



DENVER INTERNATIONAL AIRPORT

DESIGN STANDARDS MANUAL

Mechanical

Design, Engineering and Construction

Revised: Q4 2025



Copyright ©1989-2025 by City and County of Denver, Denver International Airport

Content has been reviewed and edited by Design, Engineering and Construction.

While the City provides the information in this document to anyone, the City retains copyright on all text, graphic images and other content. This means that user may not: (1) distribute the text or graphics to others without the express written permission of the City and County of Denver; (2) mirror or copy this information to another document without permission; or (3) modify or re-use the text graphics in this document. Users may print copies of the information for personal and reference for their own documents. Commercial use of the materials is prohibited without the written permission of the City. In all copies of this information, users must retain this notice and any other copyright notices originally included.

Denver International Airport reserves all other rights.

Printed in the United States of America

Table of Contents

Summary of Revisions	xxvi
Purpose of Design Standards Manuals	xxxiii
Chapter 1 - General	35
1.0 General	35
1.0.1 Intent	35
1.0.2 Definitions	35
1.0.3 General	37
1.0.4 Mechanical Engineer	38
1.0.5 Regulatory Requirements	38
1.0.6 Work Sequence, Coordination, and Installation	38
1.0.7 Site Conditions	39
1.0.8 ORAT Requirements	39
1.1 Design Criteria	39
1.1.1 System Criteria	39
1.1.2 Mechanical Design Criteria — Flexibility	41
1.1.2.1 Design Parameters	41
1.1.2.2 Design Conditions Prior to 2022	41
1.1.2.3 Indoor Design Temperatures	41
1.1.2.4 Outdoor Design Temperatures	41
1.1.3 Ventilation Standards	42
1.1.4 Energy Efficiency Requirements	42
1.1.5 Noise Criteria	42
1.1.5.1 Horn and Strobe Systems in Mechanical Equipment Rooms	43
1.1.6 Altitude Correction	44
1.1.7 Supports and Penetrations	44
1.2 Equipment Identification	44
1.2.1 General	44
1.2.2 Air Handling Unit, Unitary Equipment, and Hydronic Equipment Identification	44
1.2.2.1 Building Abbreviation	44
1.2.2.2 Building Level.....	45
1.2.2.3 Building Module	45
1.2.2.4 Equipment Abbreviation	45
1.2.2.5 Concourse AHU Alphabetical Designator	45
1.2.2.6 Numeric Designator	45
1.2.3 Dependent Unit Equipment Identifier	46
1.2.3.1 Building Abbreviations	46
1.2.3.2 Building Level.....	46
1.2.3.3 Building Module	46
1.2.3.4 Equipment Abbreviation	46
1.2.3.5 Dependency Identifier.....	46
1.2.3.6 Numeric Designator	47
1.3 DEN Mechanical/Plumbing Equipment Naming Components — Identifiers	47
1.4 Submittals	48
1.4.1 Design Submittals	48
1.4.2 As-Built Submittals	49
1.5 Equipment Supports and Thermal Expansion Compensations	49
1.5.1 Design	49
Chapter 2 - Central Utility Plant	51
2.0 Central Utility Plant	51
2.0.1 Existing Campus Heating/Cooling Systems Operation	51
2.0.2 Seasonal Operation	52

2.1 Equipment	52
2.1.1 Chillers	52
2.1.2 Cooling Towers	53
2.1.3 Boilers	54
2.1.4 Pumps	54
2.1.5 Air Compressors	55
2.1.6 Motors	55
2.1.7 Water Treatment	55
2.1.8 HVAC	56
2.1.9 Piping and Valves	56
2.1.10 Central Plant Facilities	58
2.1.11 Chilled Water System	59
2.1.11.1 As-Built Drawing Chilled Water Abbreviation	59
2.1.12 Condenser Water System	59
2.1.13 Heating System	60
2.1.13.1 Hotel As-Built Drawing Heating Water Abbreviation	61
2.2 Energy Management	61
2.2.1 General	61
2.3 Equipment Tags and Re-Numbering	61
Chapter 3 - HVAC Systems	63
3.0 HVAC Systems	63
3.0.1 Air Handling Systems	63
3.0.1.1 Air-Handling Unit Access Doors	64
3.0.2 Single-Zone Systems	64
3.0.3 Multi-Zone Systems	64
3.0.4 Heat-Pump Systems	64
3.0.4.1 Ground-Source Heat Pumps	65
3.0.5 Roof-Mounted HVAC Systems	65
3.0.5.1 Maintenance	65
3.0.5.2 Energy Efficiency	65
3.0.5.3 Thermal Performance	65
3.0.5.4 Surface Condensation	65
3.0.5.5 Maximum Leakage	66
3.0.5.6 Deflection Performance	66
3.0.5.7 Wind-Restraint Performance	66
3.0.5.8 Noise and Vibration	66
3.0.5.9 Aesthetics	66
3.0.5.10 Fall Protection	66
3.0.5.11 Rooftop Penetrations	66
3.0.6 Variable Air Volume Systems	66
3.0.7 Perimeter Systems	67
3.0.8 HVAC for Unfinished (Tenant) Areas	67
3.0.8.1 Concourse C West Expansion - Tenant Areas	68
3.0.9 Fan Walls	68
3.1 Special Systems	68
3.1.1 Computer Rooms	68
3.1.2 Evaporative Cooling	68
3.1.3 Humidification	69
3.1.4 Air Curtains	69
3.2 Ventilation Systems	69
3.2.1 Outdoor Air Requirements	69
3.2.2 Air Economizer Control	70
3.2.3 Return Air/Transfer Air	70

3.2.4 Ventilation Rates	70
3.2.5 Filtration	70
3.3 Heating, Ventilation, and Exhaust Systems	71
3.3.1 General	71
3.3.2 Bag Makeup and Tug Drive Area	71
3.3.2.1 Ventilation	71
3.3.2.2 Heating	71
3.3.3 Truck Dock Ventilation	71
3.3.4 Toilet Exhaust	71
3.3.5 Service Level	72
3.3.5.1 Ventilation	72
3.3.5.2 Heating	72
3.3.6 Atrium/Great Hall	72
3.3.7 Fire Sprinkler Valve Room With Nitrogen Generator	72
3.4 Existing Systems	72
3.4.1 General	72
3.4.2 Existing Air Handling Systems	72
3.4.3 Existing HVAC Air Distribution	74
3.4.4 Existing Base Building Compressed Air Systems	74
3.4.5 Existing Ventilation/Smoke Control Fans (Historical Reverence Only)	74
3.5 Tenant Remodel Requirements	74
3.5.1 Tenant Design Parameters	74
3.5.2 Existing Base Building Mechanical Design Capabilities	75
3.5.2.1 Hotel Level 5 - Fan Coil Units are Sized Only for Existing Shell Load.....	75
3.5.3 VAV Terminal Air Units	75
3.5.4 New Tenant HVAC Systems	76
3.5.5 New Tenant Air Handling Units	76
3.5.6 Food and Beverage Tenant Equipment	76
3.5.7 Electrical Closets/Communications Rooms/Fire Control Rooms/ Fire Pump Rooms	77
3.6 Sustainability	77
Chapter 4 - Air Distribution Systems	79
4.0 Air Distribution Systems	79
4.0.1 Ductwork Design	79
4.0.2 Ductwork Requirements	79
4.0.3 Dampers	80
4.0.4 Diffusers	80
4.0.5 Grilles	80
4.0.6 Transfer Air	80
4.0.7 VAV Terminal Air Units	80
4.0.8 Security Gates	81
4.0.9 Ductwork Supports	81
4.0.10 Presentation of Ductwork Systems	81
Chapter 5 - Controls	83
5.0 Controls	83
5.0.1 General	83
5.0.2 Existing Base Building HVAC Control Systems	84
5.0.3 New and Replacement HVAC Control Systems	85
5.1 Control System Instrument Air	86
5.1.1 General	86
5.2 Sample Control Components and Requirements	86
5.2.1 AHU Controls	86
5.2.2 VAV Terminal Unit Controls	87
5.2.3 Unit Heaters Controls	88

a Split Systems - Fan Coil Units (FCU)	88
5.2.4 Exhaust Fan	88
5.2.5 Pump Controls	88
5.2.6 Monitoring	88
5.2.7 HVAC Control Functions	88
5.2.7.1 AHUs	89
5.2.7.2 VAV Boxes	89
5.2.8 Thermostats and Temperature Sensors	90
5.2.9 Carbon Monoxide Sensors	90
5.2.10 Oxygen Sensors	91
5.3 Central Control Systems for Main Airport Buildings	91
5.3.1 Software	91
5.3.2 Graphic Capabilities	92
5.3.3 Trend Logging and Graphing	92
5.4 Sequence of Operation	92
5.4.1 Emergency Shutdown	92
5.4.2 Automatic Shutdown	93
5.5 Controls Points Naming	93
5.5.1 General	93
5.5.2 Supervisory Controller Point Naming	93
5.5.2.1 Equipment Tag	93
5.5.2.2 TCP Extension	94
5.5.2.3 Function Abbreviation	94
5.5.3 Non-supervisory Controller Point Numbering	94
5.5.3.1 Equipment Tag	94
5.5.3.2 Equipment Controlled	94
5.5.3.3 Numeric Designator	95
5.5.3.4 Function Abbreviation	95
5.6 Equipment Alarming	95
5.6.1 Alarms in the EMCS	96
5.6.2 Alarm Points Only Trended in SkySpark	98
Chapter 6 - Hydronic Systems	101
6.0 Hydronic Systems	101
6.0.1 Existing Campus Heating/Cooling Systems Operation	101
6.1 Equipment	101
6.1.1 Chilled Water System	101
6.1.2 Heating System	101
6.1.3 Hydronic Requirements	102
6.1.4 Tenant Loops	102
6.1.5 Piping and Valves	103
6.1.6 Pumps	104
6.1.7 Motors	104
6.2 Design Criteria	104
6.2.1 General Requirements	104
6.2.2 Flushing and Cleaning for Closed Hydronic Systems - Metallic Piping Systems	106
6.2.3 Expansion Requirements	106
6.3 Piping Supports	107
6.3.1 Design	107
6.3.2 Products	107
6.4 Existing Systems	107
6.4.1 Hydronic Requirements	107
6.5 Update of Standard Diagrams	107
6.5.1 Flow Diagrams	107

Chapter 7 - Space Requirements and Maintainability	109
7.0 Space Requirements and Maintainability	109
7.0.1 General	109
7.1 Design Requirements	109
7.1.1 Design	109
7.1.2 Equipment Selection	109
7.1.3 Bearings	109
7.1.4 Construction Requirements	109
7.1.5 Fan Housing	110
7.1.6 Access Doors	110
7.2 Space Requirements	110
7.2.1 Mechanical Rooms	110
7.2.2 Mechanical Chases	110
7.2.3 Equipment Clearance	110
7.2.4 EMCS/Control Equipment Clearance	111
7.2.5 Equipment Removal Routes	111
7.2.6 Plumbing Chases	111
7.2.7 Mechanical Rooms	111
7.3 Equipment Protection	111
7.3.1 General	111
Chapter 8 - Plumbing Requirements	113
8.0 Plumbing Requirements	113
8.0.1 General	113
8.0.2 System Requirements	113
8.1 Plumbing Design Parameters	113
8.1.1 General	113
8.1.2 Fixture Count	113
8.1.3 Calculations	114
8.1.4 Terminal	114
8.1.5 Concourses	114
8.1.5.1 Concourse C West Expansion	114
8.1.6 Sand Traps	115
8.1.7 Grease Traps	115
8.1.8 Floor Drains	117
8.1.9 Cleanouts	117
8.1.10 Industrial Waste	117
8.1.11 Backflow Prevention	117
8.1.12 Coordination	118
8.1.13 Piping Movement	118
8.1.14 Future Tenant Spaces	118
8.1.15 HVAC Coil Condensate Drains	118
8.1.16 Secondary Condensate Drains	119
8.2 Plumbing System Components	119
8.2.1 General	119
8.2.2 Plumbing Fixtures and Equipment	119
8.2.3 Piping	120
8.2.4 Plumbing Pumps	121
8.2.5 Plumbing Sumps	121
8.2.6 Heat Trace Systems	121
8.2.6.1 Tenant Use of Heat Trace Systems	121
8.3 Energy Conservation in Plumbing System Design	122
8.3.1 Domestic Hot Water	122
8.3.2 Temperature	122

8.3.3 Safety Devices	122
8.4 Natural Gas	122
8.4.1 Sizing	122
8.4.2 Metering	122
8.4.3 Gas Systems Protection	122
8.4.4 Sustainability	124
8.5 Tenant Remodel Requirements	124
8.5.1 Plumbing Requirements	124
8.5.2 Grease Waste	125
8.5.3 Water Heaters	125
8.5.4 Water Meters	125
8.5.5 Backflow Prevention	125
8.5.6 Roof Water	125
Chapter 9 - Energy Analysis and LEED	127
9.0 Energy Analysis and LEED	127
9.0.1 Codes and Standards	127
9.0.2 LEED Certification	127
9.0.3 LEED and On-Site Solar Power Generation	128
9.1 Heat Recovery Systems	128
9.2 Existing Facility Design and Analysis Conditions	129
9.3 Building Envelope Evaluation (Historical Reference)	129
9.4 U Values (Historical Reference)	129
9.4.1 Glazing	129
9.4.2 Walls	129
9.4.3 Roof	129
9.4.4 Floors Over Unheated Spaces	130
9.4.5 Slab-on-Grade Floors	130
9.4.6 Alternatives	130
9.4.7 Summary	130
9.5 Building Components (Historical Reference)	130
9.5.1 Daylighting	131
9.5.2 Entrances	131
9.5.3 High-Bay Areas	131
9.6 Air Leakage - All Buildings (Historical Reference)	131
9.6.1 Windows	131
9.6.2 Swinging, Revolving or Sliding Doors for Nonresidential Use	131
9.7 HVAC Systems (Historical Reference)	131
9.7.1 Controls and Automation	131
9.7.2 Variable Water Volume (VWV) Pumping	131
9.7.3 Simultaneous Heating and Cooling	132
9.7.4 Outdoor Air Reset	132
9.7.5 Energy Recovery (Historical Reference)	132
9.8 HVAC Equipment (Historical Reference)	132
9.8.1 Equipment Efficiency	132
9.8.2 Minimum Coefficient of Performance/Efficiency Levels	132
9.9 Insulation (Historical Reference)	133
9.9.1 Air-Handling Duct System Insulation	133
9.9.2 Piping Insulation	133
9.10 Plumbing Systems (Historical Reference)	133
9.10.1 General	133
Chapter 10 - Gate Services	135
10.0 General Requirements	135
10.0.1 Acronyms and Definitions	135

10.0.2 Concourse A	135
10.0.3 Concourse B	135
10.0.4 Concourse C	135
10.0.5 Plant Description	135
10.0.6 Plant Design	136
10.0.6.1 Chiller Selection	136
10.0.6.2 CUP Connection Criteria	136
10.0.7 PCA Hydronic Design	136
10.0.8 Equipment Support	137
10.1 PCA Units	137
10.1.1 PCA Unit Sizing	137
10.1.2 United Airlines PCA Hose Adapters/Connectors	140
10.1.3 Hydronic PCA Units	140
10.1.4 DX PCA Units	141
10.1.5 Condensate Drains	141
10.2 General PCA Unit Requirements	141
10.2.1 PCA Unit Supports	141
10.2.2 PCA Controls	141
10.2.3 Accessories	141
10.2.4 Painting	142
10.3 Fixed Walkways and Passenger Loading Bridges	142
10.3.1 Ventilation and Conditioning	142
10.3.2 PLB Pressure Monitoring	142
10.3.3 Fire Protection	142
10.4 Potable Water Cabinets	142
10.4.1 Locations	142
10.4.2 Services	143
10.5 Update of Standard Diagrams	143
10.5.1 Flow Diagrams	143
Chapter 11 - Facility Design	145
11.0 Facility Design	145
11.1 Passenger Terminal —Ticketing Level	145
11.1.1 Design Conditions	145
11.1.2 Air Handling Systems	145
11.1.3 Perimeter Systems	145
11.1.4 Air Curtains	145
11.1.5 Outdoor Air Requirements	145
11.1.6 Ventilation Rates	145
11.1.7 Filtration	146
11.1.8 AHU Controls	146
11.1.9 Central Utility Plant	146
11.1.10 Plumbing Requirements	146
11.1.11 Fire Protection	146
11.1.12 Smoke Control	146
11.2 Passenger Terminal — Baggage Claim	146
11.2.1 Indoor Design Conditions	146
11.2.2 Air Handling Systems	146
11.2.3 Perimeter Systems	147
11.2.4 Air Curtains	147
11.2.5 Outdoor Air Requirements	147
11.2.6 Ventilation Rates	147
11.2.7 Filtration	147
11.2.8 AHU Controls	147

11.2.9 Central Utility Plant 147

11.2.10 Plumbing Requirements 147

11.2.11 Fire Protection 148

11.2.12 Smoke Control 148

11.3 Passenger Terminal — Atrium 148

11.3.1 Indoor Design Conditions 148

11.3.2 Air Handling Systems 148

11.3.2.1 Occupied Space 148

11.3.2.2 Great Hall Area 148

11.3.3 Outdoor Air Requirements 148

11.3.4 Ventilation Rates 148

11.3.5 Filtration 149

11.3.6 AHU Controls 149

11.3.6.1 Occupied Space (VAV System) 149

11.3.6.2 High Bay (Makeup Air System)..... 149

11.3.7 Central Utility Plant 149

11.3.8 Plumbing Requirements 149

11.3.9 Fire Protection 149

11.3.10 Smoke Control 149

11.4 Passenger Terminal — Train Station Security 150

11.4.1 Indoor Design Conditions 150

11.4.2 Air Handling Systems 150

11.4.3 Ventilation Rates 150

11.4.4 Filtration 150

11.4.5 AHU Controls 150

11.4.6 Central Utility Plant 150

11.4.7 Plumbing Requirements 150

11.4.8 Fire Protection 150

11.4.9 Smoke Control 151

11.5 Passenger Terminal — Train Station Exit Pavilions 151

11.5.1 Design Conditions 151

11.5.2 Air Handling System 151

11.5.3 Outdoor Air Requirements 151

11.5.4 Ventilation Rates 151

11.5.5 Filtration 151

11.5.6 AHU Controls 151

11.5.7 Central Utility Plant 151

11.5.8 Plumbing Requirements 152

11.5.9 Fire Protection 152

11.5.10 Smoke Control 152

11.6 Passenger Terminal — Train Station Loading Platforms 152

11.6.1 Design Conditions 152

11.6.2 Air Handling Systems 152

11.6.3 Outdoor Air Requirements 152

11.6.4 Ventilation Rates 152

11.6.5 Filtration 153

11.6.6 AHU Controls 153

11.6.7 Central Utility Plant 153

11.6.8 Plumbing Requirements 153

11.6.9 Fire Protection 153

11.7 Passenger Terminal — Concessions and Services 153

11.7.1 Design Conditions 153

11.7.2 Air Handling Systems 154

11.7.3 Outdoor Air Requirements	154
11.7.4 Kitchen Exhaust	154
11.7.5 Ventilation Rates	154
11.7.6 Filtration	154
11.7.7 AHU Controls	154
11.7.8 Central Utility Plant	155
11.7.9 Plumbing Requirements	155
11.7.10 Fire Protection	155
11.7.11 Smoke Control	155
11.8 Passenger Terminal — Rest Rooms	155
11.8.1 Design Conditions	155
11.8.2 Air Handling Systems	155
11.8.3 Toilet Exhaust	156
11.8.4 Filtration	156
11.8.5 Controls	156
11.8.6 Central Utility Plant	156
11.8.7 Plumbing Requirements	156
11.9 Passenger Terminal — Ground Transportation Level	157
11.9.1 Design Conditions	157
11.9.2 Air Handling Systems	157
11.9.3 Perimeter Systems	157
11.9.4 Outdoor Air Requirements	157
11.9.5 Ventilation Rates	157
11.9.6 Filtration	157
11.9.7 AHU Controls	157
11.9.8 Central Utility Plant	157
11.9.9 Plumbing Requirements	158
11.9.10 Fire Protection	158
11.10 Passenger Terminal — Rental Car Level	158
11.10.1 Design Conditions	158
11.10.2 Air Handling Systems	158
11.10.3 Perimeter Systems	158
11.10.4 Outdoor Air Requirements	158
11.10.5 Ventilation Rates	158
11.10.6 Filtration	159
11.10.7 AHU Controls	159
11.10.8 Central Utility Plant	159
11.10.9 Plumbing Requirements	159
11.10.10 Fire Protection	159
11.11 Passenger Terminal - Baggage Handling Level	159
11.11.1 Indoor Design Conditions	159
11.11.2 Air Handling Systems	159
11.11.3 Evaporative Cooling	160
11.11.4 Outdoor Air Requirements	160
11.11.5 Ventilation Rates	160
11.11.6 Filtration	160
11.11.7 AHU Controls	160
11.11.8 Central Utility Plant	160
11.11.9 Plumbing Requirements	160
11.11.10 Fire Protection	160
11.12 Passenger Terminal - Baggage Handling Level — Baggage Screening Areas	161
11.12.1 Design Conditions	161
11.12.2 Air Handling Systems	161

11.12.3 Outdoor Air Requirements	161
11.12.4 Ventilation Rates	161
11.12.5 Filtration	161
11.12.6 AHU Controls	161
11.12.7 Central Utility Plant	161
11.12.8 Plumbing Requirements	161
11.12.9 Fire Protection	162
11.13 Passenger Terminal — Tenant Spaces	162
11.13.1 Design Conditions	162
11.13.2 Air Handling Systems	162
11.13.3 Perimeter Systems	162
11.13.4 Outdoor Air Requirements	163
11.13.5 Ventilation Rates	163
11.13.6 Kitchen Exhaust	163
11.13.7 Filtration	163
11.13.8 AHU Controls	163
11.13.9 Central Utility Plant	163
11.13.10 Plumbing Requirements	163
11.13.11 Fire Protection	163
11.13.12 Simplicity of Systems	164
11.14 Passenger Terminal — Electrical Rooms	164
11.14.1 Design Conditions	164
11.14.2 Air Handling Systems	164
11.14.3 Outdoor Air Requirements	164
11.14.4 Filtration	164
11.14.5 AHU Controls	164
11.14.6 Central Utility Plant	164
11.14.7 Plumbing Requirements	164
11.14.8 Fire Protection	165
11.15 Passenger Terminal — Telecommunications and UPS Room	165
11.15.1 Design Conditions	165
11.15.2 Air Handling Systems	165
11.15.3 Outdoor Air Requirements	165
11.15.4 Filtration	165
11.15.5 AHU Controls	165
11.15.6 Central Utility Plant	166
11.15.7 Plumbing Requirements	166
11.15.8 Fire Protection	166
11.16 Passenger Terminal - Employee Gym	166
11.16.1 Design Conditions	166
11.16.2 Air Handling Systems	166
11.16.3 Outdoor Air Requirements	166
11.16.4 Toilet Exhaust	167
11.16.5 Ventilation Rates	167
11.16.6 Filtration	167
11.16.7 AHU Controls	167
11.16.8 Plumbing Requirements	167
11.16.9 Central Utility Plant	167
11.16.10 Fire Protection	167
11.16.11 Smoke Control	168
11.17 International Concourse	168
11.17.1 Design Conditions	168
11.17.2 Air Handling Systems	168

11.17.3 Perimeter Systems	168
11.17.4 Air Curtains	168
11.17.5 Outdoor Air Requirements	168
11.17.6 Toilet Exhaust	168
11.17.7 Kitchen Exhaust	169
11.17.8 Ventilation Rates	169
11.17.9 Filtration	169
11.17.10 AHU Controls	169
11.17.11 Central Utility Plant	169
11.17.12 Plumbing Requirements	169
11.17.13 Fire Protection	170
11.17.14 Smoke Control	170
11.18 Domestic Concourse	170
11.18.1 Design Conditions	170
11.18.2 Air Handling Systems	170
11.18.3 Perimeter Systems	171
11.18.4 Air Curtains	171
11.18.5 Outdoor Air Requirements	171
11.18.6 Toilet Exhaust	171
11.18.7 Kitchen Exhaust	171
11.18.8 Ventilation Rates	171
11.18.9 Filtration	171
11.18.10 AHU Controls	171
11.18.11 Central Utility Plant	171
11.18.12 Plumbing Requirements	171
11.18.13 Fire Protection	172
11.18.14 Concourse A Ground Load Facility	173
11.18.15 Concourse B East Regional Jet Facility	173
11.19 Domestic Concourse — Tenant Spaces	173
11.19.1 Design Conditions	173
11.19.2 Air Handling Systems	173
11.19.3 Perimeter Systems	174
11.19.4 Outdoor Air Requirements	174
11.19.5 Ventilation Rates	174
11.19.6 Kitchen Exhaust	174
11.19.7 Filtration	174
11.19.8 AHU Controls	174
11.19.9 Central Utility Plant	174
11.19.10 Plumbing Requirements	174
11.19.11 Fire Protection	174
11.19.12 Smoke Control	175
11.19.13 Simplicity of Systems	175
11.20 Domestic Concourse — Electrical Rooms	175
11.20.1 Design Conditions	175
11.20.2 Air Handling System	175
11.20.3 Outdoor Air Requirements	175
11.20.4 Filtration	175
11.20.5 AHU Controls	175
11.20.6 Central Utility Plant	176
11.20.7 Plumbing Requirements	176
11.20.8 Fire Protection	176
11.21 Domestic Concourse — Telecommunications and UPS Rooms	176
11.21.1 Design Conditions	176

11.21.2 Air Handling Systems	176
11.21.3 Outdoor Air Requirements	177
11.21.4 Filtration	177
11.21.5 AHU Controls	177
11.21.6 Central Utility Plant	177
11.21.7 Plumbing Requirements	177
11.21.8 Fire Protection	177
11.22 Domestic Concourse — Service Animal Relief Areas (SARA)	177
11.22.1 Design Conditions	177
11.22.2 Air Handling System	178
11.22.3 Perimeter Systems	178
11.22.4 Exhaust	178
11.22.5 Ventilation Rate	178
11.22.6 Filtration	178
11.22.7 AHU Controls	178
11.22.8 Central Utility Plant	178
11.22.9 Plumbing Requirements	178
11.22.10 Fire Protection	179
11.23 Control Tower	179
11.23.1 Design Conditions	179
11.23.2 Air Handling Systems	179
11.23.3 Perimeter Systems	179
11.23.4 Computer and Electronic Equipment Rooms	179
11.23.5 Outdoor Air Requirements	180
11.23.6 Toilet Exhaust	180
11.23.7 Ventilation Rates	180
11.23.8 Filtration	180
11.23.9 AHU Controls	180
11.23.10 Plumbing Requirements	180
11.23.11 Fire Protection	181
11.23.12 Smoke Control	181
11.24 Hotel	181
11.24.1 Design Conditions	181
11.24.2 Air Handling Systems	181
11.24.2.1 Meeting Rooms, Restaurants, Public Areas.....	181
11.24.2.2 Guest Rooms	181
11.24.2.3 Kitchens	182
11.24.3 Perimeter Systems	182
11.24.4 Air Curtains	182
11.24.5 Outdoor Air Requirements	182
11.24.6 Toilet Exhaust	182
11.24.7 Kitchen Exhaust	182
11.24.8 Ventilation Rates	182
11.24.9 Filtration	182
11.24.10 AHU Controls	182
11.24.11 Central Utility Plant	182
11.24.12 Plumbing Requirements	183
11.24.13 Fire Protection	183
11.25 Structured Parking	183
11.25.1 Ventilation Systems	183
11.25.2 Filtration	183
11.25.3 Exhaust Fan Controls	183
11.25.4 Plumbing Requirements	184

11.25.5 Fire Protection	184
11.26 Parking Toll Plaza	184
11.26.1 Design Conditions	184
11.26.2 Air Handling Systems	184
11.26.3 Outdoor Air Requirements	184
11.26.4 Toilet Exhaust	184
11.26.5 Ventilation Rates	185
11.26.6 Filtration	185
11.26.7 AHU Controls	185
11.26.8 Plumbing Requirements	185
11.26.9 Fire Protection	185
11.27 Office Building	185
11.27.1 Design Conditions	185
11.27.2 Air Handling Systems	185
11.27.3 Perimeter Systems	186
11.27.4 Computer Rooms	186
11.27.5 Air Curtains	186
11.27.6 Outdoor Air Requirements	186
11.27.7 Toilet Exhaust	186
11.27.8 Ventilation Rates	186
11.27.9 Filtration	186
11.27.10 AHU Controls	187
11.27.11 Plumbing Requirements	187
11.27.12 Central Utility Plant	187
11.27.13 Fire Protection	187
11.27.14 Smoke Control	187
11.28 Central Utility Plant Facilities	188
11.28.1 Design Conditions	188
11.28.2 Office/Control Room Systems	188
11.28.3 Plant/Shop System	188
11.28.4 Heating System	188
11.28.5 Outdoor Air Requirements	188
11.28.6 Toilet Exhaust	188
11.28.7 Ventilation Rates	188
11.28.8 AHU Controls	188
11.28.9 Plumbing Requirements	189
11.28.10 Fire Protection	189
11.28.11 Smoke Control	189
11.29 Maintenance Facility	189
11.29.1 Design Conditions	189
11.29.2 Conditioned Systems	189
11.29.3 Shop System	190
11.29.4 Outdoor Air Requirements	190
11.29.5 Toilet Exhaust	190
11.29.6 Ventilation Rates	190
11.29.7 Filtration	190
11.29.8 AHU Controls	190
11.29.9 Plumbing Requirements	190
11.29.10 Fire Protection	191
11.29.11 Smoke Control	191
11.29.12 Evaporative Cooling	191
11.30 Air Cargo Facility	191
11.30.1 Design Conditions	191

11.30.2 Conditioned Systems	191
11.30.3 Warehouse System	191
11.30.4 Air Curtains	192
11.30.5 Outdoor Air Requirements	192
11.30.6 Toilet Exhaust	192
11.30.7 Ventilation Rates	192
11.30.8 Filtration	192
11.30.9 AHU Controls	192
11.30.10 Plumbing Requirements	192
11.30.11 Fire Protection	193
11.30.12 Smoke Control	193
11.31 Aircraft Hanger	193
11.31.1 Design Conditions	193
11.31.2 Ventilation Systems	193
11.31.3 Shop and Hanger System	193
11.31.4 Outdoor Air Requirements	194
11.31.5 Toilet Exhaust	194
11.31.6 Ventilation Rates	194
11.31.7 Filtration	194
11.31.8 Controls	194
11.31.8.1 AHUs	194
11.31.8.2 Exhaust Fans	195
11.31.8.3 Unit Heaters	195
11.31.8.4 Infrared Heaters	195
11.31.9 Plumbing Requirements	195
11.31.10 Fire Protection	195
11.31.11 Evaporative Cooling	196
11.32 Flight Kitchen	196
11.32.1 Design Conditions	196
11.32.2 Air Handling Systems	196
11.32.3 Outdoor Air Requirements	196
11.32.4 Toilet Exhaust	196
11.32.5 Kitchen Exhaust	196
11.32.6 Ventilation Rates	197
11.32.7 Filtration	197
11.32.8 AHU Controls	197
11.32.9 Plumbing Requirements	197
11.32.10 Fire Protection	197
11.33 Snow Removal Equipment Facility	198
11.33.1 Design Conditions	198
11.33.2 Conditioned Systems	198
11.33.3 Shop System	198
11.33.4 Outdoor Air Requirements	198
11.33.5 Toilet Exhaust	198
11.33.6 Ventilation Rates	198
11.33.7 Filtration	198
11.33.8 AHU Controls	199
11.33.9 Plumbing Requirements	199
11.33.10 Fire Protection	199
11.33.11 Evaporative Cooling	199
11.34 Fire Crash Rescue Facility	199
11.34.1 Design Conditions	199
11.34.2 Conditioned Systems	200

11.34.3 Vehicle/Maintenance Systems	200
11.34.4 Outdoor Air Requirements	200
11.34.5 Toilet Exhaust	200
11.34.6 Kitchen Exhaust	200
11.34.7 Ventilation Rates	200
11.34.8 Filtration	200
11.34.9 Controls	201
11.34.10 Plumbing Requirements	201
11.34.11 Fire Protection	201
11.34.12 Evaporative Cooling	201
11.35 Rental Car Support Facility	201
11.35.1 Design Conditions	201
11.35.2 Ventilation Systems	202
11.35.3 Maintenance/Shop System	202
11.35.4 Outdoor Air Requirements	202
11.35.5 Toilet Exhaust	202
11.35.6 Ventilation Rates	202
11.35.7 Filtration	202
11.35.8 Controls	202
11.35.9 Plumbing Requirements	202
11.35.10 Fire Protection	203
11.35.11 Evaporative Cooling	203
11.36 Auto Service Station	203
11.36.1 Design Conditions	203
11.36.2 Conditioned Systems	203
11.36.3 Shop System	204
11.36.4 Outdoor Air Requirements	204
11.36.5 Toilet Exhaust	204
11.36.6 Automobile Exhaust System	204
11.36.7 Ventilation Rates	204
11.36.8 Filtration	204
11.36.9 Controls	204
11.36.10 Plumbing Requirements	204
11.36.11 Fire Protection	205
11.36.12 Evaporative Cooling	205
11.37 Aircraft Fueling Control Facility	205
11.37.1 Design Conditions	205
11.37.2 Conditioned Systems	205
11.37.3 Maintenance/Shop System	206
11.37.4 Outdoor Air Requirements	206
11.37.5 Toilet Exhaust	206
11.37.6 Ventilation Rates	206
11.37.7 Vehicle Exhaust System	206
11.37.8 Filtration	206
11.37.9 Controls	206
11.37.10 Plumbing Requirements	206
11.37.11 Fire Protection	207
11.37.12 Evaporative Cooling	207
11.38 General Aviation Facilities	207
11.38.1 Design Conditions	207
11.38.2 Air Handling Systems	207
11.38.3 Shop and Hangar System	208
11.38.4 Outdoor Air Requirements	208

11.38.5 Toilet Exhaust	208
11.38.6 Ventilation Rates	208
11.38.7 Filtration	208
11.38.8 Controls	209
11.38.9 Plumbing Requirements	209
11.38.10 Fire Protection	209
11.38.11 Evaporative Cooling	209
11.39 Communications Center	209
11.39.1 Design Conditions	209
11.39.2 Air Handling Systems	210
11.39.3 Computer and Electronic Equipment Rooms	210
11.39.4 Outdoor Air Requirements	210
11.39.5 Toilet Exhaust	210
11.39.6 Ventilation Rates	210
11.39.7 Filtration	210
11.39.8 AHU Controls	210
11.39.9 Plumbing Requirements	210
11.39.10 Fire Protection	211
11.40 Security Guard House	211
11.40.1 Design Conditions	211
11.40.2 Air Handling Systems	211
11.40.3 Outdoor Air Requirements	212
11.40.4 Toilet Exhaust	212
11.40.5 Ventilation Rates	212
11.40.6 Filtration	212
11.40.7 Plumbing Requirements	212
11.40.8 Fire Protection	212
11.40.9 AHU Controls	212
11.41 Warehouse Facility	213
11.41.1 Design Conditions	213
11.41.2 Conditioned Systems	213
11.41.3 Warehouse System	213
11.41.4 Air Curtains	213
11.41.5 Outdoor Air Requirements	213
11.41.6 Toilet Exhaust	213
11.41.7 Ventilation Rates	213
11.41.8 Filtration	214
11.41.9 AHU Controls	214
11.41.10 Plumbing Requirements	214
11.41.11 Fire Protection	214
11.42 Bulk Storage Facility (Urea and Sand Storage)	214
11.42.1 Design Conditions	214
11.42.2 Ventilation System	215
11.42.3 Ventilation Rate	215
11.42.4 Exhaust Fan Controls	215
11.42.5 Unit Heater Controls	215
11.43 Baggage Tunnel	215
11.43.1 Design Conditions	215
11.43.2 Ventilation System	215
11.43.3 Ventilation Rate	215
11.43.4 Exhaust Fan Controls	215
11.43.5 Smoke Control	216
11.44 Utility Tunnel	216

11.44.1 Design Conditions 216

11.44.2 Ventilation System 216

11.44.3 Exhaust Fan Controls 216

11.44.4 Smoke Control 216

11.45 Train (AGTS) Tunnel 216

11.45.1 Design Conditions 216

11.45.2 Ventilation System 216

11.45.3 Exhaust Fan Controls 216

11.45.4 Smoke Control 216

11.45.5 Electrical Rooms 216

11.46 Data Center 217

11.46.1 Design Conditions 217

11.46.2 Ventilation System 217

11.46.3 Exhaust Fan Controls 217

11.46.4 Smoke Control 217

11.47 Elevator Equipment Rooms 217

11.47.1 Design Conditions 217

11.47.2 Air Handling System 217

11.47.3 Outdoor Air Requirements 217

11.47.4 AHU Controls 217

11.47.5 Plumbing Requirements 217

11.47.6 Fire Protection 218

Chapter 12 - Technical Specification Requirements 219

12.0 General 219

12.0.1 How to Use DEN Standard Specifications 219

12.0.1.1 DEN Technical Requirements..... 219

12.0.1.2 DEN Technical Requirements..... 219

12.0.1.3 Notes to the Designer 219

12.0.2 Specification Numbering 219

12.0.2.1 Numbering of Deliverables 219

12.0.2.2 Numbering Provided in this Chapter 220

12.0.2.3 Product and Manufacturer Listings 220

12.1 DEN Standard Specifications 220

12.2 DEN Technical Requirements 220

Chapter 2 - Appendix A - Controls Points Abbreviations 221

Chapter 14 - Matrix A: DEN Concourse A West Expansion Concessions 231

Chapter 14 - Matrix B: DEN CEP Concourse B West Expansion Concessions 233

Chapter 14 - Matrix C: DEN Concourse C East Expansion Concessions 235

This page is intentionally blank.

Table of Figures

Chapter 4 - Air Distribution Systems 79
 Figure 4-1: Allowable Duct Static Pressure Callouts Examples 82

Chapter 5 - Controls 83
 Figure 5-1: AHU Control 89
 Figure 5-2: VAV Contol 90

Chapter 8 - Plumbing Requirements 113
 Figure 8-1: Concourse B: Tug Damage to Wall 123
 Figure 8-2: Gas Piping Strike: Side and Front Views 124

This page is intentionally blank.

Table of Tables

Chapter 1 - General	35
Table 1-1: Definitions	35
Table 1-2: NC Criteria by Space	43
Table 1-3: Equipment Abbreviations	47
Chapter 2 - Central Utility Plant	51
Table 2-1: Chiller Design Temperature	53
Table 2-2: Cooling Tower Design Parameters	53
Table 2-3: Water Piping Sizing	57
Table 2-4: Water Piping Friction Factors	57
Chapter 3 - HVAC Systems	63
Table 3-1: Basis for Existing Air Handling System Air Supply	73
Chapter 4 - Air Distribution Systems	79
Table 4-1: Ductwork Air Velocity Limits	79
Table 4-2: Allowable Direction Callouts	81
Chapter 5 - Controls	83
Table 5-1: Alarms in the EMCS	96
Table 5-2: Alarm Points Only Trended in SkySpark	98
Chapter 6 - Hydronic Systems	101
Table 6-1: Water Piping Sizing	105
Table 6-2: Water Piping Friction Factors	105
Chapter 8 - Plumbing Requirements	113
Table 8-1: Grease Trap Capacities	115
Chapter 9 - Energy Analysis and LEED	127
Table 9-1: Heating and Cooling Criteria	130
Table 9-2: Commercial/Industrial Furnace and Boilers	132
Table 9-3: Electrically Driven HVAC System Equipment	133
Chapter 10 - Gate Services	135
Table 10-1: Gate Services Acronyms and Definitions	135
Table 10-2: Sizing of Aircraft Specific to DEN	137
Appendix A - Controls Points Abbreviations	221
Appendix A - Control Point Abbreviations	221
Appendix A - VAV Points Abbreviations	227
Matrix A: DEN Concourse A West Expansion Concessions	231
DEN Concourse A West Expansion Concessions Matrix	231
Matrix B: DEN CEP Concourse B West Expansion Concessions	233
DEN CEP Concourse B West Expansion Concessions Matrix	233
Matrix C: DEN Concourse C East Expansion Concessions	235
DEN Concourse C East Expansion Concessions Matrix	235

This page is intentionally blank.

Summary of Revisions

The following tables list revisions to the Mechanical DSM within the past year.

2025 Revisions

Fourth Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
Table 1-1: Definitions	Added LCCA (Life-Cycle Cost Analysis) to Definition table
1.0.4 Mechanical Engineer	Updated address
1.1.1 System Criteria	Added information
Table 1-3: Equipment Abbreviations	Added equipment abbreviations
3.0.1 Air Handling Systems	Updated temperatures
3.3.4 Toilet Exhaust	Added requirements
3.5.6 Food and Beverage Tenant Equipment	Updated and added information
5.2.1 AHU Controls	Updated information and added information
Table 5-1: Alarms in the EMCS	Updated and added information
Table 5-2: Alarm Points Only Trended in SkyS-park	Updated information
8.1.7 Grease Traps	Updated information
8.5.4 Water Meters	Updated information
8.5.6 Roof Water	Added new section
10.0.3 Concourse B	Added information
10.1.1 PCA Unit Sizing	Added information
Table 10-2: Sizing of Aircraft Specific to DEN	Updated information
10.1.4 DX PCA Units	Updated information
Chapter 11- Facility Design	Design Conditions throughout chapter: Updated information and Cooling temperatures
11.16 Passenger Terminal- Employee Gym	Added new section

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes

Second Quarter (Continued)

Reference	Revision Description
1.0.3.General	Added construction drawings general note information
2.0.1.Existing Campus Heating/Cooling Systems Operation	Added information on the chiller temperature and added information on the gates dividing the sumps
2.0.2.Seasonal Operation	Added information on the heating plant capacity in the summer.
2.1.2 Refrigerant Recovery	Removed Section
2.1.3.Boilers	Changed the date of anticipated install date for the new boilers
2.1.13.Heating System	Updated information
3.0.5.Roof-Mounted HVAC Systems	Added a note on rooftop equipment
3.0.5.10.Fall Protection	Added exceptions
3.3.5.1.Ventilation	Added information
5.0.1.General	Added designer responsibilities
5.0.2.Existing Base Building HVAC Control Systems	Updated information
5.0.3.New and Replacement HVAC Control Systems	Added information on what needs to be provided to DEN
5.5.1.General	Added information for Designer to include
5.6.Equipment Alarming	Added information
6.1.3.Hydronic Requirements	Updated heating water return temperature
6.2.1.General Requirements	Added information outdoor air dampers
6.2.2.Flushing and Cleaning for Closed Hydronic Systems- Metallic Piping Systems	Added DEN Technical Requirement
6.4.1.Hydronic Requirements	Updated information
7.0.1.General	Added information for the designer to include
7.2.1.Mechanical Rooms	Added information for the designer to include
7.2.6.Plumbing Chases	Updated information
8.5.4.Water Meters	Added information
10.0.7.PCA Hydronic Design	Added information on the individual PCA units
10.0.8.Equipment Support	Updated information
10.2.2.PCA Controls	Updated information

2024 Revisions

Fourth Quarter

Reference	Revision Description
Throughout	Accessibility improvements
1.0.8 ORAT Requirements	New ORAT Requirements section
1.2.2 Air Handling Unit, Unitary Equipment, and Hydronic Equipment Identification	Updated information
1.5.1 Design	Added information
3.6 Sustainability	Added information
4.0.7 VAV Terminal Air Units	Added information
5.2.9 Thermostats and Temperature Sensors	Added information
5.5.1 General	Added information
6.15 Piping and Valves	Added information
8.2.3 Piping	Added information
11.7,1 Design Conditions	Added information
11.18.1 Design Conditions	Added information
Section 230523.13: Butterfly Valves for HVAC Piping	Added new engineers note

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
1.0.3 General	Added designer responsibility
1.2.3.5 Dependency Identifier	Updated abbreviation information
3.3.7 Fire Sprinkler Valve Room With Nitrogen Generator	Added new section
5.0.1 General	Updated and added new information
5.0.2 Existing Base Building HVAC Control Systems	Updated information
5.0.3 New and Replacement HVAC Control Systems	Updated information
5.2.2 VAV Terminal Unit Controls	Added information
5.2.3 Unit Heater Controls	Updated information
5.2.8 HVAC Control Functions	Added information on new devices
5.2.11 Oxygen Sensors	Added new section

Second Quarter (Continued)

Reference	Revision Description
5.6 Equipment Alarming	Added new section
6.4.1 Hydronic Requirements	Updated information
8.2.2 Plumbing Fixtures and Equipment	Added minimum pipe size
8.2.3 Piping	Updated information
8.5.4 Water Meters	Updated information
11.21.2 Air Handling System	Updated information
11.46 Elevator Equipment Rooms	Added new section
Section 220400: Basic Plumbing Requirements	Added 3.01 WORKMANSHIP section
Section 221316: Sanitary Waste and Vent Piping	Added 2.03 HUBLESS, EPOXY COATED, CASTIRON SOIL PIPE AND FITTINGS section and 2.04 STAINLESS STEEL DRAINAGE PIPE AND FITTINGS section, also updated Information under 3.01 PIPING INSTALLATION
Section 230400: Basic HVAC Requirements	Added 3.02 WORKMANSHIP'

2023 Revisions***Fourth Quarter***

Reference	Revision Description
Throughout	Design temperatures for non-CCD areas that are not subject to Executive Order 123
Throughout	Corrections to text formatting
Table 1-1: Definitions	Added definition for Terminal Complex
1.0.5 Regulatory Requirements	Inclusion of Environmental and Sustainability Stakeholders
1.0.6 Work Sequence, Coordination, and Installation	Design including duplication of Appurtenances
1.0.7 Site Conditions	Designers having a better understanding of existing systems
1.1.1 System Criteria	Inclusion of specific Stakeholders, Inclusion of special considerations to the floor plans, Existing systems needing modifications, Provisions for Temporary Equipment or bypass
1.1.2.3 Indoor Design Temperatures	Indoor design temperature changes for non-CCD areas.
1.4.1 Design Submittals	Identify equipment nuances to reviewers

Fourth Quarter (Continued)

Reference	Revision Description
2.0.1 Existing Campus Heating/Cooling Systems Operation	Updated for ongoing work
2.1.4 Boilers	Updated for ongoing work
2.1.8 Water Treatment	Updated for recent work.
2.1.14 Heating System	Updates to Heating System Operation
3.5.6 Food and Beverage Tenant Equipment	Reference to Chapter 5 for tenant controls requirements added.
5.0.1 General	Added clarification for non-HVAC controls, Equipment manufacturer controls system requirements, Tenant alarming and integration into the EMCS, Location of sensors.
5.2.9 Thermostats and Temperature Sensors	Displays on temperature sensors.
5.4 Sequence of Operation	Designer to research and coordinate integration of new systems into the legacy systems.
6.1.3 Hydronic Requirements	Updated heating water supply and return temperatures to match current operations, Limit height of devices requiring service.
6.1.5 Piping and Valves	Reliance on existing valves and installing a bypass on mains.
6.1.6 Pumps	Include high-performance shaft seals and a spare
6.2.2 Flushing and Cleaning for Closed Hydronic Systems -Metallic Piping Systems	New section
8.1.15 HVAC Coil Condensate Drains	Added condensate drain terminations
8.5.4 Water Meters	Defined threshold for metering requirements
10.0.6.2 CUP Connection Criteria	Updated heating water temperatures
10.3.1 Ventilation and Conditioning	Updated requirements
Chapter 11: Facility Design	Temperature updates in the Design Conditions for most facilities, Updated plumbing requirements
11.14.2 Air Handling Systems	Updated location of air handling units
11.15.2 Air Handling Systems	Updated location of air handling units
11.19.2 Air Handling Systems	Updated location of air handling units
11.20.2 Air Handling Systems	Updated location of air handling units

Fourth Quarter (Continued)

Reference	Revision Description
11.26.1 Design Conditions	Cooling set points for City occupied spaces per XO-123
11.43.2 Ventilation System & 11.43.3 Exhaust Fan Controls	Updated existing conditions
11.44.5 Electrical Rooms	Added electrical room cooling requirements
Chapter 12: Technical Specification Requirements	Corrections to text and formatting throughout the chapter
Section 220500: Common Work Results for Plumbing Equipment	3.01 Piping Systems -Common Requirements: Added high point vents and low point drains
Section 220516: Expansion Fittings and Loops for Plumbing Piping	Updated flexible pump connectors. Engineering Notes: Added specific types of pump connectors
Table 12-2: Division 23 DEN Standard Specifications	Removed sections 230993 & 238126 from list of Standard Specifications
Section 220719: Plumbing Piping Insulation	Added information on insulation jacketing
Section 221113: Facility Water Distribution Piping	Removed PVC Piping for aboveground water-service piping and updated allowed piping materials
Section 221116: Domestic Water Piping	Removed CPVC and PVC Piping for above-ground domestic water piping NPS 2 and smaller and updated allowed piping materials
Section 221119: Domestic Water Piping Specialties	Added engineering note for water meter controls integration.
Section 230400: Basic HVAC Requirements	Added section 3.01 -Flushing and cleaning for closed hydronic systems – metallic piping systems
Section 230500: Common Work Results for HVAC Equipment	No flange-to-flange connections allowed. Exclusion of the installation of valves beyond what is shown in the documents. Include chain-up device and safety restraint system for valves using chainwheels. Added high point vents and low point drains.
Section 230516: Expansion Fittings and Loops for HVAC Piping	Updated flexible pump connectors
Section 230519: Meters and Gauges for HVAC Piping	Added locations for Test Ports
Section 230523.11: Globe Valves for HVAC Piping	Updated specification designation from 230523.44 to 230523.11 for Globe Valves

Fourth Quarter (Continued)

Reference	Revision Description
Section 230523.12: Ball Valves for HVAC Piping	Added chain-up devices for ball valves
Section 230523.13: Butterfly Valves for HVAC Piping	Added chain-up devices for ball valves
Section 230523.14: Check Valves for HVAC Piping	Corrections to section 3.02 VALVE INSTALLATION for check valves
Section 230523.16: Plug Valves for HVAC Piping	Added chain-up devices for ball valves
Section 230716: HVAC Equipment Insulation	Section 3.02 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION is added.
Section 230719: HVAC Piping Insulation	Updated requirements for the painting of pipe insulation
Section 230800: Commissioning of HVAC	Added section
Section 230923.14: Flow Instruments & Section 230923.17: Level Instruments	Limit height of remote displays
Section 231113: Facility Fuel-Oil Piping & Section 231123 Facility Natural-Gas Piping	Updated requirements for the painting of the pipe
Section 232113: Hydronic Piping	Broaden system types in 3.01 PIPING APPLICATIONS. Updated section 3.02 PIPING INSTALLATIONS for additional requirements.
Section 232123: Hydronic Pumps	Added requirements for pump seals

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
1.1.7 Supports and Penetrations	Added information on supports and anchors
3.5.6 Food and Beverage Tenant Equipment	Added information on what should be included in inspection report
Section 230923: Direct Digital Control (DDC) System for HVAC	Added note on Tenant Water and BTU Meters
Section 232113: Hydronic Piping	Added Filter Backwash Piping information

Revision Notation: Revisions made to this Manual during this revision cycle are annotated as shown in the example below:

A vertical line in the left-hand margin is used to annotate paragraphs that have been added or revised in the current publication. Revisions may include items such as new requirements, clarifications of existing requirements, or removal of requirements that no longer apply to projects. Revision annotation is applied to each publication individually; revisions made in past publications are not annotated in subsequent publications.

