COMPOSITE INDEX

ASHRAE HANDBOOK SERIES

This index covers the current Handbook series published by ASHRAE. The four volumes in the series are identified as follows:

R = 2014 Refrigeration

A = 2015 HVAC Applications

S = 2016 HVAC Systems and Equipment

F = 2017 Fundamentals

Alphabetization of the index is letter by letter; for example, **Heaters** precedes **Heat exchangers**, and **Floors** precedes **Floor slabs**.

The page reference for an index entry includes the book letter and the chapter number, which may be followed by a decimal point and the beginning page in the chapter. For example, the page number S31.4 means the information may be found in the 2016 HVAC Systems and Equipment volume, Chapter 31, beginning on page 4.

Each Handbook volume is revised and updated on a four-year cycle. Because technology and the interests of ASHRAE members change, some topics are not included in the current Handbook series but may be found in the earlier Handbook editions cited in the index.

Abbreviations, F38	industrial exhaust gas cleaning, S30.23	types
Absorbents	moisture, F32.1	air washers, S41.9
liquid, F2.14; F32.3	solid-vapor sorption, F2.20	combination, S29.5
refrigerant pairs, F2.15	Aeration, of farm crops, A25	electronic, S10.2; S29.5, 7; S33.2
Absorption	Aerosols, S29.1	evaporative coolers, S41.9
ammonia/water, F30.71	AFDD. See Automated fault detection and	maintenance, S29.8
hydrogen cycle, R18.8	diagnostics (AFDD)	media filters, S29.5
technology, R18.7	Affinity laws for centrifugal pumps, S44.8	Air conditioners. (See also Central air
chillers, S3.5	AFUE. See Annual fuel utilization efficiency	conditioning)
turbines, S8.6	(AFUE)	packaged terminal (PTAC), S50.5
coefficient of performance (COP), F2.14	AHU. See Air handlers	design, S50.6
dehumidification, S24.12	Air	heavy-duty commercial grade, S2.3
equipment, R18.1	age of, and ventilation, F16.5	sizes and classifications, S50.5
evolving technologies, R18.10	changes per hour (ACH), F16.4	testing, S50.7
ideal thermal, F2.13	drying, S24.13	residential, A1
industrial exhaust gas cleaning, S30.17	flux, F25.2	split systems, S2.6
refrigeration cycles, F2.13	liquefaction, R47.8	through-the-wall room units, A1.7
ammonia/water, F30.71	permeability, F25.2	unitary, A1.4
calculations, F2.19	permeance, F25.2	retail stores, A2.1
cascaded, F2.17	separation, R47.17	rooftop units, S2.9
coupling, F2.16	transfer, F25.2	room
double-effect, F2.17	Air barriers , F25.9; F26.5	codes and standards, \$50.4
lithium bromide/water, F2.17; F30.71	Airborne infectious diseases, F10.7	design, S50.1
modeling analysis and performance,	Air cleaners. (See also Filters, air; Industrial	features, S50.3
F2.17	exhaust gas cleaning)	filters, S50.4
	8	,
phase constraints, F2.14	gaseous (indoor air)	installation and service, S50.5
representations, F2.16	adsorbers, A46.7	noise, S50.4
solar cooling, A35.18, 27; S37.4, 10	chemisorbers, A46.9	performance, \$50.2
water/lithium bromide technology	economics, A46.15	sizes and classifications, S50.1
components, R18.1	energy consumption, A46.15	split systems, S49.1
control, R18.5	environmental effects on, A46.17	coil placement, S49.9
double-effect chillers, R18.3	installation, A46.16	residential and light-commercial, S2.6
maintenance, R18.7	media selection, A46.11	unitary
operation, R18.5	operation and maintenance, A46.17	air handlers, S49.8
single-effect chillers, R18.2	safety, A46.16	application, S49.1
single-effect heat transformers, R18.3	sizing, A46.12	capacity control, S49.8
terminology, R18.1	terminology, A46.1	certification, S49.7
working fluids, F2.15	testing, A46.17	circuit components, S49.7
Acoustics. See Sound	types, A46.11	codes and standards, S49.6, 7
Activated alumina, S24.1, 4, 12	industrial exhaust systems, A32.8	desuperheaters, S49.4
Activated carbon adsorption, A46.7	particulate	efficiency, S49.6
Adaptation, environmental, F9.17	contaminants, S29.1	electrical design, S49.8
ADPI. See Air diffusion performance index	industrial ventilation, S29.2	installation, S49.2
(ADPI)	particle collection mechanisms, S29.2	mechanical design, S49.9
Adsorbents	penetration, S29.3	piping, S49.7
impregnated, S30.24	residential, S29.10	refrigerant circuit control, S49.7
solid, A46.7; F32.4	safety requirements, S29.11	service, S49.2
Adsorption	selection, S29.8	space conditioning/water heating, S49
dehumidification, S24.1, 12	standards, S29.3, 5	types, S49.2
indoor air cleaning, A46.7	test methods, S29.2	unit ventilators, S28.1

window-mounted, S2.3	telecommunication facilities, A19	draft, F20.2
Air conditioning. (See also Central air	temporary exhibits, A5.8	effective area, F20.2, 5
conditioning)	textile processing plants, A21.4	equipment, S20
airports, A3.6	theaters, A5.3	free area, F20.2
animal buildings, A24.4	transportation centers, A3.6	induction, F20.2
arenas, A5.4	warehouses, A3.8	induction ratio, F20.2
atriums, A5.9	wood products facilities, A26.1	neck area, F20.2
auditoriums, A5.3	Air contaminants, F11. (See also	occupied zone, F20.2
automobiles, A10.1	Contaminants)	outlets, F20.2
bakeries, R41	Aircraft, A12	primary air, F20.2
buses, A11.2	air conditioning, A12.10	space, F20.1
bus terminals, A3.7	air distribution, A12.12	stratification height, F20.2
changeover temperature, S5.12, 13	air filters, A12.9, 14	stratified zone, F20.2
clean spaces, A18	air quality, A12.13	terminology, F20.2
commercial buildings, A3.1; S2.7	cabin pressurization	thermal plumes, F20.7
computer rooms, A19	control, A12.11, 13	total air, F20.2
concert halls, A5.4	performance, A12.9, 15	Air diffusion performance index (ADPI),
convention centers, A5.5	carbon dioxide concentration, A12.14	A57.5
data centers, A19	environmental control system (ECS),	Air dispersion systems, fabric, S19.11
desiccant dehumidification and, S24.11	A12.11, 13, 15	Air distribution, A57; F20; S4; S20
dormitories, A6.1, 8	air-conditioning packs, A12.9	aircraft cabins, A12.12
educational facilities, A7.1	air-cycle machine, A12.10	air terminals, A57.1
engine test facilities, A17.1	cabin pressure control, A12.9, 11, 13, 15	animal environments, A24.3, 6
equipment	design conditions, A12.1	applications, A57
outdoor, S2.9	engine bleed air system, A12.9	buildings, S4.1
refrigeration, S3.4	load determination, A12.1	central system, A42.1
exhibition centers, A5.5		control, S4.17
,	outdoor air, A12.9	· · · · · · · · · · · · · · · · · · ·
fairs, A5.8	pneumatic system, A12.9	ductwork, S1.8; S4.10
fixed-guideway vehicles, A11.7	regulations, A12.14	equipment, S20
gymnasiums, A5.5	heating, A12.6	fixed-guideway vehicles, A11.9
health care facilities, A8	humidity, A12.12	forced-air systems, small, S10.7
hospitals, A8.2	oxygen levels, A12.1, 9	industrial environments, A31.3
nursing facilities, A8.15	ozone concentration, A12.12, 14, 15	in-room terminal systems, S5.10
outpatient, A8.14	ventilation, A12.6, 15	isovels, A57.5
hotels and motels, A6	Air curtains	kitchen makeup air, A33.22
houses of worship, A5.3	display cases, R15.5	laboratories, A16.9
ice rinks, A5.5	units, \$20.12	mapping, A57.5
industrial environments, A14; A31	Air diffusers, S20	occupied zone, A57.1
kitchens, A33	sound control, A48.14	places of assembly, A5.2
laboratories, A16.1	testing, A38.2	rail cars, A11.7
mass transit, A11.2	Air diffusion, F20	retail stores, A2.1
mines, A29	air jets, F20.2, 3	ships, A13.2, 4
natatoriums, A5.6	Archimedes number, F20.6	sound control, A48.8, 38
nuclear facilities, A28	attached, F20.2, 7	systems, A57.1
office buildings, A3.1	axial, F20.2, 3	design considerations, A57.2
paper products facilities, A26.2	behavior, F20.3	fully stratified, A57.6
photographic processing and storage areas,	centerline velocity, F20.4	mixed, A57.2
A22.1	Coanda effect, F20.2, 7	partially mixed, A57.9
places of assembly, A5	drop, F20.2	rooms, A57.1
plant growth chambers, A24.17	entrainment ratios, F20.6	terminal boxes, A47.13
power plants, A27.11	expansion zones, F20.4	testing, adjusting, balancing, A38.3
printing plants, A20	free, F20.2, 3	textile processing plants, A21.6
public buildings, A3.1	fundamentals, F20.3	zone control, A47.17
rail cars, A11.5	isothermal, F20.2, 3	Air exchange rate
retrofitting, contaminant control, R7.10	multiple, F20.7	air changes per hour (ACH), F16.4
solar energy systems, A35.15, 18, 27	nonisothermal, F20.2, 3	modeling, F16.23
subway stations, A15.14	spread, F20.2	multizone measurement, F16.7
swimming areas, A5.6	surface (wall and ceiling), F20.7	time constants, F16.4
systems	throw, F20.2, 5	tracer gas measurement method, F16.6
decentralized, S2.1	velocity profile, F20.6	Air filters. See Filters, air
floor-by-floor, S2.7	velocity, terminal, F20.2	Airflow
forced-air, small, S10.1	vena contracta, F20.2	air-to-transmission ratio, S5.13
packaged, S2.9	applications, A57	around buildings, F24
radiant panel S6.1	aspect ratio, F20.2	air intake contamination estimation, F24.12
selection, S1.1, 9	core area, F20.2	coefficients wind pressure, F24.4
self-contained, S2.7	diffuser, F20.1	computational modeling, F24.12
space requirements, S1.6	discharge, coefficient of, F20.2	internal pressure, F24.10
split S2.6	distribution F20.2	LES model F24 13

Composite much		110
modeling and testing, F24.12, 12	location to avoid contamination, A45.2	air handlers, S4.3
patterns, A45.3; F24.1	outdoor, S4.7	air terminal units (ATUs), S4.16
RANS model, F24.13	vehicular facilities, enclosed, A15.37	buildings, S4.1
through building components, F25.9	Air jets. See Air diffusion	constant-volume, S4.11, 12
clean spaces, A18.4	Air leakage. (See also Infiltration)	control, S4.17
computational fluid dynamics, A40.14	area, F16.16	cooling, S4.4, 8
computer-aided modeling, A18.5	building distribution, F16.17	costs, S4.3
condensers	commercial buildings, F16.26	dehumidification, S4.6, 9
air-cooled, S39.9	controlling, air-vapor retarder, F16.18	disadvantages, S4.1
evaporative, S39.16	leakage function, F16.15	dual-duct, S4.12
control, F25; F26; F27	measurement, F16.15, 16	economizers, S4.7
and convection, F25.6	Air mixers, S4.8	heating, S4.2, 5
displacement flow, F16.3	Air outlets	humidification, S4.5, 9
entrainment flow, F16.3	accessories, \$20.5	multizone, S4.13
exhaust hoods, A32.3	dampers, S20.5, 5, 7	primary equipment, S4.4
furnaces, S33.2	location, S10.3	single-duct, S4.11
with heat and moisture flow, F25.14	selection, S20.2, 4	variable-air-volume (VAV), S4.11, 12
laminar, A18.4	smudging, S20.2	zoning, S4.2
measurement of, A38.2	sound level, S20.2	Altitude, effects of
modeling	supply, S20.2	air-cooling and dehumidifying coils, S23.3, 4, 6
in buildings, F13	surface effects, S20.2	air transport, R27.1, 2, 3
hygrothermal, F25.15	temperature differential, S20.2	ambient temperature, F25.3
nonunidirectional, A18.4	types, S20.2	chimney, vent, and fireplace draft calculations,
perfect mixing, F16.3	Airports, air conditioning, A3.6	\$35.7, 33
pressure differentials, F25.5	Air quality. [See also Indoor air quality (IAQ)]	combustion and fuel calculations, F28.3; S7.8,
solar energy systems, A35.26	aircraft cabins, A12.13	10, 19; S31.10 fans, S21.5
terminology, F25.2 tracking, A47.10	animal buildings, A24.2	
transport velocity, A32.7	bus terminals, A15.24 diesel locomotive facilities, A15.28	hydronic heat-distributing units and radiators, S36.5
unidirectional, A18.4, 17, 18	parking garages, A15.19	load calculations, F16.12; F18.14
velocity measurement, F37.15	road tunnels, A15.9	outdoor air thermal loads, F16.11
volumetric rate, F16.3	tollbooths, A15.27	psychrometrics, F1.1, 16
and water vapor flow, F25.12	Air terminal units (ATUs)	Ammonia
wind	air distribution, S4.16	absorption
data, F24.4, 7	constant volume, \$4.16	ammonia/water, F2.19; R18.7
effects on system operation, F24.8	fan-powered, S4.17	ammonia/water/hydrogen, R18.8
velocity pressure (Bernoulli equation), F24.4	humidifiers, S4.17	in animal environments, A24.2, 9
wind tunnels, F24.12	induction, S4.17	properties, F30.40–41
Airflow retarders, F25.9	reheat boxes, S4.16	system practices, R2
Air flux, F25.2. (See also Airflow)	throttling, S4.16	and water, F30.70–71
Air handlers	variable-air-volume (VAV), S4.16	Anchor bolts, seismic restraint, A55.7
all-air systems, S4.3	Airtightness, F37.24	Anemometers
cooling, S4.4	Air-to-air energy recovery, S26	air devices, A38.2
dampers, S4.7, 7	Air-to-transmission ratio, S5.13	types, F37.15
dehumidification, S4.6, 9	Air transport, R27	Animal environments
distribution systems, A42.1	altitude effects, R27.1, 3	air contaminants
draw-through, S4.3	animals, R27.2	ammonia, A24.2, 9
economizers, S4.7	commodity requirements, R27.2	carbon dioxide, A24.2
fans, S4.4, 6, 9	design considerations, R27.2	air distribution, A24.3, 6
filter, S4.8	galley refrigeration, R27.5	air inlets, A24.6
heating, S4.5	ground handling, R27.4	air quality control, A24.2
humidification, S4.5, 9	perishable cargo, R27.1	air transport, R27.2
location, S4.4	refrigeration, R27.3	cattle, beef and dairy, A24.7
mixing plenum, S4.7	shipping containers, R27.3	cooling, A24.4
psychrometrics, S4.4	Air washers	design, A24.1
reheat, S4.9	air cleaning, S41.9	disease control, A24.3
sequencing, A42.42	coolers, S41.7	evaporative cooling, A24.4; A52.14
set point reset, A42.43	dehumidification performance factor, S41.8	fans, A24.6
sound levels, A48.8	heat and mass transfer, simultaneous, F6.12	heating, A24.4
strategies, A42.42	humidification, S41.8	hydrogen sulfide, A24.2
unitary, air conditioners, S49.8	maintenance, S41.9	insulation, A24.5
vibration isolation, S4.10	spray, S41.7	laboratory conditions, A16.14; A24.9
Air inlets	textile processing plants, A21.4	moisture control, A24.2
applications, S20.7	water treatment, A49.18; S41.9	particulate matter (PM), A24.2
types, S20.7	Algae, control, A49.11	poultry, A24.8
Air intakes	All-air systems	shades, A24.3
design, A45.1 hospitals, A8.3	advantages, S4.1 air distribution, S4.10	swine, A24.7

ventilation, A24.5	kitchen ventilation systems, A33.2	burners, S31.1
Annual fuel utilization efficiency (AFUE),	refrigeration systems, R5.1	burner types, S32.7
S34.2	steam distribution systems, A38.15	carbonic acid, S11.2
Antifreeze	temperature controls, A38.16	central
coolants, secondary, F31.4	variable-air-volume (VAV) systems, A38.4	multifamily, A1.7
ethylene glycol, F31.4	BAS. See Building automation systems	classifications, S32.1
hydronic systems, S13.24	(BAS)	codes, S32.6
propylene glycol, F31.4	Baseboard units	combination, S32.4
Antisweat heaters (ASH), R15.5	application, S36.5	condensing, S32.3
Apartment buildings	design, S36.3	construction materials, S32.1
service water heating, A50.11, 18	finned-tube, S36.2	controls, A42.39; A47.1; S32.7
ventilation, A1.8	nonstandard condition corrections, S36.3	flame safeguard, S32.8
Aquifers, thermal storage, S51.7	radiant, S36.2	draft types, S32.3
Archimedes number, F20.6	rating, S36.3	dry-base, S32.2
Archives. See Museums, galleries, archives,	Basements	efficiency, S32.6
and libraries	conditioned, A44.11	electric, S32.5
Arenas	heat loss, F17.11; F18.35	equipment, S3.5
air conditioning, A5.4	heat transfer, F27.2	gas-fired, S31.5, 11
smoke control, A53.16	moisture control, A44.11	venting, S35.20
Argon, recovery, R47.17	unconditioned, A44.11	integrated, \$32.4
Asbestos, F10.5	Bayesian analysis, F19.37	modeling, F19.21
ASH. See Antisweat heaters (ASH)	Beer's law, F4.16	noncondensing, S32.3
Atriums	BEMP. See Building energy modeling	oil-fired venting, S35.21
air conditioning, A5.9	professional (BEMP)	piping, \$11.3
smoke control, A53.16	Bernoulli equation, F21.1	rating, S32.6
Attics, unconditioned, F27.2	generalized, F3.2, 6	residential, A1.3 scotch marine, S32.3
Auditoriums, A5.3 Automated fault detection and diagnostics	kinetic energy factor, F3.2 steady flow, F3.12	selection, S32.5
(AFDD), A39.5; A61.1	wind velocity pressure, F24.4	service water heating, A50.25
benefits, A61.3, 5	Best efficiency point (BEP), \$44.8	sizing, S32.6
controller-embedded, A61.4	Beverages, R39	standards, S32.6
detection, A61.1, 5	beer, R39.1	steam, S32.1
diagnosis, A61.1	storage requirements, R21.11	systems, S11.3
evaluation, A61.2	carbonated, R39.10	stokers, S31.17
methods, A61.2	coolers, R39.10	venting, S35.20, 21
tools, A61.4	fruit juice, R38.1	wall-hung, S32.4
Automobiles	liquid carbon dioxide storage, R39.12	waste heat, S11.3
engine test facilities, A17.1	refrigeration systems, R39.11	water, S32.1
HVAC, A10	refrigerators for, R16.2	water treatment, A49.15
design factors, A10.1	thermal properties, R19.1	blowdown, A49.17
subsystems, A10.3	time calculations	wet-base, S32.2
Autopsy rooms , A8.9; A9.6, 7	cooling, R20.1	wet-leg, S32.2
Avogadro's law, and fuel combustion, F28.11	freezing, R20.7	working pressure, S32.1
Backflow-prevention devices, S47.14	wine	Boiling
BACnet [®] , A40.18; F7.18	production, R39.8	critical heat flux, F5.4
Bacteria	storage temperature, R39.10	evaporators
control, A49.11	BIM. See Building information modeling	flow mechanics, F5.4
food, growth in, R22.1	(BIM)	heat transfer, F5.6
humidifiers, growth in, S22.1	Bioaerosols	film, F5.2
pathogens, F10.8	airborne	natural convection systems, F5.1
Bakery products, R41	bacteria, F11.2, 6	nucleate, F5.1, 2
air conditioning, R41.1	fungus spores, F11.2	pool, F5.1
bread, R41	microbiological particulate, F11.6	Brake horsepower, S44.8
cooling, R41.4	mold, F11.7	Brayton cycle
dough production, R41.2	pollen, F11.2	cryogenics, R47.11
freezing, R41.5	sampling, F11.7	gas turbine, S7.19
ingredient storage, R41.1	testing, F11.8	Bread, R41
refrigeration, R16.2; R41.1 slicing, R41.5	viruses, F11.2 origins, F11.1	Breweries carbon dioxide production, R39.6
wrapping, R41.5	•	*
Balance point, heat pumps, \$49.9	particles, F10.5 Biocides , control, A49.13	refrigeration fermenting cellar, R39.4
Balancing. (See also Testing, adjusting, and	Biodiesel, F28.8	Kraeusen cellar, R39.4
balancing)	Biological safety cabinets, A16.5	stock cellar, R39.5
air distribution systems, A38.3	Biomanufacturing cleanrooms, A18.9	systems, R39.8
dual-duct systems, A38.4	Bioterrorism. See Chemical, biological, radio-	wort cooler, R39.3
HVAC systems, A38.1	logical, and explosive (CBRE) incidents	storage tanks, R39.6
hydronic systems, A38.6	Boilers, F19.21; S32	vinegar production, R39.8
induction systems, A38.6	air supply, S35.28	Brines. See Coolants, secondary

Building automation systems (BAS), A40.18;	vapor	operation areas, A15.24
A61.1; F7.14	barrier, continuous, A44.5	platforms, A15.24
Building energy modeling professional	diffusion control, A44.2	Butane, commercial, F28.5
(BEMP), F19.5 Building energy monitoring, A41. (See also	retarder (vapor barrier), A44.2 wall/window interface, A44.6	CAD. See Computer-aided design (CAD)
Energy, monitoring)	walls, A44.9	Cafeterias, service water heating, A50.11, 21
Building envelopes	curtain, A44.9	Calcium chloride brines, F31.1
air barrier, A44.1	precast concrete panels, A44.9	Candy
requirements, A44.5	steel-stud, A44.10	chocolate, R42.1
air intrusion, A44.2	water-resistive barrier (WRB), A44.2	manufacture, R42.1
air leakage control, A44.4	wind washing, A44.2	storage, R42.6
attics, A44.8	zone method, A44.4	Capillary action, and moisture flow, F25.10
bound water, A44.2	Building information modeling (BIM) , A40.15	Capillary tubes
building assembly, A44.1	Building materials, properties, F26	capacity balance, R11.25
building enclosure, A44.1	Buildings	characteristic curve, R11.25
component, A44.1	air barrier, A62.6	pressure-reducing device, R11.24
condensation, A44.1; S22.3 convective loop, A44.2	airtight duct connections, A62.9	restrictor orifice, S23.2 selection, R11.27
driving rain load, F25.4	damp, A62.1 human health, A62.1	Carbon dioxide
dropped ceiling, A44.7	dampness risk, A62.3	in aircraft cabins, A12.14
durability, A44.1	dew point, A62.8	in animal environments, A24.2
energy conservation, A44.1	drainage plane, A62.6	combustion, F28.1, 13
exfiltration, A44.2	flashing, A62.6	greenhouse enrichment, A24.14
existing buildings	moisture, A62.2	liquefaction, R39.7
changing HVAC equipment in,	content, A62.11	measurement, F37.25
A44.11	risk, A62.3	refrigerant, R3.1
envelope modifications in, A44.12	mold, A62.1	storage, R39.12
face-sealed systems, A44.9	mold-resistant gypsum board, A62.7	Carbon emissions, F34.7
fenestration, A44.2	positive pressure, A62.9	Carbon monoxide
foundations, A44.11 heat transfer through, A44.11	problems causes, A62.1	analyzers, A15.10, 11 health effects, F10.15
moisture effects, A44.11	dampness A62.1	parking garages, A15.19, 20
historic buildings, A44.11	roof overhang, A62.7	road tunnels, A15.9
hygrothermal design analysis, A44.2	sill pans, A62.6	tollbooths, A15.27
infiltration, A44.2	vinyl wall covering, A62.7	Cargo containers, R25
insulation, F26.1	water barrier, A62.6	airborne sound, R25.8
interstitial spaces, A44.7	Building thermal mass	air circulation, R25.3
interzonal environmental loads, A44.7	charging and discharging, S51.20	ambient design factors, R25.7
material properties, F26	effects of, S51.19	commodity precooling, R25.11
moisture content, A44.2	precooling, A42.44	control, R25.6, 12
moisture control, A44.5	Burners	controlled atmosphere, R25.6
museums, galleries, archives, and libraries, A23.13	air supply, S35.28 controls, S31.20	costs, owning and operating, R25.11 design, R25.1
plenum, A44.2	conversion, S31.4, 6	equipment
return air, A44.7	dual-fuel gas/oil, S31.14	attachment provisions, R25.3
rain screen designs, A44.9	gas-fired, S31.3	design and selection factors, R25.7, 9
roofs, A44.8	altitude compensation, S31.10	operating efficiency, R25.8
insulated sloped assemblies, A44.8	combustion and adjustments, S31.20	qualification testing, R25.9
low-slope assemblies, A44.8	commercial, S31.6	selection, R25.10
steep-roof assemblies, A44.8	industrial, S31.6	system application factors, R25.9
vegetated roofing, A44.8	residential, S31.5	types, R25.3
R-value, A44.2	venting, S35.20	heating only, R25.6
clear-wall, A44.4	oil-fired, S31.11	insulation barrier, R25.1
material, A44.2 system, A44.2	commercial, S31.12 fuel handling, S31.15	load calculations, R25.10 maintenance, R25.12
total, A44.2	industrial, S31.12	mechanical cooling and heating, R25.3
sorption, A44.2	residential, S31.11	operations, R25.11
structural failure, from moisture, F25.16	venting, S35.21	qualification testing, R25.9
surface condensation, A44.7	venting, S35.20, 21	safety, R25.8
terminology, A44.1	Buses	sanitation, R25.3
thermal	air conditioning, A11.2	shock and vibration, R25.7
break, A44.2	garage ventilation, A15.22	space considerations, R25.12
bridges, A44.2; F25.8	Bus terminals	system application, R25.9
insulation, A44.2	air conditioning, A3.7	temperature-controlled transport, R25.1
mass, A44.4	physical configuration, A15.24	temperature settings, R25.11
performance, A44.4	ventilation	use, R25.11
transmittance, A44.2 U-factor (thermal transmittance), A44.2; F25.7	effects of alternative fuel use, A15.26 equipment, A15.33	vapor barrier, R25.1 ventilation, R25.6, 12
ο - ιωτιοι (ιποιτιιαι ιταποππιαπου), Δ 11 .2, Γ23./	equipment, A15.55	vontilation, 1825.0, 12

