HVAC နယ်ပယ်၌ အလုပ်လုပ်နေသူများ၊ ၊ Marine & Offshore HVAC System
အကြောင်းကို စနစ်တကျ လေ့လာသိရှိလိုသော သဘော်သားများနှင့်
HVAC အကြောင်းကို စိတ်ဝင်စားသော နည်းပညာ ကျောင်းသားများအတွက် ရည်ရွယ်၍
လွယ်ကူ ရှင်းလင်းစွာ နားလည်သဘောပေါက်နိုင်စေရန် အတတ်နိုင်ဆုံး ကြိုးစား၍
အသေးစိတ် ရှင်းလင်း တင်ပြ ထားပါသည်။

သီအိုရီများ၊ အဓိပ္ပါယ် ရှင်းလင်းချက်များနှင့် အတူ
ပရောဂျက် တစ်ခု၏ တင်ဒါအစမှသည် ပရောဂျက် ပြီးဆုံးသည် အထိ
ဒီဇိုင်း အင်ဂျင်နီယာ တစ်ယောက် တွေ့ကြုံရမည့်၊ လုပ်ဆောင်ရမည့်
အဆင့်များကို အဓိက ထား၍ အစဉ်လိုက်အတိုင်း ပုံများ၊ စာများဖြင့်
ရှင်းလင်းစွာ တင်ပြထားသည့် အတွက် ပရောဂျက် တစ်ခုကို မည်ကဲ့သို့ လုပ်ဆောင်ရမည်
ဆိုတာကို ကောင်းစွာ သဘောပေါက် နားလည် သွားမည် ဖြစ်သလို
HVAC engineer တစ်ယောက် အနေနှင့် အလုပ်ဝင်ရန် အဆင်သင့် ဖြစ်သွားစေမည်။

စာရေးသူ၏ အမှာ

HVAC ဆိုသည် Heating, Ventilating and Air-conditioning ကို ဆိုလိုသည်။ Marine and Offshore အတွက် ဆိုသည်မှာ ပင်လယ်ပြင်တွင် အခြေအနေအမျိုးမျိုးနဲ့ သွားလာသော သင်္ဘောအမျိုးမျိုး (ships) gas carriers, crane vessels များ ကမ်းလွန် ရေနံတူးဖော်ရေးအတွက် drill ships, jack-up rigs, FPSO (Floating Production Storage and Offloading), platforms စသည်တွေ အတွက် HVAC system provide လုပ်ခြင်းကို ဆိုလိုပါသည်။ HVAC system provide လုပ်ရတဲ့ နေရာတွေကတော့ လူနေတဲ့ နေရာတွေ ဖြစ်တဲ့ living quarters (LQ) လို့ ခေါ်တဲ့ accommodation တွေ [illegible] machinery space တွေ E-House တွေ ဖြစ်ပါတယ်။

HVAC design for Marine and Offshore ဖြစ်တဲ့အတွက် commercial building တွေ, Industrial building တွေ အတွက် [illegible] design နည်းတွေ [illegible] သတိပြုစေချင်ပါတယ်။ အခြေခံသဘောတရားနဲ့ equipment တွေ ရွေးချယ်ပုံတွေ တူပေမယ့် Marine & Offshore HVAC အတွက် reference လုပ်ရတဲ့ codes တွေ standards တွေ rules and regulations တွေကတော့ အရမ်းများပါတယ်။ ကိုယ်လုပ်မဲ့ project တစ်ခုချင်းစီက သတ်မှတ် ပြဋ္ဌာန်းထားတဲ့ specifications တွေ သင်္ဘောဆိုင်ရာ classification societies တွေရဲ့ requirements တွေ ထို့ပြင် international standards တွေ vessel operating လုပ်မယ့် နိုင်ငံရဲ့ national codes တွေ စတာတွေ ကို လိုက်နာပြီး design လုပ်ရပါတယ်။