This page is intentionally blank.

Purpose of Design Standards Manuals

The DEN Design Standards have been developed to ensure a unified and consistent approach to the thematic and technical design for DEN. These standards are for use and strict implementation by all consultants under contract to DEN, to tenants, and all other consultants under contract to any other entity for the design of projects at DEN.

The Standards Manuals are working documents, which will be revised and updated, as required, to address the general, conceptual, design, and technical standards for all areas of design for DEN.

This Design Standards Manuals (DSM) for DEN has been prepared for use by competent, professionally licensed architectural and engineering consultants under the direction of DEN Maintenance and Engineering or tenants of DEN.

The Design Standards shall not be quoted, copied, or referenced in any bidding or construction contract documents. Content contained in this Manual shall not be copied in any bidding or construction documents, except where specifically instructed to do so. All information contained in these standards must be fully explained and shown in all bidding and contract documents.

The Design Standards Manuals are intended to be used as a whole, as each manual is complimentary to the other DSMs. To understand the overall thematic and design standards for DEN, the applicable manuals must be utilized together and not separated from the Design Standards Manuals.

The Consultant shall not reproduce, duplicate in any manner, transmit to other consultants or other entities, or use in conjunction with other projects without the express written consent of DEN.

NOTE: This document is optimized for duplex (double-sided) printing.

VARIANCE FROM DEN DESIGN STANDARDS MANUALS

Requests for non-conformance or variance from DEN Design Standards manuals, for any DEN or Tenant Projects, must be formally submitted using the online DSM Variance Request form at the following website:



[DEN DSM Variance Request](#)

Variance requests may or may not be approved by DEN and response will be communicated to the requestor.

This page is intentionally blank.

Chapter 1 - General

1.0 General

1.0.1 Intent

The Mechanical systems consist of HVAC, plumbing, fire protection, automatic controls, and process systems located in the terminal building, the Airport Office Building, concourses, and outlying support buildings. The goals and objectives are to develop a Mechanical design to achieve an efficient, economical, maintainable, and reliable installation consistent with the goals and objectives of the Denver International Airport/City and County of Denver.

The space environment shall be designed to be controllable within an acceptable year around comfort and health levels. The Design Engineer shall utilize the latest state-of-the-art, energy-conservative, readily available equipment and components based on proven design techniques.

1.0.2 Definitions

The following terminology is used throughout this manual.

Table 1-1: Definitions

Term	Definition
AFF	Above Finish Floor
AGTS	Automated Guided Transit System. The AGTS is the train that travels between the airport terminal and concourses.
ALP	Airport Layout Plan
AOB	Airport Office Building
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BIM	Building Information Management. The BIM system consists of 3-D models in Revit, Civil 3D, and interfaces to CMMS systems.
BTU	British Thermal Unit
CCD or City	City and County of Denver
CFM	Cubic feet per minute
CMMS	Computerized Maintenance Management Software
Concealed	Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, in soffits, or in enclosures.
Contractor	Tenant's contractor and sub-contractors
Control or actuating devices	Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches, and electrodes controlling operation of equipment.
CUP	Central Utility Plant

Table 1-1: Definitions (Continued)

Term	Definition
DEC	Design, Engineering, and Construction. DEC is a division within DEN.
Designer	Designer of Record
DDC	Direct Digital Controls in a centralized network-oriented approach to control systems that are integrated into the EMCS including HVAC, Electrical Metering, Lighting, and others. Reference the Communication & Electronic Systems DSM for other items included in the Controls Network.
DDS	Denver Development Services. DDS is the Denver Building Department.
DEN	Denver International Airport. DEN is operated by the City and County of Denver's Department of Aviation.
DFD	Denver Fire Department
DSM	Design Standards Manual
ECS	Emergency Communication System
EMCS	Energy Management Control System
EMS	Emergency Management System
Exposed	Not installed underground or concealed as defined above
Furnish	To supply and deliver to the project site, ready for unloading, unpacking, assembly, and installation as applicable to the project, unless noted otherwise.
GPM	Gallons per minute
HTC	Hotel and Transit Center
HVAC	Heating, Ventilating, Air Conditioning systems
HV	Heating, Ventilating systems
Install	Operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, and cleaning as applicable to the project, unless noted otherwise.
LCCA	Life Cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design. LEED consists of a suite of rating systems for the design, construction, and operation of high performance, homes, and neighborhoods.
Material	All mechanical system components required for project construction including equipment.
Mechanical Systems	HVAC, plumbing, fire protection, and related control systems as contained herein.
Motor Controllers	Manual or magnetic starters (with or without disconnects), individual push buttons or hand-off-automatic switches controlling the operations of motors.
Piping	Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

Table 1-1: Definitions (Continued)

Term	Definition
PM	Project Manager. The PM is the Project Engineering representative of DEN.
Provide	To furnish and install as defined herein.
Related work	Includes, but is not necessarily limited to, mentioned work associated with, or affected by, the work specified. All related work is included as work of this division unless otherwise specifically excluded.
SARA	Service Animal Relief Area
SF	Square feet
Similar or equal	Equal in materials, weight, size, design, capacity, performance, and efficiency of specified product.
Supply	To purchase, procure, acquire, and deliver complete with related accessories.
Tenant	Lessee to the City and County of Denver and DEN, including the Tenant's Architectural/Engineering Consultants.
Terminal Complex	Refers to the Main Terminal (Great Hall), Concourses A,B, & C, Central Utility Plant (CUP), Hotel, and the Transportation Center.
Wiring	Raceway, fittings, conduit, wire, boxes, and related items
Work	Labor, materials, equipment, fixtures, trim, apparatus, controls, accessories, and other items required for proper and complete installation.

1.0.3 General

The Designer shall prepare the design, construction documents, drawing, and specifications for HVAC equipment, ductwork and piping, exhaust equipment, controls, insulation, structural, plumbing, fire protection, automatic control systems, energy management systems, and operational services such as aircraft and vehicle fuel and glycol systems. The Designer shall coordinate the mechanical design with the applicable sections of the architectural, electrical, structural, civil, and DEN standards and criteria.

All construction documents shall be developed by the designer and reflect a complete engineered design. The installing contractor may perform certain engineering tasks, such as fire protection, but the designer is responsible for the total overall design.

The designer is responsible for including aspects of this Mechanical DSM and other pertinent DSM divisions into the design documents. An example of this can be found in [Section 3.5.6.Food and Beverage Tenant Equipment](#) where the designer is to add a note to the drawings regarding the cleaning of grease duct or notes on removal of existing equipment and control points in [Section 5.0.2.Existing Base Building HVAC Control Systems](#).

Designers are to add to the Construction Drawing's general notes itemizing materials and methods that are not allowed at DEN. Examples include push-on or press-on piping connectors, grooved piping or piping connections, powder actuated supports, cable duct/pipe supports, etc.

Designers are to add to the Construction Drawing's general notes for the contractor to hold a mandatory meeting with DEN Stakeholders prior to connections to any piping (DEN Utilities). Tie-in to Plumbing systems to coordinate with DEN Plumbing and tie-in into Mechanical systems (duct or piping) to coordinate with DEN HVAC. Meetings are to be scheduled through the DEN PM and are to indicate the location of the tie-in, how the tie-in is to be made, size

of the tie-in, and any factors that require deviance from the construction documents. Meetings with Stakeholders is necessary to avoid delays and additional costs to the project.

DEN has had issues with shop drawings, equipment and materials submittals receiving an Approved as Noted (AAN) designation and the notes are not being picked up by the submitter. Miscommunication has happened in the interpreting of notes made on submittals by designers. Designers are to include in the specifications and drawing general notes that a submittal must be confirmed compliant with the notes made by the designer to the DEN PM in writing prior to being released for order or fabrication if designated as AAN. Designers are not to mark submittals as AAN unless the comments are minor in nature. See the Standards and Criteria DSM Chapter 8 for additional information.

DEN Mechanical Engineer requires that designers perform at least two project site inspections during the construction of a project that they have designed; more complex projects will require additional site visits. Designer is to submit this as a construction observation report to DEN PM for tracking the adherence to project drawings and specifications as well as the quality of workmanship opinions. Designers are to include the date and time of the observation, items being observed and excluded from the observation and photographs of the items noted in the observation report. See the Standards and Criteria DSM Chapter 8 for additional information.

1.0.4 Mechanical Engineer

All references in this document to the DEN Mechanical Engineer refer to the individual listed below. For questions, updates, or requests for deviations to this document, contact:

Manager of Systems Engineering
Design, Engineering, and Construction
26100 E 68th Ave.
Aurora, CO 80019

1.0.5 Regulatory Requirements

Designers shall specify that work shall be per underwriters; public utility; local; state, and federal codes; ordinances; and applicable regulations. Work shall also comply with the latest editions of all applicable codes, ordinances, and regulations in effect as of the date of the contract documents. If discrepancies occur between the contract documents and any applicable codes, ordinances, acts, or standards, the most stringent requirements shall apply. Where hourly fire ratings are indicated or required, designs shall provide for components and assemblies meeting the requirements of the American Insurance Association, Industrial Risk Insurers, Factory Mutual Insurance Association, and listed by Underwriters Laboratories, Inc.

Designers shall include stakeholders from DEN Environmental and DEN Sustainability for DEN specific requirements. An example is the requirement that flue gas monitoring ports be added to flues, and environmental permits be indicated in the construction documents and specifications when necessary in the project.

1.0.6 Work Sequence, Coordination, and Installation

Project documents shall be developed so that work is furnished and installed in a logical sequence and performed in an expeditious manner for an efficient flow of work. Attention is to be given to the positioning of large equipment items and tie-ins to existing systems that will require system shutdowns. Progress of mechanical work shall be coordinated with other trades.

All site conditions and dimensions shall be verified by field measurements. Chases, slots, and openings shall be verified and designed to allow for mechanical installation. When mounting heights are not specifically detailed or dimensioned, systems, materials, and equipment are to be installed to provide the maximum headroom possible with minimum headroom of 7'-6" above the finished floor (AFF). If there are spaces with finished ceilings, the systems shall be of adequate height above the ceiling.

All systems that require periodic servicing or equipment replacement shall be readily accessible from the space. Coordinate connection of mechanical systems with exterior underground and utility services.

Contract drawings shall indicate the general arrangement of mechanical systems. Information shown may be schematic. Field verification by the designer of all existing architectural, mechanical, electrical, civil, and structural system locations is required.

Drawings and specifications are to complement each other. The designer shall clearly identify any work, materials, or equipment indicated on the drawings but not described by the specifications or described by the specifications but not shown on the drawings. In case of a conflict, the Contractor shall obtain clarification from the designer through the DEN PM in writing prior to bidding the job. After the job is bid, the conflict shall be resolved at the sole discretion of the DEN PM.

Although the general criteria may not be specifically indicated, Designers shall design and specify all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a complete mechanical system. Designers are to coordinate with devices being installed to prevent duplication of appurtenances internal to the device.

The designer shall fully detail all demolition drawings, and all unused mechanical and plumbing systems shall be demolished. No mechanical or plumbing systems, including equipment, ductwork, piping, supports, controls, power conduit, etc., shall be abandoned in place.

1.0.7 Site Conditions

The designer shall field verify the site location and availability of existing mechanical and electrical systems and the building structure. The designer shall examine site premises and utilities to become familiar with existing local conditions affecting work, such as obstructions, levels, necessary cutting, and any other existing services, before submitting the design. Designer shall research and coordinate with the appropriate stakeholders until a thorough understanding of how existing systems and equipment operate. Construction documents are to include the integration of new and existing equipment services with any upgrades in existing equipment or service necessary for proper operation. No allowance will subsequently be made due to any misunderstanding with respect to existing site conditions. All possible interferences inhibiting the routing of services shall be verified.

1.0.8 ORAT Requirements

The Operational Readiness, Activation, and Transition (ORAT) team at DEN plays a critical role in ensuring that DEN's Design Standards Manuals integrate operational requirements throughout the design and construction phases. By collaborating closely with project teams, architects, and engineers, ORAT ensures that the DSMs align with the airport's functional and operational needs. This alignment is achieved by gathering feedback based on operational expertise, identifying potential challenges in facility layouts, and ensuring that the final design facilitates a seamless transition to full-scale operations. Program and project design teams are expected to be familiar with the DEN ORAT Standards Manual (OSM) and actively participate in ORAT-led meetings, charrettes, workshops, trials, and testing at the request of the DEN Project Manager.

1.1 Design Criteria

1.1.1 System Criteria

The mechanical systems for all facilities at DEN are to be based on straightforward, proven design techniques utilizing the latest state-of-the-art development in readily available equipment and hardware. The overriding criteria for the use of systems and equipment shall be the safety, convenience of maintenance, simplicity, and comfort of the traveling public.

It is most important that the systems installed serve the public well, are readily serviceable and maintainable, are stable and direct in their operation, and provide flexibility for future change and development. All equipment, appurtenances, and hardware shall be accessible for adjustment and maintenance. Suitable access is required to permit the removal and replacement of equipment items. Maintenance clearances for existing equipment, even if said equipment is not in project scope shall be maintained. Special care shall be taken in areas with high ceilings, such as Concourse holdrooms, where DEN Maintenance personnel require the use of scissor lifts to perform maintenance on equipment a level above the finished floor. Provisions are to be made for the centralization of operating and maintenance diagnostics.

Include stakeholders in evaluating the condition of the existing systems to be modified for their input and experience during the development of any designs. Work in the Terminal Complex should involve at a minimum the HVAC Maintenance, Electrical, and Plumbing Supervisors input for any nuances that the designers should be aware of effecting their designs. Work in the CUP or any system served from the CUP in the Terminal Complex shall also require input from the Utility Plant Supervisor. Specifically include DEN Mechanical, Life Safety, and Electrical Engineers in any decisions needed in the progress of the designs. Other stakeholders to include would be DEN Environmental and DEN Sustainability at a minimum for requirements specifically to DEN systems. Record and include in the design analysis report (DAR) decisions and notes from any conversations that support those decisions for future reference.

Equipment and or major components that are routinely replaced weighing over 100 pounds and the top of the equipment located more than 60 inches above the finish floor shall have an equipment removal system. The system shall, at a minimum, allow for a chain fall to be mounted and the equipment to be safely moved. This system shall be designed by a Colorado Licensed Structural Engineer and be approved by the DEN Mechanical engineer.

Alternate methods for lifting heavy equipment for maintenance may be considered but must be approved by the DEN Mechanical Engineer by the 60% (or equivalent) Contract Document submittal.

Equipment or devices requiring special considerations shall be included in the design and not left up to the contractor as a requirement in the specifications. This includes designing and depicting on floor plans the required straight pipe and straight duct for measuring devices, locating control items such as outdoor pressure sensors, duct static pressure sensor locations, and similar items.

High discharge flows from backflow preventors, relief valves, hydronic blowdown and similar shall discharge into a receptor with adequate capacity to accept the entire flow without overflow. Design is to include any modifications needed to the existing drainage systems. Alternate methods of accepting high discharge rates must be approved in writing by the Mechanical Engineer prior to implementation to the design documents.

It is anticipated that there will be changes and development in many areas of the airport facilities, and the mechanical systems must be revised or expanded to accommodate these changes. In addition, development in state-of-the-art technology may suggest updating systems and system components in the future. All designs of mechanical systems must include built-in flexibility in keeping with the nature of change that is present for air transportation facilities.

Much of the existing equipment no longer functions according to the original intent and may be replaced. Old equipment, isolation valves, control valves, etc. are to be evaluated and included in the project scope as necessary for adequate installation and operation of the new and replaced systems. Provisions for temporary systems needed for permanent equipment installation shall be included in the design. Examples include indication of temporary heating/cooling equipment if any main hydronic or ducting work is to occur, installation of temporary bypass piping or ducting to minimize the impact of the “downstream” components affected. Do not rely on existing isolation valves to hold for new piping or equipment replacement but include provisions for the replacement of existing or the addition of new isolation valves and method of temporarily isolating the systems for minimum impact to the airport facilities.

In addition, energy conservation and cost savings will also be guiding criteria in the design of mechanical systems. All facilities must meet the energy conservation requirements included in these standards. Both initial system and

equipment costs and life cycle owning, operating, and maintenance costs are to be important considerations in concept design efforts, and these considerations must be carried through final design and construction.

Simplicity in operations and maintenance is key to efficiently running a large air transportation facility. Where possible, Consultants shall reduce or eliminate redundant systems and equipment or sequences of operation. DEN staff understand that certain provisions in the Design Standards Manuals, codes, and regulations, and project-specific requirements or constraints may necessitate the use of redundant systems, equipment, or sequences of operation. In these instances, the Consultant shall provide a narrative describing what requirement necessitates the use of the redundant systems, equipment, or sequences of operation in the Design Criteria section of the DAR. Refer to Chapter 3 of the Standards and Criteria DSM for more information.

1.1.2 Mechanical Design Criteria — Flexibility

Special provisions are to be made in determining terminal and concourse building heating and air conditioning load requirements to properly allow for the dynamic nature of the application of these loads. During normal operation, these loads can vary dramatically from zone to zone, and the peak load can fluctuate significantly within each zone. This is due to the rapid mass movement of people within the building, as well as the shifting solar load on glass walls, infiltration loads associated with people and baggage movement in and out of the building, and out-side air ventilation requirements.

Heating and air conditioning system controls must provide system flexibility to satisfy the shifting internal cooling loads. The HVAC system must be able to handle varying perimeter loads during heating and cooling seasons while the internal and other loads fluctuate between no load and peak conditions. In addition, appropriate air quality conditions must be maintained in the spaces while the natural/nearby ambient (outside) conditions are very often of less than ideal quality.

1.1.2.1 Design Parameters

All new systems or major modifications to existing systems shall be designed and selected based on the latest ASHRAE Standards 90.1 and 55 requirements. Design conditions for DEN according to the latest version of *ASHRAE Standard 169 - Climatic Data for Building Design Standards*

Historical Reference: Many existing base building systems were designed and selected based on the following design conditions:

1.1.2.2 Design Conditions Prior to 2022

Design conditions for DEN according to *ASHRAE Handbook- Fundamentals 2013* are as follows (rounding to the nearest degree F):

- A. Cooling at the 1% level: 92°F (DB)/60°F (MCWB)
- B. Evaporation at the 1% level: 64°F (WB)/81°F (MCDB)
- C. Heating at the 99.6% level: 1°F (DB)

1.1.2.3 Indoor Design Temperatures

It is intended that the mechanical systems (in general) maintain indoor design conditions in all occupied spaces normally accessible to the public as follows (unless specified otherwise):

- A. Summer: 75°F, 50% maximum relative humidity
- B. Winter: 72°F

1.1.2.4 Outdoor Design Temperatures

Original outdoor design conditions used for system designs are as follows:

- A. Summer: 92°F dry bulb/59°F wet bulb (coincident conditions)

96°F air-cooled condensing temperature

63°F wet bulb design condition.

B. Winter: -5°F

These design criteria conditions are based on the recommended conditions listed for areas near Denver in the *1987 ASHRAE Fundamentals Handbook* at the 2-1/2% summer condition and the 99% winter condition. That is, based on historical data, the outdoor temperatures can be expected to exceed the summer design conditions 2-1/2% of the time and exceed the winter design conditions 1% of the time.

The more stringent design condition is required for winter criteria due to the inherent outdoor air infiltration condition present in most airport situations. The design wet bulb condition is based on the 2- 1/2% mean coincident wet-bulb condition.

1.1.3 Ventilation Standards

All new systems or major modifications to existing systems shall be designed and selected based on the latest version of ASHRAE standard 62.1 or the IMC, including CCD amendments; whichever is more stringent.

Historical Reference: Many existing base building systems were designed and selected to meet the following:

Ventilation Standards for occupied spaces are to be based upon ASHRAE standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*. The minimum required ventilation rate of outdoor air per person is to be 15 CFM per person, with several special-use areas in the buildings having significantly higher requirements. The distinction between smoking permitted and smoking prohibited has been abandoned in the revised standard; Denver Executive Order No. 99 prohibits smoking in all indoor public places, including bars, restaurants, and food courts.

1.1.4 Energy Efficiency Requirements

Energy efficiency is an important consideration in the design of mechanical systems for all DEN facilities. Heating, ventilating, and air conditioning systems are to be designed to meet or exceed the requirements of the latest version of ASHRAE standard 90.1- *Energy Efficient Design of New Buildings except for Low-Rise Residential Buildings* and the CCD building code. Projects seeking LEED certification must meet all requirements to achieve LEED Gold certification or higher as defined by CCD Executive Order 123.

Equipment selections must be specified to meet or exceed these standards. The equipment and systems described herein must be selected to obtain the optimum in conserving life cycle owning and operating costs considering energy efficiency, initial costs, maintainability, and comfort. Refer to [Chapter 9- Energy Analysis and LEED](#) for further information on energy performance criteria and energy analysis.

1.1.5 Noise Criteria

The mechanical (HVAC) system shall be designed to minimize noise in the occupied space. The system and components shall be designed so as not to transmit or generate sound above a specified noise level in the space. Sound attenuators, duct liner, lower duct velocities and appropriate ductwork fittings and components shall be utilized as required to attain acceptable sound levels. Vibration isolation shall also be evaluated and utilized. Sound attenuators shall be isolated from the building structure.

For all HVAC and sound attenuation equipment provide schedules defining sound pressure levels in all 8-octave bands in dBA and calculated Noise Criteria (NC).

Sound tests shall be conducted in accordance with accepted procedural standards in and around all major sound-producing equipment either to confirm adequate attenuation or to identify problem areas requiring additional modifications as required by the DEN PM.

Maximum noise levels in the occupied space produced by HVAC equipment shall be in accordance with the NC curves listed in [Table 1-2: NC Criteria by Space](#).

Table 1-2: NC Criteria by Space

Occupied Space	NC Curve
Main Terminal	40
Concourse	40
Baggage Handling Areas	45
Restaurant and Food Service	40
Retail	40
Private Lounges	35
Offices	35
Conference Room	30
Control Tower Offices	35
AARF Station	35
Maintenance Work Area	45
Hotel Rooms	30
Mechanical Equipment Room	50

Notes:

- For NC curves, the lower number, the quieter the background noise
- Noise is to be free of tonality.
- Noise is to be free of low frequency time modulations (fluctuations).
- For any additional spaces not listed in the table above, refer to the NC Curves in the latest
- AHRAE Handbook - HVAC applications or other applicable standards.

Where mechanical noise is to be utilized for sound masking, RC (room criteria) curves shall be utilized as described in Chapter 8, Sound and Vibration of the most recent *ASHRAE Handbook, Fundamentals*.

Equipment and ductwork noise levels to permit attaining sound pressure levels in all 8-octave bands in Tenant occupied spaces shall conform to noise criteria NC-35 curves. Motor drives for pumps or any equipment shall operate with noise levels not exceeding OSHA 8-hour 90dBA Time Weighted Average (TWA). Noise levels shall be determined in accordance with IEEE Standard #85, Test Procedure for Air-Borne Noise Measurements on Rotating Electric Equipment.

1.1.5.1 Horn and Strobe Systems in Mechanical Equipment Rooms

Mechanical equipment room NC curves may exceed the levels listed above with written permission from DEN Mechanical Engineer. To obtain written permission from DEN Mechanical Engineer, the Consultant must provide a comparison of all different equipment and strategies for reducing NC curves to the DEN Mechanical Engineer by the 60% Contract Document Submittal and a written explanation of why these alternatives were rejected. Cost premiums on more quiet equipment or sound masking shall not constitute a reason for rejection. If DEN accepts deviation from the above standards, a horn and strobe system may be used in mechanical equipment rooms only. The horn and strobe shall be installed per the most recent edition of NFPA 72.

1.1.6 Altitude Correction

The design of all air systems, gas-fired equipment, and other affected mechanical equipment shall incorporate an adjustment for the altitude at DEN of 5,400 feet above sea level. The following parameters for altitude conditions are:

- A. Relative density correction factor = 0.819
- B. Air density = 0.0614 lbs/cu.ft
- C. CFM transfer factor = 0.884

1.1.7 Supports and Penetrations

All supports and anchors for mechanical and plumbing equipment shall be designed, detailed, and specified by a Colorado-licensed Structural Engineer. Provide detail including how attachment is to be made, i.e., between roof curb and equipment as well as roof curb and roof structure. A specification section is not sufficient for detailing any connections. Support sizing by the contractor is prohibited.

In general, cable and/or wire supports are not allowed.

Penetrations and reinforcement of penetrations through structural floors and/or walls shall be designed, detailed, and specified by a Colorado-licensed Structural Engineer.

1.2 Equipment Identification

1.2.1 General

All mechanical and plumbing equipment shall have a unique equipment designation. As of 2014, DEN modified the original scheme for tagging all assets.

These new naming conventions standardize the naming and numbering of all DEN mechanical and plumbing equipment. All DEN mechanical and plumbing equipment shall contain a numbering system according to the criteria out-lined below. Any deviation from the naming convention must receive written approval from the DEN mechanical engineer before implementation. The naming convention outlined below should be fully coordinated with the requirements of tagging in the BIM model. Refer to the DFI DSM.

1.2.2 Air Handling Unit, Unitary Equipment, and Hydronic Equipment Identification

The components used to identify large equipment, such as Air Handling Units (AHUs), and unitary equipment, such as Unit Heaters (UHs), Cabinet Unit Heaters (CUHs), and Fan Coil Units (FCUs), depend on the location and requirements of the project. The DEN naming system consists of five standard components and one optional component, as follows. Use an underscore character to separate components as shown in the examples below.

LLL	_	NN	_	NL	_	LLL	_	L	_	NN
(1)		(2)		(3)		(4)		(5*)		(6**)

L = Alphabetical character

N = Numerical character

** = Only used for AHUs*

*** = Only used for Unitary Equipment*

1.2.2.1 Building Abbreviation

The three-character abbreviation for each building shall be used to designate the location of equipment. This abbreviation is assigned by DEN, for example: TML = Terminal, AOB = Airport Office Building, CCx = Concourse x, where x is the alpha designation of the concourse, e.g., A, B, C, etc.

CCB	–	04	–	7W	–	AHU	–	A	–
------------	---	-----------	---	-----------	---	------------	---	----------	---

1.2.2.2 Building Level

The building level is a two-digit indicator used to further refine the location of equipment. This abbreviation is assigned by DEN, for example: 00 is the Basement Level, 02 is the Concourse Level, etc.

CCB	–	04	–	7W	–	AHU	–	A	–
------------	---	-----------	---	-----------	---	------------	---	----------	---

1.2.2.3 Building Module

The building module is a two-digit designator that combines the building module and direction. It shall be used to further refine the location of equipment. This abbreviation is assigned by DEN, for example: 3W is module 3 West.

CCB	–	04	–	7W	–	AHU	–	A	–
------------	---	-----------	---	-----------	---	------------	---	----------	---

1.2.2.4 Equipment Abbreviation

Equipment abbreviations are assigned by DEN and are listed in [Table 1-3: Equipment Abbreviation](#).

CCB	–	04	–	7W	–	AHU	–	A	–
------------	---	-----------	---	-----------	---	------------	---	----------	---

1.2.2.5 Concourse AHU Alphabetical Designator

AHUs in the Concourses are identified by an alphabetical designator (a letter). Generally, AHU-As serve holdroom, subcore, and center core perimeter zones, AHU-Bs serve holdroom, subcore, and center core interior zones, AHU-Cs serve holdroom conveyances, and letters beyond C are used for other various zones. Refer to Concourse AHU zoning details for zones existing AHUs serve. In general, Designers should try to replicate existing AHU zones when designing new buildings or expansions.

Each building module must only have one AHU of each designation (e.g., module 7W cannot have two AHU-As in it).

CCB	–	04	–	7W	–	AHU	–	A	–
------------	---	-----------	---	-----------	---	------------	---	----------	---

1.2.2.6 Numeric Designator

The numeric designator shall produce a unique identifier that belongs to only one piece of equipment. The numeric designator ranges from 01 – 99, where a placeholder of zero will be utilized for values less than 10. This is to be unique for each room unless replicated somewhere else. In the Concourses, this designation is only used for non-AHU unitary and hydronic equipment at DEN, such as FCUs and pumps. In the Terminal, Hotel, AOB, and outlying buildings, AHUs are also designated numerically 01 – 99 within the building (e.g. in the Terminal, there is only one AHU with the Equipment Abbreviation and Numeric Designator combination AHU_01).

CCB	–	04	–	7W	–	AHU	–	A	–	09
------------	---	-----------	---	-----------	---	------------	---	----------	---	-----------

1.2.3 Dependent Unit Equipment Identifier

Due to the sheer number of terminal units at DEN (e.g., terminal devices such as VAVs, ATs, and FPBs), additional information must be included to ensure each equipment name is unique. Points for terminal equipment will have a naming component identifying the equipment that serves them inserted as follows. This naming convention shall also be used for split-system DX cooling and heat pumps where applicable. Any split system air conditioner and/or heat pump shall include the dependency identifier for both pieces of equipment.

LLL	–	NN	–	NL	–	LLL	–	XXXLLL (LL)	–	NN
(1)		(2)		(3)		(4)		(5)		(6)

1.2.3.1 Building Abbreviations

The three-character abbreviation for each building shall be used to designate the location of equipment. This abbreviation is assigned by DEN, for example: TML = Terminal, AOB = Airport Office Building, CCx = Concourse x, where x is the alpha designation of the concourse, e.g., A, B, C, etc.

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.2.3.2 Building Level

The building level is a two-digit indicator used to further refine the location of equipment. This abbreviation is assigned by DEN, for example: 00 is the Basement Level, 02 is the Concourse Level, etc.

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.2.3.3 Building Module

The building module is a two-digit designator that combines the building module and direction. It shall be used to further refine the location of equipment. This abbreviation is assigned by DEN, for example: 3W is module 3 West.

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.2.3.4 Equipment Abbreviation

Equipment abbreviations are assigned by DEN and are listed in [Table 1-3: Equipment Abbreviation](#).

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.2.3.5 Dependency Identifier

This series of numbers and letters is an abbreviated version of the parent unit's equipment name and represents the AHU, coil section, or condensing unit that serves the terminal unit or the other half of the split system. The first two numbers in the abbreviation represent the floor the AHU is on (in the example below, 04 represents the fourth floor). The third and fourth number and the first letter represent the building module where the AHU is located (in the example below, 07W represents holdroom 7 west). The final letters represent the equipment type and equipment identifier (in the example below, AB represents AHU-B). For a make up air unit, use the shortened abbreviation M instead of MAU. For an air-cooled condensing unit, these last letters would be ACU##. For a fan coil

unit that includes the DX cooling coils, the last letters would be FCU##. Thus, an ACU as the parent equipment would have the FCU as a dependent, and an FCU as the parent equipment would have the ACU as a dependent.

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.2.3.6 Numeric Designator

The numeric designator shall produce a unique identifier that belongs to only one piece of equipment. The numeric designator ranges from 01 – 99, where a placeholder of zero will be utilized for values less than 10. This is to be unique for each room unless replicated somewhere else. For terminal units with heating (e.g., a VAV box with reheat), an H shall be added to the end of the numeric designator.

CCB	–	03	–	6E	–	VAV	–	0401WAB	–	05H
-----	---	----	---	----	---	-----	---	---------	---	-----

1.3 DEN Mechanical/Plumbing Equipment Naming Components — Identifiers

The following table provides the identifiers and their descriptions for use in equipment naming conventions.

Table 1-3: Equipment Abbreviations

Identifier	Description	Identifier	Description
AC	Air Compressor	GWH	Gas Water Heater
ACT	Actuator	ACUH	Air Curtain
ACU	Air Conditioning Unit (CRAC)	HRC	Heat Recovery Coil
ADS	Air/Solid Separator	HRP	High Resolution Pump
AHU	Air Handling Unit	HSC	Horizontal Split Case Pump
AS	Air Separator	HWP	Heating Water Pump
BFP	Backflow Preventor		
B	Boiler	HX	Heat Exchanger
C	Chiller	IRH	Gas Infrared Heater
CRAC	Computer Room Air Conditioner	MAU	Makeup Air Handling Unit
CT	Cooling Tower	P	Pump
CUH	Cabinet Unit Heater	PCA	Pre-conditioned Air Handler
CHWP	Chilled Water Pump	PWC	Potable Water Closet
CV	Control Valve	PCU	Pollution Control Unit (Scrubber)
DWP	Domestic Water Pump	RAF	Return Air Fan
EBB	Electric Baseboard Heater	RHC	Reheat Coil Unit
EF	Exhaust Fan	RTU	Roof-Top Air Handling Unit
EIH	Electric Infrared Heater	SF	Supply Fan

Table 1-3: Equipment Abbreviations (Continued)

Identifier	Description	Identifier	Description
EMCS	Energy Management Control System	SG	Slide Gate
ET	Expansion Tank	SP	Sump Pump
EUH	Electric Unit Heater	TP	Transfer Pump
EWB	Electric Water Heater	UH	Unit Heater
FCU	Fan Coil Unit with Heating and Cooling Coil	VAV or AT	Variable Air Volume Box (Terminal Unit). Note that AT is for historical reference only, no new units shall be called AT
FCU-DX	Fan Coil Unit with DX Cooling	VAV-H or ATH	Variable Air Volume Box with Heating Coil (Terminal Unit with Heating). Note that ATH is for historical reference only, no new units shall be called ATH
FCU-H	Fan Coil Unit with Heating Coil	VFD	Variable Frequency Drive
FPVAV	Fan-Powered Variable Air Volume Box	VLT	Vault Supply Fan System
F-SE	Smoke Exhaust Fan	VSCF	Ventilation Smoke Control Fan (Historical Reference Only)
FTR	Fin-tube Radiator	WG	Waste Disposal Grinder (Triturator)
GR	Open Channel Grinder	WH	Water Heater
GV	Gate Valve		

1.4 Submittals

1.4.1 Design Submittals

Regardless of the requirements outlined by the Design Analysis Report, or lack of, the Designer shall submit the following electronic files at the 100% phase of the project to the DEN Project Manager:

- A. Space load calculations'
- B. Ventilation calculations defined by the latest version of ASHRAE 62.1
- C. Equipment sizing and selection (AHU, MAU, FCU, Pump, Expansion tank, water heater, etc.)
- D. Duct sizing and static pressure analysis
- E. Hydronic piping sizing and static pressure analysis
- F. Plumbing piping sizing and code analysis
- G. Building pressurization analysis
- H. Smoke Control Analysis
- I. Energy Analysis
- J. Tenant airflow requirements (if required)
- K. Additional calculations, as requested by DEN Design, Engineering, and Construction

- L. Cut sheets of all equipment selected and labeled to match scheduled equipment tags. Identify any nuances to the equipment for reviewers to be aware of.

Each item shall be included as a single, book-marked PDF file. No paper copies are required or will be accepted. All equipment shall be labeled as identified on the contract drawings. Each filename should include the contract number

Refer to the Digital Facilities and Infrastructure Design Standards Manual and the Standards and Criteria Design Standards Manual for additional design submittal requirements.

1.4.2 As-Built Submittals

The Designer shall submit electronically through the DEN Project Manager the information outlined in [1.4.Submittals](#) with corrections made due to field changes in construction.

Refer to the Digital Facilities and Infrastructure Design Standards Manual for additional as-built submittal requirements.

1.5 Equipment Supports and Thermal Expansion Compensations

1.5.1 Design

All equipment supports and thermal expansion compensation shall be manufactured systems or designed and detailed by a Colorado Registered Professional Engineer. Supports shall be coordinated with Architectural and Structural disciplines. Under no circumstances shall the construction documents direct a Contractor to provide supports without detailed performance specifications outlining the criteria and requirements of supports and their design and installation.

Wire and cable hangers are not allowed to support equipment, piping or ductwork. Powder-actuated fasteners are not allowed at the DEN Terminal Complex.

End of Chapter

This page is intentionally blank.

Chapter 2 - Central Utility Plant

2.0 Central Utility Plant

2.0.1 Existing Campus Heating/Cooling Systems Operation

Chilled water and heating water for the HVAC systems in the terminal buildings, HTC, AOB, and concourses are supplied from the Central Utility Plant (CUP).

- A. Heating water is provided by hot water generators consisting of one (1) 62,500 MBH main boiler and six (6) 20,000 MBH boilers. In 2024, work began to replace the existing 62,500 MBH boiler with two (2) 20,000 MBH boilers.
- B. Chilled water is produced by eight (8) 2,500-ton variable speed centrifugal chillers that consist of two (2) compressors each.

The hot water and chilled water systems consist of boiler and chiller primary distribution piping loops located in the CUP and the utility tunnels below the AGTS tunnel.

- A. The primary distribution piping supplies the variable speed secondary loop pumps located at the terminal, AOB, Hotel Transit Center, and the three (3) concourses (the 6 main zones).
- B. The variable speed secondary pumps deliver water to the loads, which consist of coils in the air handling units (AHU), Variable Air Volume (VAV) systems, fan-powered boxes, and other terminal air devices. Each secondary loop consists of pumps in parallel supplying a variable flow as required to maintain static pressure setpoint in the critical hydraulic circuit of each zone loop.

All main AHU coil flows are modulated with 2-way pressure-independent control valves.

An energy management system (the CUP EMCS) controls the water supply temperature in the primary loop and controls the flow and pressure relationships between the primary loop and the secondary loops to match the load.

The primary hot water discharge temperature from the boilers and in the primary loop is variable between 200°F and 230°F that is controlled by a reset schedule. Control valves at the secondary loops then mix the hot water temperature down to 190°F for distribution to the secondary zones.

- A. During the cooling seasons, when the Chiller compressors are energized, the secondary chilled water supply temperature is 40°F± (although this can vary). Chilled water supply temperature can be reset up to a maximum of 48°F under non-peak loading conditions. Designers are encouraged to include a 2°F temperature increase due to the length of the chilled water distribution system.
- B. When the refrigeration load decreases because of lower outside temperatures during the fall, winter, and spring seasons, the cooling mode utilized is the free cooling system using plate and frame heat exchangers (PHEs).

In the free cooling mode, the chillers are bypassed, and the condenser water is pumped from the 322,500-gallon sump through the plate and frame heat exchanger that cools the chilled water. A minimum of two cooling towers run during this time. The system changeover to free cooling mode is selectable at the EMCS terminal. Changeover to the PHEs is not instantaneous due to the amount of time it takes for the sump temperature to stabilize. The manual changeover to free cooling occurs when outdoor air temperatures do not rise above 60°F to 65°F and chilled water supply temperature can be maintained below 48°F±. On a further increase in demand when the chilled water rises to 48°F±, the heat exchangers will be bypassed, and additional cooling towers and chillers will come on sequentially.

As of 2013, the sump was separated into two sections. The two sections are connected or isolated using a series of automated slide gates. This allows several operational modes that were previously unavailable, such as isolating a

section of the sump for maintenance and operating the sump/condenser water system at dual temperatures for transition between mechanical and free cooling in the shoulder seasons. Maintenance on the gates dividing the sumps has removed the gates, no longer allowing for operation at dual temperatures.

In 2013 and 2014, the CUP underwent a major controls renovation and upgrade. A centralized Johnson Controls Metasys EMCS was installed to supervise the control of all equipment, pumps, and control valves. Controllers and/or operational sequences are being updated for most CUP systems, and the Optimum Energy CPO30 system is being installed to manage chiller plant energy performance.

Historical Reference: The current configuration and description differ from the original CUP design. The original design featured three sets of pumps that hydronic water passed through before reaching loads. The legacy configuration was as follows:

- A. The plant distribution pumps, variable volume transport-primary pumps (for the five main zones), and constant volume user-secondary pumps were located throughout the terminal complex.
- B. Due to major hydronic optimization and controls retrofit projects, the old user-secondary pumps have been removed throughout, and the hydronic system has been converted to a primary-secondary arrangement (no tertiary pumps as before).
- C. The old plant distribution pumps have been renamed the primary pumps, and the old variable volume transport-primary pumps have been renamed the secondary pumps, as described in the preceding paragraph.
- D. The decoupler line between the secondary and primary loops remains but is no longer used for differential pressure control. It is used for primary loop pressure relief and will open if the differential pressure raises in the system too much.
- E. The legacy BRDG-TNDR (Bridge Tender) controls have been removed.

2.0.2 Seasonal Operation

The heating and chilled water systems do not run continuously throughout the year. In general, the heating plant is operates at a minimum capacity to supply the hotel with heating water needed year round and reduced temperatures to the Terminal, AOB, and Concourses from May 15 to September 15. The chilled water system runs without chillers in a free cooling mode from November 15 to March 15. Weather plays an important scheduling factor in the operations of these systems. Typically, when average daily temperatures drop below 50°F, the boiler plant is operational.

2.1 Equipment

2.1.1 Chillers

The final chiller selection and sizing shall be determined based on refined load calculations and profiles. The chillers shall be open drive, centrifugal type, using a refrigerant not currently listed by the United Nations Environmental Program Montreal Protocol for production and consumption limitations. The CUP includes eight (8) nominal 2,500-ton chillers using R-123 refrigerant. All chiller prime movers for new machines shall be electric-driven and variable speed. Chillers shall have a maximum energy consumption of 0.60 kW/ton at design conditions. Chillers should be selected based on a lifecycle cost analysis (LCCA).

Cooling plant design shall provide sufficient space and equipment support for adding future capacity of at least two additional chillers of the larger percent capacity range.

Table 2-1: Chiller Design Temperature

Parameter	Temperature
Chiller entering chilled water temperature	56°F
Chiller leaving chilled water temperature	40°F
Chiller entering condenser water temperature	71°F
Chiller leaving condenser water temperature	81°F

Chillers shall be provided and rated in accordance with ARI-550-88 (or the latest addition) and the latest edition of ASHRAE standards 30 and 90.1. Large chillers shall be provided with a free cooling option that consists of piping and valves, which permit the use of reduced condenser water temperature for cooling via thermally migrating refrigerant.

Chillers shall be furnished and piped in such a manner as to provide easy access to the tube bundles for cleaning. The chiller machine motor, gear drive, and compressor shall be mounted on a common base to ensure shaft alignment.

The chillers shall be provided with controls to modulate the chiller operating capacity to match load or as required by the CUP EMCS. The chillers shall be provided with all safety controls, limits, interlocks, and accessory devices to maintain efficient, safe operation per the manufacturer's recommendations.

In addition to the migrating refrigerant-free cooling option mentioned earlier, a waterside economizer (plate frame heat exchanger utilizing tower water), piping, valves, and controls for mild weather-free cooling shall be provided. The heat exchangers shall cool water in the chilled water system from sub-cooled condenser water. Installation shall allow for all maintenance and servicing clearances. Construction documents shall indicate all servicing and maintenance clearances required.

Absorption chillers may be used in the CUP for waste heat recovery applications only.

2.1.2 Cooling Towers

The cooling tower capacity shall be based on chiller selection, free cooling requirements, PCA, and other miscellaneous loads on the condenser water system. The cooling towers shall be architectural concrete tower exterior, counter-flow evaporative type cooling towers with induced air fans that operate at variable speeds (via VSD/VFDs). The selection shall be made to minimize energy consumption and initial cost and to provide for ease of maintenance. Alternate tower selections requiring less energy consumption shall be solicited from the construction contract bidders for review by DEN as to the suitability and cost savings. The final selection is to be made by DEN based on an evaluation by the Design Consultant.

Table 2-2: Cooling Tower Design Parameters

Parameter	Temperature/ Flow Rate
Chiller entering condenser water temperature	71°F
Chiller leaving condenser water temperature	81°F
Wet bulb temperature	64°F
Cell flow rate	6,500 GPM

The towers shall be provided with means of controlling tower capacity for mild and low ambient operation and with adequate means for winter operation without excessive ice buildup or damage to the tower. The towers and chillers shall be designed to take advantage of the large number of operating hours at low ambient conditions for indirect free cooling with condenser water temperatures reaching as low as 38°F. Tower water flow across each section or cell should be held constant during low ambient conditions.

The tower fill media shall have a 25-year life with a maximum temperature rise of 1°F in leaving water conditions over that life span. Fill shall be suitable for winter operation.

All towers shall be certified in accordance with Cooling Tower Institute Standard 201 Certification Standard for Water Cooling Towers or field tested in accordance with ASME Standard PTC23 or Cooling Tower Institute Bulletin ATC-105 to verify tower performance.

2.1.3 Boilers

The existing boiler plant currently contains six (6) 20,000 MBH boilers and one (1) 62,500 MBH main boiler. In 2015, Boiler #6 was added due to the failure of boiler #2. Boiler #6 is a steam boiler that converted hot water and runs off of natural gas. Due to current piping and pump limitations, its capacity is reduced to 52,000 MBH. The boiler is currently inoperable and is slated for demolition in the near future. In 2016, boiler #2 was replaced with three (3) 20,000 MBH boilers and piping and pump modifications. In 2023, boiler #1 and #3 were replaced with three (3) 20,000 MBH boiler and piping and pump modifications. It is anticipated that by the end 2025, the last large boiler will be replaced with two (2) 20,000 MBH boilers.

New boilers shall be provided with dual burners and controls and shall be fired on natural gas, with jet fuel (or light oil) as a standby fuel source. The boilers shall have a minimum efficiency of 80% fired on natural gas and shall be provided with combustion controls to maintain maximum combustion efficiency over the full burner modulating range.

The boiler burners shall be arranged for a high turndown ratio for improved operation at low firing rates. Ultra-Low-NOX burners shall be used with emissions at 15 ppm or less when firing on natural gas. Flue gas economizers shall not be used unless subsequent economic studies indicate that suitable cost savings could be realized. Flue gas recirculation shall be provided to minimize air pollution effects.

The boilers shall supply hot water to the hot water heating distribution piping system. The boiler plant is provided with treatment equipment to minimize corrosion and other detrimental effects on the boilers and piping system. Boiler safety devices shall be provided as required by the Denver Building Code and as recommended by ASME.

2.1.4 Pumps

Pumps shall be selected for maximum operating efficiency (i.e., slightly to the right of the maximum efficiency point on the pump curve). Single pumps to be used in throttling applications without variable speed drives shall have relatively flat performance curves and be selected for operation on the pump performance curve to the right of the point of highest efficiency. Multiple pumps for parallel operation shall have relatively steep performance curves. Multiple pumps for series operation shall have relatively flat performance curves. Pumps for variable speed drive applications shall have relatively steep performance curves. All pumps shall be specified with suction and discharge flange taps for pressure gauge connections.

The final selection of pump types and the application arrangement shall be made to maximize pump efficiency without excessive initial pump costs. All pumps that are selected for both current and future needs will be sized for future requirements, where practical, and equipped with the necessary accessories. In general, pumps shall be lead-lag with N+1 operational redundancy consideration. N+1 selection is required for critical operational equipment. The lower initial performance requirement will be met by balancing valves or using a trimmed impeller to provide energy-efficient operation in start-up performance.

Standby pumps and accessories shall be provided for both heating and cooling systems. Pumps shall be arranged in a parallel configuration and headered to maximize pumping flexibility.

In general, vertical turbine pumps shall be used for pumping cooling tower water. Hydronic water applications shall use end suction pumps for flow rates below 500 GPM. Horizontal split case: double suction pumps shall be used for flow rates above 500 GPM.

High-rpm pumps (>1750 rpm) should only be used when no other alternative exists.

All pumps in the heating water system shall be specified with components that are rated for 230°F continuous operation.

2.1.5 Air Compressors

The main control air compressors shall be the oil-free, screw type provided with regenerative air dryers. The final compressor capacity and storage volume shall be determined from the compressed air demands of the temperature controls, pneumatic operating door systems, and any other functions that require oil-free air.

The control compressed air system shall be designed for a compressed air main pressure of 100 psig. Air dryers shall dry the compressed air to a pressure dew point of -40°F. Regenerative or refrigeration-type systems shall be used. The regenerative air dryer shall be provided with an external heat source for drying element regeneration.

The control air compressor system shall be complete with an air-cooled after-cooler, storage tank, regenerative air dryer and coalescing, and particulate filters. The central compressed air system shall have full standby redundancy in the compressors, dryers, and after-coolers.

All main equipment rooms shall have quick-disconnect fittings and valves to facilitate using portable air compressors should the main control air compressor system fail.

Any shop air compressors may be lubricated reciprocating type for 100 psig and equipped with an aftercooler, storage tank, and inlet air filters. No regenerative or refrigerated air dryers are required.

2.1.6 Motors

Electric motors shall conform to NEMA Standards. All 3-phase motors shall be high-efficiency types. Motors shall not be selected for operation in the service factor range.

The minimum system installed power factor shall be 90%, with a goal to attain a 95% system power factor. Motors larger than 15 hp shall have power factor correction.

Motors shall be specified to be provided with adequate thermal protection, integral or external control, branch circuit protection, and starters suitable for use with the motors. Motor and starter types shall be selected to minimize voltage fluctuations and current surges. Motors and starters shall be provided with auxiliary contacts for control and operation interface with the central EMCS and any other control functions included.

2.1.7 Water Treatment

Chemical treatment systems shall be provided at the CUP for the protection of the chilled water, condenser water, and hot water systems from scale, corrosion, biological growths, and suspended solids.

Chemical treatment for the chilled and hot water systems shall include the use of a corrosion inhibitor. The water treatment for the condenser water system shall include blowdown, pH, and micro biocide control.

The services of a qualified water treatment specialist shall be used and specified for running tests on the water supply and the establishment and implementation of the water treatment programs for the CUP systems.

Water cleaning shall be accomplished by providing a strainer at the suction of each pump. In addition, a final strainer shall be installed downstream of the last system pump.

The chilled water and hot water systems use air-dirt separators on the main lines to remove debris in the piping system. There are centrifugal side stream filters on the main lines as backup. The condenser water systems shall each have a bypass sand filter installed.

2.1.8 HVAC

The CUP shall be provided with equipment to heat and ventilate the CUP equipment areas and to provide boiler room combustion air. Heating of ancillary spaces shall be provided with hot water unit heaters. Ventilation for summer heat relief in non-conditioned spaces shall be provided by the application of outside air louvers and exhaust fans. A minimum air change rate of 10 AC/HR shall be provided for summer. In addition, ventilation shall be provided for the sump to prevent stagnation and odor migration, and emergency exhaust shall be provided for equipment areas subject to possible refrigerant leakage.

The existing CUP main air handling systems are:

A. AHU-B1, B2, B3, and B4 – Boiler Room Combustion Air:

- a. 100% OSA
- b. Hydronic heat

B. Constant volume

C. AHU-ER – Pump Room:

- a. Recirculation with economizer
- b. Hydronic heat/cool

D. Constant volume

E. AHU-CR – Pump/Control Room:

- a. Recirculation with economizer
- b. Hydronic heat/cool

F. Constant volume

G. AHU-C1, C2, and C3 – Chiller Room:

- a. Recirculation with economizer
- b. Hydronic heat/cool

H. Constant Volume

The existing chiller room emergency exhaust fan is sized for 12 ACH.

