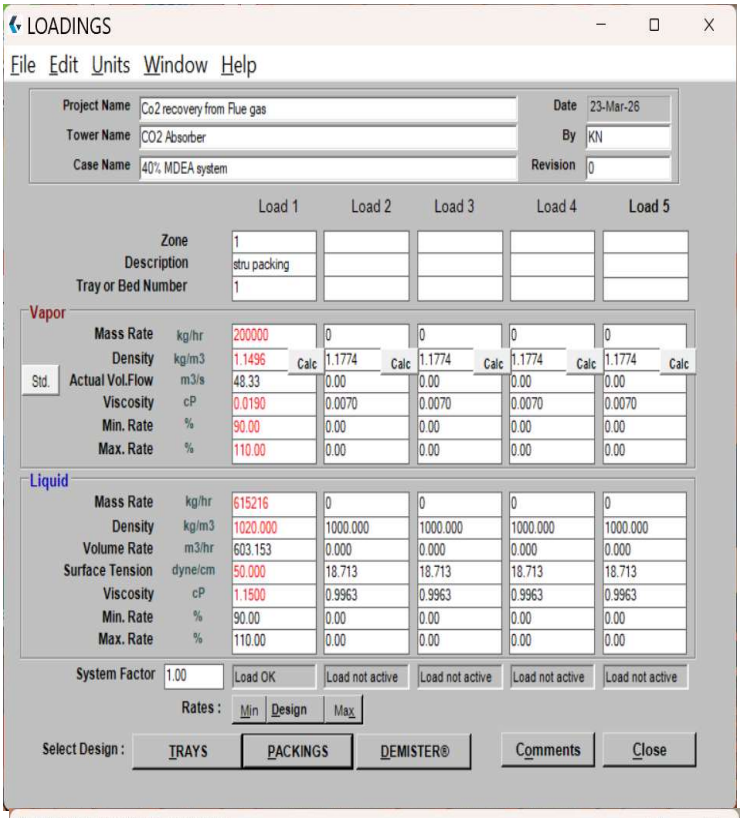
| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| **Gas Data (NTPC data considered for the calculation)** | | |
| Gas mass flow rate | 200.00 | TPH |
| Gas Composition | | |
| Carbon dioxide ($CO_2$) | 11.00 | % v/v |
| Oxygen ($O_2$) | 7.00 | % v/v |
| Water ($H_2O$) | 9.00 | % v/v |
| Nitrogen ($N_2$) | 73.00 | % v/v |
| Sulphur compound ($SO_x$) | 100.00 | ppm |
| Nitrous compound ($NO_x$) | 600.00 | ppm |
| Particulate matter (PM) | 50.00 | ppm |
| Molecular weight of components | | |
| Carbon dioxide ($CO_2$) | 44.01 | kg/kgmol |
| Oxygen ($O_2$) | 32.00 | kg/kgmol |
| Water ($H_2O$) | 18.02 | kg/kgmol |
| Nitrogen ($N_2$) | 28.02 | kg/kgmol |
| MDEA | 119.16 | kg/kgmol |
| Average molecular weihght of gas | 29.16 | kg/kgmol |
| Gas molar flow rate | 6859.30 | kgmol / hr |
| Carbon dioxide ($CO_2$) | 754.52 | kgmol / hr |
| Oxygen ($O_2$) | 480.15 | kgmol / hr |
| Water ($H_2O$) | 617.34 | kgmol / hr |
| Nitrogen ($N_2$) | 5007.29 | kgmol / hr |
| Ga volumetric flow rate at NTP condition | | |
| Pressure at NTP (P1) | 1.00 | atm |
| Temperature at NTP (T1) | 273.15 | deg.K |
| Volume at NTP (V1) | 153744.32 | $Nm^3/hr$ |
| Carbon dioxide ($CO_2$) | 16911.88 | $Nm^3/hr$ |
| Oxygen ($O_2$) | 10762.10 | $Nm^3/hr$ |
| Water ($H_2O$) | 13836.99 | $Nm^3/hr$ |
| Nitrogen ($N_2$) | 112233.35 | $Nm^3/hr$ |
| Gas actual operating condition | | |
| Pressure at actual (P2) | 10.00 | mmWC |
| | 1.01 | atm |
| Temperature at actual (T2) | 65.00 | deg.C |
| | 338.15 | deg.K |
| Volume at actual condition (V2) | 187858.19 | $Am^3/hr$ |
| Gas desmity at operating condition | 1.06 | $kg/m^3$ |
| Component to be removed from the mixture | Carbon - dioxide | |
| Recovery rate required | 96.00 | % v/v |
| Molar flow rate of recovered Carnbon - dioxide | 724.34 | kgmol / hr |
| Molar flow rate of carbon dioxide in the gas | 30.18 | kgmol / hr |

