Seismic Force Coefficient
	K_v
All Floors	0.041

END OF SECTION

SEISMIC QUALIFICATION FOR MECHANICAL EQUIPMENT 20 05 49.23

1.1 Scope

- .1 Provide seismic qualification (certification) of specified mechanical equipment where applicable methods and method of qualification is specified in other technical Specification sections of Divisions 20 to 25.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 49.13 Seismic Restraint for Mechanical Services

1.3 Definitions

- .1 The following definitions apply for the purpose of this section.

Hazardous liquids – means any liquid which is subject to the Transportation of Dangerous Goods Act (Canada) including but not limited to flammable liquids and combustible liquids.

Seismic Qualification: equipment which has been evaluated to withstand design lateral and vertical seismic induced forces:

Attachment seismic qualification (Level I qualification) - means the equipment is evaluated at the equipment's attachment point to the building structure to retain the position of the equipment during a design seismic event.

Structural seismic qualification (Level II qualification) - means the equipment's internal structural elements and components have been evaluated to remain in place and not be dislodged during a design seismic event and includes Level I qualification. Also referred to as the Equipment Force Resisting System ("EFRS").

Functional seismic qualification (Level III qualification) - means the equipment is evaluated to continue its functional operation after being subjected to a design seismic event and includes a Level I and II qualification.

- .2 Refer to Specification section 20 05 49.13 for other applicable definitions and abbreviations.

1.4 Interpretation:

- .1 In this specification, for shake table testing the parameter " S_{DS} " (5% damped spectral response acceleration parameter at short periods) used in ASCE7, ICC-ES AC156, AHRI 1271, NFPA 13, ASHRAE, SMACNA and MSS SP-127 for estimating the horizontal seismic force, has the same meaning as the parameter " $S(0.2)$ " for the Project site-specific design spectral response acceleration value at 0.2 seconds as defined in article 4.1.8.18 of the 2020 National Building Code of Canada.

1.5 Applicable Codes and Standards

- .1 Legislation
 - .1 Provincial building code applicable to the place of the Work.
- .2 Product standards:
 - .1 AHRI 1271 Standard for Seismic Qualification of HVACR Equipment (SI units)
 - .2 ICC- ES AC156 Acceptance Criteria for Seismic Certification by Shake-Table Testing of Non-structural Components

.3 Other documents:

- .1 ASCE 7-10 American Society of Civil Engineers: Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- .2 NEMA BI 50010-2024: Seismic Certification Criteria for Nonstructural Electrical Components for Commercial Building Code Applications

1.6 Seismic Qualification Design Criteria

.1 Common site specific design parameters:

Item	Description	Abbrev.	Value
1	Site Class	X _s	C
2	Building Category	---	Post-Disaster
3	Building Importance Factor	I _E	1.5
4	Design Spectral Response acceleration value at a period of 0.2 s.	S(0.2)	0.309

.2 Seismic force calculations for use in analysis and in shake table tests are to comply with the following:

- .1 calculate lateral seismic forces in accordance with the building code at the place of the Work, or in its absence the 2020 National Building Code of Canada ("NBC"):

$$V_p = 0.3 S(0.2) I_E C_p \frac{A_r}{R_p} \left(1 + 2 \frac{h_x}{h_n} \right) W_p$$

- .2 the NBC equipment specific parameters "Ar", "Rp", and "Cp" are found in Schedule "A at the end of this section.
- .3 the NBC parameter "hx/hn" ratio for the location of the equipment in the building is to be take as a value of 1.0 except where otherwise specified.

.3 For shake table testing, the force calculation parameters in ASCE7 are to be interpreted relative to the 2020 NBC as follows:

- .1 the ASCE7 parameter "SDS" is taken as being equivalent to "S(0.2)" where S(0.2) is as defined in the NBC and is the maximum of S(0.2,X) and S(0.5,X),
- .2 the ASCE7 parameter "ap" is equivalent to the NBC "Ar" parameter.
- .3 the ASCE7 parameter "Rp" is equivalent to the NBC "Rp" parameter.
- .4 the ASCE 7 Component importance factor "Ip" is to be read as the NBC Building Importance Factor "IE".
- .5 the ASCE7 parameter "z/h" is to be read as the NBC parameter "hx/hn",
- .6 the ASCE7:2022 parameter "Ω0" and "Rμ" has no equivalent in the NBC and is not to be used and therefore the ASCE7 reduction credit in the seismic force transmitted to the equipment due to building structure ductility and overstrength factor shall not be used,
- .7 the NBC equipment specific parameter "Cp" has no equivalent in ASCE7 but is to be included in the force calculation,

.4 The shake table test force-time response parameters are in accordance with the following table and as follows:

- .1 parameters for test acceleration values AFLX-H, ARIG-H, AFLX-V, and ARGD-V are as defined in ICC-ES AC156.

Location	Test Criteria	Design S(T,X) (g) [Note 1]	h_x/h_n (z/h)	Horizontal Acceleration		Vertical Acceleration	
				AFLX-H	ARIG-H	AFLX-V	ARIG-V
Grade Level and Basements	ICC-ES AC156	0.309	0	0.309	0.124	0.207	0.083

Notes:

[1] Has the same meaning as ASCE7 parameter S_{DS} .

1.7 Method for Seismic Qualification of Equipment

- .1 Refer to each applicable equipment Specification section for the equipment-specific seismic qualification level and certification method. This information is summarized in Schedule A at the end of this section. Where a conflict or inconsistency exists between Schedule A and the requirements of each technical specification section, the requirements in the technical section specifications shall take precedence.
- .2 For hazardous liquid atmospheric storage tanks, certify equipment for Functional seismic qualification (Level III) by static analysis with sloshing effect or by dynamic analysis, in accordance with ASCE7.
- .3 Where seismic qualification is by shake table test, equipment product line may be qualified by extrapolation or interpolation analysis from a suitable range of shake table tested sample products of the same model by either:
 - .1 in accordance with ICC ES AC156 for equipment within the scope of that standard, or
 - .2 with equipment manufacturer's supporting calculations for such equipment which are prepared by an engineer licensed in the jurisdiction of the Project.

1.8 Prequalified Equipment

- .1 Evidence of seismic qualification by analysis or shake table testing as specified herein by the following means is acceptable as evidence of complying with this specification.
- .2 By analysis:
 - .1 qualification calculations for static or dynamic analysis shall be performed and sealed by a professional engineer licensed in the jurisdiction of the manufactured product or the jurisdiction of the Work when the product is manufactured in Canada,
 - .2 where equipment is manufactured outside of Canada, the qualification calculations for static or dynamic analysis shall be either:
 - (a) performed and sealed by a professional engineer licensed in the jurisdiction of the Work, or
 - (b) performed by the equipment manufacturer or their designate and the calculations reviewed by a professional engineer licensed in the jurisdiction of the Work who will also prepare a sealed review report attesting that the reviewed calculation methods and results demonstrate the equipment is designed for the applicable seismic forces.
- .3 By shake table testing:
 - .1 shake table test report in accordance with AHRI 1271 from a testing laboratory accredited under ISO/IEC 17025 to the requirements of ICC ES AC156,
 - .2 shake table test report in accordance with NEMA BI 50010 from a testing laboratory accredited under ISO/IEC 17025 to the requirements of ICC ES AC156,
 - .3 shake table test report published by ICC-ES AC156,
 - .4 equipment which is pre-approved and listed on the California Department of Health Care Access and Information "Special Seismic Certification Preapproval (OSP)" program.

- .5 in all cases, the horizontal acceleration factor " F_p/W_p " is equal to or greater than the Project horizontal acceleration ratio " $V_p/W_p = K_s$ " as stated in Specification section 20 05 49.13.

1.9 Submittals

- .1 Submit applicable supporting qualification documents with the equipment shop drawings:
- .1 accredited testing laboratory shake table test report,
 - .2 California HCAI OSP listing including data for design horizontal seismic forces (shake table test),
or
 - .3 manufacturer's analysis calculation report sealed by a professional engineer as specified herein.

2 PRODUCTS

- .1 Not Used

3 EXECUTION

3.1 Schedules

- .1 The following appended equipment schedules form part of this specification section.
- .1 Schedule A: Summary of Equipment Seismic Qualification Requirements
- .2 Legend for Schedule A:

Seismic Force Calculations

Cp, Ar, Rp and Ax have the meanings defined in article 4.1.8.18 of the building code.

Equipment Types

Control Panel - an energized control panel which may include motor controllers.

Unit – a complete piece of equipment and which may include control panels

Unit / CP – Requirements for a Unit (excluding a control panel) and separate requirements for the Control Panel

Evaluation Method

SA - Static Analysis

DA - Dynamic Analysis

STT - Shake Table Test

"AA" & "BB" Different equipment requires different evaluation methods

"AA", "BB", "CC" Different evaluation methods may be used.

"AA" / "BB" The first equipment type listed required method "AA" evaluation and the second equipment type listed requires method "BB" evaluation.

END OF SECTION

Schedule A - Equipment Seismic Qualification Summary Requirements

Project: QH BGH Generator Replacement
Project No. 2230693

Where a conflict or inconsistency occurs between this schedule and the requirements of a technical specification section, the technical specification section takes precedence.
Refer to referenced notes at the end of this schedule.

Spec	Equipment	Cp	Ar	Rp	Ax	Equipment Type	Evaluation Method	Notes
20 05 14.13	Constant Speed Motor Controllers	1.00	1.00	1.25	3.00	Control Panel	STT	
23 12 13	Facility Fuel-Oil Pumps	1.00	1.00	1.25	3.00	Unit / CP	SA / STT	[Note 1, 2]
23 13 23	Aboveground Oil Storage Tanks	1.00	1.00	1.25	3.00	Unit	SA, DA	SA with sloshing
23 51 33	Insulated Sectional Chimneys	1.00	2.50	2.50	3.00	Unit	SA, DA	
25 05 12	Building Automation Control Panels and Wiring	1.00	1.00	1.25	3.00	Control Panel	STT	[Note 3]

Notes

- [1] Alternate method: system control panel by shake table test and remotely mounted on building structure; remainder of equipment
equipment by static analysis.
- [2] Alternate method: motor controllers by STT, special control design to exempt system control panel, remainder of equipment
by static analysis.
- [3] Only applies to Supervisory Control units; distributed application specific controllers are exempt.

IDENTIFICATION FOR MECHANICAL SERVICES

20 05 53

1 GENERAL

1.1 Scope

- .1 Provide identification nameplates, labeling for piping, ductwork, equipment, and valves, and specialty signage.

1.2 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ANSI Z535.1 Standards for Safety Signs and Labels
 - .2 ASME A13.1 Scheme for the Identification of Piping Systems

1.3 Submittals

- .1 Shop drawings:
 - .1 Submit product data sheets for materials specified herein.

2 PRODUCTS

2.1 General

- .1 Manufactured identification systems:
 - .1 resistant to general chemical, and ultraviolet stabilized for outdoor use,
 - .2 minimum operating temperature: -25°C (-12°F),
 - .3 maximum operating temperature: 121°C (250°F).
 - .4 language: English

Standard of Acceptance

- Brady - identification tapes, bands, and markers.
- Seton - Setmark Pipe Markers.
- Smillie McAdams Summerlin.
- Craftmark Identification Systems.
- Primark

2.2 Engraved Equipment Identification Nameplates

- .1 Laminated nameplates:
 - .1 laminated two-layer coloured plastic plates, with engraved lettering,
 - .2 minimum size: 90 mm x 40 mm x 2.5 mm (3 in x 1½ in x ¼ in),
 - .3 letter height:
 - (a) ID and name: 20 mm (¾ in.) minimum
 - (b) power source: 10 mm (⅜ in) minimum,
 - .4 provided with Class 125 barcode and tag file,
 - .5 nameplate colours:
 - (a) nameplate and letter colours are dependent on type of electrical power supply to equipment.

Power Source	Background Colour	Letter Colour
Normal or None	White	Black
Life-Safety/ Emergency	Red	White
Stand-by (non-life safety)	Orange	White
UPS	Blue	White

2.3 Piping Identification – Piping Systems

.1 General:

- .1 conform to ASME A13.1 and as shown in Schedule A at the end of this Section for marking colours and global harmonization system (GHS) hazard identification symbols.
- .2 text height:

Pipe/Tube NPS	Marker Length mm (in)	Text Height mm (in)
≤ 1-1/4	200 (8)	13 (0.5)
1.5 to 2	200 (8)	19 (0.75)
2.5 to 6	300 (12)	32 (1.25)
8 to 10	600 (24)	65 (2.5)
>10	800 (32)	90 (3.5)

.2 Flexible coil-wrap manufactured markers:

- .1 PVC plastic coated markers with integral printing, or plastic cover with field applied self-adhesive markers,
- .2 reversing text with integral arrow markers,
- .3 application method:
 - (a) NPS ½ to NPS 6: full wrap of pipe
 - (b) NPS 8 and over: partial pipe wrap with perforations for securing with nylon tie-wraps, tie-wraps included.

.3 Self-adhesive polyester pipe name marking tape:

- .1 reversing text with integral flow direction arrow markers,
- .2 tape height: 65 mm (2.5 in) minimum.]

.4 Self-adhesive vinyl flow direction marking bands:

- .1 colour band tape with flow direction arrows,
- .2 colours: as specified for pipe name markers.
- .3 tape width: 50 mm (2 in)
- .4 tape length: wrapped around pipe or covering with ends overlapping one pipe diameter but not less than 25mm (1 in).
- .5 flow arrow: 20 mm (¾ in) minimum high

2.4 Valve Identification

- .1 Engraved plastic laminate tags:
 - .1 text for valves:
 - (a) piping system fluid service, area location description, following by a series number
 - (b) where a valve is shown on drawings to be normally closed, include "Normally Closed"
 - .2 tag background colour and test colour: same as for pipe markers in accordance with Schedule A at the end of this section.
 - .3 brass or stainless steel chain.

2.5 Miscellaneous Identification

- .1 Self-adhesive polyester marking labels with global harmonized system (GHS) hazard pictograms.
 - .1 red border on white field,
 - .2 symbol height: 100 mm (4 in) minimum.

2.6 Signage

- .1 Rigid plastic signs, UV stabilized and suitable for indoor and outdoor installation, for surface mounting.
- .2 Graphic symbols:
 - .1 graphic image in accordance with WHIMS and ISO 7010,
 - .2 sign dimensions:
 - (a) indoors: 300 x 300 mm (12 in. x 12 in.)
 - (b) outdoors: 450 x 450 mm (18 in. x 18 in.)
- .3 Colours:
 - .1 Field and text colours in accordance with ANSI Z535.1

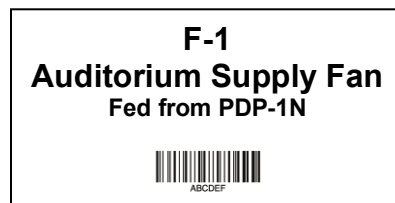
Information Type	Background Colour	Letter Colour	Primary Notification Text
General information	Blue	White	NOTICE
General Safety, Exiting	Green	White	---
Caution	Yellow	Black	CAUTION
Warning	Orange	Black	WARNING
Danger	Red	White	DANGER
Biological	Fluorescent Orange	Black	BIOHAZARD

3 EXECUTION

3.1 Equipment Identification

- .1 Where required:
 - .1 provided for equipment identified with number designations shown in equipment schedules, drawings, specifications, and/or equipment selection sheets.

- .2 marked with equipment ID, service name, and power source using wording and numbering used in contract documents.
- .3 for clarity, equipment identification nameplates are in addition to manufacturers plates.
- .2 Locate nameplates to be easily read, and fasten securely with mechanical fasteners. For pressure vessels, secure nameplates to equipment with high-tensile epoxy adhesive.
- .3 Do not paint over equipment manufacturer or field installed nameplates.
- .4 Provide metal standoffs on insulated equipment.
- .5 Examples:
 - .1 at equipment (fan, pump, etc.), illustrated for Normal Power:



- .2 at motor starter, adjustable frequency drive, and separate local disconnect, illustrated for Emergency Power:



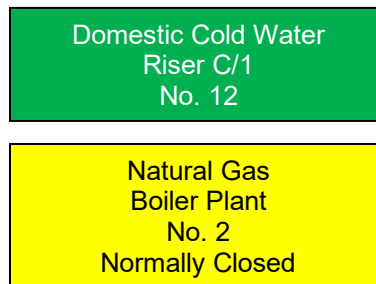
3.2 Piping Identification - General

- .1 Except where otherwise specified herein, provide manufactured pipe markers of the following types based on area of the building:
 - .1 self-adhesive type:
 - (a) indoor uninsulated piping,
 - (b) indoor insulated piping with PVC or smooth metal jackets,
 - .2 flexible coil-wrap:
 - (a) outdoor piping,
 - (b) indoor insulated piping with any type of jacket.
 - .3 Install self-adhesive markers on cleaned and prepared surfaces free of dirt and oil.
- .2 Install pipe markers in the following locations:
 - .1 maximum every 6 m (20 ft) along length of pipe for fuel oil,
 - .2 within 1 m (3 ft) of each side of barriers, floors and walls,
 - .3 within 1 m (3 ft) of and behind access doors ,
 - .4 within 1 m (3 ft) of piping termination point.
- .3 Marker colours and hazard identification:

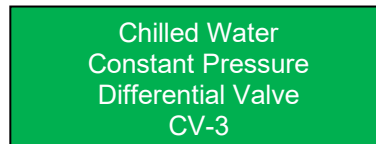
- .1 Use the existing piping marker colour coding system for building additions and alterations.

3.3 Valve Identification

- .1 Provide valves with a numbered tag showing valve type and size, attached to valve stem or wheel handle with chain.
 - .1 Valve identification is not required at the following valves:
 - (a) inside fire hose cabinets,
 - (b) radiation heating units, unit heaters, or fixture stops,
 - (c) plumbing fixture service stops,
 - (d) within 4 m (12 ft) and in sight of equipment, fixtures, or apparatus that the valve controls provided there is no branch piping between the valve and equipment served,
 - (e) existing valves that are not provided under this project.
 - .2 Identification information – manual valves:
 - .1 each valve tag to indicate fluid service, sequential valve number (unique for each service) including supply or return, location identifier, and normal operating position
 - .2 examples (colour coding shown for illustration):



- .3 Identification information – automatic control valves:
 - .1 provide valve tags for all automatic control valves except as follows:
 - (a) within sight of equipment that the valve controls.
 - .2 each valve tag to indicate fluid service, control function, control valve identification number,
 - .3 examples (colour coding shown for illustration):



- .4 Provide a tag schedule for each system, designating valve numbers, fluid service, function, valve size, and location of each tagged item and normal operating position of each valve. Submit copies in original file format (Excel, Word) on two (2) removable mass storage devices.

3.4 Schedules

- .1 The following Schedules form part of this specification section.
 - .1 Schedule A: Piping Marker Colours and Hazard Labels

Schedule A – Piping Marker Colours and Hazard Labels

Fluid Service Category	Piping Services	Background Colour	Lettering Colour	GHS Hazard Symbol
Combustible Liquids	Diesel	Brown	White	None
Compressed Air	Compressed Air	Blue	White	None
Other Gases	Plumbing Vents	Grey	White	None

END OF SECTION

SAFETY BOLLARDS AND EQUIPMENT GUARDS

20 05 63

1 GENERAL

1.1 Scope

- .1 Provide safety bollards for protection of mechanical equipment and services as shown.

1.2 Related Sections

- .1 20 05 02 Painting for Mechanical Services
- .2 23 11 13 Fuel-oil Piping and Accessories

1.3 Submittals

- .1 Submit manufacturer's data sheets for manufactured safety bollards with model numbers, performance and design data, outline dimensions and power requirements.

2 PRODUCTS

2.1 Safety Bollards - Fabricated

- .1 Field or shop fabricated safety bollards.
- .2 Posts:
 - .1 material: ASTM A53, Gr. B, schedule 40 carbon steel pipe.
 - .2 diameter: NPS 8
 - .3 length: minimum 1100 mm (44 in) above grade level, plus buried length of 1400 mm (55 in).
 - .4 posts filled with concrete and top of concrete finished to create a hemi-spherical dome on top of pipe end.
- .3 Finish: prime and finish coat in accordance with specification section 20 0502.
 - .1 Finish colour:
 - (a) Outdoors: Safety Yellow
 - .2 Paint entire post including portion extending below grade level.

3 EXECUTION

3.1 Installation

- .1 Install fabricated outdoor bollards as follows:
 - .1 in a Ø300 mm (12 in. dia.) concrete post support, minimum 1200 mm (4 ft) deep but not less than the local ground frost level, with the guard or bollard extending to 75% of the depth of the concrete pier,
 - .2 with 4-bolt foot flanges where shown supported on prepared concrete curbs or pads provided under Division 03.
- .2 Minimum post spacing:
 - .1 for protection of fuel oil equipment and piping: maximum 1300 mm (51 in)
 - .2 for all other equipment: as shown.
- .3 Touch-up finish coats of safety bollards to match finished coat.

End of Section

START-UP AND PERFORMANCE TESTING REPORTING

20 08 01

1 GENERAL

1.1 Scope

- .1 Provide integrated reporting of start-up and performance testing of mechanical equipment and systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 08 11 Testing of Integrated Mechanical Life Safety and Fire Protection Systems

1.3 Coordination

- .1 Coordinate the work of testing companies;
 - .1 schedule sufficient time so that testing and balancing can be completed before occupancy begins and coordinate with trades involved,
 - .2 keep testing and balancing firm informed of any major changes made during construction and furnish same with a set of project drawings and reviewed Shop Drawings,
 - .3 furnish balancing devices, test connections access openings, balancing probe inlets and plugs,
 - .4 clean and pre-run all equipment, filters, etc. and place all heating, ventilating and air conditioning systems into full operation and continue same during each working day of testing and balancing,
 - .5 provide labour from pertinent mechanical trades and tools, equipment and materials to make equipment and system alterations and adjustments, as required including control adjustments,
 - .6 Building Automation System technical representative to operate the BAS during air and water balancing testing,
 - .7 where required in applicable Specification sections, refrigeration machine manufacturer service representative conducts performance testing of the refrigeration equipment, and Testing and Balancing contractor to witnesses and records all test results.
 - .8 where required in applicable Specification sections, fuel-fired heating equipment manufacturer service representative, or other qualified service company technical representative, conducts performance testing of heating equipment and Testing and Balancing contractor to witnesses and records all test results.
- .2 Be responsible for systems constructed, installed and adjusted to provide optimum performance as required by design intent. Perform any re-adjusting required as the result of spot checks by the Consultant at no increase in Contract Price.

1.4 Submittals

- .1 Submit a report format template a minimum 14 days prior to start of air and water balancing on-site.
 - .1 submit proposed format of initial report,
 - .2 include a complete list of instruments and tests for which they are to be used as they relate to this project, including date of last calibration

2 PRODUCTS

2.1 Not applicable.

3 REPORT FORMAT

3.1 General

- .1 Include the following information for each test report:
 - .1 Owner Name,
 - .2 Project Name,
 - .3 Contractor Name,
 - .4 Consultant Name,
 - .5 Name of Test Report,
 - .6 Name and signature of the person submitting the report,
 - .7 Date of report.
- .2 Submit two (2) copies of test reports in hardcopy form in 3-“D” ring binders, indexed for each type of report, separately bound from the Operations and Maintenance manuals. Provide two (3) copies of the same reports in Adobe Acrobat version 7 PDF format.

4 START-UP AND PERFORMANCE REPORTS

4.1 Required reports

- .1 Provide the following Start-Up and Performance Testing reports:
 - .1 Equipment start-up report,
 - .2 Authorities inspection reports,
 - .3 Air and water balancing report,
 - .4 Controls / BMS operation report,

4.2 Equipment Start-up Report

- .1 Provide a test report in spreadsheet format which summarizes the following data for each piece of equipment which is powered or has automatic controls:
 - .1 equipment ID and name,
 - .2 motor insulation megger test - result and initialed by contractor,
 - .3 motor rotation (bump test) - result and initialed by contractor,
 - .4 equipment start-up report - status and initialed by contractor,
 - .5 manufacturer Start-Up report – status and initialed by contractor,
 - .6 test completion date.
- .2 Provide a test report in spreadsheet format which summarizes the following data for testing of piping systems, organized by each piping system:
 - .1 system name,
 - .2 system limits (if system is not tested in its entirety),

- .3 type of test (pneumatic, hydrostatic),
- .4 pressure at start of test,
- .5 pressure at end of test,
- .6 duration of test,
- .7 contractor dated and initialed,
- .8 pressure relief valves installed – record setpoint and initialed by contractor.
- .3 Provide a test report in spreadsheet format which summarizes the following data for testing of ductwork systems, organized by each ductwork system:
 - .1 system name,
 - .2 system limits (if system is not tested in its entirety),
 - .3 test pressure,
 - .4 duration of test,
 - .5 seal Class,
 - .6 tested duct surface area,
 - .7 allowable airflow leakage rate,
 - .8 estimated leakage rate,
 - .9 contractor dated and initialed.
- .4 Equipment/System Start-Up Test Report:
 - .1 Provide a separate start-up report for each piece of the following equipment. The SMACNA “Systems Ready to Balance Check List”, where applicable, may be used for this report.
 - .2 Diesel generator room/enclosure ventilation systems,
 - (a) Diesel generator room/enclosure ventilation system
 - (b) Diesel fuel oil system
 - (c) Diesel generator exhaust selective catalytic reduction (SCR) system
- .5 Manufacturer’s Start-Up Test:
 - .1 Provide a separate start-up report for each piece of the following equipment, utilizing the manufacturer’s start-up check list. This report may be prepared by the manufacturer’s service representative:
 - (a) Fuel oil pumps and control panels
 - (b) Aboveground main fuel oil supply tank
 - (c) SCR system
 - (d) Building Automation Systems.

4.3 Authorities Inspection Reports

- .1 Submit copies of authorities-having-jurisdiction inspection and test reports, including:
 - .1 plumbing and drainage municipal inspector reports,
 - .2 AHJ for electrical safety inspection reports and, if applicable, field certification reports.
- .2 Where an AHJ inspects the work but does not issue an inspection report, provide a signed and dated written declaration of the name of the AHJ inspector, the date of their inspection, what they inspected, and any comments they provided orally or in writing (other than an inspection report).

5 REPORT SUBMISSIONS

5.1 Deficiencies

- .1 Immediately report to Consultant, any deficiencies in the systems or equipment performance resulting in design requirements being unobtainable.

5.2 Draft Report

- .1 On completion of the start-up, testing, adjusting and balancing of all systems, submit to the Consultant, two (2) typewritten copies of a full report on all tests, adjustments, and balancing performed.
- .2 Attachments including systems schematics with numbered terminals for referring to data above.

5.3 Spot Checks

- .1 After review of the draft report by the Consultant, Consultant has the right to require a retest of up to 10% of all air and water balancing measurements in locations as directed by the Consultant, at no cost extra to the contract.
- .2 If results indicate unusual testing inaccuracy, omissions, or incomplete balancing/adjustment, in the opinion of the Consultant, re-balance entire affected system(s) at no increase in Contract Price.

5.4 Interim Report

- .1 After completion of any retesting described above, submit three (1) typewritten copies of the interim report bound in a 3-hole "D" style binder, and two (2) removable drives (thumb drive) of the report in PDF format.
- .2 This report is required to obtain Substantial Performance of the Contract.

5.5 Final Report

- .1 Submit to Consultant the final report following completion of alternate season testing and balancing. Submit two (2) typewritten copies bound in a 3-hole "D" style binder,, and two (2) removable drives (thumb drive) of the report in PDF format.

5.6 Acceptance

- .1 The Substantial Performance of the Mechanical Work will be considered reached when the interim Start-Up and Performance Testing report is reviewed by the Consultant and in the opinion of the Consultant all systems have been satisfactorily installed, operated tested, balanced, and adjusted to meet the specified and intended performance, except for deferred seasonal-dependent work or other deferred work agreed by the Owner.
- .2 The substantial performance is not dependent upon alternate season testing.
- .3 The total performance of the Mechanical Subcontract (Contract) will not be considered reached until the alternate season testing and balancing and any other deferred Work is completed and the final report submitted and reviewed by the Consultant.

END OF SECTION

**TESTING OF INTEGRATED MECHANICAL FIRE PROTECTION AND LIFE SAFETY
SYSTEMS
20 08 11**

1 GENERAL

1.1 Scope

- .1 Provide testing of integrated fire protection and life safety systems and related equipment provided under Division 20 to 25 with those provided under other Divisions of the Work, in accordance with specification section 01 75 11.
- .2 This specification is limited to testing of the interconnections between fire protection and/or life safety systems. Refer to separate technical specification sections for the individual testing and commissioning requirements for those systems.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 Section 01 75 11 Testing of Integrated Fire Protection and Life Safety Systems

1.3 Definitions and Abbreviations

- .1 Refer to section 01 75 11.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CAN/ULC-S1001 Integrated Systems Testing of Fire Protection and Life Safety Systems

1.5 Qualified Tradesperson

- .1 Refer to section 01 75 11.

2 PRODUCTS

- .1 Not used.

3 EXECUTION

3.1 General Requirements

- .1 Conduct complete and thorough testing and documentation of the systems interface and integration between various FPLS systems provided under Divisions 20 to 25 and those provided under other Divisions of the Work.
- .2 Include all labor and material as required to participate in and implement the integrated FPLS testing process for equipment and systems provided under Division 20 to 25.

3.2 Integrated Test Plan and Procedures - Development

- .1 Participate in the development of the integrated FPLS test plan and procedures in accordance with the requirements of specification section 01 75 11.
- .2 Supply manufacturer's operating and testing instructions to the ITC prior to the development of the integration FPLS test plan.

3.3 Integration Test Plan – Implementation

- .1 Complete related FPLS system testing in accordance with the applicable technical specification sections of Divisions 20 to 25, prior to implementation of integrated FPLS testing. Where testing of such systems inherently test the FPLS system interconnection(s), such testing is not required to be duplicated for the integrated FPLS testing provided the results of the integration test are recorded in accordance with the requirements of the integrated FPLS test plan.
- .2 Prior to implementing any integrated FPLS test,
 - .1 provide written confirmation from each trade contractor under Divisions 20 to 25 of the Work, that their respective FPLS related equipment or systems, or parts thereof, have been installed in accordance with the design and are ready for integrated FPLS testing,
 - .2 provide test verification reports from the organization that verified the installation of any FPLS system as required by referenced codes or standards, such as NFPA or ULC.
 - .3 provide a copy of inspection reports from an authority having jurisdiction governing a FPLS system.
- .3 Coordinate with the ITC and provide all necessary resources to implement the integrated FPLS test plan.

3.4 Final Test Results Report

- .1 The final test report will be prepared by the ITC.

END OF SECTION

MECHANICAL COMMISSIONING

20 08 15

1 GENERAL

1.1 Scope

- .1 Provide commissioning of mechanical systems provided under Division 20.
- .2 Mechanical system installation, start-up, testing, balancing, preparation of Operating and Maintenance manuals and operator training are the responsibility of the Division 20 Contractors, with the coordination of the commissioning process the responsibility of the Contractor.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 08 01 Start-up and Performance Testing
 - .2 20 08 11 Testing of Integrated Mechanical Fire Protection and Life Safety Systems

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Contractor** – means the general contractor or construction manager who is responsible for the management and overall execution of the Work as applicable to the type of project delivery method used.
 - .2 **Major deficiency** – an item which if not corrected renders the equipment or system unsuitable or un-safe for use by the Owner. Major deficiencies must be corrected as a condition for achieving Substantial Performance.
 - .3 **Minor deficiency** – an item which does not impact on the operation of the equipment or system and will allow the Owner to use the system safely. Minor deficiencies may be corrected before or after Substantial Performance, but will not prevent certification of Substantial Performance of the Work.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASHRAE Guide 0 The Commissioning Process
 - .2 ASHRAE Guide 1.1 HVAC&R Technical Requirements for the Commissioning Process
 - .3 ASHRAE Guide 1.3 Building Operations and Maintenance Training for the HVAC&R Commissioning Process
 - .4 ASHRAE Guide 1.5 The Commissioning Process for Smoke Control Systems

1.5 Commissioning Process

- .1 The Commissioning process develops, coordinates, and documents the following:
 - .1 equipment start-up,
 - .2 control system calibration,
 - .3 testing and balancing,
 - .4 verification and Performance Testing,

- .5 operation documentation,
- .6 operator training.
- .2 The Commissioning Program is divided into the following parts:
 - .1 Part 1: Pre-Start and Start-Up testing
 - .2 Part 2: Installation Verification testing
 - .3 Part 3: Performance Validation testing
 - .4 Part 4: Systems Operating Manuals
 - .5 Part 5: Operator Training

1.6 Work Included

- .1 Commissioning work of Division 20 includes, but is not limited to:
 - .1 testing and start-up of equipment,
 - .2 testing, adjusting and balancing of hydronic and air systems,
 - .3 cooperation with the Commissioning Authority in developing and implementation of the commissioning plan,
 - .4 providing qualified personnel for participation in implementing commissioning test procedures, including seasonal testing required after the initial testing,
 - .5 providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process,
 - .6 providing operation and maintenance manuals, and as-built drawings to the Commissioning Authority for verification,
 - .7 providing training and demonstrations for the systems specified in this Division.
- .2 Conduct complete and thorough evaluation and documentation of the operation and performance of all components, systems, and sub-systems, including the following equipment and systems:
 - .1 Building automation systems (BAS),
 - .2 Diesel fuel systems,
 - .3 Diesel generator room/enclosure ventilation systems,
 - .4 Diesel generator exhaust selective catalytic reduction (SCR) systems.
- .3 Commission equipment which has been pre-tendered, pre-purchased, or pre-ordered by the Owner or their Agent, and the value of which has been assigned to the Mechanical Contractor or their sub-trades and is included in the value of the Work.
- .4 Commission services to equipment, but not the equipment itself, where the supply of the equipment does not form part of the mechanical Work.
- .5 Provide the following commissioning documentation:
 - .1 recording completed Pre-start and Start-up procedures test results,
 - .2 recording completed Installation Verification and Performance Validation test results,
 - .3 as-built records.
 - .4 operation and maintenance manuals
- .6 The final commissioning report will be prepared by the Commissioning Authority.

1.7 Excluded Work

- .1 Unless otherwise specified, equipment which is not supplied by the mechanical contractor or their sub-trades, where the value for the supply of equipment is not included as part of the Work, such as:
 - .1 Supplied by Owner (SBO) equipment,
 - .2 Equipment marked Not in Contract (NIC) or Not in Mechanical Contract (NIMC).

1.8 Submittals - Commissioning Schedule

- .1 Provide a detailed commissioning schedule for consolidation into the main construction schedule.
- .2 Include:
 - .1 equipment and systems start-up predecessors
 - .2 time periods for pre-start and start up testing, verification and validation testing for each equipment and system.

1.9 Submittals - Documentation

- .1 Identify documents including test documents, binder covers, etc. using equipment ID numbers provided on equipment schedules.
- .2 Scan original signed test reports, including verification and performance test reports, manufacturers service reports, etc. in Adobe Acrobat *.pdf version 8 format. For original document chapters, provide Adobe chapter referencing.
- .3 Submit three (3) copies of each completed and accepted Verification and Functional Performance Test reports, both preliminary and final issues.
- .4 Collate final, accepted and signed test results in separate binders as follows:
 - .1 HVAC Systems
 - .2 Building Management Systems
- .5 Provide three (3) CD-R or DVD-R copies of commissioning documentation.

1.10 Substantial Performance

- .1 Application for Substantial Performance of the Work is precedent on the Work being ready for Owner's use which includes completion of the following commissioning elements:
 - .1 start-up and testing, including TAB reports,
 - .2 commissioning Verification testing including submission of completed records,
 - .3 commissioning Performance Validation testing including submission of completed records, except for alternate season tests,
 - .4 commissioning Controls Validation testing,
 - .5 training of Owner's operations personnel,
 - .6 as-built documentation issued for Consultant's review,
 - .7 Operations and Maintenance manuals which have been reviewed by the Consultant and accepted by the Owner.

2 PRODUCTS

2.1 Test Equipment

- .1 Furnish tools and equipment required during the commissioning process.