2.1.9 Piping and Valves

Piping for both the CUP and the distribution systems shall be designed to minimize pressure losses and maximize energy use efficiency. Valves to be specified for equipment servicing shall be selected to minimize losses while open and have suitable pressure drop characteristics for the intended use. The piping shall be designed to allow for CUP equipment expansions.

Control valves shall be sized for the correct and appropriate Cv value at the design flow rate. All valves shall be suitable for extended service operation without extensive requirements for lubrication or servicing.

Tees, valves, and blind flanges shall be provided to allow for additions of equipment and piping to the CUP without interruption of services. Piping systems shall be sized for ultimate loads. Tees, valves, and blind flanges shall be provided on distribution piping systems for the expansion of distribution systems; sectional valves shall be provided

in the distribution piping for piping system repairs and at key locations to provide isolation and servicing of equipment. On compressed air lines, quick disconnect connections shall be installed downstream of sectional valves to enable the use of portable compressors in emergencies. The piping design and materials selection shall be in accordance with ANSI/ASME Standard B31.9 Building Services and ANSI/ASME Standard B31. Power Piping.

The hydronic systems design shall be based upon the following criteria.

- A. Piping shall be designed in accordance with specified technical criteria. Water pipe sizing shall be based on the stricter of the two following parameters:

Table 2-3: Water Piping Sizing

Pipe Size	Max Velocity (fps)	Max Pressure Drop* (ft per 100 ft pipe)
up to 2"	4	8.5
2-1/2" thru 6"	6	4
8" thru 12"	8.5	2.5
14" thru 20"	10.5 (14)**	2.5
24" thru 42"	11.0 (14)**	1.5

* Based on new, clean steel pipe

** Number in parentheses is velocity limit applicable to long straight runs where noise is not critical (such as pipe tunnels, etc.). Maximum pressure drop still applies.

- B. Pressure drops in piping systems shall be calculated to allow for aging and corrosion of the interior surface. Therefore, all water piping systems shall be designed with the following friction factors (C values) based on the Hazen Williams Friction Factor formula.

Table 2-4: Water Piping Friction Factors

System Type	C Value
Closed Water	120
Closed, treated water	130
Open water	100
(New clean steel pipe)	(140)

- C. Hot and chilled water distribution systems should be designed for variable volume flow.
- D. Hydronic systems should be designed for the widest practical ΔT and the closest possible approach of the return water temperature to the terminal equipment supply air temperature.
- E. The terminal equipment must be selected not only for its full load capacity but also for its performance over the full range of partial loads. Laminar fluid flow in the coils shall be avoided.
- F. Integral face and bypass coils should be utilized with preheat coils.
- G. Coils subject to 100% outside air at winter design conditions shall be protected by one of the following methods:
- Provide propylene glycol in the water loop serving the AHU coils for those units arranged for smoke removal - automatic 100% outside air capacity. These units must not be equipped with protective

- override controls to shut off the fan if a freezing condition is determined when operating for smoke removal. The glycol-water loop for this system is to be linked to the main heating hot water system through a plate and frame-type heat exchanger.
- b. For those units not arranged for smoke removal use, provide freeze protection thermostats on the coil face to shut down the unit fan if a freezing condition is detected.
- H. The impact of the change in volume due to the thermal expansion of the distribution system fluids during all operations must be addressed in the design process.
- I. Control valves in hydronic systems must not be oversized. The flow characteristics and pressure drops are to be selected for the appropriate Cv value corresponding to the design flow to be controlled.
- J. Provide automatic air vents at all coils and at the high points of all piping. Provide drains at the low points of all piping.
- K. Hydronic systems controls shall be automatic and adjustable to optimize pumping and thermal efficiency.
 - a. As of 2012, three-way valves are no longer allowed at DEN at the terminal complex.
 - b. Use pressure-independent two-way valves at coils in variable flow systems.
 - c. Hot water coil valves shall fail to the open position.
 - d. All valves in the heating water system shall be specified with components that are rated for 230°F continuous operations.

2.1.10 Central Plant Facilities

- A. Chillers
- B. Chiller pumps
- C. Chilled water primary distribution pumps
- D. Boilers
- E. Hot water pumps
- F. Cooling tower and pumps
- G. Water treatment equipment
- H. Water treatment chemicals
- I. Air compressors
- J. Compressed air aftercoolers
- K. Compressed air dryers
- L. Compressed air storage tank and the associated piping and valves for the chilled water, condenser water, hot water, and compressed air systems
- M. Miscellaneous equipment

Each water distribution system shall be designed to maximize system and equipment performance and minimize energy usage under all load conditions throughout the system's seasonal operation. The system must also provide the required water flow to and from all load points under all system load conditions. The following proposed system configurations describe a means to accomplish the system objectives. However, the final system configuration and layout should be determined based on the actual equipment capacities and sizes and system requirements. The chilled water, hot water, and condenser water system configurations should be refined and finally established when the final system parameters are determined.

2.1.11 Chilled Water System

The chilled water system shall be configured in a primary-secondary arrangement. The first loop is the primary loop, which shall use chiller pumps in parallel and headered to circulate water through the chillers that are piped in parallel.

The pumps shall be connected in parallel on suction and discharge headers with a 1-to-1 ratio of chiller pumps to chillers. Pumps shall modulate speed to maintain flow through the operating chillers and around the primary loop. Under no circumstances shall the chilled water pumps deliver flow below the minimum allowable flow to an operating chiller. The chiller loop must be arranged to easily adapt additional chillers and chiller pumps for future capacity requirements.

The distribution loops are labeled secondary loops and are variable flow systems. The primary loop distributes the chilled water from the chillers to the terminal building, concourses, and other buildings and areas to be served with cooling, where secondary pumps in parallel supply the secondary distribution piping with chilled water.

The secondary pumps shall be modulated and staged based on static pressure at the most hydraulically remote point of the critical circuit of each secondary distribution loop. The CUP EMCS shall cycle the primary loop pumps to match the combined system load of the secondary loops by maintaining a slight positive flow (approximately 1–2%) in the decoupler line between the primary and secondary loops.

Flow measuring devices are required in each loop and subcircuit, as well as in the decoupler.

2.1.11.1 As-Built Drawing Chilled Water Abbreviation

Existing drawings for much of DEN denote the Chilled Water Supply and Chilled Water Return abbreviations as CWS and CWR, respectively. New drawing sets shall use industry-standard abbreviations for Chilled Water Supply and Chilled Water Return: CHWS and CHWR, respectively. CWS and CWR shall be used to denote Condenser Water Supply and Condenser Water Return, respectively.

2.1.12 Condenser Water System

The condenser water system shall be arranged with vertical turbine pumps, piped in parallel to supply condenser water from the sump to the chillers that are also piped in parallel. Each chiller also has its own dedicated condenser water pump upstream, with control valves and piping arrangements that provide several bypass options. When the condenser water leaves the chillers, it is routed to the cooling towers for heat rejection.

The condenser water system shall be provided with the necessary accessory piping, valves, controls, and equipment for the utilization of free cooling directly as part of the chiller equipment or provided through a separate heat exchanger.

The 2013 sump separation project introduced significant changes to the operations of the sump, cooling towers, and pumps (collectively, the condenser water system). The ability to isolate the sump into halves creates the possibility for seven (7) distinct operating modes:

- A. Mechanical cooling with no sump separation.
 - a. Normal summer/hot season mechanical cooling mode.
 - b. All chillers and cooling towers are enabled.
- B. The only mode that achieves maximum chiller plant capacity.
- C. Mechanical cooling with west sump isolation (West sump is full; East is unavailable).
 - a. Used if sump maintenance is required during mechanical cooling operation.
 - b. Limited to 39,000 GPM maximum condenser water flow to isolated sump section.
 - c. Maximum six of the eight existing cooling tower cells (75% of max condenser load).
- D. Mechanical cooling with east sump isolation (East Sump is full; West is unavailable).

- a. Used if sump maintenance is required during mechanical cooling operation.
 - b. Limited to 26,000 GPM maximum condenser water flow to isolated sump section.
 - c. Maximum four of the eight existing cooling tower cells (50% of max condenser load).
- E. Plate Frame HX-free cooling mode with no sump separation.
- F. The following sequences are implemented in the CUP for the free cooling mode of operation:
- 1. Plate and frame exchanger 3 is the default exchanger.
 - 2. Plate and frame exchangers 1 and 2 now have a single toggle on the new "Plate N Frame" graphics to enable or disable them when the system is in Free Cooling mode.
 - d. Condenser water pumps control to maintain 34 PSI in the condenser water header.
 - e. Chilled water pumps control to maintain a positive 50 GPM through the decoupler.
 - f. Normal winter/cold season free cooling mode.
 - g. Maximum four cooling tower cells operated simultaneously for PHE-free cooling (14,260 GPM).
 - h. Cooling Tower activation shall be staged based on outside air temperature (OAT):
 - 1. Upon a fall in temperature below 38°F OAT, four (4) Towers shall run.
 - 2. Upon a fall in temperature below 36°F OAT, three (3) Towers shall run.
 - 3. Upon a fall in temperature below 33°F OAT, two (2) Towers shall run.
 - 4. Upon a fall in temperature below 24°F OAT, one (1) Tower shall run.
 - 5. At any OAT below 24°F, only one cooling tower shall run to prevent towers from icing.
 - 6. Upon a rise in temperature above 28°F OAT, two (2) Towers shall run.
 - 7. Upon a rise in temperature above 35°F OAT, three (3) Towers shall run.
 - 8. Upon a rise in temperature below 38°F OAT, four (4) Towers shall run.
- G. Plate Frame HX free cooling mode with west isolation.
- a. Used for sump maintenance during PHE-free cooling operation.
NOTE: Sump maintenance will take place primarily during the cold season.
 - b. Turbine pumps serving isolated sump modulate/stage to provide condenser flow and a pressure of 34 PSI in the header.
 - c. Only towers in cells 2 – 5 shall be used.
- H. Plate Frame HX free cooling mode with east isolation.
- a. Used for sump maintenance during PHE-free cooling operation.
NOTE: Sump maintenance will take place primarily during the cold season.
 - b. Turbine pumps serving isolated sump modulate/stage to provide condenser flow and a pressure of 34 PSI in the headers.
 - c. Only towers in cells 6 – 9 shall be used.
- I. Transition mode with sump separation but no isolation
- a. Normal shoulder season transition mode with full PHE and partial chiller capacity available (not simultaneously).
 - b. Sump, respective cooling tower banks, and the 48" CS header are completely separated.
 - c. Resulting in a dual-temperature condenser system that independently serves the PHEs and chillers.
 - d. Limited to 26,000 GPM maximum condenser water flow to East sump section; maximum four cooling tower cells available for chillers (50% of max condenser load.)
- J. CT-5 is not available in this mode.

2.1.13 Heating System

Heating in all building spaces shall be provided by hot water from hot water generators (boilers) located in the CUP. The hot water system will consist of a variable flow, primary hot water distribution system loop from the boilers to the Terminal Complex, and a secondary variable flow distribution system loop serving each building within the complex. The boilers are fed return water from a common header piping system that the primary pumps pump into. Primary hot water boiler pumps shall be equal in number to the boilers plus two spares (N+2) and shall circulate and maintain a constant temperature at each boiler outlet. The primary loop will consist of pumps in

parallel supplying a variable flow at a constant temperature of 220°F (reset with outside temperature), as required by demand from the secondary loops. The primary pumps shall be modulated to match the total system load, which is the combined load of the secondary loops. Primary pumps are controlled to maintain a pressure differential set-point at the end of the mains serving the concourses.

Each concourse and major facility adjacent to the CUP shall have its own secondary loop. Pumps serving the secondary loops shall provide a variable flow sufficient to maintain a pressure differential setpoint in the most hydraulically remote point on the critical circuit of the secondary loop. The concourses have several different sets of piping mains supplying different sections of the concourse and can control to different setpoints depending on the load distribution. The hot water supply temperature to each secondary distribution loop is maintained at a constant 190°F using a bypass across the secondary supply and return with a modulating control valve. This valve blends the 220°F water entering from the primary loop with the cooler (~170°F) return water to maintain the supply water temperature to the secondary zone. The return water temperature back to the primary loop can fluctuate, but under design conditions, should be 170°F. Designers shall provide one stand-by pump for each loop system.

Any work done on the boilers or heating water distribution system throughout the Terminal Complex is generally done during the summer months. The Hotel requires heating from the CUP year-round, and any heating system work must keep heating water supplied to the Hotel from either a temporary bypass or another temporary means depending on the type of work.

2.1.13.1 Hotel As-Built Drawing Heating Water Abbreviation

The Hotel/Transit Center (HTC) as-built drawings use a different abbreviation system for hot water than the rest of the Airport. HTC as-built drawings abbreviate the Heating Water Supply and Return as MTWS and MTWR. Because the HTC heating water hydronic system is fed by the CUP, the water temperatures of the HTC heating water hydronic system never exceed those in the primary hydronic loop.

2.2 Energy Management

2.2.1 General

Part of the 2013 CUP controls upgrade included the installation, via JCI, of the Optimum Energy CPO30 chillerplant optimization platform. This platform, which piggybacks off the CUP EMCS, is used to optimize the energy performance of the entire chiller plant by automatically adjusting setpoints and monitoring components and total system energy usage. The chiller plant will run primarily in this loop mode, with CPO30 providing setpoints and commands to the CUP EMCS (within certain pre-specified limitations). Secondly, and as a backup, the chiller plant can be run in JCI mode according to the default JCI control sequences, which are designed to meet loads and safely operate all equipment but are not necessarily optimized for energy performance.

Previously, in 2009, an energy management system (Honeywell Energy Manager) was installed to monitor the energy usage of the chillers. This system connects to the Facilities EMCS (Honeywell EBI). This system will remain in place and will feed data to the new CUP EMCS.

2.3 Equipment Tags and Re-Numbering

In 2012, some equipment and essentially all pumps and control valves were renamed to follow a standard convention throughout the plant. Legacy ID tags are no longer used for these items. Please contact DEN Mechanical Engineer for the current naming schedule, which indicates new tags to be used for all current and future projects, as well as legacy ID tags for reference.

End of Chapter

This page is intentionally blank.

Chapter 3 - HVAC Systems

3.0 HVAC Systems

3.0.1 Air Handling Systems

The most appropriate designs for an airport terminal necessitate that the space conditioning system be flexible and responsive to wide swings in thermal loads. Factors include constantly changing people loads, high people door usage, air infiltration, shifting passenger densities, shifting solar loads, and baggage handling transfers in and out of the building. These items change in timing and intensity depending on changes in aircraft schedules and special peak passenger periods.

The air handling systems, including fans, motors, and duct static pressure losses, shall be adjusted for the high altitude at the airport site.

The AHU selection must also consider the primary system design. For DEN, the AHUs will utilize hot and chilled water from a four-pipe distribution system. Separate cooling and heating coils shall be required. The heating coils shall be selected for a minimum 30°F temperature differential (190°F to 160°F, plus or minus). The cooling coils shall be selected for an approximate 16°F temperature differential (42°F to 58°F, plus or minus 2°F) or as required by the psychometrics of the specific system design. This criterion shall be coordinated with the CUP design.

Packaged AHUs should be used for applications below 10,000 CFM. Customized, built-up AHUs may be used in applications above 10,000 CFM.

Cooling and heating coils are to be sized and arranged for water velocities in the 6 fps range. Air cooling coils shall be designed to have a maximum air face velocity of 600 fpm. Air heating coils shall have a maximum air face velocity not to exceed 800 fpm. Fin spacing shall be as wide as possible to provide the specified leaving coil conditions.

DX cooling coils shall be row split (in lieu of face split) where multiple coil sections are required. All refrigerants used at DEN shall be hydrofluorocarbons (HFCs) or HFC blends with a global warming potential (GWP) of less than 1800 and a refrigerant class A1 according to ISO 817. Other refrigerants not banned or phased out by the Montreal Protocol and amendments may be used only with written permission from DEN Mechanical Engineer.

Natural gas-fired heating coils shall be indirectly fired. Direct-fired heating coils shall only be used with written permission from DEN Mechanical Engineer. See [3.6.Sustainability](#) for the use of natural gas-fired equipment at DEN.

All supply AHUs shall be draw-through, built-up systems except in instances where sound control would favor the application of blow-through units. Each unit shall consist of a non-overloading supply air fan selected for maximum efficiency. Fan selection shall be based on noise criteria requirements. Centrifugal fans shall be used; however, vane-axial fans may be considered if economy, efficiency, and noise criteria parameters can be assured.

In addition, each AHU system shall contain separate cooling and heating coils (includes cooling only units), a final filter section, a throwaway filter section, an air blender section to eliminate air stratification, a mixed air plenum for outside air and return air duct damper connections, and a sound attenuation section if required. Integral face and bypass dampers shall be considered for preheating coils in appropriate areas. Each AHU section shall be provided with an access door and non-breakable plenum light (coordinate with corresponding electrical designs). Heating coils shall be located upstream of the cooling coils, with space in between the two coil sections to facilitate access for maintenance and inspection. Tight shutoff-type dampers shall be provided for the outside air damper.

The following air handling systems may be used for various applications at the DEN terminal, concourse areas, and other support facilities. These include single-zone systems, Multi-zone systems, variable volume systems, heat pump systems, and rooftop HVAC systems.

3.0.1.1 Air-Handling Unit Access Doors

Walk-in access doors shall be installed in Air Handling Units to provide access for maintenance at every fan, damper, filter, coil, and sensor. Doors shall be sufficiently sized to allow for any motor, coil, filter, and/or damper to be removed from the unit without disassembling the unit's frame or walls. Doors shall be mounted flush to unit walls and shall not compromise structural or thermal performance. Doors shall be hinged and, when open, shall not impede the removal of internal unit components such as motors, fans, or coils from the unit. Doors large enough shall have a 12x12 inch inspection window constructed of ¼ inch thick plexiglass.

Doors shall not limit any other maintenance requirements in this Design Standards Manual.

3.0.2 Single-Zone Systems

Single-zone type air handling systems will effectively handle any local area (zone) of a facility. However, a multitude of different temperature zones may necessitate a high number of single-zone AHUs. The disadvantages of such a design would be the requirement for more mechanical room space, higher maintenance costs, and increased capital costs due to the number of individual units that would be required. The use of single-zone AHUs on a large scale is not economical. A multitude of single-zone units serving large main spaces would also reduce the flexibility required to accommodate future space modifications.

Single-zone AHUs do have suitable applications; however, to serve certain perimeter zones of the terminal building and concourses. They also have applications in many areas in the various support facilities, where their use would prove to be the most suitable solution.

3.0.3 Multi-Zone Systems

Multi-zone air handling systems offer the advantage of centralizing air handling equipment to an extent; however, the use of this equipment is not an energy-efficient alternative. This is due to the constant mixing of heated and cooled air that could create a situation where the cost of distribution ductwork could exceed that of other alternatives. In addition, multi-zone units operate most of the time in a partial reheat mode (the air is cooled and dehumidified and then warmed, thus the term reheat). This is an energy waste that cannot be reconciled with current energy standards of the Model Energy Code and ASHRAE standard 90.1. Multi-zone units do not offer the flexibility desirable in airports for future space modifications.

Multi-zone units shall not be utilized in the design of DEN, its terminal, or concourses. Multi-zone units should be used only in unusual situations in remote facilities where only a few zones are required, and the economics justify their use.

Dual duct systems are similar to multi-zone systems in that both systems have a hot and cold deck. Constant volume dual duct systems will not be permitted. VAV dual duct systems, where there is no mixing of the hot and cold decks, are NOT an acceptable system for an application at DEN.

3.0.4 Heat-Pump Systems

Air-source heat pumps are not recommended for application in non-net-zero-energy facilities due to the predominately cooler climate of Denver, Colorado. Nearly 40% of the heating hours in Denver are below 30°F. At approximately 30°F and below, air-source heat pumps no longer function efficiently, and some other form of auxiliary heating is required.

Reverse cycle chiller-type heat pump systems and Variable Refrigerant Flow (VRF) systems may be used in any building at DEN designed for net-zero-energy usage. When designing these systems, designers must submit a life cycle cost analysis over the baseline of electrical resistance heating, along with any other systems considered for energy reduction measures during the schematic design phase. Where these systems are used, supplemental heating is required.

Air-source heat pumps may be used in very remote facilities where economic evaluations justify such systems. In these cases, supplemental heating is required.

3.0.4.1 Ground-Source Heat Pumps

Ground-source heat pump systems may be used for newly constructed buildings. Design of ground-source heat pumps must not require currently installed apron, taxiway, or runway panels to be demolished during construction. No ground-source heat pumps may be installed under movement area taxiways or runways. When designing ground-source heat pumps for a non-net-zero energy building, designers must submit a life cycle cost analysis over baseline hydronic heating or natural gas heating where hydronic heating systems are not available, along with any other systems considered for energy reduction measures during the schematic design phase. Where these systems are used, supplemental heating is required.

All loops for ground-source heat pumps must be individually isolated. Loop isolation must be inside mechanical rooms in the building the heat pump serves or in lockable vaults outside of the building. Vaults must not be located in taxiways, runways, or in aircraft parking footprints.

3.0.5 Roof-Mounted HVAC Systems

Another alternative, viable in many building applications, is the decentralized, roof-mounted, packaged HVAC system. The greatest advantage of this type of system is its lower initial cost (both mechanical system cost and building space allocation costs).

The disadvantages of the packaged rooftop equipment include the concerns of aesthetic appearance, maintenance, energy efficiency, and noise:

Rooftop HVAC equipment shall not be incorporated into the designs for the DEN terminal, its concourses, or other airside buildings without written approval from DEN Mechanical Engineer. However, this equipment does have applications for some of the support facilities. These shall be in accordance with FAA standards. Rooftop equipment is not to interfere or hinder the use of existing fall protection systems. Whenever a rooftop unit is utilized in the mechanical design of a building, the following concerns should be addressed in detail:

NOTE: All roof-mounted equipment surfaces shall be a dull, non-reflective white or gray finish to prevent sun reflection from obstructing control tower operations.

3.0.5.1 Maintenance

Equipment shall be readily accessible.

NOTE: Certain weather conditions (e.g., lightning, high wind speeds, etc.) can restrict access to roofs. Air- port Operations can also restrict access to roofs at their discretion. Designers should be aware of these possible restrictions and consult the PM about risks and other options.

New roof-mounted equipment shall maintain clear space for required service areas, and new reinforced roof walkway pads shall be installed from the nearest roof access to the equipment. Walkways shall extend around the entire equipment.

3.0.5.2 Energy Efficiency

This equipment is normally air-cooled and is often not designed to be energy efficient.

3.0.5.3 Thermal Performance

Thermal performance shall comply with the requirements in the latest edition of ANSI/AHRAE/IES 90.1. Effects of metal-to-metal contact and thermal bridges shall be included in the calculations.

3.0.5.4 Surface Condensation

Unit cabinets shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior of the cabinet. Portions of cabinets located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casing to prevent condensation from occurring on the interior and exterior surfaces. The thermal break shall not compromise the structural integrity of the cabinet.

3.0.5.5 Maximum Leakage

Unit cabinets shall have a maximum leakage of 0.5 percent of the total supply-air flow at a pressure rating equal to the fan shut-off pressure.

3.0.5.6 Deflection Performance

Unit cabinet wall and roof deflection shall be within 1/240 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits shall be measured at any point on the surface.

Cabinet floor deflections shall be within 1/360 of the span considering the worst-case condition caused by the following:

- A. Service personnel
- B. Internal components
- C. Design working pressure defined for the walls and roof

3.0.5.7 Wind-Restraint Performance

All wind restraints shall be designed by Colorado Licensed Structural Engineer. Wind-restraint design shall not be delegated to the contractor.

3.0.5.8 Noise and Vibration

Proper vibration isolation is usually not provided unless special requirements are specified.

3.0.5.9 Aesthetics

This equipment can have a negative impact on the appearance of a building, depending on the elevation of other buildings or facilities in the vicinity. An architectural enclosure shall be provided around roof-mounted mechanical equipment. Any mechanical equipment or architectural enclosure that can be seen from a public area requires coordination with PM or Design Review Committee approval.

3.0.5.10 Fall Protection

Rooftops at DEN do not have built-in fall protection with the exception of Concourse C East and Concourse A West expansions. Maintenance for any equipment located within 10 feet of the edge of a rooftop will require additional fall protection installed. Any forms of fall protection visible from public areas (e.g., railings) require coordination with PM for Design Review Committee approval.

3.0.5.11 Rooftop Penetrations

Any rooftop penetrations shall be detailed by Colorado licensed Structural Engineer. Penetration design by the contractor is prohibited. Penetrations shall be designed in a manner that does not void the roof warranty.

3.0.6 Variable Air Volume Systems

In a VAV system, the air volume supplied to the conditioned space is modulated to maintain the space temperature utilizing a constant supply of air temperature. This system can offer the best approach to meet two major goals, energy efficiency, and moderate initial capital costs.

The VAV system shall contain the air-handling system components described above for air handling systems, plus variable frequency fan motor drives. Fan inlet vane controls are not an acceptable method of achieving variable flow. The air distribution system shall be of a single or dual duct design based upon further analysis of such items as maintenance, capital, and operating costs. The appropriate variable volume terminal boxes shall then be provided to control the airflow to the space.

It is important with VAV systems that proper outside air ventilation rates be maintained, as well as building pressurization. Additional HVAC equipment or controls may be required with VAV systems to control pressurization. This issue will be addressed in the temperature control system requirements. The advantages of VAV systems in both flexibility and energy efficiency outweigh the additional control requirements.

VAV systems are recommended for several areas in DEN terminal buildings, office areas, concourses, and many other interior and perimeter zone applications.

Systems shall be designed to deliver a minimum 0.5" WC at the most remote VAV box.

3.0.7 Perimeter Systems

Any expanse of the exterior glass wall area in the terminal, concourses, or other areas will require a perimeter thermal conditioning system. These systems are to be designed to handle at least the conduction and infiltration loads of the perimeter walls, plus potentially some radiant solar and internal loads near the perimeter, depending on the application.

There are two suitable methods to handle the perimeter loads:

- A. Perimeter finned-tube hot water radiation system

This is effective but only serves during the winter heating system.

- B. Forced air system at the perimeter

Air circulation at the perimeter reduces pockets of stagnant hot or cold air. Air movement near the glass can also minimize the chance of condensation forming on the glass.

A perimeter forced air system is to be provided for the terminal and concourse buildings. This should be a variable volume system to provide the necessary throw-at-the-sill diffusers during mild weather. The perimeter system is preferably located at the sill rather than overhead to counteract downdraft at the windows during the winter. Some perimeter areas with low ceilings (9 ft. or less AFF) may use ceiling supply for the perimeter system; in addition, these areas could be VAV with heat if the system supplies only the perimeter and can handle both heating and cooling peak load conditions. New installations shall take into consideration the limitations to reheat imposed by ASHRAE 90.1.

Perimeter finned-tube hot water radiation systems are recommended in vestibules and other areas where there are small expanses of glass limited in height. In these cases, the winter heating condition is the only condition of need.

Caution should be used in providing sill system components so that they do not easily collect trash.

Due to the constant volume nature of parallel or series fan-powered VAV boxes and the increased maintenance costs, they are generally not allowed. If fan-powered boxes are desired, the engineer shall submit an energy, maintenance, and life cycle cost analysis over the baseline VAV system to the DEN Mechanical Engineer for justification of usage in any project.

Electric heating coils should not be considered when hydronic heating systems are present.

3.0.8 HVAC for Unfinished (Tenant) Areas

HVAC systems for unfinished future Tenant areas shall be designed to provide for heating and cooling in accordance with the same criteria as for the systems described previously. The interior spaces (defined as that space 12+/- feet

from the exterior wall) shall be designed for VAV with only cooling primary air ductwork routed to the terminal units. The VAV units shall be sized to deliver approximately 1.25 CFM of supply air per square foot. Prior to setting airflows, the anticipated use of Tenant areas shall be reviewed for functions that may require airflow rates above this amount (i.e., kitchens, bars, etc.). Additional CFM shall then be built into the air handling system design to easily handle these special areas. Controls will be connected to the VAV terminal unit only if some cooling or ventilation is required in the space.

The exterior glass walls shall utilize a perimeter forced air system as described previously. The perimeter system shall be complete in the unfinished area. The interior system shall be complete only to the VAV terminal system components.

3.0.8.1 Concourse C West Expansion - Tenant Areas

Existing VAV systems serving exclusively perimeter loads shall not be demolished or modified to include interior space loads. A separate VAV or makeup air system shall address interior loads as required.

When tenant spaces are designed for future use (e.g., grey box) with no terminal equipment installed, the final contract documents shall indicate the minimum and maximum allocated airflows for each space.

3.0.9 Fan Walls

Fan wall systems are generally acceptable. When fan counts exceed more than two (2) fans in a fan wall, the engineer shall submit an energy and life cycle cost analysis over the baseline single and/or two fan system to the DEN Mechanical Engineer for justification of usage in any project. Fan failure analysis should be default for all fan walls, not just four (4) or more. The engineer shall also submit a fan failure analysis with an O&M impact study to the DEN Mechanical Engineer. Fan wall systems shall identify removal methods/paths for all major components (fan wheels, motors, dampers, etc.).

3.1 Special Systems

3.1.1 Computer Rooms

Computer rooms that do not require cooling year-round shall have their HVAC systems connected to the CUP chilled water system for cooling. Electric resistance coils shall be used for reheating when dehumidification is required. Computer room units shall also have electric, steam-generating humidifiers equipped with suitable controls that limit supply humidity. Computer rooms that require year-round cooling shall have separate dedicated air conditioning systems for winter operation. HVAC systems serving computer rooms with a design capacity greater than or equal to 65,000 Btu/h shall have an economizer per requirements of ASHRAE standard 90.1-2010.

In remote areas where chilled water and hot water are not available, computer room units shall have a dedicated, dual-circuit refrigeration system, with remote condensing units located on the building roof and with electric reheat coils. If economically feasible, a condenser water system water-cooling tower may be installed to replace the condensing units. The condenser must have head pressure control and a P trap if the lineset has more than a 10-foot drop. A hot gas bypass shall also be installed.

3.1.2 Evaporative Cooling

Since evaporative cooling is economically practical, it should be considered where acceptable air quality is available. The use of evaporative cooling is limited at DEN to specific areas such as support facilities. Evaporative cooling shall not be considered as the sole means of cooling for the public areas in the terminal or concourses.

Evaporative cooling may be considered as an energy reduction measure to be utilized in conjunction with the DEN Chilled Water System. When evaporative cooling is used, the engineer shall submit an energy and life cycle cost

analysis over baseline DEN Chilled Water System cooling without an additional evaporative cooling unit to the DEN Mechanical Engineer.

Total evaporative cooling may be utilized, with an indirect/direct method of operation to limit the humidity level. The use of evaporative cooling is economically attractive, especially in the low-humidity climate of the Denver area. However, if a backup chilled water or DX system is incorporated with the evaporative cooling to handle humid days, the economics are unfavorable, and this should be avoided.

The disadvantages of the indirect/direct evaporative cooling units that must be addressed in the design process include the following:

- A. Additional AHU cost and space requirements.
- B. Increased maintenance requirements. (Evaporative media replacements, chemical treatment, water usage, etc.)
- C. Increased potential for water leakage and resulting damage.
- D. Decreased reliability due to the historical rapid deterioration of equipment utilized in evaporative cooling.

3.1.3 Humidification

Areas having special humidification requirements, such as computer rooms, radar equipment rooms, radio equipment rooms, etc., shall utilize individual electric humidifier units located either in the zone ductwork or in the individual room air conditioning units. Humidification through the main air handling systems is not to be provided. Humidifiers shall be the steam generator type. Provide high-limit humidity sensors downstream of the humidifiers. Downstream ductwork shall not be internally lined.

3.1.4 Air Curtains

Air curtains, plastic curtains, and rapid operation doors are to be considered for use at doors and openings at all maintenance-type facilities and at baggage doors and openings.

Overhead fan-coil units or fan-powered terminal boxes may be used as a modified type of air curtain at each concourse gate aircraft entrance. The fan-coil units shall be activated, if not already in operation, whenever the gate aircraft door is opened utilizing a 30-second time delay, and the supply air temperature is to be controlled from a space thermostat.

3.2 Ventilation Systems

3.2.1 Outdoor Air Requirements

Outside air shall be brought in through the air handling systems to satisfy minimum ventilation requirements plus provide building pressurization and minimize air infiltration at building entrance door areas.

Existing outdoor air requirements on air handling equipment in the terminal complex Facilities were designed around ASHRAE standard 62-1989. Outside air ventilation amounts shall be provided in accordance with the latest edition of ASHRAE standard 62 or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. The Engineer shall coordinate those requirements with the DDS and provide electronic copies of correspondence and documentation of the final design direction to the DEN PM. The Engineer is responsible for providing documentation that states the existing equipment can comply with any modifications in outdoor air.

Outside air intakes shall be located high and away from landside vehicle traffic and airside jet exhaust to the greatest extent possible, a minimum of ten feet above grade. All ventilation air will be brought in through air

intakes in the mechanical penthouses. If additional ventilation air is required, consideration should be given to using indirect-fired gas make-up air units or heat pump make-up air units with electric reheat with roof-mounted intakes. If heat pump make up air units with reheat are selected, refer to [3.0.4.Heat-Pump Systems](#) for heat pump requirements. In some locations, National Fire Protection Agency (NFPA) 415 may have requirements that are more prohibitive and shall be followed.

3.2.2 Air Economizer Control

All air-handling units used for comfort cooling with a design capacity greater than or equal to 54,000 Btu/hr shall be equipped with airside, dry-bulb economizer cycle operation. The control system for this operation must be arranged to modulate outside and return air dampers to maintain a mixed air setpoint temperature. Outside air dampers will close to the minimum position and return air dampers open when the O.A. is 75°F (adjustable).

It may not be appropriate to provide AHUs to be located on the apron level and similar areas with 100% outdoor air capability due to the air quality in these areas. Therefore, some air handlers shall be provided with continuous minimum outside air levels. All units with minimum outdoor air requirements shall have freeze protection. Upon restarting supply fans after freeze protection has tripped, outdoor air dampers shall remain closed for 5 minutes (adjustable) to allow supply air temperature sensors or freeze stats to reheat to avoid re-tripping freeze protection.

These units shall utilize waterside economizer cycles (if applicable).

3.2.3 Return Air/Transfer Air

Return air from the conditioned space back to the AHU should be via ductwork and ceiling plenums. The pressure drop in the return air system shall be minimized in the design. Return air fans should not be required in most cases. Maximum velocity shall be 500 fpm over net free area for general return and transfer air openings and 200 fpm over net free area for smoke control openings.

Eggcrate grilles shall be used in return air plenums that are used for smoke control. Perforated face grilles shall not be used.

3.2.4 Ventilation Rates

As described earlier in this document, the outside air ventilation rate shall be as recommended in the latest edition of ASHRAE standard 62.1. Careful consideration shall be given to these new recommended rates, particularly considering recent attention in the HVAC industry to indoor air quality. Applicable ventilation rates are published in ASHRAE standard 62.1.

Outside air requirements, unless otherwise specified, shall be as follows for normal occupancy levels.

The occupancy load in many public areas of the airport (i.e., concourses, hold rooms, ticketing areas, baggage claim, etc.) is highly variable. As an alternate to the ventilation air flows indicated as based on normal occupancy levels, it is acceptable to calculate the minimum ventilation rate of 10 CFM per person, based on peak load occupancy, unless exhaust requirements override this amount.

Ventilation shall be provided in all ground-level spaces that may have occasional or full-time occupancy. This ventilation shall be such as to minimize any possibility of an accumulation of radon gas; however, shall not be less than one (1) air change per hour.

Unoccupied crawl spaces in contact with the ground shall be ventilated likewise to eliminate radon gas hazards at a rate of one (1) air change per hour- on a time clock to run not less than four one-hour periods in each 24-hour day.

3.2.5 Filtration

Air filtration is an important consideration in the design of HVAC systems to serve airport facilities. Air should be brought in at the roof or penthouse level wherever possible to use the highest quality air available. As a minimum,

outside air is to be filtered using a 30" x 30" x 2" dry type pre-filter section having a minimum rating of MERV 8, 30" x 30" x 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

Filters for small air-handling units serving maintenance or non-public areas should be provided with a 4" dry type pre-filter section having a minimum rating of MERV 10.

Each filter sections shall have a digital differential pressure transmitter that connects to the EMCS for trending and maintenance activities.

3.3 Heating, Ventilation, and Exhaust Systems

3.3.1 General

This section covers areas of the building that are primarily mechanically heated and/or ventilated only, no air conditioning to be included. In general, ventilation rates, filtration, etc., mentioned previously for HVAC systems will apply unless otherwise indicated. Special exhaust requirements are also discussed.

3.3.2 Bag Makeup and Tug Drive Area

3.3.2.1 Ventilation

These spaces shall be maintained under negative pressure in relation to the main terminal (public space) area. This will be accomplished with the use of exhaust fans. The exhaust shall exceed the 100% O.A. makeup air quantities by approximately 10% in the bag makeup area. Ventilation rates shall be a minimum of 6 air changes per hour in the bag makeup area and 10 air changes per hour in the tug drive area if internal combustion engines are utilized. If all electric vehicles are utilized, the air change rate may drop to 2.0 air changes per hour of makeup air. Makeup air units shall be sized to supply 60°F discharge air during winter design conditions unless heat recovery is being used.

3.3.2.2 Heating

The bag makeup area shall have a 100% outside air makeup unit with filters and heating coils or indirect gas-fired equipment. In addition, hot water unit heaters or low-intensity infrared heaters shall be strategically located throughout the area and near overhead doors to maintain space temperature. Consideration will be given to providing low-intensity infrared heat in lieu of some unit heaters, depending on overhead door activity. This will be based on input from the individual Tenants that will utilize this space. Consideration shall also be given to recover heat from the exhaust air stream. The tug drive shall be tempered with low-intensity infrared heaters placed at bag drop-off areas.

3.3.3 Truck Dock Ventilation

An exhaust system shall be provided to ventilate truck docks on the apron level. This exhaust system shall continuously provide 10 air changes per hour in the truck dock area. This ventilation system will provide the added benefit of creating air movement and reducing carbon monoxide build-up.

3.3.4 Toilet Exhaust

Unless a more stringent requirement occurs in the current building code or current ASHRAE standards, the ventilation (exhaust) rate for all toilet room facilities shall be a minimum of 0.5 CFM/sq. ft. of floor space, six air changes per hour, or as required by the latest edition of ASHRAE 62.1, whichever is more stringent. Toilets with extremely high traffic, such as those located in concourse areas, should have a minimum exhaust rate of 10 ACH. Variable flow systems shall not be considered for public spaces.

Toilet exhaust systems are to be equipped with flow measurement stations equipped to send an alarm to the EMCS if the flow drops below 80% of design totals.

Under no circumstance shall a positively pressurized toilet exhaust duct run through a return air plenum or occupied space.

3.3.5 Service Level

3.3.5.1 Ventilation

Provide motorized-dampened air intakes and exhaust fans in all electrical and mechanical equipment rooms for adequate ventilation. Air intakes should be from the ramp or apron area. Compliance with applicable fire codes is essential.

3.3.5.2 Heating

Provide hot water or gas-fired unit heaters to heat the storage and equipment room areas where a heat loss is involved.

3.3.6 Atrium/Great Hall

The Atrium or Great Hall of the terminal building shall contain a relief air system in the high bay area that will relieve air due to pressure or temperature build-up. A makeup air unit shall also serve the high bay area to provide ventilation air and pressurization when required. These systems shall also be incorporated into a smoke removal system as required by NFPA and the Denver Building Code for high-rise structures.

3.3.7 Fire Sprinkler Valve Room With Nitrogen Generator

Oxygen sensors are required to be provided in fire sprinkler valve rooms where nitrogen generators are installed. The ventilation system shall be controlled by an oxygen sensor(s) and sized to provide a minimum ventilation rate of 1.0 CFM/FT². See section [5.2.10.Oxygen Sensors](#) for control requirements. Special situations where the designer can demonstrate that this requirement is not practical (like in a closet large enough for only the equipment), a DSM Variance may be submitted for consideration.

3.4 Existing Systems

3.4.1 General

The following is a general overview of the HVAC systems used in the base buildings at DEN. This narrative is general in nature and should not be used as the basis for sizing of equipment in tenant spaces, general specifications, and/or control sequence modifications.

3.4.2 Existing Air Handling Systems

In the present designated Tenant areas of the Terminal building, Concourses, and AOB, the HVAC systems consist of variable air volume air handling units with heating and cooling capability. The VAV systems provide the flexibility required to maintain comfort during shifting cooling loads. The holdrooms in the Concourses are supplied by both VAV and constant-volume air handling units. The exterior walls are supplied by heating-cooling VAV boxes that discharge out perimeter slot diffusers. The interior areas are supplied by constant-speed fans.

The air handling units in the Concourses and Terminal are located on the fourth level. The air handling units supplying the AOB are located on the roof. In the North Terminal, the air handling units are in the third-level mechanical equipment rooms. The first and second levels of the terminal have hot water only. The third-level has a

constant volume of air and access to both hot and chilled water. Verify the locations and available quantities for Tenant usage with the PM.

The Concourse basement levels have a limited amount of Central Plant heating water available for Tenant development. Most heating will have to be provided by electrical heat or gas-fired equipment. Presently the basements have four (4) air changes per hour of tempered air. In the Concourse B basement, the Ventilation/Smoke Control Fans (VSCFs) serve both ventilation and smoke exhaust. VSCFs are a legacy system and are being phased out. No new VSCFs shall be installed; new ventilation systems shall not serve double duty as smoke exhaust systems. For smoke control requirements, refer to the Smoke Control chapter in the Life Safety DSM. This smoke and ventilation air is not available to the Tenant for comfort heating or cooling.

The air handling units are dedicated to distinct zones with overlapping airflows via a common return/relief fan system. The perimeter zones are VAV and fan-powered units with heating water heating at the terminal unit. The interior concourse holdrooms and subcore areas are cooling only VAV units. The central circulation zone is served by a constant volume system. The VAV perimeter air handling unit discharge temperature will be reset based on the “worst space load.” All VAV heat terminals have double-ended control to increase air temperature and volume in unison.

The air handling units were sized based on normal heating and cooling loads for the public levels. The airflows are governed by the sensible cooling and winter heating load. There is no provision for latent loads. Air supply was based on the following:

Table 3-1: Basis for Existing Air Handling System Air Supply

Space	Minimum Occupancy
Bars	7 SF per person
Concession Areas	30 SF per person
Dining Rooms	15 SF per person
Holdrooms	100 SF per person
Offices	100 SF per person

Due to the large glassed area curtain wall configuration of the south perimeter zones of the Concourse and Terminal, large airflows were required by the South perimeter zone. To minimize the size of the South perimeter air handling units, a portion of the load was shared by the VAV air handling units serving interior zones.

Air handling unit airside economizer controls utilize free cooling when possible during mild weather. Outside and return air dampers modulate to maintain 55°F± mixed air temperature. At the minimum mixed air temperature of 45°F± or on a temperature rise over 75°F±, the outside air damper goes to a minimum position. Space temperature modulates hot and chilled water coil valves.

Variable volume control is monitored from static pressure control sensors located approximately 2/3 of the total duct length downstream of the air unit supply fan.

The control logic permits a reduction in outside air ventilation requirements when unoccupied. The specified ventilation rate is the minimum condition required at peak occupancy. Control elements for air handling unit operation also include high discharge fan static, low-pressure return air fan static, smoke detectors, and multiple function freeze stats.

Return air fan tracks the supply air fan to return 80-90% (adjustable) of the total related air handling units total supply to ensure positive space pressure.

3.4.3 Existing HVAC Air Distribution

The existing perimeter supply air system in the Terminal, AOB, and Concourses consists of in-place heating-cooling VAV terminal air units complete with supply ducts and slot diffusers. The amount of perimeter air per linear foot of the outside wall varies with the location. The interior supply air system generally consists of a SMACNA Class 4" WG primary duct that is supplied from the existing building supply system. The duct is routed in the ceiling of the Tenant spaces.

3.4.4 Existing Base Building Compressed Air Systems

Compressed air is generated from a centralized compressed air facility with oil-free reciprocating or screw-type compressors. Because of the critical nature of this system, there is one operational system with at least one stand-by system under all circumstances. This means that if one system is down for maintenance, there will be one system in operation and one additional system as a stand-by for a minimum of three systems.

The main distribution system air pressure is 80 to 100 psig with pressure-reducing stations to reduce the pressure to the respective usable levels for temperature control systems. The main control air is dried with externally heated, regenerative air dryers to a -40°F dewpoint to prevent airlines from freezing ambient air temperatures.

The dryers have adequate filters located both before and after the dryer. The dryers are interlocked to operate with their respective air compressor.

These systems are largely undocumented. Any project modifying systems with pneumatic controls shall not reuse the pneumatics. All new work shall be DDC.

3.4.5 Existing Ventilation/Smoke Control Fans (Historical Relevance Only)

Ventilation/Smoke Control Fans (VSCFs) are a legacy system used exclusively in the basement of Concourse B. The VSCFs at DEN are being phased, and new VSCFs shall not be installed. VSCFs work by using dampers to reverse the flow of air through ventilation ductwork, changing their function from providing ventilation to smoke exhaust.

No new VSCFs shall be installed at DEN. All fans used for smoke exhaust or smoke pressurization shall be used exclusively in these functions and shall be labeled as Smoke Exhaust Fans (SEFs) or Smoke Pressurization Fans (SPFs), respectively. Refer to the Smoke Control chapter in the Life Safety DSM for smoke control requirements.

3.5 Tenant Remodel Requirements

3.5.1 Tenant Design Parameters

The Tenant shall provide adequate cooling to provide comfort conditions. Tenant shall not exceed the maximum amount of Lighting and Connected loads as defined in the Electrical DSM. If the allowable electrical load exceeds the following cooling capabilities, the Tenant shall provide additional cooling. The Tenant shall provide heat load calculations to confirm adequate cooling is being provided.

The Tenant shall provide a complete HVAC system to meet loads that exceed the requirements listed below. The Tenant shall verify the heating and cooling loads from the perimeter, adjoining structures, and adjacent spaces affecting the Tenant area. All Tenant areas in the Terminal are in the interior spaces and are unaffected by the perimeter heating /cooling loads. Tenant Designers shall provide DEN with heating and cooling load calculations.

Reference the Tenant DSM for Tenant Remodel Requirements.

3.5.2 Existing Base Building Mechanical Design Capabilities

The base building air handling system in the Concourses has been designed to accommodate the following loads for Restaurants, Food Courts, Offices, and Concession Spaces (aka ALLOWABLE LOAD):

- A. Basic Office, Retail, Airline Tenant: Exterior Load + 1.00 CFM/SF
- B. Restaurant Tenant: Exterior + 1.25 CFM/SF for the seating area. Kitchen is to be conditioned with a tenant-supplied mechanical make-up air system.
- C. Bar Tenant: Exterior load + 1.25 CFM/SF
- D. Food Court Tenant: Exterior load + 1.25 CFM/SF for seating areas. Source of make-up air will be by each tenant and coordinated between DEN and each tenant.
- E. Concourse C West expansion & Concourse B South Regional Jet Facility: No Tenant HVAC (hydronic on airside) accommodations have been made. Tenant shall provide a complete stand-alone HVAC system.
- F. Concourse A West Expansion (MOD 6W and 9W). See [DEN Concourse A West Expansion Concessions Matrix](#).
- G. Concourse B West Expansion (MOD 8W and 9w). See [DEN CEP Concourse B West Expansion Concessions Matrix](#).
- H. Concourse C East Expansion (MOD 6E and 9E). See [DEN Concourse C East Expansion Concessions Matrix](#).

3.5.2.1 Hotel Level 5 - Fan Coil Units are Sized Only for Existing Shell Load

The Tenant shall provide adequate cooling for occupant comfort conditions with the Base Building supply air. When the Tenant's defined load cooling load exceeds the allowable load listed above, the Tenant shall provide a separate HVAC system to meet the load difference. If the allowable electrical load exceeds the allowable load, the Tenant shall provide additional cooling equipment. This may be accomplished with air conditioning units utilizing the DEN chilled water system or with a make-up air unit with DX cooling and an air-cooled condenser. Heating may be supplied by the DEN heating water system, direct or indirect-fired natural gas heat, or electric heat. The designer shall verify the availability of the existing system capacity. No system shall be assumed to have sufficient capacity without supporting calculations.

3.5.3 VAV Terminal Air Units

The interior Tenant VAV boxes and controls shall be furnished and installed by the Tenant. All variable air volume (VAV) units shall be pressure independent with normally closed, electronic damper actuators that have a minimum air flow rate adjustment to zero (fully closed). Heating coils shall be sized for heating the maximum air flow rate of each unit. All heating coil control valves shall fail open. All VAV terminal boxes shall have native BACnet communication and connect directly to the DEN EMCS. Refer to [Chapter 5- Controls](#) for additional requirements.

Perimeter VAV boxes are the property of the DEN and shall not be altered from original design. These systems are designed specifically for the curtain wall load. Tenants shall not use perimeter VAV systems for supplemental conditioning due to new Tenant loads. In some cases, VAV boxes, controls, and diffusers will need to be moved to meet Tenant architectural cases. Relocated equipment shall perform in the exact manner of the original installation. Refer to other chapters for operation and accessibility requirements of DEN systems.

Designer shall ensure all components of DEN VAV terminals are completely accessible for maintenance and no additional HVAC or Tenant equipment is required to be removed from operation to complete maintenance activities. Control modules shall have a minimum twenty-four (24 x 24) inches of clear space in front of the controls and an area directly to floor below to allow for maintenance activities.

3.5.4 New Tenant HVAC Systems

Most Curtain Walls areas on the Concourses and the Terminals are served by existing base building heating-cooling VAV and/or Fan-powered terminal air conditioning units. The exterior space is defined as that space from the exterior wall to 8 feet in from the exterior wall.

The Tenant shall provide terminal air units and appropriate ductwork if required for the perimeter areas. The system shall consist of heating-cooling VAV boxes.

The use of light-troffer diffusers is not allowed.

Interior spaces are designed for VAV terminal air units with 55°F± cooling-only air available from the existing primary duct supplied from the existing system. The Tenant shall connect to the primary duct to supply perimeter or interior areas and route to the VAV terminal units.

3.5.5 New Tenant Air Handling Units

Areas requiring year-round cooling requirements (such as computer rooms) shall have individual refrigerant systems. They shall be complete with roof-mounted or horizontal cabinet-mounted condensing units if access to the outside air for cooling through an economizer control is not available. Apron-level stand-mounted condensing units should be avoided due to the increased potential of damage by apron service equipment.