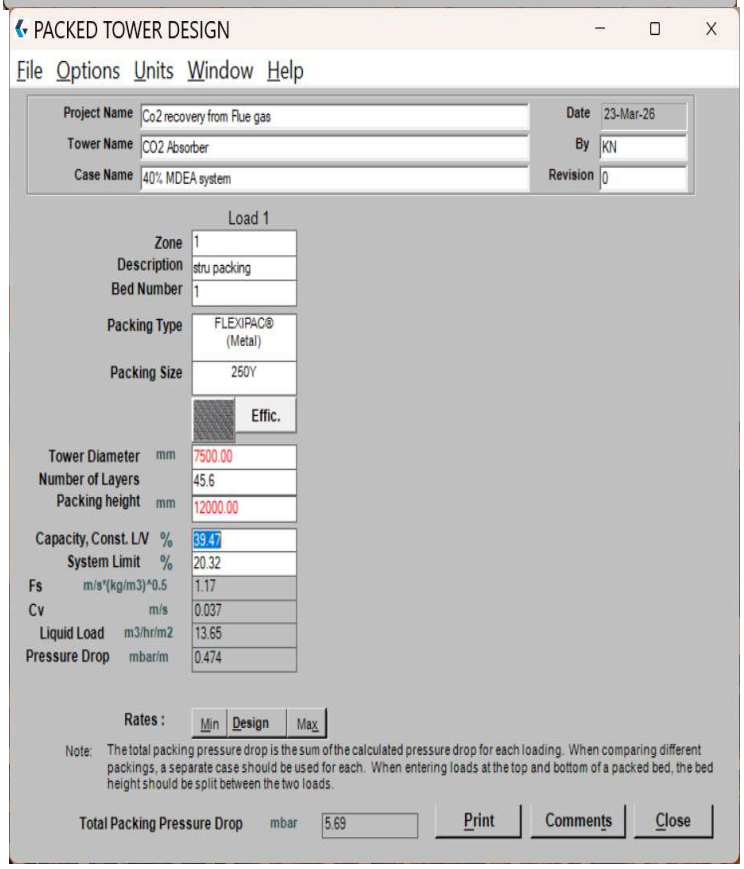
| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| Mole fraction of Carbon dioxide in feed gas (y1) | 0.11 | |
| Mole ratio of Carbon dioxide (Y1) | 0.12 | |
| Mole fraction of Carbon dioxide in exit gas (y2) | 0.00492 | |
| Mole ratio of Carbon dioxide (Y2) | 0.00 | |
| Henry Constant (Ha) | 23.60 | $cm^3$.bar / gmol |
| Desnity of the solvent | 1.04 | $g/cm^3$ |
| Molecular weight of solvent | 119.16 | g/gmol |
| Equilibrium slope (m) | 0.20 | |
| Mole ratio of Carbon dioxide in the liquid at the bottom (X1) | 0.62 | |
| Mole ratio of Carbon dioxide in the liquid at the top (X2) | 0.02 | |
| **Absorber Material Balance** | | |
| **LS (X1 - X2) = GS (Y1 - Y2)** | | |
| Mole flow rate of solvent required | 1376.79 | kgmol / hr |
| | 246086.74 | kg/hr |
| Solvent concentration in aqueous solution | 40.00 | % w/w |
| | 615216.85 | kg/hr |
| | 603.15 | $m^3$/hr |
| | | |
| **Liquid Data** | | |
| Liquid mass flow rate | 615216.85 | kg/hr |
| Liquid Composition | | |
| MDEA | 40.00 | % w/w |
| Water | 60.00 | % w/w |
| Average molecular weihgt of liquid phase | 58.46 | kg/kgmol |
| | | |
| **L/G Ratio** | | |
| By Mole basis | 1.53 | |
| By mass basis | 3.08 | |
| | | |
| **Absorption factor** | | |
| **A = L / (m.G)** | | |
| A | 1.50 | |
| Recommended range for A is 1.2 to 1.8 | | |
| | | |
| **Column Diameter determinaion** | | |
| Gas volumetric flow rate at actual condition after cooling | 187858.19 | $m^3$/hr |
| | 52.18 | $m^3$/se |
| By using Souder Brown equation, | | |
| **Gas flooding velocity = $k * ((P_L - P_G) / P_G)^{0.5}$** | | |
| Value of "k" | 0.04 | m/sec |
| Gs flooding velocity | 1.08 | m/sec |
| Cross sectional diameter of the Absorber | 48.29 | $m^2$ |
| | 7.84 | m |
| | 7.75 | m |
| Cross sectional area for the selected diameter | 47.17 | $m^2$ |

| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| **Packing Data** | | |
| Type of packing | Structural | |
| Make of packing | Sulzer | |
| Model of packing | 250 Y | |
| | | |
| Liquid surface loading check | 12.79 | $m^3/m^2.hr$ |
| Recommended liquid loading for the structural packing. The value is 12.786 is within the range. | | |
| | | |
| **Number of thermotical stages (Kremser Equation)** | | |
| NTS = $\ln[(y_1 - m \cdot x_2)/(y_2 - m \cdot x_2) \times (1 - 1/A) + 1/A] / \ln(A)$ | | |
| | | |
| Mole fraction of CO2 in the liquid pahse at the top | 0.02 | |
| y1 - m.x2 | 0.11 | |
| y2 - m.x2 | 0.00 | |
| | | |
| NTS | 14.59 | |
| Design NTS | 16.59 | |
| | 17.00 | |
| **Packing height (HETP method)** | | |
| HETP for Sulzer Mellapak 250 Y strutural packing | 0.70 | vender data |
| Height required | 11.90 | m |
| | 12.00 | m |
| | | |
| **Column Total Height** | | |
| Column packing height | 12.00 | m |
| No of beds | 3.00 | |
| Each bed height | 4.00 | m |
| Space between each bed | 1.00 | m |
| Space between liquid surface to packing bottom | 1.00 | m |
| Sump volume required (pump circulation & liquid hold up) | 3.00 | m |
| Space above the top of the bed to demister | 3.00 | m |
| Total height rquired | 21.00 | m |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | Flexera CONSULTING |
|---|---|