Carnot refrigeration cycle, F2.6	refrigeration	maintenance, S43.5, 12, 15
Cattle, beef and dairy, A24.7. (See also Animal	compressors, R46.6	marine water boxes, S43.3
environments)	condensers, R46.6	noise generation, A48.15; S43.10
CAV. See Constant air volume (CAV)	cooling towers, R46.8	optimization, A47.5
Cavitation, F3.13	equipment, R46.3, 6	prerotation vanes, S43.4, 9
pumps, centrifugal, S44.10	evaporators, R46.7	reciprocating
valves, S47.2	load, R46.2	components, S43.5
CBRE. See Chemical, biological, radiological,	safety requirements, R46.2	control, S43.6
and explosive (CBRE) incidents	spray ponds, R46.8	equipment, S43.5
CEER. See Combined energy efficiency ratio	systems, R46.1, 5	performance, S43.6
(CEER)	safety requirements, R46.2	refrigerant selection, S43.6
Ceiling effect. See Coanda effect	specifications, R46.1	selection methods, S43.6
Ceilings	tanks, R46.8	refrigeration cycle, S43.1
natural ventilation, F16.13	Chemisorption, A46.9	screw
sound correction, A48.31	Chilled beams, S20.10	applications, S43.15
sound transmission, A48.38	Chilled water (CW)	capacity control, S43.14
Central air conditioning, A42. (See also Air	combined heat and power (CHP) distribution,	components, \$43.13
conditioning)	S7.44	equipment, S43.13
Central plants	district heating and cooling, S12.9, 27	maintenance, S43.15
chiller, S12.2	optimal temperature, A42.12	performance, S43.14
cooling and heating, S3.1	pumping system, A42.13, 24	selection methods, S43.3, 6, 10
distribution design, S12.11	pump sequencing, A42.12, 15	sequencing, A42.15, 19
district heating and cooling, S12.8	reset, A42.12, 13	standards, S43.4
emission control, S12.11	systems, S13.1, 18	subcooling, S43.1
heating medium, S12.8	central plant, A38.14	and turbines, S8.5
hotels and motels, A6.8	heat transfer vs. flow, A38.7	variable-flow, S43.2
thermal storage, S12.10	one-pipe, S13.19	variable-speed, S43.4, 9
Central systems	testing, adjusting, balancing, A38.8	vibration control, S43.10
cooling and heating, S3.1	two-pipe, S13.20	walk-in, R16.4
features, S1.4	thermal storage, S51.4	Chilton-Colburn <i>j</i> -factor analogy, F6.7
furnaces, S33.1	water treatment, A49.18	Chimneys, S35
humidifiers, S22.6	Chillers	accessories, S35.30
residential forced air, \$10.1	absorption, S3.5	capacity calculation examples, \$35.14
space requirements, \$1.6	ammonia/water, R18.7	caps, S35.33
in tall buildings, A4.14	heat-activated, \$7.38	codes, \$35.35
acoustical considerations, A4.17	water/lithium bromide, R18.2	design equations, S35.3
economic considerations, A4.14	blast, R16.3	draft, S35.1
location, A4.16	central plants, A47.4; S12.2	altitude effects, \$35.7, 32
ventilation, with in-room terminal systems, \$5.3	centrifugal	available, S35.1, 3
Cetane number, engine fuels, F28.9	air-cooled, \$43.12	theoretical, S35.2, 3
CFD. See Computational fluid dynamics (CFD)	controls, \$43.10	fireplace, S35.1, 23 flue gas, S35.1
Change-point regression models, F19.28	equipment, S43.7 fouling, S43.10	functions, S35.1
Charge minimization, R1.36	free cooling, \$43.11	gas, appliance venting, S35.20
Charging, refrigeration systems, R8.4	hot-gas bypass, S43.9	masonry, S35.20, 22
Chemical, biological, radiological, and	maintenance, S43.12	materials, S35.28
explosive (CBRE) incidents, A59	purge units, \$43.11	standards, \$35.28
biological events, A59.9	rating, S43.10	terminations, S35.33
building envelope as protection, F16.11, 20	refrigerant	wind effects, S35.3, 33
chemical agent types, A59.6	selection, S43.8	Chlorinated polyvinyl chloride (CPVC), A34.6
gases and vapors, A59.8	transfer units, S43.11	Chocolate, R42.1. (See also Candy)
incapacitating, A59.7	selection methods, \$43.10	Choking, F3.13
irritants, A59.7	temperature lift, S43.9	CHP systems. See Combined heat and power
toxic, A59.7	control, A47.4	(CHP)
chemical events, A59.6	capacity, S43.3, 14	Cinemas, A5.3
commissioning, A59.6	considerations, S43.10	CKV. See Commercial kitchen ventilation
explosive events, A59.11	regulating, S43.4	(CVK)
design considerations, A59.11	safety, S43.4	Claude cycle, R47.8
loading description, A59.11	costs, S43.3	Cleanrooms. See Clean spaces
radiological events, A59.10	direct expansion, R1.22; S43.1	Clean spaces, A18
Chemical plants	economizing, S43.1	aerospace, A18.17
automation, R46.3	expansion turbines, S43.1	air filters, A18.3, 12, 17
energy recovery, R46.4	flash, S43.1	airflow, A18.4, 5, 17, 18
flow sheets, R46.1	heat recovery, S43.11	applications, A18.2
instrumentation and controls, R46.8	injection, S43.1	biomanufacturing, A18.9
outdoor construction, R46.4	liquid-chilling systems, S43	construction, A18.24
piping, R46.8	liquid heads, S43.3	contaminant control, A18.3, 12
pumps, R46.8	load distribution, A42.16	cooling, A18.19

energy conservation, A18.22	duct construction, S19.1	Combined energy efficiency ratio (CEER),
fire safety, A18.20	electrical, A56.15	S50.3
high-bay, A18.17	furnaces, S33.9	Combined heat and power (CHP), S7
humidity control, A18.20	makeup air units, S28.9	economic feasibility,
makeup air, A18.19, 23	motors, S45.2	load duration curve, S7.51
noise control, A18.24	nuclear facilities, A28.12	simulation, S7.53
operation, A18.24	piping, S46.6	electrical systems, S7.43
particle sources, A18.3	tall buildings, A4.20	utility interface, S7.43
pharmaceutical	Coefficient of performance (COP)	expansion engines/turbines, S7.31
aseptic, A18.10	absorption, F2.14	heat-activated chillers, S7.38
biomanufacturing, A18.9	compressors, S38.2	heat recovery
contaminant control, A18.12	refrigeration, F2.3, 14	engines, S7.32, 33
control and monitoring, A18.14	room air conditioners, S50.3	turbines, S7.37
design, A18.11	Coefficient of variance of the root mean square	load profiling, S7.4
isolators, A18.13	error [CV(RMSE)], F19.33	maintenance, S7.17
nonaseptic, A18.14	Cogeneration. See Combined heat and power	modular systems, \$7.3
unidirectional hoods, A18.13	(CHP)	packaged systems, S7.3
pressurization, A18.20	Coils	peak shaving, S7.4
process exhaust, A18.19, 23	air-cooling, S4.8	prime movers
semiconductor, A18.17	airflow resistance, \$23.6	fuel cells, S7.22
start-up, A18.14	applications, S23.1, 4	selection, S7.4
system sizing and redundancy, A18.21	aqueous glycol coils, S23.2	thermal output, S7.32
temperature control, A18.20	construction and arrangement, S23.1	turbines
terminology, A18.1	control, A47.7; S23.3	combustion, S7.18, 45
testing, A18.9	direct-expansion coils, \$23.2	steam, \$7.24, 46
vibration control, A18.24	fluid flow arrangement, S23.3	thermal energy storage, \$7.39
Clear-sky solar radiation, calculation, F14.8	heat transfer, \$23.6	utility interface, electric, \$7.43
Climate change	load determination, \$23.14	utilization systems
and design conditions, F14.15	maintenance, \$23.15	air, S7.42
and refrigerants, F29.1	performance, S23.7	district heating and cooling, S7.43
Climatic design information, F14	rating, S23.6	hydronic, \$7.42
annual design conditions, F14.1	refrigerant coils, \$23.2	service hot water, \$7.43
calculation of, F14.5 changes in, F14.6	selection, S23.5 on ships, A13.4	vibration control, foundations, S7.16 Combustion, F28
climate change's effect on, F14.15	water coils, \$23.2	air pollution, F28.17
cooling, F14.7	air-heating, S27.1	air required for, F28.11
data sources, F14.3	aqueous glycol, S27.2	altitude compensation, F28.3; S7.9, 10, 19;
heating, F14.7	construction, S27.1	S31.10
monthly design conditions, F14.2	design, S27.1	calculations
precipitation, F14.2	electric, A47.3; S27.3	air required for, F28.11
return period of extremes, F14.7	installation, S27.4	carbon dioxide, theoretical, F28.13
uncertainties in design data, F14.13	maintenance, S27.5	efficiency, F28.15
Clinics, A8.14	rating, S27.3	flue gas, F28.11
Clothing	refrigerant, S27.3	coals
insulation, clo units, F9.8	selection, S27.3	classification, F28.10
moisture permeability, F9.8	shipboard, A13.4	heating value, F28.10
CLTD/CLF. See Cooling load temperature	steam, S27.1	types, F28.10
differential method with solar cooling load	water, S15.6; S27.2	condensation in, F28.18
factors (CLTD/CLF)	altitude effects, S23.5, 6	continuous, F28.2
Coal	condensers, S39	corrosion in, F28.18
classification, F28.10	evaporative, S39.15	diesel fuel, F28.9
handling facilities, A27.5, 10	cooling, F19.20	efficiency, F28.15
heating value, F28.10	dehumidifying, S23.1	engine fuels, cetane number, F28.9
stokers, S31.17	desuperheating, S39.17	excess air, F28.12
types, F28.10	energy recovery loops, S26.11	flammability limits F28.1
Coanda effect, A33.17; F20.2, 7; S20.2	halocarbon refrigeration systems, R1.22	flue gas, F28.1, 2, 11, 16, 19
Codes, F40. (See also Standards)	heat and mass transfer, simultaneous,	fuel oils, F28.7
air conditioners, room, S50.4	F6.13	gaseous fuels
air distribution, A57.1	heat reclaim, S27.3	illuminants, F28.12
boilers, S32.6	preheat, S4.8	liquefied petroleum gas, F28.5
building codes, S19.1	reheat, S4.9; S27.2	natural gas, F28.5
chilled-beam system, A57.19	Colburn's analogy, F4.17	types and properties, F28.5
chimneys, fireplaces, and gas vents, S35.34	Colebrook equation	gas turbine fuel, F28.9
condensers, S39	friction factor, F21.6	heating value, F28.3
evaporative, S39.19	pressure drop, F22.5	ignition temperature, F28.2
water-cooled, S39.7	Collectors, solar , A35.6, 11, 24, 25; S37.3	illuminants, F28.12
coolers, liquid, S42.4	(See also Solar energy)	liquid fuels, F28.7
dehumidifiers, room, S25.4	Colleges and universities, A7.11	engines, F28.9

noise, F28.19	design concepts, A3.3	crankcase, R1.34
oscillation, F28.19	ducts, S19	rotary, S38.12
pollution, F28.17	furnaces, S33.5	screw, S7.45
principles, F28.1	general design considerations, A3.1	single, S38.15
pulse, F28.2	humidifiers, S22.6	twin, S38.20
reactions, F28.1	ice rinks, R44	scroll, S38.24
resonance, F28.19	kitchen ventilation, A33.1	trochoidal (Wankel), S38.29
solid fuels, F28.9	load characteristics, A3.2	Computational fluid dynamics (CFD), F13.1,
		•
soot, F28.20	malls, A2.7	F19.25
sound, F28.19	materials, \$19.10	assessing predictions, F13.11
stoichiometric, F28.1	office buildings, A3.1	boundary conditions for
types, F28.1	retail facilities, A2.1	inlet, F13.6
Combustion air systems	service water heating, A50.13	outlet, F13.7
air required, S35.28	transportation centers, A3.6	reporting, F13.13
analysis, F37.35	warehouses, A3.8	sources/sinks, F13.8
burners	Commercial kitchen ventilation (CKV), A33	surfaces, F13.7, 8
gas, S31.20	Commissioning, A43	walls, F13.7
•	<u>o</u> .	
oil, S31.11	acceptance, A43.8	considerations, F13.9
control, \$31.2	basis of design (BOD), A43.2, 5	grids, F13.4
efficiency boilers, S32.6	certification, A43.13	mathematical approaches, F13.1
industrial exhaust gas cleaning, S30.26	checklist, A43.2, 9	meshing, F13.4
venting, S35.1	construction, A43.6	reporting, F13.9, 13
Combustion turbine inlet cooling (CTIC),	control systems, F7.19	steps, F13.9
S7.21; S8.1	costs, A43.12	turbulence modeling, F13.3
thermal storage, S51.23	desiccant dehumidifiers, S24.9	validation, F13.9, 10
Comfort. (See also Physiological principles,	design, A43.5; A47.21	verification, F13.9
	•	
humans)	design review, A43.7	viscosity modeling, F13.10
environmental indices, F9.21	existing buildings, A43.1, 13	Computer-aided design (CAD), A18.5; A40.15
environmental parameters	humidifiers, S22.15	Computers, A40
air velocity, F37.31	in integrated building design, A58.8	abbreviations for programming, F38.1
asymmetric thermal radiation, F9.14	issues log, A43.9	BACnet®, A40.18; F7.18
draft, F9.15	laboratories, A16.20	building automation systems (BAS), A40.18
floor temperature, F9.16	makeup air units, S28.9	computational fluid dynamics, A15.3; A40.14
radiant temperature, F9.12	new construction, A43.1	A53.22
vertical air temperature difference, F9.15	objectives, A43.2	computer-aided design (CAD), A18.5; A40.1:
humidity, F25.16; F37.32	occupancy and operations, A43.11	for control, F7.4, 11, 21
•	1 2 1	
local discomfort, F9.14	owner's project requirements (OPR), A43.2	design tools
models	predesign, A43.5	acoustic calculations, A40.12
adaptive, F9.20	pumps, centrifugal, S44.15	building information modeling (BIM),
multisegment, F9.20	recommissioning, A43.1, 11	A40.15
two-node, F9.18	retrocommissioning, A43.1	combined heat and power (CHP), S7.54
nonuniform conditions, F9.14	steam systems, S11.16	computational fluid dynamics, A40.14
predicted mean vote (PMV), F9.18; F37.32	systems manual, A43.2, 7, 11	computer-aided design (CAD), A40.15
predicted percent dissatisfied (PPD), F9.18	team, A43.3	duct design, A40.10
	test procedures, A43.9	© ,
productivity, F9.14	1 ,	equipment selection and simulation, A40.12
radiant heating, A54.3	Comprehensive room transfer function	load calculations, A40.9
special environments	method (CRTF), F19.11	piping design, A40.11
extreme cold, F9.27	Compressors, S38	refrigerant properties, A40.17
hot and humid environments, F9.26	air conditioners, room, S50.2	smoke control analysis, A53.7, 22
infrared heating, F9.23	ammonia refrigeration systems, R2.1	ventilation, A40.17
personal environmental control (PEC)	bearings	road tunnel, A15.3
systems, F9.26	centrifugal, S38.36	equipment, A40.12
radiant heating, comfort equations, F9.25	reciprocating, S38.8, 10	graphics, A40.15
steady-state energy balance, F9.17	rotary, S38.13	hardware, A40.1
multisegment models, F9.20	•	
,	single-screw, S38.15	heat gain, F18.12
two-node model, F9.18	twin-screw, S38.21	HVAC simulation, A40.13
task performance, F9.14	centrifugal, S7.45; S38.30	Internet, A40.7
thermal sensation scale, F9.12	chemical industry refrigeration, R46.6	modeling, F7.21
zones, F9.20; F10.16	drives, R2.1	monitoring and control, A40.17
Commercial and public buildings, A3	dynamic, S38.1	networking components, A40.5
air leakage, F16.26	engine-driven, S7.45	peripherals, A40.5
airports, A3.6	halocarbon refrigeration systems, R1.20	smoke control analysis, A53.7, 22
burners	heat pump systems, \$9.5	software, A40.2
	1 1 2	
gas, S31.3, 6	motors, S38.6; S45.5	antispyware, A40.2
oil, S31.12	noise generation, A48.15; S38.5, 34	custom programming, A40.4
bus terminals, A3.7	operation and maintenance, S38.40	development tools, A40.4
central cooling systems, A42.1	positive-displacement, S38.2	energy analysis, F19.5
cruise terminals, A3.6	reciprocating, S7.45; S38.7	firewall, A40.2

graphics, A40.3	pressure control, R1.33	volatile organic compounds (VOCs),
HVAC, A40.9	water, R1.33	F10.9, 11; F11.14
readymade, A40.4	retail food store refrigeration, R15.17	total (TVOCs), F11.14
road tunnel, A15.3	water-cooled, S39.1	indoor, concentration prediction, F13.16
terminology, A40.2	codes, S39.7	organism destruction, R22.4
utilities, A40.2, 16	Darcy-Weisbach equation, S39.5	particulate
supervisory control, A40.17	fouling factor, S39.4	aerosols, S29.1
World Wide Web, A40.8	heat removal, S14.1; S39.1	asbestos, F10.5
Concert halls, A5.4	heat transfer, S39.2	classification, F11.1
Concrete	liquid subcooling, S39.5	coarse, F11.3
cooling, R45.1	maintenance, S39.8	collection mechanisms, S29.2; S30.10, 15
pozzolanic admixtures, R45.1	noncondensable gases, S39.7	combustion, F28.17
selection, R45.1	pressure drop, S39.4	dusts, F11.20; S29.1
thermal design, R45.4	standards, S39.7	environmental tobacco smoke (ETS), F11.2
water heating for, A50.25	types, S39.5	fine, F11.3
Condensate	water circuiting, S39.5	fogs, F11.1, 4
steam systems, F22.34; S11.6; S12.14, 27	Conductance, thermal, F4.3; F25.1	fumes, F11.1
water treatment, A49.17	Conduction	measurement, F37.35
Condensation	display cases, R15.5	mists, F11.1, 4
in building components, F25.15	steady-state, F4.3	pollen, F11.7
in combustion systems, F28.18	thermal, F4.1, 3	polycyclic aromatic compounds (PACs),
concealed, \$22.3	Conductivity, thermal, F25.1; F26.1	F10.6
control, with insulation, F23.3	apparent, F25.1; F26.1	radioactive, F11.21
dew-point analysis, F25.14	of thermal insulation, F26.1	size distribution, F11.4
energy recovery equipment, \$26.7	foods, R19.9	smogs, F11.1, 4
interstitial, and drying, F25.15	soils, F26.13	smokes, F11.1
oil-fired appliances, S35.21	Constant air volume (CAV)	suspended particles, counters, F11.6 synthetic vitreous fibers, F10.6
prevention, dehumidification for, S24.11	control, A42.2	•
surface, F25.2, 14	supply air temperature reset, A42.43 versus variable air volume (VAV), A16.11	ultrafine, F11.3
visible, S22.3 Condensers, S39	Constant-volume, all-air systems	refrigerant systems, R7.1 dirt, R7.6
air conditioners, room, S50.2	air terminal units, S4.16	field assembly, R7.8
air-cooled, R15.17; S39.8, 11		filter-driers, R7.6
air-cooled, K13.17, S39.8, 11 airflow, S39.9	dual-duct, S4.12 single-duct, S4.11	generation by high temperature, R6.5
control, S39.11	Construction. (See also Building envelopes)	lubricants, R7.7
fans, S39.9	curtain wall, F15.6	metallic, R7.6
heat transfer, S39.10	glass block wall, F15.32	moisture, R7.1
installation, S39.13	in integrated building design, A58.7, 8	motor burnout, R7.8, 8
machine room, R15.17	Containers. (See also Cargo containers)	noncondensable gases, R7.8
maintenance, S39.13	air transport, R27.3	residual cleaning agents, R7.7
noise, R15.18	marine transport, R19.2	sampling, R7.10
pressure drop, S39.10	Contaminants	sludge, tars, and wax, R7.7
rating, S39.11	clean spaces, A18.3, 12	solvents, R7.7
types, S39.8	food, R22.1	special system characteristics, R7.9
ammonia refrigeration systems, R2.5	gaseous	textile processing, A21.7
cascade, R5.1	combustion, F28.17; S30.26	Continuity, fluid dynamics, F3.2
chemical industry refrigeration, R46.6	concentration, indoor, measurement, A46.5	Control. (See also Controls, automatic;
in chillers, S43.5, 8, 13	control, S24.12; S30.18, 23, 26	Supervisory control)
evaporative, R15.18; S39.14	environmental tobacco smoke (ETS), F11.2	absorption units, R18.5, 9
airflow, S39.16	flammable, F11.20	aircraft cabin pressure, A12.11, 13
capacity control, S39.18	indoor air, F11.18	air-handling systems, A42.1, 42; A47.10
codes, S39.19	industrial, F11.17	all-air systems, S4.17
coils, S39.15	inorganic, F11.15	authority, F7.7
freeze prevention, S39.16	measurement, F11.12; F37.35	automobile air conditioning, A10.8
heat transfer, S39.14	microbial volatile organic compounds	boilers, A42.39; A47.1; S32.7
liquid subcoolers, S39.17	(MVOCs), F10.8	building automation systems (BASs), A47.1
location, S39.16	nuclear facilities, A28.3, 5, 8	building pressurization, A47.9
maintenance, S39.19	outdoor air, F11.16	burners, S31.19
multicircuiting with liquid coolers, S39.18	ozone, A46.15	bus terminal ventilation, A15.26
multiple-condenser installations, S39.16	polycyclic aromatic compounds (PACs),	central air conditioning, A42.1
purging, S39.19	F10.6	chemical plants, R46.3
rating, S39.17	radioactive, F11.21	chilled beams, A47.14
standards, S39.19	radon, A46.15; F10.22	chilled-water pumps, A42.12, 13, 24
water, S39.18	removal, A46.7	chillers, A42.16; A47.5
halocarbon refrigeration systems	semivolatile organic compounds (SVOCs),	combustion turbines, S7.21
air-cooled, R1.34	F10.4, 12; F11.15	components, F7.4
evaporative, R1.33	soil gases, F11.22	condensers
piping, R1.28	vapors, flammable, F11.20	air-cooled, S39.11

evaporative, S39.18	ship air conditioning	positive positioners, F7.8
cooling, S6.20	merchant, A13.3	proportional/integral (PI), F7.3
coils, A47.7; S23.3	naval surface, A13.4	proportional-integral-derivative (PID), F7.3
tower fans, A42.8, 12	smoke, A53.1	proportional-only (P), F7.3
towers, A47.6	snow-melting systems, A51.10	refrigerant flow, R11.1
corrosion, A49.6, 18	solar energy, A35.12, 25, 27; S37.17	safety, A47.18
dehumidifying coils, S23.3	differential temperature controller, S37.17	sensors, F7.9, 10; R11.4
demand-controlled ventilation (DCV), A47.11	hot-water dump, S37.19	location, A47.21
design principles	overtemperature protection, S37.18	static pressure, A47.9
controlled area size, A47.21	solid-state, A47.3	switches, R11.1
energy conservation, A47.19	sound, A48.1, 50; F8.15	systems, F7.1
load matching, A47.21	static pressure, and variable flow rates, A47.9	terminology, F7.1
sensor location, A47.21	steam coils, A47.3	testing, A38.16
system selection, A47.20	steam systems, S11.13	thermostats, F7.12
direct expansion (DX), A47.7	system selection, A47.20	transducers, pressure, R11.4
economizers, A47.2, 11	terminal units, A47.13	transmitters, F7.9
electric heating slabs, S6.20	thermal storage systems, A42.29; S51.29	tuning, F7.3, 19, 20
energy recovery equipment, S26.7, 10	unit heaters, S28.6	two-position, F7.2
engines, S7.15	unit ventilators, A47.16; S28.3	valves, F7.4
fans, A47.8; S21.12	variable-air-volume (VAV) systems, A42.1;	actuators, F7.6
air volume, S45.13	A47.8	flow characteristics, F7.5
fire, A53.1	ventilation reset control (VRC), A47.11	selection and sizing, F7.5, 6
fixed-guideway vehicle air conditioning,	vibration, A48.41	Convection
A11.8	zone systems, A47.17	flow, fully developed turbulent, F4.17
freezestat, A47.3	zone valves, S11.13	forced, F4.17
functional performance testing (FPT), A47.21	Controlled-atmosphere (CA) storage	evaporation in tubes, F5.4, 7, 12
fundamentals, F7	apples, R35.2	laminar, F4.17
furnaces, S33.2, 5	apricots, R35.13	transition region, F4.17
heaters, S34.2, 4	berries, R35.13	turbulent, F4.17
infrared, S16.4	cherries, sweet, R35.12	free, F4.19
heat exchangers, A47.2	figs, R35.13	mass, F6.5
heating coils, A47.2	grapes, R35.8	natural, F4.19, F5.1
heat pumps, A47.7; S49.11	nectarines, R35.12	steam heating systems, \$11.11
heat recovery systems, S9.22	peaches, R35.12	thermal, F4.1
heat timers, \$11.13	pears, R35.6, 7	Convectors
humidifiers, S22.12	plums, R35.11	application, S36.5
humidity, A47.15; S22.14; S24.1	refrigerated facilities, R23.3	design, S36.3
hydronic heating systems, S13.13; S15.6	strawberries, R35.13	heat-distributing unit, \$36.1
induction VAV terminals, A47.13	vegetables, R37.4	nonstandard condition corrections, \$36.3
justice facilities, A9.3	Controlled-environment rooms (CERs), and	rating, S36.3
laboratory systems, A16.11	plant growth, A24.16	Convention centers, A5.5
liquid chillers, \$43.3, 6, 10, 14	Controls, automatic, F7. (See also Control)	Conversion factors, F39
low-temperature, R2.15	actuator, F7.4	Cooking appliances
makeup air units, A47.17; S28.9	authority, F7.7	heat gain, F18.7
measurement and verification (M&V), A47.20	classification, F7.4	Coolants, secondary
morning warm-up, A47.12	closed loop (feedback), F7.1	brines
motors, S45.5, 6	commissioning, F7.19	corrosion inhibition, A49.20; F31.4 properties, F31.1
protection, S45.7 nuclear facilities, A28.5	components control devices, F7.4	calcium chloride solutions, F31.1
optimization, A42.1	controllers, A38.17; F7.11, 20 sensors, F7.9	d-limonene, F31.12
outdoor air quantity, A47.10 paper moisture content, A20.2	transducers, electronic-to-pneumatic (E/P),	ethyl alcohol solutions, F31.1
parking garage ventilation, A15.20	F7.13	halocarbons, F31.12
1 00 0	computers, A40.17; F7.4	inhibited glycols
performance monitoring, A47.6 photographic materials processing, A22.3	control action types, F7.2, 4, 19	corrosion inhibition, F31.5 ethylene glycol, F31.4
	• • • • • • • • • • • • • • • • • • • •	
pipe-tracing systems, A51.20 plant growth chambers, A24.17	dampers, F7.6 actuator mounting, F7.8	foaming, F31.4 propylene glycol, F31.4
pneumatic, A47.1, 16, 19	<u>e</u> ,	service considerations, F31.11
	actuators, F7.8	
pressurization, A47.4, S6.10	types, F7.7	unwanted impurities, F31.4
radiant panels, A47.4; S6.19 radioactivity, A28.8	direct digital (DDC), F7.4, 11, 20 explosive atmospheres, A47.19	low-temperature refrigeration, R48.10 nonhalocarbon nonaqueous fluids, F31.12
· · · · · · · · · · · · · · · · · · ·	- · · · · · · · · · · · · · · · · · · ·	•
rail car air conditioning, A11.7	extraordinary incidents, A47.19	polydimethylsiloxane, F31.12
refrigerant flow, R11.1 residential heating and cooling, A1.6	feedback (closed loop), F7.1	potassium formate solutions, F31.1 refrigeration systems, R13.1
9	fuzzy logic, F7.3	• •
return fan, A47.9, 12	mobile applications, A47.18	sodium chloride solutions, F31.1
road tunnel ventilation, A15.11 scale, A49.4	modeling, F19.23 modulating, F7.3	sodium nitrate and nitrite solutions, F31.1 Coolers. (See also Refrigerators)
sequence of operation, A47.19	open loop, F7.1	beverage, R39.10
sequence of operation, A+1.13	open 100p, 1 /.1	ocrotago, 1007.10