Areas having special humidification requirements, such as computer rooms, radar equipment rooms, and radio equipment rooms, shall utilize electric humidifier units located in the zone ductwork or in unitary or split air conditioning units. Humidification from the main air handling system is not provided.

Evaporative-type air handling units will be considered for isolated buildings such as maintenance, shops, and hanger building offices. In these instances, only indirect evaporative cooling with backup refrigeration will be considered. Direct evaporative cooled systems will be allowed for kitchen systems if all other refrigeration cooling systems are deemed not practical in writing by the DEN Mechanical Engineer.

All roof-mounted equipment surfaces shall be a dull, non-reflective white or gray finish to prevent sun reflection from obstructing control tower operations. These shall be in accordance with FAA standards. New roof-mounted equipment shall maintain clear space for required service areas, and new reinforced roof walkway pads shall be installed from the nearest roof access to the equipment. Walkways shall extend around the entire equipment.

3.5.6 Food and Beverage Tenant Equipment

All kitchens shall be air-conditioned. The exhaust requirements will be determined by the cooking exhaust hoods installed within the facility. All cooking and food reheating equipment, including ovens, fryers, grilles, conveyor toasters, and similar, shall have dedicated exhaust hoods serving the equipment. The kitchen exhaust system shall be designed in accordance with the latest version of NFPA 96, "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations," and the latest editions of the International Mechanical and International Energy Conservation Codes, including City amendments. Re-circulating hoods are not allowed.

Tenant shall furnish and install, if applicable, a complete kitchen exhaust system and mechanical make-up air system. In the Concourses and Terminal, each Food and Beverage Tenant shall provide their own mechanical make-up air system. Kitchen grease exhaust hoods shall be UL listed. UV systems may be used in type 1 hoods with the exceptions of heavy-duty and extra heavy-duty cooking appliances. In heavy-duty and extra-heavy-duty applications, UV hoods may be used in combination with another approved grease, smoke, and odor control system.

Exhaust and make-up air quantities shall be determined per food service Tenant. The system shall be complete with a hood, grease removal system, exhaust fan, and control panel. Roof-mounted exhaust fans shall be utility-set type and arranged in an upblast configuration.

Wherever food service has the potential for odor propagation outside of tenant areas, the tenant shall provide exhaust and make-up air.

The exhaust air from kitchen hoods shall be free from grease, vapor, and smoke. Installation of a water wash scrubber with filters shall be the preferred method. In the Terminal Building, the air scrubber shall be mounted on the roof. In the Concourses, the Tenant shall provide space for the exhaust fan and air scrubber within the Tenant's return air plenum space. Tenant air scrubbers may only be mounted on Concourse roofs with written permission obtained from DEN Mechanical Engineer. All roof-mounted tenant equipment in the Terminal and Concourses must conform with standards in [3.0.5.Roof-Mounted HVAC Systems](#). All clean-outs for grease-laden exhaust ducts must be located in Tenant space.

Designer to include a note on the drawing that upon completion of construction, general contractor is to provide an inspection report to DEN from a qualified kitchen exhaust cleaning contractor, confirming that sufficient access to clean the entire kitchen grease exhaust system has been provided. Any required modifications to allow complete system cleaning shall be installed prior to DEN acceptance.

Locations with roof mounted kitchen grease exhaust equipment shall include the installation of a frost-free roof hydrant for cleaning within 50 feet of the equipment. It shall be connected to the tenant's water supply, and include dedicated backflow prevention. Drains from the hydrant shall be routed into an approved receptor within the tenant's space.

Heat recovery from kitchen hood exhaust should be considered in the final design if grease buildup or collection can be avoided. Make-up air should be heated to 70°F or cooled via evaporative cooling equipment and supplied at the kitchen hoods. Packaged, factory-designed, and NFPA-approved kitchen exhaust hoods with make-up air systems are acceptable. To reduce cross-contamination and odors, no air from active cooking commercial kitchens shall return to the DEN base building air handling systems. Under no circumstance shall a positively pressurized kitchen or hood exhaust duct run through a return air plenum or occupied space.

Makeup air for kitchens shall be provided by a dedicated makeup air unit designed for a minimum of 100% of exhaust airflow. In no instance shall makeup air be taken from HVAC systems adjacent to the kitchen. All kitchens shall maintain a negative air balance in respect to adjacent spaces during active cooking operations.

See [Chapter 5- Controls](#) for additional tenant controls requirements.

3.5.7 Electrical Closets/Communications Rooms/Fire Control Rooms/ Fire Pump Rooms

Ductwork shall not be routed through transformer vaults and their electrical equipment spaces and enclosures except for ducts specifically serving those areas. If a Tenant's leased area is on a level directly above an electrical closet and if that tenant requires water, sanitary waste, or grease waste lines, those lines shall be installed in such a manner to avoid being routed directly above the electrical closets. Sanitary waste and grease waste lines may not be routed in or through Fire Pump Rooms. Lines above the Communications and Fire Control Rooms shall be sleeved to protect equipment with written approval from DEN Mechanical Engineer.

3.6 Sustainability

As part of the City and County of Denver's Office of Climate Action, Sustainability, and Resiliency (CASR), the [Energize Denver Ordinance](#), which establishes energy use intensity targets for buildings over 25,000 sq. ft., DEN is working to reduce our carbon emissions impact. As such, gas-fired HVAC equipment or fixtures, except for kitchen cooking equipment (stoves, ovens, etc.), needs to be evaluated by the consultant for alternate energy sources. Evaluation needs to include available electrical and heating water capacities as a replacement for natural gas. Also, areas in the Terminal Complex that need heating for any type of heating load shall be connected to the existing heating water system unless there is not enough capacity available. Remodeling of spaces may not replace the existing hydronic heating systems as a heating source with electric heat without an evaluation and justification.

Equipment heating source evaluations shall be presented and accepted in writing by the DEN Mechanical Engineer prior to proceeding with the design.

End of Chapter

Chapter 4 - Air Distribution Systems

4.0 Air Distribution Systems

4.0.1 Ductwork Design

Ductwork layout and sizing shall be performed using the best practices to ensure minimum energy loss by thermal transfer and friction. Design shall ensure that the minimal duct length is achieved and that no unnecessary loops or branches are used. Ductwork shall be routed in the most direct route feasible. Ductwork fittings shall be selected based on best practices for optimal performance in energy (friction and thermal) and sound transmission. Ductwork shall generally be designed for low pressure, i.e., 2.0" WG or less, positive or negative. All medium-pressure ductwork (operating pressures in excess of 2" WG, positive or negative) shall be sized based on the static regain method. All low-pressure ductwork shall be sized using either the static regain method or the equal friction method. The existing main ductwork upstream of VAV boxes is considered medium pressure. All ductwork systems shall be designed to minimize noise transmission through the ductwork and avoid noise generation from components or fittings. Ductwork air velocities shall not exceed the following limits:

Table 4-1: Ductwork Air Velocity Limits

Area	Velocity Limits
Mains - Equipment rooms and non-occupied spaces	3400 fpm
Mains - Occupied spaces	2200 fpm
Branch or mains with diffuser connection	600 fpm
Branch with diffusers	1200 fpm

Aspect ratios shall not exceed 4:1 for mains

4.0.2 Ductwork Requirements

Ductwork shall be either rectangular or round (spiral) as appropriate for the specific application. All designs shall be in accordance with SMACNA HVAC Duct Construction Standards and the technical criteria in this manual. All supply air distribution ductwork shall be galvanized sheet metal with flanges, seams, supports, etc., to match the appropriate duct classification as defined by SMACNA unless moisture in the system dictates the use of aluminum or stainless-steel materials. Kitchen exhaust ductwork shall be welded stainless steel.

Although SMACNA allows spin-in fitting for medium-pressure ductwork, because they are difficult to differentiate in field inspections from low-pressure fittings, spin-in fittings are not allowed at DEN. Spin-in fittings shall not be represented on plans or sketches for medium-pressure systems. Spin-in fittings are allowed on low-pressure systems.

Exposed ductwork used as an architectural feature shall be round and constructed of sufficient gauge metal to prevent dings or dents. Ductwork material shall be either aluminum finish or suitable for painting. No external insulation shall be provided on architecturally exposed ductwork. Lined ductwork shall be used in exposed areas when radiated sound level exceeds that required in [Chapter 1- General](#).

All 90-degree elbows in both medium and low-pressure ductwork shall contain double-walled, airfoil-type turning vanes unless long-radius elbows are used.

Ductwork near air-handling units and outside air ductwork will be lined, as required, for thermal performance, noise control, and condensation control.

The Design Consultant shall designate the calculated duct static pressure on the drawings to establish duct construction classification. Changes in duct pressure classifications shall be called out via note or symbol.

Flexible round duct shall be a maximum of 5 feet in length and be of material acceptable by the Denver Building Code.

In general, no ductwork shall be run underground.

No ductwork shall be routed through/across the AGTS tunnel.

4.0.3 Dampers

All control dampers shall be the parallel-blade type.

- A. Outside air intake, dampers shall have air-tight seals at both the edges and ends of the blades. The seals shall be of a material that will not disintegrate with exposure to jet exhaust fumes.
- B. Control dampers shall be provided on all main branch take-offs and on the main ductwork downstream of a branch take-off.
- C. Fire and combination fire/smoke dampers shall be UL listed and conform to the standards and requirements of the International Building Code and CCD building code amendments. To limit fire alarm addressing and maintenance of combination fire/smoke dampers, these dampers are only to be installed where required by code; use fire dampers to the greatest extent possible. Fire and combination fire/smoke dampers shall have access doors provided for service and maintenance no more than 12" away from the damper. Access doors shall be 12" x 12" or larger.

Due to long intervals of typical operational modes and various system pressure changes, all backdraft dampers shall have motorized actuators. No barometric-type dampers shall be specified on any system without written permission from DEN mechanical engineer. Tenant projects shall not use barometric-type dampers. Motorized dampers shall fail in a condition that provides maximum protection to occupants and equipment.

4.0.4 Diffusers

Various types of diffusers are to be considered based on architectural input. Consideration shall be given to quality, durability, capacity, aesthetics, throw, and noise level. Coordinate with the architect all diffuser types and locations. Linear slot diffusers shall be individual, 4-foot maximum sections with individual supply boots. Perforated face diffusers are not to be used. Diffusers with face-adjustable dampers/throw blades shall not be used.

4.0.5 Grilles

Standard core 1/2" x 1/2" x 1/2" eggcrate grilles shall be used in return, air plenums/systems. Eggcrate grilles shall have a minimum free area of 90%. Perforated face, louvered face, or other face types shall not be used in return air systems in smoke control areas.

4.0.6 Transfer Air

Transfer air openings are required in all walls to structure, in return, air plenums and smoke control zones. Transfer air openings shall be sized for a maximum velocity of 200 fpm in smoke zones and 500 fpm in return air plenums that are not used for smoke control. Sizing shall accommodate the entire return air/smoke control system to the point of installation. Refer to the Life Safety DSM for additional requirements.

4.0.7 VAV Terminal Air Units

Designer shall ensure all components of VAV terminals are completely accessible for maintenance, and no additional HVAC or Tenant equipment is required to be moved or removed from operation in order to complete maintenance activities. Control modules shall have a minimum of twenty-four (24) inches of clear space to allow for

maintenance activities. Each VAV Terminal Air Unit is to have its own method of disconnecting the controls for maintenance. Clear space shall be defined to mean the space directly in front of the device. Access to the clear space shall also be unobstructed. VAV controls shall be of the direct digital control (DDC) type and shall be able to interface with the Johnson Controls MetaSys control front end.

4.0.8 Security Gates

Security grates shall be installed on all ductwork and transfer air openings larger than 144 square inches between public spaces and private/security spaces. All roof penetrations larger than 144 square inches with a direct path of access indoors shall be required to have a security grate.

4.0.9 Ductwork Supports

Cable or wire ductwork supports shall not be used.

4.0.10 Presentation of Ductwork Systems

All ductwork shall be shown on construction documents as double lines, regardless of the drawing scale and pressure classification. Round ductwork shall be indicated with a centerline. Limits of all lined ductwork shall be identified clearly by double-line symbology. The Design Consultant shall detail all ductwork fittings and connection types.

Single line ductwork can be shown on Schematic Design, Design Development, 30%, and limited portions, 60% submittals only.

All ductwork shall be identified by system type (exhaust, supply, return, etc.). All callouts for ductwork continuations off the plan shall identify its termination/origin. All callouts shall be in the direction of airflow. General notes of direction are not allowed.

Table 4-2: Allowable Direction Callouts

Not Allowed	Allowed
24 x 24 up	24 x 24 SA up to mezzanine tenant service
24 x 84 SA from below	24 x 84 SA from AHU-D
22 x 36	22 x 36 EX
84 x 36 up	84 x 36 RA to REF-4

Designers shall indicate on plans all changes in SMACNA duct static pressure classifications. Changes shall be represented with a double diamond symbol containing the static pressure of each section. For example:

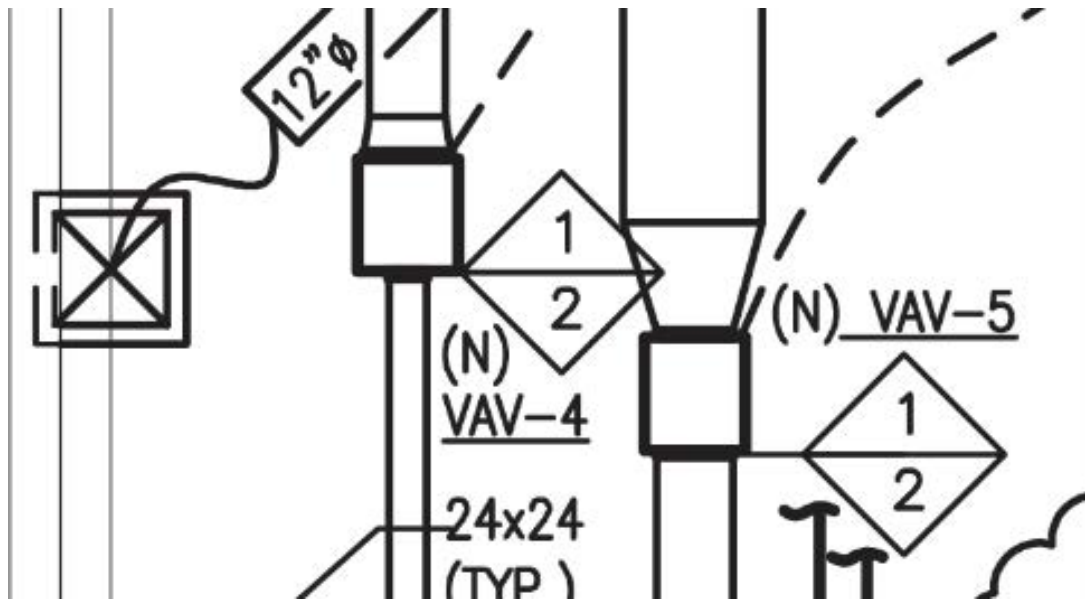


Figure 4-1: Allowable Duct Static Pressure Callouts Examples

End of Chapter

Chapter 5 - Controls

5.0 Controls

5.0.1 General

A complete system of automatic controls shall be provided to maintain space conditions within allowable limits. When heating and cooling are incorporated into one system for personnel comfort, the automatic temperature controls shall not be capable of simultaneous heating and cooling and shall provide a deadband. Automatic temperature control devices for personnel comfort shall have a heating control range between 65°F and 74°F and a cooling control range between 72°F and 85°F.

Designers are responsible for indicating in the construction documents (construction drawings and specifications) any aspects of Controls requirements for any project at DEN. Designers are not to refer to the DSM's directly, but include the relevant aspects of these DSM's into the construction documents.

Not all controls are for HVAC systems. Designer to coordinate with DEN for requirements for plumbing and other systems. Plumbing systems will include electric water heaters not used in Tenant spaces, sump pump status and alarms, emergency drainage flow switches and domestic booster pumps. Water detector alarms at water entry and mechanical rooms are to be included near backflow preventors and around each air-handling unit. Water detector alarms are to close the source of water that may be leaking at the room's boundary.

The system shall consist of all necessary control devices, control valves, control dampers, damper motors, pneumatic and electric switches, relays, gages, panel boards, tubing, and fittings, including all necessary accessories required for a complete and operative control system. All control wiring and control system electric power is to be furnished to provide complete environmental control and central panel functions. Products are to be of the latest design to avoid becoming untimely obsolete.

Control systems shall be electronic, digital systems controlling all HVAC equipment utilizing local microprocessor field panels located in the applicable adjacent equipment rooms. The field panels shall be capable of interfacing with the Energy Management Control System (EMCS) and shall be equipped with backup power in accordance with the Electrical DSM, Chapter 2. Field panels located in the CUP shall be housed in NEMA 4X cabinets. Electric motor operators shall be used for all new valve and damper actuators; pneumatic operators are used for many existing valve and damper actuators. The existing pneumatic control systems located throughout the concourses and terminal are largely undocumented and should not be used for new projects.

Equipment utilizing manufacturer's controls system shall control all elements of their equipment and not rely on external controls for part of its operation. As an example, equipment such as a DOAS unit with heat recovery to control freeze protection and not rely on an additional controls system for that function. Intent is to not have three different controls system for a single system.

The local field panels shall be tied to the Facilities EMCS for equipment outside of the CUP or the CUP EMCS (for CUP equipment) located at the CUP but capable of standalone operation. If a network engine is required, it is to be located in a DEN COMM room.

Projects integrating DDC controls, or other non-HVAC related controls systems, shall be completely independent of the HVAC controls' MS/TP networks and controllers. The intent is that non-HVAC controls cannot affect the HVAC systems during a loss of continuity in the controlling system's network.

Tenants that utilize their own HVAC systems and subsequently the maintenance of those systems, must have controls that indicate alarms and equipment shutdowns from a local control panel. Tenant controls systems are not to be integrated into the DEN EMCS. Where there are DEN building systems used by the tenant, additional critical alarms must be sent to the EMCS for response by DEN. Such critical alarms would include low air temperature alarms at make-up air units utilizing base building heating or chilled water systems, low heating water return

temperature, etc. The intent is to give an indication of a failure of tenant equipment such that DEN Maintenance will be notified that a DEN maintained system may be in danger of being compromised.

Airline tenant HVAC equipment status is to be integrated into the DEN EMCS system including modifications to the graphic interface. If a BACnet interface does not exist from the manufacturer for the particular equipment, then current monitoring in addition to space temperature could be included to give an indication of status when the equipment is supposed to be operating and isn't. Alarming will be similar to other stand alone equipment in the Concourses and Terminal. Other requirements for connecting equipment to the DEN EMCS are included in the DSM's (Mechanical, Electrical, and the Communication and Electronic Systems).

Any new HVAC equipment must be coordinated with DEN through the project manager even though DEN will not be operating or maintaining the equipment. In general, if airline tenants attach HVAC equipment in their space and connect it into a DEN utility (i.e., electrical, HVAC or Plumbing) then it will need to be added to the DEN EMCS system. The extent if the addition will be through a BACnet interface to monitor the equipment. Metering for the HVAC equipment will not be required for airline tenants.

Designer is responsible for locating sensors where external influences will not affect the sensor (i.e., don't locate space temperature sensors where sunlight can hit them or near heat producing equipment).

Reference the Communication and Electronic Systems DSM for more information and requirements.

5.0.2 Existing Base Building HVAC Control Systems

The HVAC host control system consists of a network of fully independent direct digital control (DDC) controllers that are interconnected via a multiplexed digital data trunk. Data available to any one direct digital controller is available to all DDC controllers. Each macro controller may supervise a sub-network of micro-level DDC controllers. Sensor input devices and output devices shall be connected to either the macro or the micro-level DDC controllers. Each room with macro controllers has a local operator interface using an English language format. The control system interfaces over a phone modem or Ethernet connection with a main server in the Network Operations Center and can be accessed remotely. Each macro in the system is connected together by a Local Area Network (LAN) for peer-to-peer communication, multiple-user programming, and data gathering.

Existing building control system manufacturers and integration requirements shall be verified with the DEN Mechanical Engineer during project design. The following listing is subject to change as ongoing projects are implemented:

- A. AOB: Honeywell. Transitioning to Johnson Controls.
- B. Terminal: Honeywell and Johnson Controls. Transitions to Johnson Controls as Great Hall work is progressing through the terminal.
- C. Concourse A: Honeywell and Automated Logic (West Concourse Expansion). Transitioning from Honeywell to Johnson Controls and Automated Logic.
- D. Concourse B: Johnson Controls BACnet
- E. Concourse C: Honeywell. Transitioning from Honeywell to Johnson Controls, except for Concourse Expansion Program C-East (Building Modules 5E-10E), which will remain Honeywell.
- F. CUP: Johnson Controls
- G. Hotel/Transit Center (HTC): Johnson Controls LonWorks with JCI Metasys and Honeywell EBI Interface
- H. PCA Plants: Johnson Controls with JCI Metasys interface
- I. Gate PCA Systems: Various interfaces. New systems shall be compatible with JCI Metasys. Ground-mounted units must be hard-wired. Bridge-mounted units may utilize wireless communication.

As of 2016, all new controls shall use the BACnet communication protocol to connect to the existing Johnson Controls Inc. Metasys Control System (EMCS). In many locations, routers exist for connections for new controls. In

most locations, these routers are LonMark-certified devices that will need to be replaced with any new control work. Contact the DEN Mechanical Engineer for a copy of the latest router location map.

Facilities outside of the CUP are being converted to communicate to a common Johnson Controls Inc. Metasys Control System (EMCS). All renovations, building expansions, and new buildings that are maintained by DEN maintenance personnel shall be connected to this control system.

Currently, the Terminal, AOB, Concourse A, Concourse C, and various outlying buildings use an aging Honeywell CNAP controls system. CNAP controls are no longer supported by Honeywell, and new and replacement parts are not available. Additionally, Honeywell will not support connecting additional CNAP VAV/FPB controllers (mcels) to the CNAP AHU controllers (xl-plus boards). Due to their volatility and lack of replacement parts, DEN will not allow additional VAVs or FPBs to be added to AHU systems that still use the xl-plus controllers. When designing mechanical systems in these areas, designers should re-use existing mcels already connected to the xl-plus boards. If additional VAVs or FPBs are required, the xl-plus board must be replaced with new BACnet-compatible controllers. Wherever xl-plus boards are replaced, all VAV controllers (mcels) and any other devices connected to the xl-plus boards and associated controls cabling must also be replaced with new BACnet-compatible controllers and cables. All associated terminal control devices (temperature sensors, thermostats, duct static pressure sensors, etc.) must also be replaced with BACnet-compatible devices. Equipment removed must be tracked by the contractor performing the system upgrade and point removal coordinated with the controls vendor that was previously in the space. All controls points no longer used must be removed from the project by the temperature controls contractor, regardless of the manufacturer. All graphics in the EMCS or outdated Honeywell system must reflect the removal of the points. Designer is to include these requirements in the design documents. Contact the DEN Mechanical Engineer when designing mechanical systems in the areas listed above for current controls-based restrictions.

The fire and security automation systems are independent and separate systems from the HVAC automation system.

5.0.3 New and Replacement HVAC Control Systems

For continuity of operation of the controls systems at DEN, HVAC DDC controls systems are limited to systems manufactured by Johnson Controls, Inc., Automated Logic Corporation, and Alerton. New devices connected to AHU's must use the same controls manufacturer as the AHU for communication with the AHU. Designer is to include the requirements in the design documents. Consult DEN PM and DEN Mechanical Engineer for existing controls system in the area of work.

Work associated with equipment in the Central Plant (CUP), Concourse Pump Rooms, Terminal Pump Room, and the AOB pump room is to be Johnson Controls, Inc. for direct integration into the EMCS system. Remove any existing Honeywell and Automated Logic Corporation controls for existing equipment to remain in these areas and replace with Johnson Controls for direct integration into the EMCS. Update the existing equipment's Sequence of Operation as needed for control replacement.

Design each network of the DDC system to include at least 30 percent available spare bandwidth with the DDC system operating under normal and heavy load conditions. Calculate bandwidth usage and apply a safety factor to ensure that this requirement is satisfied when subjected to testing under worst-case conditions. Do not use an existing network controller that is at 70 percent capacity or greater. If DDC equipment is added to a controller which is below 70 percent capacity, it must not exceed 70 percent capacity once the equipment is installed. Reference the Communication & Electronic Systems DSM for more information.

Include spare processing memory for each new or replacement controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

- A. Network Controllers: Not less than 30 percent spare capacity.
- B. Programmable Application Controllers: Not less than 30 percent spare capacity.
- C. Application-Specific Controllers: Not less than 30 percent spare capacity.

New and replacement DDC Controllers shall include 20 percent spare I/O point capacity of each AI, AO, BI, and BO point. The minimum spare I/O Points per controller shall be:

- A. AIs: Three
- B. AOs: Three
- C. BIs: Five
- D. BOs: Five

All trend data shall be stored on an SQL database accessible by DEN staff.

All EMCS front-end Graphics shall be MUI (MetaSys UI) compatible. Views and points for all areas shall be imported into MetaSys. All controls points no longer used, no matter the manufacturer, must be removed from the project by the temperature controls contractor. Contractor is to provide DEN a matrix of which equipment and subsequent controls points have been removed from the project, what is remaining to be re-used and what is new. All graphics in the EMCS or outdated Honeywell system must reflect the removal of the points. Designer is to include these requirements in the design documents.

Designer to include Controls Points Abbreviations located in Appendix A in their construction documents.

5.1 Control System Instrument Air

5.1.1 General

Independent instrument air systems are present in the CUP, terminal, and each concourse. These systems are largely undocumented and should not be used for building expansions or renovations. All new control devices shall be electrically operated/actuated. The information below is for historical design reference only.

Compressed air is generated from a centralized compressed air facility with oil-free reciprocating or screw-type compressors. Because of the critical nature of this system, there is one operational system with at least one standby system under all circumstances. This means that if one system is down for maintenance, there will be one system in operation and one additional system as a standby for a minimum of three systems.

The main distribution system air pressure is 80 to 100 psig with pressure-reducing stations to reduce the pressure to the respective usable levels for temperature control systems. The main control air is dried with externally heated, regenerative air dryers to a -40°F dew point to prevent airlines from freezing ambient air temperatures. The dryers have adequate filters located both before and after the dryer. The dryers are interlocked to operate with their respective air compressors.

5.2 Sample Control Components and Requirements

5.2.1 AHU Controls

- A. Provide economizer controls to utilize free cooling when possible during mild weather.
- B. Variable volume control should be monitored from reliable static pressure control sensors located approximately two-thirds of the total duct length downstream of the air unit supply fan. Static pressure sensors shall be placed in a position such that the controller setpoint is no greater than one-third of the total design fan static pressure, or the static pressure setpoint shall be dynamically reset. Static pressure sensor shall be located on plan documents and have dedicated access for maintenance/calibration.
- C. Provide control logic to permit reduction in ventilation (outside air) requirements at night and during any extended off-peak periods that can be determined. (The specified ventilation rate is the minimum condition required at peak occupancy; this condition will occur infrequently.) This functionality shall be achieved by using occupancy and/or CO2 monitoring controls.

- D. Provide control elements required by code and for efficient AHU operation (i.e., smoke detectors, freeze stats, etc.) in addition to the items just described. In general, AHUs shall have the following:
 - a. Outdoor air temperature
 - b. Mixed air temperature (entering unit)
 - c. Supply air temperature
 - d. Supply air flow
 - e. Hydronic coil inlet and outlet temperatures (fluid)
 - f. Pre- and final filter air pressure drop
 - g. Coil air pressure drop
 - h. Coil control valve position
 - i. Hydronic coil flow rates (CW and HHW)
 - j. Fan status
 - k. Motor runtime
 - l. VFD speed percentage (as applicable)
 - m. Control damper positions
 - n. Supply duct static pressure
 - o. High limit static pressure alarm (at unit, not downstream in a duct)
 - E. Provide an adjustable non-averaging element freezestat to be mounted on the downstream side of every heating coil section arranged to stop the supply fan (and return air fan as applicable), close the outside and exhaust air dampers, and open return air dampers when any one-foot section of the element of the freezestat senses a temperature below the setpoint (36°F).
- NOTE:** Freezestat controls shall be prevented from shutting down any air unit when it is operating in a smoke removal mode. No equipment is to be provided that could shut down a unit fan when it is operating in a smoke removal mode.
- F. Provide airflow measuring stations and install them on the discharge of each supply fan, on the intake duct for any return air fan installed, and on the outside air duct for each unit. This is to provide ventilation airflow rate monitoring and fan tracking control between the supply and return air fans where used.
 - G. Provide override control to reset the outside air dampers during extreme weather or in emergencies.
 - H. In the event of a power loss, the AHU outside air dampers shall fail to the fully closed position. Return Air dampers shall fail to the fully open position. Heating Hot Water control valves shall fail to the fully open position, and Cooling Water control valves shall fail to the fully closed position.
 - I. Provide separate differential pressure sensors across both pre- and final filters.

5.2.2 VAV Terminal Unit Controls

- A. Zone temperature controls shall be designed to have a 5°F space temperature setpoint deadband between heating and cooling operation.
- B. In general, VAV controls shall be selected and configured for proportional control and not floating point control. Designers shall discuss any concerns (e.g., first cost impacts) or recommended deviations with a DEN Mechanical Engineer.
- C. VAV boxes with heating coils control shall be provided with a discharge air temperature sensor to be located downstream of the VAV box for temperature setpoint reset control.
- D. VAV box controls shall prohibit reheat or simultaneous heating and cooling operations per ASHRAE 90.1.
- E. Where reheat is required due to existing system limitations, the system may be designed to comply with the exceptions to ASHRAE 90.1 reheat restrictions. In these cases, reheat shall be minimized to the extent possible. Refer to [5.2.7.HVAC Control Functions](#).
- F. New devices must use the same controls manufacturer as the AHU for communication with the AHU. Designer to specify the controls manufacturer in the design documents.

- G. Terminal boxes must be included into existing logic sequence (voting for pressure, temperature, CO₂, building pressure etc).

5.2.3 Unit Heaters Controls

Small unit heaters shall be controlled by cycling the fan on and off and controlling a two-way valve on the hot water coil. Large unit heaters, cabinet unit heaters and air curtains with heating coils shall run continuously while heating is required, and water flow to the coil shall be modulated to maintain the set space temperature. All modulating control valves shall be pressure-independent type.

a. Split Systems- Fan Coil Units (FCU)

Where split systems are installed in critical spaces such as telecommunications and electrical rooms, the Facilities EMCS shall monitor the status of the fan coil unit fan and air-cooled condensing unit with the use of a current transformer and shall alarm the system in the event of a fan or compressor failure. The EMCS shall also monitor the room temperature. The fire alarm system shall stop fans. The split system shall run through factory controls based on the room thermostat.

Hydronic FCUs shall be utilized where design conditions permit. Small unitary FCU installations shall use 2-position control valves for hydronic coil control. Larger or multi-zone FCUs, or designs requiring finer flow control (e.g., for discharge temperature setpoint control) shall use modulating control valves. All modulating control valves shall be pressure-independent type. Hydronic control valves shall be located on the downstream side of cooling/heating coils.

In the event of a power loss, the FCU outside air dampers shall fail to the fully closed position. Return Air dampers shall fail to the fully open position. Heating Hot Water control valves shall fail to the fully open position, and Cooling Water control valves shall fail to the fully closed position.

5.2.4 Exhaust Fan

In general, exhaust fans should be interlocked with the building AHU and run continuously.

5.2.5 Pump Controls

Hydronic system pumps shall be selected to operate at variable speeds and shall be provided with all necessary control devices, variable speed drives, and inverter duty motors to allow variable speed operation. Variable frequency drives shall be capable of independently logging and storing operating data, including speed (expressed as a percentage of maximum), run time, and instantaneous power consumption (kW). Small constant-speed pumps may be used for long runs, but these applications shall be limited and require approval from a DEN Mechanical Engineer.

Heating and cooling coils shall not utilize pumped coil loops for freeze protection. Pumped loops for waterside economizers shall not be used unless previously approved by a DEN Mechanical Engineer.

5.2.6 Monitoring

Fire system monitoring or security provisions are not incorporated into the EMCS initially; however, provisions should be made to allow these features to be added should this requirement change.

5.2.7 HVAC Control Functions

The AHUs and the spaces they condition shall be controlled by standalone, remote, automation control systems. These systems shall be located directly in areas of equipment. The microprocessor-based control system shall communicate with the EMCS through an Ethernet port interface via BACnet communication protocol and all other

necessary equipment for proper signal-level reception and transmission. New devices must use the same controls manufacturer as the AHU for communication with the AHU. Designer to specify the controls manufacturer in the design documents.

The following control functions shall be programmed into the control system:

- A. Provide airside economizer controls to utilize free cooling when possible on all AHUs with a design capacity greater than 54,000 Btu/h (or current ASHRAE 90.1/IECC requirements, whichever is more stringent).
- B. VAV boxes are to be controlled by the temperature control system. The controller shall adjust the box's damper position based on the space temperature. VAV boxes with heating coils shall also reset discharge air temperature in a heating mode based on the space temperature signal.
- C. The total supply air volume shall be controlled by static pressure sensors located in the main supply air duct. The supply fan's motor speed controller shall be modulated to maintain the duct static pressure setpoint.
- D. Variable air systems that have heating coils at the VAV terminal units shall be designed to control to the following sequences/reset schedules unless a clear need is demonstrated and alternate control sequence is approved by DEN Mechanical Engineer. Reset control examples are presented below. The engineer shall review the validity of the examples for use in design on a unit-by-unit basis.
- E. New VAV Boxes connected to a DEN AHU are to have the controls fully integrated into the Sequence of Operation and the EMCS including modifications to the Graphic screens.

5.2.7.1 AHUs

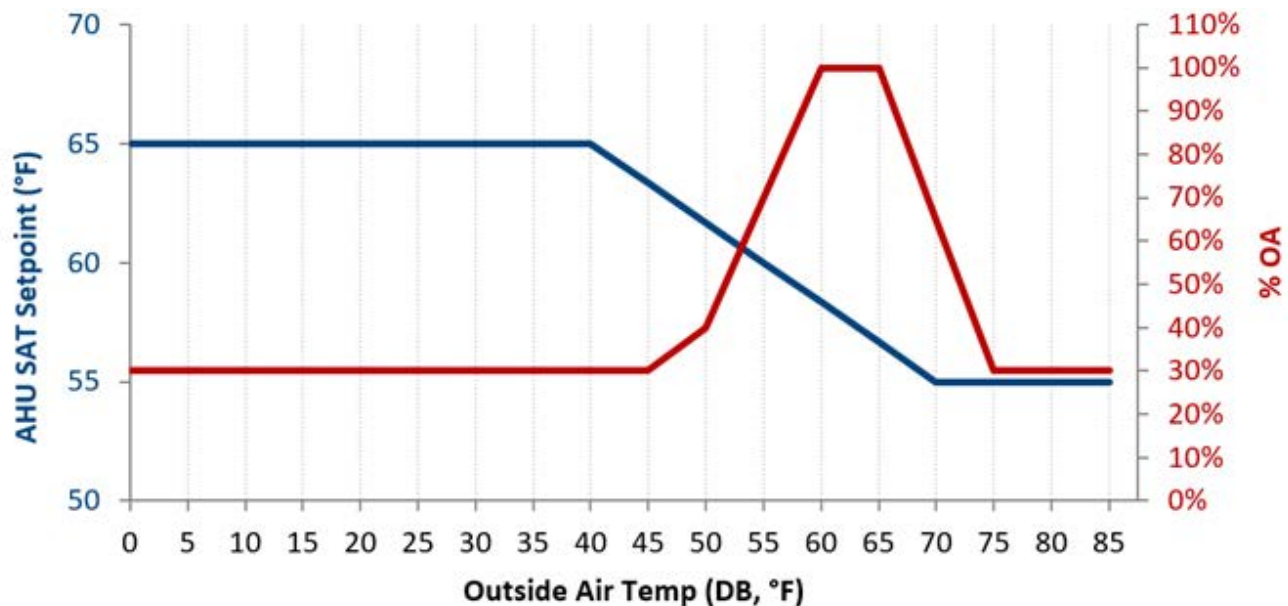


Figure 5-1: AHU Control

5.2.7.2 VAV Boxes

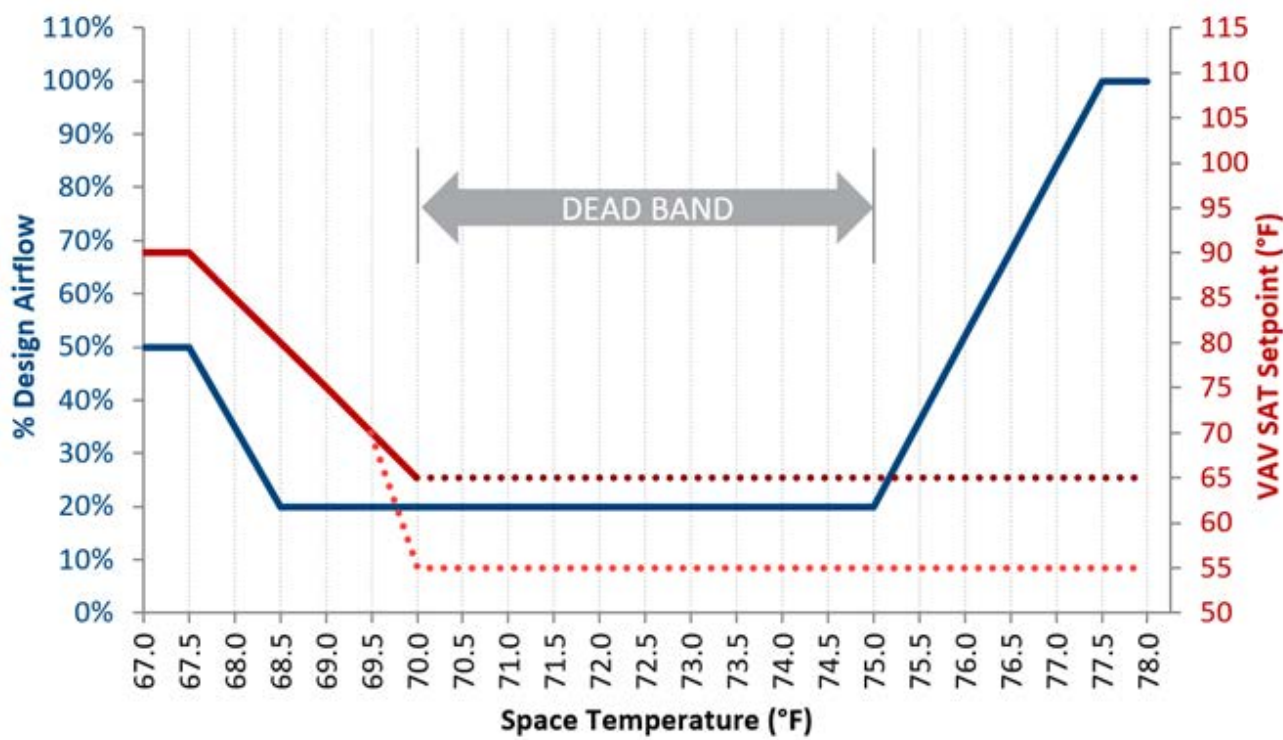


Figure 5-2: VAV Control

NOTE: Designs may require alteration of the minimum percent Design Airflow and/or percent OA setpoints shown above (indicated as 20% and 30%, respectively) for zones or AHUs to meet code-required minimum ventilation rates. Conversely, designs utilizing Demand Control Ventilation may warrant a reduction of these minimum setpoints.

5.2.8 Thermostats and Temperature Sensors

Thermostats are only allowed on unitary equipment that is not connected to the EMCS. Temperature sensors shall be provided in all other locations. All new temperature sensors shall be furnished with a service port for remote laptop connection to the unit controller and EMCS.

In areas of the airport accessible to passengers, thermostats and temperature sensors shall not have displays.

Thermostats and temperature sensors shall be mounted in accordance with all codes and standards adopted by the City and County of Denver. Additionally, thermostats and temperature sensors shall be located on surfaces that do not receive any direct sunlight, are not obstructed by furniture or other appliances, and are away from sources of heating or cooling which might impinge on their ability to accurately measure zone temperature. Designers shall use industry best practices when locating all sensors.

5.2.9 Carbon Monoxide Sensors

Carbon monoxide sensors shall be provided in the service drive or wherever internal combustion engine traffic is utilized in an enclosed space. Sensors shall increase airflow and/or alarm out-of-tolerance conditions.

5.2.10 Oxygen Sensors

Oxygen sensors are required to be provided in fire sprinkler valve rooms where nitrogen generators are installed. Sensor(s) are to be monitored by fire alarm system and activate FA notification within room and outside of door(s). Sensors are typically provided by mechanical as they also activate ventilation systems and are to be monitored by the EMCS as well and alarm at maintenance control center.

Alarm set points shall be set at:

- A. Oxygen levels below 19.5 percent - Self re-setting (non-latching) alarm.
 - 1. Visual notification only in approved locations (local, typically provided with sensor).
 - 2. Activate ventilation system (1.0 CFM/FT²).
- B. Oxygen levels below 17.5 percent - Latching Alarm
 - 1. Visual and audible notification in valve room and exterior to the room (though fire alarm system with amber lens strobes in room and outside of door to the room an amber horn/strobe).
 - 2. Evacuate room/area and call 911.
- C. Signal to Fire Alarm System.

5.3 Central Control Systems for Main Airport Buildings

The EMCS consists of a central host computer, including an IBM-PC/AT computer (or compatible) with a VGA/- color monitor. This host computer is in the CUP, and standalone remote system controllers shall be located in the areas under control. The EMCS shall be a user programmable, all-electronic, digital control system. The central host computer shall have, as a minimum, an EGA/color monitor, printer, alarm printer, mouse (or ball), and storage and shall consist of all necessary components to provide communications to the field panels. This shall be a comprehensive system and shall be coordinated with all other ongoing projects at the airport that will be tied to the EMCS.

NOTE: All new field controllers and panels outside of the CUP shall be BACnet-compatible devices and must be able to interface with the Facilities EMCS. All controllers and devices in the CUP shall be designed to interface via BACnet IP with Johnson Controls Metasys EMCS (the CUP EMCS) that was installed in 2014.

5.3.1 Software

The EMCS shall have all software necessary for real-time monitoring, program loading/editing, report generation, and data acquisition. The software shall be programmed to display color graphic screens of the areas and systems controlled and provide operating reports, trend logs, energy consumption, analysis capability, and alarm reports.

The software shall display actual operating conditions on the graphics display screens. Software should be non-proprietary and reprogrammable by the user. Source codes, custom programming, custom graphics, etc., shall be provided to the owner along with a duplicate set of backups. The Design Consultant shall review the current stage in the development of the universal protocol and make every practical effort to incorporate this into the temperature control automation system.

The software shall have the following capabilities:

- A. Run time
- B. Optimum start/stop
- C. Economizer controls
- D. Load shedding
- E. Time of day scheduling

- F. Chilled water outdoor air reset
- G. Hot water outdoor air reset
- H. Variable condenser, hot, and chilled water pumping (to optimize hp vs load)
- I. Night set back
- J. Status
- K. Change of status
- L. Smoke venting and control
- M. Ambient high/low alarms
- N. Energy totalizing
- O. Maintenance and alarm reports
- P. Heating/cooling mode
- Q. Electrical system monitoring, as outlined in the electrical design standards

5.3.2 Graphic Capabilities

The central computer terminal shall have a dynamic color graphic display programmed for each air handling system, secondary pump room, and the areas being monitored and controlled. Any project that requires modification of building controls shall include specifications for the replacement of the system graphics with the most current templates. When new control graphics are introduced, all previous versions of controls graphics shall be removed.

5.3.3 Trend Logging and Graphing

Trend logs and graphing capability shall be provided. All new control applications and/or any project that requires modification of building controls shall require that trend data be set up for all major AHUs and pumps. Trending data that is automatically uploaded to the controls data server must be programmed at a coordinated time to minimize network traffic during the data transfer. Include noting in the construction documents to coordinate such timing with the EMCS administrator.

5.4 Sequence of Operation

The startup, operation, and shutdown of systems shall be sequenced in accordance with the general control sequences outlined in the Technical Specifications of the Mechanical Design Standards. Prior to the installation of a specific system, a specific and more detailed sequence of operations shall be developed for each type of HVAC, HV, or ventilation system. In these sequences of operation, specific points of measurement of temperature, humidity, pressure, etc., shall be designated.

Designer is to ensure accuracy of the Sequence of Operation and coordinate with any existing systems and equipment. Designer shall research and coordinate with the appropriate stakeholders until a thorough understanding of how existing systems and equipment operate. Construction documents are to include the integration of new and existing equipment operation into the Sequence of Operation.

5.4.1 Emergency Shutdown

Operating facilities with potentially explosive, toxic, or otherwise hazardous processes shall be equipped with emergency process shutdown panic buttons located at the main control panel and at all exits to the affected areas. Each HVAC system shall have a manual shutdown button per National Fire Protection Agency (NFPA) 90A located at a firefighter's emergency shutdown station.

5.4.2 Automatic Shutdown

Each HVAC system with 2,000 cfm or more capacity shall be equipped and arranged to automatically shut down fans (and close dampers on units larger than 15,000 cfm) in accordance with NFPA 90A, Denver Building Code Amendments, and initiate the fire alarm. Smoke detectors installed in HVAC ductwork shall be tested prior to acceptance for proper airflow and voltage sensitivity in the presence of the Project Engineer of Record. The shutdown circuit shall prevent the AHU from restarting until the smoke detectors have been reset by DEN's fire protection personnel. This test for proper operation shall be made with the AHU in all modes of operation.

Those units that are to be used for smoke removal shall be arranged such that no control function can shut down the unit fan and override the smoke removal function when activated.

5.5 Controls Points Naming

5.5.1 General

Controls points in the EMCS front end shall be named in a consistent and informative way. Every point name shall indicate the equipment it is associated with and the function of the point itself. Each point name shall consist of the entire equipment tag, described in [1.2.Equipment Identification](#), and a standard abbreviation describing the function of the point. A list of all standard abbreviations used by DEN can be found in non-standard abbreviations must be approved in writing by DEN Mechanical Engineer.

Each point name must be unique. Because of this, smaller terminal equipment with non-supervisory controllers must include the abbreviated equipment name from their supervisory controller in their point names. Refer to [5.5.3.Non-supervisory Controller Point Numbering](#).

IP addresses for BACnet and LonWorks routers are not available to the public. Written approval from the DEN PM, DEN Mechanical Engineer, DEN Manager of Systems, and DEN Information Security is required to access this information.

Points for Tenant equipment shall be flagged in Metasys metadata as tenant points. Coordinate flagging requirements with the DEN EMCS administrator.

Designer must include the complete control points list along with naming from [5.5.2.Supervisory Controller Point Naming](#) and [5.5.3.Non-supervisory Controller Point Numbering](#) in the Construction Documents.

5.5.2 Supervisory Controller Point Naming

Naming for supervisory controller points shall include the name of the equipment associated with the point, followed by an abbreviation of the function of the point. A period shall separate the equipment name from the function abbreviation.

LLL_XX_LX_LLL_L (L)(_XX)	—	LLL	—	Abbreviation
(1)		(2)		(3)

L = Alphabetical character
N = Numerical character

For example, the point name for the discharge air temperature for AHU-B in the 4th floor mechanical room of Holdroom 7 West of Concourse B would be CCB_04_7W_AHU_B_TCP.DA-T. The effective discharge air temperature setpoint for the same unit would be CCB_04_7W_AHU_B_TCP.DAT-EFF-SP.

5.5.2.1 Equipment Tag

The first component of the point name shall be the equipment tag, as defined in [1.2.Equipment Identification](#).

CCB_04_7W_ AHU_B	—	TCP	.	DA-T
---------------------	---	-----	---	------

5.5.2.2 TCP Extension

AHU control panels are all tracked as separate sub-assets in the DEN Asset Management Program from the AHUs they control. Because of this, the abbreviation _TCP shall be added to the end of the equipment name when naming AHU control points.

CCB_04_7W_ AHU_B	—	TCP	.	DA-T
---------------------	---	-----	---	------

5.5.2.3 Function Abbreviation

The third component of the point name shall be the function abbreviation. A period shall separate the first three components of the point name from the function abbreviation. Abbreviations can be found in [Appendix A- Controls Points Abbreviations](#).

CCB_04_7W_ AHU_B	—	TCP	.	DA T
---------------------	---	-----	---	------

5.5.3 Non-supervisory Controller Point Numbering

Due to the sheer number of non-supervisory controllers at DEN (e.g., terminal device controllers such as VAV or UH controllers), additional information must be included to ensure each control point name is unique. Points for non-supervisory controllers will have four components as follows.

LLL_XX_LX_LLL	—	XXXLLL(L)	—	XX(L)	.	Abbreviation
(1)		(2)		(3)		(4)

L = Alphabetical character

N = Numerical character

For example, the point name for the occupied heating setpoint for ATH-05, located on the Mezzanine Level of Sub-core 6 West of Concourse B, served by AHU-B in the 4th floor mechanical room of Holdroom 7 West would be CCB_03_6W_VAV_047WAB_05H.OCC-HTG_SP. The discharge air temperature for the same unit would be CCB_03_6W_VAV_047WAB_05H.DA-T.

5.5.3.1 Equipment Tag

The first component of the point name shall be the equipment tag, as defined in [1.2.Equipment Identification](#). The numeric designator shall be removed from the equipment identification.

CCB_03_6W_VAV	—	047WAB	—	05H	.	OCC-HTG- SP
---------------	---	--------	---	-----	---	----------------

5.5.3.2 Equipment Controlled

The second component of the point name shall identify the equipment that the supervisory controller controls. This shall be an abbreviated version of the equipment tag for the supervisory controller's equipment. The building

identifier shall be removed, along with all the underscores. The equipment abbreviation shall be shortened to the first letter of the abbreviation.

For example, the shortened abbreviation for AHU B located in the 4th floor mechanical room of Holdroom 7W of Concourse B would be shortened from CCB_04_7W_AHU_B to 047WAB.

CCB_03_6W_VAV	_	047WAB	_	05H	.	OCC-HTG- SP
---------------	---	---------------	---	-----	---	----------------

5.5.3.3 Numeric Designator

The third component of the point name shall be the numeric designator of the equipment. The first 3 components of the point name shall be separated by underscores. In instances where there would be two sequential underscores, only a single underscore shall be used.

CCB_03_6W_VAV	_	047WAB	_	05H	.	OCC-HTG- SP
---------------	---	--------	---	------------	---	----------------

5.5.3.4 Function Abbreviation

The fourth component of the point name shall be the function abbreviation. A period shall separate the first three components of the point name from the function abbreviation. Abbreviations can be found in [Appendix A-Controls Points Abbreviations](#)

CCB_03_6W_VAV	_	047WAB	_	_	.	OCC HTG SP
---------------	---	--------	---	---	---	-----------------------

5.6 Equipment Alarming

DEN has thousands of pieces of mechanical equipment controlled by the EMCS. Most of these pieces of equipment have alarms for various failure states in the EMCS. Because the EMCS software requires each individual alarm to be acknowledged each time it occurs, having every failure state alarm in the EMCS is not useful.