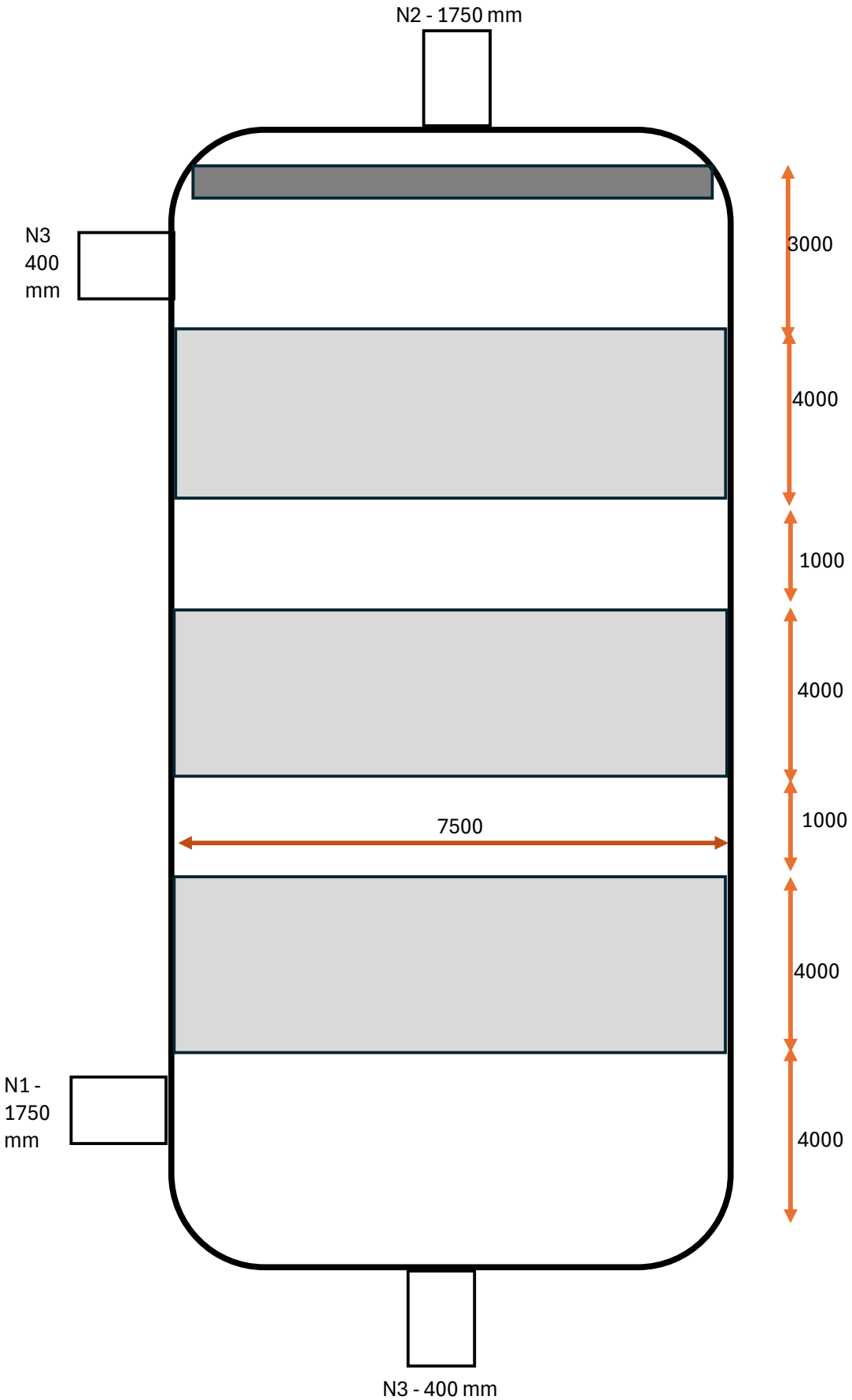
**Absorber Hydraulics**



**RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION**

Flexera CONSULTING



| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| **Stripper Data** | | |
| Solvent entered at the top of the stripper | 647095.14 | kg/hr |
| Stripper operating pressure | 2 | bar a |
| Stripper Operating Temperature | 120 | deg.C |
| | | |
| Energy required for desorption of MDEA | | |
| Heat of desorption of CO2 from MDEA | 60 | KJ/mol of CO2 |
| Energy required for the desorption | 10380544.3 | kcal/hr |
| | | |
| Sensible heat load to raise the temperature of solvent | | |
| Solvent temperature after the inter exchanger | 105 | deg.C |
| Solvent temperature required at the inlet of stripper | 120 | deg.C |
| Temperature difference | 15 | deg.C |
| Specific heat of aq solvent | 0.84 | kcal/kg deg.C |
| Sensible heat load | 8153398.77 | kcal/hr |
| | | |
| Energy required for the water evaporation along with solvent | | |
| Ratio of H2O / CO2 (on mole basis) | 0.725 | |
| Mass flow rate of CO2 in the stripper outlet | 31718.90 | kg/hr |
| Molar flow rate of CO2 in the stripper outlet | 720.72 | kgmol/hr |
| Molar flow rate of H2O in the stripper outlet | 522.52 | kgmol/hr |
| Mass flow rate of H2O in the stripper outlet | 9415.85 | kg/hr |
| Heat load required for the water evaporation | 5084558.67 | kcal/hr |
| | | |
| Total energy requried for the stripper | 23618501.7 | kcal/hr |
| Energy supplied by the steam through the reboiler | | |
| Steam operating pressure | 4.5 | bar a |
| Saturated steam temperature | 148 | deg.C |
| Latent heat of steam | 503.4 | kcal/kg |
| Steam requirement for the reboiler | 46917.96 | kg/hr |
| Specific steam requirement (kg steam / kg $CO_2$) | 1.48 | |