cryocoolers, R47.11	latent, F18.15	in boilers, A49.15
forced-circulation air, R14.1	heat sources, F18.3	cathodic protection, A49.10
installation and operation, R14.6	radiant time series (RTS) method, F18.2, 22	buried pipe, S12.34
liquid (See also Evaporators)	sol-air temperature, F18.24	in cooling towers, A49.11
Baudelot, S42.2	system effects, F18.41	coupons, A49.6, 11
brazed (semiwelded) plate, S42.2	total equivalent temperature differential	cycles of concentration, A49.10
in chillers, S43.5, 7, 8, 13	method with time averaging (TETD/TA),	in geothermal energy systems, A34.6
evaporative, with evaporative condensers,	F18.57	inhibitors, A49.10
S39.18	transfer function method (TFM), F18.57	materials selection, A49.10
flooded, S42.2	residential, F17	passivation, A49.11
freeze prevention, S42.5	heat balance (RHB) method, F17.2	protective coatings, A49.10
heat transfer, S42	load factor (RLF) method, F17.2	in steam and condensate systems, A49.17
coefficients, S42.3	space, F18.2	energy recovery equipment, S26.7
fouling factor, S42.4	Cooling load temperature differential method	galvanized metals, F31.12
maintenance, S42.6	with solar cooling load factors (CLTD/CLF),	glycol degradation, F31.5
oil return, S42.6	F18.57	inhibited glycols, F31.5
piping, R1.21, 22	Cooling towers, S40	under insulation, F23.7; R10.2
pressure drop, S42.4	approach to wet bulb, S40.1	of insulation jacketing, R10.6
refrigerant flow control, S42.5	capacity control, S40.11	microorganism influence, A49.7, 12
residential, A1.5	airflow, A42.9	oil-fired appliances, S35.22
shell-and-tube, S42.1	fan sequencing, A42.8	oxygen corrosion, A49.8, 18
tube-in-tube, S42.1	flow modulation, A42.27	secondary coolant systems, R13.5
vessel design requirements, S42.4	variable- vs. fixed-speed fans, A42.26	service water systems, A50.32
retail food store, R15.1	construction materials, \$40.8	tuberculation, A49.22
walk-in, R15.10; R16.4	design conditions, S40.2	types, A49.6
water, R39.10	drift, S40.14	white rust, A49.11
Cooling. (See also Air conditioning)	eliminators, \$40.14, 15	Costs. (See also Economics)
absorption equipment, R18.1	economics, S40.9	all-air systems, S4.3
animal environments, A24.4	fill, \$40.3	analysis period, A37.2
bakery products, R41.4 concrete	fogging, S40.14 free cooling, S40.13	economic analysis techniques computer analysis, A37.13
active systems, R45.5	freeze protection, S14.3; S40.13	inflation, A37.11
air blast, R45.2	heat and mass transfer, simultaneous, F6.13	internal rate of return, A37.12
chilled water, R45.1	hybrid, S40.2, 7	life-cycle cost analyses, A37.9
embedded coils, R45.1	indirect evaporative coolers, \$14.4; \$41.5	payback, A37.10
inundation, R45.2	inspections, S40.15	present value (worth), A37.10
passive, R45.4	Legionella pneumophila, S40.15, 16	savings-to-investment ratio (SIR), A37.11
controls, A42.8, S6.20	maintenance, S40.15	energy, A37.4, 9
foods and beverages, time calculations,	model, F19.22	financing alternatives, A37.8
R20.1	number of transfer units (NTU), S40.19	inflation, A37.11
fruits and vegetables	performance, S40.17	interest and discount rate, A37.4
evaporative, R28.8	piping, S14.2; S40.11	laboratory systems, A16.21
forced-air, R28.6	plumes, S40.14	life-cycle, A37.12
hydrocooling, R28.3	principle of operation, S40.1	energy recovery equipment, S26.12
load calculation, R28.1	recommissioning, A49.14	operation and maintenance, A39.1
package icing, R28.8	selection, S40.8	piping insulation, S12.25
vacuum cooling, R28.9	shutdown, A49.15	maintenance, A37.7
geothermal energy systems, A34.9	siting, S40.10	operating
greenhouses, A24.13	sound, attenuators, S40.14	actual, A37.4
radiant panel systems, S6.1	start-up, A49.14	electrical energy, A37.5
radiative, A35.16	testing, A38.16; S40.18	natural gas, A37.6
solar energy systems, A35.15, 18, 27	theory, S40.18	other fuels, A37.6
water systems, S13.1, 18	types, S3.5; S40.2	snow-melting systems, A51.8, 10
dynamometers, A17.4	open systems, S14.1	owning
Cooling load	water treatment, A49.11, 14, 18; S14.3; S40.16	initial cost, A37.1
calculations, F17; F18	start-up and shutdown, A49.14	insurance, A37.4
central plant, S3.2	winter operation, S40.13	taxes, A37.4
coil, F18.2	inspections, S40.16	periodic, A37.4
cooling load temperature differential method	Cool storage, S51.1	refrigerant phaseout, A37.8
with solar cooling load factors (CLTD/CLF),	COP. See Coefficient of performance (COP)	Cotton, drying, A25.8
F18.57	Corn, drying, A25.1	Courthouses, A9.5
nonresidential, F18	Correctional facilities. See Justice facilities	Courtrooms, A9.5
conduction transfer functions, F18.20	Corrosion	CPVC. See Chlorinated polyvinyl chloride
heat balance (HB) method, F18.2, 16	brines, F31.4	(CPVC)
heat gain	in combustion systems, F28.18	Crawlspaces
fenestration, F18.16	concentration cell corrosion, A49.9	heat loss, F17.11
infiltration, F18.14	contributing factors, A49.8	insulation, A44.11
internal, F18.3	control, A49.6, 10, 18	vented vs. unvented, A44.11

wall insulation, A44.11	storage systems, R47.26	air-source heat pump coils, S9.7, 8; S49.10
Critical spaces	transfer systems, R47.27	ammonia liquid recirculation systems, R2.21
data centers, A42.8	Curtain walls, F15.6	household refrigerators and freezers, R17.5
forensic labs, A9.7	Cycloparaffins, R12.3	meat coolers, R30.2
health care, A8.1, 4, 5, A8.12	Dairy products, R33	retail food store refrigerators, R15.19
justice facilities, A9.4	aseptic packaging, R33.21	Degree-days, F14.12
Crops. See Farm crops	butter	method, F19.6
Cruise terminals, A3.6	manufacture, R33.6	bin, F19.8
Cryogenics, R47	refrigeration load, R33.9	cooling, F19.6
biomedical applications	buttermilk, R33.5	heating, F19.6
cryomicroscopy, R49.6	cheese	infiltration, F16.13
cryopreservation, R49.1	cheese room refrigeration, R33.13	modified bin, F19.8
cryoprotective agents, R49.2	manufacture, R33.10	variable base, F19.7
cryosurgery, R49.7	cream, R33.5	Dehumidification, A47.15; S24
induced hypothermia, R49.7	display refrigerators, R15.6	absorption, \$24.12
refrigeration, R49.1	ice cream	adsorption, S24.12
specimen preparation, R49.6	freezing, R33.17	air washers, S41.8
Brayton cycle, R47.11	hardening, R33.17	all-air systems, S4.6
cascade cycle, R47.8	milkfat content, R33.14	desiccant, S24.1
Claude cycle, R47.8	mix preparation, R33.15	applications, S24.1, 10
cryobiological, R49.8	refrigeration	capacity, \$24.2
cryocoolers	equipment, R33.19	equipment, S24.3
recuperative, R47.11	requirements, R33.16	high-pressure, S24.12
regenerative, R47.14	milk	liquid, F32.3
cryopumping, R47.1	dry, R33.23	solid, F32.4
equipment	evaporated, R33.22	evaporative cooling, A52.2; S41.8
coiled-tube exchanger, R47.21	fresh, R33.1	performance factor, S41.8
compressors, R47.20	sweetened condensed, R33.22	residential, A1.5
expansion devices, R47.20	thermal properties, R19.1	Dehumidifiers
heat exchangers, R47.21 regenerators, R47.23	UHT sterilization, R33.19 yogurt, R33.5	dedicated outdoor air system (DOAS), S18.2, 8; S25.4
systems, R47.20	Dampers	desiccant, S24
turboalternators, R47.21	air outlet, S20.5, 5, 7	capacity, S24.2
turboanternators, R47.21 turboexpanders, R47.21	controls, automatic, F7.6, 7	commissioning, S24.9
fluids	fire and smoke, A53.2	high-pressure, S24.12
cold burns, R47.28	opposed-blade, S4.7; S20.5, 7	liquid, S24.3
flammability, R47.29	outdoor air, A47.10	operation, S24.8
storage vessels, R47.26	parallel-blade, S4.8; S20.5, 7	rotary solid, S24.5
transfer, R47.27	return air, S4.7	solid, S24.4
freezers, industrial, R29.5	sound control, A48.13	ice rinks, S25.8
hazards, R47.28	vehicular facilities, enclosed, A15.35	indoor swimming pool, S25.6
Heylandt cycle, R47.8	vent, S35.31	industrial, S25.8
instrumentation, R47.27	Dampness problems in buildings, A62.1	installation, S25.9
insulation	Dams, concrete cooling, R45.1	mechanical, S25.1
low-temperature, R47.23	Darcy equation, F21.6	components, S25.1
selection (table), R47.26	Darcy-Weisbach equation	psychrometrics, S25.1
thermal conductivity (table), R47.24	ductwork sectional losses, F21.13	types, S25.3
isenthalpic expansion, R47.6	pressure drop, F3.7; F22.5	service, S25.9
isentropic expansion, R47.7	water-cooled condensers, S39.5	tunnel dryer, S25.9
Joule-Thomson cycle, R47.6	water systems, \$44.5	wraparound heat exchangers, \$25.10
Kleemenko cycle, R47.13	Data centers, A19	Dehydration
Linde cycle, R47.6	Data-driven modeling	of eggs, R34.12
liquefaction	black-box, F19.27	farm crops, A25.1
balanced flow condition, R47.6	empirical, F19.27	industrial systems for, A30.1
of gases, R47.6	examples, F19.33	refrigeration systems, R8.1
liquid-level sensors, R47.28	gray-box, F19.28	Density
mixed refrigerant cycle, R47.8	neural network, F19.33	fluids, F3.1
natural gas processing, R47.19	steady-state, F19.28	modeling, R19.6
properties	Daylighting, F19.26	Dental facilities, A8.14
electrical, R47.5	interior building illumination, F15.54	Desiccants , F32.1; S24.1
magnetic, R47.5	light transmittance, F15.56	absorption, S24.1
mechanical, R47.6	solar radiation, F15.1	adsorption, S24.1
thermal, R47.3	DDC. See Direct digital control (DDC)	cosorption of water vapor and air contaminants,
purification of gases, R47.19	Dedicated outdoor air system (DOAS), F36.12;	F32.5
recovery of gases, R47.17, 18	S4.14; S18.2, 8; S25.4	dehumidification, S24.1
separation of gases, Gibbs phase rule, R47.16	Definitions , of refrigeration terms, R50	isotherms, F32.5
staging, R47.15	Defrosting	life, F32.5
Stirling cycle, R47.14	air coolers, forced-circulation, R14.4	liquid, S24.2, 3, 4

materials, F32.1	energy transfer station, S12.37	flash, A30.7
refrigerant systems, R7.5	flow control, S12.44	fluidized-bed, A30.6
equilibrium curves, R7.4	indirect, with heat exchangers, \$12.42	freeze drying, A30.6
moisture, R7.3	steam, S12.27, 40	mechanism, A30.1
solid, S24.2, 4	temperature differential control, S12.45	microwave, A30.4
types	costs, A37.9	psychrometrics, A30.1
liquid absorbents, F32.3	distribution system	radiant infrared, A30.3
solid adsorbents, F32.4	aboveground systems, S12.26, 28	selection, A30.3
Design-day climatic data, F14.12	condensate drainage and return, S12.14, 27	superheated vapor, A30.6
Desorption isotherm, F26.20	conduits, S12.31, 33	tunnel, A30.5
Desuperheaters	constant-flow, S12.11	ultraviolet (UV), A30.3
air conditioners, unitary, S49.4	construction, S12.26	vacuum drying, A30.6
in ammonia refrigeration, R2.11	entry pits, S12.35	desiccant, high-pressure, S24.12
condensers, evaporative, S39.17	hydraulic design, S12.13	farm crops, A25.1
heat pumps, unitary, S49.4	insulation, pipe, S12.15, 25, 30	Drying
Dew point, A62.8	pipe, S12.13	air, S24.13
analysis, F27.8	thermal design conditions, S12.14	desiccant, high-pressure, S24.12, 13
method, F25.14	underground systems, S12.29	dew-point control, S24.13
Diamagnetism, and superconductivity, R47.5	valve vaults, S12.35	farm crops, A25.1
Diesel fuel, F28.9	variable-flow, S12.12	gases, S24.13
Diffusers, air, sound control, A48.12	water hammer, S12.13	DTW. See Dual-temperature water (DTW)
Diffusion	economics, S12.3	system
coefficient, F6.2	geothermal heating systems, A34.8	Dual-duct systems
eddy, F6.7	heating conversion to, S12.42	all-air systems, S4.12
moisture flow, F25.11	heat pumps, S9.25	control, A47.17
molecular, F6.1	heat transfer analysis, S12.15	terminal boxes, A47.14
space air, F20.1	ground to air, S12.17	testing, adjusting, balancing, A38.4
Diffusivity	pipes, S12.22	Dual-temperature water (DTW) system,
thermal, of foods, R19.17	single buried pipe, S12.17	S13.1
water vapor, F25.2	soil temperature calculation, S12.16	DuBois equation, F9.3
Dilution	two pipes buried, S12.21	Duct connections, A62.9
exhaust, F24.12	master planning, S12.2	Duct design
smoke, A53.5	metering, S12.45	air leakage, F21.15
ventilation, A31.2; A46.7	pressure losses, S12.13	all-air systems, S4.10
Dining halls, in justice facilities, A9.4	thermal storage; S12.10; S51.7, 23	commercial, small applications, S10.9
DIR. See Dispersive infrared (DIR)	water systems, S12.1	computer analysis, A40.10
Direct digital control (DDC), F7.4, 11	d-limonene, F31.12	Darcy-Weisbach equation, F21.13
Direct numerical simulation (DNS), turbulence	DNS. See Direct numerical simulation	design methods
modeling, F13.4; F24.13	(DNS)	equal friction, F21.23
Dirty bombs. See Chemical, biological, radio-	DOAS. See Dedicated outdoor air system	static regain, F21.23
logical, and explosive (CBRE) incidents	(DOAS)	design recommendations, F21.21
Discharge coefficients, in fluid flow, F3.9	Doors	duct fitting database, F21.12
Dispersive infrared (DIR), F7.10	air exchange, F16.28	duct shape selection, F21.19
Display cases, R15.2, 5	U-factors, F27.7	dynamic losses
District energy (DE), S12.1	Dormitories	duct fitting database, F21.12
costs, S12.3	air conditioning, A6.8	local loss coefficients, F21.8
economics, S12.5	design criteria, A6.1	fan-system interface, F21.13
final design, S12.4	energy systems, A6.1	fan system effect coefficients, F21.13
financial feasibility, S12.4	load characteristics, A6.1	friction losses, F21.6
flow control, S12.44	service water heating, A50.13, 17, 20	duct fitting database, F21.12
metering, S12.45	Draft	industrial exhaust systems, F21.29; S30.28
utility rates, S12.3	burners, S31.1, 14	louvers, F21.18
District heating and cooling (DHC), S12	chimney, S35.1	noise control, F21.24
applicability, S12.1	comfort affected by, F9.15	pressure, F21.2
central plants	cooling towers, S40.4, 5	residential, S10.7
boiler, S12.8	Drag , in fluid flow, F3.5	roughness factors, F21.6
chiller, A47.4; S12.2	Driers, R7.6. (See also Dryers)	security, F21.18
distribution design, S12.11	Drip station , steam systems, S12.14	stack effect, F21.2
emission control, S12.11	Dryers. (See also Driers)	system air leakage, F21.15
equipment, S12.8	commercial and industrial	testing and balancing, F21.21
heating medium, S12.8	adsorption, S24.12	Ducts
thermal storage, S12.10	agitated-bed, A30.6	acoustical lining, A48.21
combined heat and power (CHP), S7.43; S12.2	calculations, A30.2	in hospitals, A8.13
components, S12.1	conduction, A30.3	acoustical treatment, \$19.9
consumer interconnections	constant-moisture solvent, A30.7	airflow measurement in, A38.2
chilled water, S12.9, 27	convection, A30.4	antimicrobial, S19.10
components, S12.42	dielectric, A30.4	classifications (pressure), S19.1
direct connection, S12.37	drying time determination, A30.2	cleaning, S19.2

construction	Economic coefficient of performance (ECOP),	building electrical systems, A56.1
codes, S19.1	S7.2	codes, A56.15
commercial, S19.5	Economic performance degradation index	costs, A37.5, 9
industrial, S19.9	(EPDI), A61.3	emergency and standby power systems, A56.4
kitchen exhaust, S19.10	Economics. (See also Costs)	generation, on-site, A37.9
master specifications, S19.12	district heating and cooling, S12.3	grid, A61.8
outdoor ducts, S19.12	energy management planning, A36.1	imbalance, S45.1
residential, S19.5	evaporative cooling, A52.17, 18	measurement, F37.27
seismic qualification, S19.12	indoor gaseous contaminant removal, A46.15	motors, A56.5
sheet metal welding, S19.12	insulation thickness, pipe, S12.25	motor starting, A56.6; S45.8
standards, S19.1, 9	laboratory systems, A16.21	performance, A56.2
thermal insulation, S19.12	owning and operating costs, A37.1	power quality variations, A56.7
underground, S19.12	Economizers	principles, A56.2
desiccant dehumidifiers, S24.8	air-side, F16.19	safety, A56.1
efficiency testing, S10.10	compressors, single-screw, S38.16	smart grid, A61.7
fibrous glass, S19.8	control, A42.42	utility strategies, A61.9
flat oval, F21.8	humidification load calculation, S22.4	voltage, A56.1
flexible, F21.6	kitchen ventilation, A33.6	wiring, A56.2
flexible air connectors and, S19.8	water-side, S2.3	Electric thermal storage (ETS), S51.17
fluid flow, F3.1	ECOP. See Economic coefficient of	Electronic smoking devices ("e-cigarettes"),
forced-air systems, small, S10.2, 7	performance (ECOP)	F11.19
friction chart, F21.8	ECS. See Environmental control system (ECS)	Electrostatic precipitators, S29.7; S30.7
grease systems, S19.10	Eddy diffusivity, F6.7	Elevators
industrial, S19.1. (See also Industrial	Educational facilities, A7	smoke control, A53.5, 12
applications)	air conditioning, A7.1	in tall buildings, A4.2
industrial exhaust systems, A32.6	service water heating, A50.23	Emissions, pollution, F28.9
insulation, F23.15	EER. See Energy efficiency ratio (EER)	Emissivity, F4.2
insulation, thermal, S19.12	Effectiveness, heat transfer, F4.22	Emittance, thermal, F25.2
leakage, system, S19.2. (See also Leakage,	Effectiveness-NTU heat exchanger model,	Enclosed vehicular facilities, A15
HVAC air systems)	F19.19	Energy
moisture-laden vapor systems, S19.10	Effective radiant flux (ERF), A54.2	audit, A36.7
noise in, A48.12	Efficiency	balance
noncircular, F21.8	air conditioners	comfort, F9.2, 17
outdoor, S19.5	room, S50.3	refrigeration systems, R5.3
phenolic, S19.8	unitary, S49.6	conservation
•	boilers, S32.6	air conditioners, room, S50.3
plastic, rigid, S19.11 rectangular, F21.8; S19.10	combustion, F28.15	building envelopes, A44.1
road tunnels, A15.10		building supervisory control, A42.1
roughness factors, F21.6	compressors	clean spaces, A18.22
round, S19.10	centrifugal, S38.32 positive-displacement, S38.3	educational facilities, A7.1
sealing, A62.9; S19.2	reciprocating, S38.9, 10	farm crop drying, A25.3
	rotary, S38.13	greenhouses, A24.16
security concerns, A59.11 seismic, S19.12		hospitals, A8.13
	single-screw, S38.18 fins, F4.6	industrial environments, A31.6
ships, A13.3		
sound	furnaces, S33.9	infrared heaters, S16.1 kitchen ventilation, A33.4
attenuation, A48.18	heat pumps, unitary, \$49.6	· · · · · · · · · · · · · · · · · · ·
control, F8.13	industrial exhaust gas cleaning, S30.3	pumps, centrifugal, S44.15
underground, S19.12	infrared heaters, S16.4	refrigerators, commercial, R16.7
velocity measurement in, F37.18	motors, \$45.2	temperature and ventilation control, A47.19
vibration control, A48.52	pumps, centrifugal, S44.7	textile processing, A21.7
welding sheet metal, S19.12	refrigerating, F2.3	thermal insulation, F23.1
Dust mites, F25.16	Eggs, R34	consumption
Dusts, \$29.1	composition, R34.1	benchmarking, A36.6
synthetic, S29.3	dehydration, R34.12	building HVAC, control effect on, A42.25
Dynamometers, A17.1	processing plant sanitation, R34.13	emergency reduction, A36.15
Earth, stabilization, R45.3, 4	products, R34.9	gaseous contaminant removal, A46.15
Earthquakes, seismic-resistant design,	shell eggs	humidifiers, S22.3
A55.1	packaging, R34.8	United States, F34.7
Economic analysis, A37	processing, R34.5	world, F34.5
computer analysis, A37.13	refrigeration, R34.6	costs, A37.4
inflation, A37.11	spoilage prevention, R34.4	efficiency
internal rate of return, A37.12	storage, R34.8	in commercial and food service refrigerators,
life-cycle cost analyses, A37.9	structure, R34.1	R16.7
payback, A37.10	transportation, R34.8	and humidity, F25.16
improved, A37.10	storage, R34.1	ratio. See Energy efficiency ratio (EER)
simple, A37.10	thermal properties, R19.1	emergency use reduction, A36.15
present value (worth), A37.10	Electricity	estimating, F19
savings-to-investment ratio (SIR), A37.11	billing rates, A56.13	analysis, F19.5

forecasting, A42.36	Engines, S7	Evaporation, in tubes
general considerations, F19.1	air systems, compressed, S7.13	forced convection, F5.4, 7
integration of systems, F19.23	applications, S7.45	natural convection, F5.1
models, F19.1	continuous-duty standby, S7.4	Evaporative coolers. (See also Refrigerators)
simulating, F19.3	controls and instruments, S7.15	liquid (See also Evaporators)
software selection, F19.5	exhaust systems, S7.14	in chillers, A1.5; S39.18; S43.5, 7, 13
field survey audit, A38.17	expansion engines, S7.31	Evaporative cooling, A52
forecasting building needs, A42.36	fuels, F28.9; S7.11	applications
forward modeling, F19.1	cetane number, F28.9	air cleaning, A52.2; S41.9
management, A36	heat recovery, S7.33	animal environments, A24.4; A52.14
cost control, A36.10, 11	heat release, A17.1	commercial, A52.10
emergency energy use reduction, A36.15	jacket water system, S7.13	dehumidification, A52.2; S41.8
energy audits, A36.7	lubrication, S7.13	gas turbines, A52.13
energy-efficiency measures (EEM),	noise control, S7.16	greenhouses, A24.13; A52.14
comparing, A36.11	performance, S7.10	humidification, A52.2; S41.8
implementation, A36.15	reciprocating, S7.9, 10	industrial
improving discretionary operations,	vibration control, S7.16	air conditioning, A14.8
A36.10	water-cooled, S7.14	area cooling, A52.12
resource evaluation, A36.1	Engine test facilities, A17	process cooling, A52.13
modeling, F19	air conditioning, A17.1	spot cooling, A52.12
Bayesian analysis, F19.37	dynamometers, A17.1	laundries, A52.13
calculating, F19.8	exhaust, A17.2	makeup air pretreatment, S41.6
change-point, F19.28	noise levels, A17.4	motors, A52.12
regression, F19.30	ventilation, A17.1, 4	power generation facilities, A52.14
classical approach, F19.1	Enhanced tubes. See Finned-tube heat transfer	precooling, S41.6
data-driven approach, F19.2	coils	produce storage, A52.14
data-driven models, F19.27	Enthalpy	residential, A52.10
Gaussian process, F19.30	calculation, F2.4	wood and paper products facilities, A52.13
heat balance method, F19.9	definition, F2.2	cooling towers, S40.1
hybrid inverse change point, F19.31	foods, R19.8	direct, A52.1, 2; S41.1
in integrated building design, A58.9	water vapor, F6.10	economics, A52.17
occupant behavior, F19.14	wheels, \$26.9	entering air condition, A52.18
primary system components, F19.21	Entropy, F2.1	equipment
system controls, F19.23	calculation, F2.4	indirect, S41.3
weighting-factor method, F19.10	Environmental control	maintenance, S41.9
monitoring, A41	animals. See Animal environments	two-stage, S41.5
applications, A41.1–5	humans. See Comfort	exhaust requirement, A52.10
data, A41.6–15	plants. See Plant environments	heat recovery and, A52.7; S41.5
design and implementation methodology,	retail food stores, store ambient effect, R15.3	humidification, S22.10
A41.6	Environmental control system (ECS), A12	indirect, A52.1, 2; S41.3
documentation, A41.7, 15	Environmental health, F10	psychrometrics, A52.1, 11, 17, 18
planning, A41.6, 15	biostatistics, F10.3	staged
quality assurance, A41.6, 14	epidemiology, F10.3	booster refrigeration, A52.8, 18
recovery (See also Heat recovery)	exposure, F10.6	two-stage (indirect/direct), A52.11, 17;
in air-handling units, \$4.9	industrial hygiene, F10.3	S41.5
air-to-air, S26; S41.4	microbiology/mycology, F10.3	water treatment, A49.18; S41.10
in chemical industry, R46.4	physical hazards	Legionella pneumophila, \$41.10
industrial environments, A31.6	electrical hazards, F10.19 electromagnetic radiation, F10.21	Evaporators. (See also Coolers, liquid)
renewable, F35.2	e ,	air conditioners, room, S50.2
resources, F34; F35.2 demand-side management (DSM), F34.4	noise, F10.20	ammonia refrigeration system equipment, R2.
£ ,,,	thermal comfort, F10.16 vibrations, F10.19	automobile air conditioning, A10.6, 11
integrated resource planning (IRP), F34.3	· · · · · · · · · · · · · · · · · · ·	chemical industry refrigeration, R46.7
nonrenewable, F34.2	standards, F10.12	halocarbon refrigeration systems, piping,
renewable, F34.2	Environmental tobacco smoke (ETS)	R1.23 liquid overfeed systems, R4.6
United States, F34.7 world, F34.4	contaminants, A46.3 secondhand smoke, F11.19	Exfiltration, F16.2
,		Exhitiation, F10.2 Exhaust
savings verification, A41.2 self-imposed budgets, F35.8	sidestream smoke, F10.6 superheated vapors, F11.2	
storage, S51	EPDI. See Economic performance degradation	animal buildings, A24.6 clean spaces, A18.19, 23
wheels, S26.9	index (EPDI)	engines
Energy efficiency ratio (EER)	Equipment vibration, A48.43; F8.17	heat recovery, \$7.35
evaporative cooling, A52.8	ERF. See Effective radiant flux (ERF)	installation recommendations, S7.14
geothermal systems, A34.15	ESPC. See Energy savings performance	engine test facilities, A17.2
room air conditioners, \$50.1, 3	contracting (ESPC)	industrial environments, A14.8; A32.1
unitary equipment, \$49.6	Ethylene glycol, in hydronic systems, S13.24	kitchens, A33.36
Energy savings performance contracting	ETS. See Environmental tobacco smoke (ETS);	laboratories, A16.3, 9
(ESPC), A37.8	Electric thermal storage (ETS)	stack height, A16.13
Energy transfer station, S12.37	Evaluation. See Testing	photographic processing areas, A22.3
Energy transier station, 512.37	Liamation, Dec 1 comig	photographic processing areas, A22.3