- .2 Utilities (water, gas, fuel oil, electrical power) are provided by the Owner
- .3 Provide any proprietary test equipment and software required by equipment manufacturer for programming and / or start-up, whether specified or not.
- .4 Manufacturer provides test equipment, demonstrate its use, and assists in the commissioning process as needed.
- .5 Turn-over proprietary test equipment to the Owner upon completion of the commissioning process, where such requirement is specified in the relevant equipment specification sections.

3 EXECUTION

3.1 General

- .1 Perform commissioning in accordance with ASHRAE Guide 0, Guide 1.1 except/and as specified herein.
- .2 Complete all phases of work so that the systems can be started, tested, balanced, and owner's acceptance procedures be undertaken in a timely manner such that only one acceptance test is conducted at any one time.
- .3 Participate and assist in the development of the Commissioning Plan and schedule by the Contractor, by providing necessary information pertaining to the equipment and installation. Provide commissioning schedule information to be incorporated into the overall Construction Plan schedule.
- .4 Acceptance procedures may begin prior to completion of a system and/or sub-system. Start of acceptance procedures before system completion does not relieve the Contractor from completing those systems in accordance with the commissioning and construction schedule.

3.2 Participants

- .1 Commissioning Team consists of multiple parties with separate responsibilities.
- .2 Owner:
 - .1 establishes acceptance criteria,
 - .2 provides operations staff to receive training, and to witness any or all tests at their discretion,
 - .3 final acceptance of commissioning results.
- .3 Design Consultant:
 - .1 responsible for the construction review activities in accordance with local building code requirements,
 - .2 may participate in development and / or review of commissioning procedures,
 - .3 reviews commissioning test results,
- .4 Commissioning Authority:
 - .1 develops commissioning plan and procedures,
 - .2 coordinates Owner's commissioning team members who witnesses tests,
 - .3 selectively witnesses commissioning tests on an audit basis to confirm compliance by the Contractor to the Commissioning Plan,
 - .4 reviews commissioning test results and makes recommendations to the Owner for acceptance.
- .5 Contractor:
 - .1 coordinates and manages commissioning activities,

- .2 develops and integrates commissioning activities into the construction schedule,
- .3 ensures commissioning procedures are completed and documented, and commissioning records including any required attachments are submitted.
- .6 Mechanical trades subcontractors:
 - .1 Provide the services of qualified technician(s) who are familiar with the construction and operation of the system, to start-up and debug equipment and systems within the Division 20 scope of Work. Include for labour, materials, and subsistence costs for these same technicians to assist the Commissioning Authority in completing the commissioning program.
 - .2 Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
 - .3 Ensure the qualified technician(s) are available and present during commissioning testing to complete the tests, make adjustments and to assist in problem resolutions.
 - .4 Should any equipment or system experience performance problems and/or reconstruction or replacement of components is required, include for additional technician time for subsequent retesting of systems until required system performance is achieved.
 - .5 The Commissioning Authority reserves the right to approve proposed technicians with regard to the technical skill level required for each type of equipment and/or system, and a willingness by the individual(s) to work within the Commissioning Group.
- .7 Controls subcontractor, in addition to the requirements described above:
 - .1 Provide test reports using own documentation formats, for wiring tests, loop testing, loop tuning, and sequence functional tests.
 - .2 Provide details of the control system, schematics, and a narrative description of control sequences of operation.
- .8 Electrical subcontractor:
 - .1 provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces and interlocks.
- .9 Equipment suppliers:
 - .1 provide the services of manufacturers' service personnel to provide assistance with pre-start and initial start-up of the equipment, as required.

3.3 Commissioning Meetings

- .1 Participate in periodic commissioning team meetings, and trade commissioning meetings.
- .2 Pre-construction:
 - .1 participate in a pre-construction meeting of commissioning team members, to familiarize parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
- .3 Construction and Post-Construction:
 - .1 participate in commissioning meetings as scheduled by the Contractor.
 - .2 participate in trade commissioning meetings as required, in addition to the regular commissioning team meetings,
 - .3 identify to the commissioning group problems relating to the commissioning schedule, identification of start-up issues, etc., and participate in the resolution of these problems.

3.4 Commissioning Procedures

- .1 The Owner's designated Commissioning Authority provides the commissioning procedures (checklists, etc.) for use by the Contractor and trade subcontractors.
- .2 Each commissioning procedure tests the equipment and systems, and consists of the following elements:
 - .1 Document sign-off
 - .2 Pre-start and Initial test
 - .3 Installation Verification - Equipment
 - .4 Installation Verification - Systems
 - .5 Performance Validation
 - .6 Controls Validation
 - .7 Appendices.
- .3 Document Sign-Off:
 - .1 each completed procedure is signed off by the following parties:
 - (a) Contractor, for testing,
 - (b) Commissioning Consultant, for review and witnessing,
 - (c) Owner, for test acceptance.
- .4 Pre-Start and Initial Test:
 - .1 Checklists included: confirmation of authorities inspections, pre-start safety checks (where applicable), system cleaning and pressure testing, and confirmation of availability of supporting systems.
- .5 Installation Verification - Equipment
 - .1 Checklists to verify the installation of equipment, including: design specification requirements, drawing requirements, manufacturer installation requirements, and other experience-related items.
 - .2 Use of pre-printed manufacturer installation and start-up checklists are permitted and encouraged; however, the commissioning procedure checklists may contain supplemental items.
- .6 Installation Verification - System:
 - .1 Checklists to verify the installation of the system associated with the equipment.
- .7 Performance Validation:
 - .1 Specific test procedures and record documentation requirements for performance measurements of the various systems.
- .8 Controls Validation:
 - .1 Step-by-step testing methodologies to prove the functional operation of control systems, for normal and abnormal operating conditions, and alarm conditions.
- .9 Appendices:
 - .1 Collate test reports from authorities having jurisdiction, manufacturer start-up and test reports, balancing reports, etc.

3.5 Commissioning Test Methodology

- .1 Step 1: complete the pre-start, start-up and testing, and adjusting and balancing tests. On completion of this phase, complete the related documentation and submit to the Commissioning Authority and Consultant.
- .2 Steps 2 and 3: on completion of Step 1, conduct the Verification and Validation testing of the operating systems. Identify deficiencies and correct. After the deficiencies have been corrected, notify the Commissioning Authority and agree on dates to demonstrate the commissioned systems.
- .3 Step 4: where the Commissioning Authority identifies systems which require witness demonstration, repeat Steps 2 and 3. These demonstrations may be coordinated with training demonstrations of Owner's operations staff.
- .4 On completion of systems which do not require witness demonstration, finalize the report and submit to the Commissioning Authority and the Consultant for review.
- .5 On completion of systems which have been witness demonstrated, the Commissioning Authority is to sign-off the completed document, before they are issued for review.

3.6 Commissioning Implementation

- .1 Conduct operating tests and checks to verify that all components, equipment, systems, and interfaces between systems, operate in accordance with contract documents.
- .2 Demonstrate and verify operating modes, interlocks, specified control sequences, specific responses to abnormal or emergency conditions, and verification of the proper response of the Building Automation System.
- .3 Validate the results of the TAB report.
- .4 Roles and Responsibilities:

Organized by:	Contractor
Test sheets provided by:	Commissioning Authority
Testing conducted by:	Div. 20 trade subcontractors
Testing recorded by:	Div. 20 trade subcontractors
Tests witnessed by:	Commissioning Authority (selected tests) Design Consultant (selected tests)
Reports reviewed by:	Contractor Commissioning Authority Design Consultant Owner
Reports Accepted by:	Owner

3.7 Operating Checks

- .1 The Commissioning Authority witnesses selected equipment and system tests on an audit basis.
- .2 Set the system equipment into operating mode to be tested including but not limited to:
 - .1 Normal shut-down
 - .2 Normal auto position
 - .3 Normal manual position
 - .4 Unoccupied cycle

- .5 Emergency power operation, including transition states.
- .6 Alarm conditions
- .3 Inspect and verify the position of each device and interlock identified on the checklist.
- .4 Repeat the above tests for each operating cycle that applies to the system being tested.
- .5 Check the operating condition of the following elements during all modes of operation of the system:
 - .1 Safety interlocks
 - .2 Alarms
 - .3 Smoke control and smoke venting interlocks
 - .4 Life safety systems
- .6 For failed test items, provide appropriate comments to the checklist data sheet and classify whether it is a "Major" or "Minor" deficiency.
 - .1 The Consultant retains the right to make the final decision regarding classifications of deficiencies.
- .7 Verify the operational control of the systems through the Building Management System as follows:
 - .1 TAB airflow rates and calibrate terminal boxes in all modes of operation
 - .2 Equipment operation in both heating and cooling modes.
 - .3 Minimum outdoor air intake positions, air-side economizer cycles, and multi-set outdoor air damper positions as required for each operating sequence and mode.
 - .4 Building pressurization and other specialty programs
- .8 Verify the proper responses of instrumentation and control devices (actuators) as follows:
 - .1 For each controller or sensor, record the indicated monitoring and control system reading, and the test instrument reading.
 - .2 If the initial test indicates that the test reading is outside of the control range of the installed device, check the calibration of the installed device and adjust as required. Re-test the deficient device and record the results on the checklist data sheets.
- .9 The Commissioning Authority witnesses the field verification of the final TAB report as follows:
 - .1 Select, at random, 10% of the report data for verification.
 - .2 The TAB contractor will be provided advance notice of the date of retesting, but not the equipment to be tested.
 - .3 The TAB contractor uses the same equipment and instruments used for collecting the original data.
- .10 Test failure is defined as:
 - .1 For all readings other than sound, a deviation of more than 10 percent from the TAB report results.
 - .2 For sound pressure readings, a deviation of 2 dB at any bandwidth, not including differences in background noise readings.
 - .3 A failure rate greater than 10% of the selected items (1% of all TAB test results) will result in rejection of the final TAB report.
- .11 Acceptance

- .1 The final reports will be reviewed by the Commissioning Authority and the Consultant, to determine if verification is complete and the operating systems are functioning in accordance with the contract documents.
- .2 The Commissioning Authority, in conjunction with the Consultant, reviews and makes final classification of all noted deficiencies. Correct deficiencies classified as "Major" before acceptance of the Verification stage.
- .3 The Owner will make the final acceptance of test results.

3.8 Performance Validation Testing

- .1 Conduct performance tests and checks to validate that equipment and system components are providing the required heating and cooling performance (capacity), including but not limited to:
 - .1 Capability of the Chilled water system to deliver the required flow rate, and water temperature at design conditions.
 - .2 Capability of the hydronic and domestic water heating systems to deliver the required flow rate, and temperature.
 - .3 Capacity of electric heating systems at design temperatures.
 - .4 Confirm the ability of the HVAC systems to deliver the required cooling/heating services, at the design supply air temperature, required static pressure, and proper outside air ventilation rate.
- .2 Special testing requirements:
 - .1 Test water chillers in accordance with ARI 590 and 591, at design conditions for full load ratings, and IPLV ratings.

3.9 Problem Resolution

- .1 In the event that additional work is required to either correct systems, misapplied equipment, and/or deficient performance under varying load conditions, assist the Owner and Commissioning Authority in developing an acceptable resolution to the problem, including the resources of equipment suppliers.
- .2 The Owner has final approval over any additional work required to achieve the required level of performance.
- .3 Complete corrective work in a timely fashion to permit the completion of the commissioning process.

3.10 Acceptance

- .1 Any identified deficiencies will be reviewed by the Consultant in conjunction with the Contractor to determine if correction of the deficiency is as a result of a defect in the equipment or installation.
- .2 If it is determined the performance deficiency is as a result of a defect in the equipment or its installation, rectify the deficiency and repeat the performance test until the required performance levels are achieved.
- .3 If it is determined the equipment or system has been constructed in accordance with the contract documents, the Owner will decide whether to accept the performance as is, or, direct the installation contractor to make changes to the system as required to obtain performance levels which meet the design intent, and retest the system.

3.11 Additional Commissioning

- .1 Additional commissioning activities may be required after completion of system performance testing. Include in the tender cost a reasonable reserve to complete this work, including assistance from manufacturers' service technicians.

3.12 Systems Operating Manuals

- .1 Provide Operating and Maintenance Manuals in accordance with the requirements of section 20 01 01.
- .2 The Systems Operating Manuals (SOM) are in addition to the Operating and Maintenance Manuals (OMM) required under Section 20 01 01.
 - .1 Provided by Commissioning Authority and/or Consultant.

3.13 Training

- .1 Perform training in accordance with ASHRAE Guideline 1.3 except/and as specified herein.
- .2 Equipment Training:
 - .1 Provide equipment training in accordance with Section 20 01 01. The manufacturer's representative training will emphasize operating instructions and preventative maintenance.
- .3 Systems Training:
 - .1 In addition to the equipment training described above, provide additional training to describe the operational requirements and design intent of each system.
 - .2 Include classroom instruction, delivered by competent instructors. Place emphasis on overall systems diagrams and descriptions, and design criteria and conditions.
 - .3 If required, obtain and pay for the services of the Design Consultant to provide the instructor services and to provide lecture material for inclusion in the training manual.
 - .4 Training topics to include:
 - (a) Types of installed systems
 - (b) Design intent and design criteria
 - (c) Design constraints
 - (d) Different operating modes – occupied, unoccupied, emergency conditions, etc.
 - (e) Seasonal operating modes
 - (f) IAQ
 - (g) Energy efficiency
 - (h) System operation
 - (i) Automatic controls
 - (j) Service, maintenance, diagnostics and repairs
 - (k) Use of reports and logs
 - (l) Troubleshooting
- .5 Structure each session to start with the classroom instruction for the overall system, followed by hands-on instruction for each equipment, with the services of the manufacturers' representative as required. Demonstrate the start-up and shut-down of each system.
- .6 Organize and schedule each training session to deliver the required instruction in an efficient and effective manner on a schedule agreed upon with the Owner. Allow for two (2) training sessions for each topic, separated by approximately one week each, to allow for shift coverage.
- .7 Structure each training session based on type of maintenance personnel attending the training session, i.e. Plumbers, fitters, general maintenance, controls technicians, etc. Develop the proposed training plan and obtain approval from the Owner before commencing the training.

- .8 Complete the training as close to Substantial Performance as possible, so that the Owner's operations staff are prepared to operate the system after Substantial Performance is certified.
- .4 Training Manuals
 - .1 Provide training material hand-outs for each session.
 - .2 Collect training material and bind into separate binders.]

END OF SECTION

CLOSEOUT REQUIREMENTS FOR MECHANICAL WORK 20 77 19.20

1 GENERAL

1.1 Scope

- .1 Provide documentation deliverables at completion of the Work for the following milestone events:
 - .1 Occupancy permit (where applicable) (Form OP1M),
 - .2 Substantial Performance of the Work (Form SP1M),
 - .3 Ready for take-over by Owner (Form RFT1M),
 - .4 Total Performance of the Work (Form TP1M).

1.2 Definitions

- .1 The following definitions apply to this section.
 - .1 **Occupancy permit** – means either: (i) a permit issued by a regulatory authority to allow the Owner to occupy the building subject to the building permit, or (ii) a building permit close-out procedure where documentation must be submitted to the building authority for that purpose.

1.3 General

- .1 The prerequisites and submittal of supporting documentation for the aforementioned milestone events may be combined as a single submission at one point in time for the following combination of events:
 - .1 Occupancy Permit, and Substantial Performance.
- .2 Where a prerequisite is listed in more than one milestone event, it shall be included in the earliest-occurring milestone event unless expressly specified otherwise.

1.4 Occupancy Permit

- .1 Submit the reviewed final record of the Testing of Integrated Life Safety and Fire Protection Commissioning report two weeks prior to application for occupancy permit, where such a report is required.
- .2 Complete the Occupancy Permit Checklist and submit with required documentation to support the Owner's application for occupancy.

1.5 Substantial Performance

- .1 Complete the Substantial Performance Checklist and submit with required documentation when applying for Substantial Performance of the Work.
- .2 Where the work is sub-divided into separate scopes of Work, each requiring a separate Substantial Performance application, provide a separate checklist for each application.
- .3 Within five working days of the Consultant's review report which indicates that Substantial Performance of the Work has been achieved, provide a detailed schedule for completion and/or correction of the Work of all items described in the Contractors' and the Consultants' deficiency list.

1.6 Ready-for-Takeover by Owner

- .1 The basic prerequisites to attaining Ready-for-Takeover of the Work are described in the General Conditions and Supplementary General Conditions of the Contract.
- .2 Complete the Ready-for-Takeover Checklist and submit with required documentation when applying for Ready-For Takeover of the Work.

1.7 Total Performance

- .1 Complete the Total Performance Checklist and submit with required documentation when applying for Total Performance of the Work.

Form OP1M: OCCUPANCY PERMIT CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Building department inspection reports.
- ☐ AHJ pressure piping inspection reports (if applicable).
- ☐ AHJ fuel system inspection reports (if applicable).
- ☐ AHJ electrical systems inspection reports.

- ☐ Integrated Fire Protection and Life Safety test report to ULC-S1001.
- ☐

Consultant Review	
Status:	☐ Reviewed ☐ Incomplete or deficient - resubmit
Signed:	
Date:	

Form SP1M: SUBSTANTIAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Occupancy permit has been issued by the AHJ (where applicable).
- ☐ Systems have been started-up, tested, and demonstrated to Owner or Consultant.
- ☐ First submission TAB reports have been submitted to Consultant.
- ☐ Controls / BMS operation report submitted to Consultant (if specified).
- ☐ Equipment, pipeline, and valve identification completed
- ☐ Spare parts and replacement parts turned over to Owner, transmittal attached.

Consultant Review	
Status:	☐ Reviewed ☐ Incomplete or deficient - resubmit
Signed:	
Date:	

Form RFT1M: READY-FOR-TAKEOVER APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and documentation included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ Substantial Performance has been certified or verified.
- ☐ Occupancy permit has been issued by the AHJ (where applicable).
- ☐ Final cleaning and waste removal completed.
- ☐ Delivery to Owner of Operating and Maintenance documents for systems being taken-over by Owner.
- ☐ Submit copies of up-to-date as-built drawings.
- ☐ Final start-up, testing and balancing reports completed and submitted to Owner, including any items requiring corrections identified by Consultant.
- ☐ The portions of the building being turned over to the Owner can be secured by Owner.
- ☐ Demonstration and training are completed, or Contractor and Owner has agreed to a schedule to provide such training to be completed within one month after the date of Ready-for-Takeover.
- ☐ All commissioning activities except for those activities that are identified or otherwise agreed by the Owner to be deferred commission activities which may be completed after Ready-for-Takeover of the Work.
- ☐ Integrated systems testing of fire protection and life safety systems.
- ☐ All warranties have been submitted to the Owner.
- ☐ A comprehensive list of items to be completed or corrected is provided to Owner and Consultant and included in the application for Ready-for-Takeover, and includes a schedule of when such work will be completed.

Consultant Review	
Status:	☐ Reviewed ☐ Incomplete or deficient - resubmit
Signed:	
Date:	

Form TP1M: TOTAL PERFORMANCE APPLICATION CHECKLIST	
Project Name:	
Contract:	
Contract Scope:	
Application Date:	
Signed:	

The following requirements are completed and included in this application. Where documentation has been issued directly to the Owner, a copy of the transmittal is enclosed.

- ☐ All final Operating and Maintenance documents have been delivered to Owner.
- ☐ All final up-to-date as-built drawings have been delivered to Owner.
- ☐ Any follow-up testing and balancing reports have been submitted to Owner.
- ☐ All demonstration and training are completed.
- ☐ All commissioning activities are completed, including deferred alternate season commissioning activities.
- ☐ All known deficiencies have been corrected, including latent deficiencies reported by the Owner.
- ☐ All inspections and tests required to be performed by Contractor or manufacturer's prior to expiry of the warranty period have been completed, and documentation for those inspections and tests are included in this application.

Consultant Review	
Status:	☐ Reviewed ☐ Incomplete or deficient - resubmit
Signed:	
Date:	

End of Section

OIL SYSTEM DEMOLITION

23 11 05

1 GENERAL

1.1 Scope

- .1 Demolition, removal and disposal of:
 - .1 aboveground tank located outside of the boiler plant and associated piping,
 - .2 existing generators, auxiliary tank located in the boiler plant, and associated piping and
 - .3 ancillary devices, safely dispose of materials, and backfill and repair existing grade level finishes.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 23 11 13 Fuel Oil Piping and Accessories

1.3 Applicable codes and standards

- .1 Legislation:
 - .1 to section 23 11 13.
 - .2 SOR/2001-286 Transportation of Dangerous Goods Regulation
- .2 Installation standards, codes and guidelines:
 - .1 to section 23 11 13 and as follows.
 - .2 ISO 4406 *Hydraulic fluid power -- Fluids -- Method for coding the level of contamination by solid particles*

1.4 Qualified Tradesperson

- .1 Work to be done by a specialist firm with an established reputation in this field, employed as a subtrade under this contract.
- .2 Removal of storage tank systems and associated piping and ancillary equipment to be performed by a licensed petroleum equipment contractor of the applicable class for the equipment in accordance with:
 - .1 Ontario Regulation 215/01 *Fuel Industry Certificates* - OBT1
 - .2 Ontario Regulation 216/01 *Certification of Petroleum Mechanics* - PM2 and PM3 as applicable to the type of tank.

1.5 Submittals

- .1 Provide the following documentation for review by the Owner and Consultant, and for record purposes:
 - .1 documentation of disposal of storage tanks at a regulatory authority approved disposal site for such contaminated waste,
 - .2 laboratory test results of soil samples,
 - .3 laboratory test results of on-site water separation and oil filtration service for transferring of oil to a new tank,
 - .4 documentation of transfer of oil and/or residual oil/water/sludge to a regulatory authority licensed oil reclamation center,

- .5 documentation of disposal of contaminated soil (if found) to a regulatory authority licensed disposal site.

2 PRODUCTS

2.1 Section not used.

3 EXECUTION

3.1 General

- .1 After the new fuel oil system is installed and operational, schedule the removal of existing tanks and piping systems to be demolished with the Owner.
- .2 Remove oil from storage tanks and piping prior to demolition of same, and as further specified herein.
- .3 Remove aboveground tanks and piping systems in accordance to all legislation and government agency requirements.

3.2 Storage Tank and Piping - Liquid and Solids Removal

- .1 Drain existing oil piping to be demolished, by draining to the existing tank or to a remote location where oil can be collected for disposal.
- .2 Use a wire-drawn or pneumatic pipe cleaner (i.e a pipe cleaning pig) to remove residual oil film;
 - .1 If necessary to aid in moving oil, use dry nitrogen gas not to exceed 70 kPa (10 psig) at the remote end of the piping system to remove oil back to the tank wherever possible.
- .3 Remove the bulk of the fuel oil (except bottom sludge and water) and recycle and clean fuel oil prior to transferring it to the new tanks.

3.3 Fuel Recycling and Cleaning Treatment:

- .1 Transfer usable oil down to approximately 300 mm (12 in) from bottom of existing storage tank to new storage tank using a filter/re-conditioner system provided by a specialty oil conditioning treatment company.
- .2 Place suction line 300 mm (12 in) above bottom of tank to reduce risk of transferring water and sludge.
- .3 Filter and treat re-used oil during the transfer process to achieve a maximum particulate code rating of 18/16/13 in accordance with ISO 4406, and emulsified water not to exceed 200 ppm. Provide a laboratory test report confirming oil quality samples of two samples taken from the new tank at completion of transfer at the 1/3 and 2/3 oil level height. If samples do not meet the specified limits, continue filtering the new tank oil content on a recirculating basis until subsequent laboratory test samples meet these limits.

Standard of Acceptance

- Refuel Systems Inc.

3.4 Sludge Removal

- .1 After removal of the bulk of the fuel oil, provide samples of remaining liquids from the existing storage tank to a qualified hazardous waste testing facility for laboratory analysis and approval for the disposal of the remaining liquids.
- .2 Remove the remaining liquid from the existing storage tank and arrange and pay for its proper disposal prior to removing the tank from the ground.

- .3 Provide documentation of the liquid removal and its disposal in a final report.

3.5 Storage Tank - Cleaning and Disposal

- .1 Transport the removed tank from the site. Transportation on public roads shall conform to the requirements of the Transportation of Dangerous Goods Regulation, except where the tank is cleaned in accordance with the following procedure prior to transport.
- .2 Measure levels of combustible vapors and oxygen, and initiate ventilation of the tank, if needed as follows:
 - .1 ventilate tank using an explosion-proof gas exhauster until the vapor concentration is reduced to 10 percent or less of the lower explosive limit for diesel fuel (LEL = 0.6% by volume of air). Extract air from the bottom of the tank;
 - .2 oxygen content of samples of exhaust air shall range from 19.5 to 23.5 percent;
 - .3 cut access ports for cleaning into tank after vapor and oxygen concentrations have met the requirements noted above;
 - .4 cut additional holes if necessary along the tank spring line, minimum of two (2) 200 mm x 200 mm (8 in x 8 in) holes both side of the tank;
 - .5 clean the tank by mopping, scraping, and sweeping the interior of the tank, providing a final surface clean with solvents suitable for the removal of oil film;
 - .6 ensure final vapor and oxygen concentration are within the requirements noted above before proceeding to cut and dismantle the tank for transport to a disposal facility;
- .3 Collect, contain and place residue in DOT approved portable containers for transporting and disposal.
- .4 Remove the dismantled tank to an approved disposal facility.
- .5 Obtain disposal facility receipts noting proper tank disposal.

END OF SECTION

FACILITY FUEL-OIL PIPING

23 11 13.13

1 GENERAL

1.1 Scope

- .1 Provide aboveground fuel oil piping, valves, specialties and accessories for stationary engines including diesel-generators.
- .2 For solenoid valves, and actuators for motorized valves, refer to specification section 23 11 13.23.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 02 Painting for Mechanical Services
 - .2 20 05 24 Welding and Brazing
 - .3 20 05 53 Identification
 - .4 20 05 63 Safety Bollards and Equipment Guards
 - .5 23 11 13.23 Facility Fuel-Oil Controls and Instrumentation

1.3 Definitions and Abbreviations

- .1 In this section and related sections, the following definitions apply;
 - .1 **Carrier piping:** the secondary non-product piping in a double wall piping system which encloses the product piping. *Containment piping* has the same meaning.
 - .2 **High-pressure piping:** piping systems with design pressures exceeding the pressure limits for Low-pressure piping.
 - .3 **Low-pressure piping:** a fuel-oil piping systems with a design pressure not exceeding the design pressure and design temperature specified herein.
 - .1 **Oil Code:** means CSA B139 Series of the edition and with amendments, if any, as adopted by the AHJ for fuel safety.
 - .4 **Petroleum equipment contractor:** a person or company which holds the appropriate and required license, certificate of qualification or similar status for installation of oil burning equipment and associated ancillary equipment as required by applicable law.
 - .5 **Product piping:** all piping except tank vent piping. For greater certainty, an auxiliary supply tank overflow pipe is a product pipe even if it is used for venting an auxiliary supply tank.
 - .6 **Vent piping:** the piping that provides positive and negative pressure relief for a tank and which is piped directly to outdoors, but does not include tank overflow piping used to vent an auxiliary supply tank to a main supply tank.
- .2 In this section and related sections, the following abbreviations apply;
 - .1 **ATTP** Auxiliary supply tank test panel
 - .2 **DPCP** Diesel pump control panel
 - .3 **OFAS** Overflow alarm system
 - .4 **MSCP** Main fuel system control panel
 - .5 **RFCP** Remote fuel system control panel

1.4 Applicable Codes and Standards

.1 Legislation:

- .1 Regulation 213/01 Fuel Oil
- .2 Regulation 215/01 Fuel Industry Certificates
- .3 Regulation 216/01 Certification of Petroleum Mechanics
- .4 TSSA HPP-2020 Fuel Safety High-pressure Piping Code

.2 Installation standards and codes:

- .1 ASME B31.1 Power Piping Code
- .2 ASME B31.9 Building Service Piping Code
- .3 ASME BPVC Section V Nondestructive Examination
- .4 CSA B139 Installation code for oil-burning equipment
 - (a) Edition and as amended by provincial adoption, otherwise the latest published edition.

.3 Product standards:

- .1 ASTM A53 Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless.
- .2 ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service
- .3 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
- .4 ASTM A307 Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
- .5 ASTM A563 Standard Specification for Carbon and Alloy Steel Nuts
- .6 ASME B16.3 Malleable Iron Threaded Fittings
- .7 ASME B16.5 Pipe Flanges and Flanged Fittings
- .8 ASME B16.9 Factory Made Wrought Steel Buttwelding Fittings
- .9 ASME B16.11 Forged Fittings, Socket-Welding and Threaded
- .10 ASME B16.39 Malleable Iron Threaded Pipe Unions: Classes 150, 250 and 300
- .11 ASME B18.2.1 Square and Hex Bolts and Screws
- .12 ASME B18.2.2 Square and Hex Nuts
- .13 ASME B16.21 Non-Metallic Flat Gaskets for Pipe Flanges
- .14 ASME B16.20 Metallic Gaskets for Pipe Flange: Ring-Joint Spiral Wound and Jacketed
- .15 ISO 5211 Industrial Valves – Part-turn Actuator Attachments
- .16 ULC/ORD C536 Flexible Metallic Hose
- .17 UL/ULC 842 Valves for Flammable and Combustible Liquids
- .18 ULC S631 Isolation Bushings for Steel Underground Tanks Protected with External Corrosion Protection System
- .19 CAN/ULC S661 Standard for Overfill Protection Devices for Flammable and Combustible Liquide Storage

- .20 CAN/ULC S663 Standard for Spill Containment Devices for Flammable and Combustible Liquid Aboveground Storage Tanks.
- .21 MSS SP-97 Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends
- .22 FM Class 7440 Approval Standard for Liquid and Gas Safety Shut-off Valves.

1.5 Quality Tradesperson

- .1 Installation and on site testing of fuel oil systems to be performed in accordance with applicable regulations and standards by a specialist licensed petroleum equipment contractor of the applicable class for the equipment, in accordance with:
 - .1 Ontario Regulation 215/01 *Fuel Industry Certificates* - OBT1
 - .2 Ontario Regulation 216/01 *Certification of Petroleum Mechanics* - PM2 and PM3 as applicable to the type of tank.

1.6 Registration and Inspection

- .1 Submit applications, as required, and arrange and pay for field inspection of the installation by the Authority Having Jurisdiction for the following work elements:
 - .1 field inspections for variances issued by the AHJ.
- .2 Contractor shall prepare, coordinate, submit and pay for an expedited application for approval with the AHJ for the following alternative solutions (variances). Contractor shall also arrange and pay for any required field inspections by the AHJ related to such alternate solutions:
 - .1 Venting of an auxiliary (sub-base) tank directly to atmosphere.

1.7 Design Criteria

- .1 Piping system design criteria:
 - .1 Low-pressure piping:
 - (a) design pressure: 690 kPa (100 psig)
 - (b) design temperature: 38°C (100°F)
- .2 Piping Design and Installation Code:
 - .1 Low-pressure piping: to CSA B139, and ASME B31.9 for elements not covered by the CSA code.

1.8 Submittals

- .1 Submit manufacturer's data sheets for valves, flange gaskets and fuel oil specialties, with model numbers, performance and design data, outline dimensions and power requirements.
- .2 For equipment required to be listed (certified) to a standard, include the following information marked on the product data sheet or as a separate file listing sheet:
 - .1 the standard to which it is listed,
 - .2 name of testing organization or their recognized mark, and
 - .3 the testing organization testing class reference and/or listing file.

2 PRODUCTS

2.1 Steel Pipe and Fittings

- .1 General:

- .1 Pipe fittings and flanges to have Canadian Registration Number (CRN) listing to CSA B51, and be manufactured by an ISO9001 certified company.

Standard of Acceptance

- Anvil
- Bonney Forge

- .2 Pipe:

- .1 NPS ½ to 10:

- (a) ASTM A106 Gr B, schedule 40 Seamless, or
 - (b) ASTM A53 Gr B, schedule 40 Electric Resistance Weld (type E) or Seamless (type S)

- .2 for vent piping located outdoors: as specified above with galvanized coating unless piping is field painted.

- .3 Fittings:

- .1 NPS 2 and under:

- (a) ASME Class 3000 forged steel fittings, socket welding type, to ASME B 16.11,
 - (b) ASME Class 150 and 300, malleable iron threaded fittings, to ASME B16.3,
 - (c) ASME Class 150 and 300, malleable iron, bronze face, ground joint unions, to ASME B16.39.

- .2 Fittings for tank vent piping, NPS 2 and under:

- (a) ASME Class 150 malleable iron threaded fittings, to ASME B16.3.

- .3 NPS 2 ½ and over:

- (a) ASME Class 3000 forged steel fittings, socket welding type, to ASME B 16.11,
 - (b) Buttweld type fittings, long radius elbow, wall thickness to match pipe, to ASME 16.9,

- .4 Branch outlet fittings:

- (a) Standard Class integrally reinforced branch outlet fittings for buttweld branch connection to MSS SP-97.

- .4 Flanges:

- .1 NPS ½ and over:

- (a) ASME Class 150 and 300 forged steel raised face flanges, to ASME B16.5,
 - (b) weld-neck with wall thickness to match pipe, or slip on type.

- .2 Gaskets:

- (a) To ASME B16.21 of heavy duty graphite impregnated compressed sheet 1.6 mm (1/16 in) thick
 - (b) Minimum service temperature: 600°C (1110°F).

Standard of Acceptance

- Chesterton 198

- .3 Studs, bolts and nuts:

- (a) "High strength" type to ASME B18.2.1 with ASME 18.2.2 or ASTM A307 with ASTM A563 or ASTM A194.

2.2 Manual and Motorized Valves

.1 Ball valves, brass/bronze body, NPS 2 and under:

- .1 listed to UL/ULC 842.
- .2 for manual operation only,
- .3 two-piece brass or bronze body,
- .4 pipe ends: threaded NPT to ASME B1.20.1.
- .5 full ported solid ball, stainless steel or chrome plated brass,
- .6 PTFE seats and Viton seals,
- .7 lockable lever handle with nylon grip,
- .8 minimum pressure rating (flammable liquid):
 - (a) 1720 kPa (250 psig) at 93°C (200°F):

Standard of Acceptance

- Conbraco (Apollo) - fig. 77F-100 series
- Jomar - fig JF-100T-LH

- (b) 4130 kPa (600 psi) at 93°C (200°F):

Standard of Acceptance

- Crane - fig. F9202

.2 Ball valves, carbon steel body, NPS 2 and under:

- .1 listed to UL/ULC 842.
- .2 for manual operation,
- .3 cast steel body, two-piece split body design,
- .4 pipe ends: threaded NPT to ASME B1.20.1 or socket-welded,
- .5 full ported solid ball, stainless steel ball,
- .6 PTFE seats and seals,
- .7 gear operator with standard wheel and locking device for NPS 3 – NPS 10
- .8 minimum pressure rating (flammable liquid):
 - (a) 1720 kPa (250 psig) at 93°C (200°F):

Standard of Acceptance

- Jomar - fig. T-CS-2000N-SS (threaded)

- (b) 4130 kPa (600 psi) at 93°C (200°F):

Standard of Acceptance

- Jomar - fig. T-CS-1001N-SS (threaded)
- Jomar - fig. T-CS-2002N-SS-DUE (threaded, five-piece body)
- Jomar - fig. S-CS-2002N-SS-DUE (socket-welded, five-piece body)

.3 Ball valves, carbon steel body, NPS 3/4 to NPS 8, ISO 5211 mount:

- .1 listed to UL/ULC 842.

- .2 for manual or motorized operation,
- .3 cast steel body, two-piece split body design,
- .4 pipe ends: ASME flanged,
- .5 full ported solid ball, chrome plated carbon steel or stainless steel ball,
- .6 PTFE seats and seals,
- .7 ISO 5211 mounting pad, and lockable lever handle with nylon grip for NPS 2½,
- .8 gear operator with standard wheel and locking device for NPS 3 – NPS 10
- .9 minimum pressure rating (flammable liquid):
 - (a) 1720 kPa (250 psig) at 93°C (200°F):

Standard of Acceptance

- Apollo - fig 88A-200
- Jomar - fig. FL-CS-100-150

- (b) 4130 kPa (600 psi) at 93°C (200°F):

Standard of Acceptance

- Apollo - fig 88A-900

- .4 Operators for motorized valves: conform to specification section 23 11 13.23.