Marine and Offshore HVAC system မှာ cooling tower တွေကို သုံးလေ့မရှိပါဘူး။ Water-cooled နဲ့ air-cooled units တွေ ကိုသုံးတယ်။ Cooling load တွက်တဲ့အခါ [illegible] နေရာတစ်ခုတည်းကို ပုံသေယူပြီးတွက်လို့ မရဘူး။ [illegible] vessel တွေအတွက် operation လုပ်မယ့် နေရာအပေါ် အခြေခံပြီး design လုပ်ရပါတယ်။ ဥပမာ offshore vessel တွေ ရဲ့ HVAC design life ဟာ အနှစ် ၂၀ မှ အနှစ် (၃၀) အတွက် ရည်ရွယ်ပြီး design လုပ်ကြပါတယ်။ Operating လုပ်မယ့်နေရာဟာ ပြောင်းလဲနိုင်ပါတယ်။ အခု Brazil မှာ operation လုပ်နေပေမယ့် နောက်ဆို Australia ရောက်ချင် ရောက်နေနိုင်ပါတယ်။ Temperature -20°C ရှိတဲ့ နေရာတွေမှာ operation လုပ်ရတာလဲ ရှိသလို ပူပြင်းတဲ့ Middle East လို နေရာမျိုးတွေမှာလဲ operation လုပ်ရပါတယ်။

ပင်လယ်ပြင်ဖြစ်တော့ safety နှင့် ပတ်သက်လျှင် ပို၍ တင်းကြပ်သည်။ Hazardous gas များနှင့် အလုပ်လုပ်ရသည့် vessel တွေ အတွက် ပိုဆိုးသည်။ ပင်လယ်ထဲမှာဖြစ်တဲ့အတွက် လူတွေရဲ့အသက်ကို ပိုဂရုစိုက်ရသည်။ သုံးတဲ့ပစ္စည်းတွေကလဲ ပင်လယ်ရေ [illegible] တွေရဲ့ဒဏ်ကို ခံနိုင်ရလိုသည်။ [illegible]

[illegible] Marine and Offshore Industry မှာ [illegible] HVAC ကို [illegible] Marine and Offshore HVAC system ကို [illegible] hydronic ဆိုင်ရာ နှင့် အသေးစိတ် control ပိုင်းများ [illegible] နောက်ထွက်ရှိမည့် volume (2) တွင် ကျန်ရှိသော အခရာ [illegible] ဖြစ်ကြောင်း အသိပေးလိုပါသည်။

[illegible]
[illegible]
[illegible]

Content **Page**

Chapter (1) Understanding Psychrometrics 1
1.1 Basic of the Psychrometric Chart
1.2 Psychrometric Properties
1.3 Dry-bulb Temperature (t_{db})
1.4 Wet-bulb Temperature (t_{wb})
1.5 Dew-point Temperature (t_{dp})
1.6 Relative Humidity (RH)
1.7 Barometric Pressure (p_{bar})
1.8 Specific Enthalpy (h)
1.9 Specific Volume (v)
1.10 Humidity Ratio (W)
1.11 Water Vapour Pressure (p_{wv})
1.12 Psychrometric Process
1.13 Process Calculations
1.14 Load Calculation
1.15 Additional Information & Useful Formulae

Chapter (2) Refrigeration Basics 42
2.1 Saturation Temperature
2.2 Latent Heat
2.3 Basic Refrigeration Cycle
2.4 Understanding of P-H Chart
2.5 Understanding of Bubble Point, Dew Point and Temperature Glide
----
Chapter (3) Refrigerants 53
3.1 Refrigerant History
3.2 Classification of Refrigerants
    3.2.1 Halocarbons
    3.2.2 Hydrocarbons (HCs)
    3.2.3 Inorganic Compounds
    3.2.4 Azeotropic Mixtures
    3.2.5 Nonazeotropic (Zeotropic) Mixtures

3.3 Prefixes of Refrigerants
3.4 Numbering of Refrigerants
    3.4.1 Decoding the Number
    3.4.2 Isomers
3.5 Stratospheric Ozone Layer
3.6 Stratospheric Ozone Layer Depletion
3.7 Ozone Depletion Potential (ODP)
3.8 Greenhouse Effect (Global Climate Change)
3.9 Global Warming Potential (GWP)
3.10 Safety Group Classifications
3.11. Secondary Refrigerants
3.12. Alternative Refrigerants
3.13. Selection of Refrigerants
3.14 Comparison of Refrigerant Performance
3.15 Refrigerant Cylinder Color
3.16 Refrigerants Phase Out Schedule According to Montreal Protocol