| | | |
| Total Vapour mass flow rate | 41134.75 | kg/hr |
| Total Vapour molar flow rate | 1243.24 | kgmol/hr |
| Total Vapour volumetric flow rate @ NTP condition | 27866.03 | $Nm^3/hr$ |
| Total Vapour volumetric flow rate @ actual condition | 20321.55 | $m^3/hr$ |
| Density of the vapour | 2.024 | $kg/m^3$ |
| | | |
| Stripper column diameter | | |
| By using Souder Brown equation, | | |
| **Gas flooding velocity** = **$k * ((P_L - P_G) / P_G)^{0.5}$** | | |
| Value of "k" | 0.025 | |
| Gs flooding velocity | 0.560 | m/sec |
| Cross sectional diameter of the Absorber | 3.58 | m |
| | 4.00 | m |

| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| | | |
| **Number of thermotical stages (as per industries practice)** | 8 | |
| | | |
| **Packing Data** | | |
| Type of packing | Structural | |
| Make of packing | Sulzer | |
| Model of packing | 250 Y | |
| | | |
| **Packing height (HETP method)** | 0.60 | vender data |
| HETP for Sulzer Mellapak 250 Y strutural packing | 4.80 | m |
| Height required | 5.00 | m |
| | | |
| | | |
| **Column Total Height** | | |
| Column packing height | 5.00 | m |
| No of beds | 1.00 | |
| Each bed height | 5.00 | m |
| Space between each bed | 0.00 | m |
| Space between liquid surface to packing bottom | 1.00 | m |
| Sump volume required (pump circulation & liquid hold up) | 3.00 | m |
| Space above the top of the bed to demister | 3.00 | m |
| Total height rquired | 12.00 | m |

**Absorber Hydraulics**

LOADINGS

File Edit Units Window Help

| | | | | | | |
|---|---|---|---|---|---|---|
| Project Name | Co2 recovery from Flue gas | | | | Date | 23-Mar-26 |
| Tower Name | CO2 Absorber | | | | By | KN |
| Case Name | 40% MDEA system | | | | Revision | 0 |