2.3 Check Valves

- .1 NPS 2 and under:
 - .1 listed to API 602.
 - .2 forged steel body, swing check, steel disc +13% Cr overlay, bolted bonnet,
 - .3 pipe ends: socket-weld, threaded
 - .4 pressure rating: ASME Class 800.

Standard of Acceptance

- Crane - fig. B-3675XU-W (socket weld)
- Crane - fig. B-3675XU-T (threaded)
- Bonney Forge - fig. HL-41-SW (socket weld)
- Bonney Forge - fig. HL-41-T (threaded)
- OMB - fig. 860

- .2 NPS 2½ and larger:
 - .1 cast carbon steel body, swing check steel disc +13% Cr, bolted cover,
 - .2 pipe ends: ASME flanged,
 - .3 pressure rating: ASME Class 300

Standard of Acceptance

- Crane - fig. 159XU
- Kitz - fig. 300SCOS

2.4 Tank Overfill Protection Valve

- .1 Positive shut-off valve for pressurized fill delivery as applicable;
 - .1 single action shut-off valve, with internal drain vents,
 - .2 integral to fill tube,
 - .3 integral pressure relief,
 - .4 adjustable fill height,
 - .5 NPT connections for remote fill, or cam-and-lock dry fill connector in on-tank spill containment device as shown,
 - .6 listed to CAN/ULC S661,
 - .7 for NPS 4 or 6 tank connections:

Standard of Acceptance

- OPW - 61fstop-2000 (pressure fill)
- Franklin Fuels – 709 Warden (pressure fill)
- Morrison Brothers – 9095AA (pressurized fill)

2.5 Flexible Hose Connectors for Combustible Liquids

- .1 Listed to ULC/ORD C536,
- .2 Construction:
 - .1 pipe size NPS 3/4 to NPS 3,
 - .2 inner hose: corrugated T304 stainless steel,
 - .3 outer jacket: braided T304 stainless steel wire mesh,
 - .4 end fitting: NPT with wrench lands, non-swivel type,
 - .5 rated working pressure: 1034 kPa (150 psi),
 - .6 minimum working pressure: full vacuum,
 - .7 maximum working temperature: 66°C (150°F),
 - .8 live length: 400 mm (16 in) not including end fittings.

Standard of Acceptance

- Flex-Pression Ltd – fig. UFP series
- OPW Inc – fig. FC series
- Hose Master LLC – fig. FS series

2.6 Remote Tank Fill Station

- .1 Listed to ULC-S663,
- .2 Construction:
 - .1 powder coated steel, welded construction,
 - .2 bottom outlet connection,
 - .3 lockable access lid,
 - .4 grounding lug,
 - .5 floor mounting with adjustable support legs,
 - .6 NPS 3 tight-fill connections,

- .7 instructions decal,
- .8 minimum 5 litre (1 gal) capacity for tanks < 5000 litres, and 15 litre capacity for tanks > 5000 litres,
- .9 sump valved drain to fill line or external container,

Standard of Acceptance

- Morrison Brothers - fig. 715 series
- OPW - fig. 6211, 6221 (211-RMOT)

2.7 Truck Fill-Hose Connections

- .1 Pressurized fill connection:
 - .1 cam-and-groove type adaptor, dry-disconnect style with internal spring-loaded poppet valve, and dust cap.
 - .2 tank fill hose attachment: matching coupler with poppet valve handle, and male threaded end.
 - .3 size: as shown.

Standard of Acceptance

- OPW - fig. 1611AN / 634A / 1711D
- Morrison Brothers - fig. 927 / 800DC / 928

2.8 Vent Terminals

- .1 Tank normal vent terminal:
 - .1 for continuous pressure and vacuum venting,
 - .2 aluminum body, 40-mesh brass insect screen.
 - .3 pipe size: NPS 2 and 3.

Standard of Acceptance

- OPW - fig. 23
- Morrison Brothers - fig. 354

- .2 Tank emergency vent terminal:
 - .1 listed to ULC-S601 (Appendix B)
 - .2 normally closed vent, opening on pressure.
 - .3 aluminum body and cast iron lid
 - .4 pressure setting: 7 kPa (16 oz/in²)
 - .5 pipe size: NPS 2 to NPS 10

Standard of Acceptance

- OPW - fig. 201, 301
- Morrison Brothers - fig. 244O

2.9 Anti-siphon Oil Valve

- .1 General:

- .1 spring loaded, two position angle valve;
- .2 listed to UL/ULC 842
- .3 body: E-coated cast or ductile iron, or anodized aluminium body, machined seats and elastomeric seals,
- .4 normally closed operation,
- .5 fitted with thermal pressure relief trim.
- .6 Non-adjustable antisiphon valve: non-field adjustable,
- .7 factory-set head pressure setting, with selection range between 0 and 6 m (0 to 20 ft),
- .8 selected for the hydrostatic head measured from the piping on top of tank to fuel pump inlet,
- .9 size: NPS $\frac{3}{4}$ to 2.

Standard of Acceptance

- OPW - fig. 199ASV
- Morrison Brothers - fig. 910

.2 Adjustable anti-siphon valves:

- .1 field-adjustable valve head pressure setting, with ranges between 0 and 7.5 m (0 to 25 ft),
- .2 with locking pin,
- .3 size: NPS $\frac{3}{4}$ to 2

Standard of Acceptance

- Franklin Fueling - fig. EBW 600 series.

2.10 Pipeline Pressure Relief Valves

.1 Construction:

- .1 carbon steel body with carbon or stainless steel internals;
- .2 Viton O-ring cap seal,
- .3 pressure rating: minimum 150% of design pressure but not less than 1700 kPa (250 psig),
- .4 pipe connections:
 - (a) NPS 2 and smaller: threaded NPT
 - (b) NPS 2-1/2 and larger: flanged.
- .5 for installation at fuel pump discharge piping:
 - (a) non-positive shut-off type, allowing small bypass leakage permitted prior to setpoint release.

Standard of Acceptance

- Fulflo - fig. FV

.6 for installation at all other locations:

- (a) brass body,
- (b) positive shut-off type, with no leakage prior to setpoint release.

Standard of Acceptance

- Fulflow - fig. SVB

- .2 Pressure relieving setpoint (unless otherwise shown):
 - .1 pump relief: equal to piping system design pressure at pump discharge.
 - .2 line relief other than at pump discharge: as shown.

2.11 Tank Drop Tube and Dipstick Protection Assembly

- .1 Aluminium and stainless steel sliding bracket with Viton base, designed to protect the bottom of the tank from abrasion and damage to due dipsticks

Standard of Acceptance

- OPW - fig. 6111-1400 with 61TP
- Franklin Fueling

2.12 Fusible-link Emergency Shut-Off Valves

- .1 NPS 2 and under:
 - .1 listed to UL/ULC 842,
 - .2 fusible link valve for flammable liquid service, stainless steel body with stainless steel trim, threaded ends.
 - .3 spring loaded, held-open actuator with fusible link set to release at 73°C (165°F),
 - .4 pressure rating: 345 kPa (50 psi).

Standard of Acceptance

- Morrison Brothers- fig. 446 (NPS ½ to NPS 1)
- OPW - fig. 178S (NPS 2 only)

2.13 Signage

- .1 Signage for shut-off valves for outdoor or underground fuel tanks:
 - .1 2 mm (0.08 in) thick aluminum front and back faces, with polyethylene core sandwich construction.
 - .2 minimum 300 mm x 250 mm (12 in x 10 in), with rounded corners and mounting holes in each corner.
 - .3 painted enamel yellow background with black lettering minimum 25 mm (1 in) high.
 - .4 Wording (three signs):
 - (a) "EMERGENCY EQUIPMENT DIESEL FUEL SHUT-OFF VALVE"
 - (b) "BUILDING SERVICE FUEL SHUT-OFF VALVE"
 - (c) "FUEL SHUT-OFF VALVE LOCATED AT FUEL TANK"

3 EXECUTION

3.1 Piping Installation – General Requirements

- .1 Install piping systems in accordance with the Oil Code and as described herein.
- .2 Slope piping down in direction of the associated supply tank.
- .3 Ream steel pipe after cutting to length, clean off scale and dirt inside and outside of pipe.
- .4 Cap ends during construction to prevent entry of foreign matter.
- .5 Use eccentric reducers at pipe size change installed FOB to provide positive drainage.

- .6 For outdoor vent piping, used galvanized pipe unless the piping is required to be painted.
- .7 Where piping passes through pavement, sidewalk or concrete slab, protect the pipe with a PVC sleeve with a minimum clearance of 12 mm (½ in) between vent pipe and sleeve. Sleeve to extend 50 mm (2 in) above the pavement, sidewalk or concrete slab. Fill the clearance space at the top of the sleeve with flexible grey mastic sealant.

3.2 Selection of Pressure Rated Components

- .1 Except as specified below, select piping system components with pressure ratings that are equal to or greater than the piping system design pressure.
- .2 Fittings and components that are ASME Class pressure-temperature rated are to be selected in accordance with the following:
 - .1 ASME Class 150 or higher Class for piping system design pressures of 1400 kPa (200 psi) and less,
 - .2 ASME Class 300 or higher Class for piping system design pressures greater than 1400 kPa (200 psi).

3.3 Hanger Installation

- .1 Provide hangers for steel pipe with spacing and hanger rod diameter in accordance with table 1.

Table 1 : Hanger Spacing for Steel Piping		
Pipe Size NPS	Rod Diameter	Maximum Spacing
½	10 mm (⅜ in)	1.8 m (6 ft)
¾ to 1¼	10 mm (⅜ in)	2.1 m (7 ft)
1½	10 mm (⅜ in)	2.7 m (9 ft)
2	10 mm (⅜ in)	3.0 m (10 ft)
2½	13 mm (½ in)	3.0 m (10 ft)
3	13 mm (½ in)	3.3 m (12 ft)
4	16 mm (⅝ in)	4.2 m (14 ft)
6	16 mm (¾ in)	5.1 m (17 ft)
8	22 mm (¾ in)	5.7 m (19 ft)
10	22 mm (⅞ in)	6.7 m (22 ft)
12	22 mm (⅞ in)	7.0 m (23 ft)

- .2 Support vertical riser piping:
 - .1 NPS 1 and smaller: at every other floor level.
 - .2 NPS 1-1/4 and larger: at every floor level.

3.4 Pipe Joints and Fittings

- .1 Make joints in piping in accordance with the following:
 - .1 product piping (except as otherwise specified):
 - (a) NPS 2 and smaller: socket-weld fittings.
 - (b) NPS 2-1/2 and larger: butt-welded joints.
 - .2 vent piping:

- (a) as above for product piping, and may be threaded for NPS 2 and smaller,
- .3 valve connections:
 - (a) indoor piping: threaded or flanged based on pipe size,
 - (b) outdoor piping: socket-welded and flanged based on pipe size.
- .4 equipment connections:
 - (a) NPS 2 and smaller: threaded unions.
 - (b) NPS 2-1/2 and larger: flanged.
- .2 Pipe welding:
 - .1 welding of piping systems to conform to specification section 20 05 24 and as specified herein,
 - .2 weld joints in accordance with contractors qualified weld procedures as applicable to the specified piping standard,
 - .3 make branch connections to mains in accordance with Table 2:
 - (a) Table 2 is valid for mains openings without additional reinforcement for design pressures of 2000 kPa (300 psi) or less,
 - (b) in Table 1, the following abbreviations apply.

Abbreviations:

TH Threaded fitting to ASME B16.3
SW Socket weld fittings to ASME B16.11
BW Buttweld fitting to ASME B16.9
OF Reinforced Outlet Fittings to MSS SP-97
DP Direct welding of Branch Pipe to Main as specified below.

Table 2 – Allowable Branch to Main Connections										
Branch Pipe NPS	Mains Pipe, NPS									
	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10
3/4	SW	SW	SW	SW	BW, OF SW	BW, OF SW DP	BW, OF SW DP	BW, OF DP	BW, OF DP	BW, OF DP
1	SW	SW	SW	SW	BW, OF SW	BW, OF SW DP	BW, OF SW DP	BW, OF DP	BW, OF DP	BW, OF DP
1-1/4	---	SW	SW	SW	BW, OF SW	BW, OF SW DP	BW, OF SW DP	BW, OF DP	BW, OF DP	BW, OF DP
1-1/2	---	---	SW	SW	BW, OF SW	BW, OF SW DP	BW, OF SW DP	BW, OF DP	BW, OF DP	BW, OF DP
2	---	---	---	SW	BW, OF SW	BW, OF SW	BW, OF SW DP	BW, OF DP	BW, OF DP	BW, OF DP

Table 2 – Allowable Branch to Main Connections										
Branch Pipe NPS	Mains Pipe, NPS									
	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10
2-1/2	---	---	---	---	BW SW	BW, OF SW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
3	---	---	---	---	---	BW	BW, OF SW	BW, OF DP	BW, OF DP	BW, OF DP
4	---	---	---	---	---	---	BW	BW, OF	BW, OF DP	BW, OF DP
6	---	---	---	---	---	---	---	BW	BW, OF	BW, OF DP
8	---	---	---	---	---	---	---	---	BW	BW, OF
10	---	---	---	---	---	---	---	---	---	BW

- .4 Direct-welding of branch piping to main piping ("DP") is permitted in accordance with the following requirements:
 - (a) the centerline of the branch pipe intersects the centerline of the main pipe,
 - (b) the branch pipe centerline is 90° to the main pipe centerline,
 - (c) branch pipe sits-on mains pipe, and does not insert into the main pipe,
 - (d) branch pipe attachment end is shaped to closely following the surface of the main pipe, and is prepared with a bevel-end suitable for a full penetration groove weld,
 - (e) cut openings in main true and square. Openings to be sized to prevent entry of welding metal and slag into pipes,
 - (f) branch pipe is attached with a groove weld and covered with a smooth finishing fillet weld.
- .5 Where integrally reinforced branch welding outlet fittings or direct welding of branch pipe is used, hole saw or drill and ream mains pipe to maintain full inside diameter of branch line prior to welding.
- .6 Where multiple branch pipes attach to the main pipe in close proximity to each other, provide a minimum separation between the centerlines of adjacent branch pipes equal to or greater than the sum of the OD dimensions of the branch pipes.
- .7 If threaded fittings have been installed where the specification requires welded fittings, either cut-out and replace the fitting, or fully seal-weld the exposed threads.

3.5 Valves

- .1 Install valves in locations as shown.
- .2 Install valves with stems upright for horizontal piping.
- .3 Install solenoid valves, motorized valves and safety valves with actuators upright and accessible for inspection and maintenance. Valve bodies may be installed in a vertical orientation if valve/actuator manufacturer installation instructions permit.
- .4 Install check valves only in the horizontal position.

3.6 Tank Vent Terminals

- .1 Terminate tank vents as follows:
 - .1 Vertical vents above roof;
 - (a) NPS 2 and 3 vent pipes: manufactured vent terminal.
 - (b) NPS 4 and larger: 180° gooseneck fabricated from long radius welded fittings and a 40 mesh stainless steel insect screen welded to open end of pipe.
 - .2 Horizontal vents;
 - (a) NPS 3 and smaller: 90° elbow and union with 40 mesh stainless steel insert,
 - (b) NPS 4 and larger: 90° long radius elbow and a 40 mesh stainless steel insect screen welded to open end of pipe.

3.7 Anti-siphon Valves

- .1 Size anti-siphon valves to be the same as connected pipes size, except as otherwise specified herein.
- .2 Where fuel supply line is NPS 3 size, provide two (2) x NPS 2 anti-siphon valves piped in parallel at the tank connection.
- .3 Install non-adjustable anti-siphon valves on the suction line between the main supply tank and the fuel transfer pump as close to the tank as possible;
 - .1 select the valve pressure head setting to be equal to the elevation difference between the tank high-fill level and the elevation of the inlet to the pump,
- .4 Install adjustable anti-siphon valves on the suction line between a supply tank and the engine (generator) that is connected to;
 - .1 field-set the anti-siphon valve to be equal to the elevation difference between the tank high-fill level and the lowest elevation in the piping between the tank and the engine.

3.8 Miscellaneous Pipeline Material

- .1 Install remote fill stations as shown. Install remote high level alarm panel within 1000 mm (3 ft) of fill station. Fit fill pipe with tight fill connectors, and leave tanker hose adaptor fitting inside containment box at project hand-over.
- .2 Install vacuum breakers at locations shown.

3.9 Safety Bollards

- .1 Provide safety bollards to protect fuel-oil piping and/or appliances from damage due to vehicles, in accordance with section 20 05 63 and as shown.
- .2 Provide safety bollards where vehicle traffic, including lift trucks, can pass within 1 m (39 in.) of fuel piping.

3.10 Identification

- .1 Provide label identification of piping in accordance with section 20 05 53.

3.11 Pipe Painting

- .1 Paint fuel piping in the following locations:
 - .1 piping located outdoors,
 - .2 piping located indoors.
- .2 Paint piping in accordance with section 20 05 02, with finish colours in accordance with the following:

- .1 outdoor piping: Pantone 11-0601 TPX (bright white)
- .2 other indoor piping: Pantone 18-0940 TPG (golden brown)

3.12 Signage

- .1 Install building shut-off valve signs where outdoor piping passes through into the building. Install signs with bottom of sign between 1200 mm and 1500 mm (4 ft and 5 ft) above local grade level.
- .2 Provide a self-adhesive label attached to each tank and appliance, located adjacent to the tank or appliance nameplate, and include the following information:
 - .1 Identification of equipment;
 - .2 Name of licensed petroleum contractor;
 - .3 License number of petroleum contractor;
 - .4 Date of installation.
- .3 For outdoor aboveground tanks, provide signage in accordance with the following:
 - .1 self-adhesive signage or painted stenciling, located at the mid-point sidewalls of the tank (both sides) identifying the fuel type ("DIESEL", "NO.2 HEATING OIL") in black lettering 200 mm (8 in.) high.
 - .2 Self-adhesive OSHA label adjacent to the above tank label, stating "DANGER – NO SMOKING", approximately 355 mm wide x 250 mm high (14 x 10 in).

3.13 Weld Examinations – Low-pressure Piping

- .1 Arrange and pay for examination of welds in low-pressure piping in accordance with the requirements of ASME B31.9 and Specification section 20 05 24.
- .2 Where double-wall piping is required:
 - .1 examine product piping welds before installation of carrier pipe,
 - .2 examination of welds on carrier pipe is not required; conduct a pressure test only.

3.14 Pressure Testing

- .1 Arrange for and pay charges for the AHJ inspector to be present to witness pressure testing, where such inspection activity is required by the AHJ.
- .2 Pressure test the piping system as described herein to verify that pipe joints are liquid and air tight.
- .3 Conduct pneumatic pressure testing of piping systems prior to connection to appliances and tanks, using air, nitrogen or carbon dioxide.
- .4 Take pressure measurements using calibrated measuring instruments with graduations in increments not greater than:
 - .1 2 kPa (0.5 psi) for test pressures up to 200 kPa (30 psi), and
 - .2 10 kPa (1 psi) for test pressures exceeding 200 kPa (30 psi) and up to 700 kPa (100 psi)
 - .3 20 kPa (2 psi) for test pressure exceeding 700 kPa (100 psi).
- .5 While conducting the piping pressure tests, isolate tanks from the pressure test by means of service valves, flange hydrotest paddle blinds, or disconnecting pipe from tanks and temporarily capping the pipe.
- .6 Pressure test piping located aboveground and inside of building;
 - .1 temporarily install pressure gauges at test points or tapped fittings,

- .2 for test pressures in excess of 175 kPa (25 psi), conduct an initial pneumatic pressure test at 70 kPa (10 psi) to locate any major leaks. Correct leaks before commencing final pressure test,
- .3 pneumatically pressure test piping at test pressures in accordance with Table 5:

Table 5: Pneumatic Pressure Test Settings	
Portion of Piping System	Pneumatic Test Pressure kPa (psi)
Main supply tank vent pipe,	28 kPa (4 psi)
Auxiliary supply tank vent pipe	
Main supply tank fill pipes	350 kPa (50 psi)
Suction piping between the main supply tank and the transfer pumps	
Supply and return piping between an auxiliary	
Supply piping downstream of a fuel pump	120% of piping design pressure but not less than 350 kPa (50 psi)
Auxiliary supply tank overflow piping between auxiliary tank and main supply tank(s)	
Heating oil return piping between the boiler plant and main supply tank(s)	

- .4 When pressure testing piping to 120% of the design pressure, raise the pressure to 120% of design pressure for 10 minutes, then reduce the pressure to design pressure and hold at that pressure during leak checking.
- .5 Where entire piping system is accessible for inspection, maintain the test pressure for a period of not less than 30 minutes to allow examination for leakage at all joints, using a suitable leak-detection solution.
- .6 Where a portion of the piping system is not accessible for inspection, maintain the test pressure for a period of not less than 24 hours. Provide a pressure recording device (chart recorder) to record test pressure at not less than 5-minute intervals,
- .7 If a leak is detected during the leakage test, correct the leak and retest the system until there are no further leaks.
- .7 In-service pressure test:
 - .1 After cleaning and flushing of the system and after the system has been filled with oil product, operate the system and conduct a final visual check of exposed piping joints at tanks, pumps, other equipment and appliances. Make corrections to joints where leaks are discovered.
 - .2 For pressurized supply piping and piping risers, shut-off distribution pumps and check and record pump discharge oil pressure. Re-check discharge pressure after a 24 hour period and confirm no change in oil pressure. If there is a reduction of pressure, verify that there is no external leakage;
 - .3 A pressure reduction not exceeding 2% of the initial test pressure is acceptable provided there are no visible leaks.

3.15 Flushing and Cleaning

- .1 After completion of pressure testing and correction of all leaks, provide 2000 litres (444 Imp. Gal.) of No. 2 diesel fuel or No.2 heating fuel oil (as applicable to the system) for flushing and cleaning of piping.

Only add product to one supply tank in each system. Take a 500 ml (17 US oz.) sample of delivered oil.

- .1 Where necessary, arrange and pay for temporary approval from the Authority having Jurisdiction to allow an initial fill for the purpose of flushing and cleaning.
- .2 Circulate oil for 4 hours to flush out oil piping and drain or return oil to the same storage tank.
- .3 The same oil may be used to test each system. Provide temporary water separation and oil filtration systems to clean oil before being transferred to another tank.
- .4 Clean pump strainers at completion of each flush.
- .5 At completion of flushing and cleaning of the system, remove oil from tanks, clean tanks to remove debris and water, and dispose of flushing oil as contaminated waste. As an alternative to waste oil disposal, provide the services of a specialist oil-filtration service company to filter the oil on-site in the tanks to remove debris and water using temporary filtration equipment.
- .6 At completion of on-site oil filtration, take oil samples from the bottom and low end of the tank. Compare the sample to the as-delivered sample for clear-and-bright test. Recheck as-delivered and post-cleaning samples after 24 hours for presence of free water or sediment at the bottom of the sample. If water or sediment is present, re-clean the tanks and repeat sample tests.

3.16 System Testing and Commissioning

- .1 Provide services of trained oil technicians to operate fuel oil systems during testing and commissioning of the fuel oil systems, until systems are accepted by the Owner.
- .2 Provide supervision, instruction and operation of the fuel system during initial filling operations, testing, commissioning and until the fuel oil systems are approved by the AHJ and accepted by the Owner.

3.17 Initial Tank Fill for System Testing

- .1 In addition to the oil fill for flushing and cleaning, include in tender price and provide additional oil required for testing and commissioning of the system.
 - .1 For new heating appliances, include sufficient oil to allow operating of each heating appliance at 70% full load rating for 2 hours, but not less than 1000 litres (222 Imp. Gal.) in total.
 - .2 For new generators being installed under Division 26, provide sufficient diesel fuel for testing of the generators for a 4 hour heat run test, allowing for 1.2 L (0.27 Imp. Gal.) per kW of generator capacity.
 - .3 For existing generator installations, provide 1000 L (222 Imp. Gal.) of diesel fuel.
- .2 Where applicable in the jurisdiction of the Work, arrange and pay for temporary approval from the Authority having Jurisdiction to allow an initial fill for the purpose of flushing and cleaning.
- .3 During first fuel delivery, arrange and pay for delivery truck supplemental stand-by time to permit calibration of main fuel tank level controllers during tank fill.
- .4 Where the Owner requests additional tests other than as specified above prior to acceptance of the system by the Owner, the additional fuel will be paid for by the Owner but arranged and supervised by the installation contractor.

3.18 Final Tank Fill

- .1 At conclusion of all testing and commissioning, including Owners additional testing, refilling of the main supply tanks will be paid for by the Owner and/or the building operator, but arranged and supervised by the installation contractor. Where the fuel delivery company conducts an inspection of the installation, provide a copy of any inspection reports to the Owner.

3.19 Authority Having Jurisdiction Demonstration Tests

- .1 Refer to Section 23 12 13 for demonstration testing requirements of auxiliary tank high level limit controls.

3.20 Training and Instructions

- .1 Provide fuel system training to the Owner's operations staff on all control functions, including manual operations, and tank refilling operations.
- .2 Provide written instructions for operations of the system.
- .3 Provide laminated instruction sheets which includes both graphic and written instructions and post instructions in a permanent location adjacent to each control panel. Instructions sheets to include:
 - .1 written step-by-step instructions for automatic operation, manual operation, and testing operations as applicable,
 - .2 system filling instructions.
- .4 Provide a draft of the instructions for review and approval by the Owner.

3.21 Reports

- .1 Submit a completed test record to the Engineer and the Owner on completion of testing, signed by the supervisor responsible for conducting the test, and include the following information:
 - .1 date of test(s)
 - .2 name of person conducting the tests,
 - .3 piping installation license number of person conducting the test,
 - .4 start and end times of test, and total duration,
 - .5 applied test pressures, and
 - .6 description of location of each leakage point discovered (if any), and remedial means taken to correct the leak.
- .2 Provide to Owner and Consultant a consolidated final installation report which includes:
 - .1 name and licenses number of the petroleum equipment contractor(s) who supervised the installation,
 - .2 date of completed installation,
 - .3 copy of pressure test reports,
 - .4 copy of fuel distributor inspection report (if applicable),
 - .5 copy of AHJ inspection reports (if any),
 - .6 test reports as required under other related sections.

END OF SECTION

FACILITY FUEL-OIL CONTROL AND INSTRUMENTATION DEVICES

23 11 13.23

1 GENERAL

1.1 Scope

- .1 Provide equipment for automatic control of fuel-oil systems including:
 - .1 solenoid valves,
 - .2 motorized valves,
 - .3 tank level measurement devices for aboveground supply tanks,
 - .4 leak detection devices,
 - .5 oil pressure switches,
 - .6 auxiliary tank commissioning control switch station
 - .7 control signal wiring and power wiring.
- .2 Provide the fuel-oil system automatic control devices as part of a coordinated and integrated fuel-oil control system. Coordinate the supply of material and services under this section with those products and services provided under other sections related to fuel oil systems.
- .3 The fuel-oil controls vendor shall coordinate with the vendor/manufacturer of any fuel storage tank for mounting requirement of instrumentation.

1.2 Definitions and Abbreviations

- .1 Refer to specification section 23 11 13.13.

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Equipment
 - .2 23 11 13.13 Facility Fuel Oil Piping

1.4 Submittals

- .1 Submit manufacturer's data sheets for valves, instrumentation and controls with model numbers, performance and design data, outline dimensions and power requirements.

1.5 Applicable Codes and Standards

- .1 Legislation:
 - .1 Refer to Section 23 11 13.13.
- .2 Installation standards:
 - .1 Refer to Section 23 11 13.13.
- .3 Product standards:
 - .1 Refer to section 21 11 13.13 and as follows.
 - .2 CSA C22.2 No. 139 Electrically Operated Valves
 - .3 CSA C22.2 No. 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements,

.4	CAN/ULC-S661	Overfill protection devices for flammable and combustible liquid storage tanks
.5	CAN/ULC-S675.2	Nonvolumetric Precision Leak Detection Devices for Underground and Aboveground Storage Tanks and Piping for Flammable and Combustible Liquids

1.6 Quality Control

- .1 Installation and on site testing of fuel oil systems to be performed in accordance with referenced regulations and standards by a specialist firm with an established reputation in this field.

2 PRODUCTS

2.1 Level Transmitter/Switch (Type "LTS2")

- .1 Level transmitter/switch:
- .1 RF capacitance type level transmitter, with two programmable relays.
 - .2 Output:
 - (a) 4-20 mA non-isolated, for continuous measurement level,
 - (b) two programmable SPDT relays, narrow differential (alarm) with programmable time delay, rated 3 A at 240 VAC.
 - .3 NEMA 4X enclosure with viewing window,
 - .4 Listed to CSA C22.2 No. 61010-1, for Class 1, Div 1 or 2, Group D,
 - .5 power supply: 120 VAC, 60 Hz.
- .2 Tank probe:
- .1 T316 stainless steel and Teflon coated, with integral concentric reference shield, suitable for No. 2 fuel oil in horizontal cylindrical tanks.

Standard of Acceptance

- Arjay Engineering – model 2882W-LT

2.2 Level Transmitter (Type "LT")

- .1 Level transmitter:
- .1 Continuous magnetic float and micro-reed switch level sensor,
 - .2 Stainless steel shaft,
 - .3 Stainless steel magnetic float,
 - .4 Performance:
 - (a) resolution: 6 mm (1/4 in.)
 - .5 Output:
 - (a) two-wire, 4-20 mA non-isolated, loop powered,
 - .6 Enclosure: NEMA 4X, aluminium, explosion proof, Class 1, Div 1, Groups C & D,
 - .7 Maximum operating pressure: 1380 kPa (200 psig)
 - .8 Operating temperature range: -29 to 121°C (-20 to 250°F),
 - .9 NPS 2 threaded bushing mounting fitting.

Standard of Acceptance

- Albany Pump Company Ltd. - fig. CLIS-APC-0121

2.3 Magnetic Reed Level Switch (“LSx” designation)

- .1 Magnetic reed switches:
 - .1 SPDT (Form C), hermetically sealed, magnetically activated dry-contact type,
 - .2 electrically insulated to minimum 1.6 kV dielectric breakdown test,
 - .3 switches rated 0.5A @ 250 V for each switch.
 - .4 T316 stainless steel support shaft,
 - .5 stainless steel floats with internal magnets,
- .2 Enclosure: NEMA 4X, minimum rating of Class 1, Div 2, Group D,
- .3 Mounting: NPS 2 threaded bushing fitting,
- .4 Listed to CSA C22.2 No. 157.
- .5 Number of switches:
 - .1 refer to drawings for applicable type.

Number of Switches	HHA Reference
1	LS1
2	LS2
3	LS3
4	LS4
5	LS5

Standard of Acceptance

- Albany Pump Company Ltd. – fig. LEVCON series
- FPI Sensors – fig. CLIS series

2.4 Water Level Sensor Tanks (Type “LTW”)

- .1 Continuous level sensor for detection of oil/water interface in supply tanks:
 - .1 Float type, with 4-20 mA loop powered, continuous measurement output,
 - .2 NEMA 4X enclosure,
 - .3 Stainless steel float stem, with stainless steel floats
 - .4 Float specific gravity to detect for water in fuel oil,
 - .5 Bottom deadband: 25 mm (1 in),
 - .6 Measurement range: 200 mm (8 in),
 - .7 Listed to CSA C22.2 No. 61010-1, for Class 1, Div 1 or 2, Group D,

Standard of Acceptance

- FPI Sensors – CLIS series

2.5 Tank Overfill Level Alarm System (“OFAS”)

.1 General:

- .1 Packaged level sensors and electric overfill alarm panel as a complete certified assembly.
- .2 Control panel and level switch device listed to CAN/ULC-S661 as a complete system.

Standard of Acceptance

- Albany Pump Co. – fig. APA-FILL

.2 Control panel:

- .1 NEMA 4 or 4X fiberglass enclosure, with lockable front cover.
- .2 Two level switch discrete inputs:

Parameter	Percent Tank Volume	Horizontal Cylindrical Percent Tank Height
Pre-High warning level	80%	75%
High level and stop fill	90%	84%

- .3 Tank level alarm circuit arranged for fail-safe function on event of an open level detection circuit.
- .4 Audible and visual alarm.
- .5 Output high level alarm relay (dry contacts).
- .6 Internal electric heater and thermostat switch.
- .7 Panel door-front indicating lights:

Lamp Colour	Function
White	Panel energized
Red	Warning at 80% fill level
Red	Tank at 90% fill level

- .8 Operating switches:
 - (a) alarm silence switch.
- .9 A permanent label is affixed to the panel door, providing operational and pre-fill test instructions to confirm functioning of alarm devices.
- .10 Power:
 - (a) 120 VAC, 60 Hz main power
- .3 Level switches: type LTS2.
- .4 Digital display meter (“DDM”):
 - .1 mounted on panel door front.
 - .2 configurable digital display meter, LED display, with 4-20 mA input to indicate tank fill level,
 - .3 4-20 mA output to replicate the fuel level to another control panel or device,

- .4 4 programmable output relays,
- .5 NEMA 4X enclosure,
- .6 isolated 24 VDC transmitter power supply,
- .7 24 or 120 VAC power,
- .8 listed to CSA C22.2 No. 142 or CAN/CSA C22.2 No. 61010-1.

2.6 Leak Detector – Single Point Switch Type

.1 Type LDP1 – non-adjustable float switch:

- .1 For indoor use.
- .2 SPST single point float switch,
- .3 Thermoplastic body and float,
- .4 Prewired two conductor, PVC insulation wiring lead,
- .5 Dry-contact float switch rated 10 W, 50-100 VDC.

Standard of Acceptance

- ° Gems fig. LS-10

.2 Type LDP2 – adjustable height float switch:

- .1 For indoor use.
- .2 SPST hermetically-sealed magnetic reed switch, stainless steel float and stem,
- .3 Suitable for fluids with specific gravity of 0.70 and higher,
- .4 Field reversible NO and NC contact operation,
- .5 Prewired two conductor, PVC insulation wiring lead,
- .6 Dry-contact rated 50 VA, maximum 1.0 A DC/AC up to 240 V AC/DC,
- .7 Listed for CSA Class 1, Division 1 and 2, Groups A,B,C,D,T5.

Standard of Acceptance

- ° Albany Pumps fig. Levcon FS-LEAK

.3 Type LDP3 – discriminating water/oil sensor:

- .1 For use in wet areas which may contain water and oil.
- .2 Listed for CSA Class 1, Division 1 and 2, Groups A,B,C,D,T5.
- .3 Combination conductivity sensor (for water) and reed float switch (for oil) to discriminate between water detection and oil detection.
- .4 SPST switches, reversible NO and NC contact, for hydrocarbon detection,
- .5 SPST switch for conductivity sensor for water detection,
- .6 BUNA float, PVC body and stainless steel mesh or perforated screen,
- .7 Prewired three conductor, PVC insulation wiring lead,
- .8 Dry-contact float switch rated 50 W @ 240 VAC,

Standard of Acceptance

- ° Albany Pumps - fig. FS-LEAK-OW

2.7 Commissioning Switch Station for Auxiliary Supply Tanks

.1 Switch enclosure:

- .1 metal or plastic enclosure, Type 1, 4 or 4X to CSA C22.2 No. 94.1/94.2.
- .2 sized for single switch,
 - (a)

Standard of Acceptance

- ABB - fig. CA1-8054
- Allen Bradley – fig. 800H-1HZ4CY
- Scheider
- Siemens

.3 labels:

- (a) center (released) position (contacts open): "NORMAL"
- (b) momentary key position (contacts closed): "TEST".

.2 Control switch:

- .1 momentary, spring-return, key-operated, with key only removable from the center position (contacts non-actuated).
- .2 normally open contacts in center position, closed contacts in the momentary position,
- .3 randomly selected key code.

Standard of Acceptance

- ABB - fig. M2SSK3-1xx series
- Allen Bradley - fig. 800T-H48 series
- Schneider
- Siemens

2.8 Oil Pressure Switches

.1 Bourdon tube or spring loaded bellows type

Standard of Acceptance

- Mercoid type DA
- United Electric

2.9 Wiring

- .1 Instrumentation and control wiring:
 - .1 Refer to section 20 05 12.

3 EXECUTION

3.1 Manufacturer's Services

- .1 Provide the services of the manufacturers or vendors' technical services representative of control system panels to;
 - .1 supervise and provide instruction on the installation of control devices and termination of wiring,

- .2 start-up and test control equipment, and
- .3 provide instruction and training to the Owner's personnel.