Chapter (4) Heat Transfer 89
4.1 Conduction
4.2 Convection
4.3 Radiation
4.4 Additional Information

Chapter (5) Heating Load & Cooling Load Calculation Procedures 103
5.1 International Standard (ISO 7547)
    5.1.1 Accommodation
    5.1.2 Design Conditions
    5.1.3 Occupancy
5.2 Calculation of Heat Gains and Losses
    5.2.1 Heat Transmission
    5.2.2 Solar Heat Gain
    5.2.3 Heat Gain from Persons
    5.2.4 Heat Gain Form Lighting and Other Sources

5.3 Airflow Calculation
    5.3.1 Volume of Space
    5.3.2 Supply Airflow
    5.3.3 Temperature of Supply Airflow
    5.3.4 Exhaust Airflow
    5.3.5 Air Balance
Annex A (informative) Guidance and good practice in the design of ventilation and air-conditioning systems in ships
Annex B (informative) Thermal Conductivities of Commonly Used Construction Materials
5.4 International Standard ISO 8864
    5.4.1 Design Conditions
    5.4.2 Occupancy
    5.4.3 Calculation of Heat Gains and Losses
    5.4.4 Air flow calculation
Annex Guidance and good practice
5.5 International Standard ISO 8862
    5.5.1 Design Conditions
    5.5.2 Occupancy
    5.5.3 Calculation of heat gains
    5.5.4 Air flow calculation
Annex Guidance and good practice

Chapter (6) Starting Engineering 125
6.1 Understanding the work before Starting engineering
6.2 Starting Engineering
    6.2.1 Inputs (or) Design Requirements
    6.2.2 Air Change
    6.2.3 Cooling Capacity and Heating Capacity
    6.2.4 Selection of Main Equipment
6.3 Classification Societies
6.4 Client's Specification

Chapter (7) Heating & Cooling Loads Calculation Examples 137
7.1 Load Calculations for Wheelhouse AHU Sizing

7.1.1 Design Conditions
7.1.2 Heat Transmission Calculation for Summer
7.1.3 Solar Heat Gain
7.1.4 Heat Gain from Persons
7.1.5 Heat Gain Form Lighting and Other Sources
7.1.6 Total Heat Gain
7.1.7 Heat Transmission Calculation for Winter
7.1.8 Final Air Change and Air Quantity
7.1.9 Equipment Sizing
7.2 Load Calculations for Accommodation AHU Sizing
7.2.1 Heat Transmission Calculation for Summer
7.2.2 Solar Heat Gain
7.2.3 Heat Gain from Persons
7.2.4 Heat Gain Form Lighting and Other Sources
7.2.5 Total Heat Gain
7.2.6 Heat Transmission Calculation for Winter
7.2.7 Final Air Change and Air Quantity
7.2.8 Equipment Sizing
7.3 Comparison of Capacities After Taking the Density Effect into Consideration

---

Chapter (8) Chillers 167
8.1 Compressor
8.1.1. Reciprocating Compressor
8.1.2 Rotary Compressor
8.1.3 Centrifugal Compressor
8.1.4 Absorption Chiller
8.1.5 Compressor Selection
8.2 Evaporator
8.2.1 Flooded Shell and Tube Evaporator
8.2.2 Direct Expansion Evaporator
8.2.3 Plate Type Evaporator
8.3 Condenser
8.3.1 Water-cooled Condenser
8.3.1.1 Shell and Tube Condenser