stacks	plug, S21.1	standards, F15.62
buildings, A45.1	pressure relationships, S21.6	thermal radiation, F15.17
design strategies, A45.1	effect of duct system on, S21.7	U-factors, F15.5, 7
exhaust dilution prediction equations,	rating, S21.4	Fick's law, F6.1
A45.11	selection, A48.10; S21.9	and moisture flow, F25.12
exhaust velocity, A45.1	series operation, S21.10	Filters, air, S29. (See also Air cleaners)
industrial exhaust systems, A32.8	ships, naval surface, A13.3	air conditioners, room, S50.4
location relative to air intake, A45.2	smoke exhaust, A53.3	aircraft, A12.9, 14
wake downwash, A45.2	sound level, A48.8; S21.11	in air-handling units, S4.8
vehicular facilities, enclosed, A15.37	stall, S21.9	clean spaces, A18.3, 12, 17
Exhibit buildings, temporary, A5.8	surge, S21.9	demisters, A28.8
Exhibit cases, A23.5, 16	system effects, S21.8	desiccant dehumidifiers, S24.8
Exhibition centers, A5.5	temperature rise across, S21.7	dry, extended surface, S29.6
smoke control, A53.16	testing, S21.4	electronic, S29.5, 7
Expansion joints and devices, S46.10	types, S21.1	furnaces, S33.2
bends; S46.11	unstable operation, A47.10	high-efficiency particulate air (HEPA) filters
joints	variable- vs. fixed-speed, A42.26	A18.1; A28.3; S29.4, 6; S30.3
district heating and cooling, S12.25	vehicular facilities, enclosed, A15.33	hospitals, A8.4
packed, S46.13	vibration, S21.11	industrial air-conditioning, A14.8
packless, F22.21; S46.13	Farm crops, drying and storing, A25	industrial exhaust gas
loops, F22.13; S46.11	aeration, A25.4, 10	S
Expansion tanks, \$12.10	dryeration, A25.4 dryeration, A25.4	fabric, \$30.10
•		granular bed, \$30.14
hydronic systems, S15.3	drying	installation, S29.10
closed, S13.4	combination, A25.4	kitchens, A33.7, 18
diaphragm, S13.4	corn, A25.1	laboratories, A16.9
expansion chamber, S13.4	cotton, A25.8	maintenance, S29.8
functions of, S13.4, 11	deep-bed, A25.4	nuclear facilities, A28.3, 8
open, S13.4	energy conservation, A25.3	panel, S29.5
sizing equations, S13.5	equipment, A25.2	places of assembly, A5.1
secondary coolant systems, R13.3	full-bin, A25.4	printing plants, A20.4
solar energy systems, A35.11	hay, A25.8	renewable media, moving-curtain, S29.6
Explosions. See Chemical, biological, radio-	layer, A25.6	residential, A1.6
logical, and explosive (CBRE) incidents	peanuts, A25.9	safety requirements, S29.11
Fairs, A5.8	rice, A25.9	selection, S29.8
Family courts, A9.4. (See also Juvenile	shallow-layer, A25.3	ships, A13.4
detention facilities)	soybeans, A25.7	standards, S29.3, 5
Fan-coil units, S5.6	specific, A25.7	test methods, S29.2
capacity control, S5.7	microbial growth, A25.1	types, S29.5
maintenance, S5.7	recirculation, A25.3	ultralow-penetration air (ULPA) filters,
performance under varying load, S5.11	storing	A18.2, 3; S29.4, 6; S30.3
systems, S20.10	grain aeration, A25.10	viscous impingement, S29.5, 6
types, S5.6	moisture migration, A25.9	Finned-tube heat-distributing units, S36.2, 5
ventilation, S5.7	Faults, system, reasons for detecting, A39.6	design, S36.3
wiring, S5.7	f-Chart method, sizing heating and cooling	nonstandard condition corrections, S36.3
Fans, F19.18; S21	systems, A35.21	rating, S36.3
air conditioners, room, S50.2	Fenestration. (See also Windows)	Finned-tube heat transfer coils, F4.25
all-air systems, S4.4, 6, 9	air leakage, F15.53	energy recovery loops, S26.11
altitude effects, S21.5	area, A44.2	two-phase flow in, F5.19
animal environments, A24.6	attachments, F15.35	Fins , F4.6
arrangement, S21.12	building envelopes, A44.2; F15.1	Fire/smoke control. See Smoke control
control, A47.8; S21.12	codes, F15.62	Firearm laboratories, A9.7
cooling tower capacity control, A42.8; S40.11	components, F15.1	Fire management, A53.1
draft, S35.32	condensation resistance, F15.58	Fireplaces, S34.5
fan efficiency grade (FEG), S21.9	control of rain entry, A44.10	chimney design, S35.23
fan motor efficiency grade (FMEG), S21.9	cooling load, F18.16	altitude effects, S35.7, 32
fixed- vs. variable-speed, A42.26	draperies, F15.37	Fire safety
flow control, S21.12; S45.13	durability, F15.62	clean space exhaust systems, A18.20
furnaces, S33.2	energy flow, F15.3	industrial exhaust gas cleaning, S30.29
industrial exhaust systems, A32.8	energy performance, annual, F15.57	insulation fire resistance ratings, F23.7
installation, S21.12	exterior shading, F15.1	justice facilities, A9.3, 7
isolation, S21.12	glazing (glass), F15.1	kitchens, A33.29
kitchen exhaust, A33.28	infiltration, F19.13	laboratories, A16.11
laws, S21.5	occupant comfort, F15.60	nuclear facilities, A28.2
noise, S21.11	opaque elements, F15.33	penetration fire stopping, A53.1
operating principles, S21.1	shading devices, F15.35	smoke control, A53.1
parallel operation, S21.10	skylights, F15.21	thermal insulation, F23.6
performance, S21.4	solar gain, A44.10	Fish, R19; R32
plenum, S21.1	solar heat gain, F15.14, 19	fresh, R19.2; R32.1
p	Joint Heat Suil, 1 13.17, 17	110011, 1117.2, 1102.1

frozen, R19.4; R32.4	pipe friction, F3.6, 7	water content, initial freezing point, R19.2
thermal properties, R19.1	Poiseuille, F3.3	Food service
Fitness facilities. (See also Gymnasiums)	properties, F3.1	refrigerators for, R16.1
in justice facilities, A9.6	Reynolds number, Re, F3.3	service water heating, A50.11, 21
Fittings	section change losses, F3.8	vending machines, R16.5
duct fitting database, F21.10 effective length, F3.8	sensors, F7.10 separation, F3.4	Forced-air systems, residential, A1.1 multifamily, A1.7
halocarbon refrigeration systems, R1.6	turbulent, F3.3	Forensic labs, A9.6
loss coefficients, F3.8	two-phase	autopsy rooms, A9.6, 7
pipe	boiling, F5.1	critical spaces, A9.4, 7
design, F22.6, 28	evaporation, F5.2, 4	firearm labs, A9.6, 7
standards, F22.18; S46.2	pressure drop, F5.15	intake air quality, A9.7
tees, F22.28	unsteady, F3.11	Fouling factor
Fixed-guideway vehicles, A11.7. (See also	valve losses, F3.8, 9	condensers, water-cooled, S39.4
Mass-transit systems)	vena contracta, F3.4	coolers, liquid, S42.4
Fixture units, A50.1, 27	wall friction, F3.3	Foundations
pipe design, F22.23	Food. (See also specific foods)	heat transfer, F19.12
Flammability limits, gaseous fuels, F28.1	codes, R15.2	moisture control, A44.11
Flash tank, steam systems, S11.14	cooling times, R20.1	Fountains, Legionella pneumophila control,
Floors	freezing times, R20.1	A49.14
coverings panel systems, S6.6	industrial freezing methods, R29.1 long-term storage, R40.7	Four pipe systems \$5.5
temperature comfort, F9.16	microbial growth	Four-pipe systems, S5.5 load, S13.20
slabs, heat loss, F17.11; F18.40	control, R22.3	room control, S5.15
Flowers, cut	generalized, R22.1	zoning, S5.15
air transport, R27.1, 3	requirements, R22.2	Framing, for fenestration
cooling, R28.11	plants, R40.3	materials, F15.2
refrigerators, R16.3	poultry products	solar gain, F15.20
storage, temperatures, R21.12	freezing, R31.5	Freeze drying, A30.6
Flowmeters, A38.13; F37.18	refrigeration, R31.1	biological materials, R49.4
bypass spring impact meters, A38.13	processing facilities	Freeze prevention. (See also Freeze protection
in conduits, F3.13	contamination prevention, R22.3	systems)
devices, A38.13	dairy, R33.1	condensers, evaporative, S39.16
district heating and cooling systems, S12.45	fruits, R40.5	coolers, liquid, S42.5
flow nozzles, F37.21	main dishes, R40.1	cooling tower
hoods, F37.20	meat, R30.1	basin water, \$40.13
orifice plates, A38.13; F37.21	organism destruction, R22.4	piping, \$14.3
positive-displacement meters, F37.24 rotameters, F37.23	potato products, R40.5 poultry, R31.1	energy recovery equipment, S26.7 hydronic systems, S13.23
turbine meters, A38.13; F37.24	precooked foods, R40.1	insulation for, F23.5
ultrasonic, A38.13	refrigeration systems, R40.3, 4, 6	solar energy systems, A35.24; S37.3, 19
velocity impact meters, A38.13	regulations and standards, R22.5	Freeze protection systems, A51.18, 19
venturi meters, A38.13; F37.21	sanitation, R22.4	Freezers
Fluid dynamics computations, F13.1	vegetables, R40.3	blast, R16.3, R23.10; R29.1; R30.15
Fluid flow, F3	refrigeration	household, R17.1
analysis, F3.6	dairy products, R33	cabinet construction, R17.3
Bernoulli equation, F3.6	eggs and egg products, R34.1	cabinets, R17.2
kinetic energy factor, F3.2	fishery products, R32	defrosting, R17.5
pressure variation, F3.2	fruits, fresh, R35; R36	durability, R17.12
boundary layer, F3.3	meat products, R30	efficiency, R17.9
cavitation, F3.14 choking, F3.13	vegetables, R37	performance evaluation, R17.9
compressible, F3.13	refrigerators commercial, R16	refrigerating systems, R17.4 safety, R17.12
expansion factor, F3.13	retail food store, R15.1	testing, R17.9
pressure, F3.12	storage requirements	industrial, R29.1
continuity, F3.2	canned foods, R21.11	walk-in, R16.4
Darcy-Weisbach equation, F3.7	citrus fruit, R36.3	Freezing
devices, F3.5	commodities, R21.1	beverages, R20.7
discharge coefficients, F3.9	dried foods, R21.11	biomedical applications, R49.1
drag, F3.5	fruit, R35	foods
friction factors, F3.7	thermal properties, R19	bakery products, R41.5
incompressible, F3.9	enthalpy, R19.8	egg products, R34.9
laminar, F3.3	heat of respiration, R19.17, 19, 20	fish, R32.5
measurement, A38.12; F3.10; F37.20	ice fraction, R19.2	freezing time calculations, R20.7
noise, F3.14	surface heat transfer coefficient, R19.25	ice cream, R33.15
nonisothermal effects, F3.5 parabolic velocity profile, Poiseuille, F3.3	thermal conductivity, R19.9, 12, 16 thermal diffusivity, R19.17	meat products, R30.16 poultry products, R31.5
patabolic velocity profile, Poiseume, F3.5 patterns, F3.4	transpiration coefficient, R19.19, 25	processed and prepared food, R40.1
Partitio, 1 5. 1	anophanon coemicion, R17.17, 25	processed and propared rood, 10-0.1

industrial, R29.1	controls, S33.2, 5	absorption units, R18.1, 10
soil, R45.3, 4	derating, S31.10	combined heat and power (CHP), S7.40
Friction, in fluid flow	duct, S33.5	Geothermal energy, A34
conduit, F3.6	duct furnaces, S31.6	corrosion control, A34.6
wall, F3.3	electric, S33.4, 9	direct-use systems, A34.3
Fruit juice, R38	fans and motors, S33.2	cooling, A34.9
Fruits	floor furnaces, S34.2	equipment, A34.5
dried	gas-fired, S33.1, 8	heating, A34.8
storage, R42.7	codes, S33.9	service water heating, A34.8
thermal properties, R19.1	commercial, S33.5	district heating, A34.8
fresh	installation, S33.9	geothermal fluids, A34.1
air transport, R27.1	residential, S33.1	disposal, A34.4
apples, storage, A52.14; R35.1	standards, \$33.10	temperature, A34.1, 4
apricots, R35.13	upflow, \$33.5	ground-source heat pump (GSHP) systems,
avocados, R36.8	humidifiers, \$33.2	A34.10, 38; S9.4
bananas, R36.5	installation, S33.9	heat exchangers, A34.7, 37
berries, R35.13	location, S33.6	materials performance, A34.5
cherries, sweet, R35.12	natural gas, S31.11; S33.1, 4, 8	resources, A34.1
citrus, A52.14; R36.1	residential, S33.1, 8	valves, A34.7
cooling, R28.1	venting, S33.2; S35.20	water wells
deciduous tree, R35	oil, \$33.4, 9	flow rate, A34.3
desiccation, R21.1	venting, S35.21	pumps, A34.6, 36
deterioration rate, R21.1	performance criteria, S33.8	terminology, A34.33
display refrigerators, R15.8	propane, \$33.4, 9	water quality testing, A34.4
figs, R35.13	regulating agencies, \$33.10	Geothermal heat pumps (GHP), A34.10
grapes, R35.8	residential, A1.3; S33.1	Glaser method, F25.15
mangoes, R36.8	floor furnaces, S34.2	Glazing
nectarines, R35.12	indoor or outdoor, S33.4	angular averaging, F15.17
peaches, R35.12	performance criteria, S33.8	glass, F15.1
pears, R35.6 pineapples, R36.8	selection, S33.6 selection, S33.6	plastic, F15.32 solar-optical properties, F15.14
plums, R35.11	standards, S33.10	spectral averaging, F15.17
storage diseases, R35.1	stokers, S31.17	spectral range, F15.17
strawberries, R35.13	thermal storage, S51.18	systems, F15.16
thermal properties, R19.1	unducted, S33.5	Global climate change, and refrigerants, F29.1
vine fruits, R35.1	upflow, S33.5	Global warming potential (GWP), F29.5
frozen, R40.5	venting, S35.20, 21	Glossary, of refrigeration terms, R50
Fuel cells, combined heat and power (CHP),	wall furnaces, S34.1	Glycols, desiccant solution, S24.2
S7.22	Galleries. See Museums, galleries, archives,	Graphical symbols, F38
Fuels, F28	and libraries	Green design, and sustainability, F35.1
classification, F28.5	Garages	Greenhouses. (See also Plant environments)
combustion, F28	automotive repair, A15.21	evaporative cooling, A52.14
altitude effects, F28.3; S7.8, 10, 19; S31.10	bus, A15.22	plant environments, A24.10
engines, S7.11	contaminant criteria, A15.19	Grids , for computational fluid dynamics, F13.4
flammability limits, F28.1	parking, A3.8; A15.18	Ground-coupled heat pumps (GCHP)
gaseous, F28.5	ventilation	closed-loop ground-source, A34.10
heating value, F28.3; S7.12	airflow rate, A15.19	heat exchanger, S49.13
ignition temperature, F28.2	control, A15.20	Ground-coupled systems, F19.23
liquid, F28.7	equipment, A15.33	Ground-source heat pumps (GSHP), A34.1, 10
oil. See Oil, fuel	residential, F16.21	Groundwater heat pumps (GWHP), A34.32
systems, S7.12	system configuration, A15.21	GSHP. See Ground-source heat pumps
solid, F28.9	Gases	(GSHP)
turbines, S7.20	compressed, storage, A16.8	Guard stations, in justice facilities, A9.5
Fume hoods, laboratory exhaust, A16.3	drying, S24.13	GWHP. See Groundwater heat pumps
Fungi	liquefaction, R47.6	(GWHP)
and moisture, A62.10	purification, R47.16, 19	GWP. See Global warming potential
pathogens, F10.8	separation	(GWP)
spores, F11.2	gaseous oxygen, R47.18	Gymnasiums, A5.5; A7.3
Furnaces, S33	Gibbs phase rule, R47.16	HACCP. See Hazard analysis critical control
air cleaners and filters, S33.2	Gas-fired equipment, S34. (See also Natural	point (HACCP)
airflow configurations, S33.2	gas)	Halocarbon
air supply, S35.28	noise, F28.19	coolants, secondary, F31.12
burners, S31.1; S33.2	Gas vents, S35.1	refrigerant systems, R1.1
casings, S33.1	Gaussian process (GP) models,	Hartford loop, S11.3
codes, S33.9	F19.30	Hay, drying, A25.8
commercial, S33.5	GCHP. See Ground-coupled heat pumps	Hazard analysis and control, F10.4
efficiency, S33.9	(GCHP)	Hazard analysis critical control point
components, S33.1	Generators	(HACCP), R22.4

in meat processing facilities, R30.1	radiant, S31; S34	steam, S11.3
Hazen-Williams equation, F22.6	electric, S16.2	water, medium- and high-temperature, S15.6
HB. See Heat balance (HB)	gas-fired, S16.1; S31.7; S34.1	wraparound, S25.10
Health	infrared, S31.7	Heat flow, F25. (See also Heat transfer)
airborne pathogens, F10.8	oil-fired infrared, S16.3	and airflow, F25.14
asbestosis, F10.5	panels, S34.4	through flat building component, F25.7
carbon monoxide, F10.15	quartz, S34.4	hygrothermal modeling, F25.15
coalworker's pneumoconiosis, F10.5	residential, S34.1	and moisture, F25.14
in justice facilities, A9.4	room, S34.1	paths, series and parallel, F25.7
Legionella pneumophila, F10.7	solid fuel, S34.4	Heat flux, F25.1
and moisture problems, F25.16	standards, S34.6, 7	radiant panels, S6.2
silicosis, F10.5	steam, S28.4	Heat gain. (See also Load calculations)
synthetic vitreous fibers (SVFs), F10.6	stoves, S34.5	appliances, F18.7
Health care facilities, A8. (See also specific	testing, S34.7	calculation
types)	unit, S28.4; S31.6	solar heat gain coefficient (SHGC), F18.18
air quality, A8.3	control, S28.6	standard air values, F18.15
design criteria, A8.5	location, S28.4	control, F25; F26; F27
disease prevention, A8.2	maintenance, S28.8	electric motors, F18.6
regulatory requirements, A8.1	piping, S28.7	engine test facilities, dynamometers, A17.1
sustainability, A8.13	ratings, S28.6	fenestration, F18.16
Health effects, mold, A62.1	selection, S28.4	floors, F18.25
Heat	sound level, S28.6	hospital and laboratory equipment, F18.11
flow rates, F18.1	types, S28.4	humans, F18.3
latent	ventilators, S28.1	laboratories, A16.2
respiratory loss, F9.4	water, A50	latent, permeable building materials, F18.15
skin loss, F9.3, 10	Heat exchangers, S48	lighting, F18.3
sensible	air-to-air energy recovery, S26.1	office equipment, F18.11
respiratory, F9.4	heat pipes, S26.14	radiant panels, \$6.6
skin, F9.3	liquid-desiccant cooling systems, S26.18	space, F18.1
space extraction rate, F18.2	rotary enthalpy wheels, \$26.9	Heating
timers, \$11.13	thermosiphon, S26.16	absorption equipment, R18.1
transfer, F4; F25; F26; F27	twin-tower enthalpy recovery loops,	animal environments, A24.4
Heat and moisture control, F27.1	S26.19	control, A42.39
Heat balance (HB), S9.23	animal environments, A24.4	equipment, S3.1; S27–S34; S49
air, F18.19 conduction transfer function, F18.20	antifreeze effect on, S13.24 chimneys, S35.31	baseboard units, S36.2 boilers, S32.1
cooling load calculation methods, F18.2, 16	counterflow, F4.22; S48.1	convectors, S36.1
equations, F18.20	district heating and cooling, S12.42	finned-tube units, S36.2
input procedure, F18.21	double-wall construction, \$48.3	furnaces, S33.1
model, F18.17	effectiveness, capacity rate ratio, F4.22	radiators, S36.1
studies, S9.23	enhanced surfaces, F5.19	geothermal energy systems, A34.8
surface, F18.17	fouling, S48.6	greenhouses, A24.11
Heat balance method, F19.3	furnaces, S33.1	industrial environments, A14.7
Heat capacity, F25.1	geothermal energy systems, A34.7, 37	infrared, S16.1
Heat control, F27	halocarbon refrigeration systems, R1.29	radiant, A54.1, 8
Heaters, S34	heat transfer, S48.1	nonresidential, S13.17
automobiles, A10.5	installation, S48.6	passive, F19.27
catalytic, S34.1	liquid suction, R1.29	places of assembly, A5.1
control, S34.2, 4	number of transfer units (NTU), F4.22	plant growth chambers, A24.17
direct-contact, S15.5	parallel flow, F4.22	power plants, A27.11
electric, S16.2; S34.3	plate, F4.24; R1.30; S42.2	residential, A1.1
fireplaces, S34.5	brazed, S12.42; S48.3	solar energy, S37.1
gas, S16.1; S31.6; S31.7; S34.1	components, S48.4	systems
control valves, S34.2	gasketed, S12.42; S48.3	all-air, S4.2, 5
efficiency requirements, S34.2	plate-and-frame, S12.42	selection, S1.1, 9
infrared, S16.1	pressure drop in, F5.18	small forced-air, S10.1
room, S34.1	welded, S12.43; S48.3	solar energy, A35.15, 26
thermostats, S34.2	selection, S48.5	steam, S11.1
wall furnaces, S34.1	shell-and-coil, R1.30; S12.43; S48.2	thermal storage, S51.16
hot-water, S28.4	shell-and-tube, R1.30; S12.43; S42.1	Heating load
hydronic snow melting, A51.12	components, S48.4	calculations, F18.30
infrared, S16.1; S31.7	converters, S48.2	central plant, S3.2
indirect, S31.7	straight-tube, S48.2	residential calculations, crawlspace heat loss,
oil-fired, S16.3	tube-in-tube, R1.30; S42.1	F17.11
radiant, A54.1, 4, 8	U-tube, S48.2	Heating seasonal performance factor (HSPF),
in-space, S34.1	solar energy, S37.15	S49.6
kerosene, S34.3	systems	Heating values of fuels, F28.3, 9, 10
oil, S16.3; S34.3	solar energy, A35.11	Heat loss. (See also Load calculations)

basement, F18.39	testing, S49.13	turbulent region, F4.1
crawlspaces, F17.11	water loop, S49.12	definition, F25.1
floor slabs, F18.40	water-to-air, S9.5	diffuse radiators, F4.15
latent heat loss, F17.11; F18.40	water-to-water, S9.5	district heating and cooling pipes, S12.15
radiant panels, S6.6	window-mounted, S2.3	effectiveness, F4.22
Heat pipes, air-to-air energy recovery, S26.14	Heat recovery. (See also Energy, recovery)	extended surfaces, F4.6
Heat pumps	balanced heat recovery, S9.22	factor, friction, F4.17
absorption, R18.3	coils, S27.3	film
air-source, S49.1, 9	combined heat and power (CHP), S7.32	coefficient, F25.1
add-on, S49.9	combustion turbines, \$7.37	resistance, F25.6
air-to-air, S9.5, 10	evaporative cooling, A52.7; S41.5	fins, F4.6, 7
air-to-water, S9.5, 10	heat-activated chillers, \$7.38	forced convection, air coolers, F4.17
balance point, S49.9	heat balance, S9.23	Fourier's law, F25.5
compressor selection, S49.11	heat pumps, S9.9	heat exchangers, S48.1
control, S49.11	industrial exhaust systems, A32.8	insulation, F37.34
defrost cycle, S49.10	kitchen ventilation, A33.5	lakes, A34.38
installation, S49.11	laboratories, A16.20	mass transfer
refrigerant circuits, S49.11	liquid chillers, S43.11	convection, F6.6
selection, S49.9	multiple buildings, S9.25	molecular diffusion, F6.3
boosters, S51.18	reciprocating engines, \$7.33	simultaneous with, F6.10
cascade systems, S9.5	service water heating, A50.10	cooling coils, F6.13
components, S9.7	steam	number of transfer units (NTU), F4.23
compression cycles, S9.2	systems, S11.3, 14	radiant balance, F4.15
control, S9.7, 8	turbines, S7.37	radiation
efficiency, S49.6	supermarkets, A2.4	actual, gray, F4.2, 12
engine-driven, S7.45	terminology, S9.1	angle factor, F4.13
ground-source	waste heat, S9.14	Beer's law, F4.16
ground-coupled, A34.10, 13; S49.13	Heat storage. See Thermal storage	blackbody, F4.12
groundwater, A34.11, 32; S49.12	Heat stress	black surface, F4.2
surface water, A34.12, 38; S49.13	index (HSI), A31.6; F9.21	energy transfer, F4.11
terminology, A34.10	industrial environments, A31.5	exchange between surfaces, F4.14
heat recovery heat pumps, S9.9	thermal standards, A31.5	in gases, F4.16
design principles, S9.13	Heat transfer, F4; F25; F26; F27. (See also Heat	gray surface, F4.12
waste heat recovery, S9.14	flow)	hemispherical emissivity, F4.12
heat sources and sinks, S9.2, 4	across air space, F25.6	Kirchoff's law, F4.12
ice-source, R43.6	antifreeze effect on water, S13.24	monochromatic emissive power, F4.12
industrial process, S9.9	apparent transfer coefficient, F25.6	spectral emissive power, F4.12
closed-cycle systems, S9.10	augmentation	Stefan-Boltzmann law, F4.2, 12
design, S9.13	active, F4.29	thermal, F4.2
heat recovery, S9.9, 9	passive, F4.25	Wien's displacement law, F4.12
open-cycle systems, S9.12	building materials, F37.34	simultaneous with mass transfer, F6.10
semi-open-cycle systems, S9.12	coefficients, F15.6	snow-melting systems, A51.1
multisplit system, S18.2	convective, F9.7	fluids, A51.10
packaged terminal heat pumps (PTHPs), S50.6	convective evaporation, F5.7	solar energy systems, A35.11
testing, S50.7	evaporative, F9.8	steady-state, F25.5
room, S50.1	foods, R19.25	surface, F25.6
split systems, A1.3; S49.1	Lewis relation, F9.4	terminology, F25.1
supplemental heating, S9.9	low-temperature, R48.10	thermal bridging, F25.8
through-the-wall, S2.3	overall, F4.26	transient
types, S9.5	coils	cooling time estimation, F4.9
unitary, S49.1	air-cooling and dehumidifying, S23.6	cylinder, F4.9
application, A1.3; S49.1	air-heating, S27.4	radiation, F4.8
certification, S49.7	condensers, S39.2	slab, F4.9
codes, S49.6	water-cooled, S39.2	sphere, F4.9
desuperheaters, S49.4	conductance, F4.3	transmission data, F26
installation, S49.2	conduction, F4.1, 3	two-phase, F5.15, 17
service, S49.2	shape factors, F4.4	water, S13.3
space conditioning/water heating, S49.5	control, F25; F26; F27	Heat transmission
standards, S49.6	convection	doors, F27.7
types, S49.2	buffer layer, F4.1	floor slabs, F18.40
water heaters, A50.9	coefficient, F4.1	windows, F27.7
water-source	external, F4.17	Heat traps, A50.1
certification, S49.13	flow, fully developed laminar, F4.17	Helium
design, S49.13	forced, boundary layer, F4.17	in air, F1.1
entering water temperature, S49.13	free, F4.1, 19	recovery, R47.18
groundwater, A34.11, 32; S49.12	internal, F4.17	and thermal radiation, F4.16
indirect systems, A34.37	laminar sublayer, F4.1	High-efficiency particulate air (HEPA) filters,
surface water, A34.12, 38; S49.13	natural, F4.1, 19	A28.3; S29.6; S30.3