3.2 Control Valves Installation

- .1 Refer to specification section 23 11 13.13.

3.3 Wiring and Conduit Installation

- .1 Refer to specification section 20 05 12 and as specified herein.
- .2 Colour code field wiring as follows:
 - .1 120 V power, line: Red
 - .2 Neutral: White
 - .3 Ground: Green
 - .4 24 VDC, relay contact Line side: Orange
 - .5 24 VDC, relay contact Load side: Blue

3.4 Tank Instrumentation Selection and Installation

- .1 Refer to drawings for the type of fuel-oil level instrumentation to be provided for each tank.
- .2 Coordinate with tank manufacturer for tank nozzle sizes and mounting requirements for each instrument. Provide adaptor flanges and double-tapped bushings as necessary to mount instruments to tank fittings.
- .3 Install level transmitters and level switches in accordance with manufacturer's instructions.
- .4 Provide pipe bushing adaptors to mount instruments on tank pipe couplings.
- .5 Order level shaft lengths to suit inside dimension of tanks and instrument mounting height. For level switches, determine switch position height measured from inside bottom surface of tank.
- .6 Calibrate level switches and transmitters. Unless otherwise shown, setpoints for main supply tanks and auxiliary supply tanks level controls are expressed as a percentage of tank volume. Convert specified tank volumes percent values to tank fluid height levels based on tank geometry.
- .7 For horizontal cylindrical tanks, the following conversion table may be used for selected typical tank volumes.

Conversion Factors for Selected Tank Volume vs Tank Height											
Tank Type	Percent Tank Volume										
	10	20	25	30	35	50	75	80	85	90	95
	Percent Tank Height										
Horizontal Cylindrical	16	25	30	34	38	50	70	75	79	84	90
Rectangular	10	20	25	30	35	50	75	80	85	90	95

- .8 Provide wiring and conduit from level transmitters and level switches to designated control panel or control system.

3.5 Programmable Level Switches

- .1 Except as described below, configure programmable level switches in their normally-open or normally-closed state as shown.
- .2 For auxiliary supply tank level switch type LTS2,
 - .1 Configure switch 1 as Critical-High as follows:
 - (a) contact opens on level rising above setpoint, and
 - (b) contact closes on loss-of-power to the device or failure of the unit.
 - .2 Configure switch 2 as Critical-Low as follows:
 - (a) contact closes on level dropping below setpoint, and
 - (b) contact closes on loss-of-power to the device or failure of the unit.

3.6 Overfill Alarm Panels Installation

- .1 Install overfill level alarm system in accordance with manufacturer's certified instructions.
- .2 Locate OFAS alarm panel within 1000 mm (40 in.) of the fill station.
- .3 Provide galvanized steel posts and mounting hardware to mount the OFAS panel so that the top of the OFAS panel is between 1650 and 1700 mm (65 and 67 in.) above the local working surface except as otherwise shown.
- .4 Provide wiring directly from associated high level switches to the remote alarm panel.
- .5 Where shown, wire the level transmitter to the OFAS direct digital display.
- .6 Provide 120 VAC power supply with a 15 A breaker, fed from the nearest power distribution panel.

3.7 Installation of Commissioning Switch Station for Auxiliary Supply Tanks

- .1 Install the commissioning switch station in close proximity to the auxiliary supply tank. Install the switch at a height of between 1000 and 1200 mm above the finished floor level.
- .2 Wire the switch to the associated diesel fuel pump control panel.

3.8 Single Point Type Leak Detection Sensor Installation

- .1 Provide point leak detector type in accordance with the following table for aboveground locations:

Application	LDP1	LDP2	LDP3
Beneath aboveground tanks	Yes	---	---
Aboveground double wall piping	---	Yes	---
Pumpset drip pans	Yes	Yes	---
Other contained areas indoors	---	Yes	---
Other containment areas outdoor aboveground	---	---	Yes

- .2 Provide control wiring for each leak detector sensor and connect to associated control panel. Provide remote alarm wiring to the building automation system or other monitoring system as shown.

3.9 Alarm Monitoring to BAS

- .1 Coordinate with the BAS contractor under Division 25 of the Work for wiring monitoring and alarm outputs from control panels to the Building Automation System.

3.10 Testing

- .1 Test instrumentation along with associated system control panel testing.
- .2 Test valve actuators through all modes of operation.
- .3 Provide a written test report of all control devices verifying correct operation.

3.11 Training and Instructions

- .1 Refer to specification section 23 11 13.13.

END OF SECTION

FACILITY FUEL-OIL PUMPS FOR ENGINE-DRIVEN EQUIPMENT

23 12 13.13

1 GENERAL

1.1 Scope

- .1 Provide fuel-oil transfer pumpsets for generators, fire pumps, and other diesel-engine driven equipment. Fuel-oil transfer pumpsets to include:
 - .1 diesel fuel pumps,
 - .2 packaged fuel pumpsets,
 - .3 pump control panels.
- .2 Pumps, pump control panels and associated instrumentation and control devices are to be provided by one manufacturer/vendor as part of a coordinated system.
- .3 The manufacturer of the pump control panels to coordinate with the fuel storage tank manufacturer for mounting requirement of instrumentation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 05 49.23 Seismic Qualification for Mechanical Equipment
 - .3 23 11 13.13 Facility Fuel-oil Piping

1.3 Applicable Codes and Standards

- .1 Legislation;
 - .1 Refer to section 23 11 13.13.
- .2 Installation standards;
 - .1 Refer to section 23 11 13.13
- .3 Product standards;
 - .1 Refer to section 23 11 13.13 and as follows.
 - .2 ASME/ANSI B16.3 Malleable Iron Threaded Fittings: Classes 150 and 300
 - .3 ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - .4 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .5 CSA C22.2 No. 94.2 Enclosures for Electrical Equipment, Environmental Considerations
 - .6 CSA C22.2 No. 286 Industrial Control Panels and Accessories
 - .7 CAN/ULC-S661 Overfill Protection Devices for Flammable and Combustible Liquids
 - .8 ULC/ORD C536 Flexible Metallic Hose
 - .9 UL/ULC 842 Standard for Valves for Flammable and Combustible Liquids

1.4 Seismic Requirements

- .1 Seismically qualify the following equipment in accordance with the referenced Specification section.

Equipment	Seismic Qualification Level	Qualification Method	Specification
Packaged fuel pumpsets including control panels	Functional	Shake Table Test (Note 1)	20 05 49.23

Note 1: Refer to specification section 20 05 49.23 for any applicable alternative qualification methods

1.5 Design Criteria

- .1 Fuel parameters;
 - .1 No. 1 and 2 diesel fuel.
 - .2 Specific gravity: 0.83 to 0.88
 - .3 Viscosity: 50 S.S.U at 10°C (50°F).
- .2 Control panel design to comply with requirements for prevention of overfill of auxiliary supply tanks when vented to atmosphere in accordance with 2024 edition of CSA B139.

1.6 Submittals

- .1 Submit manufacturer's data sheets for pumps with model numbers, performance and design data, outline dimensions, and power requirements.
- .2 Submit manufacturers shop drawings for control panels, including ladder logic diagram, terminal strip identification, and a coordinated control panel inter-wiring schematic drawing including details for field wiring termination, and size and number of conductors.
- .3 Submit seismic qualification document with shop drawing submittal.

2 PRODUCTS

2.1 Aboveground Fuel-oil Pumpsets

- .1 General;
 - .1 Packaged duplex pumpset, factory-piped and mounted on a fabricated steel baseplate with an integral drip pan.
 - .2 Motor controllers and system controller in a common control panel.
 - .3 Pump performance and motor HP and voltage are as shown.
 - .4 Prime and topcoat painted finish of piping and baseplate, resistant to fuel oil and cleaning solvents.
- .2 Pumps:
 - .1 base mounted, gear-type constant displacement pumps, directly coupled to totally enclosed fan cooled motors,
 - .2 cast iron housing with helical gear set, stainless steel shaft and self-priming design,
 - .3 Viton mechanical seals,
 - .4 suction lift: 70 kPa. (17 in Hg) minimum.
- .3 Pumpset piping and joints:
 - .1 pipe: ASTM A53 Gr. B, schedule 80,
 - .2 fittings and joints:

- (a) butt-weld or socket welded for pipe couplings, elbows and tees,
- (b) malleable iron fittings to ASME/ANSI B16.3, Class 300 for connection to equipment, valves and instrumentation, with threaded ends to ASME B1.20.1.

.4 Valves:

- .1 pump discharge check valve: Class 300, bronze or cast steel swing check, with Viton or Teflon seats,
- .2 shut-off valves: Class 300, two-piece bronze valves, full port, with Viton or Teflon seats,
- .3 shut-off valve on pump inlet and outlet,
- .4 shut-off valve on pumpset common discharge pipe connection,
- .5 shut-off valves listed to UL/ULC 842.

.5 Accessories:

- .1 compound suction vacuum gauge to 30 in Hg,
- .2 liquid filled discharge pressure gauge,
- .3 pressure relief valve with stainless steel trim sized for pump capacity, for each pump and mounted between pump and discharge check valve,
- .4 duplex basket oil suction strainer, top access and with three position selector valve, listed to ULC/ORD C331.
- .5 combination high/low oil pressure switch mounted on common pump discharge pipe,
- .6 single point leak detection device switch located in the pump containment base,
- .7 300 mm (12 in) long flexible fuel connectors for suction and discharge connections, listed to ULC/ORD C536.

Standard of Acceptance

- Albany Pump Company Ltd

2.2 Diesel Pump Control Panel ("DPCP") – General Requirements

.1 General:

- .1 Automatic control of diesel fuel transfer pumps supplying fuel to auxiliary supply tanks.
- .2 Factory-mounted panels on aboveground fuel-oil pumpsets.
- .3 Packaged pump control panels complete with PLC based control system.
- .4 Control panels listed to CSA C22.2 No. 286 and CAN/ULC S661.

.2 System control interface with auxiliary supply tank level control:

- .1 Each pumpset serves one auxiliary supply tank and is controlled by a multi-point level controller for lead and lag pump operation, and redundant overfill protection for auxiliary supply tanks vented to atmosphere.
- .2 Pumpset controls for auxiliary tank overfill protection:
 - (a) each pump motor controller is provided with redundant contactors wired in series and controlled in parallel,
 - (b) auxiliary supply tank High-High oil level limit alarm and separate Critical-High oil level limit alarm,
 - (c) both the High-High and Critical-High level limit devices wired independently of each other,

- (d) if an interposing relay is used, each limit device is provided with a separate relay,
- (e) normally closed (opening on high level) limit contacts for both limit devices wired in series in the common power supply to the motor contactors and are not bypassed by any PLC or Programmable Relay controller.

Standard of Acceptance

- Albany Pump Company Ltd

.3 Control panel:

- .1 Enclosure: Type 1, 4 or 4X to CSA C22.2 No. 94.1 and 94.2.
- .2 Power supply arrangement:
 - (a) two separate motor power feeders, but provided with dual line lugs and factory installed feeder jumpers to allow single power feeder which may be removed in the field,
 - (b) main service disconnects (x2), one for each power supply,
 - (c) circuit breaker overcurrent protection, electronic overload protection, and magnetic motor contactors for each pump motor,
 - (d) redundant primary and secondary magnetic motor contactors for each pump, controlled in parallel and power wired in series, suitable for redundant safety interlock for auxiliary supply tank venting to atmosphere applications,
 - (e) overloads provided on the primary contactor only.
- .3 Control power circuit:
 - (a) redundant control power transformers,
 - (b) fused primary overcurrent protection,
 - (c) circuit breakers or fused secondary overcurrent protection,
 - (d) single 120 VAC/24 VDC power supply,
 - (e) separate circuit breakers for overcurrent protection for power supply to control valves.
- .4 Voltage monitoring relay.
- .5 Time delay relays of 5 seconds (hardware or internal software timer) for panel energization before control functions respond to input device commands.
- .6 Numbered terminal strip for connection of external power and control wiring.

.4 System controller:

- .1 Programmable logic control unit ("PLC"), with expandable communications, memory, and I/O block elements.
- .2 I/O modules: discrete and analog inputs and outputs of quantities to perform specified control functions and integration with other building systems as shown,
- .3 Control logic: software decisions are made based on field inputs rather than memory of the previous decision,
- .4 Control system capability: discrete control, Boolean logic control, and proportional/ integral/ derivative (PID) mode control,
- .5 Building Automation System communications interface gateway for Modbus TCP/IP or BACnet/IP, configured for operating states, alarm state, and measured values.

2.3 DPCP – Operator Display and Interface

- .1 Digital display meter (“DDM”) for tank fuel level:
 - .1 one DDM for each supply tank, for up to 4 tanks serving a single pumpset,
 - .2 programmable digital display meter, LED display, with 4-20 mA input to indicate tank fill level,
 - .3 4-20 mA output to replicate the fuel level to another control panel or device,
 - .4 4 programmable output relays,
 - .5 NEMA 4X enclosure,
 - .6 isolated 24 VDC transmitter power supply,
 - .7 24 or 120 VAC power.

2.4 DPCP – Control Switches, Status Lights and Alarms

- .1 Manual operating control switches located on enclosure door:

Switch Type	Function	Remarks
Two-Position (maintained)	On/Off control power switch	Shuts off control power and power supply to valves
Two-Position (maintained)	Select power source “Normal Source/Auto” and “Emergency Source”	
Test-Off-Auto	One switch for each pump. Momentary “Test” spring return to maintained “Off” position. Maintained “Auto” position.	OFF position shuts down pump regardless of automatic control input. TEST position bypasses automatic command input. Operation of pump(s) in Test position does not disable or otherwise bypass High-High or Critical-High level alarm pump shutdown functions, AUTO position allows pump to run under automatic control.
Push Button (momentary)	Auxiliary Supply Tank Top-Up	May be included as an input function in a GUI.
Push Button (momentary)	Alarm buzzer silence	
Push Button (momentary)	Alarm reset	
Test-Auto (momentary)	Momentary key-operated “Test” spring return to “Auto” position selector switch for each auxiliary supply tank	Mounted on side of panel. See requirements specified below.

- .2 Panel door-front indicating lights:

Lamp Colour	Function
White	Power source “A” (normal) available
White	Power source “B” (emergency) available
White	Power source “A” in-service
White	Power source “B” in-service
Green	Pump run light for Pump No. 1
Green	Pump run light for Pump No. 2
Red	Pump No. 1 Overload alarm
Red	Pump No. 2 Overload alarm
Red	Discharge fuel-oil high pressure alarm
Red	Discharge fuel-oil low pressure alarm
Red	Room oil leak alarm (common, if specified)
Red	Main supply tank(s) containment alarm (common for all aboveground tanks)
Red	Main supply tank(s) low level alarm (one per aboveground tank)
Red	Auxiliary supply tank High level alarm

.3 Other panel mounted alarm devices:

Device Type	Function	Remarks
Audible Alarm Buzzer	Annunciates all alarms	Silencing the first alarm results in no audible alarm for subsequent alarms unless alarm reset switch is activated first.

2.5 DPCP – Auxiliary Tank Level Controller Bypass Test Switch

.1 Auxiliary supply tank level controller bypass test switch:

- .1 two-position “Test-Auto” test switch located on the side of the pump control panel,
- .2 function: to bypass the auxiliary supply tank High-High level switch (“LHHA1”). This switch is only used during commissioning of the auxiliary supply tank critical high level alarm switch,
- .3 test switch type: key-operated selector switch, spring-return to normally-open contact position,
- .4 this switch is wired in series with a similar test switch located in an auxiliary tank test panel or auxiliary tank control panel,
- .5 both switches must be activated at the same time (contacts closed) to electrically bypass the High-High level switch to allow testing of the auxiliary supply tank Critical-High level switch,
- .6 self-adhesive label stating “Critical-High Tested”, to be applied over the switch after commissioning and demonstration of the Critical-High level switch (“LHHA2”) to the AHJ,
- .7 switch operating keys to remain in possession of the control panel manufacturer or installation contractor.

2.6 DPCP - Inputs

- .1 Discrete Inputs - General:
 - .1 auxiliary supply tank auxiliary supply tank Critical-High Level pump shut-down and alarm command,
 - .2 auxiliary supply tank High-High Level pump shut-down and alarm command,
 - .3 generator run interlock,
 - .4 remote emergency shut-down (e.g. from FAS, BAS or E-stop switch),
 - .5 pump discharge high fuel-oil pressure limit switch,
 - .6 pump discharge low fuel-oil pressure limit switch,
 - .7 pump-base leak detection,
 - .8 general room leak detection,

2.7 DPCP – Outputs for B.A.S. Remote Monitoring

- .1 Discrete and Analog Outputs for remote monitoring to the Building Automation System:
 - .1 As described under “System Integration” in the sequence of operation FMS-201 at the end of this specification section.
- .2 Network data communications to Building Automation System:
 - .1 As described under “System Integration” in the sequence of operation FMS-201 at the end of this specification section.

2.8 Control Sequence of Operation

- .1 Refer to Part 3, control sequence FMS-201.

3 EXECUTION

3.1 Manufacturer’s Services

- .1 Provide the services of the manufacturers or vendors’ technical services representative of control system products to:
 - .1 supervise and provide instruction on the installation of control devices and termination of wiring,
 - .2 start-up and test control equipment,
 - .3 provide instruction and training to the Owner’s personnel.

3.2 Wiring and Conduit Installation

- .1 Refer to specification section 20 05 12 and as specified herein.
- .2 Use flexible liquid-tight conduit for the final 300 mm (12”) length at connections to control instruments, valves and motor driven equipment.

3.3 Base Mount Oil Pump Installation

- .1 Place pumpset level on concrete housekeeping pad and fasten down the baseplate to the pad.
- .2 Align couplings before and after piping connections have been made.
- .3 Bleed air from pump suction piping and manually fill pumps with applicable fuel prior to priming the system.

3.4 Diesel Pump Control System Installation

- .1 Provide field power and control wiring. Refer to Section 20 05 13.
- .2 Mount and wire control devices including but not limited to level switches, flow switches and pressure switches and connect to pump control panel.
- .3 Provide main power to fuel pump control panel. Provide dual feeds where shown. Where the pump control panel is mounted remote from the pumpset, provide power and control wiring between the control panel and the pumpset.
- .4 Provide control and interlock wiring between pump control panel, auxiliary supply tank control panels, and other field installed devices.
- .5 Program software and configure control devices to suit sequence of operation for each panel. For control panels with GUI displays, create graphics representing:
 - .1 tanks and current volume levels, including percent of volume and actual volume,
 - .2 tank height and volume setpoints for fixed level switches, and indicate current state,
 - .3 pump(s) operating status, including associated generator run status,
 - .4 tank control valve open and closed positions.

3.5 Alarm Monitoring to BAS

- .1 Coordinate with the building automation system ("BAS") contractor under Division 25 of the Work for:
 - .1 wiring of monitoring and alarm outputs from control panels to the BAS,
 - .2 network communications integration to the BAS (where such integration is specified).

3.6 Testing - Fuel Pump Control

- .1 Program and commission the pump controllers and level measurement devices, including adjusting of time delays based on simulated power failure scenarios.
- .2 Test control system through all modes of operation:
 - .1 test automatic level control of pumps and valves for Lead and Lag pump operation,
 - .2 test alarm annunciation at local panels and at BAS,
 - .3 test control integration with auxiliary supply tank control panels, alarm panels and test panels as applicable,
 - .4 test all other control functions.
- .3 Submit a signed and dated test report to the owner documenting the testing of all operating conditions including equipment fault and power failure fault operating functions.

3.7 Training and Instructions

- .1 Provide control system training to Owner's operations staff on all control functions, including manual operations, and tank refilling operations.
- .2 Provide written instructions for operations of the system.
- .3 Provide laminated instruction sheets which includes both graphic and written instructions and post instructions in a permanent location adjacent to each control panel. Instructions sheets to include:
 - .1 photo or graphic illustration of control panel,

- .2 written step-by-step instructions for automatic operation, manual operation, and testing operations as applicable.

3.8 Sequence of Operation

- .1 Program control panels for the following sequences of operation:
 - .1 Diesel fuel pumps, duplex pumps: FMS-201.

3.9 Standard Details

- .1 The following standard details illustrate general wiring requirements to illustrate key functions including tank venting safety control interlocks. Refer to Part 2 of this specification section for detailed requirements.
 - .1 23 12 13 – 001 Duplex Fuel Pump Motor Controller – Redundant Control Power Wiring Diagram
 - .2 23 12 13 – 002 A Duplex Fuel Pump Motor Controller – Dedicated Pumpset Arrangement - Overfill Control Logic Diagram
- .2 Not all control and other devices are shown; refer to specifications for requirements for each panel type.

FMS-201 – Diesel Fuel Pump Control Panel

Applicable

Systems: Diesel Fuel Pumps.

- Each diesel fuel pumpset supplies only one auxiliary supply tank.

Reference

Drawing: Standard Details: 23 12 13-01, 23 12 13-02A and 23 12 13-03.

Drawings: Detail 2 / M1-30

System

Start and Run: **Test-Off-Auto Selector Switch**

When a pump Test-Off-Auto (“TOA”) switch is in the AUTO position, the pump is allowed to run based on the remote auxiliary supply tank run command input (“call for oil”).

When a pump TOA switch is in the OFF position, the associated pump shuts-down regardless of remote call for oil.

When a pump TOA switch is in the TEST position, the remote call for oil inputs are bypassed and the pump will run while the switch is manually maintained in the Test position.

- The auxiliary supply tank High-High level shut-down and Critical-High level shut-down continue to function.

Low Pressure Bypass

If the pump discharge low-pressure limit switch is activated, the Operator may activate a low-pressure limit switch bypass to allow the pump to operate for 60 seconds.

Note: This function is intended to be used during first start before oil is introduced into the FOS line, or when restarting the system after the FOS risers were drained.

Start of Lag Pump

When the lead pump is commanded On, and auxiliary supply tank level continues to drop, the auxiliary supply tank Low-Low level control causes the Lag pump to start.

When auxiliary supply tank is at High level, both Lead and Lag pumps stop.

Lead-Lag Designation

Lead and Lag pumps automatically alternate at each run command. If the Lead pump has been operating for more than two weeks continuously, the lag pump starts and then the existing lead pump shuts-down, and lag and lead designations are reassigned.

Generator Run Interlock

Associated generator run signal is monitored by the pump control panel PLC as a permissive for fuel pump operation in Auto mode

Lead Pump Selection

When the P1-Auto-P2 switch is in Auto position, the pumps will alternate Lead-Lag designation at each pump run command. When placed in P1 or P2, only that pump will operate automatically on pump run command.

Automatic Auxiliary Supply Tank Level Control

When a pump Test-Off-Auto (T-O-A) switch is in Auto position, pumps are started and stopped automatically from the auxiliary supply tank level switch controller

Pump	Start (LS2)	Stop (LS2)
Lead Pump	Low Level	High Level
Lag Pump	Low-Low Level	High Level

The pump will only start in automatic when the generator is operating, except as allowed for in the automatic tank top-up function.

NOTE: If one pump T-O-A switch

Automatic Tank Top-up

When the Generator Run signal changes from On to Off;

- if the pump is already running, it continues to run until auxiliary supply tank is filled and pump is commanded Off by tank level controller (Lead Pump and/or Lag Pump).
- if the pumps are Off, the lead pump is automatically started and runs until the auxiliary supply tank is filled and pump is commanded Off by the tank level controller (All Pumps Off).

This function occurs automatically only once immediately after Generator Run signal changes to Off. In both cases, the pump only runs for a time period equal to 1.10 times the time requires to normally fill the tank from the Low-level setpoint to the High-level setpoint but shall not exceed 30 minutes after the Generator Run signal changes to Off.

Manual Tank Top-up

The operator may initiate a manual tank top-up through an input command in the Operator Display Unit. Lead pump operates as above for automatic tank top-up. This function only operates if pumps are Off at the time of the command initiation. Pump shuts-down automatically in accordance with Automatic Level Control described above.

System
Stop:

High Limit Operating Control

Pumps shut-down for any of the following level controls:

- Auxiliary supply tank normal High level,
- Auxiliary supply tank High-High level and alarm,
- Auxiliary supply tank secondary Critical-High level and alarm.

Pressure Limit shutdown

Pump discharge high pressure switch shuts-down pump when discharge pressure exceeds 120% of the normal operating discharge pressure (field determined).

Pump discharge low pressure switch shuts-down pump when discharge pressure decreases below 50% of normal discharge-side static head pressure (field determined).

Schedule: None.

Alarms: ***Local Alarms***

As specified for local alarm indicating lights.

Remote Alarms (to BAS)

As specified below under System Integration

System
Integration: ***Hardwired Output to BAS:***

- Summary Alarm

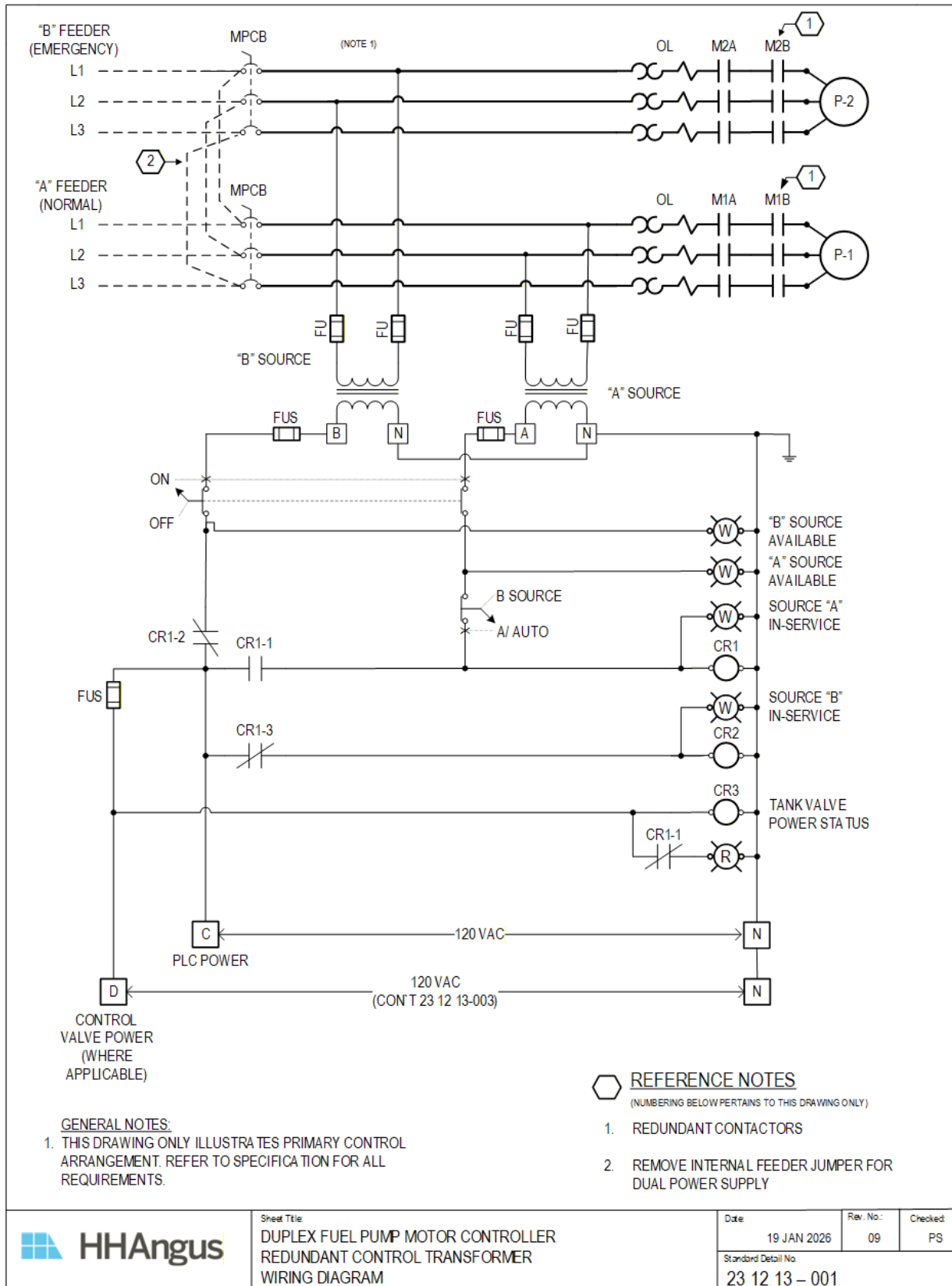
BACnet/IP or Modbus TCP/IP Read Objects

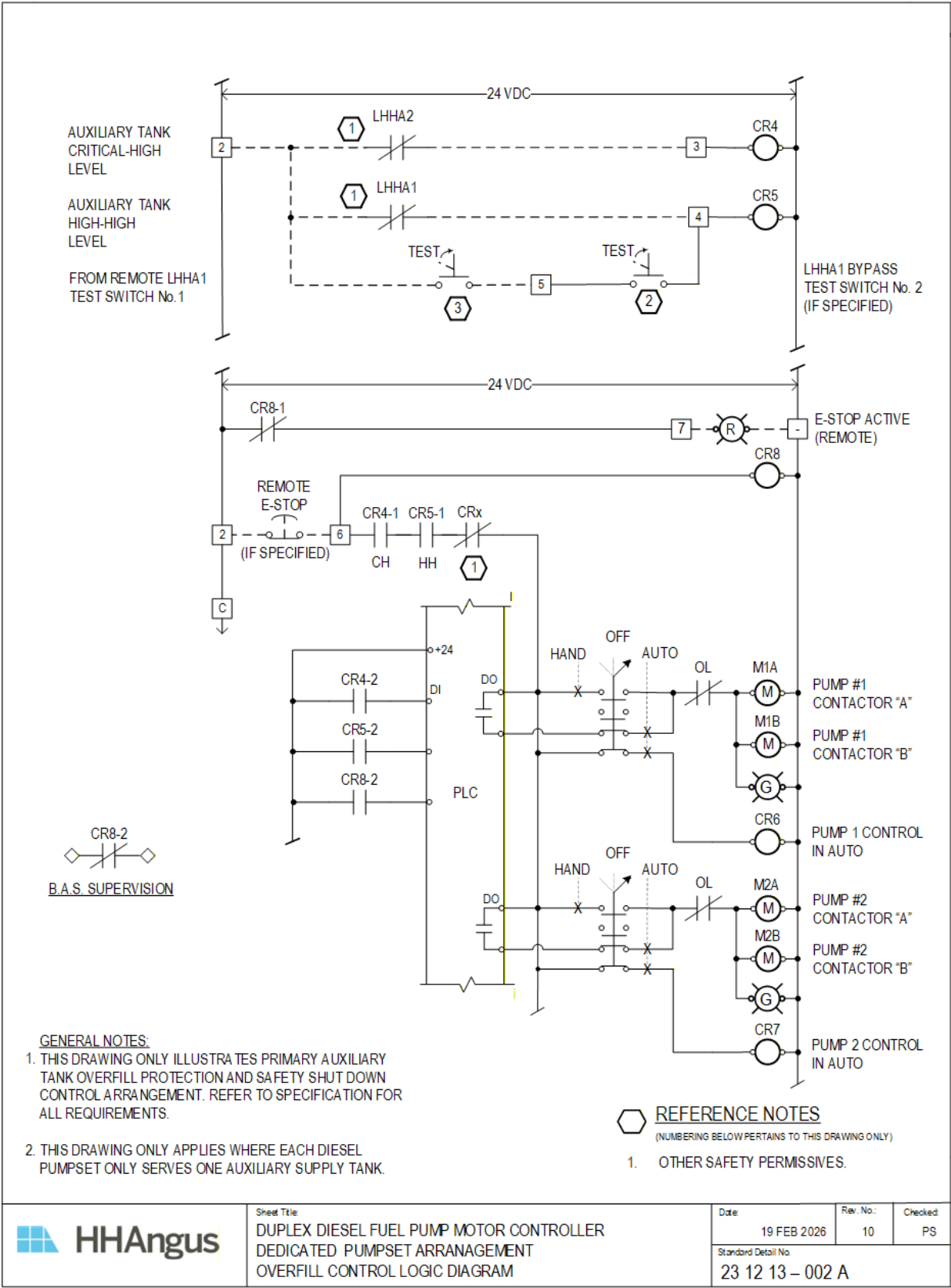
- Panel power source "A" in-service,
- Panel power source "B" in-service,
- Pump 1 On/Off status,
- Pump 2 On/Off status,
- Pump 1 Not-in-Auto (TOA switch) status,
- Pump 2 Not-in-Auto (TOA switch) status,
- Pump 1 Overload
- Pump 2 Overload
- Pump Discharge Pressure High Alarm
- Pump Discharge Pressure Low Alarm
- Auxiliary Supply Tank High Level Alarm (each instance)
- Generator Running
- Room leak detection alarm (each instance)
- Auxiliary Supply Tank High Level Alarm

Notes:

1. Coordinate with diesel generator vendor for location of generator run signal: generator panel or emergency power control panel.
2. Both the auxiliary supply tank High-High level switch and the Critical High level switch must interlock to both the Test and Auto switch positions.

End of Control Sequence





END OF SECTION

ABOVEGROUND OIL STORAGE TANKS 23 13 23

1 GENERAL

1.1 Scope

- .1 Provide fuel tanks and accessories for:
 - .1 aboveground steel supply tanks,

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section integrates with or refers to the following specification sections:
 - .1 20 05 49.23 Seismic Qualification for Mechanical Equipment
 - .2 23 11 13 Facility Fuel Oil Piping and Accessories
 - .3 23 11 13.23 Facility Fuel-Oil Controls and Instrumentation

1.3 Applicable Codes and Standards

- .1 Legislation:
 - .1 To section 23 11 13.
- .2 Installation standards and codes:
 - .1 To section 23 11 13.
- .3 Product standards:
 - .1 To section 23 11 13 and as follows.
 - .2 CAN/ULC S601 Standard for Shop Fabricated Steel Aboveground Horizontal Tanks for Flammable and Combustible Liquids,
 - .3 CAN/ULC S602 Standard for Aboveground Steel Tanks for Fuel Oil and Lubricating Oil,
 - .4 CAN/ULC S653 Standard for Aboveground Steel Contained Tank Assemblies for Flammable and Combustible Liquids
 - .5 CAN/ULC S661 Standard for Overfill Protection Devices for Flammable and Combustible Liquide Storage
 - .6 CAN/ULC S663 Standard for Spill Containment Devices for Flammable and Combustible Liquid Aboveground Storage Tanks.
 - .7 ULC/ORD-C180 Liquid Level Gauges and Indicators for Fuel Oil and Lubricating Oil Tanks.

1.4 Design Criteria

- .1 Design tanks for storage of no. 2 diesel fuel or heating oil:
 - .1 specific gravity: 0.83 to 1.10
 - .2 viscosity: 50 S.S.U at 41°F.

1.5 Seismic Qualification

- .1 Seismically qualify (certify) the following equipment specified herein:
 - .1 aboveground fuel tanks.

- .2 The seismic qualification of the above-listed equipment is to conform to Specification section 20 05 49.23 for the following seismic qualification level and certification method:
 - .1 Functional seismic qualification (Level III) for atmospheric liquid fuel storage tanks: by static analysis with sloshing effect or by dynamic analysis,
- .3 The following equipment specific seismic force parameters are to be used:

Tank	C_p	A_r	R_p	h_x/h_n
Tanks at grade level	1.00	1.00	1.25	0.0

1.6 Submittals

- .1 Submit shop drawings for each tank with model number and capacity, outline dimensions, support details, connection arrangements, and instrumentation. Identify on drawing the maximum allowable field test pressure.
- .2 For tanks specified with a design pressure exceeding 35 kPa (5 psig) at the bottom of the tank, submit shop drawings designed and sealed by a professional engineer licensed in the province of manufacture, with tanks designed in accordance with CSA B51 or ASME Boiler and Pressure Vessel Code.
- .3 Submit certification test certificate for seismic qualification in accordance with Specification section 20 05 49.

1.7 Authority Approvals

- .1 For tanks specified for a design static pressure exceeding 35 kPa (5 psi) at the bottom of the tank, submit a copy of the shop drawings and a copy of the factory pressure test at the specified design pressure to the Authority Having Jurisdiction upon request.

1.8 Quality Control

- .1 Installation and on site testing of fuel oil systems to be performed in accordance with applicable regulations and standards by a specialist licensed petroleum equipment contractor of the applicable class for the equipment.