8.3.1.2 Shell and Coil Condenser
8.3.1.3 Tube-in Tube Condenser
8.3.1.4 Brazed Plate Condenser
8.3.1.5 Heat Removal and Heat Transfer
8.3.1.6 Understanding of Log Mean Temperature Difference (LMTD)
8.3.1.7 Suggestion for Design Consideration of Condensers
8.3.1.8 Codes and Standards
8.3.1.9 Design Pressure
8.3.2 Air-cooled Condenser
8.3.2.1 Air-cooled Condenser Coil Construction
8.3.2.2 Fan and Air Requirements
8.3.2.3 Application and Rating of Condensers
8.3.3 Evaporative (Air- and Water-cooled) condenser
8.3.4 Codes and Standards
8.4 Chiller Efficiency
8.5 AHRI conditions and guide for selection of water chillers
8.6 Additional Information

Chapter (9) Air Handling Units 207
9.1 Air Handling Units (AHU)
9.1.1 Air Filters
9.1.1.1 Air Filter Standard (EN779)
9.1.1.2 Other Standards for Air Filters and Comparison
9.1.1.3 The Most Important Standard for Air Filters (ISO 16890)
9.1.1.4 Construction and Installation of Filters
9.1.1.5 Area Calculation for Air Filter
9.1.2 Cooling Coils & Heating Coils
9.1.2.1 Chilled Water Cooling Coil
9.1.2.2 DX Cooling Coil
9.1.2.3 Steam Heating Coils
9.1.2.4 Hot Water Coil
9.1.2.5 Electric Heater
9.1.2.6 Face Area, Air Velocity, and Bypass Factor
9.1.2.7 Water Velocity in Tube

9.1.2.8 Draw-Through and Blow-Through Arrangement
9.1.3 Droplet Eliminator (or) Mist Eliminator
9.1.4 Fan (Blower)
9.1.4.1 SISW, DIDW Fans and Plenum Plug Fan
9.1.4.2 Fan and Noise
9.1.4.3 Fan and Vibration
9.1.4.4 Gease for Fan Bearing
9.1.4.5 How to change the Pulley Size
9.1.5 UV (Ultraviolet) System
9.1.5.1 Lamps and Ballasts
9.1.5.2 Germicidal Lamp Cooling and Heating Effects
9.1.5.3 UV-C Lamp Irradiance
9.1.5.4 Design Guideline
9.1.5.5 Example for Sizing
9.1.5.6 UV System Applied in HVAC
9.1.5.7 Safety
9.1.6 Humidifier
9.1.6.1 Electrode & Resistive Steam Humidifiers
9.1.6.2 Humidification Load Calculation (or) Steam Humidifier Sizing
9.1.7 Dampers at AHU
9.1.8 Pressure Differential Indicator, Transmitter and Switch at AHU
9.1.9 Drain System for AHU
9.1.9.1 Calculation for Condensed Water
9.1.9.2 AHU Condensate Drain Problems
9.1.9.3 Proper Trapping
9.1.10 AHU Casing Leakage Test (EN 1886)
9.1.11 AHU Control
9.2 Fan Coil Unit (FCU)
9.3 Self-Contained Unit (SCU) and Package Unit (PU)
9.4 Rooftop Unit (RTU)
9.5 AHU with Recovery Wheel (or) Enthalpy Wheel
9.6 Equipment Panel and Frame Construction
9.7 Additional Information

Content **Page**

Chapter (10) Enclosure Rating & Area Classification
10.1 Ingress Protection Rating (IP rating)
10.2 NEMA Rating
10.3 Classified Area, Hazardous Area Rating

Chapter (11) Ductwork 287
11.1 Air Ducts and Fittings
11.1.1 Circular Ducts
11.1.2 Circular Duct Fittings
11.1.3 Flexible Ducts
11.1.4 Rectangular Ducts
11.1.5 Rectangular Duct Fittings
11.1.6 Acoustic Ducts
11.1.7 Inspection Door
11.2 SMACNA and HVCA Standards for Air Ducts
11.3 Manufacturer's Standard for Rectangular Ducts
11.4 ISO 15138 Flange Standard
11.5 Typical Duct Connection Drawings
11.6 Typical Duct Support Drawings
11.7 Typical Duct Penetration
11.8 Thermal Insulation
11.9 Minimum Insulation Thickness Calculation to Prevent Surface Condensation