| | | Load 1 | Load 2 | Load 3 | Load 4 | Load 5 |
|---|---|---|---|---|---|---|
| Zone | | 1 | | | | |
| Description | | stru packing | | | | |
| Tray or Bed Number | | 1 | | | | |
| **Vapor** | | | | | | |
| Mass Rate | kg/hr | 41134 | 0 | 0 | 0 | 0 |
| Density | kg/m3 | 2.0240 Calc | 1.1774 Calc | 1.1774 Calc | 1.1774 Calc | 1.1774 Calc |
| Std. Actual Vol.Flow | m3/s | 5.65 | 0.00 | 0.00 | 0.00 | 0.00 |
| Viscosity | cP | 0.0160 | 0.0070 | 0.0070 | 0.0070 | 0.0070 |
| Min. Rate | % | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Max. Rate | % | 110.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Liquid** | | | | | | |
| Mass Rate | kg/hr | 615216 | 0 | 0 | 0 | 0 |
| Density | kg/m3 | 1020.000 | 1000.000 | 1000.000 | 1000.000 | 1000.000 |
| Volume Rate | m3/hr | 603.153 | 0.000 | 0.000 | 0.000 | 0.000 |
| Surface Tension | dyne/cm | 38.000 | 18.713 | 18.713 | 18.713 | 18.713 |
| Viscosity | cP | 0.8000 | 0.9963 | 0.9963 | 0.9963 | 0.9963 |
| Min. Rate | % | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Max. Rate | % | 110.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| System Factor | | 1.00 | Load OK | Load not active | Load not active | Load not active | Load not active |

Rates : Min Design Max

Select Design : TRAYS PACKINGS DEMISTER® Comments Close

PACKED TOWER DESIGN

File Options Units Window Help

| | | | | | | |
|---|---|---|---|---|---|---|
| Project Name | Co2 recovery from Flue gas | | | | Date | 23-Mar-26 |
| Tower Name | CO2 Absorber | | | | By | KN |
| Case Name | 40% MDEA system | | | | Revision | 0 |

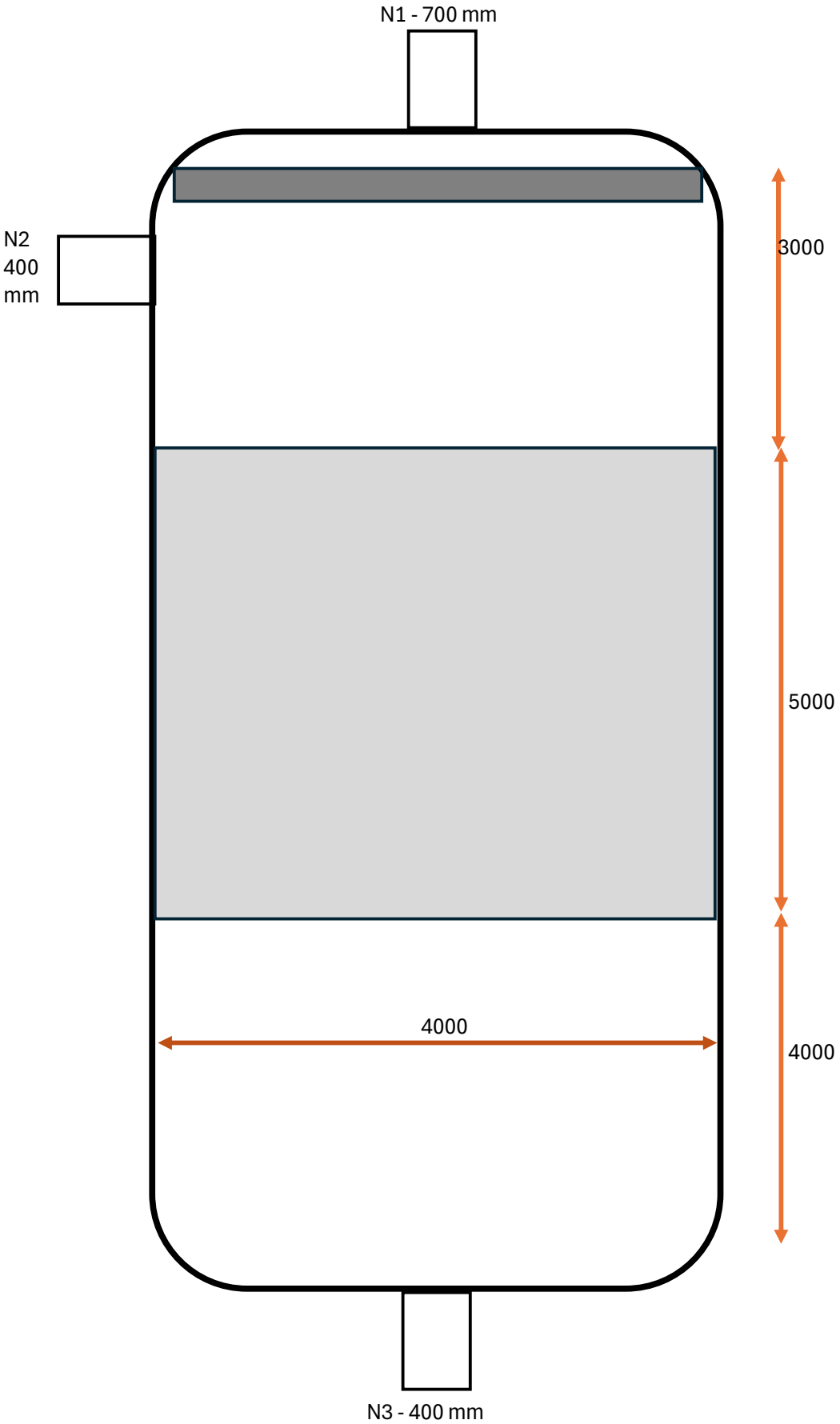
| | | Load 1 |
|---|---|---|
| Zone | | 1 |
| Description | | stru packing |
| Bed Number | | 1 |
| Packing Type | | FLEXIPAC® (Metal) |
| Packing Size | | 250Y |
| | | Effic. |
| Tower Diameter | mm | 4000.00 |
| Number of Layers | | 19.0 |
| Packing height | mm | 5000.00 |
| Capacity, Const. L/V | % | 41.10 |
| System Limit | % | 11.75 |
| Fs | m/s*(kg/m3)^0.5 | 0.64 |
| Cv | m/s | 0.020 |
| Liquid Load | m3/hr/m2 | 48.00 |
| Pressure Drop | mbar/m | 0.180 |