2 PRODUCTS

2.1 Aboveground Steel Tank, Outdoor, Horizontal Cylindrical Tanks

- .1 General:
 - .1 Listed to ULC-S601 for standard tanks.
 - (a) tank style: double wall, vacuum monitored

Tank Design and Field Test Pressures			
Vent Height	Design Pressure at top of tank	Design Pressure at bottom of tank	Field Pneumatic Test Pressure
m (ft)	kPa (psi)	kPa (psi)	kPa (psi)
≤ 7 (23)	7 (1)	35 (5)	35 (5)

Standard of Acceptance

- Steelcraft

- Granby Industries
- Drummond Welding and Steel Works
- Westeel
- STEM CAN
- Industries Desjardins Ltd

.2 Construction:

- .1 Fabricated from minimum 2.5 mm (12 ga) carbon steel,
- .2 Lifting lugs, support saddles, anchor lugs, and access stairs, non-slip platform and handrails.
- .3 Tank designed to allow a slope of 2% for tanks 1250 litres (278 l.gall) or less, and 0.5% for larger tanks.
- .4 Access stairs and non-slip service platform and handrails where shown on drawings,
- .5 Internal piping for level gauge, fill and suction drop tubes,
- .6 Pipe connection fittings along top of tank in accordance with the following table, and additional tank connections as shown:

Tank Pipe Fitting Schedule			
Item	Description	Size NPS	Fitting Type
1	Normal vent	As per listing	NPT coupling or Flange
2	Emergency vent	As per listing	Flange
3	Tank fill	6	
4	Oil return	As shown	NPT coupling
5	Supply oil to appliance/transfer pump	As shown	NPT coupling
6	Tank level switch/transmitter	2	NPT coupling
7	Tank overfill level switch	2	NPT coupling
8	Tank water level transmitter	2	NPT coupling
9	Tank level gauge	3	NPT coupling
9	Tank cleaning fitting #1/water withdrawal	3	NPT coupling with plug
10	Tank cleaning fitting #2	3	NPT coupling with plug

- .7 Internal drop-tube piping for tank fill, appliance oil suction, and appliance oil return lines.
 - (a) for appliance/auxiliary tank oil return drop tube, provide a Ø6 mm (¼n.) hole at approximately 25 mm (1 in) below underside of top of tank.
- .8 For standard tanks only: double wall, vacuum monitored and provided with
 - (a) factory applied vacuum,
 - (b) tank mounted vacuum gauge,
 - (c) tank mounted vacuum switch, 120 VAC, 2 A rated SPDT Form C contacts.
- .9 Ground lug,
- .10 Finish: two coats white epoxy or polyurethane paint or manufacturers standard paint product.

.3 Accessories:

- .1 Emergency vent cap for primary tank,
- .2 Low vacuum audible and visual alarm panel;
 - (a) 120 VAC,
 - (b) remote alarm SPDT Form C contacts, rated for 120 VAC @ 2 A.
- .3 Overfill protection valve listed to CAN/ULC S661,
- .4 Dipstick and gauge chart for tanks installed outdoors,
- .5 Spill containment fill box to CAN/ULC S663 for tanks installed outdoors,

.4 Mechanical tank gauge:

- .1 Float operated, mechanical register gauge,
- .2 Accuracy: +/- 50 mm.
- .3 NPS 2 fitting.
- .4 Readings: meters and 1/100 meter

Standard of Acceptance

- ° OPW model 200TG

2.2 Tank Overfill Protection Valve

- .1 Refer to Specification section 23 11 13.
 - °

2.3 Remote Spill Containment Devices

- .1 To Section 23 11 13.

3 EXECUTION

3.1 Tank Installation

- .1 Position tanks using lifting lugs, hooks and spreader bars. Do not use chains or slings.
- .2 Provide reinforced concrete housekeeping base slabs or plinths, and anchor tanks to base or plinth.
- .3 Provide concrete curbs at pipe penetrations through floors.
- .4 Provide concrete pipe trenches and trench covers as shown.
- .5 Extend fill line from tank into fill box and terminate with fill adaptors.
- .6 Install tank mounted spill containment device for outdoor tanks to fill drop tube.
- .7 Provide plugs on tank cleaning connections.
- .8 Where fuel or vent piping passes through a roof, provide a Thaler roof flashing unit and install and secure to the roof membrane in accordance with the manufacturer's instructions.
- .9 For tanks of 1250 litres (278 Imp. Gall) or less, pitch the tank downward in the direction opposite to the fuel suction fitting, at a slope of 2%.

- .10 For tanks larger than 1250 litres capacity, pitch the tank downwards in the direction opposite to the fuel suction fitting, at a slope not to exceed 0.5%; the acceptance test is when water is poured onto the top of the tank, the water moves in the direction of the low end.

3.2 Vent Pipes

- .1 Install tank vent pipes to drain back to the associated tank with a slope of not less than 1 in 50 (2%), and install so they are free of sags or traps.
- .2 Terminate vent piping;
 - .1 when on a roof, at a minimum height of 1.8 m (5 ft) above the roof,
 - .2 when terminating through a wall, not project more than 300 mm (12 in) from the face of the wall, and at least 2.4 m (8 ft) above local grade level,
 - .3 when terminated remote from a building, at least 2.4 m (8 ft) above local grade level, and
 - .4 at least 600 mm (24 in) from any operable window, building opening, or the vertical project of any building opening located below the level of the vent termination.
- .3 Provide vent hood or vent cap at termination, unless otherwise shown.

3.3 Tank Level Control

- .1 Install main supply tank level control devices in accordance with section 23 11 33.
- .2 Install auxiliary supply tank level control devices in accordance with section 23 11 33.

3.4 Testing

- .1 Aboveground steel tank testing:
 - .1 Test above ground steel tanks for leaks in accordance with tank manufacturer recommendations and as a minimum as follows:
 - (a) for vacuum monitored tanks, check and record vacuum pressure is reading the minimum required by the manufacturer;
 - (b) for secondary containment tanks, after tank is filled with oil, visually check for presence of liquids in the containment section and for activation of oil detection device.
 - .2 Submit a test report to Owner and Engineer, complete with pre-installation photos of underground tanks, pressure test record results, and manufacturer installation report for underground tanks.

3.5 Fuel

- .1 Refer to Section 23 11 13 for initial and final filling requirements.

3.6 Final Report

- .1 Consolidate and submit to the Owner all pressure test reports, and include inspection reports issued by the Authority Having Jurisdiction.

END OF SECTION

SELECTIVE CATALYTIC REDUCTION SYSTEMS 23 24 17.13

1 GENERAL

1.1 Scope

- .1 Provide Selective Catalytic Reduction ("SCR") systems for emission for engine-driven generators.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
- .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 08 15 Mechanical Commissioning
 - .3 23 05 01 HVAC Piping Systems General Requirements
 - .4 23 24 19 Diesel Exhaust Fluid System
 - .5 23 26 16 Process Tubing and Accessories – Stainless Steel
 - .6 23 51 33 Insulated Sectional Chimney
 - .7 26 01 01 Electrical General Requirements
 - .8 26 05 49 Seismic Restraint
 - .9 26 08 15 Electrical Commissioning

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
- .1 **BAS** – the building automation system under Division 25,
 - .2 **Catalytic packing** – the equipment that provides the catalytic reaction between the engine exhaust gases and the reactant chemicals.
 - .3 **NOx** – nitrogen oxides, consisting of a mix of nitric oxide (NO) and nitrogen dioxide (NO₂)
 - .4 **NMHC** – non-methane hydrocarbons
 - .5 **Reactor** - the portion of the SCR that contains the catalytic packing, the reactant chemical injection equipment, and the reaction ductwork section.
 - .6 **Reactant chemicals** – the injected urea consumed in the engine exhaust reduction process.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
- .1 ASME B31.3 Process Piping Code
 - .2 ASME B31.9 Building Service Piping Code
 - .3 CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code
 - .4 CSA C22.1 Canadian Electrical Code, as adopted and amended by the authority having jurisdiction at the place of the Work
- .2 Product standards:
- .1 ASTM A240 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

- .2 ASTM A269 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
- .3 CSA C22.2 No. 14 Industrial Control Equipment
- .4 CSA SPE-1000 Model Code for the Field Evaluation of Electrical Equipment
- .5 ISO 22241-1 Diesel Engines – NOx Reduction Agent AUS 32
- .6 ANSI/CAN/UL/ULC 2200 Stationary Engine Generator Assemblies (3rd edition).

1.5 Registration and Inspection

- .1 Before commencing work, make arrangements and pay for registration and inspection by the AHJ responsible for;
 - .1 electrical safety: where the control panel is not listed to CSA C22.2. No. 14.
 - .2 boiler and pressure vessel safety: for compressed air except where safety regulations at the Place of the Work exempts such piping based on pipe size.

1.6 Design Criteria

- .1 Emissions and noise reduction performance:
 - .1 As specified in Part 2.
- .2 Piping design criteria:
 - .1 compressed air piping:
 - (a) design pressure: 1030 kPa (150 psig) at 121°C (250°F),
 - (b) piping code: ASME B31.3, fluid category D.
 - .2 urea piping:
 - (a) design pressure: 860 kPa (125 psig) at 38°C (100°F),
 - (b) piping code: ASME B31.9.
 - .3 exhaust gas sample tubing:
 - (a) design pressure: 70 kPa (10 psi) at 540°C (1000°F).
 - (b) piping code: ASME B31.3 with fluid category D.
- .3 Piping and fittings to have Canadian Registration Number in accordance with CSA B51.

1.7 Manufacturer's Site Services Representation

- .1 SCR manufacturer, their authorized representative, or manufacturer-trained Contractor personnel shall provide services to assist in the installation, start-up and testing of SCR equipment including but not limited to the following:
 - .1 pre-start inspection of the completed installation of the equipment, including mechanical and electrical interconnections between SCR equipment components,
 - .2 on-site assistance during start-up and testing, including programming or configuration of software, calibration of instrumentation, and tuning of control loops,
 - .3 on-site assistance during site acceptance testing and commissioning, to make adjustments to the system as necessary based on testing results,
 - .4 provide testing of generator exhaust gas content for NOx, PM, CO and NMHC before and after the SCR, to verify emissions reduction performance. Prepare a test report and submit to Consultant in support of application for environmental permits.
 - .5 provide testing reports for all activities and submit to Owner and Consultant for review and approval.

- .6 provide detailed training instruction to the Owner's operations staff, in the operation and maintenance of the equipment. Include for a total of four (4) separate full day training sessions. Should equipment fail during a training session, conduct a repeat session at no cost.
- .2 One month prior to the expiry of the general construction warranty period, provide testing of generator exhaust gas content for NOx and PM before and after the SCR, to verify emissions reduction performance.
- .3 These services are to be provided without limitation for as long as necessary to make final adjustment for acceptance of the system.

1.8 Submittals

- .1 Shop drawings:
 - .1 Submit product data sheets for materials specified herein.
 - .2 Submit shop drawings for SCR structural support on top of generator enclosure including exhaust stack on top of SCR, designed and sealed by a Professional Engineer licensed in the province of Ontario.
 - .3 Submit shop drawings of completely engineered design and fabrication drawings for the SCR and include the following information:
 - (a) piping process and instrumentation (P&ID) drawings,
 - (b) control panel power wiring and control wiring schematic drawings,
 - (c) interface control wiring diagrams, schedules and wire running lists between all components supplied,
 - (d) process piping (compressed air and urea) maximum allowable working pressures and concurrent operating temperatures,
 - (e) Canadian Registration Number for applicable pressure piping systems,
 - (f) narrative description of operating control sequence,
 - (g) narrative description of chemical process sequence,
 - (h) predicted NOx conversion performance and efficiency,
 - (i) supplementary support steel requirements,
 - (j) support loads transferred to the building structure.
 - .4 Submit a copy of certificate of compliance to ANSI/CAN/UL/ULC 2200.
 - .5 Submit general arrangement drawings of equipment in plan and section, identifying equipment weights, center-of-mass dimensions in X, Y, Z coordinates, and dimensioned location of mounting points, including identifying support points and support loads.
- .2 Acoustic analysis report:
 - .1 Provide a noise emission analysis at the exhaust gas venting system termination point, which includes the following performance data:
 - (a) using generator manufacturer published or tested exhaust gas noise emission data,
 - (b) sound attenuation performance of the SCR and silencers, and
 - (c) sound attenuation/regeneration of the exhaust venting system downstream of the SCR as shown on the mechanical design drawings or shop drawings for the exhaust system whichever is the most current at time of preparation of SCR shop drawings.

1.9 Quality Control

- .1 Manufacturer production test and records:
 - .1 Submit certified copies of reports of manufacturer's product testing for the following equipment:

- (a) SCR pollution abatement,
 - (b) SCR acoustic attenuation (if applicable).
- .2 Site acceptance testing ("SAT"):
- .1 Manufacturer to provide authorized service personnel at the place of the Work to participate in the site acceptance testing in accordance with the requirements of Part 3 of this specification.

2 PRODUCTS

2.1 SCR General Requirements

- .1 Manufactured, packaged SCR system including but not limited to reactor chamber with catalytic packing, diesel particulate filters, SCR preheater system, SCR control system, and related equipment and accessories for the reduction of NOx to nitrogen gas and water vapour.

Standard of Acceptance

- Safety Power Inc.
- .2 SCR listed to ANSI/CAN/UL/ULC 2200.
- .3 SCR electrical equipment listed to CSA C22.2 No. 14 or manufacturer to be responsible to obtain field approval in accordance with CSA SPE-1000 and requirements of the electrical AHJ applicable to the place of the Work.
- .4 Provide a dedicated SCR and associated support equipment for each generator, except where shared equipment is expressly stated to serve multiple SCRs.
- .5 SCR designed to use urea/water mixture at 32.5% by mass concentration to ISO 22241.
- .6 Installation location: outdoors.
- .7 Mounting configuration: top of the generator enclosure.
- .8 Include for all the components, engineering services, field assembly drawings, on-site technical services to assist the installation contractor for the assembling the system and for the initial testing, commissioning, training, and post-handover testing.
- .9 Include for one (1) re-test of pollution reduction performance prior to the expiry of the warranty.

2.2 SCR Performance Requirements

- .1 Generator exhaust gas parameters:
 - .1 SCR manufacturer to verify generator flue-gas emissions with generator manufacturer before selecting SCR equipment,
 - .2 the following data may be used subject to final verification with generator manufacturer.

Generator Unit	Manufacturer	Power Rating kW	Gas Flow Rate Act. m ³ /min	Exhaust Gas Temperature °C	NOx g/kWh	Particulate Matter g/kWh
G-01	Kohler	1250	241	496	5.72	0.14
G-02	Kohler	1250	241	496	5.72	0.14

- .2 SCR environmental performance criteria:
 - .1 Exhaust gas by-products measured at the outlet of the SCR unit,

- .2 Emissions to meet the Ontario Ministry of the Environments, Conservation and Parks discharge limits for emergency generators used for non-emergency purposes as listed in EBR 010-2463.]

SCR Performance Parameters	Value
SCR system air pressure drop at exhaust gas temperature, maximum	5.23 kPa
Reactor casing design pressure, minimum	14 kPa (2 psi)
Nitrogen Oxides (NOx) @ SCR outlet, maximum	0.67 kg/MW-hr
Particulate matter (PM) @ SCR outlet, maximum	0.02 kg/MW-hr
Non-Methane Hydrocarbons (NMHC) @ SCR outlet, maximum	0.19 kg/MW-hr
Carbon Monoxide (CO) @ SCR outlet, maximum	3.5 kg/MW-hr

2.3 SCR Reactor Chamber

- .1 Unit construction:
- .1 Unit designed to allow for exhaust system as follows:
- (a) entry: bottom inlet
 - (b) exit: top outlet
- .2 Casing:
- (a) minimum 1.2 mm (18 ga) type 304L or 409 stainless steel sheet to ASTM A240, with welded joints and seams,
 - (b) flanged sections to allow removal of the catalytic packing,
 - (c) exhaust venting pipe connections: minimum 12.5 mm thick flanges and drilled bolting patter to ASME Class 150 flange,
 - (d) designed and constructed to allow for floor mounting or suspended support, complete with floor support legs and suspension lugs,
 - (e) NPS $\frac{3}{4}$ bottom drain connection with NPT pipe ends, located in the reactant injection section and at the exit from the SCR unit.
- .3 Access doors:
- (a) of same material as casing, with type 304 stainless steel butt hinges and door hardware,
 - (b) high-temperature door seal gaskets,
 - (c) provide access doors to the downstream side of the diesel particulate filters, and to the reactant chemical injection quills.
- .2 Catalytic packing:
- .1 Expanded Vanadium honeycomb material. Wash-coat catalysts are not acceptable.
- .3 Reactant chemical injection quills:
- .1 Type 304 or 409 stainless steel reactant chemical injection quills, with internal distribution manifold to provide uniform spray coverage inside the reactor,
 - .2 ASME B1.20.1 NPT connections for urea and compressed air process connections.
- .4 Safety relief valve:
- .1 Relief valve to protect the SCR against overpressure events due to engine backfire.
 - .2 Provide flange for safety relief valve connection on reactor chamber near exhaust gas inlet.

- .3 Supply safety relief valve in coordination with supplier of insulated sectional chimney, refer to section 23 51 33 article 2.2.4.2.

- .5 Test ports:

- .1 Ø40mm (1-1/2 in. dia.) test ports with threaded caps to allow NOx emissions sampling pre and post SCR treatment.

2.4 Diesel Particulate Filters (“DPF”)

- .1 Two-stage, 85% reduction of particulate matter and carbon monoxide, integrated into SCR reactor unit.
- .2 Passive thermal regeneration.

2.5 SCR Housing Insulation

- .1 Factory insulated SCR casing on exterior surface:
 - .1 combination of insulation system and external jacket to result in a surface temperature of the jacket cladding not to exceed 70°C (160°F),
 - .2 1st insulation layer (in contact with reactor): minimum 25 mm (1 in.) thick ceramic fibre insulation,
 - .3 2nd insulation layer: minimum 50 mm (2 in.) thick ceramic fibre or mineral wool insulation.
 - .4 insulation jacket: minimum 1.2 mm (18 ga) thick galvanized steel sheet.
 - .5 removable insulation sections at access doors.

2.6 SCR Preheater Unit

- .1 General:
 - .1 Preheater fan with electric heater, designed to preheat the catalytic packing to a temperature of not less than 150°C within five (5) minutes of engine start signal with engine at 100% full load.
 - .2 Preheat unit mounted on top or side of SCR unit as shown.
- .2 Control panel:
 - .1 Control panels listed to CSA C22.2. No. 14 or field-evaluated to CSA SPE-1000;
 - (a) electrical enclosure: listed to CSA C22.2 No.94.1, Type 2, 3, or 4 for indoor installations,
 - (b) main fused disconnect switch,
 - (c) control power disconnect switch,
 - (d) fan motor controller FVNR, including overload protection, overcurrent protection and motor contactors,
 - (e) electric heater overcurrent protection and contactors,
 - (f) remote operating control.
 - .2 Power supply:
 - (a) fan and heater: 575 V, 60 Hz, 3 ph.
 - (b) control panel: 120 VAC, 60 Hz, 1 ph.
- .3 Two-position control air damper with electric actuator.
- .4 Instrumentation:
 - .1 Air-flow proving switch for electric heater interlock (supplied for field installation),
 - .2 Air temperature sensor at outlet of electric heater.

2.7 Integrated Silencer

- .1 Integrated acoustic silencer contained within the same physical housing as the SCR reactor unit.
- .2 Type: [media-free reactive silencers,] [combination media-free reactive and acoustic media with type 316 stainless steel perforated inner liner between exhaust gases and acoustic media,]
- .3 If the specified insertion losses cannot be met by the combination SCR/silencer, include a separate field-installed silencer to achieve the total sound attenuation parameters. The selection of the SCR and external silencer and resulting aggregate exhaust gas pressure drop is not to exceed the maximum allowable pressure drop specified herein.
- .4 Performance: minimum sound dynamic insertion loss in accordance with the following table.

Octave Band Hz	Minimum Silencer Insertion Loss (dB)
63	
125	26
250	29
500	38
1000	37
2000	41
4000	39
8000	44

2.8 SCR Control System

- .1 Control panel:
 - .1 Microprocessor-based controller with closed-loop feedback and feed-forward PID control of urea injection rate based on exhaust gas temperature, measured NOx pre-and -post reduction treatment, and exhaust gas mass flow rate.
 - .2 Control panels listed to CSA C22.2. No. 14 or field-evaluated to CSA SPE 1000.
 - .3 Control panel enclosure:
 - (a) listed to CSA C22.2 No.94.1, Type 2, 3, or 4 for indoor installations,
 - (b) separate internal barriered section for factory-installed urea and compressed air flow control valves and associated panel piping.
 - .4 HMI interface: colour TFT touchscreen LCD display, to display operating conditions and alarm events.
 - .5 Communications interface: Modbus RTU or TCP communications gateway, for connection to the building automation system (BAS), with owner selectable data for operating parameters, measured values, and alarm states.
 - .6 Internal wiring with required power supplies, overcurrent protection, main panel service disconnect switch, main control power switch, and panel indicating lights for power On (white), summary alarm (red), and in-service (green).
 - .7 Power supply: 120 VAC, 60 Hz, 1 phase (@15A max) or 24 VDC
- .2 Instrumentation:
 - .1 NOx analysis transmitter located upstream of the SCR catalytic packing,
 - .2 NOx analysis transmitter sensor located downstream of the SCR catalyst.

- .3 Temperature and pressure transmitters located in the SCR exhaust gas stream ahead of the catalytic packing,
- .4 Exhaust gas mass flow transmitter located in the SCR exhaust gas stream ahead of the catalytic packing.
- .3 Urea and compressed air piping (inside SCR control panel):
 - .1 Piping: T304 stainless steel tubing to ASTM A269, with welded joints or double-ferrule compression joints.
 - .2 Control solenoid valves for compressed air flow control.
 - .3 Modulating three-way control valves for urea flow control.

2.9 SCR Miscellaneous Materials

- .1 Supply nuts, bolts, gaskets and all miscellaneous hardware required to complete the installation of connection to the exhaust venting system.

2.10 Urea Storage Tank System

- .1 Urea storage tanks, transfer pumps (if any) and piping provided under Specification section 23 24 19.

2.11 Air Compressor

- .1 General:
 - .1 Provide packaged air compressor to serve all SCRs.
 - .2 Tank mounted simplex type with compressors, motors, starters, and controls:
 - .3 Selected for required airflow at minimum 276 kPa g (40 psig), maximum 760 kPa g (125 psig) with motor power rating selected for specified condition.
 - .4 Air compressor inlet air temperature range: between 18 and 40°C (64 and 104°F)
 - .5 Vertical or horizontal configuration acceptable.
 - .6 Canadian Registration Number to CSA B51.
- .2 Performance:
 - .1 Delivered air: 0.991 standard m³/min at 621 kPa.
- .3 Compressor:
 - .1 duplex reciprocating or screw compressors mounted on a common air receiver,
 - .2 compressor assembly with unloading devices, motor, replaceable inlet filter, discharge check valve, inlet silencer, motor slide rails, "V-belt" drive and belt guard.
- .4 Receiver:
 - .1 inspection port constructed in accordance with ASME Code for unfired pressure vessels for 1379 kPa (200 psi) working pressure,
 - .2 fitted with valved pressure gauge, automatic condensate bleed piped to drain, pressure relief valve,
 - .3 sized so that number of compressor operating cycles is less than eight per hour.
- .5 Control panel:
 - .1 Factory-wired FVNR motor controller, with pressure switches, alternator relay (for duplex compressors), and compressor unloading devices to maintain receiver pressure and to minimize motor starting load.
 - .2 electrical enclosure: listed to CSA C22.2 No.94.1, Type 2, 3, or 4 for indoor installations,

- .3 Control panel mounted selector switches to control lead-lag-standby operation for duplex compressor units.
- .4 Power supply: 120 VAC, 60 Hz, 1 phase (@15A max).

2.12 Flange Gaskets/Sealants

- .1 High temperature gaskets and sealants:
 - .1 Minimum operating temperature: 760°C (1400°F)
 - .2 6.5 mm (1/4" thick extruded gasket, or caulking sealant

Standard of Acceptance

- Deacon - 3300 (gasket) or 8875-Thin (sealant)
- McGill AirSeal - Uni-Extreme Sealer (sealant).

2.13 Slide Pads for Equipment Support

- .1 General:
 - .1 slide pads for equipment supports for equipment subject to thermal expansion,
 - .2 designed for continuous-weld and/or tack-welding of backing plate to the equipment support,
 - .3 assembled in pairs per load point.

Standard of Acceptance

- Piping Technologies & Products Inc.

- .2 Graphite bearing plate bonded to carbon steel backing plate:
 - .1 graphite thickness: 13mm & 6mm (1/2 in & 1/4 in.)
 - .2 backing plate: 6 mm (1/4 in.) thick carbon steel plate,
 - .3 compressive strength: 19.3 MPa (2800 psi)
 - .4 temperature rating: -45 to +537°C (-50 to +1000°F)
 - .5 coefficient of friction: 0.15

3 EXECUTION

3.1 Work Restrictions

- .1 Coordinate and obtain approvals from Owner for all on-site testing/commissioning, including work which requires shutdowns of existing building services.

3.2 SCR Installation

- .1 Before setting SCR in its designated location, conduct a field inspection to verify connection size and three-axis dimensional locations of exhaust gas piping connections to the SCR relative to the connections to the generator-engine and the downstream exhaust stack. Make adjustments to the SCR support system as necessary to allow the exhaust gas piping connections to be aligned without requiring unplanned offsets in the exhaust gas piping.
- .2 Install SCR in accordance with manufacturer instructions. Where unit is shipped in sections, include for assemble of complete unit with required fastening hardware.
- .3 Provide leg supports, anchors, and guides for the SCR as specified herein.
- .4 Where a SCR is suspended from the structure, provide support hangers with spring isolators.

- .5 Where a SCR is supported on building structure or structural steel frame, fasten equipment to structure supports to accommodate thermal expansion in accordance with manufacturer's instructions. In the absence of such instructions, fasten equipment supports to the structure as follows unless otherwise shown;
 - .1 rigidly mechanically-fasten one fixed support point which is closest to the inlet exhaust piping connections,
 - .2 for supports located on the same transverse or longitudinal axis as the fixed support point, provide slide guides with lateral limit-stops (lateral to the direction of thermal movement) with a lateral clearance gap not exceeding:
 - (a) 6 mm (1/4 in.) lateral movement for outdoor equipment and/or equipment subject to seismic restraint,
 - (b) 12 mm (1/2 in.) total movement otherwise.
 - .3 for other support points, provide guides with two-axis horizontal limit-stops to allow free movement under thermal conditions,
 - .4 when installed outdoors, or where subject to seismic restraint, or both, provide vertical movement limit stops to limit free movement due to wind loading or seismic forces to not more than 6 mm (1/4 in.).
 - .5 support SCR on graphite slide pads, attaching one slide pad to the SCR support leg by continuous weld, and attaching the mating slide pad to the support frame by continuous welding.
- .6 Provide transition sections and flanges at inlet and outlet of SCR.
- .7 Install safety relief valve in accordance with manufacturer's instructions. Refer to specification section 23 51 33 Insulated Sectional Chimney, article 3.4.
- .8 Prior to first generator run test, place match marks on SCR support legs / support guides. During testing check for free movement of legs and guides. Adjust hold down tabs to clear support leg as necessary.

3.3 Piping Installation General Requirements

- .1 Provide compressed air tubing between air compressor, SCR control panel, and SCR injection lances, complete with isolating valves as shown. Arrange compressed air piping to drain conduit down to a low point.
- .2 Provide SCR exhaust gas inlet and outlet sample tubing between SCR and SCR control panel. Provide valved sample connections complete with barbed-hose end fittings at SCR panel.
- .3 Run exposed piping parallel to walls and conserve headroom and space. Group piping wherever practical.
- .4 Slope piping down in direction of flow 1:1000 (1/8 in in 10 ft).
- .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
- .6 Ream pipe after cutting to length and clean off scale and dirt inside and outside of pipe before joining.
- .7 Cap ends during construction to prevent entry of foreign matter.

3.4 Compressed Air System Installation

- .1 Install compressed air piping in accordance with Specification section 23 26 16 except/and as specified herein.
- .2 Install air compressor and filters in locations as shown, and in accordance with manufacturer instructions.

- .3 Provide an automatic drain valve on the outlet connection on the air receiver and run in Ø13mm (NPS 1/2) drain line to floor drain.
- .4 Provide Ø13mm (NPS 1/2) condensate drain lines from air filter and run to floor drain.

3.5 Urea Piping System Installation

- .1 Install urea pumping unit (if applicable) and in accordance with manufacturer instructions.
- .2 Install urea piping in accordance with Specification section 23 24 19.

3.6 Exhaust Gas Sample Piping Installation

- .1 Provide stainless-steel exhaust gas sample piping in accordance with Specification section 23 24 19 except/and as specified herein.
- .2 Provide piping for SCR exhaust gas inlet and outlet samples, between the SCR and the SCR control panel.
- .3 Provide valved sample connections complete with barbed-hose end fittings at SCR panel.

3.7 Stainless Steel Tubing Installation

- .1 Make tubing joints using double-ferrule compression fittings. Where bending of tubes for elbows and offsets is to be used, make bends using tools and methods as specified by the tubing manufacturer.
- .2 Support piping wherever possible directly to building walls and ceilings. Where piping cannot be supported directly to building structure, support and protect piping continuously along its length using standard perforated support framing systems (Unistrut or similar) to provide mechanical damage protection.
- .3 Support tubing in accordance with manufacturer's recommendations and as specified herein. Support spacing to be in accordance with the following table.

Pipe Size NPS	Rod Diameter	Maximum Spacing (SS Tubing)
½	10 mm (3/8 in)	0.6 m (2 ft)
¾ to 1¼	10 mm (3/8 in)	1.8 m (6 ft)

3.8 Installation of Power and Control Wiring

- .1 Provide power and control wiring in accordance with manufacturer's instructions and Specification section 20 05 12.
- .2 Provide power wiring to SCR equipment and control panels. Provide field-installed control wiring between SCR equipment components and control panels in accordance with SCR manufacturer instructions.
- .3 Include for services for integration and termination of start signal and load signals in the engine control panel for each generator. Provide interconnection control wiring between the engine control panel and the SCR.
- .4 Coordinate with the BAC contractor under Division 25 of the Work for termination of control wiring for monitoring of SCR system on the BAS.

3.9 Programming and Configuration

- .1 Program, configure and tune process control equipment in accordance with the manufacturer instructions to obtain the required emission reduction performance under varying loads between 30% and 100% full load.

3.10 Cleaning

- .1 Vacuum clean interior surfaces and components of control panels. Vacuum and wipe clean exterior surface of control panels.
- .2 Vacuum internal surfaces of SCR reactor section.
- .3 Clean DEF filters after commissioning testing just prior to handover of system to the Owner.

3.11 Pressure Testing

- .1 Hydrostatically pressure test tubing system in accordance with section 23 05 01.

3.12 Start-Up and Verification Testing

- .1 Start-up and test basic operation of SCR's under no-load conditions prior to conducting acceptance commissioning of this equipment. Verify all control functions, safety functions, adjust trip settings, and measure flow parameters. Use manufacturer's start-up and test reports and submit a completed test record for review.

3.13 Site Acceptance Performance Testing

- .1 Electrical contractor is to provide a temporary electrical load bank of sufficient capacity for testing of the SCR, except where building load has been identified by Consultant as an acceptable means of full load testing of the generators.
- .2 Conduct site acceptance performance testing ("SAT") in the presence of and to the satisfaction of the Owner's representative(s), after completion of the installation and start-up and verification testing but before equipment is permanently placed into service.
- .3 Conduct test on one engine at a time, at varying loads between 25% and 100% full load in 25% step increments.
- .4 SAT to include the following:
 - .1 thorough physical inspection and verification of the installation including wiring and interconnections,
 - .2 calibration of devices, relays, instrumentation and record "as tested" condition,
 - .3 function testing of each controlled device, including measured flow rates, temperatures, pressures and gas analysis,
 - .4 measure generator exhaust NOx and PM before and after SCR unit, and report on compliance with emission reduction performance,
- .5 Record the results of the performance testing and submit completed report to the Owner and Consultant.

3.14 Commissioning Program

- .1 Comply with the project commissioning requirements in accordance with specification sections 20 08 15 and 26 08 15.
- .2 The verification and testing requirements specified in this section may be concurrent with, or conducted separately from, the commissioning program, as coordinated with the Contractor and the commissioning agent.

3.15 Demonstration and Training

- .1 Demonstrate the operation of, and provide training on, the equipment and system, as applicable, in accordance with section 26 05 01.
- .2 In addition to the general training requirements, specific training is to include:
 - .1 explanation of the NOx reduction process,
 - .2 instructions on the interoperation of the various system components,
 - .3 purpose and operation of preheating equipment,
 - .4 details on operation of DEF filters with respect to exhaust gas temperatures and periodic cleaning requirements.
- .3 Portable emission analyzer:
 - .1 Demonstrate the operation of the portable NOx analyzer to the Owner during testing and commissioning phase and turned over to the owner at completion of project.

3.16 Post-Handover Testing

- .1 One month prior to the expiry of the general construction warranty period, coordinate with the Owner and the SCR manufacturer to provide testing of the SCR equipment to measure the generator exhaust gas content for NOx and PM before and after the SCR, to reverify emissions reduction performance after one year of operation.
- .2 Collect copies of the Owner's periodic generator testing records. Review these records with the SCR manufacturer and include any recommendations as to changed in engine testing methods to improve the performance of the SCR equipment. Including recommendations with the pre-warranty performance test report.

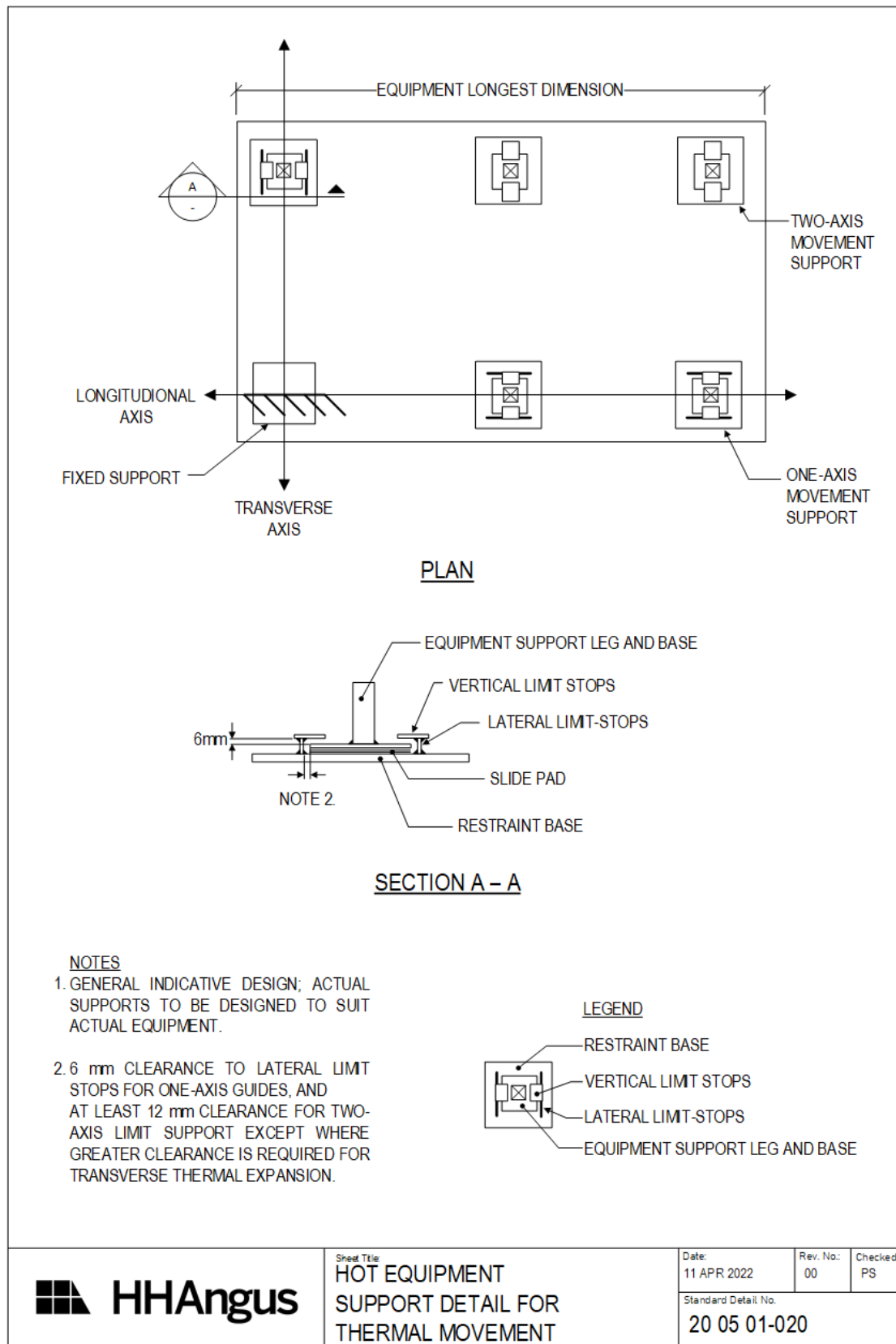
3.17 Test and Installation Records

- .1 Prior to project completion, update all wiring diagrams submitted as Shop Drawings to "As-Built" condition, and include them in the Operation and Maintenance Manual.
- .2 Provide a completed manufacturer installation checklist record for the following elements of the work and submit the original to the Owner and a copy to Consultant. Provide an additional copy when required or requested by the Authority-having-Jurisdiction.
 - .1 Start-up and verification testing reports,
 - .2 Commissioning reports, including NOx, PM, CO and NMHC reduction tests.