Only critical alarms that notify DEN maintenance users of situations which need to be addressed immediately shall be programmed into the EMCS. Critical alarms are at a minimum: controller communication error, low air temperature or freezestat trip alarms at make-up air units utilizing base building heating or chilled water systems, low heating water return temperature, device or sensor failure for any critical alarm point, etc. All critical alarms are to be trended in the EMCS. Designer to list out critical alarms in the construction documents. All other alarm states shall be trended in DEN's Fault Detection and Diagnostic (FDD) and Monitoring-Based Commissioning Software, SkySpark.

The lists below indicate whether an alarm shall be programmed to alarm in the EMCS, or trended in SkySpark.

Note: to be trended in SkySpark, an alarm point needs to be trended in the EMCS software. However, any alarm points that are trended in SkySpark must also be trended in the EMCS software. DEN simply does not want nor need these points to alarm in the EMCS.

5.6.1 Alarms in the EMCS

The following alarms shall Alarm the EMCS front-end software. They should also be trended in SkySpark.

Table 5-1: Alarms in the EMCS

Air Curtain

Point Description	Occurrence	SkySpark	BAS
Controller	Communication Failure		X
Controller	Diagnostics		X
Air Curtain Fan	Device Failure		X
Room Temperature	Sensor Failure/Unreliable		X

Air Handling Unit - VAV, SZVAV, MAU or VSCF

Point Description	Occurrence	SkySpark	BAS
Controller	Communication Failure		X
Controller	Diagnostics		X
Outside Air Temperature	Sensor Failure/Unreliable		X
Pre-Filter	Sensor Failure/Unreliable		X
Filter	Sensor Failure/Unreliable		X
Mixed Air Temperature	Sensor Failure/Unreliable		X
Chilled Water Coil Water Pipes (EWT & LWT)	Sensor Failure/Unreliable		X
Hot Water Coil Water Pipes (EWT & LWT)	Sensor Failure/Unreliable		X
Supply Fan Array	Device Failure		X
Supply Fan Array	Communication Failure		X
Supply Air (Temperature)	Sensor Failure/Unreliable		X
Return Air Smoke Detector	Smoke		X
Supply Air Smoke Detector	Smoke		X
Duct Static Pressure	Switch Trip		X
Freezestat	Switch Trip		X
Carbon Monoxide (CO)*	Sensor		X
Natural Gas*	Sensor		X
Smoke Pressurization*	Life Safety Override		X

**For VSCF units only. Edit on a per-unit basis, depending on unit configuration and coordination with life safety systems.*

Booster Pump

Point Description	Occurrence	SkySpark	BAS
Panel Power Loss	Device Failure		X
Pump Failure (qty. 3)	Device Failure		X
Pump Run Failure (qty. 3)	Device Failure		X
Pump VFD Fault (qty. 3)	Device Failure		X
Pump VFD Comm Fault (qty. 3)			

Reduced Pressure Backflow Preventer

Point Description	Occurrence	SkySpark	BAS
RPBP No Flow Alarm			X
Leak Alarm (qty. 3)			X

Fan Coil Unit

Point Description	Occurrence	SkySpark	BAS
Controller	Communication Failure		X
Controller	Diagnostics		X
Condensate Overflow (as applicable)	Switch Trip		X
Supply Fan	Device Failure		X
Offline	Device Failure		X

VAV - Cooling Only

Point Description	Occurrence	SkySpark	BAS
Controller	Communications Failure		X
Controller	Diagnostics		X
Room Temperature	Communications Failure		X

VAV - Reheat

Point Description	Occurrence	SkySpark	BAS
Controller	Communications Failure		X
Controller	Diagnostics		X
Temperature Air Discharge	Sensor Failure/Unreliable		X
Room Temperature	Communications Failure		X

Relief Fan

Point Description	Occurrence	SkySpark	BAS
Relief Fan	Device Failure		X

Domestic Water Heater

Point Description	Occurrence	SkySpark	BAS
Internal Controller Fault (as applicable)	Device Failure		X

5.6.2 Alarm Points Only Trended in SkySpark

The following alarms shall only be trended in SkySpark. None of the following alarms shall alarm in the EMCS Front-End software:

Table 5-2: Alarm Points Only Trended in SkySpark**Air Curtain**

Point Description	Occurrence	SkySpark	BAS
Hot Water Water Control Valve	Device Failure	X	
Room Temperature	High Analog	X	
Room Temperature	Low Analog	X	

Air Handling Unit - VAV, SZVAV, MAU or VSCF

Point Description	Occurrence	SkySpark	BAS
Outside Air Temperature	High Analog	X	
Outside Air Temperature	Low Analog	X	
(Outside) Air Inlet Damper	Device Failure	X	
Air Return Damper	Device Failure	X	
Pre-Filter	High Analog	X	
Filter	High Analog	X	
Mixed Air Temperature	High Analog	X	
Mixed Air Temperature	Low Analog	X	
Chilled Water Control Valve	Device Failure	X	
Chilled Water Coil Water Pipes (EWT & LWT)	High Analog	X	
Chilled Water Coil Water Pipes (EWT & LWT)	Low Analog	X	
Supply Air (Temperature)	High Analog	X	
Supply Air (Temperature)	Low Analog	X	

Air Handling Unit - VAV, SZVAV, MAU or VSCF

Point Description	Occurrence	SkySpark	BAS
Discharge Air Temperature Setpoint	High Analog	X	

Booster Pump

Point Description	Occurrence	SkySpark	BAS
Suction Pressure	High Analog	X	
Suction Pressure	Low Analog	X	
Suction Pressure	Sensor Failure	X	
System Pressure	High Analog	X	
System Pressure (3" & 6" Transducer)	Sensor Failure	X	

Reduced Pressure Backflow Preventer

Point Description	Occurrence	SkySpark	BAS
Valve Battery Alarm (qty. 2)		X	
RPBP General Alarm (qty. 3)		X	

Fan Coil Unit

Point Description	Occurrence	SkySpark	BAS
Chilled Water Control Valve	Device Failure	X	
Room Temperature	High Analog	X	
Room Temperature	Low Analog	X	

VAV - Cooling Only

Point Description	Occurrence	SkySpark	BAS
Room Temperature	High Analog	X	
Room Temperature	Low Analog	X	
Air Flow CFM	High Analog	X	
Air Flow CFM	Low Analog	X	
Damper Position (as applicable)	Device Failure	X	

VAV - Reheat

Point Description	Occurrence	SkySpark	BAS
Temperature Air Discharge	High Analog	X	

VAV - Reheat

Point Description	Occurrence	SkySpark	BAS
Temperature Air Discharge	Low Analog	X	
Room Temperature	High Analog	X	
Room Temperature	Low Analog	X	
Hot Water Control Valve	Device Failure	X	
Air Flow CFM	High Analog	X	
Air Flow CFM	Low Analog	X	
Damper Position (as applicable)	Device Failure	X	

Relief Fan

Point Description	Occurrence	SkySpark	BAS
Relief Damper	Device Failure	X	

Domestic Water Heater

Point Description	Occurrence	SkySpark	BAS
Recirculation Water Temperature	Low Analog	X	
Tank Temperature (as applicable)	Low Analog	X	

Exhaust Fan

Point Description	Occurrence	SkySpark	BAS
Fan Status	Device Failure	X	

End of Chapter

Chapter 6 - Hydronic Systems

6.0 Hydronic Systems

6.0.1 Existing Campus Heating/Cooling Systems Operation

Chilled water and heating water for the HVAC systems in the terminal buildings, AOB, and concourses are supplied from the CUP. Refer to [Chapter 2- Central Utility Plant](#) for overall systems and additional requirements.

6.1 Equipment

6.1.1 Chilled Water System

The chilled water system for the terminal complex is configured in a primary-secondary arrangement. The first loop is the primary loop, which shall use chiller pumps in parallel and headered to circulate water through the chillers that are piped in parallel.

The pumps shall be connected in parallel on suction and discharge headers with a 1-to-1 ratio of chiller pumps to chillers. Pumps shall modulate speed to maintain flow through the operating chillers and around the primary loop. Under no circumstances shall the chilled water pumps deliver flow below the minimum allowable flow to an operating chiller. The chiller loop must be arranged to easily adapt additional chillers and chiller pumps for future capacity requirements.

The distribution loops are labeled secondary loops and are variable flow systems. The primary loop distributes the chilled water from the chillers to the terminal building, concourses, and other buildings and areas to be served with cooling, where secondary pumps in parallel supply the secondary distribution piping with chilled water.

The secondary pumps shall be modulated and staged based on static pressure at the most hydraulically remote point of the critical circuit of each secondary distribution loop. The EMCS shall cycle the primary loop pumps to match the combined system load of the secondary loops by maintaining a slight positive flow (approximately 1- 2%) in the decoupler line between the primary and secondary loops.

Flow measuring devices will be required in each loop and subcircuit, as well as the decoupler.

No glycol is used in this system.

The DEN chilled water system shall not be used as condenser water for direct-expansion-unitary-type HVAC or refrigeration equipment without written approval from the Manager of DEC Systems Group. The only exception not requiring approval is low-temperature systems serving the PCA glycol system.

6.1.2 Heating System

In the Hotel/PTC only, DEN identifies hot water system temperatures and pressures as follows:

- A. Low-temperature hot-water heating system: This hot water system operates within a temperature of 250°F. The maximum allowable working pressure for a hot water system is 150 psi. All the hot water hydronic systems connected to the CUP system meet this criterion.
- B. Medium temperature hot-water heating system: This hot water system operates at a temperature of 350°F or less. The maximum allowable working pressure for this type of hot water system is 150 psi. The medium-temperature hot-water heating system is not currently in use at DEN.

- C. High-temperature hot-water heating system: This hot water system operates at temperatures exceeding 350°F. The maximum operating pressure for this type of hot water system is less than 300 psi. The high-temperature hot-water system is not currently in use at DEN.

Heating in all building spaces shall be provided by hot water from hot water generators (boilers) located in the CUP. The hot water system will consist of a boiler circuit or loop, a primary hot water distribution system loop, and a secondary distribution system loop serving the terminal units. Hot water boiler pumps shall be equal in number to the boilers and shall circulate and maintain a constant temperature in the boiler loop (reset with outside temperature). The primary loop will consist of pumps in parallel supplying a variable flow, as required by the demand and differential pressures, to the secondary loops. Based on final facility and system considerations, more than one primary loop may be justified. The secondary loop pumps shall provide a variable flow sufficient to maintain a differential pressure between the supply and return legs of the most remote unit on the secondary loop.

Flow measuring devices are required in each loop and subcircuit, as well as the decoupler.

Provide one stand-by pump for each loop system. No glycol is used in this system.

6.1.3 Hydronic Requirements

Chilled or heating water shall be sized for a maximum of 10 feet pressure drop per 100 feet of equivalent pipe for any run, but no more than an average of 4 feet pressure drop per 100 feet of equivalent pipe for the entire connected system. Circuit setters or balancing valves shall not be used for equipment isolation. Chilled Water coils shall be selected for a 16°F ΔT and Heating Water coils for a 40°F ΔT , at the following conditions:

- A. Hydronic design temperatures for primary loop :
 - a. Chilled water supply temperature: 42°F with reset controls in cooler conditions potentially allowing up to 50°F
 - b. Chilled water return temperature: 58°F (will vary)
 - c. Heating water supply temperature: 220°F
 - d. Heating water return temperature: 170°F (will vary)
 - e. No glycol is used in the DEN primary loops
- B. Hydronic design temperatures for secondary loops :
 - a. Chilled water supply temperature: 42°F with reset controls in cooler conditions potentially allowing up to 50°F
 - b. Chilled water return temperature: 58°F (will vary)
 - c. Heating water supply temperature: 190°F
 - d. Heating water return temperature: 170°F (will vary)
 - e. No glycol is used in DEN secondary loops. Glycol systems only exist on secondary or tertiary loops when used in conjunction with a heat exchanger.

Design Consultant shall review system designs to ensure chilled water temperatures in secondary systems do not exceed 58°F. Temperatures in excess of 58°F cause problems with the operation of PCA plant equipment.

Design shall ensure that the minimal pipe length is achieved, and no unnecessary loops or branches are used. Piping shall be routed in the most direct route feasible.

Designs including flow meters or other devices requiring servicing shall be located such that access to these devices is below 10'-0" AFF.

Flexible hydronic piping shall not be used in heating and chilled water hydronic systems.

6.1.4 Tenant Loops

When not defined in the record documents, no more than 20 GPM of chilled or heating water shall be used for any Tenant in the existing Concourses. Connections shall only be made to the base building Tenant hydronic loops when

they exist. Tenant loop connections are located at each central core and concourse subcore on the apron level. Other locations will be approved in writing by the DEN Mechanical Engineer on a case-by-case basis with supporting system flow analysis. Systems shall not be deemed to have adequate capacity for connections at any location there is not an existing valved connection.

When tenant spaces are designed for future use (e.g., grey box) with no terminal equipment installed and connections for future systems are provided, the final contract documents shall indicate the maximum allocated water flow (gpm) and design pressure (PSIG) for each connection in each space.

For any new Tenant service, a digital BTU meter on each hydronic service entrance to the Tenant lease area shall be installed. The meter shall be in an accessible area within the Tenant lease area. The meter shall have native BACnet communication and connect directly to the DEN EMCS.

6.1.5 Piping and Valves

Piping, for both the CUP and the distribution systems, shall be designed to minimize pressure losses and maximize energy use efficiency. Valves to be specified for equipment servicing shall be selected to minimize losses while open and have suitable pressure drop characteristics for the intended use. The piping shall be designed to allow for CUP equipment expansions.

Control valves shall be sized for the correct and appropriate Cv value at the design flow rate. All valves shall be suitable for extended service operation without extensive requirements for lubrication or servicing. Control valves shall be pressure-independent valves manufactured by either Flow Control Industries Delta-P Valves or Johnson Controls VP140 series valves. Valves and actuators used on the CUP distribution side (230°F heating water temperature) are to be rated for a minimum of 250°F; valves and actuators on the building side (190°F heating water temperature) are to be rated for a minimum of 212°F.

Many of the existing butterfly and ball valves no longer positively close and seal. Designer to anticipate that valves 2-1/2" and larger that are original will need to have line stops installed and the defective valves replaced. Verify location with the DEN Mechanical Engineer.

Tees, valves, paddle blind, and blind flanges shall be provided to allow for additions of equipment and piping to the CUP or any piping mains without the interruption of services. If a piping main must be taken out of service for any means, a bypass shall be designed into the system to avoid an extended outage. Paddle blind flanges are to be temporarily installed at connections to existing systems to prevent water from inadvertently entering the new systems. Piping systems shall be sized for ultimate loads. Tees, valves, and blind flanges shall be provided on distribution piping systems for the expansion of distribution systems; sectional valves shall be provided in the distribution piping for piping system repairs and at key locations to provide isolation and servicing of equipment. On compressed air lines, quick disconnect connections shall be installed downstream of sectional valves to enable the use of portable compressors in emergencies. The piping design and materials selection shall be in accordance with ANSI/ASME Standard B31.9 Building Services and ANSI/ASME Standard B31.1 Power Piping.

Mechanical grooved piping and fittings shall not be used for hydronic systems and should not be considered for value engineering options. Due to the operating system temperatures and system movement, mechanical grooved connections have been problematic for maintenance.

Press-fit, or push-on types of piping systems and connectors shall not be used for any hydronic or plumbing system.

Flanged connections are allowed only at valves and connections to equipment (pumps, coils, etc.). Flanged connections shall not be used in other locations.

No piping shall be routed through/across the AGTS tunnel.

Isolation valves are required at all equipment and branches. Ball valves, gate valves, or butterfly valves should be rated for the temperature and pressure of the line. Valves shall be added before and after any control valves,

strainers, air vents, coils, etc., for service. Equipment in series with no branches may all be isolated by a single pair of isolation valves.

6.1.6 Pumps

Pumps shall be selected for maximum operating efficiency (i.e., slightly to the right of the maximum efficiency point on the pump curve). Single pumps to be used in throttling applications without variable speed drives shall have relatively flat performance curves and be selected for operation on the pump performance curve to the right of the point of highest efficiency. Multiple pumps for parallel operation shall have relatively steep performance curves. Multiple pumps for series operation shall have relatively flat performance curves. Pumps for variable speed drive applications shall have relatively steep performance curves. All pumps shall be specified with suction and discharge flange taps for pressure gauge connections. Include high performance shaft seals in pump specification for system being used and a spare set for each pump.

The final selection of pump types and the application arrangement shall be made to maximize pump efficiency without excessive initial pump costs. All pumps that are selected for both current and future needs will be sized for future requirements, where practical, and equipped with the necessary accessories. The lower initial performance requirement will be met by balancing valves or by using a trimmed impeller to provide energy-efficient operation in start-up performance.

Standby pumps and accessories shall be provided for both heating and cooling systems. Pumps shall be arranged in a parallel configuration and headered to maximize pumping flexibility.

In general, vertical turbine pumps shall be used for pumping cooling tower water. Hydronic water applications shall use end suction pumps for flow rates below 500 GPM. Horizontal split case; double suction pumps shall be used for flow rates above 500 GPM.

Vertical split case and double suction pumps will be allowed for use with flow rates above 500 GPM only in existing rooms when adequate space for horizontal arrangements does not exist.

High RPM pumps (>1750 rpm) should only be used when no other alternative exists.

6.1.7 Motors

Electric motors shall conform to NEMA Standards. All 3-phase motors shall be of premium efficiency type or greater. Motors shall not be selected for operation in the service factor range. The minimum system installed power factor shall be 90%, with a goal to attain a 95% system power factor. Motors larger than 15 hp shall have power factor correction.

Motors shall be specified to be provided with adequate thermal protection, integral or external control, branch circuit protection, and starters suitable for use with the motors. Motor and starter types shall be selected to minimize voltage fluctuations and current surges. Motors and starters shall be provided with auxiliary contacts for control and operation interface with the central EMCS and any other control functions included.

All motors to be used with variable frequency drives shall be appropriately inverter-duty rated.

6.2 Design Criteria

6.2.1 General Requirements

Piping layout and sizing shall be done using the best practices to ensure minimum energy loss by thermal transfer and friction. The hydronic systems design shall be based on the following criteria:

- A. Piping shall be designed in accordance with the technical criteria in other sections of this DSM. Water pipe sizing shall be based on the stricter of the two following parameters unless code requirements overrule:

Table 6-1: Water Piping Sizing

Pipe Size	Max. Velocity (fps)	Max. Pressure Drop* (ft per 100 ft pipe)
up to 2"	4	8.5
2-1/2" thru 6"	6	4.5
8" thru 12"	8.5	2.5
14" thru 20"	10.5 (14)**	2.5
24" thru 42"	11.0 (14)**	1.5

**Based on new, clean steel pipe*

***Number in parenthesis is velocity limit applicable to long straight runs where noise is not critical (such as pipe tunnels, etc.). Maximum pressure drop still applies.*

- B. Due to availability issues and relative cost, 5-inch piping and valves shall not be used.
- C. Pressure drops in piping systems shall be calculated to allow for aging and corrosion of the interior surface. Therefore, all water piping systems shall be designed with the following friction factors (C values) based on the Hazen-Williams Friction Factor formula.

Table 6-2: Water Piping Friction Factors

System Type	C Value
Closed water	120
Closed, treated	130
Open water	100
(New clean steel pipe)	(140)

- D. Hot and chilled water distribution systems should be designed for variable volume flow.
- E. Hydronic systems should be designed for the widest practical ΔT and the closest possible approach of the return water temperature to the terminal equipment supply air temperature, but not exceed temperatures listed in this section.
- F. The terminal equipment must be selected not only for its full load capacity but also for its performance over the full range of partial loads. Laminar fluid flow in the coils shall be avoided.
- G. Integral face and bypass coils should be utilized with preheat coils.
- H. Coils subject to 100% outside air at winter design conditions shall be protected by one of the following methods:
- Provide propylene glycol in the water loop serving the AHU coils for any unit with 100% outside air capacity at winter conditions. These units must not be equipped with protective override controls to shut off the fan if the freezing condition is determined when operating for smoke removal. The glycol-water loop for this system is to be linked to the main heating hot water system through a plate and frame-type heat exchanger.
 - For those units not arranged for smoke removal use, provide freeze protection thermostats on the coil face to shut down the unit fan and close any Outdoor Air dampers if a freezing condition is detected. Outdoor Air dampers shall fail closed. Outdoor Air dampers typically used for HVAC can't

- fully restrict all of the freezing air coming into the equipment even with the fan shut off. The designer is to include sequences of operation needing to take place during freeze protection operation such as flowing water through the heating and cooling coils.
- c. Pumped coils shall not be used as a means of freeze protection.
 - I. The impact of the change in volume due to the thermal expansion of the distribution system fluids during all operations must be addressed in the design process. Expansion loops shall be used to compensate for the impact of thermal expansion. Other methods of thermal expansion compensation shall only be allowed with written permission from DEN Mechanical Engineer.
 - J. Control valves in hydronic systems must not be oversized. The flow characteristics and pressure drops are to be selected for the appropriate Cv value corresponding to the design flow to be controlled.
 - K. Provide automatic air vents at all coils and at the high points of all piping. Provide drains at the low points of all piping.
 - L. Hydronic systems controls shall be automatic and adjustable to optimize pumping and thermal efficiency.
 - a. When close control is essential, use two-way pressure-independent control valves.
 - b. Three-way valves shall not be used on any system directly connecting the CUP hydronic system.
 - c. When using three-way valves for throttling, avoid pressure under one port being significantly higher than under the other.
 - d. Use mixing three-way valves with caution for flow diversion or diverting valves for mixing since the valves have tendencies to slam shut at reduced flows.
 - e. Use two-way valves at terminal coils in variable flow systems.
 - f. Hot water coil valves shall fail to the open position.
 - g. No coil or heat exchange device shall be run wild or without a control valve.
 - M. When designing piping supports, roller hangers, and supports shall only be used with written permission from DEN Mechanical Engineer.

6.2.2 Flushing and Cleaning for Closed Hydronic Systems - Metallic Piping Systems

- A. Engineer to include methods for testing, flushing, and cleaning of metallic closed loop piping systems in the hydronic piping flow diagram. Include locations for the installation of slip blind and blind flanges or other appurtenances for isolating new piping and equipment from the old. On the contract drawings include methods for testing, flushing, and cleaning in the hydronic flow diagrams including any temporary valves, spool pieces, and a list of equipment that is not to be installed such that flushing can occur. Use multiple hydronic flow diagrams as necessary to convey this requirement; do not describe the requirements in the specifications without the use of flow diagrams. Do not use existing mechanical pumps or any of the hydronic water for filling. See 3.01 FLUSHING AND CLEANING FOR CLOSED HYDRONIC SYSTEMS- METALLIC PIPING SYSTEMS DEN TECHNICAL REQUIREMENTS- DIVISION 23 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC) SECTION 230400- BASIC HVAC REQUIREMENTS for requirements that need to be included in both the design drawings and the specifications. Refer to [Chapter 12- Technical Specification Requirements](#) for further Technical Specification requirements.
- B. If external pumps are needed, include velocity and head requirements for the temporary pump that the contractor should use or rent.

6.2.3 Expansion Requirements

In buildings that are designed to be expanded as the airport capacity increases (such as concourses and the terminal) all hydronic systems shall be sized for the maximum build out of the facility. Piping flow diagrams shall indicate all calculated or assumed flow rates/capacities and pressures of all general spaces anticipated for future construction.

6.3 Piping Supports

6.3.1 Design

All piping supports shall be manufactured systems or designed and detailed by a Colorado Registered Professional Engineer. Supports shall be coordinated with Architectural and Structural disciplines and completely detailed for connection to the structure.

Under no circumstances shall the construction documents direct a Contractor to provide supports without detailed performance specifications outlining the criteria and requirements of supports and their design and installation.

6.3.2 Products

Cable or wire piping supports and/or anchors shall not be used.

6.4 Existing Systems

6.4.1 Hydronic Requirements

Hydronic heating and cooling availability varies from area to area in the concourse and Terminal. Many concourse sub-core locations contain tenant hydronic loops within the lease area. In general, these systems are sized for 20 gpm (heating and cooling) for each original lease area.

Existing heating water loops for perimeter VAV shall not be used for Tenant space conditioning without a complete heating water system analysis and verification of capacity. The analysis shall be accepted in writing by the DEN Mechanical Engineer.

The Tenant shall furnish and install a digital BTU meter on each hydronic service entrance to the Tenant lease area. The meter shall be in an accessible area within the Tenant lease area. The meter shall have native BACnet communication to connect directly to the DEN EMCS. Tenant is to route communications conduit from Electric metering and HVAC/Plumbing Meters back to the nearest DEN controlled COMM room. Tenant is to provide a pull string to nearest DEN comm room and cap according to the Tenant DSM Volume 3 Section 3.2.1.5 Low Voltage DEN Submetering. Label conduit at both ends with location served.

Provide isolation valves on the supply and return of each hydronic system serving the Tenant lease area. The valves shall be in an accessible area within the Tenant lease area.

6.5 Update of Standard Diagrams

6.5.1 Flow Diagrams

DEN currently maintains hydronic flow diagrams of all buildings, which shall be used on any project that modifies the hydronic arrangements in these facilities. These diagrams are being updated and may not be complete but are available from the DEN Mechanical Engineer. Consultants shall submit any modifications to these diagrams directly to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal.

All new flow diagrams shall be developed using the existing diagrams as guidelines. Consultants shall submit any new diagrams to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal. Submittals are to be in Revit; refer to the Digital and Facilities Design Standards Manual for specific BIM requirements.

End of Chapter

Chapter 7 - Space Requirements and Maintainability

7.0 Space Requirements and Maintainability

7.0.1 General

Mechanical equipment and layout shall be selected to maximize equipment performance and minimize equipment servicing, repair, and maintenance. Equipment selection shall also consider durability, reliability, maintainability, and serviceability. Equipment arrangement and layout shall allow for safe and efficient accessibility for equipment removal, replacement, repair, and maintenance.

During the design phase, coordination with other design disciplines is essential to provide the necessary access to equipment. All otherwise inaccessible equipment and equipment components shall be provided with OSHA-approved catwalks, platforms, etc., to allow maintenance. The catwalks, platforms, adequate lighting, etc., shall provide for maximum safety to both personnel and equipment while allowing access for equipment maintenance. Standardization of equipment and materials shall be used to the maximum extent possible. Standardization and interchangeability will minimize the space and expense of the maintenance spare parts inventories. Items for consideration for standardization shall include but are not limited to, AHUs and components, terminal units, control components, heat exchangers, pumps, valves, and fans.

Designer is to include 7'-8' clearance for Fire Department access in tunnels and basements. Designer is to include allowances for fire sprinklers that will be located under mechanical duct and equipment. See the Architectural DSM for more information.

7.1 Design Requirements

7.1.1 Design

The design shall, in general, include equipment layouts with dimensioned maintenance and repair clearances indicated. Special maintenance items or equipment, or necessary auxiliary equipment shall be specified to be provided and installed with the equipment it is to serve. Avoid locating equipment requiring frequent service or repair above ceilings or in occupied spaces.

7.1.2 Equipment Selection

Equipment shall be selected for stable operation at both full and part-load conditions. Equipment selections shall be below maximum limits for capacity, speed, temperature, and pressure. The equipment installation design and specification shall include sufficient instrumentation for measuring, indicating, monitoring, operating, and servicing at full and part loads.

7.1.3 Bearings

Designer shall specify permanently lubricated bearings on fans, if available. Equipment that cannot be furnished with permanently lubricated bearings shall have lubrication lines extended to the exterior of the unit.

7.1.4 Construction Requirements

Designer shall require the Contractor to include in the shop drawing submittals the manufacturer's recommended spare parts lists, maintenance and service clearances, special maintenance equipment or requirements, and recommended maintenance schedules. Conflicts between equipment and maintenance requirements or clearances shall be submitted, along with Contractor's solutions to the conflicts, for approval. Approval of conflict resolution shall be required before equipment installation. Design shall require the Contractor to revise all flow

diagrams, control diagrams, and additional information to reflect any revisions to designed systems and/or required performance capabilities to suit the actual equipment installed.

The design shall require the Contractor to provide instruction for operating personnel on the operation, attendance, and maintenance of equipment. Designs shall include all data necessary to establish an efficient and effective preventive maintenance program.

7.1.5 Fan Housing

All supply fan housings shall have ladder rungs mounted on the side of each unit next to the coil pipe connections to provide access to the top of each unit without stepping on insulated pipes.

7.1.6 Access Doors

All AHUs shall be equipped with access doors for each compartment (coils, filter, fan, etc.), with piano hinges, door handles, and a viewing window in each compartment access door. The doors should be sturdy enough to permit opening the door using one handle. Access doors shall seal airtight when closed to 6" WC positive static pressure. All doors and door swings shall be shown on the drawings.

Provide in accessible locations access doors of adequate size at all fire damper locations for inspection as well as for replacing fusible links.

All required access doors and door swings for every piece of equipment shall be shown on the drawings.

7.2 Space Requirements

7.2.1 Mechanical Rooms

Mechanical room space requirements and dimensions shall be coordinated with the architect so that appropriate space is provided for the equipment and its service and maintenance. Designer is to include a clear visual representation of areas of clearance and accessibility around all equipment.

7.2.2 Mechanical Chases

Mechanical chase space requirements shall also be determined and coordinated, including space for supply and return air ductwork, outside ventilation air, exhaust air, hot and chilled water piping, domestic water piping, sanitary drainage, roof drains, etc. All chases with plumbing equipment shall have a minimum one-floor drain.

7.2.3 Equipment Clearance

Provide a minimum of four feet (clear space) around all sides of boilers and chillers, plus tube pull space. Provide a minimum of three feet (clearance space) around all sides of pumps and air handling equipment, plus coil pull space. All portions of equipment requiring replacement shall be fully coordinated with space layouts to ensure parts (coil pull areas, fan removal, gearbox, etc.) can be replaced without modifications to the space. These are minimum design requirements and shall be extended if the manufacturer's requirements are greater. Knockout walls and removable sections of ductwork, etc., shall not be considered as a viable means of access for equipment maintenance access.

All rooftop equipment shall be serviceable through an existing roof access. Provide a minimum of three feet all around air handling equipment unless the manufacturer's requirements are greater. Coordinate requirements for roof walkway/pads with Architect.

Drawings shall include dimension minimum clearances for all maintenance/service and access to equipment.

Where equipment maintenance requires overhead rails and/hoists, the entire access corridor shall be identified and dimensioned.

7.2.4 EMCS/Control Equipment Clearance

Provide a minimum of two feet (clear space) for maintenance in front of all EMCS and other control panels. For panels located above the ceiling, panel access shall be clear from the face of the panel all the way to the finished floor to allow for proper positioning of ladders. The maintenance area shall be indicated on the plans and models.

7.2.5 Equipment Removal Routes

All equipment and major components (e.g., fans, motors, VFDs, coils, dampers, etc.) shall be able to be removed from the equipment and space and hauled to a loading dock or exterior drive without the removal of doors or walls. Removal routes shall be a minimum of 36 inches clear and allow for floor transportation. In the event conduits and/or piping prohibit floor transportation, crane rails rated for the weight largest equipment component shall be provided to a location where floor transportation can occur.

7.2.6 Plumbing Chases

All restroom groups with more than four fixtures shall have plumbing chase. Chase shall be large enough to accommodate maintenance and replacement to/of all equipment (e.g., water heaters, expansion tanks, etc.) throughout the length of the chase. Minimum chase unobstructed width (not just the width so the design must include allowances for piping and carriers) is recommended at 2'-6" unless approved in writing by the DEN Mechanical Engineer. Coordinate required clear width with Architect.

Plumbing chase shall be directly accessed from a City space. No chase access shall occur through janitor's closets, electrical, or communications rooms.

7.2.7 Mechanical Rooms

In certain areas, baggage conveyors will be routed through ceiling plenums and general spaces. The space requirement for these conveyors will be approximately 4 feet deep by 4 feet wide per conveyor, plus the additional space needed for personnel catwalks (preferably 4 feet wide). Therefore, all ductwork and piping must be routed to avoid conveyors and structural members. Physical space may prohibit ductwork/piping crossing baggage conveyors. Careful coordination is required.

Design Consultant shall coordinate with all systems and disciplines throughout the design process to ensure adequate space is available and to avoid interferences.

7.3 Equipment Protection

7.3.1 General

All equipment, ductwork, piping, and associated supports exposed to potential damage from vehicles shall have a form a structural protection. Protection shall be fully detailed in the contract documents and not inhibit or restrict equipment access requirements defined by this section. Structural protection shall be fully coordinated with required clearances for surrounding vehicles and service operations. Detailing of requirements by the contractor is prohibited.

End of Chapter

This page is intentionally blank.

Chapter 8 - Plumbing Requirements

8.0 Plumbing Requirements

8.0.1 General

This section applies to the systems used to receive, transport, or discharge liquid waste or sewerage; the systems used to receive and distribute potable water; the systems used to receive and distribute fuel gas; and the systems used for the collection and transport of rainwater and cooling coil condensate drains, etc.

8.0.2 System Requirements

Facilities for the physically disabled shall be provided in all public building restrooms.

- A. Provision shall be made within the terminal building and each of the concourses for future expansion of the plumbing systems at such time that the complex is expanded to meet increased usage.
- B. All domestic hot and cold water piping and designated storm drainage piping within conditioned areas shall be insulated. The Design Consultant shall use the best practices to ensure pipes do not freeze. Heat trace systems are not considered best practices and shall only be considered when no other option exists.
- C. Buildings in the terminal complex and concourse areas shall be provided with roof drains and a drainage collection system. The roof drainage system shall be connected to the exterior storm sewer system. Overflow roof drain system shall be piped separately and terminated at grade level.
- D. Structural roadways shall be provided with deck and curb drains and a suitable collection system.
- E. An industrial waste sewer shall be provided for all liquid wastes that would be detrimental to the public sewer system or detrimental to the operation of a sewage treatment plant. Industrial waste shall be collected, treated, and disposed of as required by the authority having jurisdiction.

8.1 Plumbing Design Parameters

8.1.1 General

All plumbing systems shall conform to the requirements of the codes and standards listed in the Standards and Criteria DSM.

Projects required to have a Sewer Use and Drainage Permit (SUDP) require the engineer of record to perform site inspections and obtain photographic documentation necessary to verify installation conformance to the approved plans and specifications. Engineer is to submit documentation along with a cover letter signed and sealed from the engineer of record attesting to the installation and submit to the DEN Project Manager for Contract Director approval and submission to the Authority Having Jurisdiction.

8.1.2 Fixture Count

To determine the minimum number of fixtures required for the terminal and concourse areas, a plumbing fixture count method shall be used. The plumbing fixture method is a method of adjusting the number of people on which the number of fixtures is determined in setting the design for the plumbing facilities. After the number of people are appropriately adjusted, the fixture per persons for the type of building or occupancy from the uniform plumbing code shall be used for determining the minimum plumbing facilities.

The plumbing fixture method typically allows for additional fixtures for peak loads not adequately accounted for by the codes. The basis for the plumbing fixture count method is based on historical airport experience and the fol-

lowing criteria: (Design Consultant shall utilize these criteria or the CCD building code, whichever requires the higher number of fixtures.)

- A. Projected Peak Occupancy (per area).
- B. Thirty-three percent of passengers and 15% of visitors will use concourse facilities (departures and arrivals levels.)
- C. Fifteen percent of visitors and 15% of passengers will use terminal building facilities.
- D. The percentage of men and women in total occupancy is estimated at 55% male/45% female.
- E. Each level and area shall be subdivided into terminal public space, restaurant, office, and retail to determine the fixture count for each particular occupancy.
- F. Urinals shall be utilized in lieu of water closets in men's toilets to the maximum ratio allowed by the code.

Fixture counts and/or flow rates shall be shown on all isometric drawings.

8.1.3 Calculations

Design calculations shall be based on the latest editions of the ASPE Data Book, ASHRAE 90.1, and the Denver Amendments to the International Code Series. Recognized acceptable engineering practices shall be applied for areas where design criteria have not been established specifically by these codes and standards.

When using the International Plumbing Code (IPC) water fixture unit calculation method, only the flushometer table for conversion to flow rate shall be used since all concourse and terminal domestic water mains ultimately connect to public restrooms.

Several areas of the terminal and concourses experience dramatic pressure fluctuations. The engineer shall make every effort to ensure that new designs do not amplify current conditions. In these areas, static and dynamic pressure calculations shall be performed and submitted.

To avoid excessive system noise and the possibility of erosion-corrosion, flowrates shall not exceed flow velocities of 8 fps for cold water and 5 fps in hot water up to 140°F.

No assumptions shall be made on plumbing system capacities. All connections to existing plumbing systems shall have capacity calculations proving capacity. The design consultant shall submit all calculations directly to the DEN Mechanical Engineer in PDF format.

As of 2014, Denver Water maintains a domestic water supply pressure of 65 psi. This is 5 psi lower than the original airport system design.

8.1.4 Terminal

The terminal building plumbing facilities shall be designed for optimum passenger use and the total future terminal size to prevent under sizing of initial terminal building plumbing facilities.

8.1.5 Concourses

The plumbing facilities in the concourses shall be designed for the current initial passenger use. Expansion in concourse passenger service will be in conjunction with concourse construction expansions. Those expansions will include the necessary additional plumbing facilities. Plumbing utility systems (pipe sizes and arrangement) shall be designed to allow for future facilities expansion.

8.1.5.1 Concourse C West Expansion

As of 2014, the domestic water main serving subcore 3W and all spaces west are at the maximum design capacity. The Design Consultant shall conduct a full flow analysis and submit it to the DEN Mechanical Engineer prior to any modifications to this system.

8.1.6 Sand Traps

Sand traps and oil separators shall be installed for vehicle wash areas, deck and curb drains, and any other areas where sand and oil may enter the drainage system.

8.1.7 Grease Traps

Grease traps shall be required from fixtures and equipment with grease-laden waste located in food preparation areas. Grease traps are installed at all subcore of the concourses and many of the quadrants of the center cores. Two grease traps exist in the terminal, one serving each side of the facility.

As of 2014, the capacities are:

Table 8-1: Grease Trap Capacities

Tag	Building	Max Flow (gpm)	Capacity (gal)
A-18	Concourse A	100	2,500
A-24	Concourse A	100	2,500
A-31	Concourse A	100	3,000
A-38	Concourse A	100	2,500
A-39	Concourse A	100	2,500
A-40	Concourse A	100	2,500
A-41	Concourse A	100	2,500
A-49	Concourse A	100	3,000
A-71	Concourse A	100	2,500
B-12	Concourse B	100	2,500
B-22	Concourse B	100	2,500
B-28	Concourse B	100	2,500
B-29	Concourse B	100	2,500
B-37	Concourse B	100	2,500
B-39	Concourse B	100	2,500
B-44	Concourse B	100	2,500
B-45	Concourse B	100	2,500
B-52	Concourse B	100	2,500
B-53	Concourse B	100	2,500
B-80	Concourse B	75	1,500

Table 8-1: Grease Trap Capacities (Continued)

Tag	Building	Max Flow (gpm)	Capacity (gal)
B-88	Concourse B	75	1,500
B-63	Concourse B	100	2,500
C-27	Concourse C	100	2,500
C-30	Concourse C	100	2,500
C-31	Concourse C	100	2,500
C-39	Concourse C	100	2,500
C-38	Concourse C	100	2,500
C-41	Concourse C	100	2,500
C-40	Concourse C	100	2,500
C-48	Concourse C	100	2,500
C-49	Concourse C	100	2,500
C-54	Concourse C	100	2,500
C-57	Concourse C	100	2,500
C-62	Concourse C	100	2,500
C-63	Concourse C	100	2,500
T-East	Terminal	75	1,500
T-West	Terminal	75	1,500

As of 2016, flow/capacity diagrams have been developed to track system usage. These diagrams are available from the DEN Mechanical Engineer but are to be verified in the field for discrepancies in the area of work. Design Consultants shall submit any modifications to these diagrams directly to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal.

All new flow diagrams shall be developed using the existing diagrams as guidelines. Consultants shall submit any new diagrams to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal. Submittals are to be in Revit; refer to the Digital and Facilities Design Standards Manual for specific BIM requirements.

Grease interceptors shall be sized in accordance with the procedures established by the Denver Wastewater Management Division.

Undersink/counter interceptors are not allowed when a grease waste line exists within a reasonable distance from the appliance. Undersink/counter interceptors shall only be used with written approval from the DEN Mechanical Engineer.

All grease interceptors (excluding allowed under sink/counter-type grease interceptors) shall be installed below grade. All manhole and cleanout covers shall be located at the grade or finished floor.

All grease interceptors shall be installed outdoors, except with written permission from DEN Mechanical Engineer. Any grease interceptors installed indoors (excluding allowed undersink/counter-type grease interceptors) shall be installed in rooms with exterior access doors.

Parking for interceptor grease removal vehicles shall be no more than twenty (20) feet from the furthest grease interceptor manhole. Vertical distance from the bottom of the grease interceptor to the grade level of the parking space shall be no more than twenty (20) feet.

Grease waste removal hose drag route shall not be through any public area except parking lots. Hose drag route may be through no more than one (1) door.

8.1.8 Floor Drains

Buildings shall be provided with floor drains that have traps and cleanouts.

Mechanical rooms shall contain general area floor drains and equipment drains for condensate and other miscellaneous drainage. Equipment drains shall not serve dual duty. Equipment drains shall be located to minimize pipe runs to the drain and minimize potential tripping hazards due to floor-supported piping.

All floor drains in chases, basement areas, restrooms, mechanical rooms, and entry vestibules shall have trap primers.

8.1.9 Cleanouts

Where a horizontal drainage pipe, a building drain, or a building sewer has a change of horizontal direction greater than 45 degrees (0.79 rad), a cleanout shall be installed at the change of direction. Where more than one change of horizontal direction greater than 45 degrees (0.79 rad) occurs within 40 feet of the developed length of piping, the cleanout installed for the first change of direction shall serve as the cleanout for all changes in direction within that 40 feet of developed length of piping.

The location and types of all cleanouts shall be noted on the drawing. All drains exiting the building shall have a double cleanout so that the drain line may be cleaned into and out of the building.

8.1.10 Industrial Waste

Industrial waste sewer shall be provided for areas where fueling of aircraft and vehicles takes place.

8.1.11 Backflow Prevention

The potable water supply system shall be designed, installed, and maintained in such a manner as to prevent contamination from non-potable liquids, solids, or gases being introduced into the potable water system through cross-connections or any other connections to the system. Protective measures and the requirement for backflow prevention devices shall meet or exceed the requirements of the IPC, Denver Building Code Amendments, and the requirements of the water utility, Denver Water. If there is any conflict between these requirements, the most stringent requirement shall apply in the design and/or modification to the existing potable water system. Should existing systems be found that do not comply with the latest backflow prevention requirements, the design will include upgrading the backflow prevention of that system being renovated, added to, and/or constructed. All domestic water connections to mechanical, plumbing, and fire protection systems, including lawn sprinkling systems, shall be protected from backflow by use of backflow preventers installed in the piping. Plumbing designs shall meet best management practices for cross-connection control.

At building or building zone main service entrances, provide two backflow preventers in parallel with lockable shutoff valves for primary and backup operations. Each backflow preventer shall be sized for full-service flow.

Separate backflow prevention is required on all potable water piping inside tenant spaces. Backflow prevention shall meet the requirements of IPC for backflow prevention. Single check valves shall not be used. Provide an isolation valve upstream of the backflow prevention device.

8.1.12 Coordination

It is the responsibility of the plumbing engineer/designer to provide design, specification, and detail of all plumbing connections to systems outside of the building (i.e., water, storm drainage, sanitary sewer, natural gas, etc.).

The interface point shall note elevations (building reference and civil reference), sizes, and acceptable means of connection of differing materials and allowable tolerances of connection.

NOTE: Civil notes shall not be used to solely identify this connection.

8.1.13 Piping Movement

In underground piping systems subject to movement, ball and socket joint type flexible expansion joints (i.e., Flex-Tend) shall be used at connections to building piping. Semi-rigid elastomeric PVC couplings (i.e., Fernco) shall not be used. When exterior piping is encased in flowable backfill to the building face, flexible expansion joints are not required.

8.1.14 Future Tenant Spaces

When tenant spaces are designed for future use (e.g., grey box), the final contract documents shall indicate the following in each future space:

- A. Valved and capped Domestic water connection identifying the maximum allocated water flow (gpm) and design pressure (PSIG).
- B. Plugged sanitary connection identifying the maximum allocated drain fixture units (DFU).
- C. Plugged sanitary vent connection identifying the maximum allocated drain fixture units (DFU).
- D. (If applicable) Valved and capped natural gas connection identifying the maximum allocated flow (CFH) and design pressure (in WG).

8.1.15 HVAC Coil Condensate Drains

Coil condensate drains shall have properly sized condensate traps and shall be fully detailed in the contract documents. Condensate pumps shall only be used with written permission from the DEN Mechanical Engineer. General condensate drain trap details without a schedule of sizing are prohibited. Trap sizing by the contractor is also prohibited.

Condensate discharge to be routed to a code approved place of disposal. Discharge of HVAC coil condensate to the exterior is not allowed without written permission from the DEN Mechanical Engineer.

When Code requires a secondary method of condensate drain protection, manufacturer-furnished overflow drains with properly sized condensate traps shall be fully detailed in the contract documents. Pumped condensate and water level detection alternatives are prohibited. Secondary Condensate Drain pans may only be used when a manufacturer overflow is not available.

Wherever units equipped for cooling service are installed above facilities, such as electrical power equipment, computer equipment, data server or telecommunications equipment, or other electrical or electronic equipment susceptible to malfunction if exposed to water, Contractor shall provide a supplemental drain pan to serve as additional protection against leakage, overflow, or other failure of the primary drain pan normally comprising a part of the air conditioning equipment. Supplemental drain pans are to be constructed of 20 gauge (minimum) galvanized steel, with a minimum depth of 2 inches, fabricated, braced, and supported so as to ensure stability.

Secondary condensate drain pans shall not interfere with other maintenance and access requirements detailed in this Design Standards Manual.

All overflow drains that are required to terminate with an open site shall have signs with directions on procedures for notification of maintenance control.

8.1.16 Secondary Condensate Drains

When the code requires a secondary condensate drain from HVAC equipment coil drain pans, manufacturer-furnished overflow drains should be used. Secondary drain pans shall only be used when no option exists from the manufacturer.

Secondary drain pans shall be fully design and detailed on the contract documents. No component of the drain pan shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Secondary pans shall be supported independently of HVAC equipment.
- B. Structural supports and connections to the building structure.
- C. Dedicated piping from the drain pan to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below, immediately contact Maintenance Control at (303) 342-2800".
- D. Drain pan shall not block or inhibit access to surrounding systems.

Pumped primary or secondary pans and leak detection alternatives are prohibited.

8.2 Plumbing System Components

8.2.1 General

- A. Electric (instantaneous type or small storage tank) domestic water heaters shall be provided at each toilet room. No central domestic hot water system is provided in the Terminal Building Complex or in the Concourses.
- B. All potable water piping to Tenant lease areas shall be furnished with a digital water meter on the potable water service entrance to the Tenant lease area. The meter shall be in an accessible area within the Tenant lease area. The meter shall have native BACnet communication to be able to connect directly to the DEN EMCS.
- C. Exterior grease traps shall be provided for fixtures in kitchen and food service concessions areas as these facilities may require.
- D. All water supply to fixtures shall be protected by an approved vacuum breaker.
- E. A detailed area chart/plan shall be prominently displayed in the main equipment rooms showing the locations of all main piping and valves. The Design Consultant is to include this as a Contractor requirement.

All domestic hot and cold water and storm drainage piping within conditioned areas shall be insulated. All piping subjected to freezing temperatures shall be insulated and protected from freezing as appropriate.

8.2.2 Plumbing Fixtures and Equipment

Fixtures and Equipment are to be of the latest design to avoid becoming untimely obsolete.

All lavatory faucets in public and private toilet rooms shall be provided with flow-restricting devices on all outlets. Lavatories faucets shall be specified to flow no more than 0.5 gpm. Provide single-tempered water faucets at lavatories with 102°F supply temperature available within 30 seconds of activation and for a period of not less than 20 seconds. Metering lavatory faucets are to use no more than 0.25 gallons of water per metering cycle.

All lavatories (including physically disabled) can be wall-hung or counter-mounted. Wheelchair access must be provided for handicapped fixtures. A minimum 29" clear knee space is required with a maximum 34" rim height or as defined by the latest version of the ADA.

- A. Water closets and urinals shall be a wall-hung, blow-out type. Tank-type/cistern-type water closets shall not be used in the terminal complex. The flush valves and fixtures shall be provided as follows:
 - a. 1 GPF water closets
 - b. 0.125 GPF urinals
 - c. 0.35 GPM lavs
 - d. 1.5 GPM kitchen sinks
 - e. 1.75 GPM showers
 - f. 4" minimum pipe size (3" not allowed)
- B. To prevent urine salt buildup, urinals shall connect directly downstream of the water closet sanitary sewer main for allowance of future low-flow fixtures. Urinals shall not be headered together and then connected to the sanitary mains.
- C. Waterless urinals shall not be allowed for use at any DEN facility.
- D. Automatic valves shall be provided for urinals and lavatories in public areas. Valves shall be concealed and provided with infrared sensors for valve actuation. (Coordinate with electrical Design Consultant.) Battery-powered devices shall not be used.
- E. Stop valves shall be provided on all fixtures, including water coolers.
- F. All fixture types shall be in the design documents and called out on the contract drawings.
- G. All urinal and water closets shall have a double cleanout on the sanitary or vent riser prior to connection to the main piping to allow for cleaning of piping to the fixture and from the fixture branch to the main. Double cleanout assembly shall be completely detailed on the contract documents.
- H. All water coolers in public areas shall be barrier-free bi-level type and include a bottle fill station on the lower cooler.
- I. Roof vents (DWV) shall be of 3-inch diameter minimum.
- J. Drains from service and slop sinks shall be a minimum of 3-inch diameter.
- K. Minimum potable water line size shall be 3/4-inch except for branch to fixture, which may be 1/2-inch.
- L. Provide a floor drain below all non-carpeted interior vestibule areas. (Drain shall be located below steel mat.)
- M. Air admittance valves shall not be used unless approved in writing by the DEN Mechanical Engineer. Only continuously piping island fixture vents (aka, foot vents) as described by the IPC shall be used.
- N. A minimum of one hose bib shall be located in each mechanical and pump room for general wash down.
- O. All traps shall be protected in accordance with the IPC. Trap protection products are allowed but require written permission of the DEN Mechanical Engineer before inclusion into design. Sure Seal and similar products may be provisionally allowed, Trap Guard and similar products are prohibited.
- P. Due to availability issues and relative cost, 5-inch piping and valves shall not be used.

8.2.3 Piping

Refer to the specifications for pipe material types. Due to continuing issues with cast iron waste piping degrading and leaking, all sanitary and grease waste piping above grade is to be epoxy coated cast iron. See Chapter 12, Section 221316. PVC shall not be used inside the building above grade without written permission of the DEN Mechanical Engineer. Cast iron shall not be used for underground piping.