High-rise buildings. See Tall buildings	design criteria, A6.1	Hydrogen, liquid, R47.3
High-temperature short-time (HTST)	guest rooms, A6.4	Hydronic systems, S35. (See also Water
pasteurization, R33.2	indoor air quality (IAQ), A6.6	systems)
High-temperature water (HTW) system, S13.1	load characteristics, A6.1	central multifamily, A1.7
Homeland security. See Chemical, biological,	makeup air units, A6.7	combined heat and power (CHP), S7.42
radiological, and explosive (CBRE) incidents	public areas, A6.6	heating and cooling design, S13.1
Hoods	service water heating, showers, A50.11, 20	altitude effects, S36.5
draft, S35.30	sound control, A6.8	heat transfer vs. flow, A38.6, 7
gaseous contaminant removal, A46.7	systems, A6.3	pipe design, F22.26
industrial exhaust systems	Hot-gas bypass, R1.35	residential, A1.3
canopy hoods, A32.3, 6	Houses of worship, A5.3	snow melting, A51.10
capture velocities, A32.2	HSI. See Heat stress, index (HSI)	testing, adjusting, balancing, A38.6, 8
compound hoods, A32.5	HSPF. See Heating seasonal performance	units
design principles, A32.3	factor (HSPF)	baseboard, S36.2, 3, 5
entry loss, A32.4	HTST. See High-temperature short-time	convectors, S36.1, 3, 5
overhead hoods, A32.6	(HTST) pasteurization	finned-tube, S36.2, 3, 5
sidedraft hoods, A32.6	Humidification, S22	heaters, S28.4
volumetric flow rate, A32.2	air washers, S41.8	makeup air, S28.9
kitchen exhaust, A33.35	all-air systems, S4.5, 9	pipe coils, S36.1
ductless, A33.15	control, A47.15, 16; S22.1	radiant panels, \$36.6
recirculating systems, A33.15, 29	design, S22.4	radiators, S36.1, 2, 5
residential, A33.35	direct evaporative cooling, A52.2	ventilators, S28.1
type I, A33.7	evaporative coolers, S41.8	water treatment, A49.18
type II, A33.7 type II, A33.7, 14	in health care facilities, A8.3	Hygrometers, F7.9; F37.10, 11
laboratory fume, A16.3	load calculations, S22.4	Hygrothermal loads, F25.2
· · · · · · · · · · · · · · · · · · ·		Hygrothermal modeling, F25.15; F27.10
sound control, A48.34	Humidifiers, S22	• • • • • • • • • • • • • • • • • • • •
unidirectional, A18.13	all-air systems, S4.9	criteria, F25.16
Hospitals, A8.2	bacterial growth, S22.1	dew-point method, F25.14
air conditioning, A8.2	central air systems	transient analysis, F25.15; F27.10
air movement, A8.4	industrial and commercial, S22.7	IAQ. See Indoor air quality (IAQ)
air quality, A8.3	residential, S22.6	IBD. See Integrated building design (IBD)
control measures, A8.3	commercial, S22.6	Ice
cooling, A8.13	controls, S22.13	commercial, R43.6
design criteria	energy considerations, S22.3	delivery systems, R43.5
administration, A8.10	equipment, S22.6	manufacture, R43.1
airborne infection isolation, A8.7	evaporative cooling, S22.10	storage, R43.3
ancillary spaces, A8.8	furnaces, S33.2	thermal storage, R43.3; S51.9
autopsy rooms, A8.9	industrial, S22.6	Ice makers
diagnostic and treatment, A8.10	Legionella pneumophila control, A49.14	commercial, R16.6
intensive care units, A8.6	load calculations, S22.4	heat pumps, R43.6
laboratories, A8.8	nonducted, S22.6	household refrigerator, R17.2
nursery suites, A8.6	portable, S22.6	large commercial, R43.1
nursing areas, A8.7	residential, A1.5; S10.2; S22.6	storage, R43.3
operating rooms, A8.5	scaling, S22.5	thermal storage, R43.3
patient rooms, A8.7	supply water, S22.5	types, R43.1
pharmacies, A8.9	terminal, S4.17	Ice rinks, A5.5; R44
protective isolation, A8.7	types, S22.5	conditions, R44.4, 5
recovery rooms, A8.6	Humidity (See also Moisture)	dehumidifiers, S25.8
service areas, A8.12	building envelope affected by, S22.3	energy conservation, R44.5
sterilizing and supply, A8.11	control, A47.15; A62; F32.1; S22.1; S24.1	floor design, R44.8
surgery and critical care, A8.5	disease prevention and treatment, S22.1	heat loads, R44.2
disease prevention, A8.2	human comfort conditions, S22.1	pebbling, R44.11
energy conservation, A8.13	measurement, F37.10	surface building and maintenance, R44.11
heating and hot-water standby, A8.12	odors affected by, F12.2	water quality, R44.11
indoor air quality (IAQ), A8.3	relative, F1.12	ID ₅₀ , mean infectious dose, A59.9
infection sources, A8.3	sound transmission affected by, S22.2	Ignition temperatures of fuels , F28.2
insulation, A8.13	sources of, S25.8	IGUs. See Insulating glazing units (IGUs)
Legionella pneumophila, A8.3	static electricity affected by, S22.2	Illuminance, F37.31
smoke control, A8.5	HVAC security, A59	Indoor air quality (IAQ). (See also Air quality
sustainability, A8.13	commissioning, A59.6	bioaerosols
ventilation, A8.3	owner's project requirements (OPR), A59.1	health effects, F10.8
zoning, A8.12	risk evaluation, A59.2	particles, F10.5
Hot-box method, of thermal modeling,	system design, A59.3	sources, F10.8
F25.8	design measures, A59.4	environmental tobacco smoke (ETS), F10.6
Hotels and motels, A6	maintenance management, A59.6	e-cigarettes, F10.7
accommodations, A6.3	modes of operation, A59.3	gaseous contaminant removal, A46.1
back-of-the-house (BOTH) areas, A6.6	Hybrid inverse change point model, F19.31	hospitals, A8.3
central plant A6 8	Hybrid ventilation F19 26	hotels and motels A6 6

humidity, F25.16	energy recovery, A32.8	gas-fired, S16.1; S31.7
microbial volatile organic chemicals	exhaust stacks, A32.8	industrial environments, A14.7
(MVOCs), F10.8	fans, A32.8	oil-fired, S16.3
modeling, F13.1	hoods, A32.2	system efficiency, S16.4
particulate matter, F10.5	hot processes, A32.6	snow-melting systems, A51.16
polycyclic aromatic compounds (PACs), F10.6	operation and maintenance, A32.9	In-room terminal systems
polycyclic aromatic hydrocarbons (PAHs),	system testing, A32.9	changeover temperature, S5.12
F10.6	pressurization, A14.6	performance under varying load, S5.11
radon action levels, F10.22	process and product requirements, A14.1	primary air, S5.10
semivolatile organic compounds (SVOCs),	safety, A14.9	Instruments, F14. (See also specific instruments
F10.4, 12	spot cooling, A31.4, 6	or applications)
sensors, F7.10	thermal control, A14.5	Insulating glazing units (IGUs), F15.5
standards, F10.12	ventilation systems, A31.2	Insulation, thermal
synthetic vitreous fibers, F10.6	Industrial exhaust gas cleaning, S29. (See also	airflow retarders, F25.9
volatile organic compounds (VOCs),	Air cleaners)	animal environments, A24.5
F10.11; F11.14	auxiliary equipment, S30.28	below-ambient system, R10.1, 2
Indoor environmental modeling, F13	equipment selection, S30.1	clothing, F9.8
computational fluid dynamic (CFD), F13.1	gaseous contaminant control, S30.17	compressive resistance, F23.9
contaminant transport, F13.16	absorption, S30.17	condensation control, F23.3
multizone network, F13.14	adsorption, S30.23, 26	corrosion under, F23.7
verification and validation, F13.17	incineration, S30.26, 27	cryogenic, R47.23; R48.9
Indoor environmental quality (IEQ), kitchens,	spray dry scrubbing, S30.17	ducts, F23.15; S19.12
A33.20. (See also Air quality)	wet-packed scrubbers, S30.18, 23	flexible, F23.13
Induction	gas stream, S30.2	process, F23.15
air-and-water systems, A38.6	monitoring, S30.1	economic thickness, in mechanical systems,
systems, S5.10	operation and maintenance, S30.29	F23.1
units under varying load, S5.11	particulate contaminant control, S30	electrical, motor, breakdown of, S45.16
Industrial applications	collector performance, S30.3	energy conservation, F23.1
burners	electrostatic precipitators, S30.8	fire resistance ratings, F23.7
gas, S31.6	fabric filters, S30.10	fire safety, F23.6
oil, S31.12	inertial collectors, S30.4	flame spread index, F23.6
ducts, S19.9	scrubbers (wet collectors), S30.15	foundations, A44.3
gas drying, S24.13	settling chambers, S30.3	freeze protection, F23.5
heat pumps, S9.9	regulations, S30.1	green buildings, F23.1
humidifiers, S22.6	safety, S30.29	heat gain, F23.18
process drying, S24.13	scrubbers (wet collectors), S30.15	heat loss, F23.18
process refrigeration, R46.1	Industrial hygiene, F10.3	heat transfer, F37.34
thermal storage, S51.23	Infiltration. (See also Air leakage)	hospitals, A8.13
service water heating, A50.25	air exchange, R24.5	insertion loss, F23.6
steam generators, A27.5	rate, F16.4, 13	limited combustible, F23.7
Industrial environments, A14; A31; A32	air leakage	materials, F23.8; F26.1
air conditioning, A14	air-vapor retarder, F16.18	cellular, F23.9
cooling load, A14.6	building data, F16.16	fibrous, F23.9
design, A14.5	controlling, F16.18	foil, scrim, and kraft paper (FSK), F23.13
evaporative systems, A14.8	calculation, residential, F16.23	foil-reinforced kraft (FRK), F23.14
maintenance, A14.8	commercial buildings, F16.26	granular, F23.9
refrigerant systems, A14.7	direct flow through doorways, R24.7	reflective, F23.9
spot cooling, A31.4; A52.12	driving mechanisms, F16.13	moisture control, F26.1
ventilation, A31.1	examples, F16.24	noise control, F23.5
air distribution, A31.3	fenestration, F15.53	noncombustible, F23.7
air filtration systems, A14.8; S29.2; S30.1	indoor air quality (IAQ), F16.11	operating temperature, F23.9
commissioning, A14.9	infiltration degree-days, F16.13	performance, F26.1
contaminant control, A14.5, 8	latent heat load, F16.12; F17.5	personnel protection, F23.2
control systems, A14.9	leakage function, F16.15	pipes, F23.13
energy	measurement, F37.24	economic thickness, S12.25
conservation, A31.6	refrigerated facilities, R24.5	hangers, F23.13
recovery, A31.6	residential buildings, F16.15	underground, F23.15; S12.15
sustainability, A31.6	sensible heat load, F16.12; F17.5	properties, F25.1
evaporative cooling, A52.12	terminology, F16.1	refrigerant piping, R10.1
heat control, A31.5	thermal loads, F16.11	design, R10.1
heat exposure control, A31.6	ventilation, R15.4	installation, R10.7
heating systems, A14.7	Infrared applications	jacketing, R10.6
heat stress, A31.5	comfort, F9.23, 25	joint sealant, R10.5
local exhaust systems, A31.6; A32.1	drying, A30.3	maintenance, R10.10
air cleaners, A32.8	energy generators, S16.1	thickness tables, R10.5
airflow near hood, A32.3	greenhouse heating, A24.12	vapor retarders, R10.5
air-moving devices, A32.8	heaters, A54.1, 4, 8; S16.1	refrigerated facilities, R23.12; R24.1
ducts, A32.6; S30.28	electric, S16.2	smoke developed index, F23.6

colon ananov avatama \$27.6.12	ground stations, AOA 5	maintananaa A22.24
solar energy systems, S37.6, 13 tanks, vessels, and equipment, F23.15	guard stations, A9.4, 5 health issues, A9.4	maintenance, A33.34 makeup air systems
thermal conductivity, F23.9	heating and cooling plants, A9.3	air distribution, A33.22
thermal storage systems, water, S51.6	jail cells, A9.6	maintenance, A33.35
water absorption, F23.9	jails, A9.4	replacement, A33.20
water vapor permeability, F23.9	judges' chambers, A9.5, 5	residential, A33.36
water vapor permeance, F23.9	jury rooms, A9.5	operation, A33.34
water vapor retarders, F23.11	juvenile, A9.1	replacement air, A33.20
weather barriers, F23.10	kitchens, A9.5	residential, A33.35
weather protection, F23.10	laundries, A9.5	service water heating, A50.7
Integrated building design (IBD), A58.1, 7	libraries, A9.4, 6	ventilation, A33
budgeting, A58.3	police stations, A9.1	Kleemenko cycle, R47.13
commissioning, A58.8	prisons, A9.4	Krypton, recovery, R47.18
communication, A58.4	shooting ranges, indoor, A9.8	Laboratories, A16
construction	system controls A9.3	air distribution, A16.9
contract administration, A58.7	system requirements, A9.1	air filtration, A16.9
document phase, A58.8	tear gas and pepper spray, A9.3	air intakes, A16.13
post-construction activities, A58.7	terminology, A9.1	animal labs, A16.14
design	types of, A9.1	cage environment, A24.9
basis, A58.5	U.S. Marshals, A9.6	ventilation performance, A24.9
criteria, A58.5	Juvenile detention facilities, A9.1. (See also	biological safety cabinets, A16.5
development, A58.8	Family courts)	biosafety levels, A16.17
intent, A58.8	K-12 schools, A7.2	clean benches, A16.7
team, A58.3, 8	Kelvin's equation, F25.11	cleanrooms, A18.1
design-phase contract, A58.7	Kirchoff's law, F4.12	clinical labs, A16.18
documentation, A58.7	Kitchens, A33	commissioning, A16.20
drawings	air balancing, A33.2	compressed gas storage, A16.8
preliminary, A58.7	multiple-hood systems, A33.3	containment labs, A16.16
working, A58.7 energy modeling, A58.9	air filtration, A33.7, 18 cooking effluent	controls, A16.11
building optimization, A58.9	control of, A33.18	design parameters, A16.2 duct leakage rates, A16.10
equipment selection, A58.9	generation of, A33.1	economics, A16.21
system optimization, A58.9	thermal plume behavior, A33.17	exhaust devices, A16.7
objectives, A58.3	dishwashers, piping, A50.7	exhaust systems, A16.9
organization, A58.1	energy conservation	fire safety, A16.11
programming, A58.1	economizers, A33.6	fume hoods, A16.3
project	reduced airflow, A33.6	controls, A16.13
closeout, A58.8	residential hoods, A33.36	performance, A16.5
delivery, A58.6	restaurants, A33.4	hazard assessment, A16.2
design, A58.5	exhaust hoods, A33	heat recovery, A16.20
manual, A58.7	ductless, A33.15	hospitals, A8.8
predesign, A58.7	recirculating systems, A33.15, 29	loads, A16.2
quality assurance/quality control (QA/QC),	replacement air, A33.20	nuclear facilities, A28.11
A58.4	residential, A33.35	paper testing labs, A26.4
schematic design, A58.7	systems, A33.7	radiochemistry labs, A16.18
specifications	type I, A33.7	safety, A16.2, 11
outline, A58.7	type II, A33.7, 14	scale-up labs, A16.17
project manual, A58.7	exhaust systems, A33.7, 36	stack heights, A16.13
training, A58.4	downdraft, A33.15	supply air systems, A16.9
Intercoolers, ammonia refrigeration systems,	ducts, A33.27; S19.10	system maintenance, A16.18
R2.11	effluent control, A33.18	system operation, A16.18
Internal heat gains, F19.13	fans, A33.28	teaching labs, A16.18
Jacketing, insulation, R10.6	hoods, A33.7	types, A16.1
Jails, A9.4	maintenance, A33.35	ventilation, A16.8
Joule-Thomson cycle, R47.6	multiple-hood systems, A33.3, 31	Laboratory information management systems
Judges' chambers, A9.5	residential, A33.36	(LIMS), A9.8
Juice, R38.1	terminations, A33.28	Lakes, heat transfer, A34.38
Jury facilities, A9.5	fire safety, A33.29, 31	Laminar flow
Justice facilities, A9	fire suppression, A33.30	air, A18.4
control rooms, A9.4, 5	multiple-hood systems, A33.31	fluids, F3.3
courthouses, A9.5	prevention of fire spread, A33.31	Large eddy simulation (LES), turbulence
courtrooms, A9.5, 5	residential, A33.37	modeling, F13.3; F24.13
dining halls, A9.4	grease removal, A33.7, 18	Laser Doppler anemometers (LDA),
energy considerations, A9.2	heat recovery, A33.5	F37.17
finalamatra managamant AO2		
fire/smoke management, A9.3	high-performance green design, A33.6	Laser Doppler velocimeters (LDV), F37.17
fire/smoke management, A9.3 firearm laboratories, A9.7 fitness facilities, A9.6	indoor environmental quality (IEQ), A33.20 in justice facilities, A9.5	Latent energy change materials, S51.2 Laundries

in justice facilities, A9.5; F25.11	humidification, S22.4	refrigerant solutions, R12.14, 16, 18
service water heating, A50.23	hydronic systems, S13.3	water, R12.29
LCR. See Load collector ratio (LCR)	internal heat load, R24.3	testing, R12.1
LD ₅₀ , mean lethal dose, A59.9	nonresidential, F18.1, 20	wax separation, R12.22
LDA. See Laser Doppler anemometers (LDA)	for offices, F18.14	Lubrication, R12
LDV. See Laser Doppler velocimeters (LDV)	precooling fruits and vegetables, R28.1	combustion turbines, S7.21
LE. See Life expectancy (LE) rating	refrigerated facilities	compressors
Leakage	air exchange, R24.5	centrifugal, S38.36
air-handling unit, S19.5	direct flow through doorways, R24.7	reciprocating, S38.11
ducts, A62.1; F21.15	equipment, R24.7	rotary, S38.14
HVAC air systems, S19.3	infiltration, R24.5	single-screw, S38.15
acceptance criteria, S19.4	internal, R24.3	twin-screw, S38.22
responsibilities, S19.4	product, R24.3	engines, S7.13
sealants, S19.2	transmission, R24.1	Mach number, S38.32
testing, S19.3	residential cooling	Maintenance. (See also Operation and
Leakage function, relationship, F16.15	residential heat balance (RHB) method,	maintenance)
Leak detection of refrigerants, F29.9	F17.2	absorption units, R18.7
methods, R8.4	residential load factor (RLF) method, F17.2	air cleaners, S29.8
Legionella pneumophila, A49.14; F10.7	residential heating, F17.11	air conditioners, retail store, A2.1
air washers, S41.10	snow-melting systems, A51.1	air washers, S41.9
control, A49.14	Load collector ratio (LCR), A35.22	automated fault detection and diagnostics
cooling towers, S40.15, 16	Local exhaust. See Exhaust	(AFDD), A39.5
evaporative coolers, S41.10	Loss coefficients	chillers, S43.5, 12
hospitals, A8.3	control valves, F3.9	coils
Legionnaires' disease, A49.14	duct fitting database, F21.10	air-cooling and dehumidifying, S23.15
service water systems, A50.31	fittings, F3.8	air-heating, S27.5
Legionnaires' disease. See Legionella	Louvers, F15.33	combined heat and power (CHP) systems.
pneumophila	Low-temperature water (LTW) system, S13.1	S7.17
LES. See Large eddy simulation (LES)	LPG. See Liquefied petroleum gas (LPG)	commissioning, A39.10
Lewis relation, F6.9; F9.4	LTW. See Low-temperature water (LTW)	condensers, S39
Libraries. See Museums, galleries, archives,	system	air-cooled, S39.13
and libraries	Lubricants, R6.1; R12. (See also Lubrication;	evaporative, S39.19
Life expectancy (LE) rating, film, A22.3	Oil)	water-cooled, S39.8
Lighting	additives, R12.8	cooking equipment, A33.34
cooling load, F18.3	ammonia refrigeration, R2.17	coolers, liquid, S42.6
greenhouses, A24.14	component characteristics, R12.4	cooling towers, S40.15
heat gain, F18.3	evaporator return, R12.18	costs, A37.7
plant environments, A24.17	halocarbon refrigeration	documentation, A39.7
sensors, F7.10	compressor floodback protection, R1.31	energy recovery equipment, \$26.7, 10
Light measurement, F37.31	liquid indicators, R1.32	evaporative coolers, S41.9
LIMS. See Laboratory information	lubricant management, R1.16	filters, air, S29.8
management systems (LIMS)	moisture indicators, R1.32	gaseous air cleaners, A46.17
Linde cycle, R47.6	purge units, R1.33	industrial air-conditioning systems, A14.8
Liquefied natural gas (LNG), S8.6	receivers, R1.33	infrared heaters, \$16.5
vaporization systems, S8.6	refrigerant driers, R1.32	kitchen ventilation systems, A33.34, 37
Liquefied petroleum gas (LPG), F28.5	separators, R1.31	laboratory HVAC equipment, A16.18
Liquid overfeed (recirculation) systems, R4	strainers, R1.32	liquid chillers, \$43.15
ammonia refrigeration systems, R2.20	surge drums or accumulators, R1.31	makeup air units, \$28.10
circulating rate, R4.4 evaporators, R4.6	mineral oil	manual, A39.8 renovations and retrofits, A39.9
	aromatics, R12.3	· · · · · · · · · · · · · · · · · · ·
line sizing, R4.7	naphthenes (cycloparaffins), R12.3 nonhydrocarbons, R12.3	solar energy systems, A35.25
liquid separators, R4.7 overfeed rate, R4.4		staffing, A39.8
· · · · · · · · · · · · · · · · · · ·	paraffins, R12.3	training, A39.8 turbines
pump selection, R4.4 receiver sizing, R4.7	miscibility, R12.17 moisture content, R8.1	combustion, S7.21
C*		
recirculation, R4.1 refrigerant distribution, R4.3	properties, R12.8	steam, \$7.30
terminology, R4.1	floc point, R12.22	unit heaters, S28.8 Makeup air units, S28.8
	viscosity, R12.8	•
Lithium bromide/water, F30.71	refrigerant	applications, S28.8
Lithium chloride, S24.2	contamination, R7.7	codes, S28.9
LNG. See Liquefied natural gas (LNG)	sampling, R7.11	commissioning, \$28.9
Load calculations	solutions, R12.12	controls, A47.17; S28.9
altitude effects, F16.12; F18.15	requirements, R12.2	design, S28.8
cargo containers, R25.10	retrofitting, R12.33	maintenance, S28.10
coils, air-cooling and dehumidifying, S23.14	separators, R11.24	selection, S28.8
computer calculation, A40.9	solubility	standards, S28.9
diversity factor, F18.14	air, R12.30	types, \$28.9
elevation correction factors, F18.15	hydrocarbon gases, R12.24	Malls, A2.7