3.18 Standard Details

- .1 The following standard details are appended to the end of this Specification section.
 - .1 20 05 01-020 Hot Equipment Support Detail for Thermal Movement

End of Section



DIESEL EXHAUST FLUID SYSTEMS

23 24 19

1 GENERAL

1.1 Scope

- .1 Provide diesel exhaust fluid piping systems, equipment and accessories, serving SCR emissions control equipment.
- .2 SCR emission control equipment provided under Specification section 23 24 17.13.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 20 05 29 Common Hanger and Support Requirements for Piping
 - .3 23 24 17.13 Selective Catalytic Control Systems

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Day tank** – a tank that directly supplies DEF to the SCR and SCR control equipment.
 - .2 **DEF** (*diesel exhaust fluids*) – a urea/water mix fluid for use in SCR equipment.
 - .3 **Supply tank** – a bulk storage tank that supplies DEF to a day tank by means of a transfer pump, and which itself is filled from a truck or manually filled from portable containers.
 - .4 **SCR** (Selective Catalytic Reduction) - emissions control equipment.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 ASME B31.1 Power Piping code
 - .2 ASME B31.9 Building Service Piping code
- .2 Product standards:
 - .1 ASTM A312 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
 - .2 ASTM A351 Standard Specification for Castings, Austenitic, for Pressure Containing Parts
 - .3 ASTM A403 Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
 - .4 ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
 - .5 ANSI/ASME B1.20.1 Pipe Threads, General Purpose (inch)
 - .6 ANSI/ASME B16.5 Pipe Flanges and Flanged Fittings
 - .7 ANSI/ASME B16.9 Factory-Made Wrought Steel Buttwelding Fittings
 - .8 ANSI/ASME B16.11 Forged Fittings, Socket Welding and Threaded
 - .9 ANSI/ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges.

- .10 ANSI/ASME B18.2.1 Square and Hex Bolts and Screws,
- .11 ANSI/ASME B18.2.2 Square and Hex Nuts
- .12 ASTM A193 Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature
- .13 ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- .14 AWS D18.2 Specification for Welding of Austenitic Stainless Steel Tube and Pipe System in Sanitary (Hygienic) Applications
- .15 CSA C22.2 No. 14 Industrial Control Equipment
- .16 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
- .17 CAN/ULC S660 Standard for Nonmetallic Underground Piping for Flammable and Combustible Liquids

1.5 Registration and Inspection

- .1 Before commencing work, make arrangements and pay for registration and inspection by the AHJ responsible for boiler and pressure vessel safety for the following pressure piping systems:
 - .1 DEF piping:
 - (a) where design pressures are greater than 1717 kPa (250psig).
- .2 At the start of the Work, obtain existing pressure piping system registration numbers, if available, from the Owner and/or the AHJ.

1.6 Design Criteria

- .1 Piping design and installation code:
 - .1 to ASME B31.1 for piping subject to registration and inspection.
 - .2 to ASME B31.9 for piping not subject to registration and inspection.
- .2 System design criteria:
 - .1 design pressure: 1030 kPa (150 psig)
 - .2 design temperature: 38°C (100°F).
 - .3 fluid: DEF 40% by volume urea/water mixture; may contain low trace concentrations of ammonia
 - .4 specific gravity: 1.05 to 1.15
 - .5 dynamic viscosity: 0.982 centipoise at 20°C (70°F)

1.7 Submittals

- .1 Submit manufacturer's data sheets for valves, special piping, and pumps with model numbers, performance and design data, outline dimensions and power requirements.

2 PRODUCTS

2.1 General

- .1 Do not use copper, brass or other copper alloy materials that are in contact with DEF.

2.2 Aboveground Stainless Steel Piping

- .1 Pipe; NPS 3/4 and larger:

- .1 ASTM A312 Type 316L, seamless,
 - (a) schedule 10 for socket-welded joints,
 - (b) schedule 40 for threaded-joints and socket-welded joints.
- .2 Fittings:
 - .1 material: of same stainless-steel alloy as pipe,
 - .2 fittings: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A351 Gr. CF8 or CF8M stainless steel,
 - .3 unions: Class 150 and Class 1000 to MSS SP-114, and material to ASTM A182 Gr. CF8 or CF8M stainless steel,
 - .4 welded fittings: wall thickness to match pipe wall thickness,
 - .5 butt-weld ends: forged steel to ASTM A403, long-radius type,
 - .6 socket-weld ends: to ASTM A182 and ASME B16.11.
 - .7 threaded-end: to ASME B1.20.1.
- .3 Flanges:
 - .1 raised face style,
 - .2 stainless steel Type 316L, Class 150 to ASTM A182,
 - .3 forged, to ANSI B16.5, weld neck or slip-on type, with wall thickness to match pipe,
 - .4 studs and bolts: stainless steel type 316, to ASTM A193,
 - .5 nuts: stainless steel type 316, to ASTM A194.
- .4 Gaskets for flanges:
 - .1 TMGore-Tex PTFE cut sheet gaskets, 3 mm (1/8 in) thickness

Standard of Acceptance

- Ameraflex Rubber & Gasket Co
- James Walker Co

2.3 Aboveground Stainless Steel Tubing, Fittings and Valves

- .1 Stainless steel OD-dimension tubing systems including fittings and valves to conform to Specification section 23 26 16.

2.4 Valves for Stainless Steel Piping

- .1 Applies to valves for piping systems of Schedule 10 and 40 pipe wall thickness.
- .2 Ball valves, NPS 2 and under:
 - .1 to MSS SP-110, 1500 CWP/150 SWP, three-piece type ASTM A351 CF8M stainless steel body, full port, stainless steel ball, PTFE gaskets and seat.
 - .2 handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
 - .3 ISO 5211 mounting pad.
 - .4 required MCPR: 3500 kPa (507 psig) at 121°C (250°F).
 - .5 socket weld ends.

Standard of Acceptance

- M.A.Stewart – fig. G3SW <<400 psig>>
- Kitz - fig. 329FS
- Apollo - fig. 86A-200

- .6 NPT threaded ends.

Standard of Acceptance

- M.A.Stewart – fig. G3
- Kitz - fig. 327F

Standard of Acceptance Apollo - fig. 86A-100

- .3 Check Valves, NPS 2 and under:

- .1 to MSS SP-80, Class 125, ASTM A351 CF8M stainless steel body, spring-controlled inline style (non-flapper), body guided disc, resilient EPDM or PTFE seat or disc; stainless steel spring.
- .2 required MCPR: 1170 kPa (170 psig) at 121°C (250°F).
- .3 NPT threaded ends.

Standard of Acceptance

- Apollo - fig. 62-500

2.5 Transfer Pumps

- .1 General;

- .1 packaged duplex pumpset, factory-piped and mounted on a fabricated steel baseplate with an integral drip pan.
- .2 motor control panel for wall mount installation.
- .3 pump performance and motor HP and voltage are as shown.
- .4 prime and topcoat painted finish of piping and baseplate, resistant to water and cleaning solvents.

Standard of Acceptance

- Albany
- Fluid-o-Tech

- .2 Pumps:

- .1 base mounted, gear-type constant displacement pumps, magnetically-coupled to totally enclosed fan cooled motors,
- .2 all stainless-steel construction including housing, helical gears, and drive shaft,
- .3 self-priming design,
- .4 Teflon coated bearings and Viton mechanical seals,
- .5 suction lift: 70 kPa. (17 in Hg) minimum.

- .3 Pumpset piping and joints:

- .1 materials: stainless steel as specified herein except use only schedule 40 pipe,
- .2 pipe joints: NPT threaded or welded.

- .4 Valves:

- .1 type: as specified herein for schedule pipe size,
- .2 pump inlet and outlet shut-off valves for each pump,
- .3 pump discharge check valve for each pump.

- .5 Accessories:

- .1 compound suction vacuum gauge to 30 in Hg,
- .2 liquid filled discharge pressure gauge,
- .3 pressure relief valve with stainless steel trim sized for pump capacity, for each pump,
- .4 simplex basket-style suction strainer with top access,
- .5 combination high/low fluid pressure switch mounted on common pump discharge pipe.
- .6 Control panel:
 - .1 motor controller listed to CSA C22.1 No. 14.
 - .2 electrical enclosure: type 4 to CSA C22.2 No. 94.1.
 - .3 panel mounted disconnect switch with fuse or circuit breaker overcurrent protection,
 - .4 programmable relay-based control system,
 - .5 Hand-Off-Auto operator switch for each pump,
 - .6 pump operation in automatic mode controlled by day tank level controller,
 - .7 time delay relays (hardware or internal software timer) for day tank level point switches HIGH, LOW, and LOW-LOW set for 5 secs debounce time on level switch power-up,
 - .8 time delay relay (hardware) for day tank high level alarm, set for 5 secs debounce time on level switch power-up,
 - .9 day-tank high-high level alarm contact wired as permissive interlock for both Auto and Hand operation,
 - .10 amber power on light,
 - .11 green pump run light for each pump,
 - .12 red fault light for each pump,
 - .13 timer for each pump to override pressure switch on start-up,
 - .14 relays to activate automatic valves (where specified),
 - .15 numbered terminals for connection of external power and control wiring.
- .7 Sequence of operation:
 - .1 when selector switch is in Auto position, pump(s) are started and stopped by day tank Low level switch and High level switch,
 - .2 when selector switch is in Hand position; control overrides day tank Low level control input and pump starts. Pump shuts-down on High level switch,
 - .3 day tank High-High level switch shuts down all pumps and annunciates an alarm,
 - .4 for duplex pumpsets;
 - (a) the two pumps operate in an alternating lead-lag operating cycle on day tank Low level switch,
 - (b) the day tank Low-Low level switch starts the lag pump and annunciates an alarm,
 - .5 fluid pressure switches in pump discharge are normally open and close to stop pump on loss of discharge fluid pressure.
 - .6 automatic valves open when pump(s) start.

2.6 DEF Storage Tank – Aboveground Stainless Steel

- .1 Construction:
 - .1 type 316 stainless-steel tanks, vacuum-monitored double-wall design,
 - .2 tank design and construction to conform to ULC-S601,
 - .3 tank dimensions: as shown,

- .4 design pressure: 210 kPa (30 psi),
 - .5 design temperature: for stored fluids at maximum of 66°C (150°F),
 - .6 lifting lugs, support saddles, and anchor lugs,
 - .7 internal piping for level gauge, fill and suction.
 - .8 double wall, vacuum monitored and provided with
 - (a) factory applied vacuum,
 - (b) tank mounted vacuum gauge,
 - (c) tank mounted vacuum switch, 120 VAC, 2 A rated SPDT Form C contacts.
 - .9 post-weld treatment:
 - (a) internal welds: weld heat-tint removed by pickling,
 - (b) exterior welds: weld heat-tint removed by pickling or mechanical grinding.
 - .10 finish: No. 2B finish.
- .2 Fittings:
- .1 tank pipe fittings: FNPT threaded to ASME B1.20.1.
 - .2 fitting gaskets: EPDM,
 - .3 tank pipe fitting connections to include removable bung,
 - .4 product return piping connection to include stainless steel drop tube terminating 100 mm (4 in.) above the bottom of the tank. Provide a 2 @ Ø3mm (1/8 in. dia.) drilled holes near the top of the tube just beneath the underside of the tank top.

No.	Function	Size	Location	Remarks
1	Product Supply	NPS 1/2	Tank shell at bottom of tank	---
2	Tank fill	NPS 2	Top of tank	---
3	Product Return	NPS 1/2	Top of tank	With internal stainless steel drop tube
4	Tank vent	NPS 3	Top of tank	---
5	Level sensor	NPS 2	Top of tank	---
6	Spare	NPS 2	Top of tank	---
7	Spare	NPS 2	Top of tank	---
8	Spare	NPS 2	Top of tank	---

2.7 Remote DEF Tank Fill Station

- .1 Construction:
 - .1 T316 stainless-steel, 2.8 mm (12 ga.) thick, welded construction,
 - .2 bottom outlet connection,
 - .3 lockable access lid,
 - .4 grounding lug,
 - .5 NPS 2 or 3 tight-fill connections,
 - .6 instructions decal,
 - .7 minimum 5 L (1.3 US gall) capacity,

- .8 sump valved drain to fill line or external container,

Standard of Acceptance

- OPW - fig. 6221-AST
- Steelcraft - fig. 3325

2.8 Truck Fill-Hose Connections

- .1 Gravity fill connector:

- .1 T304 or 316 stainless steel, or aluminium construction for DEF wetted-parts,
- .2 cam-and-groove style adaptor with device to prevent open-filling, with matching dust cap.
- .3 tanker fill hose coupler: matching coupler with male threaded end.
- .4 size: as shown.

Standard of Acceptance

- OPW - fig. 633AST-0200/ 634B / 633BD
- Morrison Brothers - fig. 587 / 800DC / 800D

- .2 Pressurized fill connection:

- .1 T304 or 316 stainless steel, or aluminium construction for DEF wetted-parts,
- .2 cam-and-groove type adaptor, dry-disconnect style with internal spring-loaded poppet valve, and dust cap.
- .3 tank fill hose attachment: matching coupler with poppet valve handle, and male threaded end.
- .4 size: as shown.

Standard of Acceptance

- OPW - fig. 1611AN / 634A / 1711D
- Morrison Brothers - fig. 927 / 800DC / 928

2.9 Vent Terminals

- .1 Tank normal vent terminal:

- .1 designed for DEF; does not include copper, brass or other copper alloy materials,
- .2 for continuous pressure and vacuum venting,
- .3 aluminum body, 40-mesh stainless-steel insect screen.
- .4 pipe size: NPS 2 and 3.

Standard of Acceptance

- OPW - fig. 623V
- Morrison Brothers - fig. 354T

2.10 Level Transmitter/Switch with Remote Display (type “LTS-RD”)

- .1 Tank probe:

- .1 T316 stainless steel and Teflon coated, with integral concentric reference shield, suitable for DEF in horizontal cylindrical tanks.
- .2 transmitter:

- (a) RF capacitance type level transmitter:
- (b) 4-20 mA non-isolated, for continuous measurement level.
- (c) NEMA 4X enclosure with viewing window,
- .2 Remote Display unit:
 - .1 microprocessor based monitoring panel with touchscreen full colour display screen.
 - (a) 4-20 mA input,
 - (b) 4-20 mA output with power supply,
 - (c) Four SPDT programmable relays, rated 10 A @ 240 VAC,
 - .2 NEMA 4 enclosure.
 - .3 listed to CSA C22.2 No. 14
 - .4 120 VAC, 60 Hz power.

Standard of Acceptance

- Arjay Engineering – model 4100-LEV

2.11 Leak Detection

- .1 For indoor use.
- .2 SPST single point magnetic reed switch, reversible NO and NC contact,
- .3 Hermetically sealed reed switch, in stainless steel body,
- .4 Prewired two conductor, PVC insulation wiring lead,
- .5 Dry-contact float switch rated 1.0 A @ 240 VAC,
- .6 Listed for CSA Class 1, Division 1 and 2, Groups A,B,C,D,T5.

Standard of Acceptance

- Albany Pumps fig. Levcon FS-LEAK

3 EXECUTION

3.1 Aboveground Piping/Tubing Materials Selection

- .1 Provide pipe and tube in accordance with the following table:

Piping Element	Schedule 10 or 40 ^[1] Stainless-Steel Pipe	OD-Dimension Stainless-Steel Tube
Tank fill	•	
Tank vent	•	
Tank to tank transfer	•	
Between day tank and SCR equipment		•
Return to day tank		•
Day tank overflow to supply tank	•	

Notes:

[1] Schedule 40 for threaded joints.

3.2 Piping Installation – Aboveground Services

- .1 Install concealed pipes close to building structure to keep furring spaces to minimum and minimize obstruction to other services in ceiling spaces.
- .2 Run exposed piping parallel to walls and conserve headroom and space. Group piping wherever practical.
- .3 Slope main piping up in direction of flow 1:1000 ($\frac{1}{8}$ in in 10 ft).
 - .1 branch piping to have greater slope.
- .4 Use eccentric reducers at pipe size changes arranged flat on bottom to assist venting.
- .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
- .6 Ream pipe after cutting to length and clean off scale and dirt inside and outside of pipe before threading grooving or welding.
- .7 Cap ends during construction to prevent entry of foreign matter.
- .8 Do not weld branch piping directly to mains, or use pulled Tees. Use only welded fittings.
- .9 Equipment connections:
 - .1 NPS 1-1/2 and smaller: NPT threaded.
 - .2 NPS 2 and larger: flanged connections.

3.3 Tubing Installation – Aboveground Services

- .1 Install OD-dimension tubing in accordance with Specification section 23 26 16.

3.4 Welding

- .1 Comply with section 20 05 24 and as specified herein.
- .2 Weld pipe using automatic orbital tungsten inert gas ("TIG") welding.
 - .1 exception: use hand TIG weld for socket welds, at integrally reinforced branch outlet fittings, and slip-on flanges.
- .3 Continuously purge inside of pipes with argon backing gas during welding;
 - .1 provide a purge restrictor on pipe to maintain oxygen levels below a nominal 50 ppm inside of pipe; actual oxygen concentration is as required to obtain a heat affected zone ("HAZ") colour of No. 3 in accordance with AWS D18.2.
 - .2 inject argon within 150 mm of weld - use extension tubes as necessary.
 - .3 use portable oxygen analyzers reading ppm on pipe sizes NPS 2 ½ and larger, to check oxygen levels at purge outlet.
 - .4 time purging is acceptable on pipe sizes NPS 2 and smaller.
- .4 Use of backing gas is not required where the inside surface of the weld is accessible for removal of the HAZ weld tint by grinding or manual application of pickling compound to remove the weld tint.

3.5 Hanger Installation

- .1 Install hangers for steel pipe with spacing and hanger rod diameter in accordance with section 20 05 29.

- .2 Support vertical riser piping:
 - .1 on riser clamps, using stainless steel hanger lugs welded to the pipe,
 - (a) NPS 1 and smaller: every floor level,
 - (b) NPS 1-1/4 and larger at every other floor level,
 - .2 support riser clamps on building structure elements or on secondary support steel in vertical service spaces,
 - .3 in vertical service spaces, provide a pipe guide at the midpoint of the riser and at every 5th floor level below and above the midpoint;
 - (a) pipe guides are not required where vertical piping passes through floor sleeves and the annulus space is fire-stopped.

3.6 Aboveground DEF Steel Tank Installation

- .1 Position tanks using lifting lugs, hooks and spreader bars. Do not use chains or slings.
- .2 Provide support as applicable to mount tank to steel floor in the generator enclosure in accordance with manufacturer instructions.
- .3 Extend fill line from tank into fill box and terminate with fill adaptors.
- .4 Provide plugs on tank cleaning connections.
- .5 Where piping passes through a roof, provide a Thaler roof flashing unit and install and secure to the roof membrane in accordance with the manufacturer's instructions.

3.7 DEF Pump Installation

- .1 Urea pump shall be provided if suction head between urea tank and dosing control panel exceed manufacturer requirements.
- .2 For floor-mounted pumpsets, place pumpsets level on concrete housekeeping base, and secure baseplate to pad, shim and grout with minimum 12 mm (½ in.) grout.
- .3 For wall-mounted pumpsets, provide a fabricated wall-mounted bracket or support.
- .4 Fill hollow portion of bases with concrete.
- .5 Align couplings before and after piping connections have been made.
- .6 Mount and wire level switches and pressure switches and connect to pump control panel.

3.8 Tank Level Measuring Devices

- .1 Provide a type LTS-RD level measurement device in each supply tank.
- .2 Coordinate with tank manufacturer for tank nozzle sizes and mounting requirements for each instrument. Provide adaptor flanges and double-tapped bushings as necessary to mount instruments to tank fittings.
- .3 Calibrate level switches and transmitters. Unless otherwise shown, setpoints for tank levels controls are expressed as percent of tank volume. Convert specified tank volumes percent values to tank fluid height levels based on tank geometry. Refer to table 3 at the end of this specification section for some selected conversion values.

3.9 Leak Detection

- .1 Provide single-point leak detection devices at locations as shown.

- .2 Fabricate a stainless steel support bracket to suspend the float switch at the lowest point for each application, sufficient to provide 50 mm (2 in.) of fluid height.
- .3 Wire each leak detection device to the Building Automation System.

3.10 Alarm Monitoring

- .1 Wire monitoring and alarm outputs from pump control panels to the Building Automation System:
 - .1 Transfer pumps:
 - (a) pump summary alarm
 - (b) pump No. 1 failure, discrete
 - (c) pump No. 2 failure, discrete
 - (d) summary alarm, discrete
 - .2 Day tank control panels - each tank:
 - (a) high day tank alarm, discrete
 - .3 Supply tank inventory control panels - each tank:
 - (a) DEF low tank level alarm, discrete
 - (b) DEF high tank level alarm, discrete
 - (c) tank DEF inventory level, 4- 20 mA

3.11 Pipe Testing

- .1 Above ground piping:
 - .1 Conduct initial pneumatic air test on aboveground piping:
 - (a) test pressure: at 110% of design pressure for not less than 30 minutes,
 - (b) conduct visual inspection for leaks, and repair as necessary,
 - .2 Conduct the final hydrostatic pressure test on aboveground piping:
 - (a) test pressure: fill the piping system with city water and conduct hydrostatic pressure test at 150% of design pressure for 2 hours,
 - (b) conduct visual inspection for leaks, and repair as necessary,
 - (c) acceptance criteria: the test passes if there is no pressure drop over the test duration.

3.12 Flushing and Cleaning

- .1 After completion of the pipe pressure tests, flush piping to drain with clean water for minimum of 30 minutes.
- .2 Drain piping system and refill system with DEF of specified concentration.

3.13 Post-weld Pickling and Passivation

- .1 Not required.

3.14 System Testing

- .1 Upon completion of DEF system and associated SCR system testing, refill main DEF storage tank with product, and leave ready for owner's use.

3.15 Schedules

- .1 The following tables form part of this Specification section:
 - .1 Table 1 Conversion factors for selected tank volume vs tank height.

Table 3: Conversion Factors for Selected Tank Volume vs Tank Height											
Tank Type	Percent Tank Volume										
	10	20	25	30	35	50	75	80	85	90	95
	Percent Tank Height										
Rectangular or Vertical Cylindrical	10	20	25	30	35	50	75	80	85	90	95
Horizontal Cylindrical	16	25	30	34	38	50	70	75	79	84	90

END OF SECTION

PROCESS TUBING AND ACCESSORIES – STAINLESS STEEL

23 26 16

1 GENERAL

1.1 Scope

- .1 Provide stainless steel tubing, valves and accessories for process piping systems.
- .2 This specification section applies to stainless steel tubing of OD1/4 to OD2 (fractional size) using double-ferrule compression-style mechanical joints.
- .3 This specification section may be referenced by multiple sections of Division 23.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 29 Hangers and Supports

1.3 Applicable Codes and Standards

- .1 Installation standards and codes:
 - .1 Refer to applicable piping system specifications for applicable piping code.
- .2 Material standards:
 - .1 ASME B1.20.1 Pipe Threads, General Purpose, Inch
 - .2 ASTM A269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service
 - .3 CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code

1.4 Registration and Inspection

- .1 Refer to applicable piping system specification section regarding requirements for registration and inspection of piping systems subject to pressure piping legislation.

1.5 Design Criteria

- .1 As defined in referencing Specification section.

1.6 Submittals

- .1 Submit shop drawings for valves and fittings.

1.7 Quality Control

- .1 Products covered by this Specification including valves, shall have Canadian Registration Numbers in accordance with CSA B51.

2 PRODUCTS

2.1 Stainless Steel Tube and Fittings

- .1 Tubing, nominal OD 1/4 to OD 2:
 - .1 Fully annealed Type 304/304L stainless steel tubing: to ASTM A269.
 - .2 Wall thickness:

Tube Size OD, NPS	Fluid Service	Maximum System Design Pressure kPa (PSIG)	Tube Wall Thickness mm (in)
1/4	Liquid, Gas	8000 (1200)	0.9 (0.035)
3/8	Liquid, Gas	8000 (1200)	0.9 (0.035)
1/2	Liquid, Gas	8000 (1200)	1.20 (0.049)
5/8	Liquid, Gas	8000 (1200)	1.65 (0.065)
3/4	Liquid, Gas	8000 (1200)	1.65 (0.065)
1	Liquid	8000 (1200)	1.65 (0.065)
	Gas	8000 (1200)	2.1(0.083)
1-1/4	Liquid	8000 (1200)	2.1(0.083)
1-1/2	Liquid	8000 (1200)	2.4 (0.095)
2	Liquid	8000 (1200)	2.77 (0.109)

- .3 Tubing to be suitable for bending and flaring.
- .4 Tube OD tolerance to meet the requirements of the selected compression fitting manufacturer requirements.
- .2 Compression fittings:
 - .1 Double-ferule, compression style, type 316 stainless steel.
 - .2 Threaded adaptor fittings: to ASME B1.20.1
 - .3 Pressure rating: minimum 8000 kPa (1200 psig) at 50°C (122°F).

Standard of Acceptance

- Swagelock
- Parker A-Lok
- Bi-Lok

- .3 Ball valves NPS 2 and under:
 - .1 To MSS SP-110, 1500 CWP/150 SWP, three-piece type ASTM A351 CF8M stainless steel body, full port, stainless steel ball, PTFE gaskets and seat, NPT ends.
 - .2 Handle extensions suitable to clear 50 mm (2 in) pipe insulation thickness.
 - .3 ISO 5211 mounting pad.
 - .4 Required MCPR: 8000 kPa (1200 psig) at 50°C (122°F).

Standard of Acceptance

- M.A.Stewart - G3
- Kitz - fig. 327F
- Apollo - fig. 86A-100
- Swagelock
- Parker
- Bi-Lok

- .4 Check valves NPS 1 and under:
 - .1 ASTM A351 CF8M stainless steel body, spring-controlled inline style (non-flapper), body guided disc, FKM or Buna-N seat; stainless steel spring; with compression or NPT tube ends.
 - .2 Required MCPR: 8000 kPa (1200 psig) at 50°C (122°F).

Standard of Acceptance

- Swagelock
- Parker
- Bi-Lok

2.2 Pressure Regulators and Safety Valves

- .1 Pressure regulator:
 - .1 line pressure regulator valves suitable for operation with compressed air and flow and pressure conditions as shown, based on selection of diaphragm materials and control springs.
 - .2 commercial/industrial service, quick-reacting type to minimize pressure transients during near-zero to full load operation and suitable for reciprocating and rotary air compressors.
- .2 Safety relief valve:
 - .1 stainless steel body, valve, valve guide, and springs,
 - .2 relieve full capacity of upstream pressure regulator rating,
 - .3 overpressure protection setpoint: 1.1 times the downstream.
- .3 Ratings:
 - .1 nominal inlet pressure: 860 kPa (125 psi)
 - .2 outlet control pressure: 700 kPa (100 psi)
 - .3 air capacity: equal to the air compressor rating supplied with the SCR.
 - .4 body pressure rating: 2060 kPa (300 psig).

Standard of Acceptance

- Swagelock
- Parker
- Bi-Lok

2.3 Tube Supports

- .1 Tubing manufacturer's product;
 - .1 split-face polypropylene tubing clamp supports, for single, twin or stacked supports,
 - .2 for mounting to standard slotted mounting rails.

Standard of Acceptance

- Swagelock
- Parker
- Bi-Lok

3 EXECUTION

3.1 Tubing Installation

- .1 Provide tubing, fittings and valves as shown.

- .2 Make tubing joints with double-ferrule compression fittings. Provide threaded connector-adapters at connections to injection lances and at connections to panels.
- .3 Run exposed piping parallel to walls and conserve headroom and space. Group piping wherever practical.
- .4 Slope piping back towards the source equipment at a slope not exceeding 1:1000 ($\frac{1}{8}$ in in 10 ft).
- .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
- .6 Ream pipe after cutting to length and clean-off scale and dirt inside and outside of pipe before joining.
- .7 Provide isolation valves at connections to equipment, control panels and as shown.
- .8 Provide pressure regulators and safety / pressure relief valves as shown.
- .9 Cap ends during construction to prevent entry of foreign matter.

3.2 Tubing Supports

- .1 Support process piping and tubing in accordance with section 20 05 29 except as otherwise specified herein.
- .2 Support piping wherever possible directly to building walls and ceilings. Where piping cannot be supported directly to building structure, support and protect piping continuously along its length using standard perforated support framing systems (Unistrut or similar) to provide mechanical damage protection.
- .3 Support tubing in accordance with manufacturer's recommendations and as specified herein. Support spacing to be in accordance with the following table.

Pipe Size NPS	Rod Diameter	Maximum Spacing (SS Tubing)
$\frac{1}{2}$	10 mm (3/8 in)	0.6 m (2 ft)
$\frac{3}{4}$ to $1\frac{1}{4}$	10 mm (3/8 in)	1.8 m (6 ft)

3.3 Pressure and Leak Testing – Compressed Gases

- .1 This test procedure applies to piping normally containing compressed gases, except for natural gas.
- .2 Conduct an initial pneumatic pressure test at 70 kPa (10 psig) as described above for the initial pneumatic test of liquid piping systems.
- .3 Conduct the final pneumatic pressure test of the piping system after installation of outlets and service connections:
 - .1 use oil free, dry compressed air or nitrogen from cylinders,
 - .2 peak test pressure: 1.2 times piping system design pressure,
 - .3 sustained test pressure: the lessor of: 1.0 times piping system design pressure, or 700 kPa (100 psig),
 - .4 raise the test pressure gradually to 50% of the peak test pressure, then increase the pressure in steps of 10% of the peak test pressure until the peak test pressure is reached, maintaining the test pressure at each step for not less than three (3) minutes before increasing the test pressure.
 - .5 maintain the peak test pressure for not less than 10 minutes, then reduce to the sustained test pressure and examine each joint for leaks with commercial leak detector solution.

Standard of Acceptance

- Snoop
- Leak-tec

- .6 repair leaks and retest the piping system; repeat as required until all leaks are repaired.
- .4 Alternate leak testing - a 24 hour standing pressure test:
 - .1 in lieu of checking each joint with commercial leak detector solution, maintain the test pressure for a period of 24 hours,
 - (a) record the gas test pressure one (1) hour after establishing the sustained test pressure,
 - (b) at the same time, measure the ambient air temperature adjacent to the piping for each pipe section that represents a different thermal environment. Where the piping runs through multiple spaces, each space is to be treated as a separate thermal environment,
 - (c) record each measured ambient air temperature and the average of all such temperatures.
 - .2 after 24 hours, measure and record the gas test pressure and repeat the ambient air temperature measurements at each location recorded in the previous step, and calculate the average air temperature.
 - .3 test result acceptance criterion - Method 1:
 - (a) the difference between pre- and post-test average ambient air temperature is not more than 1°C, and
 - (b) the maximum pressure loss over 24 hours does not exceed 2% of the sustained test pressure.
 - .4 test result acceptance criteria - Method 2:
 - (a) the maximum pressure loss over 24 hours does not exceed 2% of the sustained test pressure, corrected for ambient air temperature, and
 - (b) the correction for ambient air temperature is calculated based on the change of the pre- and post-test average ambient air temperatures and the initial calculated mass of the test gas at the start of the test period.
 - .5 repair leaks and retest until satisfactory.

3.4 Pressure Test Report

- .1 Maintain a log of all pressure tests, including locating of where leaks have been repaired. Submit the log to the Consultant for review when requesting prior to substantial completion of the Work. Where a piping system is subject to AHJ inspection, provide evidence of such inspection by means of an AHJ inspection report or name of the AHJ inspector and the date they witnessed the pressure test.

END OF SECTION

ENGINE EXHAUST SYSTEMS 23 35 16.13

1 GENERAL

1.1 Scope

- .1 Provide diesel exhaust piping systems with drip legs, guides, anchors, and expansion joints for:
 - .1 stationary diesel engine driven generators,

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 24 Welding and Brazing
 - .2 20 05 29 Common Hanger and Support Requirements
 - .3 20 05 49 Seismic Restraint
 - .4 23 51 33 Insulated Sectional Chimneys

1.3 Definitions

- .1 In this section the following definitions apply:
 - .1 **Chimney:** a vertical conduit conveying flue gases to the outside atmosphere,
 - .2 **Low-heat appliance:** appliances with a flue gas outlet temperature of 540°C (1000°F) or less,
 - .3 **Stack:** a vertical conduit containing multiple chimneys, and may also function as a single chimney,
 - (a) **coaxial stack:** a stack which functions as a chimney for one or group of appliances and also contains separate chimneys inside the stack for other appliances,
 - (b) **diesel exhaust stack:** a stack which is solely used to convey exhaust flue gases from a stationary diesel engine, and may be orientated horizontal or vertical along its length. ("exhaust pipes" has the same meaning).

1.4 Applicable Codes and Standards

- .1 Legislation:
 - .1 Ontario Regulation 213/01 Fuel Oil
- .2 Installation standards and codes:
 - .1 CSA B139 Installation Code for Oil Burning Code, as adopted by provincial legislation.
 - .2 NFPA 211 Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances, as adopted by provincial legislation
 - .3 ASTM STS-1-2011 Steel Stacks
- .3 Product standards:
 - .1 ASTM A36/M Standard Specification for Carbon Structural Steel
 - .2 ASTM A53/M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - .3 ASTM A312/M Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

- .4 ASTM A588/M Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance

1.5 Analysis, Design and Inspection Services

- .1 Provide the services of a professional engineer, licensed in the province or territory of the Work and who specializes in the design of piping thermal expansion, supports, anchors and guides (the "Specialty Engineer"), for the design of piping support systems including pipe anchors, guides, and expansion joints, and to provide inspection services of the completed installation.
- .2 Specialty Engineer design services to include;
 - .1 provide the design of the piping support system, including anchors, guides, expansion joints, and shall include seismic restraints where applicable,
 - .2 analysis of dead loads, thermal expansion loads, static seismic loads and capacity of materials utilized for connections to equipment and structure.
 - .3 provide design drawings showing locations of supports, restraints and details of construction and attachment of supports and restrains,
 - .4 seismic design to conform to Specification section 20 05 49.
- .3 Specialty Engineer inspection services to include:
 - .1 at periods during installation and at completion of the installation of the piping supports and anchor devices, the Specialty Engineer shall inspect the installation, identify and report deficiencies (if any) which are observed, and re-inspect the installation after deficiencies have been corrected,
 - .2 Specialty Engineer to submit periodic inspection reports and a final inspection report after all work is completed and deficiencies have been corrected, confirming the installation conforms to the design requirements. Prepare and submit any required declarations or similar document to this effect where required by local legislation. Include in the final report site photographs of the complete installation prior to covering with insulation, with specific photos at pipe anchors, guides, and expansion joints.
- .4 Provide shop drawings of custom anchors, guides and supports, which shall be sealed by the Specialty Engineer.
- .5 Provide signed declarations for commitment for general review and final review letters of conformity as required by applicable legislation at the place of the Work.