All piping below grade under aprons, roadways, taxiways, building structures, and paved areas shall be encased in flowable backfill. The exception to this is when installed underfloor structures that use a void form as a sacrificial element to create a space between the floor and the heave of expansive soil. In this case, a plumbing void system such as Plumbing Void by VoidForm Pipe Isolation Systems and equivalents shall be used.

All sanitary sewer piping shall slope at no less than $\frac{1}{4}$ " per linear foot (2.08%) for allowance of future low-flow fixtures.

Size of the roof and overflow piping shall be sized based on the flow rate through the roof drain. Minimum slope for roof and overflow drain piping shall be no less than $\frac{1}{8}$ " per linear foot (1.08%). Size of piping is to remain the same for the entire routing of pipe; pipe size shall not decrease for vertical leaders. If the pipe slope changes from a greater slope to a lesser slope, the entire system shall be sized based on the lesser slope.

Design shall ensure that the minimal pipe length is achieved and that no unnecessary loops or branches are used. Piping shall be routed in the most direct route feasible. No piping shall be routed through/across the AGTS tunnel.

Minimum size of piping is 2" in diameter for sanitary and grease waste and vents.

Press-fit, or push-on types of piping systems and connectors shall not be used for any hydronic or plumbing system.

8.2.4 Plumbing Pumps

All plumbing pumps shall have manual isolation on each side of the pump. An electrical disconnect shall be located within fifteen feet of the pump unless dictated otherwise by Code.

Lift station/well sanitary pumps shall be designed for easy removal from the sump without disconnecting and draining major components of the sanitary system.

All sump pumps shall have controls furnished with a high-level remote alarm and strobe/light. Signage shall be provided and located in a nearby occupied area that indicates alarm response action. For duplex (or greater) pump systems, pump controls shall also include lead/lag alternating operation and on/off settings for each pump. All operational levels shall be fully detailed on the contract documents and not left up to the contractor.

8.2.5 Plumbing Sumps

Plumbing sumps larger than three (3) feet in diameter and two feet deep shall be constructed of cast-in-place or precast concrete. Plastic or FRP sumps shall not be used in below-ground sumps due to the highly expansive nature of DEN soils. All sumps shall be fully detailed and coordinated with structural and civil engineers.

8.2.6 Heat Trace Systems

Electric heat trace is not a preferred method of thermal protection of piping. When heat trace is required and approved in writing by the DEN Mechanical Engineer, the entire system limits shall be detailed on the contract drawings, completely specified in the contract documents, and completely coordinated with other disciplines for electrical load and maintenance access. No portion of system design shall be left to the Contractor.

Plumbing Drawings shall include the following:

- A. Location of heat trace control panel and audible/visual alarm.
- B. Location of alarm signage and detailed requirements of alarm procedures.
- C. Limits of piping to be heat traced.
- D. Control diagram showing interface with DEN EMCS, sequence of operation including all devices, and complete points list.

8.2.6.1 Tenant Use of Heat Trace Systems

No tenant domestic water shall be exposed to freezing temperatures, even with heat trace systems.

8.3 Energy Conservation in Plumbing System Design

8.3.1 Domestic Hot Water

Hot water for domestic water use shall be designed in accordance with ASHRAE 90.1-2010 Section 7 and OSHA requirements. ASHRAE 90.1 establishes minimum requirements for hot water generator recovery efficiency, storage tank insulation, pipe insulation, temperature controls, pump operation, equipment automatic shutdown, and conservation of hot water.

8.3.2 Temperature

The domestic hot water system shall be designed for a supply temperature of 122°F for circulated systems and 140°F for storage systems per OSHA requirements. For the public spaces, provide lavatories with 102°F water at each point of use.

The domestic hot water serving five (5) or more fixtures or the furthest fixture is more than 30 feet from the water heater shall have a circulation loop with a temperature-controlled circulation pump. Domestic hot water shall be circulated to maintain a temperature of 122°F.

8.3.3 Safety Devices

Safety devices shall be provided on the hot water generators and storage devices. Safety devices shall be as required by code and, as a minimum, shall include energy cut-off devices, relief valves, and/or temperature or combination temperature and pressure relief valves.

All water heaters, regardless of size, shall have an expansion tank on the domestic cold water inlet.

8.4 Natural Gas

8.4.1 Sizing

Gas piping shall be sized per the requirements of the International Fuel Gas Code, CCD Amendments to the code, and local Gas Utility. Additional criteria:

- A. Gas specific gravity: 0.65
- B. Gas thermal capacity: 834 BTU per cubic foot

8.4.2 Metering

Metering and pressure regulation for all buildings shall comply with the requirements of Xcel Energy. Contact the DEN PM to coordinate the current requirements.

Natural gas service for concourse Tenants will be connected from the metered area designated by DEN. The Designer shall coordinate gas and meter requirements with the local gas utility.

All gas requirements (demand and pressure) shall be shown on the drawings.

8.4.3 Gas Systems Protection

Architect and Engineer of Record for design of facilities shall design protective measures for all gas piping systems at DEN. All gas piping above grade, both upstream and downstream of meters, shall be protected. Protection and access for all utility equipment shall be coordinated with Xcel Energy.

All gas piping, meters, pressure regulators, appurtenances, and systems shall be fully protected from possible collisions with vehicles, baggage cart tugs, support equipment, etc. To the greatest extent possible, gas systems shall be located away from areas where it is possible for vehicles and/or equipment to strike it directly and/or indirectly through adjacent walls that offer inadequate protection from such vehicle strikes. Standard CMU walls and concrete curbs do not provide adequate protection, as can be seen from the photos below. In addition, gas systems shall be protected from grade level to ceiling, as strikes can occur at nearly all elevations that are not either protected and/or concealed in ceilings.

Gas piping, meters, pressure regulators, appurtenances, and systems exposed to aircraft apron areas shall be fully protected all the way from grade level to the bottom of the soffit level.



Figure 8-1: Concourse B: Tug Damage to Wall



Figure 8-2: Gas Piping Strike: Side and Front Views

8.4.4 Sustainability

As a part of the City and County of Denver's Office of Climate Action, Sustainability, and Resiliency (CASR), the Energize Denver Ordinance, which establishes energy use intensity targets for buildings over 25,000 sq. ft. DEN is working to reduce our carbon emissions impact. As such, no new gas-fired equipment or fixtures, except for kitchen cooking equipment (stoves, ovens, etc.), shall be installed at DEN without written permission from the DEN Mechanical Engineer.

Gas fireplaces are not allowed at DEN.

8.5 Tenant Remodel Requirements

8.5.1 Plumbing Requirements

Tenant plumbing fixtures and piping systems, including all rough-in and final connections, shall be furnished and installed by the Tenant. Plumbing fixtures and accessories shall be of commercial quality and shall use best practices in water conservation. All plumbing systems shall be installed in accordance with the IPC and local plumbing codes. No plastic piping is permitted above the Tenant's ceiling, in a return air plenum, or below a floor. Plastic Piping is only allowed in below-ground applications and as indicated in section [8.2.3.Piping](#).

Indicate on floor plans the routing and size of beer and soda conduits.

Domestic water shall be sized by fixture units and the curve for flush valves per the DDS. The Tenant shall provide a domestic cold-water branch from the main located in the pump/water service entry room when service is not available in the lease area.

8.5.2 Grease Waste

Food Service Tenants shall connect all grease waste to designated grease waste lines. Flow and capacity diagrams of all existing grease interceptors are available from the DEN Mechanical Engineer but are to be verified in the field for discrepancies in the area of work. Refer to the Standards and Criteria DSM for master diagram requirements. All new flow diagrams shall be developed using the existing diagrams as guidelines. Consultants shall submit any new diagrams to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal. Submittals are to be in Revit; refer to the Digital and Facilities Design Standards Manual for specific BIM requirements.

8.5.3 Water Heaters

Provide electric water heaters when water heaters are required. Gas-fired water heaters may be used *only* with written acceptance of the DEN Mechanical Engineer and verification there is the adequate volume in space for combustion air and an accessible route for the flue. See [8.4.4.Sustainability](#) for reducing carbon emissions at DEN.

All water heaters shall have an expansion tank, regardless of the water heater size.

For increased efficiency, heat-pump water heaters shall be considered.

8.5.4 Water Meters

The Tenant shall furnish and install a digital flow meter on the water service entrance to the Tenant lease area. The meter shall be in an accessible area within the Tenant lease area. The water meter shall have native BACnet communication to be able to connect directly to the DEN EMCS. See DEN Communications & Electronic DSM for more information on the requirements. Extend temperature controls conduit and pull string to nearest DEN comm room and cap according to the Tenant DSM Volume 3 Section 3.2.1.5 Low Voltage DEN Submetering. Label conduit at both ends with location served.

Provide a lockable isolation valve directly upstream of the meter.

Domestic cold-water service to the Tenant lease area will not need to be metered if Tenant has only a single hand sink.

8.5.5 Backflow Prevention

Backflow prevention is required on all Tenant connections to the building's domestic water main, including service to a single hand sink. The backflow preventer shall be in an accessible area within the Tenant lease area.

8.5.6 Roof Water

Tenant locations with roof mounted exhaust systems shall include the installation of Frost-Free Hose Bib or Hydrant for Kitchen Exhaust System Cleaning. The design team shall include a frost-free hose bib or hydrant on the roof within 50 feet of the roof-mounted kitchen exhaust system to facilitate cleaning. It shall be connected to the project's water supply, meet local plumbing codes, and include backflow prevention. Include a set of valves to drain the water during the winter months. Valves shall be clearly labeled with a permanent sign noting that the valves are for winterization.

End of Chapter

This page is intentionally blank.

Chapter 9 - Energy Analysis and LEED

9.0 Energy Analysis and LEED

There are many factors unique to the airport terminal and other airport buildings that enter into the design of an energy and water efficient facility. These factors include economic, operational, architectural, passenger experience and environmental quality, mechanical, and electrical considerations-- all of which are interrelated.

DEN terminal, concourses, and other buildings shall include design features that emphasize energy and water conservation. Some of these features have been outlined in earlier chapters but are summarized in this section for emphasis.

Building projects in excess of 5,000 square feet and/or required by DEN Mechanical Engineer shall have a computer energy model (the Energy Analysis) performed to establish baseline and design energy performance according to the methodology established in the most current version of ASHRAE standard 90.1. Energy Analyses shall simulate performance of all relevant building spaces, components, systems, and subsystems and shall produce aggregate building energy performance estimates for both peak demand and consumption of all sources of energy to the designed building (primary and secondary) for a full year. Energy Analyses shall also include economic analyses of energy costs based upon current or expected DEN utility rates and rate structures. Energy cost budgets shall be established and shall meet the requirements of ASHRAE 90.1. This standard allows tradeoffs between mechanical and electrical systems and the building envelope. These tradeoffs shall supersede specific requirements presented after written approval by DEN Mechanical Engineer or Energy Manager.

9.0.1 Codes and Standards

All Designs and Energy Analyses shall meet the requirements detailed in the following:

- A. International Building Code
- B. International Energy Conservation Code
- C. ASHRAE 90.1 (Latest version at time of NTP)

Where the requirements of this chapter or the Codes and Standards themselves deviate from one another, the more stringent of the two shall apply.

9.0.2 LEED Certification

In order to mitigate the negative environmental impacts of the built environment, and to recognize the total cost of capital project ownership, all buildings constructed or renovated at DEN with City funds or funding capacity, and meeting the following criteria, shall be designed and constructed according to the principles outlined in the USGBC's LEED standards and other applicable design, construction and management leading practices for sustainability. The following criteria apply to projects at DEN:

All building projects over 5,000 square feet shall be certified to LEED-NC Gold certification, with the goal of achieving LEED-NC Platinum certification, under the most currently available rating system applicable for the project type.

Project less than 5,000 square feet are expected to meet the intent of LEED-NC Gold certification, with the goal of meeting the intent of LEED-NC Platinum certification credit thresholds and performance criteria, where feasible.

Projects over 5,000 square feet should also be eligible to achieve ENERGY STAR status after one year of operations. Contact the project PM for additional information.

All existing and future City operated facilities shall incorporate all applicable LEED for Existing Buildings (O&M) leading practices into facility operation and maintenance.

In the rare case that it is determined that certification is not feasible, the Designers shall submit documentation of technical and/or cost infeasibility to the DEN PM, who will seek a policy exemption. If given a formal exemption the project shall use LEED guidelines to achieve the equivalent (to the extent possible) of LEED-NC Gold certification, with the goal of achieving LEED-NC Platinum equivalent certification.

The Consultant shall review the current LEED Rating System and, in coordination with other project Designers, develop design strategies for maximizing the project's energy and water efficiency. Following the LEED Rating System, the Consultant and DEN shall determine whether the Gold or Platinum level of LEED Green Building Certification is achievable for the project. Following this decision, the Consultant shall tailor the design documents to achieve this certification. Contact the project PM for LEED Rating System documentation.

Due to the inherent operational and site-specific characteristics of DEN, some LEED credits are impossible or prohibitive to achieve. Most of the credit limitations are in the Site Selection (SS) and, to a lesser extent, Water Efficiency (WE) categories, but limitations may exist in all categories. Though any path to certification is acceptable, experience suggests that the Designers focus on achieving maximum points in the Energy & Atmosphere (EA), Materials & Resources (MR) and Indoor Environmental Quality (IEQ) categories. Designers should be careful to consider the inherent trade-off required between enhanced energy performance and increased outside air ventilation in the context of an airport environment. The already large code-required ventilation rates for densely populated public spaces generally make substantial increases over ASHRAE 62.1 requirements prohibitive. In addition, the transient nature of occupants in many airport spaces may reduce the theoretical benefit of increased ventilation.

Various credits may have previously been approved by GBCI under the DEN Airport Master Site and LEED Campus effort. Consultants shall reference the current LEED Campus and Master Site registrations as they apply to their projects.

It is important to remember as a guiding principle throughout the design process that DEN is a vital piece of transportation infrastructure. At no point shall the intended operational functionality of any new construction and/or any existing airport operations affected by the Design be compromised.

9.0.3 LEED and On-Site Solar Power Generation

Energy efficiency shall be a primary focus for reducing the total cost of ownership of capital assets constructed and certified to LEED Gold (or greater) thresholds. It is likely however, that to reach the certification levels required, projects will also need to incorporate renewable energy after all feasible steps toward efficiency have been taken. Considering this, the following approach shall be taken to follow DEN's preference of impact and return on investment: focus on energy efficiency first, then consider on-site (on-building) solar PV, then consider off-site (on-campus) solar PV, then consider off-site (off-campus) solar PV, then consider purchased renewable energy certificates and carbon offsets.

The inclusion of on-building solar PV represents the greatest potential for DEN to derive benefit from renewable energy, on both grid-provided consumption and demand reduction. Renewable energy certificates and carbon offsets are the last preference for DEN and will only be considered to help projects reach their certification thresholds on a case-by-case basis. These projects must be approved by the DEN PM or Energy Manager.

When solar PV systems are considered, roof-top panels with 16% efficiency ratings shall be the minimum efficiency allowable. PV systems shall be evaluated for use in a variety of applications, including building-integrated PV, solar canopies, and rooftop PV.

Rooftop PV systems shall use ballasted or roof-bonded racking systems rated to resist uplift pressures at wind speeds of 150 mph. Racking systems that require penetrations of roofing material will be allowed after approval from the DEN PM or Asset Manager.

9.1 Heat Recovery Systems

When airside heat recovery systems are required, indirect air-to-air heat exchangers or full-coil-heat-pipe systems shall be the basis for designs. Due to climate and cross contamination issues, enthalpy wheel systems (aka, heat wheels) shall not be a design consideration unless approved in writing by the DEN Mechanical Engineer in the 30% submittal.

9.2 Existing Facility Design and Analysis Conditions

The following sections (9.3-9.10) outline the design and analysis conditions for many existing facilities throughout the airport and are provided for Historical Reference Purposes Only.

All new Designs and Work shall meet the current prescriptive requirements found throughout the DSMs. Designers shall survey all existing conditions prior to design, analysis or modeling and any questions about existing conditions, construction vintage, etc. shall be submitted to the DEN PM or DEN Mechanical Engineer.

9.3 Building Envelope Evaluation (Historical Reference)

The following represents a summary analysis of ASHRAE standard 90A-1980 and 90.1. Applicable excerpts and specific requirements for DEN are included. The Design Consultant shall refer to these ASHRAE standards and the Model Energy Code for a complete review of the design and other issues that may not be addressed in this section. The Design Consultant shall coordinate these requirements with the architect. This section gives the design consultant criteria for completing an energy analysis during the design phase. The values presented are minimums. Actual U values shall be used in calculating building loads.

9.4 U Values (Historical Reference)

9.4.1 Glazing

Window treatment is a major consideration in providing an energy efficient building shell. The glass shall be double glazing, heat absorbing type (some surfaces with reflective coatings). Internal or external shading may be required to reflect solar rays in the summer and permit utilizing the warming rays during the winter. A U value (winter) of 0.50 Btuh/sq.ft.°F, or better shall be used in the glazing design. Maximum shading coefficient values shall be 0.3 for sloped surfaces, and 0.4 for vertical surfaces. Highly reflective glass is not permitted for airport facilities.

9.4.2 Walls

The walls of all facilities shall be well insulated to conserve energy. A U value of 0.10 Btuh/sq.ft.°F, or better shall be used in the design. The architect shall design the ratio of glass-to-wall according to [Table 9-1: Heating and Cooling Criteria](#). If the architect wishes to incorporate more glass, the U value of the opaque wall and/or the glass must be decreased accordingly to meet the U_o requirements as outlined in [Table 9-1: Heating and Cooling Criteria](#).

9.4.3 Roof

The roof of the facility shall be well insulated to conserve energy. A U value of 0.05 Btuh/sq.ft.°F, or better shall be used in the design. If the design incorporates skylights, the architect shall remain in compliance with the U_o requirements by adhering to the allowable combinations of glass vs. opaque roof.

Any building that is heated shall have a combined thermal transmittance value (U_o) for roof/ceilings not exceeding 0.074 Btuh/sq.ft.°F.

Any building that is mechanically cooled shall have a combined thermal transmittance value (U_o) for roof/ceilings not to exceed 0.074 Btuh/sq.ft.°F and shall have an Overall Thermal Transfer Value (OTTV) for the gross area of a roof assembly not exceeding 8.5 Btuh/sq.ft.

Any building that is mechanically heated shall have a combined thermal transmittance value (U_o) for the gross area of exterior walls not exceeding 0.32 Btuh/sq.ft.°F for buildings over three stories in height; 0.265 Btuh/sq.ft.°F for 3 stories and under.

9.4.4 Floors Over Unheated Spaces

For floors of heated spaces over unheated areas, the U_o value shall not exceed 0.05 Btuh/sq.ft.°F. For floors over outdoor air (i.e., overhangs) the U_o value for heating shall meet the same requirements as for roofs, 0.074 Btuh/sq.ft.°F.

Any building that is mechanically cooled shall have a combined U_o for floors exposed to the outdoors air not to exceed that which would be determined by the heating criteria.

9.4.5 Slab-on-Grade Floors

For slab-on grade floors, the thermal resistance of the insulation around the perimeter of the floor shall be $R = 7.3$ sq.ft.F/Btuh for heated slabs and $R = 5.15$ sq.ft.F/Btuh for unheated slabs. The insulation shall extend downward from the top of the slab for a minimum distance of 24 inches or downward to the bottom of the slab then horizontally beneath the slab for a minimum total distance of 24 inches.

9.4.6 Alternatives

ASHRAE standards do allow that the U_o or OTTV value for a component of the building envelope (such as the roof or the walls) can be increased above the code required value, if the U_o or OTTV values for the other components are decreased below the code required value, such that the total overall building combination U_o is still in compliance with the code. Refer to the ASHRAE 90.1 for applicable formulas for determining acceptable combinations of thermal transmittance areas.

A building designed to be both heated and/or cooled shall meet the more stringent of the heating or cooling requirements of the exterior envelope when requirements differ.

9.4.7 Summary

The evaluation of the building shell requirements for DEN in accordance with ASHRAE standards are summarized in the following table. This table indicates the allowable thermal values for walls and roofs (based upon 6283 annual heating degree days and a northern latitude of 39° for Denver, Colorado).

Table 9-1: Heating and Cooling Criteria

Building Element	Building Height	Seasonal Mode	Maximum Allowable Volume
Walls	More than 3 stories	Heating	$U_o = 0.320$ Btuh/sq.ft.°F
Walls	3 stories or less	Heating	$U_o = 0.265$ Btuh/sq.ft.°F
Roof & Ceiling		Heating	$U_o = 0.074$ Btuh/sq.ft.F
Floors- over unheated areas		Heating	$U_o = 0.050$ Btuh/sq.ft.°F
Floors- over outdoor air		Heating	$U_o = 0.074$ Btuh/sq.ft.°F
Walls		Cooling	OTTV= 33.2 Btuh/sq.ft.°F
Roof & Ceiling		Cooling	$U_o = 0.074$ Btuh/sq.ft.°F
Roof & Ceiling		Cooling	OTTV= 8.5 Btuh/sq.ft.°F
Floors - over unconditioned areas		Cooling	$U_o = 0.080$ Btuh/sq.ft.F
Floors - over outdoor air		Cooling	$U_o = 0.074$ Btuh/sq.ft.°F

9.5 Building Components (Historical Reference)

9.5.1 Daylighting

The fenestrations shall provide natural light (daylighting) to reduce the electrical energy requirements during day-time hours. Automatic photo sensing controls can reduce artificial light levels when daylight is available through skylights and windows. An appropriate balance between skylight and lighting effects shall be made with the requirement of overall thermal efficiency. ASHRAE 90.1 provides a means to evaluate alternatives and trade-offs between daylighting and other energy conserving features. This shall be coordinated with the electrical design consultant.

9.5.2 Entrances

Building entrances require special consideration in airport facilities. A high volume of traffic is experienced at personnel entrances, baggage handling, and service entrances. A high volume of air transfer also can occur at these locations. There are several reasons for this:

- A. The building pressurization due to exhaust requirements.
- B. Air pressure on doors and door openings from winds.
- C. Stack effect due to building height.

To design for the alleviation of these problems the Design Consultant shall:

- A. Provide sufficient outside air through the air handling systems to properly pressurize the facility.
- B. Provide windbreaks and vestibules at the door entrances to protect direct blasts of wind from entering the building, including door heaters for winter conditions.

Vestibules in airport facilities are less effective than they might be in other applications, due to the high volume of traffic, and percentage of time both doors will be open during busy periods. However, properly sized vestibules will significantly reduce energy consumption in airport facilities during non-peak airport use.

9.5.3 High-Bay Areas

High-bay ceiling areas shall be utilized to an energy advantage. It is proposed that supply air distribution be designed to permit stratification in the high-bay areas during the summer. The summer return air shall be drawn from the floor level. During winter months, return air shall be pulled from near the ceiling, as high as possible, capturing stratified hot air and heat dissipated by lights and people. Vertical return air shafts with automatic motorized dampers incorporated into the control scheme shall provide this energy management feature.

9.6 Air Leakage - All Buildings (Historical Reference)

9.6.1 Windows

Windows shall be designed to limit air leakage; the air infiltration rate shall not exceed 0.34 CFM per foot of operable sash crack on exterior openings. Coordinate this requirement with the architect.

9.6.2 Swinging, Revolving or Sliding Doors for Nonresidential Use

Where these types of doors are used, they shall be designed to limit air leakage; the air infiltration rate shall not exceed 11 CFM per linear foot of door crack.

9.7 HVAC Systems (Historical Reference)

9.7.1 Controls and Automation

Refer to the Controls and AHU Controls sections for each facility later in this standard.

9.7.2 Variable Water Volume (VWV) Pumping

Variable water volume pumping systems are based upon proper location of pressure transmitters (near the end of the piping loop) and variable speed pumps or staged pumps to provide only the system flow and pressures required to serve the actual cooling or heating load at a particular time. Variable water volume piping shall be employed to reduce energy consumption of hot and chilled water systems. Final design may include additional applications that could be designed with VWV pumping to advantage in reducing energy usage. This determination is left to the discretion of the Design Consultant (i.e., the condenser water systems).

9.7.3 Simultaneous Heating and Cooling

The use of both heating and cooling simultaneously to achieve comfort conditions within a space will not be permitted. The Design Consultant shall review ASHRAE standard 90.1 for exceptions, if necessary.

9.7.4 Outdoor Air Reset

As of 2014, hot and chilled water supply temperatures are no longer reset in relation to outdoor air temperature to save energy during other than design conditions. Hydronic system temperatures are allowed to drift at the CUP level as demand and energy savings analytics dictate.

9.7.5 Energy Recovery (Historical Reference)

It is recommended that consideration be given to the use of recovery systems that will conserve energy (provided the amount expended is less than the amount recovered) when the energy transfer potential and the operating hours are considered. Outside air supply ducts should be located near exhaust ducts wherever possible to increase the economics of heat recovery.

9.8 HVAC Equipment (Historical Reference)

9.8.1 Equipment Efficiency

Primary criteria for the selection of major heating and cooling plant equipment shall be its efficiency of operation. Equipment shall be selected that exceeds the requirements of ASHRAE standard 90.1.

9.8.2 Minimum Coefficient of Performance/Efficiency Levels

Minimum Coefficient of Performance (COP) and/or efficiency levels are established for HVAC system Equipment and HVAC System Components. It is intended that no lower values than those established in this Standard will be acceptable. It is further intended that where equipment of higher COP/Efficiency capability is known to be available on the open market, it will be the system Design Consultant's option to specify such higher efficiencies as they deem to be suitable.

Table 9-2: Commercial/Industrial Furnace and Boilers

Types of Equipment	Percent*
Forced-air furnaces and low-pressure steam or hot-water boilers	80
All other vented heating equipment	80

*Combustion efficiency of commercial/industrial furnaces and boilers is defined as 100% minus stack losses in percent of heat input. Stack losses are

- Loss due to sensible heat in dry flue gas
- Loss due to incomplete combustion
- Loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the fuel

Table 9-3: Electrically Driven HVAC System Equipment

Standard Rating Capacity*	EER*	COP**
Under 65,000 Btuh (19,050 W)	7.8	2.28
65,000 Btuh (19,050 W) and over	8.2	2.40

**Refer to ASHRAE 90A for standard ratings*

***The Department of Energy has established required test procedures for single phase air-cooled residential central air conditioners under 19 kW (65,000 Btuh) in capacity, which have been incorporated in ARI Standard 210-79. EER and COP values in this table are based on Test A of the DOE Test Procedures.*

9.9 Insulation (Historical Reference)

9.9.1 Air-Handling Duct System Insulation

The Design Consultant shall insulate ducts, plenums, and enclosures as required by ASHRAE standard 90.1.

9.9.2 Piping Insulation

Piping installed to service buildings and within buildings shall be thermally insulated in accordance with ASHRAE standard 90.1.

In general, piping insulation shall be fiberglass in interior installations. Insulation shall be provided with an all service jacket. Piping systems carrying fluids that will be below the ambient dew point temperature at any time shall have a vapor barrier.

9.10 Plumbing Systems (Historical Reference)

9.10.1 General

Where possible, the Consultant shall investigate systems to reduce water consumption and waste discharge. The use and availability of ultra-low flow (16 oz. or less) flush valves and powerless infrared faucets shall be investigated. These systems shall be reviewed and accepted in writing by the DEN Mechanical Engineer.

End of Chapter

This page is intentionally blank.

Chapter 10 - Gate Services

10.0 General Requirements

This chapter outlines specific requirements to be included in the overall mechanical system designs and specifications for issuance of construction documents suitable for bidding and permitting. These designs and specifications shall include PCA systems where applicable for specific locations. This chapter describes the general mechanical gate services and includes PCA system and potable water cabinet design requirements and criteria for specific locations and the scope of participation that is required by Design Professionals of record.

DEN has a mixture of PCA systems. Systems are designated and limited by building:

10.0.1 Acronyms and Definitions

Table 10-1: Gate Services Acronyms and Definitions

Term	Definition
Fixed walkway	Enclosed, fixed connector extending from an airport concourse gate to a loading bridge, enabling passengers, aircraft/concourse access without direct exposure to the elements
GPU	Ground Power Unit
Jet Bridge, Jetway, or Loading Bridge	Enclosed, movable connector that extends from an airport concourse gate or fixed walkway to an aircraft, enabling passengers, aircraft/concourse access without direct exposure to the elements
PCA	Pre-Conditioned Air
PWC	Potable Water Cabinet

10.0.2 Concourse A

Consists of a two-pipe changeover hydronic system with PCA plant located in southeast basement level of the central core. Due to limitations of clearance on the south side of the building, thus limiting aircraft parking and size, all PCA units are 45 ton. PCA units on the north side were sized based on their gate diversity as of 2006. Several stand-alone DX PCA units serve individual add-on gates. This practice has been discontinued.

10.0.3 Concourse B

Consists of unitary DX PCA units serving each gate. The concourse has a mixture of gate-mounted units and stand mounted units. Stand mounted units are generally used at congested dual-bridge international gates where bridge-mounted units would block access to bridge-mounted electrical equipment. The majority of PCA units are sized based on the original gate aircraft mix in 1994. In 2008, the south commuter finger was added, and new DX PCA units were added for commuter gates on that facility. In 2013, the PCA units at gates 32, 36, 38, 39 and 42 were replaced with larger DX units to accommodate the arrival of the 787. Airline may require a specific unit capacity, i.e. 60-Tons, and should be coordinated with each gate project.

10.0.4 Concourse C

Consists of a two-pipe changeover hydronic system with PCA plant located in southeast basement level of the central core. In 2006, all PCA units were replaced with 60-ton units. Several stand-alone 60-ton DX PCA units serve individual add-on gates. This practice has been discontinued.

10.0.5 Plant Description

The existing PCA plants on Concourses A and C are secondary two-pipe changeover utility plants that connect to the CUP to provide an isolated thermal distribution system to the gate PCA units. In general, the PCA plant consists of chillers, heat exchangers, pumps, and future space for thermal energy storage units.

All new PCA Plants shall be four pipe systems.

10.0.6 Plant Design

All PCA plants shall be designed for a full gate expansion; approximately 50 gates at Concourses A, B, and C. All plant equipment furnished shall be selected to handle a minimum of half of the full total build-out load. The following criteria shall be used for selection of PCA plant equipment:

10.0.6.1 Chiller Selection

- A. Chilled glycol mode: 20°F CWS, 40°F CWR (20°F design ΔT) - 30% ethylene glycol
- B. Heating glycol mode: 180°F HWS, 140°F HWR (40°F design ΔT) - 30% ethylene glycol

10.0.6.2 CUP Connection Criteria

- A. Chilled water condenser water 56°F CHR in, 66°F CHR out (10°F design ΔT). Note that plant equipment should be capable of operating at CHR temperatures as low as 50°F or contain mixing valves for proper equipment operation.
- B. Heating water 220°F, 170°F (50°F design ΔT)

The design of plant equipment shall accommodate component selections to provide partial system operations in the event of failure of any single component. Multiple units of each system component (50% capacity each minimum) are required. Plant designs shall not have less than two units in each system type.

Due to the use of Ethylene glycol in the system, floor drains will not be permitted within the PCA plant rooms. If equipment drains are required, provide hub/funnel drains at an elevation above the curb elevation of the room and connect it to existing drain piping.

10.0.7 PCA Hydronic Design

PCA hydronic piping shall be sized for ultimate build-out of the facility unless directed otherwise by the DEN Mechanical Engineer.

Due to large changes in aircraft mechanical conditioning loads from the original gate design of 1994, many existing PCA hydronic mains do not have capacity for ultimate concourse build-out.

Pumps shall be selected for maximum operating efficiency, (i.e., slightly to the right of maximum efficiency point on the pump curve). Multiple pumps for parallel operation shall have relatively steep performance curves. All pumps shall be specified for VFD operation. Standby pumps and accessories shall be provided for both heating and cooling systems. Pumps shall be arranged in a parallel configuration and headered to maximize pumping flexibility. New pumps shall be sized for half of design flowrate.

Pump design flowrates and selected system diversities shall be determined on a project basis and coordinated directly with the DEN Mechanical Engineer. Existing systems have diversities ranging from 15%-40% depending on Airline usage.

The individual PCA units require a minimum, constant flow to keep the piping tempered (hot or cold depending on the change-over state) otherwise the units will trip. Maintaining a variable flow condition requires additional design considerations.

All PCA hydronic systems use 30% ethylene glycol.

Shut-off valves shall be provided at every branch take-off from the PCA hydronic main, upstream, and down- stream of every expansion compensation device.

All new piping designs shall include expansion compensation, anchoring, guiding, and branch take-offs to each gate position.

Older gates at DEN use STUs (Service Transport Units) to support flexible hydronic piping and electrical cabling between the fixed building connections and PCA and GPU units mounted underneath passenger loading bridges.

Whenever passenger loading bridges are replaced, the STUs are also replaced with pantographs. Designers shall coordinate with passenger loading bridge manufacturers to ensure that replaced flexible hydronic piping fits inside pantographs.

No flexible hydronic piping shall be used in the PCA glycol hydronic system, except to connect rigid hydronic piping at building to PCA units mounted underneath passenger loading bridges.

10.0.8 Equipment Support

The entire floor in the PCA Plant is supported separately on caissons. Equipment supports must be engineered in consideration of the loading used in the design of the floor.

10.1 PCA Units

10.1.1 PCA Unit Sizing

All gates shall have a PCA unit, unless otherwise directed by the DEN PM. All PCA units shall connect to the con- course PCA Plant when available.

PCA selection shall be made based on the potential largest and smallest aircraft the gate can handle; e.g. the PCA unit at the gate shall be able to service both the largest and smallest aircraft the gate is planned on servicing. This restriction typically forces unit sizing to 60 tons. Due to the International Bridge restricting aircraft size on the south side of Concourse A, all PCA units on the south side of this concourse shall be 45 tons (special conditions apply for United Airlines gates and changes must be approved by DEN Mechanical Engineer).

Table 10-2: Sizing of Aircraft Specific to DEN contains general sizing for aircraft specific to DEN. Sizing may differ for single aircraft based on the number of loading bridges available at the gate. Units shall be specified for a min-imum leaving air temperature, as required, for a maximum air temperature of 32 ± 2°F for wide body or jumbo, 35 ± 2°F for narrow body. Contact the DEN Mechanical Engineer to discuss sizing and limitations for each project.

NOTE: Sizing for Airline expectations of 15-minute cool time from hot aircraft to conditioned is not possible with many (or any) units and aircraft configurations. Design Consultant shall document calculated load pro- files for all proposed gate configurations in Project Design Analysis Report (DAR).

Table 10-2: Sizing of Aircraft Specific to DEN

Air Carrier	Code	Type	Abbreviation	Single Bridge PCA1	Dual Bridge PCA2
Aero Mexico	(AM)	B737-700	B737	45	n/a
		B737-800	B738	45	n/a
Air Canada	(AC)	Embraer EMB-175	E175	20	n/a
		Embraer EMB-190	E190	20	n/a
		A319-100	A319	45	n/a
		A320-200	A320	45	n/a

Table 10-2: Sizing of Aircraft Specific to DEN (Continued)

Air Carrier	Code	Type	Abbreviation	Single Bridge PCA1	Dual Bridge PCA2
Alaska Airlines	(AS)	CRJ-700	CRJ-700	20	n/a
		Embraer EMB-175	E175	20	n/a
		B737-400	B734	45	n/a
		B737-700	B737	45	n/a
		B737-800	B738	45	n/a
		B737-900	B739	45	n/a
		A320-200	A320	45	n/a
Allegiant	(G4)	A320-200	A320	45	n/a
		MD-80	MD-80	45	n/a
American Airlines	(AA)	A319-100	A319	45	n/a
		A320-200	A320	45	n/a
		A321-200	A320	45	n/a
		B737-800	B738	45	n/a
		CRJ-200	CRJ-200	20	n/a
		CRJ-700	CRJ-700	20	n/a
		CRJ-900	CRJ-900	20	n/a
		Embraer EMB-170	E170	20	n/a
		Embraer EMB-175	E175	20	n/a
		Embraer EMB-190	3190	20	n/a
		Embraer ERJ-145	E145	20	n/a
		MD-80	MD80	45	n/a
Boutique Air	(BTQ)	PC-12	PC12	n/a	n/a
		King Air 350	K350	n/a	n/a
British Airways	(BA)	B777-200	B772	60	n/a
		B777-300	B773	60	n/a
		B747-400	B744	90	60
California Pacific	(DYN)	Embraer ERJ-145	E145	20	n/a
Copa Airlines	(CM)	B737-800	B738	45	n/a

Table 10-2: Sizing of Aircraft Specific to DEN (Continued)

Air Carrier	Code	Type	Abbreviation	Single Bridge PCA1	Dual Bridge PCA2
Delta Air Lines	(DL)	MD-88	MD-88	60	n/a
		MD-90	MD-90	60	n/a
		A319-100	A319	45	n/a
		A320-200	A320	45	n/a
		A321-200	A321	45	n/a
		A330-300	A333	60	n/a
		A350-900	A359	60	n/a
		Embraer EMB-170	E170	20	n/a
		Embraer EMB-175	E175	20	n/a
		Embraer EMB-190	E190	20	n/a
		CRJ-200	CRJ-200	20	n/a
		CRJ-700	CRJ-700	20	n/a
		CRJ-900	CRJ-900	20	n/a
		B717-200	B717	45	n/a
		B737-700	B737	45	n/a
		B737-800	B738	45	n/a
		B737-900	B739	45	n/a
		B757-200	B752	45	n/a
		B757-300	B753	45	n/a
		B767-300	B763	60	n/a
		B767-400	B764	60	n/a
		B777-200	B772	60	n/a
Denver Air Connection	(DAC)	D-328	D328	20	n/a
Edelweiss	(WK)	A330-300	A333	60	n/a
Frontier Airlines	(F9)	A319-100	A319	45	n/a
		A320-200	A320	45	n/a
		A321-200	A320	45	n/a
Icelandair	(F1)	B757-200W	B752W	45	n/a
JetBlue Airways	(B6)	A320-200	A320	45	n/a
Lufthansa	(LH)	B747-400	B744	90	60 n/a n/a
		A330-300	A333	60	
		A340-600	A346	60	
		A350-900	A359	60	
		A380-800	A380	90	
Norwegian	(DY)	B787-800	B788	n/a	90/60
		B787-900	B789	n/a	90/60
Southwest Airlines	(WN)	B737-700	B737W	60T	n/a
		B737-800	B738W	60T	n/a
Spirit Airlines	(NK)	A319	A319	45	n/a
		A320-200	A320	45	n/a
		A321-200	A321	45	n/a

Table 10-2: Sizing of Aircraft Specific to DEN (Continued)

Air Carrier	Code	Type	Abbreviation	Single Bridge PCA1	Dual Bridge PCA2
Sun Country	(SY)	B737-700 B737-800	B737 B738	45 45	n/a n/a
United Airlines*	(UA)	A319-100	A319	60	n/a
		A320-200	A320	60	n/a
		B737-700	B737	60	n/a
		B737-800	B738	60	n/a
		B737-900	B739	60	n/a
		B757-200	B752	60	n/a
		B757-300	B753	60	n/a
		B767-200	B762	60	n/a
		B767-300	B763	60	n/a
		B767-400	B764	60	n/a
		B777-200	B772	60	n/a
		B787-8	B787	n/a	120/60
		B787-9	B789	n/a	120/60
		B787-10	B7810	n/a	120/60
		CRJ-200	CRJ-200	60	n/a
		CRJ-700	CRJ-700	60	n/a
		CRJ-900	CRJ-900	60	n/a
		Embraer ERJ-145	E145	60	n/a
		Embraer EMB-170	E170	60	n/a
		Embraer EMB-175	E175	60	n/a
Volaris	(Y4)	A319-100	A319	60	n/a
		A320-200	A320	60	n/a
		A321-200	A321	60	n/a
WestJet	(WS)	B737-500	B735	45	n/a
		B737-700	B737	45	n/a
		B737-800	B737	45	n/a

1- PCA unit to be used when aircraft is only served by a single loading bridge

2- PCA unit to be used at each loading bridge when aircraft is only served by two loading bridges.

3- Aircraft is available with an option for two PCA connections and may vary from airline to airline Requirements coordinated on a gate by gate basis.

*UAL desired for size for all single bridge PCA units regardless of the plane type. DEN Mechanical Engineer must approve any increased capacity changes on glycol supplied units..

10.1.2 United Airlines PCA Hose Adapters/Connectors

United Airlines (UAL) uses different PCA Hose Adapters/Connectors than all other airlines. When installing PCA units on Gates primarily used by United Airlines, the Consultant shall coordinate with United Airlines representatives to ensure the correct PCA Hose Adapter/Connector is specified.

10.1.3 Hydronic PCA Units

Hydronic PCA units shall be used when a PCA plant exists in the building of connection. When replacement units are installed that are of larger capacity than the original, a hydronic and load analysis shall be performed by the Engineer to verify piping, pumping and chiller capacity. Design calculations and report shall be submitted to the

DEN Mechanical Engineer. Hydronic PCA units shall be furnished with factory-installed reheat coils (typically 18 kW for 60 Ton PC Air units). Verify required reheat capacity with DEN Mechanical Engineer.

Hydronic PC Air units are served by dedicated 2-pipe, hydraulically isolated hydronic systems that are switched over from heating water to chilled water depending on conditions and loading needs. These hydronic systems contain 30% ethylene glycol for freeze protection and low temperature operation required by the PC Air units.

10.1.4 DX PCA Units

DX units shall only be used on Concourse B and select locations where connection to the existing hydronic system is not allowed. DX units shall only be used on CCB and other areas with written permission from the DEN Mechanical Engineer.

10.1.5 Condensate Drains

Coil condensate drains can drain directly to the apron. Properly sized condensate traps are required and shall be fully detailed in the contract documents. Trap sizing by the contractor is prohibited.

10.2 General PCA Unit Requirements

10.2.1 PCA Unit Supports

PCA units shall be supported on the underside of the loading bridge as close to the cab drive as possible without impeding PCA hose distribution. Locations of PCA units shall not block access to loading bridge electrical j-boxes or access doors. Location of the PCA units shall also take into consideration the minimum bridge level to avoid damage to the unit by crushing or collision with vehicle access below. Minimum bridge position shall allow for a minimum of 12" clear between the bottom of the PCA and the apron to allow for snow.

Stand-mounted PCA units are allowed in limited applications but are not preferred. Stand design shall be performed by the Engineer and completely detailed on the plans. Manufacturer supplied stands shall not be used. Stand design shall include bollard or jersey-type barrier placement maintaining required access for maintenance to PCA Unit and any other equipment within the protected area. Stand and protection shall not interfere with air- craft gate services or concourse vehicle service roads (VSRs). Provide hail protection on DX unit condenser sections.

10.2.2 PCA Controls

All PCA units shall connect to the concourse Facilities EMCS (including graphics changes or additions) through CAT 6 or fiber optic cabling depending on distance to COMM room. Stand-alone controls are not allowed. See the Communications and Electric Systems DSM for additional controls requirements.

10.2.3 Accessories

Unless gate parking arrangement dictates otherwise, PCA hose reels shall not be used. All gate side PCA hose shall be stored in PCA hose trolleys. Hose trolleys shall be connected directly to the apron drive of the loading bridge. Single height, single hinge trolleys shall be used for all domestic gates. Dual height or width trolleys may be required at international gates and will require direct coordination with DEN Mechanical Engineer and a gate Air- line representative. Hose trolley layout and movement arcs shall be fully coordinated at each gate for all aircraft service equipment and other GSE. Due to the diversity in different airline gate operations, each gate movement shall be detailed. General details that are not airline gate specific are not allowed.

All supply and return piping at the Loading Bridges serving the PCA units shall be flexible and supported in a single or double hinge pantograph depending on the jet bridge length. In general, single hinge pantographs shall be used at two-tunnel jet bridges and double hinge pantographs at three tunnel jet bridges. Shutoff valves shall be installed at the transition from steel piping to flexible piping in the pantograph.

When PCA units are remote stand mounted, metal telescoping ductwork is required on the loading bridge. Rigid metal ductwork and fittings shall be used for the longest extent possible to connect the PCA unit to the telescoping

duct. Flexible hose shall only be used in area of movement at the loading bridge rotunda column and connection to the hose system in the hose trolley.

10.2.4 Painting

All PCA units, pantographs, piping, and conduit shall be painted to match the color for the fixed walkway and loading bridge. All structures for stand mounted equipment and safety bollards shall be painted safety yellow. Telescoping ducts and Potable water cabinets shall not be painted and be of a non-reflective finish.

10.3 Fixed Walkways and Passenger Loading Bridges

10.3.1 Ventilation and Conditioning

Fixed walkways and passenger loading bridges have specific pressurization requirements defined in NFPA 415 and additional requirements defined in the Denver Amendments to the ICC series. Denver Community Planning and Development (CPD) still has not finalized requirements for Passenger Loading Bridge (PLB) pressurization compliance.

In the existing Concourses, DEN uses transfer air from the Concourses to pressurize passenger loading bridges.

Previously, DEN has used VAVs to pressurize passenger loading bridges with fixed walkways longer than 20 feet. However, this method of pressurization is no longer required. This method still remains installed on some Gates and is beneficial for passenger comfort during aircraft boarding and deplaning.

DEN recommends installing a VAV to provide conditioned air to fixed walkways and PLBs purely for the comfort of passengers and crew boarding or deplaning aircraft. In the event the existing base building AHUs does not have capacity for an additional dedicated VAV for a new/modified gate, an existing perimeter VAV may be used with written permission of the DEN Mechanical Engineer. In this instance only, dampers shall be installed in the duct-work to isolate operation between the perimeter zone and fixed walkway. The VAV and dampers shall be inter-locked with the fixed walkway door. In normal operation, the damper to the fixed walkway will be closed and the damper to the perimeter system will be open. Whenever the walkway door is opened and for a period of five (5) minutes after door is closed the damper to the fixed walkway will be open and the damper to the perimeter system will be closed and the VAV will operate at 100% design airflow.

In new concourse hold rooms or new concourses, the designer shall meet with the DEN Mechanical Engineer to establish design criteria.

10.3.2 PLB Pressure Monitoring

Denver Community Planning and Development (CPD) have specific requirements for pressure monitoring for all new PLBs and modifications to PLBs. All PLBs must monitor and trend differential pressure across the interior PLB door (the door between the Concourse and the PLB), along with the door position status. Differential pressure must be trended at least every 10 seconds when the door is closed, and at least every two minutes when the door is opened. The door switch status must be trended on Change of Status. Per requirements in [Chapter 5- Controls](#), differential pressure and door status trends must be stored in an SQL database accessible to DEN staff.

10.3.3 Fire Protection

Fixed walkways in excess of 20 feet in length have specific fire sprinkler requirements defined in NFPA 415 and additional requirements defined in the Denver Amendments to the ICC series.

10.4 Potable Water Cabinets

10.4.1 Locations

Potable water cabinets (PWC) shall be installed at every gate that contains a loading bridge and any other location as dictated by DEN Planning and/or the DEN Mechanical Engineer. The PWC shall be oriented to face as direct as

possible the most common aircraft to be parked at the gate. Location and orientation shall minimize hose length and potential for damage due to abrasion or ground crew operations.

10.4.2 Services

PWC shall connect to the concourse domestic water and sanitary sewer systems. Sanitary vents may extend and terminate above the loading bridge rotunda. Pumped sewer systems should not be a design consideration.

10.5 Update of Standard Diagrams

10.5.1 Flow Diagrams

DEN currently maintains PCA system hydronic flow diagrams for Concourses A and C, which shall be used on any project that modifies the PCA system in these facilities. These diagrams are available from the DEN Mechanical Engineer but are to be verified in the field for discrepancies in the area of work. Consultants shall submit any modifications to these diagrams to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal.

All new flow diagrams shall be developed using the existing diagrams as guidelines. Consultants shall submit any new diagrams to the DEN Mechanical Engineer at the Issue for Construction and Record Documents phases of the project independently of any other required submittal. Submittals are to be in Revit; refer to the Digital and Facilities Design Standards Manual for specific BIM requirements.

End of Chapter

This page is intentionally blank.

Chapter 11 - Facility Design

11.0 Facility Design

This chapter is to be used by the Engineer for a basis of design unless directed otherwise by the DEN Mechanical Engineer. This section contains information on the original basis of design for existing facilities that may no longer comply with current adopted codes. **Most of this section is for historical reference.** Original cooling design was 78°F, but for comfort reasons, the allowable temperatures were lowered for occupant comfort. Be aware that there is limited capacity in the legacy systems and the designer may want to supplement the legacy cooling with additional methods. The Engineer shall review the requirements below and notify the DEN PM in writing if current codes conflict with the recommendations below and provided recommendations for modifications during the design submittal process.

11.1 Passenger Terminal —Ticketing Level

11.1.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.1.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.1.3 Perimeter Systems

The glass wall in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume, heating, and cooling. This system shall not use fan-powered VAV terminal units for heating and cooling.

11.1.4 Air Curtains

Air curtains shall be provided for use on all main terminal entrances. Overhead fan-coil systems shall be used at each entrance with ceiling supply and low return in the vestibule area.

11.1.5 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.1.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.1.7 Filtration

Outside air shall be filtered with, as a minimum, the use of 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.1.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#) for AHU and HVAC system control requirements.

11.1.9 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.1.10 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion. Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.1.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of the National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide a wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.1.12 Smoke Control

All public and Tenant areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.2 Passenger Terminal — Baggage Claim

11.2.1 Indoor Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.2.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.2.3 Perimeter Systems

The glass wall in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume, heating, and cooling. This system shall not use fan-powered VAV terminal units for heating and cooling except for the existing International.

11.2.4 Air Curtains

Air curtains shall be provided for use on all main terminal entrances. Overhead fan-coil units shall be used at each entrance with ceiling supply and low return in the vestibule area.

11.2.5 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.2.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.2.7 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.2.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.2.9 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.2.10 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.2.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of the National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.2.12 Smoke Control

All public and Tenant areas shall be served by a separate smoke control system. Refer to the LifeSafety DSM for Requirements.

11.3 Passenger Terminal — Atrium

11.3.1 Indoor Design Conditions

- A. Cooling: 74°F (No Humidity Control)
- B. Heating: 70°F (No Humidity Control)

11.3.2 Air Handling Systems

Return air shall be from the occupied space.

11.3.2.1 Occupied Space

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#). The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.3.2.2 Great Hall Area

Provide constant volume variable temperature heating and cooling.

11.3.3 Outdoor Air Requirements

Outside air shall be introduced through the VAV system and the high bay atrium makeup air units.

11.3.4 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.3.5 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.3.6 AHU Controls

11.3.6.1 Occupied Space (VAV System)

Refer to [5.2.Sample Control Components and Requirements](#).

11.3.6.2 High Bay (Makeup Air System)

- A. Provide similar basic controls and alarms as indicated for the VAV system.
- B. Air volume shall be controlled by industrial-grade differential pressure controllers (auto zeroing type) in the occupied space to maintain positive pressure.
- C. Heating coil controls shall maintain a 65°F leaving air temperature (adjustable).
- D. Relief air fans shall be utilized for air relief and high bay ventilation to maintain a preset high bay space temperature.