Manometers, differential pressure readout,	power, F37.37	cooling tower, F19.22
A38.12	pressure, F37.13	data-driven, F19.27
Manufactured homes, A1.8	rotative speed, F37.28	empirical (regression-based) models, F19.15
airflow modeling example, F13.18	sound, F37.29	equation-based, F19.3
Masonry, insulation, F26.7. (See also Building	temperature, F37.4	Gaussian process, F19.30
envelopes)	thermal comfort, F37.31	heat pump, F19.22
Mass transfer, F6	uncertainty analysis, A41.13; F37.3	moisture in buildings, F25.15
convection, F6.5	velocity, F37.15	occupant behavior, F19.14
eddy diffusion, F6.9	vibration, F37.29	part-load ratio, F19.15
Lewis relation, F6.9; F9.4	Meat, R30	thermal (hot-box method), F25.8
energy recovery, air-to-air, S26.5	display refrigerators, R15.7	uncertainty, F19.5
heat transfer simultaneous with, F6.10	food processing, R30.1	validation, F19.37
air washers, F6.12	frozen, R30.16	Moist air
cooling coils, F6.13	packaged fresh cuts, R30.11	psychrometrics, F1.1
cooling towers, F6.13	processing facilities	thermodynamic properties
dehumidifying coils, F6.13	boxed beef, R30.7	standard pressure, F1.14
direct-contact equipment, F6.10	carcass coolers, R30.2	temperature scale, F1.2
enthalpy potential, F6.10	energy conservation, R30.17	transport properties, F1.19
molecular diffusion, F6.1 in liquids and solids, F6.4	pork trimmings, R30.10 processed meats, R30.12	Moisture (See also Humidity) in animal facilities, A24.2
two-film theory, S30.21	sanitation, R30.1	barriers, R10.6
Mass-transit systems	shipping docks, R30.17	in building materials, F25.10
buses, A11.1, 2	variety meats, R30.11	capacity, F25.2
bus garages, A15.22	retail storage, R15.10	combustion, F28.13
bus terminals, A15.24	thermal properties, R19.1	condensation, S22.3
diesel locomotive facilities, A15.27	Mechanical equipment room, central	content, A62.11; F25.2
enclosed vehicular facilities, A15.1	central fan room, A4.12	control, F25; F26; F27
environmental control, A11.1	floor-by-floor fan rooms, A4.12	terminology, F25.1
fixed-guideway vehicles, A11.1	floor-by-floor units, A4.12	diffusivity, F37.34
rail cars, A11.1, 5	multiple floors, A4.11	farm crops content, A25.1
rapid transit, A11.5; A15.11	Mechanical traps, steam systems, S11.8	flow
stations, A15.14	Medium-temperature water (MTW) system,	and air- and heat flow, F25.14
thermal comfort, A11.1; A15.15	S13.1	isothermal, F25.13
thermal load analysis, A11.2; A15.15	Megatall buildings, A4.1	mechanisms, F25.11
tunnels	Meshes, for computational fluid dynamics, F13.4	modeling, F25.15
railroad, A15.16	refining, F13.11	flux, F25.2
rapid transit, A15.11	Metabolic rate, F9.6	hygrothermal modeling, F25.15
subway, A15.11	Metals and alloys, low-temperature, R48.6	indoor/outdoor vapor pressure difference,
ventilation, A11.1; A15.5	Microbial growth, R22.4	F36.9
McLeod gages, F37.13	Microbial volatile organic chemicals	dwellings, F36.7
Mean infectious dose (ID ₅₀), A59.9	(MVOCs), F10.8	natatoriums, F36.9
Mean lethal dose (LD ₅₀), A59.9	Microbiology of foods, R22.1	schools, F36.10
Mean radiant temperature (MRT),	Microphones, F37.29	student rooms, F36.10
A54.1	Mines, A29	in insulation, F26.1
Mean temperature difference, F4.22	heat sources, A29.2	for refrigeration piping, R10
Measurement, F37. (See also Instruments)	mechanical refrigeration plants, A29.10	management in buildings, F36 measurement, F37.33
air contaminants, F37.35 air exchange rates, F16.13	spot coolers, A29.10 ventilation, A29.1	measurement, F37.33 meters, A62.11
air exchange rates, F16.13 airflow, A38.2	wall rock heat flow, A29.3	paint, effects on, F25.16
air infiltration, F37.24	Modeling. (See also Data-driven modeling;	permeability, F37.34
air leakage, F16.16	Energy, modeling)	permeance, F37.34
airtightness, F37.24	airflow, A18.5	problems, in buildings, F25.10
air velocity, F37.15	around buildings, F24.12	ratio, F25.2
carbon dioxide, F37.25	in buildings, F13.1	in refrigerant systems
combustion analysis, F37.35	contaminant transport, F13.1, 16	control, R7.1
contaminants, F37.35	multizone, F13.1, 14	desiccants, R7.3
data acquisition, F37.35	turbulence, F13.3	driers, R7.6
data recording, F37.35	wind tunnels, F24.12	drying methods, R7.2
electricity, F37.27	Bayesian analysis, F19.37	effects, R7.1
fluid flow, A38.12; F3.10; F37.20	boilers, F19.21	hydrocarbon gases' solubility, R12.24
gaseous contaminants, A46.6	calibration, F19.34	indicators, R7.3
heat transfer in building materials, F37.34	coefficient of variance of the root mean	lubricant solubility, R12.29
humidity, F37.10	square error [CV(RMSE)], F19.35	measurement, R7.3; R8.3
light levels, F37.31	normalized mean bias error (NMBE), F19.35	solubility, R7.1
mechanical power, F37.37	change-point, F19.28	sources, R7.1; R8.1
moisture content, F37.32; R7.3	regression, F19.30	solar vapor drive, F25.3
in refrigeration systems, R8.3	chillers, F19.21	sorption isotherms, F37.33
odors, F12.5	controls, F19.23	sorptive surfaces, F36.4

storage in building materials, F26.13	dehumidification, A23.17, 19	laboratories, A28.11
tolerance, F36.1	exhibit cases, A23.5	medical and research reactors, A28.11
transfer, F25.2	humidification, A23.17	other buildings and rooms, A28.10
	,	
examples, F27.7	mold growth, A23.5	power plants, A28.6
transient, F25.13	outdoor air, A23.18	pressurized water reactors, A28.8
transmission data, F26.1	relative humidity, effect on artifacts, A23.5	radioactive waste facilities, A28.12
vapor balance, F36.2	system selection, A23.16	safety design, A28.2
vapor release, F36.4	temperature, effect on artifacts, A23.3	standards, A28.12
dwellings F36.7	MVOCs. See Microbial volatile organic	terminology, A28.1
natatoriums, F36.9	compounds (MVOCs)	tornado and wind protection, A28.2
water vapor retarders, F16.18; F26.12	Natatoriums. (See also Swimming pools)	Number of transfer units (NTU)
Mold, A62.1; F25.16	air conditioning, A5.6	cooling towers, S40.19
	<u> </u>	•
Mold-resistant gypsum board, A62.7	dehumidifiers, S25.6	heat transfer, F4.23
Molecular sieves , R18.10; R41.9; R47.13; S24.5.	duct design, A5.7	Nursing facilities, A8.15
(See also Zeolites)	envelope design, A5.7	service water heating, A50.11
Montreal Protocol, F29.1	load estimation, A5.6	Nuts, storage, R42.7
Morgues, A8.1	pool water chemistry, A5.8	Odors, F12
Motors, S45	ventilation requirements, A5.7	analytical measurement, F12.5
air volume control, S45.13	Natural gas, F28.5	control of, in industrial exhaust gas cleaning,
codes, S45.2	liquefaction, R47.8	S30.26, 27
	· · · · · · · · · · · · · · · · · · ·	
compressors, \$38.6	liquefied, R47.3	factors affecting, F12.2, 5
controls, S45.6	pipe design, F22.37	odor units, F12.5
current imbalance, S45.2	processing, R47.19	olf unit, F12.6
efficiency, S45.2	separation, R47.18	sense of smell, F12.1
evaporative cooling, A52.12	Navier-Stokes equations, F13.2	sensory measurement, F12.2
field assembly and refrigerant contamination,	Reynolds-averaged, F13.3	acceptability, F12.5
R7.8	NC curves. See Noise criterion (NC) curves	sources, F12.1
furnaces, residential, S33.2	Net positive suction head (NPSH), A34.34;	suprathreshold intensity, F12.3
	•	threshold, F12.1
general purpose, S45.3	R2.9; S44.10	,
harmonics, S45.18	Network airflow models, F19.25	ODP. See Ozone depletion potential (ODP)
hermetic, S45.5	Night setback, recovery, A42.43	Office buildings
burnout, R7.8, 8	Nitrogen	air conditioning, A3.2, 3
impedance, S45.15	liquid, R47.3	space requirements, A3.5
integral thermal protection, S45.5	recovery, R47.17	load density, F18.14
inverter duty, S45.16	Noise, F8.13. (See also Sound)	service water heating, A50.11, 18
noise, S45.17	air conditioners, room, S50.4	Oil, fuel, F28.7
operation above base speed, S45.8	combustion, F28.19	characteristics, F28.8
power factor correction capacitors, S45.18		
	compressors	distillate oils, F28.7
power supply (AC), S45.1	centrifugal, S38.5, 34	handling, S31.15
protection, \$45.5	single-screw, S38.19	heating value, F28.9
pumps, centrifugal, S44.9, 15	condensing units, R15.18	pipe design, F22.38
service factor, S45.4	control, with insulation, F23.5	preparation, S31.16
standards, S45.2	controls, A18.24	residual oils, F28.7
starting, and electricity, S45.8	engine test facilities, A17.4	storage buildings, A27.10
switching times, S45.15	fans, S21.11	storage tanks, S31.15
torque, S45.4	fluid flow, F3.14	sulfur content, F28.9
• '		
in variable-frequency drives, S45.15	health effects, F10.20	viscosity, F28.8
voltage imbalance, S45.1	water pipes, F22.22	Oil. (See also Lubricants)
Movie theaters, A5.3	Noise criterion (NC) curves, F8.16	in refrigerant systems, R12.3
MRT. See Mean radiant temperature (MRT)	Noncondensable gases	in two-phase flow, F5.15
Multifamily residences, A1.7	condensers, water-cooled, S39.7	Olf unit, F12.6
Multiple-use complexes	refrigerant contamination, R7.8	One-pipe systems
air conditioning, A6.8	Normalized mean bias error (NMBE), F19.33	chilled-water, S13.19
design criteria, A6.1	NPSH. See Net positive suction head	steam convection heating, S11.12; 1993
load characteristics, A6.1	(NPSH)	Fundamentals, Chapter 33, pp. 18-19 (See
	· · · · ·	
systems, A6.1, 2	NTU. See Number of transfer units (NTU)	explanation on first page of index.)
energy inefficient, A6.2	Nuclear facilities, A28	Operating costs, A37.4
total energy, A6.3	air filtration, A28.3, 8	Operation and maintenance, A39. (See also
Multisplit unitary equipment, S49.1	codes, A28.12	Maintenance)
Multizone airflow modeling, F13.14	criticality, A28.1	automated fault detection and diagnostics
applications example, F13.18	decommissioning, A28.11	(AFDD), A39.5
approaches, F13.16	Department of Energy facilities requirements	commissioning, A39.10
verification and validation, F13.17	confinement systems, A28.4	compressors, S38.40
	ventilation, A28.5	desiccant dehumidifiers, S24.8
Museums, galleries, archives, and libraries		
air distribution, A23.18	fire protection, A28.2	documentation, A39.7
air filtration, A23.18	HVAC design considerations, A28.1	industrial exhaust systems, A32.9
artifact deterioration, A23.5	Nuclear Regulatory Commission requirements	exhaust gas cleaning equipment, S30.29
building construction, A23.13	boiling water reactors, A28.9	laboratory HVAC equipment, A16.18

manuals, A39.8	system selection, A26.4	adaptation, F9.17
new technology, A39.10	testing laboratories, A26.4	age, F9.17
renovations and retrofits, A39.9	Paraffins, R12.3	body surface area (DuBois), F9.3
responsibilities, A39.8	Parallel compressor systems, R15.13	clothing, F9.8
staffing, A39.8	Particulate matter, indoor air quality (IAQ),	cooling load, F18.3
training, A39.8	F10.5	DuBois equation, F9.3
Optimization, A42.4	Passive heating, F19.27	energy balance, F9.2
applications, A42.1	Pasteurization, R33.2	heat stress, F9.21, 26
dynamic, A42.5, 27	beverages, R39.6	heat transfer coefficients
static, A42.4, 21 Outdoor air, free cooling	dairy products, R33.2	convective, F9.7
cooling towers, \$40.12	eggs, R34.4, 9 juices, R38.4, 7	evaporative, F9.8 Lewis relation, F9.4
liquid chillers, S43.11	Peak dew point, A62.9	radiative, F9.7
Outpatient health care facilities, A8.14	Peanuts, drying, A25.9	hypothalamus, F9.1
Owning costs, A37.1	PEC systems. See Personal environmental	hypothermia, F9.1
Oxygen	control (PEC) systems	latent heat loss, F9.3, 10
in aircraft cabins, A12.9	PEL. See Permissible exposure limits	mechanical efficiency, F9.6
liquid, R47.3	(PEL)	metabolic rate, F9.6
recovery, R47.17	Performance contracting, A41.2	models, F9.20
Ozone	Performance monitoring, A47.6	respiratory heat loss, F9.4
activated carbon air cleaner, A46.15	Permafrost stabilization, R45.4	seasonal rhythms, F9.17
in aircraft cabins	Permeability	sensible heat loss, F9.3
catalytic converters, A12.14	clothing, F9.8	sex, F9.17
limits, A12.15	vapor, F37.34	skin heat loss, F9.3, 5
electronic air filters, S29.8	water vapor, F25.2	skin wettedness, F9.22
health effects, F10.15	Permeance	thermal exchanges, F9.2
Ozone depletion potential (ODP),	air, F25.2	thermoregulation, F9.1
F29.5	thickness, F37.34	vasodilation, F9.1
Packaged terminal air conditioners (PTACs),	water vapor, F25.2	Pigs. See Swine
S50.5	Permissible exposure limits (PELs), F10.5	Pipes, S46. (See also Piping)
residential, A1.7	Personal environmental control (PEC)	buried, heat transfer analysis, S12.17
Packaged terminal heat pumps (PTHPs), S50.5	systems, F9.26	codes, S46.6
residential, A1.7	Pharmaceutical manufacturing cleanrooms,	cold springing, F22.14; S12.26; S46.12
PAH. See Polycyclic aromatic hydrocarbons	A18.9	computer analysis, A40.11
(PAHs)	Pharmacies, A8.9	copper tube, F22.15; S46.1
Paint, and moisture problems, F25.16	Phase-change materials, thermal storage in,	design, F22
Panel heating and cooling, S6. (See also	S51.16, 27	expansion, S12.25
Radiant heating and cooling)	Photographic materials, A22	expansion bends, S46.11
advantages, S6.10	processing and printing requirements,	expansion joints, S46.12
capillary tube mats, S6.6	A22.1	expansion loops, F22.13; S46.10, 11
cooling, S6.1	storage, A22.1, 3	fittings, F22.18; S46.2
design, S6.10	unprocessed materials, A22.1	fluid flow, F3.1
calculations, S6.7	Photovoltaic (PV) systems, S36.18. (See also	heat transfer analysis, S12.15
disadvantages, S6.10	Solar energy)	insulation, F23.13
electric heating systems, S6.14	Physical properties of materials, F33	hangers, F23.13
ceiling, S6.14	boiling points, F33.1, 2	installation, F23.13
floor, S6.16	building materials, F26	underground, F23.15
wall, S6.16	density	iron, F22.15; S46.2
heat flux	liquids, F33.2	joining methods, F22.18; S46.2
combined, S6.4	solids, F33.3	plastic, F22.25; S46.7, 8
natural convection, S6.3	vapors, F33.1	selection, S46.6
thermal radiation, \$6.2	emissivity of solids, F33.3	sizing
heating, S6.1	freezing points, F33.2	ammonia systems capacity tables, R2.15, 16
hybrid HVAC, S6.1	heat of fusion, F33.2 heat of vaporization, F33.2	fittings, F22.6, 28 fuel oil, F22.38
hydronic systems, floor, S6.13	solids, F33.3	
wall, S6.13	specific heat	gas, F22.37 hydronic systems, F22.26; S13.23
Paper	liquids, F33.2	insulation and vapor retarders, R2.18
moisture content, A20.2	solids, F33.3	isolated line sections, R2.18
photographic, A22.1	vapors, F33.1, 2	pressure drop equations, F22.5
storage, A22.3	thermal conductivity	refrigerant, retail food store refrigeration,
Paper products facilities, A26	solids, F33.3	R15.12
air conditioning, A26.2	vapors, F33.1	service water, F22.23
conduction drying, A30.3	viscosity	steam, F22.29
control rooms, A26.3	liquids, F33.2	valves, F22.6, 28; R2.15
evaporative cooling, A52.13	vapors, F33.1	water, F22.22
finishing area, A26.3	Physiological principles, humans. (See also	standards, fittings, F22.18; S46.2
machine area, A26.2	Comfort)	steel, S46.1
· · · · · · · · · · · · · · · · · · ·		

stress calculations, S46.7	air distribution, A5.2	freezing, R31.5
supporting elements, S12.26; S46.8	air filtration, A5.1	packaging, R31.7
Piping. (See also Pipes)	air stratification, A5.2	processing, R31.1, 4
boilers, S11.3	arenas, A5.4	processing plant sanitation, R31.9
capacity tables, R1.6-15	atriums, A5.9	recommended environment, A24.8
codes, S46.6	auditoriums, A5.3	refrigeration, retail, R31.10
cooling towers, S14.2; S40.11	concert halls, A5.4	storage, R31.10
district heating and cooling	convention centers, A5.5	tenderness control, R31.10
distribution system, S12.13	exhibition centers, A5.5	thawing, R31.11
heat transfer, S12.15	fairs, A5.8	Power grid, A61.7
hydraulics, S12.13	gymnasiums, A5.5	Power-law airflow model, F13.14
insulation thickness, S12.25	houses of worship, A5.3	Power plants, A27
leak detection, S12.34	lighting loads, A5.1	buildings
relative costs, S12.28	mechanical equipment rooms, A5.3	oil pump, A27.10
types, S12.27	movie theaters, A5.3	oil storage, A27.10
valve vaults, S12.35	natatoriums, A5.6	steam generator, A27.5
geothermal energy systems, A34.8	playhouses, A5.3	turbine generator, A27.7
heat carrying capacity, S13.3	precooling, A5.2	coal-handling facilities, A27.5, 10
hydronic snow melting, A51.11	sound control, A5.1	combined heat and power (CHP), S7.1
insulation, R10.1	space conditions, A5.1	combustion turbine areas, A27.9
refrigerant	stadiums, A5.4	control center, A27.9
ammonia systems, R2.1; R3.7	temporary exhibit buildings, A5.8	cooling, A27.11
below-ambient, R10.1	vibration control, A5.1	design criteria, A27.1
halocarbon systems, R1.1	Planes. See Aircraft	dust collectors, A27.11
heat gain limits, R10.1	Plank's equation, R20.7	evaporative cooling, A52.14
insulation, R10.1, 5	Plant environments, A24.10	fuel cells, S7.22
jacketing, R10.6	controlled-environment rooms, A24.16	heating, A27.11
pipe preparation, R10.2	design, A24.10	safety, A27.12
supports and hangers, R10.8	greenhouses, A24.10	substations, A27.9
	,	switchyard control structures, A27.9
vapor retarders, R10.5 service hot water, A50.3	carbon dioxide enrichment, A24.14 cooling, A24.13	turbines
	-	
solar energy, A35.11; S37.3	energy conservation, A24.16	combustion, S7.18
sound	evaporative cooling, A24.13	steam, \$7.24
control, A48.50	heating, A24.11	ventilation, A27.4
transmission, A38.24	heat loss calculation, A24.11	rates, A27.3
standards, S12.27; S46.6	humidity control, A24.14	PPD. See Predicted percent dissatisfied
system identification, F38.10	photoperiod control, A24.15	(PPD)
systems	shading, A24.13	Prandtl number, F4.17
ammonia refrigeration, R2.14	site selection, A24.10	Precooling
halocarbon refrigeration	supplemental irradiance, A24.14	buildings, A42.44
capacity tables, R1.4–10, 11–15	ventilation, A24.13	flowers, cut, R28.11
compressor, R1.20	other facilities, A24.21	fruits and vegetables, load calculation,
defrost gas supply lines, R1.26	photoperiod control, A24.15	R28.1
discharge lines, R1.24	phytotrons, A24.20	indirect evaporative, A52.2
double hot-gas risers, R1.24	plant growth chambers, A24.16	places of assembly, A5.2
draining prevention, R1.24	supplemental irradiance, A24.14	Predicted mean vote (PMV), F37.32
evaporator, R1.23	Plenums	comfort, F9.18
gas velocity, R1.2	mixing, S4.7	Predicted percent dissatisfied (PPD), F9.18
hot-gas	sound attenuation, A48.18	Preschools, A7.1
(discharge) mufflers, R1.25	stratification in, A38.2	Pressure
bypass, R1.35	PMV. See Predicted mean vote (PMV)	absolute, F37.13
insulation, R1.6	Police stations, A9.1	aircraft cabins, A12.9, 11, 13, 15
liquid cooler, flooded, R1.21, 22	Pollutant transport modeling. See Contami-	clean spaces, A18.20
location and arrangement, R1.5	nants, indoor, concentration prediction	differential, F37.13
minimum gas velocities, R1.24	Pollution , air, and combustion, F28.9, 17	conversion to head, A38.12
oil transport up risers, R1.24	Polycyclic aromatic hydrocarbons (PAHs),	hospitals, A8.4
refrigerant feed devices, R1.22	F10.6	readout, A38.12
single riser and oil separator, R1.24	Polydimethylsiloxane, F31.12	dynamic, F37.13
vibration and noise, R1.6	Ponds, spray, S40.6	gage, F37.13
solar energy, A35.11; S37.6, 7	Pope cell, F37.12	measurement, A38.2; F37.13
steam, S11.3, 5	Positive building pressure, A62.9	sensors, F7.10
water, S13.6; S15.6	Positive positioners, F7.8	smoke control, A53.6, 8
unit heaters, S28.7	Potatoes	stairwells, A53.8, 12
vibration control, A48.50	processed, R40.5	static control, A47.9; F37.13
vibration transmission, A38.24	storage, A52.14	steam systems, S11.4
Pitot tubes , A38.2; F37.17	Poultry. (See also Animal environments)	units, F37.13
Places of assembly, A5	chilling, R31.1	vacuum, F37.13
air conditioning, A5.2	decontamination, R31.4	

Pressure drop. (See also Darcy-Weisbach	cavitation, S44.10	angle factor, \$16.5
equation)	commissioning, S44.15	effective radiant flux (ERF), A54.2; S16.5
correlations, F5.15	construction, S44.1	fixture efficiency, S16.4
district heating and cooling, S12.13	efficiency, best efficiency point (BEP),	mean radiant temperature (MRT),
pipe design, F22.1	S44.7	A54.1; S6.1
in plate heat exchangers, F5.18	energy conservation, S44.15	operative temperature, A54.1
two-phase fluid flow, F5.15	impellers, trimming, S44.7, 9, 10	pattern efficiency, S16.4
Primary-air systems, S5.10	installation, S44.15	radiant flux distribution, \$16.6
Printing plants, A20	mixing, S13.8	radiation-generating ratio, S16.4
air conditioning, A20.1	motors, S44.15	test instruments, A54.7
air filtration, A20.4	operation, S44.15	total space heating, A54.6
binding areas, A20.5	performance, S13.6; S44.4	Radiant time series (RTS) method, F18.2, 22
collotype printing rooms, A20.4	power, S44.7	factors, F18.22
letterpress areas, A20.2	radial thrust, \$44.10	load calculations, nonresidential, F18.1 Radiation
lithographic pressrooms, A20.3 paper moisture content control, A20.2	selection, S44.11 types, S44.2	atmospheric, A35.5
platemaking rooms, A20.2	variable-speed, S13.9	diffuse, F15.17, 20
relief printing areas, A20.2	chilled-water, A42.12, 13, 24	electromagnetic, F10.21
rotogravure pressrooms, A20.4	sequencing, A42.12, 15	ground-reflected, F15.17
salvage systems, A20.4	condenser water, A42.24	optical waves, F10.22
shipping areas, A20.5	as fluid flow indicators, A38.13	radiant balance, F4.15
ink drying, A30.3	geothermal wells, A34.36	radio waves, F10.22
Prisons, A9.4	lineshaft, A34.6	solar, A35.3
Produce	submersible, A34.6	thermal, F4.2, 11; S6.1
desiccation, R21.1	horsepower, S44.7	angle factors, F4.13
deterioration rate, R21.1	hydronic snow melting, A51.13	blackbody, F4.12
display refrigerators, R15.8	liquid overfeed systems, R4.4	black surface, F4.2
Product load, R15.5	net positive suction head, S14.1, 2	display cases, R15.5
Propane	solar energy systems, A35.11	energy transfer, F4.11
commercial, F28.5	systems, water, S13.6; S15.5	exchange between surfaces, F4.14
furnaces, residential, S33.9	variable-speed, A42.13, 26	in gases, F4.16
Propylene glycol, hydronic systems, S13.24	Purge units, centrifugal chillers, S43.11	gray, F4.2, 12
Psychrometers, F1.13	PV systems. See Photovoltaic (PV) systems;	heat transfer, F4.2
Psychrometrics, F1	Solar energy	infrared, F15.17
air handlers, S4.4	Radiant heating and cooling, A55; S6.1; S15;	Kirchoff's law, F4.12
altitude effects, F1.1, 14	S33.4. (See also Panel heating and cooling)	monochromatic emissive power, F4.12
chart, F1.14	applications, A54.8	nonblack, F4.12
adiabatic mixing, F1.17	asymmetry, A54.5	spectral emissive power, F4.12
heat absorption and moisture gain, F1.18	beam heating design, A54.4; S16.5	transient, F4.8
moist air, cooling and heating, F1.16	control, A47.4	Radiators, S36.1, 5
thermodynamic properties, F1.14	design, A54.2, 3	design, S36.3
evaporative cooling systems, A52.1, 10, 17, 18	direct infrared, A54.1, 4, 8	nonstandard condition corrections, S36.3
humidity parameters, F1.12	equations, A54.2	types, S36.1
industrial drying, A30.1	floor reradiation, A54.5	Radioactive gases, contaminants, F11.21
moist air	infrared, A54.1, 4, 8; S16	Radiometers, A54.7
standard atmosphere, U.S., F1.1	beam heater design, S16.5	Radiosity method, F19.26
thermal conductivity, F1.20 thermodynamic properties, F1.2, 14	control, S16.4 efficiency, S16.4	Radon , F10.16, 22 control, F16.21
transport properties, F1.19	electric, S16.2	indoor concentrations, F11.19
viscosity, F1.19	energy conservation, S16.1	removal, A46.15
perfect gas equations, F1.12	gas-fired, S16.1	Rail cars, R25. (See also Cargo containers)
water at saturation, thermodynamic properties,	indirect, S16.2	air conditioning, A11.5
F1.6	maintenance, S16.5	air distribution, A11.7
PTACs. See Packaged terminal air condition-	oil-fired, S16.3	heaters, A11.7
ers (PTACs)	precautions, S16.4	vehicle types, A11.5
PTHPs. See Packaged terminal heat pumps	reflectors, S16.4	Railroad tunnels, ventilation
(PTHPs)	installation, A54.8	design, A15.17
Public buildings. See Commercial and public	intensity, S16.1	diesel locomotive facilities, A15.27
buildings; Places of assembly	panels, A54.1, 8; S34.4; S36.6	equipment, A15.33
Pumps, F19.18	applications, A54.8	locomotive cooling requirements, A15.17
cavitation, S14.2	control, A47.4	tunnel aerodynamics, A15.18
centrifugal, S44	heating, S34.4	tunnel purge, A15.18
affinity laws, S44.8	hydronic systems, S36.6	Rain, and building envelopes, F25.4
antifreeze effect on, S13.24	radiation patterns, A54.5	RANS. See Reynolds-Averaged Navier-Stoke
arrangement, S13.7; S44.12	snow-melting systems, A51.16	(RANS) equation
pumping, S44.12	terminology	Rapid-transit systems. See Mass-transit
standby pump, S44.13	adjusted dry-bulb temperature, A54.1	systems
casing, S44.2	ambient temperature, A54.1	Rayleigh number, F4.20