Chapter (12) Supply and Extract Devices 301
12.1 Cabin Units
12.1.1 Installation of Cabin Units
12.2 4-way Diffuser
12.3 Grilles
12.3.1 Single Deflection and Double Deflection Grille
12.3.2 Egg Crate Grille
12.3.3 Typical Installation for Grilles
12.4 Penthouse Louvre
12.5 Nozzle (or) Air Valve
12.6 Recommended Velocities for Supply and Extract Devices

12.7 Coanda Effect (Surface Effect)
12.8 Additional Information

Chapter (13) Inlets & Outlets (Outfitting) 351
13.1 Mist Eliminator
    13.1.1 Typical Installation of Mist Eliminator
13.2 Weather Louver
    13.2.1 Typical Installation of Weather Louver
    13.2.2 Louver Free Area Calculation
13.3 Gooseneck
    13.3.1 Typical Installation of Gooseneck
13.4 Mushroom

Chapter (14) Dampers 363
14.1 Volume Control Damper (VCD)
14.2 Non Return damper (NRD)
14.3 Pressure Relief Damper (PRD)
14.4 Shut off Damper (SOD)
14.5 Fire Damper (FD)
    14.5.1 Electric Fire Damper
    14.5.2 Pneumatic Fire Damper
14.6 Gas Tight Damper
14.7 Blast Damper
14.8 Smoke Damper
14.9 Notes for Dampers Installation

Chapter (15) Duct Heaters 379
15.1 Reason of Using Duct Heaters
15.2 Consideration of Heating Capacity for Duct heaters
15.3 Components and Control of Duct Heater
    15.3.1 Air Flow Switch
    15.3.2 Duct Heater Control Panel
    15.3.3 Air Thermostat (Overheat Protection)
    15.3.4 Element Thermostat (Overheat Protection)

    15.3.5 Heating Element with or without Fins
    15.3.6 Surface Temperature Rise of Heater Casing
    15.3.7 Micro Switch (Cover Switch for Safety)

Chapter (16) Mechanical Ventilation System 389
16.1 Static Pressure, Velocity Pressure and Total Pressure
16.2 Procedures to Select the Ventilation Fans
16.3 Procedures at Purchasing Stage for Ventilation Fans
16.4 Determination for Pressure Loss Calculation
16.5 LQ Ventilation System
    16.5.1 Mechanical Ventilation for LQ
    16.5.2 Consideration of Required Air Flow
    16.5.3 Ventilation Fan Control (LQ)
16.6 Machinery Space Ventilation System
    16.6.1 Mechanical Ventilation for Machinery Space
    16.6.2 Consideration of Required Air Flow
    16.6.3 Calculation Example for Transformer Room
    16.6.4 Engine Room Ventilation (ISO 8861)
    16.6.5 Ventilation Fan Control (MS)
16.6.6 Spark Resistance Construction for the Ventilation Fans

Chapter (17) Duct Design 419
17.1 General System Design
    17.1.1 Initial Supply Air Velocity
    17.1.2 Aspect Ratio
17.2 Duct Friction Losses (Duct Pressure Loss)
17.3 Circular Equivalents
17.4 Dynamic Losses
17.5 How to Use ASHRAE Duct Fitting Database
17.6 Fan Outlet Conditions
17.7 Fan Inlet Conditions
17.8 Useful Conversion Factors
17.9 Duct Sizing Methods

- 17.9.1 Equal Friction Method
  - 17.9.1.1 Duct Sizing Example by Equal Friction Method
  - 17.9.1.2 Equivalent Duct Length and Pressure Drop
- 17.9.2 Balanced-capacity Method
  - 17.9.2.1 Duct Sizing Example by Balanced-capacity Method
- 17.9.3 Constant Velocity Method
  - 17.9.3.1 Duct Sizing Example by Constant Velocity Method
- 17.9.4 Velocity Reduction Method
  - 17.9.4.1 Duct Sizing Example by Velocity Reduction Method
- 17.9.5 Static Regain Method
  - 17.9.5.1 Duct Sizing Example by Static Regain Method

17.10 Additional Information