11.3.7 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.3.8 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code. Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to plumbing design parameters and basis of occupancy

11.3.9 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of the National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.3.10 Smoke Control

Atrium area shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.4 Passenger Terminal — Train Station Security

11.4.1 Indoor Design Conditions

- A. Cooling: 74°F
- B. Heating: 70°F

11.4.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.4.3 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on average terminal load occupancy.

11.4.4 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.4.5 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.4.6 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.4.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code. Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.4.8 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.

- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.4.9 Smoke Control

All public areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.5 Passenger Terminal — Train Station Exit Pavilions

11.5.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.5.2 Air Handling System

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#)

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.5.3 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.5.4 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on average terminal load occupancy.

11.5.5 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.5.6 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.5.7 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.5.8 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.5.9 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.5.10 Smoke Control

All public areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.6 Passenger Terminal — Train Station Loading Platforms

11.6.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.6.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.6.3 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.6.4 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International

Mechanical Code with City amendments, whichever is more stringent. These values shall be based on average terminal load occupancy.

11.6.5 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.6.6 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.6.7 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.6.8 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.6.9 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global the current agency insurance underwriter.

- A. Provide a wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.7 Passenger Terminal — Concessions and Services

11.7.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

DEN AHUs are not designed to handle the heating and cooling loads of less energy-efficient setpoints. Refer to [11.7.2.Air Handling Systems](#) for Tenant airflow allocations. In previous projects, many tenants have found that these energy efficiency requirements are uncomfortable, and have requested DEN change their zone temperature setpoints. This causes problems for DEN HVAC systems, as modifying zone temperature setpoints without adding supplemental heating or cooling equipment often causes tenants to exceed their allotted airflow, and strains DEN

HVAC systems and equipment. If a tenant requires zone temperatures that are not feasible with their allotted airflow, the tenant must install additional mechanical equipment to make up the difference in heating or cooling loads. This equipment could include, but is not limited to fan coil units that recirculate air in the space, air or water source heat pumps, or other mechanical solutions. Care should be taken when selecting equipment and designing sequences of operation to ensure that no simultaneous heating and cooling of zones occurs.

11.7.2 Air Handling Systems

The base building air handling system has been designed to accommodate the following loads for Restaurant, Food Courts, Office, and Concession Spaces:

- A. Basic Office, Retail, Airline Tenant: Exterior Load + 1.00 CFM/SF
- B. Restaurant Tenant: Exterior + 1.25 CFM/SF for seating area. Kitchen to be conditioned with Tenant supplied makeup air system.
- C. Bar Tenant: Exterior load + 1.25 CFM/SF
- D. Food Court Tenant: Exterior load + 1.25 CFM/SF for seating areas. Source of makeup air shall be by each Tenant and coordinated between DEN and each Tenant.

The Tenant shall provide a complete HVAC system to meet loads that exceed the requirements listed above. The Tenant shall verify the heating and cooling loads from the perimeter, adjoining structures and adjacent spaces affecting the Tenant area. All Tenant areas in the terminal are in the interior spaces and are unaffected by the perimeter heating/cooling loads.

11.7.3 Outdoor Air Requirements

In general, outside air shall be brought in through the base building AHU and/or the kitchen ventilation system. Refer to [3.2.Ventilation Systems](#) for ventilation requirements. The Tenant HVAC shall makeup a minimum of 100% of what is exhausted from the space.

11.7.4 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust requirements shall be determined by the cooking exhaust hoods installed within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.7.5 Ventilation Rates

The existing system ventilation was designed in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers Standard (ASHRAE) 62-1989, Ventilation for Acceptable Indoor Air Quality. All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Filtration.

11.7.6 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.7.7 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.7.8 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.7.9 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Provide grease trap interceptors for kitchen areas.

Provide gas-fired hot water heating system for kitchen requirements.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.7.10 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and the building code for the CCD. The following description of fire protection requirements is based on NFPA.

- A. Provide a wet-pipe sprinkler system for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm station at exits.
- E. All escalator and stair opening perimeters shall be protected by providing closely spaced sprinkler heads to provide a water curtain.
- F. Provide a pre-engineered carbon dioxide extinguishing system for the kitchen exhaust hoods in accordance with NFPA 12, Standard on Carbon Dioxide Extinguishing Systems. The system shall be capable of automatic detection with local or remote manual actuation. Accessories shall be installed for mechanical or electrical gas line shut-off applications. System shall be listed with Underwriters Laboratories, Inc. (Exception alternate extinguishing system types which are acceptable to the Denver Fire Prevention Bureau are allowed in lieu of CO2 but must complete all necessary steps as outlined)

11.7.11 Smoke Control

All public and Tenant areas shall be served by the base building smoke control system. Refer to the Life Safety DSM for requirements.

11.8 Passenger Terminal — Rest Rooms

11.8.1 Design Conditions

- A. Cooling: 74°F (No Humidity Control)
- B. Heating: 70°F (No Humidity Control)

11.8.2 Air Handling Systems

This area shall be air conditioned with a VAV system.

In general, supply air shall be provided by the same AHU serving adjacent spaces.

11.8.3 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area, 6 air changes per hour or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.8.4 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.8.5 Controls

Provide control logic to permit the following:

- A. Space temperature

11.8.6 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP.

11.8.7 Plumbing Requirements

Fixture count requirements shall be determined by the following:

- A. Projected terminal occupancy.
- B. Local code requirements.
- C. Thirty-three percent of the passengers and 15% of visitors will use concourse facilities. Fifteen percent of passengers and visitors will use terminal facilities.
- D. The ratio of men to women is estimated at 55% male/45% female.
- E. Urinals shall be utilized in lieu of water closets to the maximum ratio allowed by the code.
- F. Facilities for the physically disabled shall be provided in the terminal public restrooms.
- G. All domestic hot and cold-water piping within conditioned areas shall be insulated. All piping subjected to freezing temperatures shall be insulated.
- H. All lavatory faucets in public and private toilet rooms shall be provided with flow restriction devices on all outlets. Except for faucets on physically disabled fixtures.

The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories shall be wall hung or counter mounted.
- B. Lavatories for the physically disabled can be wall hung or counter mounted with offset grid drain for wheelchairs.
- C. Water closets, standard, and handicap shall be blow-out type.
- D. Stop valves shall be provided on all fixtures, including water coolers.
- E. Urinals
- F. Floor drains and cleanouts.
- G. All water coolers in public areas shall be barrier-free bi-level type.
- H. Showers

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.9 Passenger Terminal — Ground Transportation Level

11.9.1 Design Conditions

- A. Cooling: 74°F (50% RH Max.) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.9.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#)

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.9.3 Perimeter Systems

The glass wall in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume, heating, and cooling. This system shall not use fan-powered VAV terminal units for heating and cooling.

11.9.4 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.9.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.9.6 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.9.7 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.9.8 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.9.9 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to for plumbing design parameters and basis of occupancy.

11.9.10 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global the current agency insurance underwriter.

- A. Provide a wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.10 Passenger Terminal — Rental Car Level

11.10.1 Design Conditions

- A. Cooling: 74°F (50% RH Max.) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.10.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.10.3 Perimeter Systems

The glass wall in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume, heating, and cooling. This system shall not use fan-powered VAV terminal units for heating and cooling.

11.10.4 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.10.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International

Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.10.6 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.10.7 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.10.8 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.10.9 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code. Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.10.10 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.11 Passenger Terminal - Baggage Handling Level

11.11.1 Indoor Design Conditions

- A. Cooling: 95°F (50% RH Max) No Humidity Control
- B. Heating: 40°F No Humidity Control

11.11.2 Air Handling Systems

This area shall be air tempered with constant volume direct-fired air-handling system interlocked with propeller exhaust fans. Refer to [3.0.1.Air Handling Systems](#).

11.11.3 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration. Evaporative cooling may be the indirect or direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes.

11.11.4 Outdoor Air Requirements

In general, each space must provide outside air in accordance with [3.2.Ventilation Systems](#) for ventilation requirements.

11.11.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Recommended average outside air ventilation rates shall be as follows:

- A. All areas: 4 ACH

These values shall be based on terminal peak load occupancy.

11.11.6 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.11.7 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.11.8 Central Utility Plant

Chilled water and hot water may be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.11.9 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to for plumbing design parameters and basis of occupancy.

11.11.10 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.

- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.12 Passenger Terminal - Baggage Handling Level — Baggage Screening Areas

11.12.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.12.2 Air Handling Systems

The existing air handling systems in the baggage handling areas is not designed to maintain office environment conditions.

Screening areas, which require year-round conditioning, may be connected to the CUP chilled water system for cooling and heating. Gas-fired DX units may also be used.

11.12.3 Outdoor Air Requirements

In general, each space must provide outside air in accordance with [3.2.Ventilation Systems](#) for ventilation requirements.

11.12.4 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.12.5 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.12.6 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.12.7 Central Utility Plant

Chilled water and hot water may be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.12.8 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.12.9 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.13 Passenger Terminal — Tenant Spaces

Tenant spaces include Restaurants, Food Courts, Offices, and Concessions

11.13.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

11.13.2 Air Handling Systems

The base building air handling system has been designed to accommodate the following loads for Restaurants, Food Courts, Office, and Concession Spaces:

- A. Basic Office, Retail, Airline Tenant
Exterior Load + 1.00 CFM/SF
- B. Restaurant Tenant
Exterior + 1.25 CFM/SF for seating area
Kitchen to be conditioned with Tenant supplied makeup air system
- C. Bar Tenant
Exterior Load + 1.25 CFM/SF
- D. Food Court Tenant
Exterior load + 1.25 CFM/SF for seating areas

Source of makeup air shall be by each Tenant and coordinated between DEN and each Tenant.

The Tenant shall provide a complete HVAC system to meet loads that exceed the requirements listed above. The Tenant shall verify the heating and cooling loads from the perimeter, adjoining structures, and adjacent spaces affecting the Tenant area. All Tenant areas in the terminal are in the interior spaces and are unaffected by the perimeter heating/cooling loads.

11.13.3 Perimeter Systems

The glass wall in the area shall be conditioned by the base building system.

11.13.4 Outdoor Air Requirements

In general, outside air shall be brought in through the base building AHU and/or the kitchen ventilation system. The Tenant HVAC shall make up a minimum of 100% of what is exhausted from the space. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.13.5 Ventilation Rates

The existing system ventilation was designed in accordance with the American Society of Heating, Refrigeration, and Air Conditioning Engineers Standard (ASHRAE) 62-1989, Ventilation for Acceptable Indoor Air Quality. All new design for proper ventilation shall be in accordance with the recommendations of the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. All kitchen areas shall have a separate exhaust fan.

11.13.6 Kitchen Exhaust

All kitchens shall be air-conditioned. The exhaust requirements shall be determined by the cooking exhaust hoods installed within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#)

11.13.7 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.13.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.13.9 Central Utility Plant

Chilled water and hot water connections are not available for Tenants in this area.

11.13.10 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.13.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global, the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.

- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing awater curtain.

11.13.12 Simplicity of Systems

Where possible, Consultants shall reduce or eliminate redundant systems and equipment or sequences of operation. DEN staff understand that certain provisions in the Design Standards Manuals, codes and regulations, and project-specific requirements or constraints may necessitate the use of redundant systems, equipment, or sequences of operation. In instances where redundant equipment is located outside of tenant lease bounds, the Consultant shall provide a narrative describing what requirement necessitates the use of the redundant systems, equipment, or sequences of operation on the mechanical notes or plumbing notes sheet of the drawings.

For any food service tenant space with an exhaust air quantity over 5000 CFM, there shall be one (1) make-up air unit for every one (1) kitchen exhaust fan.

11.14 Passenger Terminal — Electrical Rooms

11.14.1 Design Conditions

- A. Cooling: 95°F No Humidity Control (ventilation only)
- B. Heating: 40°F No Humidity Control (ventilation only)
- C. Maintain positive space pressure for dust control.

11.14.2 Air Handling Systems

This facility shall be air-conditioned with a single zone system or connected to the base building system.

Single zone units shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. AHUs shall contain a throwaway filter section. Air Handlers shall be located outside of the electrical room and in locations that allow for full maintenance of the units. Supply and return air shall be ducted in a low-pressure type system. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.14.3 Outdoor Air Requirements

None required.

11.14.4 Filtration

Outside air or air from a dirty area (baggage tunnel, parking garages, apron, etc.) shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7.

11.14.5 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.14.6 Central Utility Plant

Chilled water connections are available for conditioning equipment but shall not be run inside the electrical room.

11.14.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided, the gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342- 2800".
- E. Dedicated drain piping to extent to outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.14.8 Fire Protection

No sprinkler system shall be installed. Provide two-hour rated room to meet requirements of NPFA 13. Refer to the Electrical DSM for fire alarm requirements.

11.15 Passenger Terminal — Telecommunications and UPS Room

11.15.1 Design Conditions

- A. Cooling: 68°F, 65% RH max, 40% RH min
- B. Heating: 63°F, 65% RH max, 40% RH min
- C. Maintain positive space pressure for dust control.

11.15.2 Air Handling Systems

This facility shall be air-conditioned with single-zone DX system.

Single zone units shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. AHUs shall contain a throwaway filter section. Air Handlers shall be located outside of the room and in locations that allow for full maintenance of the units. Supply and return air shall be ducted in a low-pressure type system. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.15.3 Outdoor Air Requirements

None required.

11.15.4 Filtration

Outside air or air from a dirty area (baggage tunnel, parking garages, apron, etc.) shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7.

11.15.5 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.15.6 Central Utility Plant

Chilled water and hot water may be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.15.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing piping that is either new or existing shall not run through the Telecommunications and UPS Rooms or an associated electrical room. Relocate existing piping to avoid the rooms.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided. The gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".
- E. Dedicated drain piping to extent to outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.15.8 Fire Protection

No sprinkler system shall be installed. Provide a two-hour rated room to meet the requirements of NPFA 13. Refer to the Electrical DSM for fire alarm requirements.

11.16 Passenger Terminal - Employee Gym

11.16.1 Design Conditions

- A. Cooling: 72°F
- B. Heating: 70°F

11.16.2 Air Handling Systems

These areas shall be air-conditioned with VAV systems. Each unit shall consist of a centrifugal, non-overloading supply air fan selected for sound control. In addition, systems shall contain cooling and heating coil sections (includes cooling only units), an electronic air filter section (CosaTron or equal), if required, a throwaway dry-type filter section and a mixed air plenum for outside air and return air duct damper connections. Refer to 3.0.1 Air Handling Systems for air handling system requirements. The supply air ductwork system shall consist of low-pressure ductwork with variable volume terminal boxes. The system shall be sized to supply a maximum of 1.25 CFM per square foot. Return air shall be through ceiling plenums where practical.

11.16.3 Outdoor Air Requirements

Outside air shall be brought through the AHUs. Refer to 3.2 Ventilation Systems for ventilation requirements.

11.16.4 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.16.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of AHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.16.6 Filtration

Air should be brought in at the roof or penthouse level wherever possible in an attempt to use the highest quality air available. As a minimum, outside air is to be filtered using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and 12" filter section for future removable mixed media.

11.16.7 AHU Controls

Refer to 5.2 Sample Control Components and Requirements.

11.16.8 Plumbing Requirements

Refer to Chapter 8- Plumbing Requirements for plumbing design parameters. The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories- wall hung or counter mounted.
- B. Lavatories for the physically disabled- wall hung or counter mounted with offset grid drain for wheelchairs.
- C. Water closets, standard and handicap, shall be a blow out type.
- D. Stop valves- provided on all fixtures including water coolers.
- E. Urinals
- F. Floor drains and cleanouts
- G. All water coolers in public areas shall be barrier free bi-level type.
- H. Showers

All domestic water connections, to mechanical systems, including lawn sprinkling systems, shall be protected from backflow.

11.16.9 Central Utility Plant

Chilled water and hot water shall be provided from the CUP. A secondary chilled water and hot water pipe loop shall be provided. Offices remote from the CIP shall have their own central chilled water system and hot water boiler.

11.16.10 Fire Protection

- A. The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA.
- B. Provide a wet-pipe sprinkler system for this area.

- C. Provide Class I standpipe system.
- D. Provide an extinguisher at each station in the enclosed area.
- E. Provide manual pull type fire alarm stations at exits.
- F. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- G. All escalator and stair opening parameters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.16.11 Smoke Control

All elevator and refuge areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.17 International Concourse

11.17.1 Design Conditions

- A. Cooling: 74°F (No Humidity Control)
- B. Heating: 70°F

11.17.2 Air Handling Systems

This area shall be air-conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium-pressure ductwork with variable-volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.17.3 Perimeter Systems

The glass walls in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume with a minimum setpoint and use hot, chilled water reheat coils. Sill or overhead diffusers shall be used (providing overhead diffusers are not over 9 ft. 6 in. AFF).

Fan-powered boxes shall not be used.

11.17.4 Air Curtains

Overhead fan-coil units shall be used at each jetway entrance. The fan-coil units shall be activated whenever the door is opened with a 30-second time delay, and the supply air temperature is controlled from a space thermostat.

11.17.5 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.17.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as prescribed by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.17.7 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust levels shall be determined by the cooking exhaust hood requirements within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.17.8 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.17.9 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13, and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.17.10 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.17.11 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP for building heating and cooling. Secondary pumping shall not be used for these facilities.

11.17.12 Plumbing Requirements

The basis for plumbing fixture count is based on the following criteria:

- A. Projected concourse occupancy.
- B. Local code requirements.
- C. Thirty-three percent of the passengers and 15% of visitors shall use concourse facilities.
- D. The ratio of men to women is estimated at 55% male/45% female.
- E. Urinals shall be utilized in lieu of water closets to the maximum ratio allowed by the code.
- F. Facilities for the physically disabled shall be provided in the terminal public restrooms.

All domestic hot and cold water and storm drainage piping within conditioned areas shall be insulated. All piping subjected to freezing temperatures shall be insulated.

All lavatory faucets in public and private toilet rooms shall be provided with flow restriction devices on all outlets, except for faucets on physically disabled fixtures.

The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories shall be wall-hung or counter-mounted.
- B. Lavatories for the physically disabled can be wall-hung or counter-mounted with offset grid drain for wheelchairs.
- C. Water closets, standard, and handicap shall be blow-out type.
- D. Stop valves shall be provided on all fixtures, including water coolers.
- E. Urinals

- F. Floor drains and cleanouts.
- G. All water coolers in public areas shall be barrier-free bi-level type.
- H. Showers
- I. Sand traps and oil separators.
- J. Industrial waste sewer system.
- K. Hot water heater.
- L. All domestic water connections to mechanical systems shall be protected from backflow.

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider the impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.17.13 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and building code of the CCD. The following description of fire protection requirements is based on NFPA.

- A. Provide a wet-pipe sprinkler system for this area.
- B. Provide a Class I standpipe system (unless concourse width exceeds 100 feet) with extinguishers throughout the area.
- C. Provide manual pull type fire alarm station at exits.
- D. All escalator and stair opening perimeters shall be protected by providing closely spaced sprinkler heads to provide a water curtain.
- E. Single facilities larger than 1500 Square feet requires fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global and NFPA.

11.17.14 Smoke Control

All public and Tenant areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.18 Domestic Concourse

11.18.1 Design Conditions

- A. Cooling: 74°F (No Humidity Control)
- B. Heating: 70°F

11.18.2 Air Handling Systems

This area shall be air conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium pressure ductwork with variable volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through plenum spaces where possible.

11.18.3 Perimeter Systems

The glass walls in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume with a minimum setpoint and use hot and chilled water coils. Sill or overhead diffusers shall be used (providing overhead diffusers are not over 9 feet 6 inches AFF).

Fan powered boxes shall not be used.

11.18.4 Air Curtains

Overhead fan-coil units shall be used at each jetway entrance. The fan-coil units shall be activated whenever the door is opened with a 30-second time delay and the supply air temperature controlled from a space thermostat.

11.18.5 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.18.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area, 6 air changes per hour or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.18.7 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust levels shall be determined by the cooking exhaust hood requirements within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.18.8 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.18.9 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.18.10 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.18.11 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP for building heating and cooling. Secondary pumping shall not be used for these facilities.

11.18.12 Plumbing Requirements

The basis for plumbing fixture count is based on the following criteria:

- A. Projected concourse occupancy.
- B. Local code requirements.

- C. Thirty-three percent of the passengers and 15% of visitors shall use concourse facilities.
- D. The ratio of men to women is estimated at 55% male/45% female.
- E. Urinals shall be utilized in lieu of water closets to the maximum ratio allowed by code.
- F. Facilities for the physically disabled shall be provided in the terminal public restrooms.

All domestic hot- and cold-water, and storm drainage piping within conditioned areas shall be insulated. All piping subjected to freezing temperatures shall be insulated.

All lavatory faucets in public and private toilet rooms shall be provided with flow restriction devices on all outlets, except for faucets on physically handicap fixtures.

The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories shall be wall-hung or counter-mounted.
- B. Lavatories for the physically disabled can be wall-hung or counter-mounted with offset grid drain for wheelchairs.
- C. Water closets, standard and handicap, shall be blow out type.
- D. Stop valves shall be provided on all fixtures including water coolers.
- E. Urinals
- F. Floor drains and cleanouts.
- G. Water coolers shall be barrier free bi-level type in public areas.
- H. Showers
- I. Sand traps and oil separators.
- J. Industrial waste sewer system.
- K. Hot water heater

All domestic water connections, to mechanical systems, shall be protected from backflow.

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.18.13 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global the current agency insurance underwriter.

- A. Provide a wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.18.14 Concourse A Ground Load Facility

The base building HVAC systems for Concourse Ground Load Facility do not have extra capacity for Tenant spaces; additionally, there is no hydronic heating or cooling available in the Concourse A Ground Load Facility. All Tenants shall provide standalone HVAC systems for each space. Roof mounted equipment is acceptable in this area provided that it meets minimum code clearances and structural requirements of the Ground Load Facility Building. Locations of exhaust fans and exhaust openings shall be approved in writing by the DEN Mechanical Engineer.

11.18.15 Concourse B East Regional Jet Facility

The base building HVAC systems for Concourse B Regional Jet Facility do not have extra capacity for Tenant spaces. All Tenants shall provide standalone HVAC systems for each space. Roof mounted equipment is acceptable in this area provided that it meets minimum code clearances. Locations of exhaust fans and exhaust openings shall be approved in writing by the DEN Mechanical Engineer.

11.19 Domestic Concourse — Tenant Spaces

11.19.1 Design Conditions

- A. Cooling: 74°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control

DEN AHUs are not designed to handle the heating and cooling loads of less energy-efficient setpoints. Refer to [11.19.2.Air Handling Systems](#) for Tenant airflow allocations. In previous projects, many tenants have found that these energy efficiency requirements are uncomfortable, and have requested DEN change their zone temperature set-points. This causes problems for DEN HVAC systems, as modifying zone temperature setpoints without adding supplemental heating or cooling equipment often causes tenants to exceed their allotted airflow, and strains DEN HVAC systems and equipment. If a tenant requires zone temperatures that are not feasible with their allotted airflow, the tenant must install additional mechanical equipment to make up the difference in heating or cooling loads. This equipment could include, but is not limited to fan coil units that recirculate air in the space, air or water source heat pumps, or other mechanical solutions. Care should be taken when selecting equipment and designing sequences of operation to ensure that no simultaneous heating and cooling of zones occurs.

11.19.2 Air Handling Systems

The base building air handling system has been designed to accommodate the following loads for Restaurant, Food Courts, Office, and Concession Spaces:

- A. Basic Office, Retail, Airline Tenant: Exterior Load + 1.00 CFM/SF
- B. Restaurant Tenant: Exterior + 1.25 CFM/SF for seating area. Kitchen to be conditioned with Tenant supplied makeup air system.
- C. Bar Tenant: Exterior load + 1.25 CFM/SF
- D. Food Court Tenant: Exterior load + 1.25 CFM/SF for seating areas. Source of makeup air shall be by each Tenant and coordinated between DEN and each Tenant.
- E. Concourse B Regional Jet Facility: No Tenant HVAC (hydronic on airside) accommodations have been made. Tenant shall provide a complete stand-alone HVAC system.

The Tenant shall provide a complete HVAC system to meet loads that exceed the requirements listed above. The Tenant shall verify the heating and cooling loads from the perimeter, adjoining structures and adjacent spaces affecting the Tenant area.

11.19.3 Perimeter Systems

The glass wall in the area shall be conditioned by the base building system.

11.19.4 Outdoor Air Requirements

In general, outside air shall be brought in through the base building AHU and/or the kitchen ventilation system. Refer to [3.2.Ventilation Systems](#) for ventilation requirements. The Tenant HVAC shall makeup a minimum of 100% of what is exhausted from the space.

11.19.5 Ventilation Rates

The existing base building system ventilation was designed in accordance with American Society of Heating, Refrigeration, and Air Conditioning Engineers Standard (ASHRAE) 62-1989, Ventilation for Acceptable Indoor Air Quality. All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.19.6 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust requirements shall be determined by the cooking exhaust hoods installed within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.19.7 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.19.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.19.9 Central Utility Plant

Chilled water and hot water connections are not available for Tenants in this area.

11.19.10 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Provide plumbing fixtures for the physically disabled.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.19.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global the current agency insurance underwriter.

- A. Provide wet-pipe and dry-pipe sprinkler systems for this area.

- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull-type fire alarm stations at exits.
- E. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.19.12 Smoke Control

All public and Tenant areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.19.13 Simplicity of Systems

Where possible, Consultants shall reduce or eliminate redundant systems and equipment, or sequences of operation. DEN staff understand that certain provisions in the Design Standards Manuals, codes and regulations, and project specific requirements or constraints may necessitate the use of redundant systems, equipment, or sequences of operation. In instances where redundant equipment is located outside of tenant lease bounds, the Consultant shall provide a narrative describing what requirement necessitates the use of the redundant systems, equipment, or sequences of operation on the mechanical notes or plumbing notes sheet of the drawings.

For any food service tenant space with an exhaust air quantity over 5000 CFM, there shall be one (1) make-up air unit for every one (1) kitchen exhaust fan.

11.20 Domestic Concourse — Electrical Rooms

11.20.1 Design Conditions

- A. Cooling: 95°F No Humidity Control
- B. Heating: 40°F No Humidity Control
- C. Maintain positive space pressure for dust control.

11.20.2 Air Handling System

This facility shall be air conditioned with single zone system or connected to base building system.

Single zone units shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. AHUs shall contain and a throwaway filter section. Air Handlers shall be located outside of the electrical room and in locations that allow for full maintenance of the units. Supply and return air shall be ducted in a low-pressure type system. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.20.3 Outdoor Air Requirements

Not required.

11.20.4 Filtration

Outside air or air from a dirty area (baggage tunnel, parking garages, apron, etc.) shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7.

11.20.5 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.20.6 Central Utility Plant

Chilled water connections are available for conditioning equipment but shall not be run inside the electrical room.

11.20.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CC building code.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided. The gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".
- E. Dedicated drain piping to extent outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.20.8 Fire Protection

No sprinkler system shall be installed. Provide two-hour rated room to meet requirements of NPFA 13. Refer to the Electrical DSM for fire alarm requirements.

11.21 Domestic Concourse — Telecommunications and UPS Rooms

11.21.1 Design Conditions

- A. Cooling: 68°F, 65% RH max
- B. Heating: 63°F
- C. Maintain positive space pressure for dust control.

11.21.2 Air Handling Systems

This facility shall be air conditioned with single zone DX system.

Single zone units shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. AHUs shall contain and a throwaway filter section. Air Handlers shall be located outside of the room and in locations that allow for full maintenance of the units. Supply and return air shall be ducted in a low-pressure type system.

Refer to [3.0.1.Air Handling Systems](#).

11.21.3 Outdoor Air Requirements

Not required.

11.21.4 Filtration

Outside air or air from a dirty area (baggage tunnel, parking garages, apron, etc.) shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7.

11.21.5 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.21.6 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP for building heating and cooling. Secondary pumping shall not be used for these facilities.

11.21.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing piping that is either new or existing shall not run through the Telecommunications and UPS Rooms or an associated electrical room. Relocate existing piping to avoid the rooms.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided. The gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".
- E. Dedicated drain piping to extent to outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.21.8 Fire Protection

No sprinkler system shall be installed. Provide two-hour rated room to meet requirements of NPFA 13. Refer to the Electrical DSM for fire alarm requirements.

11.22 Domestic Concourse — Service Animal Relief Areas (SARA)

11.22.1 Design Conditions

- A. Cooling: 75°F (50% RH Max) No Humidity Control
- B. Heating: 70°F No Humidity Control
- C. Maintain Negative Pressure for Odor Control

11.22.2 Air Handling System

This area shall be air conditioned with a VAV system. Refer to [3.0.1.Air Handling Systems](#).

The supply air ductwork system shall consist of medium pressure ductwork with variable volume terminal boxes. Each VAV box shall have its own space temperature sensor controls tied to Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall not be used but exhausted through the exhaust system serving the room.

11.22.3 Perimeter Systems

The glass walls in the area shall be conditioned by a forced air perimeter system. This system shall be variable volume with a minimum setpoint and use hot and chilled water coils. Sill or overheard diffusers shall be used (providing overhead diffusers are not over 9 feet 6 inches AFF).

Fan powered boxes shall not be permitted.

11.22.4 Exhaust

The ventilation rate for all SARA room facilities shall be at least 10 air changes per hour or as required by the latest edition of ASHRAE, 62.1, whichever is more stringent.

11.22.5 Ventilation Rate

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. These values shall be based on terminal peak load occupancy.

11.22.6 Filtration

Outside air shall be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.22.7 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.22.8 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP. Secondary pumping shall not be used for these facilities.

11.22.9 Plumbing Requirements

The basis of plumbing fixture count is based on the following criteria:

All domestic hot- and cold-water, and storm drainage piping within conditioned areas shall be insulated. All piping subjected to freezing temperatures shall be insulated.

The following is a partial list of plumbing fixtures required for this area:

- A. Hot water tops
- B. Cold water tops
- C. Floor drains and cleanouts

- D. Hot water heater

All domestic water connections, to mechanical systems, shall be protected from backflow.

All plumbing systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code.

Plumbing design shall consider impact of future terminal expansion.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters and basis of occupancy.

11.22.10 Fire Protection

The fire protection system shall be provided in accordance with the latest edition of National Fire Protection Agency (NFPA) Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA and FM Global the current agency insurance underwriter.

- A. Provide a wet-pipe and dry-pipe sprinkler systems for this area.
- B. Provide Class I standpipe system.
- C. Provide an extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.

11.23 Control Tower

11.23.1 Design Conditions

- A. Cooling: 75°F (No Humidity Control)
- B. 74°F for Control Cab
- C. Heating: 70°F (Humidification in electronic equipment spaces only)

11.23.2 Air Handling Systems

This facility shall be air conditioned with single zone systems.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. AHUs shall contain cooling and heating coils (includes cooling only units), an optional electronic air filter section, and a throwaway filter section. Provide a mixed air plenum for outside air and return air duct damper connections on units 2000 CFM and above. Heating coils shall be located upstream of the cooling coils with space in between the two coil sections to enable access for maintenance and inspection.

Supply and return air shall be ducted in a low-pressure type system.

Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.23.3 Perimeter Systems

In the control cab, the glass wall shall be covered by a forced air perimeter system. This system shall be constant volume, variable temperature. It shall utilize sill diffusers to counteract downdrafts and provide good air circulation.

11.23.4 Computer and Electronic Equipment Rooms

Computer rooms, which require year-round cooling, may be connected to the CUP chilled water system for cooling. In addition, critical computer and/or communications rooms shall have their own DX cooling system for winter operation. The system shall have factory installed and wired controls for chilled water and DX cooling coils, heating

coils, dehumidification, and humidification. The unit shall have an electric, steam generating humidifier with controls to limit space humidity to 50% maximum.

Plumbing piping that is either new or existing shall not run through the Computer and Electronic Equipment Rooms or an associated electrical room. Relocate existing piping to avoid rooms.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided. The gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".
- E. Dedicated drain piping to extent to outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.23.5 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements. Locate outside air intakes high and away from vehicle or jet exhaust, to the greatest extent possible.

11.23.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.23.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.23.8 Filtration

Outside air should be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.23.9 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.23.10 Plumbing Requirements

All plumbing systems shall conform to the requirements of the IPC as adopted and modified by the CCD building code. Refer to for plumbing design parameters. The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories - wall hung or counter mounted

- B. Water closets, standard and handicap
- C. Stop valves on all fixtures
- D. Urinals
- E. Floor drains and cleanouts
- F. Water coolers

11.23.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and CCD building codes. The following description of fire protection requirements is based on NFPA.

- A. Provide a wet-pipe sprinkler system for all areas unless specific requirements prohibit use in electronic equipment areas. In these cases, utilize Halon systems mentioned below.
- B. Intergen or FM-200 systems in the above defined mentioned below. The system shall have manual and automatic actuation, warning alarms, flashing signs indicating halon discharge, backup systems, and all other fittings and appurtenances necessary for NFPA compliance.
- C. Provide a Class I standpipe system with extinguisher at each station in the area.
- D. Provide manual pull type fire alarm stations at exits.

11.23.12 Smoke Control

Smoke control is not required for this area.

11.24 Hotel

11.24.1 Design Conditions

- A. Cooling: 74°F (50% RH Max.)
- B. Heating: 70°F (No Humidity Control)

11.24.2 Air Handling Systems

11.24.2.1 Meeting Rooms, Restaurants, Public Areas

These areas shall be air conditioned with VAV systems. Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected in the lower range for sound control. In addition, systems shall contain cooling and heating coil sections (includes cooling only units), an electronic air filter section (Cosa-Tron or equal), a throwaway bag-type filter section, and air blender section to eliminate air stratification, and a mixed air plenum for outside air and return air duct damper connections.

The supply air ductwork system shall consist of low-pressure ductwork with variable volume terminal boxes. Each VAV box shall have its own temperature sensor and controls tied to the Facilities EMCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow. Return air shall be through ceiling plenums where possible.

11.24.2.2 Guest Rooms

Each room shall contain its own 4-pipe fan-coil unit (not through-the-wall units). The fan coil units shall have manually adjusted temperature controls. The heating and cooling coils shall modulate hydronic flow with 2-way pressure independent control valves to maintain the room thermostat setting. Provide with dry-type throwaway filters. Fan coil units shall be furnished and installed to provide an NC-35 noise level in the room.

11.24.2.3 Kitchens

Provide constant volume AHUs with the same unit components mentioned above for the VAV AHUs.

Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.24.3 Perimeter Systems

Any expanse of glass wall in the area shall be conditioned by a forced air perimeter system. This system should utilize sill diffusers to counteract downdrafts during cold weather.

11.24.4 Air Curtains

Air curtains shall be provided for use at main entrances. Overhead fan-coil units shall be used at each entrance.

11.24.5 Outdoor Air Requirements

Refer to [3.2.Ventilation Systems](#)- for ventilation requirements.

Outside air shall be brought in through the AHUs. Guest room floors shall have a separate makeup air unit to pressurize the corridors and guest rooms.

11.24.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.24.7 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust requirements shall be determined by the cooking and exhaust hoods installed within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.24.8 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.24.9 Filtration

Outside air should be filtered, as a minimum, using 2" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media (i.e., carbon/potassium permanganate) filter section.

11.24.10 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.24.11 Central Utility Plant

Chilled water and hot water shall be supplied from the CUP for building heating and cooling. Secondary pumping shall not be used for these facilities.

11.24.12 Plumbing Requirements

All plumbing systems shall conform to the requirements of the IPC as adopted and modified by the CCD building code.

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters.

11.24.13 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and CCD building codes. The following description of fire protection requirements is based on NFPA.

- A. Provide a wet-pipe sprinkler system for this area.
- B. Provide a Class III standpipe system with fire department valve and extinguishers.
- C. Provide an automatic detection system, with audible alarms in each room.
- D. Provide local and remote annunciation.
- E. Provide an extinguisher at each station in the enclosed areas.
- F. Single facilities larger than 1500 Square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- G. Provide manual pull type fire alarm stations at exits and stairwells.
- H. All escalator and stair opening perimeters shall be protected.
- I. Provide ventilation pressurization and smoke control system for high-rise buildings.

11.25 Structured Parking

11.25.1 Ventilation Systems

Areas enclosed with little exposure to outside, shall be ventilated with constant volume fans. Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected minimize noise. Supply fans will require a throwaway filter section.

The ductwork system shall consist of a main trunk duct with exhaust registers. The system shall be sized to exhaust a minimum of 500 CFM per parking space in accordance with Industrial Ventilation, A Manual of Recommended Practice, latest edition.

11.25.2 Filtration

The exhaust air shall be filtered before entering the exhaust fan. The dry-type filter media shall have a 2" filter section with a minimum MERV 7 rating per ASHRAE.

11.25.3 Exhaust Fan Controls

The exhaust fans shall be controlled by a remote automation system.

Control Functions:

- A. Equipment start/stop with equipment status.
- B. Fan failure alarm.
- C. Provide CO monitors to control fan operation.

11.25.4 Plumbing Requirements

All plumbing systems shall conform to the requirements of the building code for the CCD.

The floor drainage system shall be designed for the discharge rate of the fire protection system.

The following is a partial list of plumbing fixtures required for this area:

- A. Floor drains and cleanouts
- B. Sand traps and oil separators

11.25.5 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and CCD building codes. The following description of fire protection requirements is based on NFPA.

- A. Provide a dry-pipe sprinkler system for this area.
- B. Provide a Class I dry-pipe, standpipe system.
- C. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- D. On Levels 1, 2, and the part of Level 3 where there are no alternate baggage conveyors the dry pipe systems extends 75' from entrance doors. On Level 4, the dry pipe systems extend throughout the driving lanes in front of the doors. On Level 5, the dry systems cover the entire covered area. All covered drive lanes on all structures have either dry systems or heated blind spaces with dry pendent heads, exception is the passage.

11.26 Parking Toll Plaza

11.26.1 Design Conditions

- A. Cooling: 74°F (No Humidity Control)
- B. Heating: 70°F (No Humidity Control)

11.26.2 Air Handling Systems

This facility shall be air conditioned with a single zone system. Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain DX cooling system, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Heat pump units should be considered if gas is not available.

11.26.3 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2 Ventilation Systems](#) for ventilation requirements.

11.26.4 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.26.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.26.6 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.26.7 AHU Controls

The AHUs shall be controlled by a space thermostat. The outside air damper shall be opened when the supply fan is running and closed when it is off.

Provide control logic to permit the following:

- A. Position outside air dampers and return air dampers. The outside air and exhaust air dampers shall be normally closed, and the return air dampers shall be normally open.
- B. Monitor space temperatures.
- C. Equipment start/stop.

11.26.8 Plumbing Requirements

All plumbing systems shall conform to the requirements of the IPC as adopted and modified by the CCD building code. Refer to for plumbing design parameters. The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories - wall hung or counter mounted.
- B. Water closets
- C. Stop valves - provided on all fixtures including water coolers.
- D. Floor drains and cleanouts.
- E. Water coolers

11.26.9 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards.

- A. Provide an extinguisher in the area.

11.27 Office Building

11.27.1 Design Conditions

- A. Cooling: 74°F (No Humidity Control).
- B. Heating: 70°F

11.27.2 Air Handling Systems

These areas shall be air conditioned with VAV systems. Each unit shall consist of a centrifugal, non-overloading supply air fan selected for sound control. In addition, systems shall contain cooling and heating coil sections

(includes cooling only units), an electronic air filter section (CosaTron or equal), if required, a throwaway dry-type filter section, and a mixed air plenum for outside air and return air duct damper connections.

Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

The supply air ductwork system shall consist of low-pressure ductwork with variable volume terminal boxes. The system shall be sized to supply a maximum of 1.25 CFM per square foot. Return air shall be through ceiling plenums where practical.

11.27.3 Perimeter Systems

All perimeter glass walls shall be conditioned by a forced air perimeter system. This system shall be variable volume heating and cooling. Utilize sill diffusers to counteract downdrafts during cold weather. Perimeter finned tubed heating systems are an acceptable alternative.

11.27.4 Computer Rooms

Computer rooms, which require year-round cooling, shall be connected to the CUP chilled water system for summer cooling and/or provide a DX cooling system for winter operation, if required by the DEN Mechanical Engineer. The system shall have factory installed and wired controls for chilled water cooling coils, heating coils, dehumidification, and humidification. The unit shall have an electric, steam generating humidifier with controls to limit space humidity. Design conditions shall be:

- A. Summer: 68°F, 65% RH max
- B. Winter: 68°F
- C. Maintain positive space pressure for dust control.

In remote areas where chilled water is not available, the computer room unit shall have a dedicated, dual circuit refrigeration system with remote condensing units located on the roof and electric reheat coils.

11.27.5 Air Curtains

Air curtains shall be provided for use on all main entrances. Overhead fan-coil units shall be used at each entrance.

11.27.6 Outdoor Air Requirements

Outside air shall be brought in through the AHUs.

Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.27.7 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.27.8 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.27.9 Filtration

Air should be brought in at the roof or penthouse level wherever possible in an attempt to use the highest quality air available. As a minimum, outside air is to be filtered using 2" dry type pre-filter section having a minimum rating of

MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12" filter section for future removable mixed media.

11.27.10 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.27.11 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters.

The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories - wall hung or counter mounted.
- B. Lavatories for the physically disabled - wall hung or counter mounted with offset grid drain for wheelchairs.
- C. Water closets, standard and handicap, shall be a blow out type.
- D. Stop valves - provided on all fixtures including water coolers.
- E. Urinals.
- F. Floor drains and cleanouts.
- G. All water coolers in public areas shall be barrier free bi-level type.

All domestic water connections, to mechanical systems, including lawn sprinkling systems, shall be protected from backflow.

11.27.12 Central Utility Plant

Chilled water and hot water shall be provided from the CUP. A secondary chilled water and hot water pipe loop shall be provided. Offices remote from the CUP shall have their own central chilled water system and hot water boiler.

11.27.13 Fire Protection

- A. The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and the building code of the CCD. The following description of fire protection requirements is based on NFPA.
- B. Provide a wet-pipe sprinkler system for this area.
- C. Provide Class I standpipe system.
- D. Provide an extinguisher at each station in the enclosed areas.
- E. Provide manual pull type fire alarm stations at exits.
- F. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- G. All escalator and stair opening perimeters shall be provided with closely spaced sprinkler heads providing a water curtain.

11.27.14 Smoke Control

All elevator and refuge areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.28 Central Utility Plant Facilities

11.28.1 Design Conditions

- A. Cooling: Ventilation only in plant area, 74°F in control room, lunch and locker rooms, offices, etc.
- B. Heating: 65°F in plant, 70°F in control room, lunch and locker rooms, offices, etc.

11.28.2 Office/Control Room Systems

The office, control room, lunchroom, and locker room areas shall be air conditioned with single zone systems.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements. Ductwork shall be for low-pressure system.

11.28.3 Plant/Shop System

The main CUP areas shall be heated and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for increased life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, heating section, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.28.4 Heating System

The main mechanical equipment areas shall be heated with hot water unit heaters.

11.28.5 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHUs and makeup air units. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.28.6 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities is 0.5 CFM per square foot of floor area and 1.0 CFM per square foot of locker area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.28.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Recommended average outside air ventilation rates shall be as follows:

- A. Plant areas: 3 Air changes per hour (winter) minimum, 12 Air changes per hour (summer) minimum.
- B. Utility Tunnel: 2 ACH continuous operation.

11.28.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.28.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#). The following is a partial list of plumbing fixtures required:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

11.28.10 Fire Protection

The fire protection system shall include the following:

- A. Provide wet pipe sprinkler system.
- B. Provide a Class I standpipe system with extinguisher at each station in the enclosed areas.
- C. Provide manual pull type fire alarm station at exits.
- D. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

11.28.11 Smoke Control

No smoke control is required for this area.

11.29 Maintenance Facility

11.29.1 Design Conditions

- A. Cooling: Conditioned Spaces
74°F Shop Areas- Vent Only
- B. Heating: Conditioned Spaces 70°F
Shop Areas- 70°F

11.29.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.29.3 Shop System

The main shop areas shall be heated and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.29.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.29.5 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area, 6 air changes per hour or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.29.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.29.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.29.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.29.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.29.10 Fire Protection

The fire protection system shall be as follows:

- A. Provide a wet-pipe sprinkler system for larger maintenance facilities (over 20,000 sq. ft.).
- B. Provide a dry-pipe system in areas subject to freezing conditions. Refer to the Life Safety DSM for fire protection requirements.
- C. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Protection Bureau, FM Global, and NFPA.

11.29.11 Smoke Control

No smoke control is required for this area.

11.29.12 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration for offices and for added comfort in frequently used and populated shop areas. Evaporative cooling should be the indirect/direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes. The indirect/direct method of evaporative cooling uses both indirect and direct evaporative cooling methods to produce cool, conditioned supply air.

11.30 Air Cargo Facility

11.30.1 Design Conditions

- A. Cooling: Conditioned Spaces
74°F Shop Areas- Vent only
- B. Heating: Conditioned Spaces 70°F
Shop Areas - 70°F

11.30.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.30.3 Warehouse System

The main storage areas shall be heated and ventilated only. Provide exhaust fans for ventilation during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for increased life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper,

and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.30.4 Air Curtains

Air curtains shall be provided for use on all main service entrances. Overhead fan-coil units shall be used at each entrance. These units should be indirect gas fired.

11.30.5 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU and makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.30.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.30.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.30.8 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.30.9 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#)

11.30.10 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.30.11 Fire Protection

The fire protection system shall be as follows:

- A. Provide a wet-pipe sprinkler system that will be designed to protect the particular type of usage.
- B. Provide a hose station with extinguisher at each station in the enclosed areas, as required.
- C. Provide manual pull type fire alarm station as required.
- D. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.30.12 Smoke Control

No smoke control is required for this area.

11.31 Aircraft Hanger

11.31.1 Design Conditions

- A. Cooling: Conditioned spaces:
 - 74°F Shop Areas- Vent only
 - 78°F Hangars: No conditioning required
- B. Heating: Conditioned Spaces 70°F
- C. Heating: Conditioned spaces: 70°F
 - Shop Areas: 70°F
 - Hangars: 68°F

11.31.2 Ventilation Systems

The office and some shop areas may be air conditioned with a single zone system. Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

Provide a low-pressure ductwork system for all normally occupied areas.

Monitor Carbon Monoxide (CO) and Nitrous Oxides (NOx) levels in all hangar spaces. When CO or NOx levels are above safe levels per OSHA and the most recent ASHRAE 90.1 standards for more than five (5) minutes, provide an audible alarm, strobe, and signage in the space. Signs in hangar spaces shall direct occupants to open hangar doors. Inform occupants of unsafe levels being detected.

11.31.3 Shop and Hanger System

The main shop areas shall be heated and ventilated only with unit heaters. Provide exhaust fans for ventilation during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for increased life and sound control. Makeup air for exhaust system shall be introduced through a makeup air unit with a filter, control damper and louver plenum. The outside air shall be filtered with dry-type filter media with a

minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

The hangar area shall be heated and ventilated by one of the following systems:

- A. Low intensity vented gas-fired, infrared system for small hangars, not over 30' high.
- B. High-bay unit heaters for large hangars.
- C. Air rotation system utilizing air-handling units that circulate air through the high-bay and back to the low-level air handlers.

Provide ventilation at all hangar low points (e.g., wheel pits, etc.).

11.31.4 Outdoor Air Requirements

Outside air shall be brought in through the air handling or makeup air units. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.31.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.31.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Recommended average outside air ventilation rates shall be as follows:

- A. Shop Areas: 4 Air changes/hour (minimum)
- B. Hangar Areas: Depends on function

NOTE: These values shall be based on ventilation or exhaust requirements depending on usage or operations in the space.

Special ventilation and filtration will be required if painting will be done in the shops or hangar.

11.31.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.31.8 Controls

11.31.8.1 AHUs

- A. Off-peak setback of ventilation
- B. Cooling coil controls
- C. Heating coil controls with preheat where required
- D. Monitor space and duct temperatures
- E. Equipment start/stop with equipment status
- F. Optimal start
- G. Economizer controls
- H. Alarms for failure of the following:
 - a. Fan failure

1. Space temperature out of specification
2. Smoke detection
3. Freeze thermostat shutdown

11.31.8.2 Exhaust Fans

- A. Position the outside air dampers. The outside air dampers shall be normally closed. When the exhaust fan is running, the outside air damper shall be open. When the exhaust fan is off, the outside air damper shall be closed.
- B. Exhaust fan start/stop with equipment status. Exhaust fan start/stop shall be a function of the mechanical equipment room space temperature. Energize the exhaust fans when space temperature is greater than 85°F.

11.31.8.3 Unit Heaters

The unit heaters shall be started and stopped based on space temperature. When the space temperature is lower than 65°F, the unit heaters shall be energized. The control valve on the unit heater shall be modulated based on space temperature.

11.31.8.4 Infrared Heaters

Units shall cycle to maintain space temperature setpoint.

The automation controls system shall be provided with additional slave panels to control the single zone AHU, the exhaust fans, and the unit heaters, as necessary. Tie to the Facilities EMCS.

11.31.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled.
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.31.10 Fire Protection

The fire protection system shall be as follows:

- A. Provide a foam water deluge system in the hangar, as required by size.

- B. Provide a wet-pipe sprinkler system in the shops and offices and smaller hangars.
- C. Provide a Class I standpipe system with extinguisher at each station in the enclosed areas.
- D. Provide manual pull type fire alarm stations at exits.
- E. Evaluate need of fire pumps and water storage tanks. Provide as required.
- F. Provide monitor nozzles as required.
- G. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- H. Provide all necessary detection and actuation for the above noted systems with appropriate monitoring by the fire alarm system

Refer to the Life Safety DSM for fire protection requirements.

11.31.11 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration for offices and for added comfort in frequently used and populated shop areas. Evaporative cooling should be the indirect/direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes. The indirect/direct method of evaporative cooling uses both indirect and direct evaporative cooling methods to produce cool, conditioned supply air.

11.32 Flight Kitchen

11.32.1 Design Conditions

- A. Cooling: 74°F
- B. Heating: 70°F

11.32.2 Air Handling Systems

This area shall be air conditioned with a single zone system, constant volume systems. (VAV is an acceptable alternative if it is determined several zones are required.)