1.6 Design Criteria

- .1 Design pressure: -1.0 kPa (-4 in wc.) to + 10.0 kPa (+40 in wc.)
- .2 Maximum design temperature: 540°C (1000°F).
- .3 Operating temperature range: 10 to 540°C (50 to 1000°F)

1.7 Submittals

- .1 Submit shop drawing data sheets for manufactured products showing dimensions and describing construction.
- .2 Submit calculations and shop drawings for pipe anchors and combination roof thimble/anchors designed and sealed by a Professional Engineer licensed in the jurisdiction of the Work, and include;
 - .1 fabrication drawings showing assemblies, overall dimensions, clearance requirements, size and location of connections, and flashing details.

2 PRODUCTS

2.1 Listed Chimneys

- .1 Listed insulated sectional chimneys: in accordance with Specification section 23 51 33.
- .2 Type: industrial chimneys rated for 760°C (1400°F).

3 EXECUTION

3.1 Diesel Exhaust System Fabrication

- .1 Terminate vertical diesel exhaust stack as shown with an ASHRAE exhaust stackhead.
 - .1 stackhead OD: stack diameter plus 50 mm (2 in),
 - .2 stack head height: 4 x stack NPS above top of stack,
 - .3 stackhead supported from stack with welded support spacers,
 - .4 open bottom annulus.
- .2 To assist in pressure testing of the diesel exhaust stack, provide a flange located clear of the building:
 - .1 provide a temporary blind flange or insert a pressure test blanking plate until pressure testing is completed,
- .3

3.2 Exhaust Piping Supports

- .1 Support horizontal exhaust piping with roller hangers in accordance with Specification section 20 05 29.
- .2 Provide seismic restraint of chimneys in accordance with section 20 05 49.

3.3 Exhaust System Expansion and Vibration Control

- .1 Locate first anchor at the engine-end of the exhaust silencer. Provide additional expansion joints and anchors as follows and as shown:
 - .1 at the exhaust outlet of the silencer,
 - .2 fabricate pipe anchors from structural steel angles, channels, or plates, and fasten to building structure at locations as shown,
 - .3 locate a roller hanger support within 300 mm (12 in) of each side of an expansion joint.

3.4 Pressure Test

- .1 Pneumatic pressure test:
 - .1 Do not insulate exhaust stack until pressure testing is completed.
 - .2 Pressure test portions of exhaust stack located inside the building and up to the first joint outside the building. Provide temporary pressure blanks at outlet of the muffler/silencer and at first joint outside of building.
 - .3 Pneumatically pressure test to a minimum of pressure or 14 kPa (2 psi).
- .2 Hydraulic pressure test:
 - .1 Hydraulic pressure test is permissible only where it is not possible to blank off the exhaust stack outside of the building.
 - .2 Unless pipe supports are designed to accommodate weight of pipe and water, provide temporary supports during hydraulic testing.

- .3 Do not expose the silencer or the engine to an hydraulic pressure test.
- .4 Insert a test blanking plate in the flange at the outlet side of the silencer.
- .5 Fill the exhaust stack with clean water to a height of at least 1500 mm (5 ft) above the highest weld joint inside the building. Visibly inspect all welds for sign of water leaks; where leaks are detected, drain down water, repair welds, and re-test until no signs of leakage appear.
 - (a) hammer peening at the location of a leak is not acceptable as a repair.
- .6 On completion of test, drain the water, remove test blanks and inject high temperature sealant into the flange gap prior to resealing of flanges.
- .3 After completion of pressure testing, submit a signed and dated pressure test record to the Owner and Engineer.

END OF SECTION

INSULATED SECTIONAL CHIMNEYS 23 51 33

1 GENERAL

1.1 Scope

- .1 Provide chimneys and chimney connectors as shown for;
 - .1 Emergency diesel generators.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 49.23 Seismic Qualification for Mechanical Equipment

1.3 Definitions

- .1 In this section the following definitions apply:
 - .1 **Chimney**: a vertical conduit conveying flue gases to the outside atmosphere,
 - .2 **Chimney connector**: has the meaning as defined in CSA B139
 - .3 **Gas**: means natural gas or propane gas.
 - .4 **Low heat appliances**: appliances with a flue gas outlet temperature of 540°C (1000°F) or less.
 - .5 **Vent**: (as it applies to a vent flue) has the meaning as defined in CSA B139 and CSA B149.1
 - .6 **Vent connector**: (as it applies to a vent flue) has the meaning as defined in CSA B139 and CSA B149.1

1.4 Applicable Codes and Standards

- .1 Installation standards and codes:
 - .1 CSA B139 Installation Code for Oil Burning Code, as amended by adopting legislation.
 - .2 CSA B149.1 Natural Gas and Propane Installation Code, as amended by adopting legislation.
- .2 Product standards:
 - .1 CAN/ULC-S604 Standard for Factory-Built Type A Chimneys
 - .2 CAN/ULC-S609 Standard for Low Temperature Vents Type L
 - .3 CAN/ULC-S629 Standard for 650°C Factory-Built Chimneys
 - .4 ULC/ORD-C378 Guide for the Investigation of Draft Equipment
 - .5 ULC/ORD-C959 540°C and 760°C Industrial Chimneys

1.5 Design Criteria

- .1 Chimney systems to be self-supporting without guy wires unless otherwise shown.
- .2 Design external chimneys to withstand wind loading in accordance with the applicable building code at the place of the Work.
- .3 Chimney systems to be seismically designed to restrain equipment when subjected to the seismic forces as determined in accordance with specification section 20 05 49.

1.6 Seismic Qualification

- .1 Seismically qualify (certify) the following equipment specified herein:
 - .1 Insulated sectional chimneys and chimney connectors.
- .2 The seismic qualification of the above-listed equipment is to conform to Specification section 20 05 49.23 for the following seismic qualification level and certification method:
 - .1 Attachment seismic qualification (Level I) and Structural seismic qualification (Level II): by static analysis, dynamic analysis or shake table testing,
- .3 The following equipment specific seismic force parameters are to be used:

C_p	A_r	R_p	h_x/h_n
1.00	2.50	2.50	1.0

1.7 Manufacturer Design Services

- .1 Manufacturer to provide engineering services for design of chimney and chimney connectors based on appliance layout and general routing of chimney and chimney connectors as shown. Include:
 - .1 layout and sizing drawings,
 - .2 bill of materials,
 - .3 thermal analysis including theoretical draft and available draft,
 - .4 wind loading restraint, seismic restraint, and structural support details.

1.8 Submittals

- .1 Submit shop drawing data sheets for manufactured products and standard fittings showing dimensions and describing construction.
- .2 Submit engineering shop drawings including layout and installation details.
- .3 Submit certification test certificate for seismic qualification in accordance with Specification section 20 05 49.

2 PRODUCTS

2.1 General Requirements

- .1 Chimneys and chimney connectors to be manufacturer's catalogued products.
- .2 Chimney and chimney connector systems to include sectional pipe lengths, fittings and couplings, clean-outs, drain fittings, roof flashings, storm collars, Belmont top, roof and wall supports, roof and wall ventilated thimbles, guy sections, firestop spacers, and all other required mounting and installation accessories.

2.2 Industrial Chimneys

- .1 Application:
 - .1 diesel stationary engine-driven equipment,
- .2 General:
 - .1 listed to ULC/ORD-C959,
 - .2 maximum flue gas temperature: 750°C (1400°F) continuous,
 - .3 vent pressure: negative, neutral or positive pressure,

- .4 fuels: diesel fuel,
- .5 size: Ø150 mm to Ø1200 mm (6 to 48 in. dia.) liner ID.,
- .6 clearance to combustibles: 50 mm to 100 mm (2 in - 4 in) maximum depending on chimney size.
- .3 Construction:
 - .1 double wall construction for chimney and chimney connectors;
 - (a) flue liner: T304stainless steel,
 - (b) outer casing: T304 stainless steel,
 - (c) annular space insulation: mineral wool or ceramic fibre.
 - (d) annular minimum insulation thickness: 25, 50 and 100 mm (1, 2 and 4 in.) as specified under Part 3 of this specification section.
 - .2 joints: veebands and sealant for liner flanges and draw band for shell flanges, or proprietary band joints, as per listing requirements.
 - .3 joint sealant: manufacturer's product suitable for the flue gas temperature specified herein,
- .4 Special fittings:
 - .1 expansion joints:
 - (a) low-spring rate expansion bellows,
 - (b) with internal flow liner,
 - (c) with outer shell cover,
 - (d) suitable for installation in the vertical or horizontal position.
 - .2 overpressure relief valves:
 - (a) spring-loaded and guided overpressure relief disc,
 - (b) bolting flange, with gaskets, bolts, nuts and washers to fastening to matching flange on chimney pipe.

Standard of Acceptance

- Selkirk – fig. IPSC1, IPSC2, IPSC4
- Van-Packer – fig. DWPlus
- Metal-Fab – fig. IPIC
- Schebler – fig. P1, P2, P4

2.3 Barometric Draft Control for Non-Draft Hood Applications

- .1 Construction:
 - .1 listed to ULC/ORD-C378.
 - .2 single acting, for natural gas,
 - .3 dual acting for natural gas and oil fired applications,
 - .4 80% of full size of breeching area,
 - .5 fabricated from 3.5 mm [10 ga.] steel.

Standard of Acceptance

- Wing DA and SA
- Field M and MG2

3 EXECUTION

3.1 General

- .1 Chimneys and chimney connectors serving gaseous fuel and liquid fuel appliances to be installed by tradesmen certified for installation of fuel fired appliances.
- .2 Select chimney type base on flue gas temperature and required chimney size in accordance with the following table:

Type of Appliances	Maximum Flue Gas Temperature Limit	Appliance Flue Outlet Size or Manifolded Chimney Connector Size ⁽¹⁾	Chimney Type	Annular Insulation Thickness
Stationary Engines ⁽²⁾	≤750°C (1400°F)	All sizes	Industrial Chimney	100 mm (4 in.)

Notes:

- .1 *Whichever is greater.*
- .2 *Includes but not limited to diesel-generators, fire pumps, compressors, etc.*

3.2 Installation – General Requirements

- .1 Install chimney system in accordance with chimney manufacturer and appliance manufacturer installation requirements.
- .2 Maintain clearance between chimney connectors and combustible materials or building insulation in accordance with product installation instructions.
- .3 Position chimneys inside of enclosures to maintain minimum clearances to:
 - .1 combustible material in accordance with chimney listing requirements, and
 - .2 non-combustible materials as follows:
 - (a) 50 mm (2 in) for chimney OD size less than or equal to 450 mm (18 in)
 - (b) 100 mm (4 in) for chimney OD size larger than 450 mm (18 in).
- .4 Support chimneys at roof penetrations and provide roof flashing and counter-flashing.
- .5 Provide anchors, guides and expansion joints as required to maintain chimney system true-in-line both during operation and not in operation, and to control forces imposed on associated appliances and the building structure.
- .6 Erect chimneys true and plumb to within 1 in 1200.
- .7 For multiple appliances, manifold the chimney connectors in accordance with manufacturer installation requirements.
- .8 Where an offset is required, make offset with 45° elbow fittings whenever possible.
- .9 Provide clean-outs at base of chimney and provide access to clean-outs.
- .10 Seal double wall pressure stacks and breechings:
 - .1 seal inner joints bead of high temperature sealant,
 - .2 fill channel of vee band with high temperature sealant and install and tension vee-band,
 - .3 install insulation filler strips in air space between inner and outer walls, and secure outer shell with draw band,

- .4 caulk upper edge of drawbands exposed to the weather with silicone sealant.
- .11 Make connector connection to equipment, flue gas outlet with slip type joints and mechanically fasten with a minimum of three (3) screw fasteners.
- .12 Where chimney passes through combustible floor or wall construction, provide fire-stop fitting.
- .13 Where breeching system is designed to absorb thermal expansion make connection with flange adaptor.

3.3 Overpressure Relief Fitting Installation

- .1 Provide overpressure relief fittings on chimney systems serving engines;
 - .1 install relief fitting as close as possible to the outlet of the appliance or the outlet of any flue-gas sound attenuating equipment,
 - .2 the relief valve may be installed within the service room containing the engine or turbine, or be located outdoors,
 - (a) where located inside of the service room, position the relief valve so that it may be readily visible to allow inspection of the discharge opening.

3.4 Start-Up and Testing

- .1 Refer to applicable gas appliance specification section for appliance-specific testing requirements for the gas venting system.
- .2 Measure and record the outdoor air temperature and the draft at the appliance flue connection under the following load conditions:
 - .1 appliance maximum rated capacity, dedicated venting
 - .2 appliance maximum rated capacity with no other common vented appliances operating,
 - .3 appliance maximum rated capacity with all other common vented appliances operating to meet the load conditions at the time of the test,
 - .4 appliance minimum rated capacity (modulating burners and two-stage burners), single appliance operation only.

3.5 Test and Installation Records

- .1 Refer to applicable gas appliance specification section for appliance-specific test and installation records requirements for the gas venting system.

END OF SECTION

BUILDING AUTOMATION COMMON WORK RESULTS

25 05 01

1 GENERAL

1.1 Scope

- .1 Provide direct digital control ("DDC") system for the following mechanical systems and connecting to the existing Johnson Controls (JCI) building automation system ("BAS"):
 - .1 Interface with emergency generator control panel for BAS monitoring and alarming,
 - .2 Interface with the new programmable logic controller ("PLC") fuel oil control system (fuel pump control panels and auxiliary tank control panels) for BAS monitoring and alarming,
 - .3 Monitor generator enclosure space temperature and damper operation,
 - .4 Interface with selective catalytic reduction (SCR) control panel for BAS monitoring and alarming.
- .2 Controls contractor to include for all upgrades required to the existing system (including software/hardware/controllers/licenses/etc.) as required to interface all new points and controllers into BAS.
- .3 The BAS is to integrate with:
 - .1 other building services subsystems including lighting control systems, access control systems and fire alarm systems.

1.2 Dependent Sections

- .1 The BAS Work is further defined in the following specification sections:

25 05 06	Work on Existing Building Automation
25 05 11	Building Automation Control Panels and Wiring
25 30 16.13	Building Automation Instrumentation

1.3 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the BAS system is further described in the following the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 05 49 Seismic Restraint
 - .3 20 08 11 Testing of Mechanical Life Safety and Fire Protection Requirements

1.4 Definitions and Abbreviations

- .1 The following definitions, abbreviations, and acronyms apply to this Division of the Work:
 - .1 AI Analog Input: continuously variable value, usually a sensor, referenced to a controller
 - .2 AO Analog Output: continuously variable value, usually a control signal to an actuator device, referenced to a controller.
 - .3 ASC Application Specific Controller
 - .4 DI Digital Input: a two-state (On-Off) value, usually associated with a switch or state, referenced to a controller.

- .5 DO Digital Output: a two-state (On-Off) value, usually associated with starting or stopping equipment or generating an alarm, referenced to a controller.
- .6 FC Fail Close (valve or damper action on failure of the controller)
- .7 FO Fail Open (valve or damper action on failure of the controller)
- .8 FAS Fire Alarm System
- .9 GUI Graphic User Interface: an LED, LCD or monitor display
- .10 I/O Input/Output
- .11 LAN Local Area Network
- .12 NC Normally Closed: position of device in a de-energized state.
- .13 NO Normally Open: position of device in a de-energized state.
- .14 NSC Network Supervisory Controller
- .15 OEM Original Equipment Manufacturer
- .16 OWS Operator workstation: a PC based server or computer
- .17 Tier 1 Building level network providing communication between NSCs and workstations.
- .18 Tier 2 Field level network providing communications between ASCs and NSCs
- .19 WAN Wide Area Network

1.5 Applicable Codes and Standards

- .1 Product standards:
 - .1 ANSI/ASHRAE 135 BACnet – A Data Communication Protocol for Building Automation and Control Networks
 - .2 ANSI/CEA 709.1 Control Network Protocol Specification (Lonworks)
- .2 Interfacing Standard:
 - .1 Input/output devices to use ASCII (American Standard for Communication and Information Interchange) code and standard EI (Electronic Industry Association) interfaces.
 - (a) CSA T530 Commercial Building Standard for Telecommunications Pathways and Spaces
 - (b) IEEE 802.3 Ethernet

1.6 Existing BAS

Standard of Acceptance

- ° Johnson Controls (Metasys NAE) - Existing

1.7 Manufacturers and Installers

- .1 BAS work shall be performed by Johnson Controls (JCI) as the base building controls contractor authorized by the Owner to perform such Work. Contact information provided below:
 - Kirk Campbell*
 - HVAC Owner Account Executive*
 - 613-532-0277*
 - kirk.campbell@jci.com*

Jonathan Da Silva
HVAC Owner Account Executive
613-561-4868
jonathan.dasilva@jci.com

1.8 Design Services

- .1 Provide engineering services for the design of the BAS including product selection, wiring details, and all installation details to meet the prescribed and performance requirements described in the specifications sections of Division 25. Issued design documents are to be sealed by a professional engineer licensed in the province of the Work.
- .2 Prior to preparation of shop drawings for the BAS, provide a design assist to review Consultant's sequence of operation and provide feedback on any recommendation that may improve the installation or ease of operation, while remaining within the hardware scope as originally designed and specified herein.

1.9 Submittals

- .1 Submit one (1) completely engineered and coordinated shop drawing package. Partial or incomplete submission of data and/or drawings will be returned without review.
- .2 Submit shop drawings for designed elements;
 - .1 list of materials of equipment to be used indicating manufacturer, model number, and other relevant technical data,
 - .2 BAS riser diagram showing system controllers, operator workstations, network devices, and network wiring,
 - .3 control panel internal wiring diagrams, .
 - .4 single-line schematics and system flow diagrams showing location of control devices,
 - .5 wiring diagrams identifying interface hard-wire terminations to controlled equipment OEM control panels,
 - .6 points list for each system controller, including: Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Panel, Reference Drawing, and Cable Number,
 - (a) points to be named by function, and list to include software points such as programmable set-points, range limits, time delays, and so forth,
 - .7 detailed analysis of each Sequence of Operation from Consultant's design documents, ready for development of actual programming code,
 - .8 written Sequence of Operations to cover normal operation and operation under various alarm conditions applicable to that system.
- .3 Submit catalogue cut-sheets for;
 - .1 manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for equipment and hardware items as follows;
 - (a) instrumentation, including
 - i) accuracy data, range and scale information,
 - ii) one sheet for each device marked with applicable options. Where several devices of same type are to be used, submit one sheet for each device, individually marked.
 - (b) relays/switches,
 - (c) control panel enclosures,

- (d) power supplies,
 - (e) batteries,
 - (f) GUI operator interfaces,
 - (g) wiring and wiring accessories.
- .4 Submit supporting documentation:
- .1 representative examples of graphics for GUI to include;
 - (a) BAS network schematics,
 - (b) description of techniques used for dynamic display of information on graphics and method of how building operator drills down to secondary information and affects control of equipment.
 - .2 Protocol Implementation Conformance (PIC) statement for BACnet devices,
 - .3 where interfaces occur with control or wiring diagrams of other sections, obtain reproducible copies of those diagrams and revise to show terminal numbers at interface and include diagrams as part of interconnection schematic shop drawings.

1.10 Quality Control

- .1 Continuity of staff and subcontractors:
- .1 Controls contractor's project manager is to be nominated at time of shop drawing submission and is to remain involved with the project, from shop drawing preparation through to project acceptance, unless a request for change of personnel is submitted to and approved by Owner.
 - .2 Subcontractors listed in preliminary design submission are to execute the Work defined as sublet in preliminary design document, unless request for change is submitted to and approved by Owner.
 - .3 Requests for changes in staff, subcontractors, or extent of work subcontracted are to be submitted for approval by Owner and such approval is not to be unreasonably withheld.
- .2 Identification of non-conforming materials and equipment:
- .1 Submit documentation at time of bid, identifying nature and extent of non-conformance and variances from specifications or referenced standards.
 - .2 Failure to submit this documentation at time of bid will be interpreted as confirmation that materials, workmanship, hardware and software will be in strict accordance with specifications and standards.
- .3 All products that are connected to a piping system that is subject to registration under applicable boiler and pressure vessel legislation are to have current Canadian Registration Numbers in accordance with CSA B51.

1.11 Warranty

- .1 At completion of Work, submit written guarantee undertaking to remedy defects in work for period of two (2) years from date of acceptance, which includes:
- .1 rectification of control system failures attributable to defects in workmanship, materials, hardware, and software,
 - .2 service technician to arrive on site within 24 hours of warranty service request, to install and debug software patches, to replace defective parts, materials or equipment, and to provide incidental supplies, and labour for remedial work,
 - .3 technician to remain in attendance until system is returned to operating condition.
- .2 Submit similar guarantee for any part of the Work accepted by Owner, before completion of whole work.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in following minimum ambient condition ranges unless otherwise specified in other specification sections of Division 25:
 - .1 temperature: 0°C to 40°C (32°F to 104°F)
 - .2 relative humidity 10% to 90% non-condensing
 - .3 electrical power service of single phase, 120 VAC +/- 10%, 60 Hz nominal.
- .2 Components installed within motor control devices to be designed to operate with transient electrical fields occurring within these devices.

2.2 Equipment Standard

- .1 Products and software: manufacturer/developer/supplier's catalogued current stock.
- .2 This installation is not to be used as test site for newly developed product or software, without explicit written approval by Owner.
- .3 Equipment and systems installed to meet;
 - .1 performance specifications when subjected to VHF, UHF, FM, AM or background RFI as generated by commercial or private, portable or fixed transmitters that meet regulatory codes,
 - .2 Federal Communication Commission (FCC) Rules and Regulations, Part 15, Subpart J for computing devices.

2.3 BAS General Functional Requirements

- .1 Control mechanical and electrical equipment as specified in control sequences, shown on control schematics, and described in equipment schedules.
- .2 Scalable system architecture to be modular, permitting stepped expansion of application software, system peripherals, and field hardware.
- .3 Control system:
 - .1 high-speed, peer-to-peer network of microprocessor based Direct Digital Control (DDC) controllers with web-based operator interface,
 - .2 each mechanical system, building floor plan, and control device to be displayed through point-and-click graphics,
 - .3 Web server with network interface card to gather data from this system and generate web pages that can be accessed through conventional web browser on any PC connected to network,
 - .4 operators to access this system through web browser on connected PC's, wireless tablet PCs and smart phones to perform normal operator functions,
 - .5 scalable, modular, automatic process and optimized workflows, with automatic data acquisition and energy performance analytics,
- .4 Each controller;
 - .1 operates with local closed loop programming, independent from server, able to continue functional control if peer-to-peer communication is interrupted;
 - .2 performs resident control routines;
 - (a) receiving information from field mounted sensors and switches and
 - (b) transmitting instructions to actuators to perform control sequences.

- .3 manages local hardware and software alarms;
 - (a) to collect historical data,
 - (b) to facilitate operator input and output,
 - (c) to communicate with Central BAS web server and GUI.
- .5 Central BAS Web server;
 - .1 performs global application programs and data consolidation;
 - (a) communicating with controllers,
 - (b) obtaining data from field devices for central monitoring of building systems, and
 - (c) transmitting instructions to controllers.
 - .2 has software routines for;
 - (a) BAS Server operation,
 - (b) database creation and data storage,
 - (c) web based GUI with graphics generation and display,
 - (d) report formulation, printing, and presentation,
 - (e) alarm detection, management and reporting,
 - (f) event initiated programming.

2.4 Network Integration Functional Requirements

- .1 Open protocol:
 - .1 Provide an integrated, open protocol building automation system using BACnet to ANSI/ASHRAE Standard 135, with native integration with:
 - (a) Lonworks,
 - (b) Modbus,
- .2 Integral systems integration functionality:
 - .1 provide hardware and software to allow bi-directional digital communications between BAS and facility control subsystems including:
 - (a) HVAC,
 - (b) fire safety including fire alarm systems,
 - (c) security systems,
 - (d) power control and monitoring systems,
 - (e) lighting control systems,
 - (f) 3rd party integration with other facility systems.
- .3 OEM Controller integration:
 - .1 provide hardware and software to allow bi-directional digital communications between BAS and 3rd party manufacturers' equipment control panels including but not limited to;
 - (a) Diesel generator control panels,
 - (b) Diesel fuel oil pump control panels,
 - (c) Auxiliary tank control panels.
 - (d) Diesel generator exhaust selective catalytic converter (SCR) control panels.
 - .2 integrate real-time data from these systems.

2.5 Factory DDC Control System

- .1 Provide factory installed, wired and programmed Direct Digital Control (DDC) system, including instrumentation, to provide control and monitoring of ventilation dampers and other supervisory and control functions,
- .2 Direct Digital Control (DDC) unit:
 - .1 microprocessor based DDC controller, using commercial building automation system products,
 - .2 BTL listed DDC controller,
 - .3 having sufficient I/O to control damper ventilation system, general fan ventilation, and heating equipment,
 - .4 BACnet MSTP or BACnet/IP communication interface (for connecting the building automation system),
- .3 Mount DDC controllers in an electrical enclosure, Type 2R, 3 or 4 to CSA C22.2 No. 94.1, complete with all necessary power supplies and protective devices.
- .4 Provide wiring and conduit for power, instrumentation and communication wiring. Use flexible watertight conduit for the final 300 mm (12 in) length at connections to instrumentation, dampers, and rotating equipment.
- .5 Provide a dedicated UPS power supply to maintain DDC controller function for a period of 5 minutes after loss of power.
- .6 Instrumentation:
 - .1 Space temperature sensor:
 - (a) Provide RTD type space temperature sensor with digital display, as per Specification 25 30 16.13.
- .7 Verify operation of dampers within generator enclosure. Provide/modify controls to suit sequence of operations.
- .8 Sequence of Operation – Generator Damper Control:
 - .1 On power failure or when engine is commanded to start (in normal run mode and test mode),
 - (a) the combustion air damper fails open and remains open at all times while engine is operating,
 - (b) the outdoor ventilation air damper fails open and after a 30 second time delay, after which delay the damper is under temperature operation control.
 - .2 When the engine shuts-down, combustion air damper closes. Engine ventilation damper and exhaust dampers remain open 100% until 30 minutes (adjustable) delay has expired.
- .9 Sequence of Operation – Monitoring Functions:
 - .1 Monitor combustion air damper position switch. On start-up of engine, if damper is not proved open within 30 seconds, annunciate an alarm to the BAS or security system.
 - .2 Monitor space temperature conditions. On space temperature > 45°C or < 5°C, annunciate an alarm to the building automation system or security system.
 - .3 Monitor fuel leak detection alarms and fuel tank interstitial sensor. On detection of change of status, annunciate an alarm to the BAS or security system.

2.6 Performance

- .1 General:
 - .1 information transmission and display times are based upon network connections,
 - .2 test systems using manufacturer's recommended hardware and software for operator interface.
- .2 Performance criteria:

- .1 Graphic Display;
 - (a) display graphic with 50 dynamic points with current data within 10 seconds.
- .2 Graphic Refresh;
 - (a) update graphic with 50 dynamic points with current data within 10 seconds and
 - (b) automatically refresh every 15 seconds.
- .3 Configuration and Tuning Screens;
 - (a) special screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic to refresh every 5 seconds.
- .4 Object Command response;
 - (a) time between command of binary object at GUI and onset of reaction by device to be less than 5 seconds,
 - (b) time between command of analog object at GUI and start of adjustment to be less than 5 seconds.
- .5 Alarm Response Time;
 - (a) time between when an object goes into alarm and when it is annunciated at GUI to be less than 15 seconds.
- .6 Program Execution Frequency;
 - (a) execution repeat frequency to be selected in manner consistent with process under control,
 - (b) custom and standard applications to be capable of executing as often as once every 5 seconds.
 - (c) programmable controllers to be able to perform PID control loop routines at selectable frequency, adjustable at GUI down to once every second.
 - (d) workstations connected to network to receive alarms with not more than 5 seconds spread between first and last annunciation.

2.7 Wiring and Conduit

- .1 Wire and conduit for power wiring, control wiring, and communication wiring to conform to specification section 20 05 12.

3 EXECUTION

3.1 Examination

- .1 Inspect site and thoroughly examine documents to establish locations for control devices and equipment and report discrepancies, conflicts, or omissions for resolution before starting rough-in work.
- .2 Be responsible for correction of defects caused through neglect of inspections and examinations or failure to report and resolve discrepancies.

3.2 Protection

- .1 Protect work and material against damage during construction and be responsible for work and equipment until inspected, tested, and accepted.
- .2 Protect material not immediately installed and seal connector terminations with temporary covers or plugs during storage and construction to prevent entry of foreign objects.
- .3 Protect electronic equipment from elements during construction.

3.3 Coordination

- .1 Coordinate and schedule BAS work with other work in same area to ensure orderly progress.
- .2 Testing and balancing:
 - .1 Supply sets of tools of sufficient quantity for Testing and Balancing Technicians to interface to control system, train these technicians in use of tools, and provide qualified Control Technician to assist with testing and balancing the first 10 terminal units.
 - .2 Tools to be turned over to Owners on completion of testing and balancing.
- .3 Controls work by others:
 - .1 Integrate and coordinate this control work with controls and control devices provided or installed by others.
 - .2 Each supplier of control product to configure, program, start up, and test that product to satisfy requirements of Sequence of Operation regardless of where within contract documents product is specified or described.
 - .3 Resolve compatibility issues between control products provided under this Division and those provided under other Divisions of the Work.

3.4 General Workmanship

- .1 Installation to be performed by skilled and certified technicians.
- .2 Install equipment, piping, and wiring or raceways horizontally, vertically, and parallel to building lines.
- .3 Provide sufficient slack and flexibility in connections to allow for vibration isolation between conduit, raceways, piping and equipment.
- .4 Install instrumentation and devices in locations providing adequate ambient conditions.
- .5 Protect components placed in areas of potentially high humidity.

3.5 Wiring for Power, Control and Communications

- .1 Provide wire and raceways (conduit) for power wiring, control wiring, and communications wiring for BAS controllers and associated instrumentation and actuation devices, at voltages of 120 V and under, in accordance with specification section 20 05 12 and, for greater clarity, Schedule A appended to that specification section.
- .2 Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

3.6 Cleaning

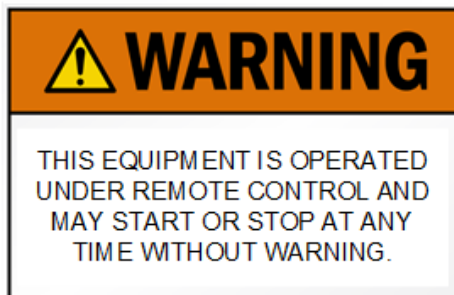
- .1 Clean up debris, remove packaging material, collect waste and place in designated location, on a daily basis.
- .2 Keep work areas free from dust, dirt, and debris.
- .3 On completion of work, check finish of equipment provided under this section for damage and repair damaged factory-finished paint, replace deformed cabinets and enclosures with new material, and repaint to match original.
- .4 Prior to hand-over to the Owner, clean the inside of control panels;
 - .1 remove debris and vacuum clean internal components,
 - .2 the use of low-pressure dry nitrogen or inert compressed gases may be used to blow dust and debris out of panels where the use of such pressurized gases will not damage equipment or loosen wiring terminations,
 - .3 after cleaning, apply a label to the exterior side of the panel to identify the date the panel was cleaned and the initial of the person who cleaned the panel.

3.7 Field Quality Control

- .1 Ensure work, materials, and equipment comply with this specification and reviewed shop drawings.
- .2 Monitor field installation for applicable safety and building code compliance and workmanship quality.
- .3 Arrange and pay for inspections by local or provincial authorities having jurisdiction over the work.

3.8 Identification of Equipment

- .1 Match labelling scheme as per base building standards.
- .2 Manufacturers' nameplates and product certification labels to be visible and legible after equipment is installed.
- .3 Identify discrete items of equipment with plastic nameplates or plasticized labels, identifying equipment and function. Identification plates are in addition to manufacturers nameplates.
- .4 Identification plates:
 - .1 provided for equipment identified with number designations in schedules and equipment shop drawings.
 - .2 marked with equipment type, number and service following wording and numbering used in contract documents and shop drawings,
 - .3 plastic laminated labels,
 - .4 white face and black background field,
 - .5 minimum size 75 mm x 40 mm x 3 mm (3 in x 1½ in x 1/8 in),
 - .6 engraved or printed with 6.5 mm (1/4 in) high lettering.
 - .7 securely attached to equipment with brass chains.
- .5 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 50 mm (2 in) of termination.
- .6 Label pneumatic tubing at each end within 50 mm (2 in) of termination with descriptive identifier.
- .7 Permanently label or code each point of field terminal strips to show instrument or item served.
- .8 Label each control component with permanent label. Label plug-in components so that label remains stationary during component replacement.
- .9 Label room sensors related to terminal boxes or valves with nameplates. Place labels on back of sensors.
- .10 Identify motor controllers that are remotely controlled by the BAS with self-adhesive labels, black letters on white background with a red border and electric shock warning icon, with wording as follows;



3.9 Checkout and Testing

- .1 Provide schedule for start-up and testing.

- .2 Calibrate and prepare for service equipment, instruments, controls, and accessories.
- .3 Start-up testing to verify completion of control system before system demonstrations begin;
 - .1 verify that control wiring is connected and free of shorts and ground faults. Verify that terminations are tight,
 - .2 enable control systems and verify input device calibration,
 - .3 verify that binary output devices operate and that normal positions are correct,
 - .4 verify failure positions of dampers and control valves are correct when power/compressed air is deenergized to the device,
 - .5 verify that analog output devices are functional, that start and span are correct, and that direction and normal positions are correct,
 - .6 check control valves and automatic dampers for proper action and closure and adjust valve stroke/rotation and damper blade travel,
 - .7 verify that damper and control valve feedback signals are correct when device is stroked fully open and closed (two position) and at any opening position between zero and fully open (modulating devices),
 - .8 verify that system operates according to Sequences of Operation. Simulate changes in variables by overriding and varying inputs and schedules and observe and record each operational mode response.,
 - .9 tune PID loops and control routines to provide stabile operation and to minimize valve and damper hunting,
 - .10 check each alarm with an appropriate signal at value that will trip alarm,
 - .11 trip interlocks using field contacts to check logic and to ensure that actuators fail in proper direction,
 - .12 test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.
- .4 Prepare and submit test log documenting start-up testing of each input and output device and each control routine, with technician's initials certifying each device and each routine is functioning correctly and sensors have been calibrated. Include list of deficiencies and a workplan schedule setting out rectification program with time lines.

3.10 Testing of Integrated Life Safety and Fire Protection Systems

- .1 Comply with the requirements of specification section 20 08 11 for the testing of the integration of controls and communications between the BAS and life safety and fire protection systems.

3.11 Control System Demonstration

- .1 Obtain approval of start-up testing log and rectification program before scheduling demonstrations.
- .2 Provide notification to Owner and Consultant not less than 10 business days before system demonstration begins.
- .3 Demonstration to follow previously submitted and approved procedures;
 - .1 submit checklists and report forms for each system as part of demonstration,
 - .2 lists and forms to have initials of technicians conducting demonstrations,
 - .3 date of each demonstration and signatures of Owner's representatives witnessing each demonstration section.
- .4 Prior to acceptance, perform the following operating tests in the presence of the Owner or Owner's representative and Consultant to demonstrate system operation and compliance with specification after and in addition to tests specified above in article Checkout and Testing.

- .5 Demonstrate field operation of;
 - .1 each Sequence of Operation,
 - .2 Operator Interface,
 - .3 control loop response with graphical trend data output showing;
 - (a) each control loop response to set point change producing an actuator position change of at least 25% of full range.
 - (b) trend sampling rate to be from 10 seconds to 3 minutes, depending on loop speed,
 - (c) loop trend data to show set point, actuator position, and controlled variable values,
 - (d) documentation of further tuning of any loop that displays significantly under- or over-damped control
 - .4 demand limiting routine with trend data output showing demand-limiting algorithm action;
 - (a) trend data to document action sampled each minute over at least 30-minute period and to show building kW, demand-limiting set point, and status of set-points and other affected equipment parameters.
 - .5 control integration with life safety and fire protection systems,
 - .6 trend logs for system points as selected by the Owner with;
 - (a) trend data to indicate set-points, operating points, valve positions, and other data as specified in points list provided with each Sequence of Operation,
 - (b) each log to cover three 48-hour periods and to have sample frequency not less than 10 minutes, except where a Control Sequence specifies other time intervals,
 - (c) show that trend logs are accessible through operator interface and can be retrieved for use in other software programs.
 - .7 substantiate calibration and response of any input and output points requested,
 - .8 provide at least two technicians equipped with two-way communication,
 - .9 provide and operate test equipment to establish calibration and prove system operation.
- .6 Tests that fail to demonstrate system operation are to be repeated after repairs and/or revisions to hardware or software is completed.