Ray tracing method, F19.27	ethane series, F30.10–21	building configuration, R23.1
RC curves. See Room criterion (RC)	flow rate, R1.2	initial building considerations, R23.1
curves	hydrolysis, R6.5	location, R23.1
Receivers	methane series, F30.2–3	shipping and receiving docks, R23.3
ammonia refrigeration systems, high-pressure,	propane series, F30.25	single-story structures, R23.2
R2.11	propylene series, F30.26-31	specialized storage facilities, R23.3
halocarbon refrigerant, R1.26	refrigeration system practices, R1.1	stacking arrangement, R23.2
liquid overfeed systems, R4.7	thermal stability, R6.3	utility space, R23.3
Recycling refrigerants, R9.3	zeotropic blends, F30.32-37	freezers, R23.10
Refrigerant/absorbent pairs, F2.15	hydrocarbons	insulation, R23.12
Refrigerant control devices, R11	ethane, F30.48–49	load calculations, R24.1
air conditioners, S49.7; S50.2	ethylene, F30.56-57	refrigerated rooms, R23.4
automobile air conditioning, A10.8	isobutane, F30.54–55	refrigeration systems
capillary tubes, R11.24	methane, F30.46-47	condensate drains, R23.9
coolers, liquid, S42.5	<i>n</i> -butane, F30.52–53	defrosting, R23.9
heat pumps	propane, F30.50-51	fan-coil units, R23.8
system, S9.8	propylene, F30.58-59	multiple installations, R23.10
unitary, S49.11	insulation for piping, R10.1	unitary, R23.7
lubricant separators, R11.24	leak detection, F29.9; R8.4; R9.2	valves, R23.9
pressure transducers, R11.4	lines, oil management, R1.16	sanitation, R21.10
sensors, R11.4	lithium bromide/water, F30.71	temperature pulldown, R23.15
short-tube restrictors, R11.31	lubricant solutions, R12.12	vapor retarders, R23.5, 12
switches	moisture in, R7.1	Refrigeration, F1.16. (See also Absorption;
differential control, R11.2	performance, F29.6	Adsorption)
float, R11.3	phaseout, costs, A37.8	absorption cycle, F2.13
pressure control, R11.1	piping, R1.2	adsorption cycle, F2.20
valves, control	pressure drop	air coolers, forced-circulation, R14.1
check, R11.21	discharge lines, R1.5	air transport, R27.3, 5
condenser pressure regulators, R11.15	suction lines, R1.3	ammonia systems, R2
condensing water regulators, R11.20	properties, F29.1	compressors, R2.1
expansion	electrical, F29.6	controls, R2.15
electric, R11.10	global environmental, F29.1	converting systems, R2.20
expansion, R11.5, 14	physical, F29.6	equipment, R2.1
float, R11.17	rail car air conditioning, A11.5	liquid recirculation (overfeed), R2.20, 21
pressure relief devices, R11.22	reclamation, R9.4	lubricant management, R2.17
solenoid, R11.18	removing contaminants, R9.2	multistage systems, R2.19
suction pressure regulators, R11.14	recovery, R9.3	piping, R2.14
Refrigerants, F29.1	recycling, R9.3	safety, R2.25
absorption solutions, F30.71	safety, F29.6	system selection, R2.18
ammonia, F30.40-41	classifications, F29.2	two-stage screw compressor, R2.19
chemical reactions, R6.4	sampling, R7.10	valves, R2.17
refrigeration system practices, R2.1	sound velocity, F29.6	vessels, R2.11
refrigeration systems, R3.1	specific heat, F30; F30.75	autocascade systems, R48.1
ammonia/water, F30.71	specific volume, F30	azeotropic mixture, F2.6
analysis, R6.1	speed of sound, F30; F30.76	beverage plants, R39.11
automobile air conditioning, A10.11	surface tension, F30	biomedical applications, R49.1
azeotropic, F2.6	sustainability, R6.11	breweries, R39.3
bakeries, R41.7	system chemistry, R6.1	carbon dioxide systems, R3.1
carbon dioxide, F30.44–45	system reactions, R6.3	cascade systems, R48.3
refrigeration systems, R3.1	systems, lubricants, R12.1	chemical industry, R46.1, 2, 5
cascade refrigeration systems, R48.3	thermal conductivity, F30; F30.75	coefficient of performance (COP),
charge minimization, R1.36	thermodynamic properties, F30	F2.3, 14
chemical evaluation techniques, R6.10	thermophysical properties, R3.2	compression cycles
and climate change, F29.1	transport properties, F30	Carnot cycle, F2.6, 7
compatibility with materials, R6.8	vapor pressure, F30; F30.75	Lorenz cycle, F2.9
computer analysis, A40.17	velocity of sound, F30; F30.75	multistage, F2.10
contaminants in, R7	viscosity, F30; F30.75	zeotropic mixture, F2.10
cryogenic fluids, F30.60–69	water/steam, F30.42–43	concrete, R45.1
density, F30; F30.75	zeotropic, F2.6, 10	condensers, cascade, R5.1
effect on materials, F29.10	Refrigerant transfer units (RTU), liquid	food
emissions, R9.1	chillers, S43.11	eggs and egg products, R34.1
enthalpy, F30; F30.75	Refrigerated facilities, R23	fish, R32.1
entropy, F30; F30.75	air handling and purification, R21.10	vegetables, R37.1
environmental acceptability, R6.1	automated, R23.4, 15	food processing facilities, R40.1
flammability, R6.1	construction, R23.4	banana ripening rooms, R36.5
halocarbons	construction, R23.4 controlled-atmosphere storage, R23.3	control of microorganisms, R22.3
azeotropic blends, F30.39	controlled-atmosphere storage, R23.3 controls, R21.10	meat plants, R30.1
charge minimization R1 36	design	food service equipment R16
CHAISC HITHIIIZALION IN 1 30	ALSI211	IAAA ACI YICE EUUIDIDEDI. N 10

fruits, fresh, R35.1; R36	storage, R15.10	Retrofitting refrigerant systems, contaminan
halocarbon systems, R1	walk-in, R16.4	control, R7.10
accessories, R1.29	Regulators. (See also Valves)	Reynolds-averaged Navier-Stokes (RANS)
charge minimization, R1.36	condenser pressure, R11.15	equation , F13.3; F24.13
heat exchangers, R1.29	condensing water, R11.20	airflow around buildings simulation, F24.12
lubricant management, R1.16	draft, \$35.30	Reynolds number, F3.3
refrigerant receivers, R1.28	pressure, steam, S11.9	Rice, drying, A25.9
subcoolers, R1.30	suction pressure, R11.14	RMS. See Root mean square (RMS)
valves, R1.6	Relative humidity, F1.12	Road tunnels, A15.3
heat reclaim, service water heating, A50.11 ice rinks, R44.1	Residential health care facilities, A8.15	carbon monoxide
	Residential systems, A1 air cleaners, S29.10	allowable concentrations, A15.9
insulation, R10.1 liquid overfeed systems, R4.1	air leakage, F16.16	analyzers and recorders, A15.10, 11 computer analysis, A15.3
loads, R24.1; R40.3	calculation, F16.24	vehicle emissions, A15.8
low-temperature	codes, S19.1	ventilation
autocascade systems, R48.1	dehumidifiers, A1.5	air quantities, A15.8, 9
cascade systems, R48.3	equipment sizing, A1.2	computer analysis, A15.3
heat transfer, R48.10	forced-air systems	controls, A15.11
material selection, R48.6	design, S10.1, 3	ducts, A15.10
secondary coolants, R48.10	distribution design, S10.7	emergency, A15.1
single-refrigerant systems, R48.2	ducts, S10.5	air quantities, A15.9
lubricant coolers, R5.2	efficiency testing, S10.10	enclosed facility, A15.3
marine, R19	furnaces, S33.1	enhancements, A15.8
fishing vessels, R19.7	zone control, S10.7	equipment, A15.33
ships' stores, R19.4	furnaces, S33.1	hybrid, A15.8
refrigerant systems chemistry, R6.1	gas burners, S31.5	mechanical, A15.5
refrigerated-facility design, R23.1	heating and cooling systems, A1.1	natural, A15.5
retail food store systems, R15.11	humidifiers, S10.2; S22.6	normal air quantities, A15.8
secondary coolant systems, R13.1	kitchen ventilation, A33.35	normal conditions, A15.1
applications, R13.5	oil burners, S31.11	pressure evaluation, A15.9
coolant selection, R13.1	ventilation, F16.18	temporary, A15.1
design, R13.2	water heating, A50.12	Roof overhang, A62.7
soils, subsurface, R45.3, 4	Resistance, thermal , F4; F25; F26. (See also	Roofs, U-factors, F27.2
systems	R-values)	Room air distribution, A57; S20.1
charging, factory, R8.4	calculation, F4.1	air terminals, A57.1
component balancing, R5.1	contact, F4.8	chilled beams, A57.18; S20.10
contaminant control, R7.1 sampling, R7.10	of flat assembly, F25.6 of flat building components, F25.6	classification, A57.1; S20.1 fully stratified, A57.6; S20.3
dehydration, factory, R8.1	overall, F4.3	mixed, A57.2; S20.2
design balance points, R5.2	radiant panels, S6.5	occupant comfort, A57.1; S20.1
energy and mass balance, R5.3	surface film, F25.6	occupied zone, A57.1
moisture in, R8.1	Resistance temperature devices (RTDs),	partially mixed, A57.9; S20.4
performance, R5.4	F7.9; F37.6	Room criterion (RC) curves, F8.16
testing, factory, R8.4	Resistivity, thermal, F25.1	Root mean square (RMS), F37.1
ultralow-temperature, R48.1	Resource utilization factor (RUF), F34.2	RTDs. See Resistance temperature devices
wineries, R39.8	Respiration of fruits and vegetables, R19.17	(RTDs)
Refrigeration oils, R12. (See also Lubricants)	Restaurants	RTS. See Radiant time series (RTS)
Refrigerators	energy conservation, A33.4	RTU. See Refrigerant transfer units (RTU)
commercial	kitchen ventilation, A33.1	RUF. See Resource utilization factor (RUF)
blast, R16.3	service water heating, A50.11, 11, 21	Rusting , of building components, F25.16
energy efficiency, R16.7	Retail facilities, A2	R-values, F23; F25; F26. (See also Resistance
freezers, R16.3	air conditioning, A2.1	thermal)
temperatures, R16.2	convenience centers, A2.6	zone method of calculation, F27.5, 5
types, R16.1	department stores, A2.5	Safety
cryocoolers, R47.11	design considerations, A2.1	air cleaners, A46.16; S29.11
food service, R16.1	discount and big-box stores, A2.2	automatic controls, A47.18
household, R17.1 absorption cycle, R18.8	load determination, A2.1 malls, A2.7	burners, S31.1, 2, 20 chemical plants, R46.2
cabinets, R17.2	multiple-use complexes, A2.7	cryogenic equipment, R47.28
defrosting, R17.5	refrigeration, R15.1; R16	electrical, A56.1
durability, R17.12	shopping centers, A2.7	filters, air, S29.11
ice makers, R17.2	small stores, A2.1	industrial exhaust gas cleaning, S30.29
performance evaluation, R17.9	supermarkets, A2.3	nuclear facilities, A28.1
refrigerating systems, R17.4	refrigerators, R15.1	refrigerants, F29.2, 6
safety, R17.12	service water heating, A50.11	service water heating, A50.32
mortuary, R16.3	Retrofit performance monitoring,	solar energy systems, A35.25
retail food store	A41.4	thermal insulation and fires, F23.6
display, A2.3; R15.2		thermal insulation for, F23.2

177707		1 1 1 7 7 7 00
UVGI systems, A60.11; S17.7	pipe design, F22.23	computer analysis, A53.7, 22
water systems, S15.8	requirements, A50.12	design fires, A53.16
wood stoves, S34.6	residential, A50.12	dilution, A53.6
Sanitation	safety, A50.32	elevators, A53.12
food production facilities, R22	scale, A50.32	extraordinary incidents, A53.23
control of microorganisms, R22.4	sizing water heaters	fire and smoke dampers, A53.2
egg processing, R34.13	instantaneous and semi-instantaneous,	fire management, A53.1
HACCP, R22.4	A50.27	hospitals, A8.5
meat processing, R30.1	storage heaters, A50.12, 15	pressurization, A53.6, 8
poultry processing, R31.9	solar energy, A35.13, 17, 26; A50.10	rapid-transit systems, A15.14
regulations and standards, R22.5	steam, S11.1	road tunnels, A15.9
refrigerated storage facilities, R21.10	system planning, A50.2	smoke movement, A53.3
Savings-to-investment-ratio (SIR),	thermal storage, S51.17	buoyancy, A53.4, 6
A37.11	water heating equipment	elevator piston effect, A53.5
Scale	placement, A50.34	expansion, A53.4
	*	*
control, A49.4	sizing, A50.12, 27	forced ventilation, A53.5
humidifiers, S22.5	types, A50.8	stack effect, A53.3
service water systems, A50.32	water quality, A50.32	wind, A53.5
water treatment, A49.4	SES. See Subway environment simulation	stairwells
scaling indices, A49.4	(SES) program	analysis, A53.9
Schneider system, R23.7	Shading	compartmentation, A53.9
Schools	devices, indoor, F15.38	open doors, A53.12
air conditioning, A7.2	fenestration, F15.3	pressurized, A53.8
service water heating, A50.23	Ships, A13	tenability systems, A53.22
elementary, A50.11	air conditioning	testing, A53.22
high schools, A50.12, 18	air distribution, A13.2, 4	weather data, A53.3
Seasonal energy efficiency ratio (SEER)	controls, A13.3, 4	zones, A53.15
unitary equipment, S49.6	design criteria, A13.1, 3	Snow-melting systems, A51
Security. See Chemical, biological, radio-	equipment selection, A13.2, 3	back and edge heat losses, A51.7, 8
	* *	
logical, and explosive (CBRE) incidents	systems, A13.2, 4	control, A51.10
Seeds, storage, A25.12	cargo holds, R19.2	electric system design
SEER. See Seasonal energy efficiency ratio	cargo refrigeration, R19.1	constant wattage systems, A51.15
(SEER)	coils, A13.4	electrical equipment, A51.13
Seismic restraint, A48.52; A55.1	ducts, A13.3	gutters and downspouts, A51.17
anchor bolts, A55.7	fish freezing, R19.8	heat flux, A51.13
design, A55.1	fish refrigeration	idling, A51.18
design calculations	icing, R19.8; R32.1	heating elements, A51.13
examples, A55.8–14	refrigerated seawater, R19.8; R32.2	infrared systems, A51.16
static analysis, A55.2, 3	merchant, A13.1	installation, A51.16
duct construction, S19.12	naval surface, A13.3	mineral insulated cable, A51.13
dynamic analysis, A55.2	refrigerated stores, R19.4	free area ratio, A51.1
installation problems, A55.14	refrigeration systems, R19.1	freeze protection systems, A51.10, 18
snubbers, A55.8	regulatory agencies, A13.3	heat balance, A51.1
terminology, A55.2	Shooting ranges, indoor, A9.8	heating requirement
weld capacities, A55.8	Short-tube restrictors, R11.31	annual operating data, A51.8
Semivolatile organic compounds (SVOCs),	Silica gel, S24.1, 4, 6, 12	heat flux equations, A51.2
F10.4, 12; F11.15	Single-duct systems, all-air, S4.11	hydronic and electric, A51.1
	• •	•
Sensors	SIR. See Savings-to-investment ratio	load frequencies, A51.3
automatic controls, F7.9, 10	(SIR)	surface size, A51.7
location, A47.21	Skating rinks, R44.1	transient heat flux, A51.7
Separators, lubricant, R11.24	Skylights, and solar heat gain, F15.21	weather data, A51.3
Service water heating, A50	Slab heating, A51	wind speed, A51.7
combined heat and power (CHP),	Slab-on-grade foundations, A44.11	hydronic system design
S7.43	SLR. See Solar-load ratio (SLR)	components, A51.10
commercial and institutional, A50.13	Smart building systems, A61.1	controls, A51.13
corrosion, A50.32	actuators, A61.7	fluid heater, A51.12
design considerations, A50.2	diagnostics, A61.1	heat transfer fluid, A51.10
distribution system	levels of intelligence, A61.6	piping, A51.11
for commercial kitchens, A50.7	Smart grid, A61.7, 10	pump selection, A51.13
manifolding, A50.8	basics, A61.7	thermal stress, A51.13
•		· · · · · · · · · · · · · · · · · · ·
piping, A50.3	interconnections, A61.8	operating costs, A51.10
pressure differential, A50.3	sensors A61.5	slab design, hydronic and electric,
return pump sizing, A50.6	strategy, A61.10	A51.8
two-temperature service, A50.7	Smoke control, A53	snow detectors, A51.10
geothermal energy, A34.8	acceptance testing, A53.23	Snubbers, seismic, A55.8
indirect, A50.10, 26	atriums, A53.16	Sodium chloride brines, F31.1
industrial, A50.25	commissioning, A53.22	Soft drinks, R39.10
Legionella pneumophila, A50.31	compartmentation, A53.5, 9	Software

AFDD, A61.4	liquid, S37.2, 7, 11	cooling towers, S40.14
antispyware, A40.2	passive, A35.15	data reliability, A48.1
custom programming, A40.4	pool heating, A35.15	design, A48.8, 38; F8.15
development tools, A40.4	recirculation, A35.15	ducts, A48.12
energy analysis, F19.5	residential, A1.4	sound attenuation, A48.18; F8.13
firewall, A40.2	sizing, A35.20	enclosures, F8.13
graphics, A40.3	thermosiphon, A35.13	engine test facilities, A17.4
HVAC, A40.9	heat pump systems, S9.4	equipment sound levels, A48.8
readymade, A40.4	hybrid systems, A35.16	fans, A48.10
road tunnel, A15.3	hydraulics, A35.26	fume hood duct design, A48.34
terminology, A40.2	installation, A35.24	hotels and motels, A6.8
utilities, A40.2, 16	irradiation, A35.3; F14.8	insertion loss, A48.21
Soils. (See also Earth)	maintenance, A35.25	justice facilities, A9.6, 7
stabilization, R45.3, 4	overheat protection, A35.25	mechanical equipment rooms, A48.35
temperature calculation, S12.16	passive systems, A35.15, 16, 22	noise criterion (NC) curves, F8.16
thermal conductivity, F26.13; S12.15	photovoltaic (PV) systems, A35.27; S37.19	outdoor equipment, A48.33
Solar energy, A35; S37.1 (See also Solar heat	quality and quantity, A35.1	piping, A48.50, 51
gain; Solar radiation)	radiation at earth's surface, A35.3	places of assembly, A5.1
active systems, A35.15, 17, 20	radiative cooling, A35.16	return air system sound transmission, A48.38
airflow, A35.26	safety, A35.25	rooftop air handlers, A48.11
collectors, A35.5, 6, 11, 25; S37.3	service water heating systems, A35.13, 18, 26;	room criterion (RC) curves, F8.16
array design, S37.7	A50.10; S51.3	room sound correction, A48.30
concentrating, A35.7	sizing heating and cooling systems, A35.19	standards, A48.55
construction, S37.6	solar angles, A35.1	terminology, F8.11
design and installation, A35.25	solar-combi systems, S37.1	troubleshooting, A38.20
efficiency, A35.10	solar time, A35.2	variable-air-volume (VAV) systems, A48.10
flat plate, A35.5 module design S37.6	spectrum, A35.3 start-up procedure, A35.25	cooling towers, S40.14 ducts, A48.12
mounting, A35.24	thermal storage systems, A35.11, 26	loudness, F8.14
performance, A35.9; S37.9	short circuiting, S37.14	measurement, F37.29
selection, S37.10	sizing, S37.15	basics, F8.6
testing, S37.10	time, A35.2, 2	instrumentation, A38.19; F8.4
types, S37.3	types, S37.14	level meter, F8.4
combi systems, A35.1, 17	uses, A35.26	power, F8.2
constant, A35.1	Solar heat gain , F15.14; F18.16	pressure, F8.1
control, A35.25, 27; S37.17	calculation, F15.19, 32	speed, F8.2
automatic temperature, S37.17	coefficient, F15.19	terminology
differential temperature, S37.17	residential load calculations, F17.9	bandwidths, F8.8
hot-water dump, S37.19	roof overhangs, F15.34	controlling, F8.11
overtemperature protection, S37.18	skylights, F15.21	decibel, F8.1
cooling systems, A35.15, 18, 27	Solar-load ratio (SLR), A35.22	frequency, F8.2
absorption refrigeration, A35.18; S37.4, 10	Solar-optical glazing, F15.14	frequency spectrum, F8.15
sizing, A35.20	Solar radiation, F14.8; F15.14	intensity, F8.2
types, A35.15	daylighting, F15.1	level, F8.1
design, installation, operation checklist,	flux, F15.33	loudness, F8.14
A35.25	optical properties, F15.16	pressure, F8.1
design values, solar irradiation, A35.3	Solid fuel	quality, F8.14
domestic hot water, A35.13, 26	burners, S31.17	wavelength, F8.2
equipment, S37.1	coal, F28.9	testing, A38.19
f-Chart method, A35.21	coke, F28.13	time averaging, F8.4
freeze protection, A35.24; S37.3, 19	Solvent drying, constant-moisture, A30.7	transmission, A38.20
heat exchangers, A35.11; S37.15	Soot , F28.20	humidity affecting, S22.2
external, S37.16	Sorbents, F32.1	paths, F8.9
freeze protection, S37.19	Sorption isotherm, F25.10; F26.20	troubleshooting, A38.20
internal, S37.16	Sound, F8. (See also Noise)	typical sources, F8.10
performance, S37.17	air outlets, S20.2	unit heaters, \$28.6
requirements, S37.15	attenuators, A48.18	Sound control, A48; F8. (See also Noise)
heating systems, A35.15; S51.3	bandwidths, F8.4	air handlers, S4.10
active, A35.15, 17	combustion, F28.19	combustion turbines, S7.21
air, S37.2, 8, 11	compressors, A48.15	engines, S7.16
components, A35.11	computerized analysis, A40.12	Soybeans, drying, A25.7
control, A35.12	control, A48; F8	Specific heat
design, S37.2	acoustical design of HVAC systems, A48.1	equation, F2.5
direct circulation, A35.13; S37.3	A-weighted sound level (dBA), F8.16	foods, R19.7
hybrid, A35.16	barriers, A48.33; F8.11	liquids, F33.2
indirect, A35.14; S37.3	ceiling sound transmission, A48.38 chillers, A48.15	materials, F33.1
integral collector storage systems, A35.14;		Split-flux method, F19.26 Spot cooling
S37.4	clean spaces, A18.24	Spot cooming

evaporative, A52.12	drainage and return, S12.14	desiccant dehumidification, S24.10
industrial environments, A31.4, 6; A52.12	drip stations, S12.14	high-pressure, S24.13
makeup air units, S28.8	return pipes, S12.27	design, refrigerated-facility, R23.1
mines, A29.10	convection heating, S11.11	eggs, R34.6
Spot heating, A54.4	design, S11.2; S36.3	farm crops, A25.9
Stack effect	piping, S11.5	fish
duct design, F21.2	pressure, S11.4	fresh, R32.3
multizone airflow modeling, F13.14	distribution, S11.13	frozen, R32.7
smoke movement, A53.3	district heating and cooling, S12.26	flowers, cut, R21.12
Stadiums, A5.4	valve vaults, S12.35	food, canned or dried, R21.11
Stairwells	district heating and cooling, S12.8, 27, 40	fruit
smoke control, A53.8	flash steam, S11.14	dried, R42.7
stack effect and infiltration, F16.7	percentage, S11.2	fresh, R35.1
Standard atmosphere, U.S., F1.1	flash tank, S11.14	furs and fabrics, R21.11
Standards, F40. (See also Codes)	gas, effects of, S11.2	ice, R43.3
air cleaners, S29.3, 5	generator buildings, A27.5	meat products, frozen, R30.16
air conditioners, S49	heat exchangers, S11.3	milk, R33.4
packaged terminal, S50.7	heating, A49.17	nursery stock, R21.12
room, S50.4	heat recovery	nuts, R42.7
unitary, S49.6, 7	direct recovery, S11.15	photographic materials, A22.3, 4
air distribution, A57.1	flash steam, S11.14	unprocessed, A22.1
boilers, S32.6	waste heat boilers, S11.3	potatoes, A52.14
chilled-beam system, A57.19	makeup air units, S28.9	poultry products, R31.10
chimneys, fireplaces, and gas vents, S35.30, 34	one-pipe systems, S11.12; 1993 Fundamentals,	refrigerated-facility design, R23.1
condensers, S39	Chapter 33, pp. 18-19 (See explanation on	seeds, A25.12; R21.13
evaporative, S39.19	first page of index.)	tanks, secondary coolant systems, R13.2
water-cooled, S39.7	piping	vegetables, R37.3
coolers, liquid, S42.4	distribution, S11.5	dried, R42.7
dehumidifiers, room, S25.4	Hartford loop, S11.3	ventilation for, F16.21
duct construction, S19.1	inlet orifices, S11.13	wine, R39.10
electrical, A56.16	return, S11.3, 6	wood products, A26.2
filters, air, S29.3, 5	sizing, F22.29	Stoves, heating, S34.5
furnaces, S33.10	supply, S11.3, 5, 13	Stratification
green buildings, F16.1	terminal equipment, S11.6	of air
heaters, S34.6, 7	temperature control, S11.13	in places of assembly, A5.2
heat pumps, S49	terminal equipment	in plenums, A38.2
packaged terminal, S50.7	forced-convection, S11.11	of water, in thermal storage tanks, S51.4
unitary, S49.6, 7	natural convection, S11.11; S36.1	Stroboscopes, F37.28
water-source, S49.13	piping design, S11.6	Subcoolers
indoor air quality (IAQ), F10.11	radiant panel, S11.11	condensers, S39
liquid chillers, S43.4	traps, S11.7	evaporative, S39.17
makeup air units, S28.9	turbines, S7.24	water-cooled, S39.5
motors, S45.2, 16	two-pipe systems, S11.12	two-stage, R1.30
nuclear facilities, A28.12	unit	Subway environment simulation (SES)
pipe fittings, F22.18, S46.2	heaters, S28.4	program, A15.3
piping, S12.27; S46.6	ventilators, S28.1	Subway systems. (See also Mass-transit
sound control, A48.55	vacuum return for, S11.12	systems)
tall buildings, A4.20	valves	car air conditioning, A11.5
ventilation, F16.19	pressure-reducing, S11.9	station air conditioning, A15.14
vibration control, A48.55	safety, S11.10	ventilation, A15.11
Static air mixers, \$4.8	temperature control, S11.13	Suction risers, R2.24
Static electricity and humidity, S22.2	water, effects of, S11.2	Sulfur content, fuel oils, F28.9
Steam	Steam traps, S11.7	Superconductivity, diamagnetism, R47.5
humidifiers, S22.5	Stefan-Boltzmann equation, F4.2, 12	Supertall buildings, A4.1
quality, S11.2	Stevens' law, F12.3	Supervisory control, A42
sources, S11.2	Stirling cycle, R47.14	air-handling systems
testing, adjusting, balancing, A38.15	Stokers, S31.17	air distribution, A42.1
thermophysical properties, F30.42–43	Storage	sequencing, A42.42
Steam systems, S11	apples, A52.14; R35.1, 2	set point reset, A42.43
air, effects of, S11.2	controlled-atmosphere, R35.1, 2	boilers, A42.39
boilers, S11.3; S32.1	bakery ingredients, R41.1	building temperature set point
classification, S11.2	candy, R42.5	night setback recovery, A42.43
coils, air-heating, S27.1	carbon dioxide, R39.12	precooling, A42.44
combined heat and power (CHP) distribution,	citrus, A52.14; R36.3	chilled-water pumps, A42.12, 13, 24
S7.43	cold, facility design, R23.1	chillers
combined steam and water, S11.16	cond, facility design, R23.1 compressed gases, A16.8	load distribution, A42.16
commissioning, \$11.16	controlled-atmosphere (CA), R23.3	sequencing, A42.16, 19
condensate removal \$11.6	cryogenic fluids R47 26	computerized A40.17
NAMES AND ADDRESS OF THE PARTY	CIVOSCIIIC HUIUS, INT / 7.0	COMPUNICIONAL ATO 17