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils (includes cooling only units), a throwaway filter section and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

11.32.3 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.32.4 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.32.5 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust requirements shall be determined by the cooking exhaust hoods within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#)

11.32.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.32.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.32.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.32.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required for this facility:

- A. Lavatory faucets - provided with flow restriction.
- B. Lavatories - wall hung or counter mounted.
- C. Lavatories for the physically disabled - wall hung or counter mounted with offset grid drain for wheelchairs.
- D. Water closets, standard and handicap - blow out type.
- E. Stop valves - provided on all fixtures.
- F. Urinals
- G. Floor drains and cleanouts.
- H. Water coolers - barrier free bilevel type.
- I. Sand traps and oil separators.
- J. Water Coolers
- K. Sinks
- L. Hot water heaters

All domestic water connections, to mechanical systems, including lawn sprinkling systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.32.10 Fire Protection

The fire protection system shall be as follows:

- A. Provide a wet-pipe sprinkler system for this area.
- B. Provide a pre-engineered carbon dioxide extinguishing system for the kitchen exhaust hoods in accordance with NFPA 12, Standard on Carbon Dioxide Extinguishing Systems. The system shall be capable of automatic detection with local or remote manual actuation. Accessories shall be installed for mechanical or electrical gas line shut-off applications. System shall be listed with Underwriters Laboratories, Inc.
- C. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.33 Snow Removal Equipment Facility

11.33.1 Design Conditions

- A. Cooling: Conditioned Spaces
74°F Shop Areas: Vent only
- B. Heating: Conditioned Spaces 70°F
Shop Areas: 70°F

11.33.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.33.3 Shop System

The main shop areas shall be heated and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

Low intensity infrared heating may be used in the equipment bays as an alternative heating method.

11.33.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.33.5 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.33.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.33.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.33.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.33.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures.
- F. Urinals
- G. Floor drains and cleanouts.
- H. Showers
- I. Sand traps and oil separators.
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.33.10 Fire Protection

The fire protection system shall be as follows:

- A. Provide fire hose stations with carbon dioxide extinguisher in cabinets throughout the area.
- B. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.33.11 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration for offices and for added comfort in frequently used and populated shop areas. Evaporative cooling should be the indirect/direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes. The indirect/direct method of evaporative cooling uses both indirect and direct evaporative cooling methods to produce cool, conditioned supply air.

11.34 Fire Crash Rescue Facility

11.34.1 Design Conditions

- A. Cooling: Conditioned Spaces 74°F
Shop Areas: Vent Only

B. Heating: Conditioned Spaces 70°F

Shop Areas: 70°F

11.34.2 Conditioned Systems

The Aircraft Rescue and Firefighting (ARFF) office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas or sleeping/residential type areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.34.3 Vehicle/Maintenance Systems

The main shop areas shall be heating and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.34.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.34.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.34.6 Kitchen Exhaust

All kitchens shall be air conditioned. The exhaust requirements shall be determined by the cooking and exhaust hoods installed within the facility. The kitchen exhaust system shall be designed in accordance with [3.5.6.Food and Beverage Tenant Equipment](#).

11.34.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.34.8 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.34.9 Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.34.10 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of required plumbing fixtures:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.34.11 Fire Protection

The fire protection system shall be as follows:

- A. Provide fire extinguishers in cabinets throughout the area.
- B. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.34.12 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration for offices and for added comfort in frequently used and populated shop areas. Evaporative cooling should be the indirect/direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes. The indirect/direct method of evaporative cooling uses both indirect and direct evaporative cooling methods to produce cool, conditioned supply air.

11.35 Rental Car Support Facility

11.35.1 Design Conditions

- A. Cooling: Conditioned Spaces 74°F
Shop Areas: Vent Only
- B. Heating: Conditioned Spaces 70°F

Shop Areas: 70°F

11.35.2 Ventilation Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.35.3 Maintenance/Shop System

The main plant areas shall be heating and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required

11.35.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.35.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.35.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.35.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.35.8 Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.35.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of required plumbing fixtures:

- A. Lavatory faucets

- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.35.10 Fire Protection

The fire protection system shall be as follows:

- A. Provide a dry-pipe sprinkler system for unheated areas.
- B. Provide fire hose station (as required) with carbon dioxide extinguisher in cabinets throughout the area.
- C. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.35.11 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) in lieu of refrigeration for offices and for added comfort in frequently used and populated shop areas. Evaporative cooling should be the indirect/direct method of operation. By acceptable air quality, the air must be free of jet fuel exhaust fumes. The indirect/direct method of evaporative cooling uses both indirect and direct evaporative cooling methods to produce cool, conditioned supply air.

11.36 Auto Service Station

11.36.1 Design Conditions

- A. Cooling: Conditioned Spaces 74°F
Shop Areas: Vent Only
- B. Heating: Conditioned Spaces 70°F
Shop Areas: 70°F

11.36.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for

outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.36.3 Shop System

The main shop areas shall be heating and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.36.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.36.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.36.6 Automobile Exhaust System

The maintenance area shall be equipped with a constant volume exhaust system. The system shall consist of a centrifugal, non-overloading, exhaust fan with fan speeds selected for sound control and equipment life.

The ductwork system shall consist of a main trunk duct with flexible duct take-offs for connection to the vehicles exhaust tailpipes. Provisions shall be made for vehicles with both single and dual exhaust systems. The system shall be sized to exhaust a minimum of 100 CFM per vehicle with an engine horsepower less than 200 HP and 200 CFM per vehicle with an engine horsepower greater than 200 HP. The design shall comply with Industrial Ventilation, A Manual of Recommended Practice, latest edition.

11.36.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.36.8 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.36.9 Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.36.10 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of required plumbing fixtures:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.36.11 Fire Protection

The fire protection system shall be provided as follows:

- A. Provide fire hose station with carbon dioxide extinguisher in cabinets throughout the area.
- B. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.36.12 Evaporative Cooling

Where the four-pipe distribution system is unavailable and acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) with an indirect/direct method of operation.

11.37 Aircraft Fueling Control Facility

11.37.1 Design Conditions

- A. Cooling: Conditioned Spaces 74°F
Shop Areas: Vent Only
- B. Heating: Conditioned Spaces 70°F
Shop Areas: 70°F

11.37.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.37.3 Maintenance/Shop System

The main shop areas shall be heating and ventilated only. Provide exhaust fans in the main mechanical equipment areas during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for extended life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.37.4 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU or makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.37.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.37.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.37.7 Vehicle Exhaust System

The maintenance area shall be equipped with a constant volume exhaust system. The system shall consist of a centrifugal, non-overloading, exhaust fan with fan speeds selected for sound control and equipment life.

The ductwork system shall consist of a main trunk duct with flexible duct take-offs for connection to the vehicles exhaust tailpipes. Provisions shall be made for vehicles with both single and dual exhaust systems. The system shall be sized to exhaust a minimum of 100 CFM per vehicle with an engine horsepower less than 200 HP and 200 CFM per vehicle with an engine horsepower greater than 200 HP. The design shall comply with Industrial Ventilation, A Manual of Recommended Practice, latest edition.

11.37.8 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.37.9 Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.37.10 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of required plumbing fixtures:

- A. Lavatory faucets

- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.37.11 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of NFPA Standards and local codes. The following description of fire protection requirements is based on NFPA. Local fire and code officials must be contacted to verify their concurrence with the proposed system.

- A. Provide an automatic heat detection system for this area.
- B. Provide a fire hose station extinguisher at each station in the enclosed areas.
- C. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.

Refer to the Life Safety DSM for fire protection requirements.

11.37.12 Evaporative Cooling

Where acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) with an indirect/direct method of operation.

11.38 General Aviation Facilities

11.38.1 Design Conditions

- A. Cooling: Conditioned spaces 74°F
Shop Areas: Ventilation only or 75°F
Hangars: No conditioning required
- B. Heating: Conditioned Spaces 70°F
Storage Areas: 70°F
Hangars: 68°F

11.38.2 Air Handling Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.HVAC Systems](#) for air handling system requirements.

For small, single office areas that might be air-conditioned: Thru-the-wall packaged units may be used in lieu of AHU systems.

Provide a low-pressure ductwork system.

11.38.3 Shop and Hangar System

The main shop areas shall be heated and ventilated only with unit heaters. Provide exhaust fans for ventilation during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for increased life and sound control. Makeup air for exhaust system shall be introduced through a makeup air unit with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

The hangar area shall be heated and ventilated by one of the following systems:

- A. Low intensity vented, gas-fired, infrared system for small hangars, not over 30' high.
- B. High-bay unit heaters for large hangars.
- C. Air rotation system, utilizing air-handling units that circulate air through the high-bay and back to the low-level air handlers.

Provide ventilation at all hangar low points (e.g., wheel pits, etc.).

11.38.4 Outdoor Air Requirements

Outside air shall be brought in through the air handling or makeup air units. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.38.5 Toilet Exhaust

The minimum ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.38.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Recommended average outside air ventilation rates shall be as follows:

- A. Shop Areas: *4 air changes/hour (minimum)
- B. Hangar Areas: *Depends on function

*These values shall be based on ventilation or exhaust requirements depending on usage or operations in the space.

11.38.7 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.38.8 Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.38.9 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of required plumbing fixtures:

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.38.10 Fire Protection

The fire protection system shall be as follows:

- A. Single facilities larger than 1,500 square feet require fire sprinkler and fire alarm systems per the requirements of Denver Fire Prevention Bureau, FM Global, and NFPA.
- B. Provide a dry-pipe sprinkler system. Wet-pipe acceptable in shops and offices.
- C. Provide fire hose stations with extinguisher at each station in the enclosed areas.

Refer to the Life Safety DSM for fire protection requirements.

11.38.11 Evaporative Cooling

Where acceptable air quality is available, total evaporative cooling may be utilized (no back-up refrigeration unit) with an indirect/direct method of operation.

11.39 Communications Center

11.39.1 Design Conditions

- A. Cooling: 74°F (50% RH Max)
- B. Heating: 72°F

11.39.2 Air Handling Systems

This facility shall be air conditioned with a VAV system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, system shall contain cooling and heating coil sections (includes cooling only units), an electronic air filter section, a throwaway filter section, air blender section to eliminate air stratification, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

The supply air ductwork system shall consist of low-pressure ductwork with variable volume terminal boxes. Each VAV box shall have its own controls tied to the FCS. The system shall be sized to supply approximately 1.25 CFM per square foot at maximum flow.

11.39.3 Computer and Electronic Equipment Rooms

Electronic equipment rooms, which require year-round cooling, may be connected to the CUP chilled water system for cooling; in addition, critical computer and/or communications rooms shall have their own DX cooling system for winter operation. The system shall have factory-installed and wired controls for chilled water and DX cooling coils, heating coils, dehumidification, and humidification. The unit shall have an electric, steam generating humidifier with controls to limit space humidity to 60% maximum.

11.39.4 Outdoor Air Requirements

Outside air shall be brought in through the AHUs. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.39.5 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.39.6 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.39.7 Filtration

Outside air shall be filtered with dry-type filter media. As a minimum outside air is to be filtered using 12" dry type pre-filter section having a minimum rating of MERV 7, 12" dry type filter section having a minimum rating of MERV 13 and a 12".

11.39.8 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.39.9 Plumbing Requirements

Refer to for plumbing design parameters. A partial listing of plumbing fixture requirements is as follows:

- A. Lavatory faucets with flow restriction devices
- B. Lavatories, wall hung or counter mounted.
- C. Lavatories for the physically disabled, wall hung or counter mounted with offset grid drain for wheelchairs.
- D. Water closets, standard and handicap, a blowout.

- E. Stop valves provided on all fixtures.
- F. Urinals
- G. Floor drains and cleanouts.

All domestic water connections, to mechanical systems, including lawn-sprinkling systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through the Computer and Electronic Equipment room or any associated electrical rooms. Relocate existing piping to avoid the rooms.

If sloped piping cannot be relocated, a sheet metal gutter under the pipe shall be provided. The gutter system shall be fully designed and detailed on the contract documents. No component of the gutter shall be left to the contractor's discretion. Details shall accommodate the following:

- A. Gutters shall be supported independently of the sloped piping.
- B. Structural supports and connections to the building structure.
- C. Details are to include minimum slope, drain location, sheet metal gauge, and drain connection to the gutter.
- D. Dedicated piping from the gutter low points to an open site location. Open site termination shall include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".
- E. Dedicated drain piping to extent to outside of the room and be protected by a secondary gutter.
- F. Do not route any drain piping over switchgear, transformers, or other electrical equipment.

Gutter shall not block or inhibit access to surrounding systems.

11.39.10 Fire Protection

The fire protection system shall be provided as follows:

- A. Provide a wet-pipe sprinkler system unless prohibited in areas having electronic equipment.
- B. Provide an automatic detection system in areas not sprinklered establish and verify any requirements for the areas above dropped ceiling/ceiling plenums require detection systems.
- C. Establish with the Denver Fire Prevention Bureau any alternate system types (FM-200).
- D. Provide extinguishers in cabinets throughout the area.

Refer to the Life Safety DSM for fire protection requirements.

11.40 Security Guard House

11.40.1 Design Conditions

- A. Cooling: 74°F
- B. Heating: 70°F

11.40.2 Air Handling Systems

This facility shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain DX cooling and heating coils, a throwaway filter section, and a mixed air plenum for

outside air and return air duct damper connections. Heat pump systems should be considered if natural gas is not available.

11.40.3 Outdoor Air Requirements

Outside air shall be brought in through the AHU. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.40.4 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.40.5 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.40.6 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.40.7 Plumbing Requirements

All plumbing systems shall conform to the requirements of the IPC as adopted and modified by the CCD building code. Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters.

The following is a partial list of plumbing fixtures required for this area:

- A. Lavatories - wall hung or counter mounted.
- B. Water closets
- C. Stop valves - provided on all fixtures including water coolers.
- D. Floor drains and cleanouts.
- E. Water coolers

11.40.8 Fire Protection

The fire protection system shall be provided as follows:

- A. Provide an extinguisher.

Refer to the Life Safety DSM for fire protection requirements.

11.40.9 AHU Controls

Provide control logic to permit the following:

- A. Position outside air dampers and return air dampers. The outside air and exhaust air dampers shall be normally closed, and the return air dampers shall be normally open.
- B. Heating and cooling coil controls.
- C. Monitor space and duct temperatures.
- D. Equipment start/stop with equipment status.
- E. Alarms for failure of the following:

- a. Fan failure.
 - b. Space temperature out of specification.
- F. Freeze thermostat shutdown.

11.41 Warehouse Facility

11.41.1 Design Conditions

- A. Cooling: Conditioned spaces 74°F
Storage Areas: Ventilation only
- B. Heating: Conditioned spaces 70°F
Storage Areas: 70°F

11.41.2 Conditioned Systems

The office and break room area shall be air conditioned with a single zone system.

Each unit shall consist of a centrifugal, non-overloading supply air fan with fan speeds selected for sound control. In addition, systems shall contain cooling and heating coils, a throwaway filter section, and a mixed air plenum for outside air and return air duct damper connections. Refer to [3.0.1.Air Handling Systems](#) for air handling system requirements.

Provide a low-pressure ductwork system.

11.41.3 Warehouse System

The main storage areas shall be heated and ventilated only. Provide exhaust fans for ventilation during the cooling season. Exhaust fans shall be centrifugal, or prop type, non-overloading with fan speeds selected for increased life and sound control. Makeup air for exhaust system shall be introduced through an AHU with a filter, control damper, and louver plenum. The outside air shall be filtered with dry-type filter media with a minimum MERV 7 rating per ASHRAE. The exhaust system shall be designed to provide the minimum ventilation rate during the periods cooling is not required.

11.41.4 Air Curtains

Air curtains shall be provided for use on all main service entrances. Overhead fan-coil units shall be used at each entrance. These units should be indirect gas fired.

11.41.5 Outdoor Air Requirements

Outside air for the conditioned spaces shall be brought in through the AHU and makeup air unit. Refer to [3.2.Ventilation Systems](#) for ventilation requirements.

11.41.6 Toilet Exhaust

The ventilation rate for all toilet room facilities shall be 0.5 CFM per square foot of floor area or as required by the latest edition of ASHRAE 62.1, whichever is more stringent.

11.41.7 Ventilation Rates

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent.

11.41.8 Filtration

Filters with 4" dry type pre-filter section having a minimum rating of MERV 10 shall be provided.

11.41.9 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.41.10 Plumbing Requirements

Refer to [Chapter 8- Plumbing Requirements](#) for plumbing design parameters. The following is a partial list of plumbing fixtures required

- A. Lavatory faucets
- B. Lavatories
- C. Lavatories for the physically disabled
- D. Water closets
- E. Stop valves provided on all fixtures
- F. Urinals
- G. Floor drains and cleanouts
- H. Showers
- I. Sand traps and oil separators
- J. Water Coolers
- K. Sinks

All domestic water connections, to mechanical systems, shall be protected from backflow.

Plumbing piping that is either new or existing shall not run through an electrical room. Relocate existing piping to avoid the electrical room.

11.41.11 Fire Protection

The fire protection system shall be as follows:

- A. Provide a wet/dry-pipe sprinkler system that shall be designed to protect the particular type of usage including density suitable for anticipated storage type and method.
- B. Provide a hose station with extinguisher at each station in the enclosed areas, as required.
- C. Provide manual pull type fire alarm station as required.
- D. Provide rack storage fire protection system as required or increased overhead densities suitable for the commodities stored.

Refer to the Life Safety DSM for fire protection requirements.

11.42 Bulk Storage Facility (Urea and Sand Storage)

11.42.1 Design Conditions

- A. Summer: Vent Only
- B. Winter: Vent Only

11.42.2 Ventilation System

The bulk storage facility shall be ventilated to remove dust particles. Provide exhaust fans for ventilation year-round. Exhaust fans shall be centrifugal, or propeller type, non-overloading with fan speeds selected for increased life. Makeup air for exhaust system shall be introduced through a wall-mounted louver with bird screen. Provide unit heaters as required for minimal heating of space.

11.42.3 Ventilation Rate

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Minimum ventilation rate shall be 2 cfm/ft².

11.42.4 Exhaust Fan Controls

Exhaust fan shall operate year-round to provide for the removal of dust particles from the Bulk Storage Facility. Alarm for failure shall include:

- A. Fan failure

11.42.5 Unit Heater Controls

Unit heaters shall operate to maintain space at 50°F. Unit heaters shall be started and stopped based on space temperature. When the space temperature is lower than 50°F, the unit heaters shall be energized.

11.43 Baggage Tunnel

11.43.1 Design Conditions

- A. Summer: Vent Only
- B. Winter: Vent Only

11.43.2 Ventilation System

The baggage tunnel shall be ventilated to remove products of combustion. Provide exhaust fans for ventilation year-round. Exhaust fans shall be centrifugal, or propeller type, non-overloading with fan speeds selected for increased life. Makeup air for exhaust system shall be introduced through the tunnel ramp openings, which are open to the outside at the apron level.

11.43.3 Ventilation Rate

All new design for proper ventilation shall be in accordance with the latest edition of ASHRAE standard 62, Ventilation for Acceptable Indoor Air Quality, or the currently enforced International Mechanical Code with City amendments, whichever is more stringent. Minimum ventilation rate shall be 4 ACH per CCD Building and Construction Division.

11.43.4 Exhaust Fan Controls

Exhaust fan shall operate year-round to provide for the removal of products of combustion from the baggage tunnel.

Alarm for failure shall include fan failure.

11.43.5 Smoke Control

All tunnel areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.44 Utility Tunnel

11.44.1 Design Conditions

- A. Summer: No ventilation, relief air only
- B. Winter: No ventilation, relief air only

11.44.2 Ventilation System

The Utility Tunnel ventilation is provided by exhaust fans located in the AGTS/Baggage Mechanical and Electrical rooms. The exhaust air fans are ducted to the Concourse roof at every Concourse.

11.44.3 Exhaust Fan Controls

Fans are controlled manually and are intended to operate continuously.

11.44.4 Smoke Control

The Utility Tunnel does not have smoke control.

11.45 Train (AGTS) Tunnel

11.45.1 Design Conditions

- A. Summer: No ventilation, relief air only
- B. Winter: No ventilation, relief air only

11.45.2 Ventilation System

The AGTS Tunnel does not have ventilation. There are relief air openings to the Concourse roof at every Concourse, along with a relief air shaft between Concourse C and the AGTS Maintenance Center, and another relief air opening at the South end of the Terminal. Air is moved by the operation of the AGTS vehicles using a piston effect.

11.45.3 Exhaust Fan Controls

The AGTS Tunnel does not have exhaust. Air is moved in the AGTS tunnel by the operation of the AGTS vehicles using a piston effect.

11.45.4 Smoke Control

All AGTS tunnel areas shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.45.5 Electrical Rooms

Electrical rooms shall have their own DX cooling system. The system shall have factory installed and wired controls and DX cooling coils. Controls for the DX units shall communicate with the EMCS to provide status and alarms.

11.46 Data Center

11.46.1 Design Conditions

Data center cooling standards are frequently subject to change. Prior to the initiation of design, consult DEN Business Technologies via the DEN PM for data center conditioning recommendations. The Consultant shall design new DEN data centers to the standards laid out by the DEN PM, or to the latest version of ASHRAE Standard 90.4 – Energy Standard for Data Centers, whichever is more stringent.

11.46.2 Ventilation System

Data centers at DEN that are not normally occupied do not require ventilation, except where required by code.

11.46.3 Exhaust Fan Controls

Data centers at DEN that are not normally occupied do not require exhaust, except where required by code.

11.46.4 Smoke Control

All DEN data centers shall be served by a separate smoke control system. Refer to the Life Safety DSM for requirements.

11.47 Elevator Equipment Rooms

11.47.1 Design Conditions

- A. Cooling: 80°F
- B. Heating: 68°F

11.47.2 Air Handling System

This facility shall be air conditioned with single zone DX system. Single zone units shall consist of a centrifugal, non-overloading supply air fan with speeds selected for sound control. AHUs shall contain and a throwaway filter section. Air Handlers shall be located inside of the room and in locations that allow for full maintenance of the units. Refer to [3.0.1.Air Handling Systems](#).

11.47.3 Outdoor Air Requirements

Not required.

11.47.4 AHU Controls

Refer to [5.2.Sample Control Components and Requirements](#).

11.47.5 Plumbing Requirements

All condensate drainage systems shall conform to the requirements of the International Plumbing Code (IPC) as adopted and modified by the CCD building code. Condensate piping shall not run through any Telecommunications, UPS or Electrical rooms.

- A. Details are to include minimum slope and, drain termination location.
- B. Overflow piping from the AUH/secondary drain pan(s) are to include signage defining procedures in the event of a leak. Sign shall read, "If water is observed from the pipe below (or above), immediately contact Maintenance Control at (303) 342-2800".

11.47.6 Fire Protection

The fire protection system shall be provided in accordance with the latest editions of National Fire Protection Agency (NFPA) Standards and the building code of the CCD.

End of Chapter

Chapter 12 - Technical Specification Requirements

12.0 General

Designers are required to provide project specifications on all DEN projects in accordance with the Standards and Criteria DSM, Chapter 11. The project specifications should encompass all aspects of the project and be based on industry-standard construction methods and products, with content based on the DEN Standard Specifications (where available) or from an industry-standard guide specification.

12.0.1 How to Use DEN Standard Specifications

12.0.1.1 DEN Technical Requirements

The DEN Standard Specifications listed in this chapter have been developed to ensure project consistency and compliance with DEN policy and procedure. For sections available as DEN Standard Specifications, the designer must obtain and use these sections for their project.

12.0.1.2 DEN Technical Requirements

This provides DEN-specific requirements that must be included in nonstandard specifications for all DEN projects. An itemized list of DEN-specific technical specification requirements is provided, which may include general requirements, product requirements, and execution requirements. The designer shall incorporate these requirements into their project specification content as appropriate for the project scope. Requirements are provided in an outline format similar to construction specifications for ease of incorporation. Content may be copied directly from this chapter, with article/paragraph numbering and structure modifications as needed to ensure a cohesive document.

Note: This chapter is intended to be used as an aid to the development of a project specification and is not intended to represent a complete specification as presented.

The designer is responsible for developing a complete specification, incorporating the requirements, which encompasses all aspects of the project and complies with general specification requirements outlined in the Standards & Criteria DSM, Chapter 11. After incorporating the requirements listed herein, the project specification should be reviewed to ensure it is free of redundant and/or conflicting information.

12.0.1.3 Notes to the Designer

Notes to the designer are included throughout the chapter, shown in red highlighted text. These are provided for guidance and clarification of requirements and are intended for use only by the designer in development of their specification.

Notes to the designer shall not be incorporated into the final project specifications.

12.0.2 Specification Numbering

12.0.2.1 Numbering of Deliverables

Project deliverables should utilize Section names and numbers contained in the latest edition of MasterFormat Numbers & Titles at the time of project kickoff, which may vary from those in this chapter. It is the designer's responsibility to ensure that all applicable DEN requirements are reflected accurately in the appropriate sections of the project specifications.

12.0.2.2 Numbering Provided in this Chapter

Specification section names and numbers provided in this chapter are based on MasterFormat Numbers & Titles, 2014 edition.

12.0.2.3 Product and Manufacturer Listings

Where manufacturers and products are listed in this chapter, they represent approved manufacturers and/or products. Do not include additional manufacturers and/or products for that Article or paragraph without written permission from the DEN Project Manager.

For sections without manufacturer and/or products listed in this chapter, the designer shall select a basis of design based on current industry standards which comply with all applicable requirements in this and other DEN DSMs, the DEN Standard Specifications, and the Denver Building Code. Provide at least (2) acceptable alternatives to the basis of design for all products, for a total of (3) or more acceptable products, except where a sole-source selection has been approved in writing by the DEN Project Manager.

12.1 DEN Standard Specifications

Please contact the DEN Project Manager.

12.2 DEN Technical Requirements

Please contact the DEN Project Manager.

End of Chapter

Appendix A - Controls Points Abbreviations

Below is a list of DEN approved standard controls points abbreviations. Non-standard abbreviations must be approved in writing by DEN Mechanical Engineer.

Appendix A - Control Point Abbreviations

Identifiers	Description
AF-OFST	Return Airflow Offset from Total Supply
AHU-MODE	AHU Mode
BYPD-C	Bypass Damper Command
CHWE-F	Chilled Water Entering Flow
CHWE-T	Chilled Water Entering Temp
CHWL-T	Chilled Water Leaving Temp
CHWR-T	Chilled Water Return Temperature
CHWS-T	Chilled Water Supply Temperature
CLG-FB	Cooling Valve Feedback
CLG-M	Cooling Mode
CLG-O	Cooling Output
CLG-O-BTU	Cooling Valve BTU
CLG-O-FLOW	Cooling Flow
CLG-VLV-FAIL	Chilled Water Valve Failure
CO2-RESET	DCV Reset Enable
CW-ALM-DLY	Chilled Water Coil Alarm Time Delay
CW-ALM-SP	Chilled Water Coil Alarm Threshold
DA-F	Discharge Air Flow
DA-P	Discharge Air Static Pressure
DAP-EFF-SP	Effective Discharge Air Press Setpoint
DAP-IGN	DA Pressure Ignore Requests
DAP-ITSP	Initial Discharge Air Pressure Setpoint
DAP-MAX-SP	Maximum DA Pressure Setpoint
DAP-MIN-SP	Minimum DA Pressure Setpoint
DAP-REQS	DA Pressure Requests
DAP-RES	Setpoint Response DA Pressure Reset
DAP-RES-MAX	Setpoint Maximum Response DA Reset

Appendix A - Control Point Abbreviations (Continued)

Identifiers	Description
DAPR-MODE	DA Pressure Reset Mode
DAP-STRT-RP	Static Pressure Setpoint Ramp Time
DAP-T-D	Time Delay DA Pressure Reset
DAP-T-INT	Time Interval DA Pressure Reset
DAP-TRIM	Setpoint Trim DA Pressure Reset
DA-T	Discharge Air Temperature
DA-T-ALM	Discharge Air Temp Setpoint Alarm
DAT-ALM-DB	AHU DAT Alarm Deadband
DAT-ALM-DLY	AHU DAT Alarm Delay Time
DAT-ALM-TM	AHU DAT Alarm Time Threshold
DAT-EFF-SP	Effective Discharge Air Temp Setpoint
DAT-HI-OAT	High OAT for DAT Reset
DAT-IGN	DAT Ignore Requests
DAT-ITSP	Initial Discharge Air Temp Setpoint
DAT-LO-OAT	Low OAT for DAT Reset
DAT-MAX-SP	Maximum DA Temp Setpoint
DAT-MIN-SP	Minimum DA Temp Setpoint
DAT-MRN-CLG	Morning Pre-Cool Discharge Temp Setpoint
DAT-MRN-WRM	Morning Warmup Discharge Temp Setpoint
DAT-REQS	DA Temperature Requests
DAT-RES	Setpoint Response DA Temp Reset
DAT-RES-MAX	Setpoint Maximum Response DA Reset
DATR-MODE	DA Temperature Reset Mode
DAT-STBK	Unoccupied Setback Disch Temp Setpoint
DAT-STUP	Unoccupied Setup Discharge Temp Setpoint
DAT-T-D	Time Delay DA Temp Reset
DAT-T-INT	Time Interval DA Temp Reset
DAT-TRIM	Setpoint Trim DA Temp Reset
DA-VP	Discharge Air Velocity Pressure
DESIGN-DA-F	Design Discharge Flow
DHC-FB	Defrost Heating Valve Feedback

Appendix A - Control Point Abbreviations (Continued)

Identifiers	Description
DHCL-T	Defrost Leaving Temp
DHC-O	Defrost Heating Output
DHWE-F	Defrost Hot Water Entering Flow
DHWE-T	Defrost Hot Water Entering Temp
DHWL-T	Defrost Hot Water Leaving Temp
DHWT-SP	Defrost Temp Setpoint
EAD-FB	Exhaust Air Damper Feedback
EAD-O	Exhaust Air Damper Output
EA-EW-T	Exhaust Air Entering Wheel Temp
EA-F	Exhaust Air Flow
EA-FILT-DP	EA Filter Diff Pressure
EA-LW-T	Exhaust Air Leaving Wheel Temp
ECON-DB	Economizer Deadband
ECON-ENA	Economizer Mode Enable
EF-AF	Exhaust Fan Associated with AHU Airflow
EF-C	Exhaust Fan Command
EFF-CDAT-SP	Effective Cooling DAT Setpoint
EFF-HDAT-SP	Effective Heating DAT Setpoint
EFF-OA-T	Effective Outside Air Temperature
EF-HP	Exhaust Fan High Pressure
EF-HSP	EF High Static Pressure Alarm
EF-O	Exhaust Fan Output
EF-S	Exhaust Fan Status
EF-VP	Exhaust Fan Velocity Pressure
ERW-C	Energy Recovery Wheel Command
ERW-O	Energy Recovery Wheel Output
ERW-S	Energy Recovery Wheel Status
ERW-ALM	Energy Recovery Wheel Alarm
FLTR-DP	Filter Differential Pressure
FIRE-ALM	Fire Alarm
FLTR-WRN	Filter Warning

Appendix A - Control Point Abbreviations (Continued)

Identifiers	Description
FLTR-WRN-SP	Filter Warning Setpoint
HI-DAT-ALM	High Discharge Temp Alarm
HI-DAT-SP	High Discharge Setpoint
HP-ALM	DA High Duct Pressure Alarm
HTG-EN	Global Heating Enable
HTG-M	Heating Mode
HW-ALM-DLY	Hot water Coil Alarm Time Delay
HW-ALM-SP	Hot water Coil Alarm Threshold
LDAT-ALM	Low Discharge Air Temp Alarm
LDAT-SP	Low DA Temp Setpoint
LTA-R	Low Temp Alarm Reset
LT-SP	Low Limit Setpoint
LP-ALM	Low Duct Pressure Alarm
LT-ALM	Low Temperature Alarm
LT-S1-ALM	Low Limit Stage 1 Alarm
LT-S2-ALM	Low Limit Stage 2 Alarm
MA-LT-ALM	Mixed Air Low Limit Alarm
MA-T	Mixed Air Temperature
MAT-LL	Mixed Air Temp Low Limit
MAT-LL-DLY	Mixed Air Temp Low Limit Release Delay
MECH-CLG-DLY	Mechanical Cooling Time Delay
MOA-CO2RSTA	CO2 Low Range
MOA-CO2RSTB	CO2 High Range
MPC-END	Morning Pre-Cool End Month
MPC-OAT	Morning Pre-Cool OAT Enable Temp
MPC-STPT	Morning Pre-Cool Space Setpoint
MPC-STRT	Morning Pre-Cool Start Month
MRN-CLG	Morning Cool-down Mode
MRN-WRM	Morning Warm-up Mode
OAD-FB	Outdoor Air Damper Feedback
OAD-O	Outdoor Air Damper Output

Appendix A - Control Point Abbreviations (Continued)

Identifiers	Description
OA-F	Outside Air Flow
OA-FILT-DP	OA Filter Diff Pressure
OA-F-SP	Outside Air Flow Setpoint
OAG-DAT-SP	OAT Greater DA Temp Setpoint
OAL-DAT-SP	OAT Less DA Temp Setpoint
OA-T	Global Outside Temperature
OCC-C	Occupied Mode
OCC-M	Occupied Mode
PFILT-DP-ALM-DLY	PreFilter Alarm Delay
PH-FB	Preheat Valve Feedback
PH-O	Preheat Output
PH-O-BTU	Preheat Valve BTU
PH-O-F	Preheat Flow
PH-T	Preheat Temp
PH-VLV-FAIL	Hot Water Valve Failure
PHW-F	Preheat Water Entering Flow
PHWR-T	Hot Water Return Temperature
PHWS-T	Hot Water Supply Temperature
PID-TMP-DB	PID Deadband Heating Econ Cooling
PWR-FAIL-DLY	Power Failure Restart Delay Time
PWR-FAIL-INT-UNIT- DLY	Power Fail Interstage Unit Delay
RAD-FB	Return Air Damper Feedback
RAD-O	Return Air Damper Output
RA-F	Return Air Flow
RAF-AF-SP	Return Airflow Setpoint
RAF-C	Return Air Fan Command
RAF-MM-ALM	Return Fan Mismatch Alarm
RAF-O	Return Air Fan Output
RAF-S	Return Air Fan Status
RA-H	Return Air Humidity
RA-SD-ALM	Return Air Smoke Detector Alarm

Appendix A - Control Point Abbreviations (Continued)

Identifiers	Description
RA-T	Return Air Temperature
RA-T	Return Air Temp
SA-F	Supply Air Flow
SA-SD-ALM	Supply Air Smoke Detector Alarm
SD-CMD	Shutdown Command
SF-C	Supply Fan Command
SF-MM-ALM	Supply Fan Mismatch Alarm
SF-O	Supply Fan Output
SF-S	Supply Fan Status
SYS-OFF	System Off Mode
SYS-RESET	System Reset
T-MIN	DAT Minimum at High OAT
TUNING-RESET	Tuning Reset
UNIT-CNT	Device No for Interstage Unit Delay
UNIT-RESET	Unit Reset
UNOCC-CLG-DB	Unoccupied Cooling Deadband
UNOCC-CLG-SP	Unoccupied Cooling Setpoint
UNOCC-HTG-DB	Unoccupied Heating Deadband
UNOCC-HTG-SP	Unoccupied Heating Setpoint
UNOCC-STATE	Unoccupied State
UNOCC-STBK	Unoccupied Setback Mode
UNOCC-STUP	Unoccupied Setup Mode
V_OT	Minimum Outside Air Setpoint -Non-DCV
V_OT-MIN	DCV Minimum Outside Air Setpoint
VAV-CO2-MAX	Maximum Zone CO2
VAV-T-AVG	VAVs Temp Average
VAV-T-MAX	VAVs Temp Maximum
VAV-T-MIN	VAVs Temp Minimum

Appendix A - VAV Points Abbreviations

Identifier	Description
AHU-SA-T	Supply Air Temperature
AHU-SF-S	AHU Supply Air Fan Status
AUTOCAL-C	Autocalibrate
AVG-MAX-CALC-ZN-T	ZN-T FOR Maximum & Average Calculation
HTG-ENA	Global Heating Enable
CLG-C	Cooling Command
CLG-MAXFLOW	Cooling Max Flow
CLGOCC-MINFLOW	Occ Cooling Min Flow
CLG-REQ	Discharge Temperature Request
DA-T	Discharge Air Temperature
DATHTGMAX-SP	Discharge Air Setpoint Heating Max
DA-VP	Discharge Air Velocity Pressure
DPR-O	Supply Air Damper Output
EFFCLG-SP	Effective Cooling Setpoint
EFFDAT-SP	Effective Discharge Setpoint
EFFHTG-SP	Effective Heating Setpoint
EFF-OCC	Effective Occupancy
EFF-SETPOINT	Active Setpoint
HTG-C	Heating Command
HTG-MAXFLOW	Heating Max Flow
HTG-O	Heating Output
HTGOCC-MINFLOW	Occ Heating Min Airflow
HTGSTBY-SP	Standby Heating Setpoint
IMP-V	Importance Factor
IRH-C	IRH Command
MIN-CALC-ZN-T	ZN-T for Minimum Calculation
NET-OCC	Supervisor Occupancy
OCC-CLG-SP	Occupied Cooling Setpoint
OCC-HTG-SP	Occupied Heating Setpoint
OCC-SCHEDULE	Occupancy Schedule
SA-F	Airflow Rate

Appendix A - VAV Points Abbreviations (Continued)

Identifier	Description
SAFLOW-SP	Flow Setpoint
SF-C	Supply Fan Command
SF-S	Supply Fan Status
SYSTEM-MODE	System/Control Mode
UNITEN-ENA	Unit Enable
UNIT-S	Unit Status
UNNOC-CLG-SP	Unoccupied Cooling Setpoint
UNNOC-DB	Unoccupied Deadband
UNNOC-HTG-SP	Unoccupied Heating Setpoint
UNNOC-STATE	Unoccupied Status
VAV-IGN-CAL	VAV Box Ignore for Calculation
WC-ADJ	Setpoint Offset
WC-C	Warmup/Cooldown
ZN-T	Zone Temperature
VFD Points	
FAULT	Fault Status
HOA	Hand/Off/ Auto Status
SPD-FBK	Speed Feedback
AMPS	Amperage/ Motor Current
HZ	Hertz/ Frequency
kWh	Kilowatt Hours
HRS	Run Hours
S	Running/ Stopped Status
C	Start/ Stop Command
O	Output
ALM	Alarm
Floating Point Valves	
OPN-C	Open Command
OPN-S	Open Status
CLO-C	Close Command
CLO-S	Close Status

Appendix A - VAV Points Abbreviations (Continued)

Identifier	Description
Equipment Control	
C	On/ Off Command
S	On/Off Status
ALM	Alarm
ENA	Enable/Disable
MS	Normal/Maintenance mode
DP	Differential Pressure
RT	Run Time
Hydronic Elements	
HWS-T	Heating Water Supply Temperature
HWR-T	Heating Water Return Temperature
HWS-F	Heating Water Supply Flow
HWR-F	Heating Water Return Flow
HWS-P	Heating Water Supply Pressure
HWR-P	Heating Water Return Pressure
CWS-T	Condenser Water Supply Temperature
CWR-T	Condenser Water Return Temperature
CWS-F	Condenser Water Supply Flow
CWR-F	Condenser Water Return Flow
CWS-P	Condenser Water Supply Pressure
CWR-P	Condenser Water Return Pressure
CHWS-T	Chilled Water Supply Temperature
CHWR-T	Chilled Water Return Temperature
CHWS-F	Chilled Water Supply Flow
CHWR-F	Chilled Water Return Flow
CHWS-P	Chilled Water Supply Pressure
CHWR-P	Chilled Water Return Pressure
GLWS-T	Glycol Supply Temperature
GLYR-T	Glycol Return Temperature
GLYS-F	Glycol Supply Flow
GLYR-F	Glycol Return Flow

Appendix A - VAV Points Abbreviations (Continued)

Identifier	Description
GLYS-P	Glycol Supply Pressure
GLYR-P	Glycol Return Pressure
DP	Differential PressureS

End of Appendix

Matrix A: DEN Concourse A West Expansion Concessions

DEN Concourse A West Expansion Concessions Matrix

Space		Plan Name					Mechanical									Plumbing								Electrical				
Location	Category	Room Number	Plan Tag	Seating Internal for F & B Operation	Dumb Waiter Shaft	Floor Area	Cooling Load		Chilled Water Flow Allowance (GPM)	Heating Hot Water Flow Allowance (GPM)	Cooking			Ventilation (CFM)		Domestic Cold Water		Domestic Hot Water		San. Sewer)	Grease Waste)	Vent		Gas		Maximum Load (AMPS)	Design Load (AMPS)	Connect Supported (VOLTS)
							Alloance (SF/TON)	Total (Tons)			(Y/N)	Type: Gas, Elect, G/E	Grease Exhaust	Diswasher Exhaust	Hood Makeup from Outside	Service	Size (IN.)	Service	Size (IN.)	Size (IN.)	Size (IN.)	Size (IN.)	Size (IN.)					
Subcore 6W Concourse Level ¹	Food & Beverage	CCA_02_6W_020	Concessions Seating	Y	Y	4,681	300	15.6	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	2	CW, Metered Up from Apron	Tenant-provided Electric Water Heater in the Space		4	N/A	N/A	3	400	424	277/480,3PH	
Subcore 6W Concourse Level ¹	Back of House	CCA_02_6W_CR51	Circulation	N/A	Y	354	500	0.7	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Subcore 6W Apron Level ²	Kitchen	CCA_01_6W_014	Concessions Kitchen	N/A	Y	1,786	300	6.0	16.7	29.3	Y	G/E	8800	700	9,500	CW, Metered	2	Tenant-provided Electric Water Heater in the Space		4	4	3	By Tenant (2400 CFH Allowance)	100	85	277/480,3PH		
Subcore 6W Apron Level ²	Storage	CCA_01_6W_013	Concessions Loading/ Storage	N/A	N	1,162	1200	1.0	3	3.7	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	3	277/480,3PH		
Subcore 6W Base-ment Level ³	Storage	N/A	N/A	N/A	N	3,290	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	8	277/480,3PH		
Holdroom 7W ¹	Travel & Convenience	CCA_02_7W_037	Concessions	TBD	N	1,468	1000	1.5	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	124	277/480,3PH		
Subcore 9W Concourse Level ¹	Food & Beverage	CCA_02_9W_020	Concessions Seating	Y	Y	4,681	300	15.6	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	2	CW, Metered Up From Apron	Tenant-provided Electric Water Heater in the Space		4	N/A	3	N/A	400	424	277/480,3PH	
Subcore 9W Concourse Level ¹	Back of House	CCA_02_9W_CR06	Circulation	N/A	Y	354	500	0.7	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	2	CW, Metered Up From Apron	Tenant-provided Electric Water Heater in the Space		4	N/A	3	N/A	100	89	277/480,3PH	
Subcore 9W Apron Level ²	Storage/ Future Kitchen	CCA_01_9W_025	Concessions Storage	N/A	Y	954	300	3.3	9.9	17.3	Y	G/E	5200	425	5,600	CW, Metered	2	Tenant-provided Electric Water Heater in the Space		4	4	3	By Tenant (2400 CFH Allowance)	100	47	277/480,3PH		
Subcore 9W Apron Level ²	Loading/ Storage	CCA_01_9W_008	Loading/ Storage	N/A	N	627	1200	0.5	1.5	1.9	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	1.1	277/480,3PH		

DEN Concourse A West Expansion Concessions Matrix (Continued)

Space		Plan Name					Mechanical								Plumbing								Electrical			
Subcore 9W Basement Level ¹	Storage	N/A	N/A	N/A	N	2,936	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	7	277/480,3PH
Holdroom 10W ³	Travel & Convenience	CCA_02_10W_050	Concessions	TBD	N	1,054	1000	1.1	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	58	277/480,3PH

Notes:

¹ If required natural gas is provided by XCEL Energy during Tenant Design. Space air conditioning is from the Concourse VAV Air Handling Systems.

² If required natural gas is provided by XCEL Energy during Tenant Design. Space air conditioning is from the Apron VAV Air Handling Systems.

³ If required natural gas is provided by XCEL Energy during Tenant Design. No Air handling systems exist in the basement for conditioning Tenant spaces.

Matrix B: DEN CEP Concourse B West Expansion Concessions

DEN CEP Concourse B West Expansion Concessions Matrix

Space		Plan Name					Mechanical									Plumbing								Electrical		
Location	Category	Room Number	Plan Tag	Seating Internal for F & B Operation	Dumb Waiter Shaft	Floor Area	Cooling Load		Chilled Water Flow Allowance (GPM)	Heating Hot Water Flow Allowance (GPM)	Cooking			Ventilation (CFM)		Domestic Cold Water		Domestic Hot Water		San. Sewer)	Grease Waste)	Vent	Gas	Maxmum Load (AMPS)	Design Load (AMPS)	Connect Supported (VOLTS)
							Alloance (SF/TON)	Total (Tons)			(Y/N)	Type: Gas, Elect, G/E	Grease Exhaust	Diswasher Exhaust	Hood Makeup from Outside	Service	Size (IN.)	Service	Size (IN.)	Size (IN.)	Size (IN.)	Size (IN.)	Size (IN.)			
Holdroom 8W Concourse Level	Travel & Convenience	CCB_02_8W_010	Travel & Convenience	TBD	N	754	600	1.3	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	64	277/480,3PH
Subcore 9W Concourse Level	Food & Beverage	CCB_02_9W_015	Concessions	Y	Y	3,784	150	25.2	N/A	N/A	N	N/A	N/A	N/A	N/A	CW, Metered Up From Apron	2	Tenant-provided Electric Water Heater in the Space		4	N/A	3	N/A	400	312	277/480,3PH
Subcore 9W Concourse Level	Back of House	CCB_02_9W_CR14	Corridor	N/A	Y	544	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subcore 9W Apron Level	Kitchen	CCB_01_9W_023	Concesions Storage	N/A	Y	1,484	300	4.9	21	33	Y	G/E	8,800	700	9,500	CW, Metered	2	Tenant-provided Electric Water Heater in the Space		4	4	3	By Tenant (2400 CFH Allowance)	100	71	277/480,3PH
Subcore 9W Apron Level ³	Storage	CCB_01_9W_020	Concesions Storage	N/A	N	1,031	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	50	277/480,3PH
Storage Apron Level	Storage	CCB_01_9W_022	Loading	N/A	N	571	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	64	277/480,3PH

Notes:

If required natural gas is provided by XCEL Energy during Tenant Design. Space air conditioning is from the Concourse VAV Air Handling Systems.

This page is intentionally blank.

Matrix C: DEN Concourse C East Expansion Concessions

DEN Concourse C East Expansion Concessions Matrix

Space		Plan Name						Mechanical																					Electrical		
Location	Category	Room Number	Plan Tag	Seating Internal for to Restaurant (Y/N)	Trash Chute Access (Y/N)	Dumb Waiter Shaft	Floor Area (S/F)	Cooling Load		Chilled Water Flow Allowance (GPM)	Heating Hot Water Flow Allowance (GPM)	Cooking		Kitchen/ Dishwasher Exhaust		Ventilation (CFM)			Domestic Cold Water		Domestic Hot Water	San. Sewer)	Grease Waste)	Vent	Gas	Allow-ance (AMPS)	Calculated Load (AMPS)	Voltage			
								Allowance (SF/TON)	Total (Tons)			(Y/N)	Type: Gas, Elect, G/E	(Y/N)	Air Flow (CFM)	Diswasher Exhaust	Hood Makeup from Outside	Makeup Air from Terminal	Service	Size (IN.)	Service	Size (IN.)	Size (IN.)	Size (IN.)	Size (IN.)						
Subcore 6E Concourse Level ¹	Concession Space	CCC_02_6E_025	Restaurant 1	Y	Y	Y	3200	300	10.7	20	15	Y	E/G	Y	4500/1400	2980	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	77	480/277V			
Subcore 6E Concourse Level ¹	Concession Space	CCC_02_6E_026	Restaurant 2	Y	Y	Y	3200	300	10.7	20	15	Y	E/G	Y	4500/1400	2980	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	77	480/277V			
Subcore 6E Concourse Level ²	Retail	CCC_02_6E_023	Travel & Convenience	N	N	N	1000	300	3.3	5	1.25	N	N/A	N	N/A	235	N/A	N/A	Concourse CW Loop, Metered	0.75	Local Electric Water Heater in Space	4	N/A	3	N/A	100	6	480/277V			
Subcore 6E Concourse Level ²	Concession Space		Gourmet Coffee Kiosk	N	N	N	1000	300	3.3	5	1.25	N	N/A	N	N/A	930	N/A	N/A	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	3	3	N/A	100	24	480/277V			
Subcore 6E Apron Level ¹	Kitchen	CCC_02_6E_023	Kitchen 1	N	N	Y	1400	300	4.7	15	10	Y	E/G	Y	4500/1400	N/A	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	67	480/277V			
Subcore 6E Apron Level ¹	Kitchen	CCC_02_6E_023	Kitchen 2	N	N	Y	1400	300	4.7	15	10	Y	E/G	Y	4500/1400	N/A	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	67	480/277V			
Subcore 6E Basement Level ³	Concession Storage	CCC_00_6E_007	Storage	N	N	N	3858	1200	3.2	5	5	N	N/A	N	N/A	465	N/A	N/A	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	3	N/A	2	N/A	125	9	480/277V			

DEN Concourse C East Expansion Concessions Matrix (Continued)

Space		Plan Name						Mechanical																		Electrical			
Subcore 9E Concourse Level ¹	Concession Space	CCC_02_9E_025	Restaurant 1	Y	Y	Y	3200	300	10.7	20	15	Y	E/G	Y	4500/1400	2980	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	77	480/277V	
Subcore 9E Concourse Level ¹	Concession Space	CCC_02_9E_027	Restaurant 2	Y	Y	Y	3200	300	10.7	20	15	Y	E/G	Y	4500/1400	2980	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	77	480/277V	
Subcore 9E Concourse Level ²	Retail	CCC_02_9E_023	Travel & Convenience	N	N	N	1000	300	3.3	5	1.25	N	N/A	N	N/A	235	N/A	N/A	Concourse CW Loop, Metered	0.75	Local Electric Water Heater in Space	4	N/A	3	N/A	100	6	480/277V	
Subcore 9E Concourse Level ²	Concession Space		Gourmet Coffee Kiosk	N	N	N	1000	300	3.3	5	1.25	N	N/A	N	N/A	930	N/A	N/A	Concourse CW Loop, Metered	0.75	Local Electric Water Heater in Space	4	3	3	N/A	100	24	480/277V	
Subcore 9E Apron Level ¹	Kitchen	CCC_01_9E_015	Kitchen 1	N	N	Y	1400	300	4.7	15	10	Y	E/G	Y	4500/1400	N/A	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	67	480/277V	
Subcore 9E Apron Level ¹	Kitchen	CCC_01_9E_015	Kitchen 2	N	N	Y	1400	300	4.7	15	10	Y	E/G	Y	4500/1400	N/A	2700	1800	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	4	4	3	By Tenant (2400 CFH Allowance)	100	67	480/277V	
Subcore 9E Basement Level ³	Concession Storage	CCC_00_9E_005	Storage	N	N	N	3589	1200	3	5	5	N	N/A	N	N/A	430	N/A	N/A	Concourse CW Loop, Metered	1.5	Local Electric Water Heater in Space	3	N/A	2	N/A	100	9	480/277V	

Notes:

¹If required natural gas is provided by XCEL Energy during Tenant Design. Cooling and heating are provided by the Concourse air conditioning systems.

²Cooling and heating are provided by the Concourse air conditioning systems.

³Apron secure storage.