3.12 Training

- .1 Materials:
 - .1 provide course outline and materials for each class at least four (4) weeks before first class,
 - .2 provide training through instructor-led sessions, with computer-based, or web-based techniques,
 - .3 instructors to be factory-trained and experienced in presenting this material,
 - .4 perform classroom training using network of working controllers representative of installed hardware.
- .2 Operating staff training:
 - .1 provide training for Owners operating staff using abovementioned training materials in self-paced mode, web-based or computer-based mode, classroom mode, or combination of these methods,
 - .2 allow for 2 repeat sessions for each category to cover operator shift rotation.
- .3 Training to enable students to accomplish following objectives:
 - .1 Group 1:
 - (a) proficiently operate system,
 - (b) understand control system architecture and configuration,

- (c) understand BAS system components,
- (d) understand system operation, including BAS system control and optimizing routines (algorithms),
- (e) understand Sequence of Operations,
- (f) operate workstation and peripherals,
- (g) log on and off system,
- (h) access graphics, point reports, and logs,
- (i) adjust and change system set-points, time schedules, and holiday schedules,
- (j) recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools,
- (k) understand system drawings and Operation and Maintenance manual,
- (l) understand project layout and location of control components,
- (m) access data from BAS controllers,
- (n) set-up trend logs,
- (o) operate portable operator's terminals

.2 Group 2:

- (a) create and change system graphics,
- (b) create, delete, and modify alarms, including configuring alarm reactions,
- (c) create, delete, and modify point trend logs (graphs) and multi-point trend graphs,
- (d) configure and run reports,
- (e) add, remove, and modify system's physical points,
- (f) create, modify, and delete application programming,
- (g) add and configure GUIs,
- (h) add new controller to system,
- (i) download firmware and advanced applications programming to controller,
- (j) configure and calibrate I/O points.

.3 Group 3:

- (a) maintain software and prepare backups,
- (b) interface with job-specific, third-party operator software,
- (c) add new users and understand password security procedures.

.4 Divide presentation of objectives into three sessions:

- .1 Group 1: Day-to-day Operators,
- .2 Group 2: Advanced Operators,
- .3 Group 3: System Managers and Administrator,
- .4 participants will attend one or more sessions, depending on knowledge and expertise level required,
- .5 provide each student with one copy of training material.

3.13 Record Submittals

- .1 Submit record documents to the Owner.
- .2 Document language: English,
- .3 Submit three copies of project record documents and obtain approval during acceptance procedures.

- .4 Submit AHJ inspection certificates.
- .5 Provide as-built drawings;
 - .1 as-built interconnection wiring diagrams, or wire lists of field installed system with identified, ordering number of each system component and service,
 - .2 floor plans with accurate depiction of location of system devices, controllers, and trunk wiring. Drawings to be constructed using Architectural backgrounds provided,
 - .3 provide copies of as-built drawings on two (2) removable storage devices,
 - .4 provide five (5) full size hard copies of floor plan drawings.
- .6 Operation and Maintenance (O&M) Manuals:
 - .1 provide two (2) paper copies of material and copies on five (5) removable storage devices in portable document format.
 - .2 describe operation, maintenance and servicing requirements of system and associated equipment,
 - .3 provide the following information in separate sections, each with an index:
 - (a) Service and parts;
 - i) names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems,
 - ii) list of recommended spare parts with part numbers and suppliers.
 - (b) System description;
 - i) outline of BAS system and system architecture,
 - ii) as-built versions of shop drawing product data,
 - iii) reduced size (11 in x 17 in) copies of record drawings,
 - iv) graphic files, programs, and database on magnetic or optical media,
 - v) licenses, guarantees, and warranty documents for equipment and systems.
 - (c) Technical literature for equipment, including;
 - i) catalogue sheets,
 - ii) calibration, adjustments and operation instructions,
 - iii) installation instructions,
 - iv) hardware and software manuals, with information supplied by original product developer, on application programs and on computers and controllers supplied,
 - v) Operator's manual with procedures for operating control systems; logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set-points and variables,
 - vi) engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware,
 - vii) original-issue documentation with installation and maintenance information for third-party hardware including computer equipment and sensors,
 - viii) recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions,
 - ix) programming manual or set of manuals with description of programming language and syntax, explanation of statements for algorithms and calculations used, procedures for

- point database creation and modification, documentation of techniques for program creation and modification, and instructions for use of editor,
 - x) documentation of programs created using custom programming language including set-points, tuning parameters, and object database. Electronic copies of programs to modify and create control logic, set-points, tuning parameters, and objects that can be viewed using programming tools.
- .7 Original Software:
- .1 Furnish one original set of application and system software on original media. Disks to bear manufacturer's label. Field copies are not acceptable.
 - .2 Original-issue copies of software to include operating systems, custom programming language, application generation, graphic support, maintenance support, operator workstation or web server software, and other utilities provided in support of installed system.
- .8 On-line record documentation:
- .1 After completion of testing and adjustment, install the following additional information on the server OWS.
 - (a) as-built record drawing files,
 - (b) detailed catalog data on all installed system components, with supplier contact information for purchasing and factory authorized repair service.

3.14 Acceptance

- .1 Application for substantial performance of the Work requires as a prerequisite the completion of the BAS including testing, demonstration, and submittal of required documentation, except where the Owner agrees to differ any work to a later date.
- .2 In support of an application for substantial performance, submit a signed declaration to the Owner certifying that:
 - .1 the BAS is complete and operating in accordance with the contract documents,
 - .2 control system checkout and testing is completed,
 - .3 control system demonstration is completed,
 - .4 training is completed,
 - .5 as-built documentation is completed and turned-over to the owner.
- .3 Certification document may identify tests that cannot be performed due to extenuating circumstances such as weather conditions, where previously agreed to be deferred to a later date by the Owner. Append a program for completion of deferred work to the certification document for rectification and completing these tests during warranty period.

3.15 Correction After Completion

- .1 After start-up, testing, and commissioning phase has been completed and satisfactory and reliable operation of equipment and systems has been demonstrated, acceptance of the system is to be given by Owner. Warranty period to begin on date established on certificate of acceptance.
- .2 Provide updates and patches to resolve software deficiencies in operator workstation or web server software, project-specific software, graphic software, database software, and firmware during warranty period.
- .3 Provide upgrades that improve routines and procedures of operator workstation software, web server software, project-specific software, graphic software, or database software, free of charge, during warranty period.
- .4 Provide details of proposed changes and obtain written authorization from Owner before installation of updates, patches, or upgrades.

- .5 Include preventative maintenance, with allowance for spare parts, labour, and emergency (24 hour) service for system and equipment during warranty period.
- .6 Equipment manufacturers to submit written undertakings to make circuit board repairs and provide spare parts, software support and patches, and technical assistance for at least five years after acceptance is certified.

End of Section

WORK ON EXISTING BUILDING AUTOMATION 25 05 06

1 GENERAL

1.1 Scope

- .1 Modifications to existing building control systems including:
 - .1 connection of new control devices to existing BAS networks,

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 25 05 01 Building Automation Common Work Results

1.3 Definitions and Abbreviations

- .1 Refer to specification section 25 05 01.

1.4 Designated Controls Contractor

- .1 BAS work shall be performed by Johnson Controls (JCI) as the base building controls contractor authorized by the Owner to perform such Work.

1.5 Design Criteria

- .1 Existing BAS networks:
 - .1 Tier 1: dedicated [BACnet /IP] [control vendor proprietary].
 - .2 Tier 2: [BACnet MSTP][control vendor proprietary].

1.6 Submittals

- .1 Shop drawings:
 - .1 In addition to the requirements of section 25 05 01, submit the following information as a shop drawing:
 - (a) documentation of existing sequence of operations for applicable equipment and systems affected by the Work.

2 PRODUCTS

2.1 General

- .1 Conform to specification section 25 05 01 and other sections of Division 01 except as specified herein.

3 EXECUTION

3.1 Existing Programming and Configuration

- .1 Document existing control device programming, configuration, and setpoint values at the start of the work, prior to any demolition or other work on existing control equipment.
- .2 Provide a copy of these documentation to the Owner.

3.2 Existing Condition Survey

- .1 Conduct a condition survey of existing control devices:

- .1 test, inspect and report on existing devices which are to be incorporated into the BAS, for satisfactory operation within 30 days of award of contract and prior to installation of any new devices,
- .2 for those items found in unacceptable condition, provide with report test data, original specification sheets or written functional requirements to confirm conclusion,
- .3 Owner to arrange for repair or replacement of those existing items judged defective, but shown to be re-used in BAS and control system,
- .4 items thus repaired or replaced by Owner will be returned to site and handed over to Contractor under this Section for storage, installation, testing, and commissioning.,
- .5 warrant reused devices that have been rebuilt or repaired. Demonstrate satisfactory operating condition of reused devices at time of acceptance,
- .6 responsibility for existing control devices that have been reused is to terminate at end of warranty period.

3.3 Demolition and Removals

- .1 Unless specifically noted or shown otherwise, remove existing control components made redundant:
 - .1 room thermostats, controllers, auxiliary electronic devices, pneumatic controllers and relays, control valves, electronic sensors, and transmitters: to be removed and placed in storage as directed by Owner.
 - .2 local control panels: removed and placed in storage as directed by Owner.
- .2 Remove and dispose of existing conduits, wiring and tubing in all areas (including above accessible ceilings) as they become redundant;
 - .1 remove existing control compressed air systems and, where applicable, connect to new control air system;
 - .2 existing hardwired interlocks to remain installed in systems.
- .3 In existing areas not otherwise involved in renovations, arrange and pay for holes and marks left by decommissioning and removal of control components, wiring, conduit, and tubing to be patched and refinished to match existing.

3.4 Maintaining Existing System Operation

- .1 Mechanical systems to remain in operation and to maintain space conditions between hours of 6 a.m. and 9 p.m., Monday through Friday.
- .2 In these periods mechanical control system shut downs of up to 15 minutes may be permitted, after obtaining written agreement from Owner.
- .3 When time required for cut-over of controls will not meet these constraints, perform work outside of operating hours after making application; outlining areas affected; and likely length of interruption, and obtain written agreement from Owner. .
- .4 Modify existing motor controllers to incorporate new local operator control switches for motors to be controlled through BAS system.

3.5 Interfacing Between New and Existing Control Systems

- .1 Certain building systems are to operate in event of building power failure or fire alarm. Under no circumstances should interfacing of equipment or controls modify these existing sequences of operation.
- .2 Where tying new system into existing control equipment, show on shop drawings;
 - .1 signal levels,

- .2 wire type,
- .3 wire numbers, and
- .4 terminal numbers.
- .3 Before attempting replacement of existing control systems, install new field panels, controllers and associated devices loose-ended ready for system changeover.
- .4 Submit written request to Owner setting out proposed starting time for changeover, duration of system down time, and establishing extent of interruption to operation of existing control system.
- .5 Do not proceed with work until Owner's written approval of time for, duration of, and extent of interruption is received.
- .6 Subsequent decommissioning and removal of control components to be carried out without interfering with normal operations or creating an interruption in service of any building systems except through an approval process similar to that noted above.

End of Section

BUILDING AUTOMATION CONTROL PANELS AND WIRING

25 05 12

1 GENERAL

1.1 Scope

- .1 Provide building automation control panels for mounting and securing building automation control equipment and devices.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 05 12 Common Electrical Requirements for Mechanical Services
 - .2 20 05 49.23 Seismic Qualification for Mechanical Equipment
 - .3 25 30 16 Building Automation Instrumentation

1.3 Definitions and Abbreviations

- .1 The following definitions apply to this section.
 - .1 **Control wiring** – has the meaning as defined in specification section 20 05 12.
 - .2 **Extra-low voltage** – any voltage not exceeding 30 V (has the same meaning as per CSA C22.1)
 - .3 **GUI** means “graphic user interface”, to display system data to the user and to allow the user to enter operating commands and data selection.
 - .4 **Power wiring** - has the meaning as defined in specification section 20 05 12.

1.4 Applicable Codes and Standards

- .1 Product standards:
 - .1 CSA C22.2 No. 0.3 Test Methods for Electrical Wires and Cables
 - .2 CSA C22.2 No. 14 Industrial Control Equipment
 - CSA C33.3 No. 18.5/UL 1565
Positioning Devices
 - .3 CSA C22.2 No. 66.2 Low Voltage Transformers – Part 2: General Purpose Transformers
 - CSA C22.2 No. 66.3 / UL 5085-3
Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers
 - .4 CSA C22.2 No. 72 Heater Elements
 - .5 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations
 - .6 CSA C22.2 No. 223 Power Supplies with Extra-Low-Voltage Class 2 Outputs.

1.5 Qualified Tradesperson

- .1 Work to be performed by qualified, licensed and recognized firm with an established reputation in this field, using tradesperson holding applicable certificates of competency.

1.6 Registration and Inspection

- .1 Where control panels are not listed in accordance with CSA C22.2 No. 14, arrange and pay for field inspection by the AHJ for electrical safety.

1.7 Seismic Qualification

- .1 Seismically qualify (certify) the following equipment specified herein:
 - .1 Building automation system control panels including microprocessor control units and all other internal devices.
- .2 The seismic qualification of the above-listed equipment is to conform to Specification section 20 05 49.23 for the following seismic qualification level and certification method:
 - .1 Functional seismic qualification (Level III) for electrical control equipment: by shake table testing,
- .3 The following equipment specific seismic force parameters are to be used:

C_p	A_r	R_p	h_x/h_n
1.00	1.00	1.25	1.0

1.8 Submittals

- .1 Shop drawings:
 - .1 submit product data sheets for materials specified herein.
 - .2 submit shop drawings for control panels including wiring diagrams and panel layout details.

2 PRODUCTS

2.1 General

- .1 Provide custom factory-made building automation control panels including all factory-installed devices and equipment required for operation of associated building equipment or systems including but not limited to DDC controllers, GUI, power supplies, transducers, solenoid air valves, relays and accessories.
- .2 Comply with the requirements of specification section 20 05 12 for products not otherwise specified herein.
- .3 Provide equipment which functions and meets detailed performance criteria when operating under the following conditions:
 - .1 ambient temperature:
 - (a) indoors: 4°C to 40°C (39°F to 104°F)
 - (b) outdoors: -30°C to + 40°C (-22°F to 104°F)]
 - .2 ambient relative humidity: 10% to 90% non -condensing,
 - .3 electrical power service: 120 VAC +/- 10%, 1 phase, 60 Hz nominal.

2.2 Control Panels

- .1 Panel enclosure:
 - .1 indoors: type 2 with sprinkler shield, 3R or 4 to CSA C22.2 No. 94.1 (NEMA 2, 3R, or 4),
 - .2 material: galvanized steel,
 - .3 with hinged door and lock,

- .4 integral cooling fans and vents with power supplies, wiring and circuit protection,
- .5 mounting backplate and/or DIN rails for mounting of wiring devices, controllers, sensors, transducers, and relays,
- .6 conduit openings and adapters in sufficient quantities and sizes to accommodate wiring terminating within enclosure,
- .7 document holder inside panel, to include one set of as built, plasticized control Shop Drawings for equipment served by that panel permanently affixed to cabinet frame,
- .8 enclosure finish: vendors standard colour,
- .2 GUI display:
 - .1 surface mounted on or semi-recessed in panel front door where GUI is required by other specification sections of Division 25.
 - .2 where GUI is mounted on the controller inside the panel, provide panel door cut-out with viewing glass to allow viewing only of GUI with panel door closed.
- .3 Control panel layout and construction:
 - .1 enclosures to be of sufficient size to house control components including controllers and associated transformers, control relays, wiring, conduits and other auxiliary equipment, so as to allow access for maintenance and replacement of components without requiring removal of other components.
 - .2 permanent engraved labels with black lettering on white background indicating:
 - (a) stating applicable building system name and reference number.
 - (b) function of each panel door mounted device.
 - .3 mount air pressure gauges on front of panel door to allow viewing from outside the panel,
 - .4 support wiring in cable ducts; arrange cable ducting and install wiring in a neat and workmanlike manner,
 - .5 provide numbered terminal strips for field wiring terminations; do not terminate field wiring directly on control devices or controllers. Arrange terminal strips in a common location adjacent to minimize routing and quantity of field wiring inside of panel.
 - .6 label both ends of internal wiring with label markers using name of cable function, or to identify wire number as shown on panel shop drawings,
 - .7 layout circuit fuses to facilitate location and replacement; provide labels at each fuse holder identifying fuse number and replacement fuse type and size,
- .4 Control devices mounted on panel door-front:
 - .1 Key-lock operated main panel power ON-OFF switch,
 - .2 alarm buzzer silence pushbutton (where applicable),
 - .3 alarm reset pushbutton (where applicable),
 - .4 indicating lights:
 - (a) main panel power ON (white),
 - (b) summary alarm (red),
 - (c) other indicating lights as specified by control sequences.
- .5 Panel mounted alarm devices:
 - .1 alarm buzzer (where applicable).
- .6 Cable Ducts
 - .1 non-metallic cable ducting with removable cover, slotted access cable restraints,

- .2 ambient temperature rating: -40 to +60°C (-40 to +140°F)
- .3 listed to CSA C33.3 No. 18.5/UL 1565.
- .7 Terminal strips:
 - .1 NEMA finger-safe terminal blocks, spring-clamp or screw fastened,
 - .2 directly fastened to panel backplane or DIN rail mounted.

2.3 Power Supplies and Line Filtering

- .1 For control panels and for field installed devices.
- .2 Transformers and Power Supplies:
 - .1 industrial control transformers to be listed to CSA C22.2 No. 66-2, and temperature rated for 40°C,
 - .2 control transformers to be listed to CSA C22.2 No. 66-3,
 - .3 AC/DC power supplies to be listed to CSA C22.2 No. 223,
 - .4 provide over-current protection in primary and secondary circuits,
 - .5 limit connected loads to 80% of rated capacity.
- .3 DC power supplies:
 - .1 output to match equipment current and voltage requirements,
 - .2 units to be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation to be 1.0% line and load combined, with 100-microsecond response time for 50% load changes,
 - .3 units to have built-in over-voltage and over-current protection and to be able to withstand 150% current overload for at least three seconds without trip-out or failure,
 - .4 units to operate between 0°C and 50°C (32°F and 120°F).
 - .5 EM/RF to meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
- .4 Power Line Filtering:
 - .1 provide internal or external transient voltage and surge suppression for workstations and control modules,
 - .2 surge protection:
 - (a) dielectric strength of 1000 V minimum,
 - (b) response time of 10 nanoseconds or less,
 - (c) transverse mode noise attenuation of 65 dB or greater,
 - (d) common mode noise attenuation of 150 dB or greater at 40-100 Hz.

2.4 Miscellaneous Electrical Control Devices

- .1 Control Relays:
 - .1 plug-in type, UL listed, with dust cover and LED "energized" indicator.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.
- .2 Time Delay Relays:
 - .1 solid-state plug-in type, UL listed, with adjustable time delay adjustable $\pm 100\%$ from set point shown.
 - .2 contact rating, configuration, and coil voltage suitable for application.
 - .3 NEMA 1 enclosure for relays not installed in local control panels.

- .3 Override Timers:
 - .1 spring-wound line voltage, UL Listed, with contact rating and configuration by application unless implemented in control software.
 - .2 0-6 hour calibrated dial.
 - .3 flush mounted on local control panel face.
- .4 Electronic signal isolation transducers:
 - .1 provided whenever;
 - (a) an analog output signal from BAS is connected to an external control system as an input (such as chiller control panel) or
 - (b) BAS is to receive an analog input signal from an external remote system.
 - .2 designed for ground plane isolation between systems.

2.5 Electro-Pneumatic (E/P) Transducers

- .1 To convert 4-20 mA, 0-5 Vdc, or 0-10 Vdc analog control input signal to a 20-100 kPa (3-15 psig) output signal;
 - .1 separate span and zero adjustments,
 - .2 manual output adjustments,
 - .3 output pressure gauge assembly,
 - .4 feedback loop control,
 - .5 mid-range air consumption of 0.05 NL/s (0.1 SCFM).

2.6 Pressure-Electric (P/E) Switches

- .1 To convert pressure signal to activate electric switch;
 - .1 diaphragm operated SPDT. snap acting contacts with electrical rating suitable for application,
 - .2 designed to withstand up to 170 kPa (25 psi) input pressure,
 - .3 adjustable cut-in and cut-out settings between 25 and 140 kPa ([3 and 20 psi).

2.7 Additional Requirements for Outdoor Panels

- .1 The following additional requirements apply where control panels are installed outdoors, or indoors in unheated spaces.
- .2 Enclosure: type 4, 4X or 12 to CSA C22.2 No. 94.1 (NEMA 4, 4X or 12),
- .3 Thermally insulated on all interior surfaces
 - .1 minimum thickness: 25 mm (1 in) at a maximum thermal conductivity of 0.0365 W/mK (0.0211 Btuh/ft²F) , or equivalent minimum RSI= 0.68 m²K/W (R = 3.86 ft²F/BTUH).
- .4 Mount GUI and other front-mount devices on inner front panel behind main panel door.
- .5 Electric resistance panel heater:
 - .1 electric resistant heaters listed to CAN/CSA C22.2 No. 72,
 - .2 sized to maintain panel interior temperature at not less than 4.5°C (40°F), at the ambient design temperature.
 - .3 integral or line mounted thermostat control, set with a temperature deadband of ON at 4.5°C (50°F) and OFF at 12°C (55°F).

2.8 Wiring and Raceways

- .1 Electrical materials, equipment and installation procedures to conform to the electrical safety code applicable to the location of the Work, in accordance with the requirements of specification section 20 05 12, and as specified herein.
 - .1 conductors for digital functions: 18 AWG minimum, twisted and shielded,
 - .2 conductors for analog functions: 18 AWG minimum, twisted and shielded, 2 or 3 wire to match analog function hardware.
 - .3 conductors for transformer current wiring: 16 AWG minimum,
 - .4 conductors for sensor wiring: 22 AWG minimum, twisted and shielded, 2 or 3 wire to match analog function hardware. Provide additional conductors as to support supplemental features of sensor (i.e. set-point adjustment, override, etc.).
- .2 Non-continuous cable supports:
 - .1 Sling strap:
 - (a) Galvanized steel support bracket with adjustable polyethylene support sling.

Standard of Acceptance

- nVent – fig. Caddy Cable 425

3 EXECUTION

3.1 Control Panel Installation

- .1 Install transmitters, transducers, controllers, solenoid air valves and relays in control panels.
- .2 Mount control panels to poured concrete or concrete block walls on mounting channels; do not fasten directly to the wall.
- .3 Where control panels are located away from concrete walls, provide a fabricated floor-mounted galvanized-steel channel support frame to mount control panels. Design support frame to withstand applicable seismic loads.
- .4 Install control panels with user interface devices on the panel door so that the centerline of the principle interface device is between 1500 and 1600 mm (60 to 64 in) above floor level.
- .5 Install other panels so that the top of the panel is located between 1800 and 1900 mm (72 to 76 in) above the floor.
- .6 Trim-back or neatly collect excess field wiring inside of control panels.

3.2 Field Wiring Installation

- .1 Provide power wiring and control wiring as needed to support operation of the building automation system. Refer to Section 20 05 12 for description of division of work and responsibility.
- .2 Installation of field wiring for power wiring and control wiring to conform to specification section 20 05 12 except/and as specified herein.
- .3 During installation follow cable manufacturer's specified cable pulling tension, and recommended minimum bend radius.
- .4 Verify entire network's integrity following cable installation using appropriate tests for each cable.
- .5 Install lightning arrester according to manufacturer's recommendations between cable and ground wherever cable enters or exits the building.
- .6 Each run of communication wiring to be continuous length without splices.

- .7 Label communication wiring to indicate origin and destination.
- .8 Ground coaxial cable according to Division 26 requirements.
- .9 Fiber optic cable installation:
 - .1 do not exceed pulling tensions specified by cable manufacturer. Post-installation residual cable tension to be in accordance with cable manufacturer's specifications,
 - .2 do not exceed minimum cable and unfaceted fiber bend radii specified by cable manufacturer.[]

3.3 Conduit and Raceways

- .1 Run power wiring and control wiring in conduit except where otherwise specified herein.
- .2 Extra-low voltage control wiring located in horizontal service spaces above dropped ceilings may be run exposed (without conduit) provided that wiring is;
 - .1 installed neatly and parallel to building lines,
 - .2 supported from J-hooks at intervals not exceeding 1200 mm (4 ft),
 - .3 have a FT6 rating in accordance with CSA C22.2 NO. 0.3 when installed in a supply or return air ceiling plenum
- .3 Low-voltage power and control wiring may be run in IT cable trays provided a metal barrier is installed in the cable tray system to prevent mixing and cross-over of cable types (communication, instrumentation, actuator control).
- .4 Run conduit and raceways parallel to building lines and be secured to building structure.
- .5 Where conduit leaves heated areas and enters unheated areas, seal conduit with weather-tight sealant at the first junction box in the unheated space.

3.4 Power Conversion and Control Relays

- .1 Provide interposing and motor control relays at local item of equipment or at associated MCC as applicable.
- .2 Provide control transformers and power supplies for system components requiring power supply that do not have integral control transformers.
- .3 Where point schematics and specifications indicate auxiliary contact provision, provide instrumentation, wiring, conduit, power supplies and services as to integrate these points into BAS.
- .4 Mount transformers in enclosures adjacent to equipment served.

3.5 Cleaning

- .1 Prior to handover to the Owner, remove all debris from and vacuum clean inside of control panels. Clean exterior surfaces of panels including GUI displays.

End of Section

BUILDING AUTOMATION INSTRUMENTATION

25 30 16.13

1 GENERAL

1.1 Scope

- .1 Provide measurement switches, sensors, and transmitter instrumentation for building automation.

1.2 Related Sections

- .1 Without limiting the scope of work or applicability of other specification sections, the work under this section directly integrates with or refers to the following specification sections:
 - .1 20 01 13 Definitions and Abbreviations – Mechanical
 - .2 23 11 33 Facility Fuel-oil Controls
 - .3 25 05 01 Building Automation Common Work Results

1.3 Definitions

- .1 The following definitions apply to this section.
 - .1 **Finished rooms/spaces** means a room or space that is not a service room.
 - .2 **Instrumentation** means products covered by this specification section.
 - .3 **Service rooms** has the meaning as defined in specification section 20 01 13.

1.4 Applicable Codes and Standards

- .1 Installation codes and standards:
 - .1 CSA B51 Boilers, Pressure Vessels, and Pressure Piping Code
- .2 Product standards:
 - .1 CSA C22.2 No. 94.1 Enclosures for Electrical Equipment, Non-Environmental Considerations.

1.5 Design Criteria

- .1 Pressure rating of instrumentation connected to pressure piping to be equal to or greater than the design pressure at the design temperature of the associated piping system.

1.6 Submittals

- .1 Submit manufacturer product data sheets in accordance with the requirements of Division 01.
- .2 Include Canadian Registration Numbers for applicable products.

1.7 Quality Control

- .1 Products that are in contact with the process fluid of a piping system that is subject to registration under applicable boiler and pressure vessel legislation are to have Canadian Registration Numbers in accordance with CSA B51.

2 PRODUCTS

2.1 General

- .1 Provide equipment which functions and meets detailed performance criteria when operating in the following minimum ambient condition ranges except where otherwise specified:
 - .1 ambient temperature:

Instrument Location	Service Temperature Range	Notes
Indoor	4°C to 40°C (39°F to 104°F)	(a)
Outdoor	-40°C to + 40°C (-40°F to 104°F)]	(b)
Intake and exhaust air plenums (with enclosure heater)	-40°C to + 40°C (-40°F to 104°F)]	(b)
Emergency equipment intake and exhaust air plenums	-40°C to + 50°C (-40°F to 122°F)	(b)

Notes:

(a) *Unheated spaces to be treated as outdoor spaces.*

(b) *Temperature ratings may be met by use of heated actuator enclosure.*

- .2 Ambient relative humidity 10% to 90% non -condensing
- .2 Components installed within motor controllers to be designed to operate with transient electrical fields occurring within these devices.

2.2 Temperature Sensors – General Requirements

- .1 Sensor element types:
 - .1 Resistance temperature device (RTD) of precision thin film platinum element type;
 - (a) linear characteristics over sensor range,
 - (b) reference resistance: 1000 ohm, ± 20 ohms (2%) at 0°C (32°F),
 - (c) temperature resistance coefficient: 0/.0385 ohms/ohm/°C (0.0212 ohms/ohm/°F),
 - (d) accuracy: $\pm 0.36^\circ\text{C}$ at 21°C ($\pm 0.65^\circ\text{F}$ at 70°F) accuracy [] to Din IEC 751
 - .2 Resistance temperature device (RTD) of precision thin film nickel element type;
 - (a) linear characteristics over sensor range,
 - (b) reference resistance: 1000 ohm, ± 20 ohms (2%) at 21°C (70°F),
 - (c) temperature resistance coefficient: 5.4 ohm/°C (3.0 ohm/°F)
 - (d) accuracy: $\pm 0.18^\circ\text{C}$ at 21°C ($\pm 0.34^\circ\text{F}$ at 70°F)
 - .3 Thermistor;
 - (a) non-linear negative temperature coefficient of resistance,
 - (b) reference resistance: 10,000 ohms at 25°C (77°F),
 - (c) accuracy: curve matched to $\pm 0.2^\circ\text{C}$ ($\pm 0.36^\circ\text{F}$) over 0°C to 70°C (32°F to 158°F),
 - (d) long term stability: 0.025°C (0.045°F) drift per year
- .2 Sensor construction general requirements:
 - .1 2 integral anchored lead wires,
 - .2 waterproof sensor to sheath seal,
 - .3 strain minimizing construction,
 - .4 standard conduit box termination with cover,
 - .5 pig-tail wire leads with wire nuts or screwed terminal connector block,
 - .6 factory calibrated and capable of end to end (sensing element to BAS) accuracy of $\pm 0.25^\circ\text{C}$ ($\pm 0.5^\circ\text{F}$) over full range of measured variable,
 - .7 transducing circuit to convert output to signal compatible with equipment controller.

2.3 Temperature Sensors – General Purpose Space Sensors

- .1 For general use space/room temperature measurement.
- .2 Space temperature sensors with display (type TSD):
 - .1 BAS network sensor with user interface display,
 - .2 user interface:
 - (a) LCD display, for measured values and setpoint values,
 - (b) temperature display resolution: 0.1°C (0.2°F)
 - (c) physical or virtual buttons for user adjustment of setpoints and selection of measured values.
 - .3 Programmable user input selection (buttons):
 - (a) physical or touchscreen buttons,
 - (b) sensor reading selection,
 - (c) sensor setpoint adjustment (temperature only),
 - .4 ambient relative humidity: 5 to 95% RH non condensing,
 - .5 temperature sensor: 10 kOhm,
 - .6 temperature sensor accuracy: $\pm 0.2^{\circ}\text{C}$ ($\pm 0.36^{\circ}\text{F}$)
 - .7 adjustable setpoint range (programmed default is 20°C to 25°C (68°F to 78°F)),
 - .8 BAS field-bus connector to allow local access to sensor and BAS controller and network,
 - .9 temperature setpoint remotely resettable from BAS,
 - .10 minimum/maximum limit set point values adjustable locally and remote from BAS,
 - .11 surface mounted plastic mono-chromatic guard with surface mounting plate and wall anchors,
 - .12 network connection: BACnet MSTP.
 - .13 guard secured to mounting plate by screws or snaps.

2.4 Fuel Oil Detection Devices

- .1 Refer to Specification section 23 11 33.

2.5 Electric Power Instrumentation

- .1 Current sensing relays:
 - .1 metering transformer ranged to match load being metered,
 - .2 plug in base and shorting shunt to protect current transformer when relay is removed from socket,
 - .3 current transformer for single or three phase metering connected into single relay,
 - .4 adjustable latch level, adjustable delay on latch and minimum differential of 10% of latch setting between latch level and release level,
 - .5 discrimination between phases in three phase applications to allow worst case selection,
 - .6 mounted in motor starter enclosure and fed from starter control transformer,
 - .7 relay contacts capable of handling 10 amps at 240 volts.
- .2 Current switches:
 - .1 self-powered, solid-state type with adjustable trip current,
 - .2 integral current transformers and relays to indicate motor status,
 - .3 SPDT output relay suitable for use as digital input to the BAS,

- .4 field adjustable output relay trip setting, over 0-100% of range. Deadband adjustment to maximum of 10% of range,
- .5 integral zero-leakage LED's indicating sensor power and switch status,
- .6 long term setting drift of current transformer and relay combination not more than 5% full range over 6 months,
- .7 over current and over voltage protection for current transformer and relay,
- .8 operating temperature range; -10°C to 50°C (14°F to 122°F),
- .9 operating humidity range; 5% to 90% RH non condensing.
- .3 Current transducer:
 - .1 output signal proportional to measured line current,
 - .2 output signal in one of following ranges; 4-20 mA, 0-5 Vdc or 0-10 Vdc
- .4 AC Current Transmitters:
 - .1 self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output,
 - .2 full-scale unit ranges of 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment,
 - .3 accuracy: $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - .4 UL/CSA listed and meet or exceed ANSI/ISSA 50.1 requirements.
- .5 AC Voltage Transmitters:
 - .1 self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
 - .2 adjustable full-scale unit ranges; 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac.
 - .3 Accuracy: $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - .4 UL/CSA listed, 600 Vac rated and conforming to ANSI/ISSA 50.1.
- .6 Power Monitors:
 - .1 three-phase type with three-phase disconnect and shorting switch assembly,
 - .2 UL listed voltage transformers, and
 - .3 UL listed split-core current transformers.
 - .4 selectable output either rate pulse for kWh reading or 4-20 mA for kW reading.
 - .5 maximum error of $\pm 2\%$ at 1.0 power factor or $\pm 2.5\%$ at 0.5 power factor.

3 EXECUTION

3.1 Instrumentation Installation – General Requirements

- .1 Mount instrumentation;
 - .1 in clean areas wherever possible,
 - .2 to be accessible to allow for replacement and servicing without interfering with access for adjacent equipment and personnel traffic in surrounding space,
- .2 Provide access doors where instrumentation is concealed behind solid surfaces.
- .3 In finished spaces and rooms, install room instrumentation on concealed junction boxes;
 - .1 fully recessed in gypsum board, wood, or similar construction,
 - .2 fully recessed in new concrete block construction, with conduit run block void spaces,

- .3 fully recessed in new poured concrete construction, with conduit and outlet box roughed-in before concrete pour.
- .4 surface mounted with exposed conduit on existing concrete block walls and existing poured concrete walls.
- .4 In service rooms, loading docks, and parking garages, install room instrumentation on surface mounted junction boxes with exposed surface-mounted conduit.
- .5 Rigidly support field mounted instrumentation on pipe stands or channel brackets.
- .6 Rigidly support duct mounted instrumentation to side of duct, in a location that will allow full removal of the instrumentation including duct probes.
- .7 Orient instrumentation sensing elements to correctly sense measured variable and to be isolated from vibrations and environmental conditions that could affect measurement or calibration.
- .8 Identify each cable and wire at every termination point.
- .9 Air seal wires attached to sensors at entry into junction box.

3.2 Power and Control Wiring

- .1 Provide power and control wiring to each instrument in accordance with the manufacturer requirements and in accordance with specification section 25 05 13.

3.3 Temperature Instrumentation

- .1 Space temperature and humidity sensors:
 - .1 Mount space temperature or combination temperature/humidity sensors / transmitters at 1200 mm (4 ft) above finished floor.

3.4 Space Temperature Sensor Selection

- .1 Select general purpose space temperature sensor types in accordance with the following table unless otherwise shown on drawings or in control sequences:

Space Types	Temperature Sensor Type
Generator Enclosure	TSD

End of Section