cooling tower fans, A42.8, 26	supertall buildings, A4.1	duct efficiency, S10.10
cool thermal storage systems, A42.29	system selection, A4.9	fans, S21.4
ice storage control optimization, A42.7	underfloor air distribution (UFAD) systems,	filters, air, S29.3
forecasting energy requirements, A42.36	A4.10	heaters, S34.7
optimization methods, A42.4	vertical transportation, A4.19	heat pumps
Supply air outlets, S20.2. (See also Air outlets)	water distribution systems, A4.17	packaged terminal air conditioners (PTACs),
Surface effect. See Coanda effect	Tanks, secondary coolant systems, R13.2	S50.7
Surface transportation	TDD. See Tubular daylighting devices	water-source, S49.13
automobiles, A10.1	Telecomunication facilities, air-conditioning	industrial exhaust systems, A32.9
buses, A11.2	systems, A19.1	radiant heating system, A54.7
fixed-guideway vehicles, A11.7	Temperature	refrigeration systems
rail cars, A11.5	ambient, A54.1	compressor, R8.5
Surface water heat pump (SWHP), A34.12	changeover, S5.12, 13	leak detection, R8.4
heat exchanger, S49.13 Sustainability, F16.1; F35.1; S49.2	dew-point, F1.12 dry-bulb, adjusted, A54.1	performance testing, R8.5 refrigerators, household, R17.9
and air, noise, and water pollution, F35.4	effective, A52.11; F9.21	smoke control systems, A53.23
airtightness, F16.26	humid operative, F9.21	solar collectors, S37.10
chlorofluorocarbon (CFC) production, F35.5	mean radiant, A54.1; F9.11; F37.32; S6.1	sound
climate, F35.5	measurement, F37.4	instrumentation, A38.19
design process, F35.8	odors affected by, F12.2	procedure, A38.19
energy resources, F35.2, 8	operative, A54.1	transmission problems, A38.20, 24
factors impacting, F35.2	plane radiant, F9.11; F37.32	vibration
global warming, F35.5	radiant asymmetry, F9.12	equipment, A38.22
and green design, F35.1	sensors, F7.9	instrumentation, A38.21
greenhouse gas (GHG) emissions, F35.5	sol-air, F18.24	isolators, A38.22; A48.53
infiltration, F16.1	and task performance, F9.14	piping transmission, A38.24
in integrated building design, A58.8	vertical differences, F9.15	procedure, A38.21
material resources, F35.3	wet-bulb, F1.12; F9.22	Testing, adjusting, and balancing. (See also
ozone, F35.5	wet-globe, F9.23	Balancing)
and refrigerant systems, R6.11	wind chill index, F9.23	air diffusers, A38.2
renewable energy, F35.2	Temperature-controlled transport,	air distribution systems, A38.3
and solid and liquid waste disposal, F35.4	R25.1	reporting results, A38.6
standards of care, F35.6	Temperature index, S22.3	airflow measurement, A38.2
unitary systems, \$49.2	Terminal units. [See also Air terminal units	balancing procedure, A38.5
ventilation, F16.1	(ATUs)], A47.13, F19.16; S20.7	central plant chilled-water systems, A38.14
water use, F35.3 chimney, S35.1	boxes reheat, A47.13	cooling towers, A38.15 design considerations, A38.1
SVFs. See Synthetic vitreous fibers (SVFs)	variable-air-volume (VAV), A48.11	dual-duct systems, A38.4
SVOCs. See Semivolatile organic compounds	ceiling, S20.8	duct design, F21.21
(SVOCs)	chilled beams, S5.8	energy audit field survey, A38.17
SWHP. See Surface water heat pump (SWHP)	dual-duct, S20.8	fluid flow measurement, A38.12
Swimming pools. (See also Natatoriums)	fan-coil, S5.6	HVAC systems, A38.1
dehumidifiers, S25.6	fan-powered, A47.13; S20.8	hydronic systems, A38.6
solar heating, A35.15	induction, A47.13	heat transfer vs. flow, A38.6, 7
water chemistry, A5.8	induction units, S5.10	water-side balancing
water heating for, A50.24	radiant floor heat, S5.9	instrumentation, A38.8
Swine, recommended environment, A24.7	radiant panels, S5.9	proportional method, A38.10
Symbols, F38	reheat, S20.8	rated differential method, A38.11
Synthetic vitreous fibers (SVFs), F10.6	steam systems, S11.11	sizing balancing valves, A38.8
TABS. See Thermally activated building	unit ventilators, S5.6	temperature difference method, A38.9
systems (TABS)	VAV box, F19.17	total heat transfer method, A38.11
Tachometers, F37.28	Terminology, of refrigeration, R50	induction systems, A38.6
Tall buildings, A4	Terrorism. See Chemical, biological, radio-	instruments, A38.3
codes, A4.20 HVAC design process, A4.8	logical, and explosive (CBRE) incidents TES. See Thermal energy storage (TES)	sound transmission problems, A38.20, 24 steam distribution systems, A38.15
hydrostatic considerations, A4.17	Testing	temperature controls, A38.16
life safety, A4.20	air cleaners, A46.17; S29.3	terminology, A38.1
low-temperature air VAV systems, A4.10	air conditioners, packaged terminal, S50.7	variable-air-volume (VAV) systems, A38.6
megatall buildings, A4.1	air leakage, fan pressurization, F16.15	TETD/TA. See Total equivalent temperature
refrigeration machine location, A4.17	clean spaces, A18.9	differential method with time averaging
reverse stack effect, A4.1	compressors	(TETD/TA)
stack effect, A4.1	centrifugal, S38.39	TEWI. See Total equivalent warning impact
elevator doors, A4.2	positive-displacement, S38.5	(TEWI)
heating problems, A4.2	condensers, S39	Textile processing plants, A21
manual doors, A4.2	evaporative, S39.19	air conditioning design
minimizing, A4.6	water-cooled, S39.7	air cleaning, A21.5, 7
smoke and odor propagation, A4.2	cooling towers, A38.15; S40.18	air distribution, A21.6
standards, A4.20	desiccant dehumidification for, S24.12, 13	collector systems, A21.5

health considerations, A21.7	tank insulation, S37.13; S51.6	Three-dimensional (3D) printers, F11.18
energy conservation, A21.7	temperature range, S51.4	Three-pipe distribution, S5.6
fabric making, A21.3	thermal stratification, S51.4, 5	Tobacco smoke
fiber making, A21.1	water heaters, S51.16, 19	contaminants, A46.3, 10, 11; F11.2, 19
yarn making, A21.2	water systems, medium- and high-temperature,	environmental (ETS), F10.6
TFM. See Transfer function method (TFM)	S15.7	Tollbooths
Theaters, A5.3	water treatment, S51.6	air quality criteria, A15.27
Thermal bridges, F25.8	Thermally activated building systems (TABS),	ventilation, A15.27, 33
Thermal comfort. See Comfort	A42.3, 33	Total equivalent temperature differential
Thermal displacement ventilation (TDV),	Thermal-network method, F19.11	method with time averaging (TETD/TA),
F19.17	Thermal properties, F26.1	F18.57
Thermal emittance, F25.2	air spaces, F26.13	Total equivalent warming impact (TEWI),
Thermal energy storage (TES), S8.6; S51	of food, R19	F29.5
applications, S51.23	insulation materials, F26.1	Trailers and trucks, refrigerated, R25. (See also
benefits, S51.3	safety, F26.7	Cargo containers)
building mass, S51.19	Thermal resistivity, F25.1	Transducers, F7.10, 13
combined heat and power (CHP), S7.39	Thermal transmission data, F26	Transfer function method (TFM), A40.10;
commissioning, S51.35	Thermal zones, F19.14	F18.57; F19.3
controls, S51.1	Thermistors, R11.4	Transmittance, thermal, F25.2
sequence, S51.29	Thermodynamics, F2.1	of flat building component, F25.7
_	•	
strategies, A42.44	absorption refrigeration cycles, F2.13	thermal bridging, F25.8
cool storage, A42.29; S51.1, 23	bubble point, F2.6	Transmitters, F7.9, 10
district cooling, S51.23	compressed liquid, F2.2	Transpiration, R19.19
district heating, S51.7	compression refrigeration cycles, F2.6	Transportation centers
district heating and cooling, S12.10	cooling and freezing of foods, R20.1	commercial and public buildings, A3.6
electric thermal storage (ETS), S51.16	cycle, F2.2	ventilation, A15.11, 24
brick storage heaters, S51.17	dew point, F2.6	Transport properties of refrigerants,
central furnace, S51.18	dry saturated vapor, F2.2	F30
grid interactive, S51.1, 22	enthalpy, F2.5	Traps
heat pump boosters, S51.18	entropy, F2.5	ammonia refrigeration systems
room units, S51.17	equations of state, F2.4	liquid level indicators, R2.13
underfloor heat, S51.19	laws, F2.2	purge units, R2.13
water heaters, S51.16, 19	liquid, F2.2	suction accumulator, R2.12
emergency cooling, S51.3, 21, 25	multicomponent systems, F2.5	vertical suction, R2.12
equipment	principles, F2.1	steam systems, S11.7
cooling, S51.4	process, F2.2	thermostatic, S11.7
heating, S51.16	properties, F2.2	Trucks, refrigerated, R25. (See also Cargo
grid-interactive electric thermal storage	calculation, F2.4	containers)
(GETS), S51.1, 17, 22	zeotropic mixture, F2.10	Tubular daylighting devices (TDDs),
heat storage, S51.2, 16	pure substance, F2.2	F15.30
ice, R43.3	of refrigerants, F30	Tuning automatic control systems, F7.19
ice storage, S51.2, 2	refrigeration cycle analysis, F2.3	Tunnels, vehicular, A15.1
charging and discharging, A42.29	saturated liquid or vapor, F2.2	fires, A15.3
control optimization, A42.7	subcooled liquid, F2.2	railroad, A15.16
encapsulated ice, S51.3, 13, 16	superheated vapor, F2.2	rapid transit, A15.11
•	* '	road, A15.3
harvesting system, S51.3, 6, 14	terminology, F2.1	
ice on coil, S51.2, 9, 13	vapor, F2.2	Turbines, S7
piping, S51.27	Thermometers, F37.5	benefits, S8.2
slurries, S51.15	black globe, A54.7	chiller systems, S8.5
industrial refrigeration, S51.23	error sources, F37.5	absorption, S8.6
insulation, S51.6	infrared	mechanical, S8.6
latent energy change, S51.2	radiometers, A54.7; F37.9	thermal energy storage (TES), S8.6
media, S51.2, 4	thermography, F37.9	combustion, S7.18, 45; S8.1
mission-critical operations, S51.23	liquid-in-glass, F37.5	Brayton cycle, S7.19
off-peak, heating, S51.16	resistance	components, S7.19
operation, S51.29	semiconductors, F37.6	controls, S7.21
phase-change materials, S51.2, 16, 27	temperature devices (RTDs), F37.6	dual-shaft, S7.19
piping, ice storage, S51.27	thermistors, F37.6	emissions, S7.21
process cooling, S51.23	thermocouples, F37.7	evaporative cooling applications, S8.3
renewable energy integration, S51.4, 22	Thermopile , F7.4; F37.9; R45.4	exhaust gas systems, S7.21
retrofits, S51.17	Thermosiphons	fuels, S7.20
solar energy systems, A35.11, 15, 26; S37.4,	heat exchangers, S26.16	heat recovery, S7.37
11; S51.3	solar energy systems, A35.13	inlet cooling, S8
system sizing, S51.23	Thermostats	instruments, S7.21
terminology, S51.1	heater control, S34.2, 4	lubrication, S7.21
water storage, S51.4, 34	heating/cooling, F7.12	maintenance, S7.21
aquifers, S51.7	location, A47.21	noise control, S7.21
performance, S51.5	types, F7.12	performance, S7.19
★ ************************************	VI /	± 2

single-shaft, S7.19	heat pumps, S2.3; S49.1, 9, 11	refrigerant control, R11.5	
split-shaft, S7.19	outdoor equipment, S2.9	regulating and throttling, R11.11	
starting systems, S7.21	self-contained, S2.7	safety, S47.11	
thermal output, \$7.33	split systems, S2.6; S49.1	solar energy systems, A35.12	
engine test facilities, gas, A17.3	through-the-wall, S2.3 solenoid, R11.18; S47.6		
expansion, S7.31; S43.1	window-mounted, S2.3	steam system, S11.9, 13	
fogging, S8.4	Unit heaters. See Heaters	stop-check, S47.14	
		*	
gas, S7.19	Units and conversions, F39	suction pressure regulating, R11.14	
evaporative cooling, A52.13	Unit ventilators, S28.1	thermostatic, S11.13; S47.12	
hybrid, S8.6	Utility interface, electric, S7.43	water hammer, S47.2	
microturbines, S7.18	Utility rates, A61.10	zone control, S11.13	
steam	demand response, A61.9	Vaporization systems, S8.6	
applications, S7.46	UV. See Ultraviolet (UV) lamp systems	liquefied natural gas (LNG), S8.6	
axial flow, \$7.24	UVGI. See Ultraviolet germicidal irradiation	Vapor pressure, F27.8; F33.2	
heat recovery, \$7.37	(UVGI)	Vapor retarders, jackets, F23.12	
• •	Vacuum cooling, of fruits and vegetables, R28.9	Variable-air-volume (VAV) systems	
maintenance, S7.30		· · · · · · · · · · · · · · · · · · ·	
wet compression, S8.4	Validation, of airflow modeling, F13.9, 10, 17	all-air	
wetted media, S8.4	Valves, S46. (See also Regulators)	dual-duct, S4.12	
Turbochargers, heat recovery, S7.34	actuators, S47.4	single-duct, S4.11	
Turbulence modeling, F13.3	ammonia refrigeration systems	versus constant air volume (CAV), A16.11	
identification, F13.10	control, R2.17	control, A42.1, 3, 43	
Turbulent flow, fluids, F3.3	relief, R2.18	diversity, A38.5	
Turndown ratio, design capacity, S13.4	solenoid, R2.18	dual-duct systems, S4.12	
Two-node model, for thermal comfort, F9.18	stop, R2.17	duct static pressure control, A47.9	
	* *		
Two-pipe systems, S5.5; S13.20	authority, S47.8	fan	
air-to-transmission ratio, S5.13	automatic, S47.4	selection, A48.10	
central ventilation, S5.12	actuators, S47.4	sequencing, A47.10	
changeover temperature, S5.13	control, F7.4; S47.6	unstable operation, A47.10	
chilled-water, S13.20	expansion, S23.2	humidity control, S22.15	
electric heat, S5.15	flow characteristics, S47.8	museums, galleries, archives, and libraries,	
nonchangeover design, S5.14	sizing, S47.9	A23.19	
steam convection heating, S11.12	types, S47.6	pressure-dependent systems, A38.4	
zoning, S5.14	backflow-prevention devices, S47.14	pressure-independent systems, A38.4	
U.S. Marshal spaces, A9.6	balancing, S47.10	single-duct, S4.11	
• '	<u> </u>		
U-factor	sizing, A38.8	sound control, A48.10	
center-of-glass, F15.5	body styles, S47.2	static pressure control, A38.4	
doors, F15.13; F27.7	cavitation, S47.2	static pressure reset, A42.43	
edge-of-glass, F15.5	check, R11.21; S47.13	system types, A38.5	
fenestration products, F15.7	compressors, reciprocating, S38.10	terminal boxes, A47.13; A48.11	
of flat building assembly, F25.7	condensing-pressure-regulating, R11.15	testing, adjusting, balancing, A38.4	
frame, F15.5	constant-pressure expansion, R11.14	variable-speed drives, S45.14	
thermal transmittance, F15.4	control valves, F3.8	Variable-frequency drives, S45.14	
windows, F27.7	coefficient, F3.9	and bearing currents, S45.9	
		· ·	
Ultralow-penetration air (ULPA) filters, S29.6;	discharge bypass, R11.16	carrier frequencies, S45.17	
S30.3	expansion	conductor impedance, S45.15	
Ultraviolet (UV) lamp systems, S17	constant-pressure, R11.11, 14	control, 14	
in-duct, A60.7, 10, 13	electric, R11.10	generator-powered, 18	
lamps, A60.1; S17.1, 3	thermostatic, R11.5	generators, S45.18	
germicidal, A60.4; S17.3	float control, R11.17	harmonic disturbances, S45.17	
maintenance, A60.13; S17.7	flow coefficient, S47.2	motors, S45.16	
photodegradation, S17.5	flow-limiting, S47.8	impedance, S45.15	
safety, S17.7	friction losses, F22.6, 26	pulse width modulation, S45.15	
surface disinfection, A60.9	geothermal energy, A34.7	transistors, S45.14	
terminology, S17.1	halocarbon refrigeration systems	voltage waveform distortion, S45.17	
upper-air, A60.9	equivalent lengths, R1.6	Variable refrigerant flow (VRF),	
Ultraviolet air and surface treatment, A60	float control, R1.22	S18.1; S49.1, 14	
Ultraviolet germicidal irradiation (UVGI),	hydronic systems	applications, S18.2	
A60.1; S17.1. [See also Ultraviolet (UV) lamp	control, S13.16	commissioning, S18.15	
systems]	safety relief, S13.21	design, S18.9	
in health care facilities, A8.5	manual, S47.2	life-cycle analysis tools, S18.3	
terminology, A60.3	materials, S47.1	life-cycle operating costs, \$18.3	
Uncertainty analysis	multiple-purpose, S47.11	modeling, S18.8	
· · ·		<u> </u>	
measurement, A41.13, 14; F37.3	pressure drop, F22.6, 28	multisplit system, S18.2	
statistical regression, A41.14	pressure-independent, S47.7	operation, \$18.5	
Underfloor air distribution (UFAD) systems,	pressure-reducing makeup water, S47.13	standards, S18.3	
A4.10; A57.9; F19.17	pressure relief, S47.11	VAV. See Variable-air-volume (VAV) system	
Unitary systems, S49	safety, R11.22	Vegetables, R37	
floor-by-floor systems, S2.7	ratings, S47.1	air transport, R27.1	

cooling, R28.1	security concerns, A59.8	moist air, F1.19	
deterioration rate, R21.1	sensible heat load, F16.12; F17.6	Volatile organic compounds (VOCs), F10.11	
display refrigerators, R15.8	ships, A13.1	contaminants, A46.3	
dried, storage, R42.7	shooting ranges, indoor, A9.8	Voltage, A56.1	
frozen, R40.3	standards, F16.19	imbalance, S45.1	
refrigeration, R37.1	tear gas and pepper spray, A9.3	utilization, S45.1	
storage, R37.3	terminology, F16.1	Volume ratio, compressors	
thermal properties, R19.1	thermal loads, F16.11	rotary vane, S38.14	
transport, R37.2	tollbooths, A15.26	single-screw, S38.17	
Vehicles	wind effect on, F24.8	twin-screw, S38.22	
AC- or DC-powered, transit, A11.6	Ventilators	VRF. See Variable refrigerant flow (VRF)	
design, R25.1	roof, A31.4	VRT. See Virgin rock temperature (VRT)	
equipment attachment provisions, R25.3	unit	Walls	
sanitation, R25.3	capacity, S28.3	glass block, F15.32	
temperature-controlled, R25.1 control, A47.16; S28.3		masonry construction, F27.4	
good practices, R25.11	location, S28.1	steel frame construction, F27.4	
Vena contracta, F3.4	selection, S28.1	wood-frame construction, F27.3	
Vending machines, R16.5	types, S28.1	Warehouses, A3.8	
Ventilation, F16	Venting	Water	
age of air, F16.5	altitude effects, S35.7, 32	activity, A62.10	
air change effectiveness, F16.5	furnaces, S33.2	alkalinity, A49.1, 21	
aircraft, A12.6, 15	gas appliances, S35.20	anion, A49.21	
air exchange rate, F16.4, 13	oil-fired appliances, S35.21	anode, A49.21	
airflow, F16.3	Verification , of airflow modeling, F13.9, 10, 17	biological growth, A49.8	
animal environments, A24.5	Vessels, ammonia refrigeration systems,	boiler thermal models, F19.21	
bus garages, A15.22	R2.11	cathode, A49.21	
bus terminals, A15.24	Vibration, F8.17	cation, A49.21	
cargo containers, R25.6	compressors	coils, S23.2	
dilution, A31.2; A46.7	centrifugal, S38.34		
	•	air-heating, S27.2	
displacement, S4.14	positive-displacement, S38.5	coolers, R39.10	
modeling, F19.17	single-screw, S38.19	corrosion, A49.21	
driving mechanisms, F16.13	control, A48	corrosivity, A49.21	
effectiveness, F16.5	air handlers, \$4.10	distribution, S3.6; S13.10; S15.6	
engine test facilities, A17.1	clean spaces, A18.24	central plants, \$12.11	
forced, F16.1	criteria, A48.43	district heating and cooling, S12.26	
garages, residential, F16.21	data reliability, A48.1	electrolyte, A49.21	
gaseous contaminant removal, A46.7	ducts, A48.52	filtration, A49.21	
greenhouses, A24.13	engines, S7.16	fungi, A62.10	
health care facilities, A8.1	equipment vibration, A38.22	galvanic corrosion, A49.21	
hospitals, A8.2	analysis, A38.23	hammer, F22.23	
nursing facilities, A8.15	fans, S21.12	pipe stress, S12.13	
outpatient, A8.14	floor flexibility, A48.54	hardness, A49.21	
hybrid, F16.15	isolators	heating	
indoor air quality (IAQ), F16.11	noise, A48.41	geothermal energy systems, A34.8	
industrial environments, A31	resonance, A48.54	solar energy systems, A35.13	
exhaust systems, A32.1	specifications, A48.45	water treatment for, A49.18	
kitchens, A33	testing, A38.22	humidifier supply, S22.5	
laboratories, A16.8	piping	inhibitor, A49.21	
latent heat load, F16.12; F17.6	connectors, A48.51	ion, A49.21	
leakage function, F16.15	noise, A48.50	Legionnaires' disease, A49.14	
mechanical, F16.1; F24.8	resilient hangers and supports, A48.50	passivity, A49.21	
mines, A29	places of assembly, A5.1	properties, A49.1; S15.2	
multiple spaces, F16.30	resonance, A48.54	refrigerant, F30.42-43	
natatoriums, A5.7	seismic restraint, A48.52; A55.1	in refrigerant systems. See Moisture, in	
natural	standards, A48.55	refrigerant systems	
airflow, F16.1, 13	troubleshooting, A38.23; A48.53	sludge, A49.22	
guidelines, F16.14	critical speeds, S21.11	systems, pipe design, F22.22	
modeling, F19.24	health effects, F10.19	thermal storage systems, S51.4, 16, 34	
stack effect, F16.14	measurement, F37.30	treatment, A49.1	
wind, F16.13; F24.8	instrumentation, A38.21	tuberculation, A49.22	
nuclear facilities, A28.5	testing, A38.21	use and sustainability, F35.3	
odor dilution, F12.5	Viral pathogens, F10.9	vapor (See also Moisture)	
power plants, A27.4	Virgin rock temperature (VRT), and heat	control, F25.2	
railroad tunnels, A15.16	release rate, A29.3	flow, F25.11	
rapid-transit systems, A15.11	Viscosity, F3.1	resistance, F25.2	
residential, F16.18	fuel oils, F28.8	retarders, F25.2 retarders, F26.6; R10.5; R23.5, 12; S22.3	
road tunnels, A15.3, 5	lubricants, R12.8	terminology, F25.2	
roof ventilators, A31.4	modeling, F13.10	transmission, F26.12	
,	11104011115, 1 13.10		

Water heaters	freeze prevention, S13.23	once-through systems, A49.18
blending injection, A50.10	hot-water	open recirculating systems, A49.18
boilers (indirect), A50.26	boilers, S32.1	scale control, A49.4
circulating tank, A50.10	combined heat and power (CHP)	sprayed-coil units, A49.18
combination, A50.11	distribution, S7.44	steam and condensate systems, A49.17
electric, A50.9	low-temperature (LTW),	terminology, A49.21
gas-fired, A50.8	design, S36.3	thermal storage, S51.6
heat pump, S49.5	terminal equipment, S36.1	Water vapor control, A44.6
indirect, A50.10, 25	medium- and high-temperature, S15	Water vapor permeance/permeability, F26.12,
instantaneous, A50.9, 27	air-heating coils, S15.6	17, 18
oil-fired, A50.8	boilers, S15.2	Water vapor retarders, F26.6
placement, A50.34	cascade systems, S15.5	Water wells, A34.33
refrigeration heat reclaim, A50.11	circulating pumps, S15.5	Weather data, F14
semi-instantaneous, A50.10, 27	control, S15.6	Weatherization, F16.18
sizing, A50.12, 27	design, S15.2	Welding sheet metal, S19.12
solar energy, A50.10	direct-contact heaters, S15.5	Wet-bulb globe temperature (WBGT), heat
storage, A50.8, 10, 12	direct-fired generators, S15.2	stress, A31.5
terminology, A50.1	distribution, S15.6	Wheels, rotary enthalpy, S26.9
usable hot-water storage, A50.33	expansion tanks, S15.3	Whirlpools and spas
waste heat recovery, A50.10	heat exchangers, S15.6	Legionella pneumophila control, A49.14
Water horsepower, pump, S44.7	piping design, S15.6	service water heating, A50.25
Water/lithium bromide absorption	pressurization, S15.3	Wien's displacement law, F4.12
components, R18.1	safety, S15.8	Wind. (See also Climatic design information;
control, R18.5	space heating, S15.6	Weather data)
double-effect chillers, R18.3	thermal storage, S15.7	data sources, F24.7
maintenance, R18.7	water treatment, S15.7	effect on
operation, R18.5	hot-water, S13.1	chimneys, S35.3, 33
single-effect chillers, R18.2	loads, S13.3	smoke movement, A53.5
single-effect heat transformers, R18.3	makeup, S13.20	system operation, F24.8
terminology, R18.1	open, S13.2; S14.1	pressure, F24.4
Water-source heat pump (WSHP), S2.4;	pipe sizing, S13.23	Wind chill index, F9.23
S49.11	piping, S13.12	Windows. (See also Fenestration)
Water systems, S13	water distribution, S13.6	air leakage, F15.53
air elimination, S13.21	pressure drop determination, S13.23; S44.5	solar gain, F15.14, 19
antifreeze, S13.24	pumps, S44.1	U-factors, F15.4, 7; F27.7
precautions, S13.25	pump curves, S13.6; S44.4	Wind restraint design, A55.15
capacity control, S13.13	pumping, S13.7; S44.12	minimum design wind load, A55.16
chilled-water, S13.1, 18	standby pump, S13.8; S44.13	Wineries
combined heat and power (CHP)	safety relief valves, S13.21	refrigeration, R39.9
distribution, S7.44	steam and, combined, S11.16	temperature control
district heating and cooling, S12.27	in tall buildings, A4.17	fermentation, R39.9
closed, S13.1, 2; S15.1	temperature classifications, S13.1	storage, R39.10
components, \$13.2	turndown ratio, S13.4	wine production, R39.8
condenser water, S14.1	two-pipe, S13.20	Wireless sensors, A61.6
closed, S14.4	water horsepower, S44.7	Wood construction, and moisture, F25.10
once-through, S14.1	Water treatment, A49	Wood products facilities, A26.1
open cooling tower, S14.1	air washers, A49.18; S41.9	evaporative cooling, A52.13
overpressure precautions, S14.4	biological control, A49.11	process area, A26.2
systems, S14.1	Legionella pneumophila, A49.14	storage, A26.2
water economizer, S14.4	boilers, A49.15	Wood pulp, A26.2
control valve sizing, S13.16	brine systems, A49.20	Wood stoves, S34.5
Darcy-Weisbach equation, S44.5	closed recirculating systems, A49.18	World Wide Web (WWW), A40.8
district heating and cooling, S12.8	condensers, evaporative, S39.18	WSHP. See Water-source heat pump
dual-temperature (DTW), S13.1, 20	condenser water, S14.3	(WSHP)
equipment layout, S13.23	cooling towers, A49.11, 14; S40.16	WWW. See World Wide Web (WWW)
expansion tanks	corrosion control, A49.6, 18	Xenon , R47.18
functions of, S13.4, 11	evaporative coolers, S41.9	Zeolites , R18.10; R41.9; R47.13; S24.5. (See also
sizing equations, S13.5	fundamentals, A49.1	Molecular sieves)
fill water, S13.20	medium- and high-temperature systems, S15.7	
four-pipe, S13.20	nonchemical (physical), A49.12, 20	