Rates : Min Design Max

Note: The total packing pressure drop is the sum of the calculated pressure drop for each loading. When comparing different packings, a separate case should be used for each. When entering loads at the top and bottom of a packed bed, the bed height should be split between the two loads.

Total Packing Pressure Drop mm Hg 0.68 Print Comments Close

| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | Flexera CONSULTING |
|---|---|



| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | Flexera CONSULTING |
|---|---|---|
| | | |
| **Solvent Inter Exchanger** | | |
| Type of Inter exchanger | PHE | |
| Lean Solvent temperature from the absorber | 50 | deg.C |
| Lean solvent temperature at the outlet of inter exchanger | 105 | deg.C |
| | 55 | deg.C |
| Rich solvent temperature from the stripper | 120 | deg.C |
| Rich solvent temperature from the interexchanger | 65 | deg.C |
| | 55 | deg.C |
| Mass flow rate of solvent | 647095.14 | kg/hr |
| Specific heat capacity of the aq solvent | 0.84 | kcal/kg deg.C |
| Heat load required | 29895795.5 | kcal/hr |
| LMTD | 15 | deg.C |
| Overall heat transfer coefficient | 2000 | kcal/hr.$m^2$ deg.C |
| Heat transfer area required | 996.53 | $m^2$ |
| | | |
| **Solvent Cooler** | | |
| Type of heat exchanger | PHE | |
| Mass flow rate of solvent | 647095.14 | kg/hr |
| Specific heat capacity of the aq solvent | 0.84 | kcal/kg deg.C |
| Heat load required | 13588997.9 | kcal/hr |
| LMTD | 15.62 | deg.C |
| Overall heat transfer coefficient | 1500 | kcal/hr.$m^2$ deg.C |
| Heat transfer area required | 579.98 | $m^2$ |
| | | |
| **Solvent Heater** | | |
| Type of heat exchanger | PHE | |
| Mass flow rate of solvent | 647095.14 | kg/hr |
| Specific heat capacity of the aq solvent | 0.84 | kcal/kg deg.C |
| Heat load required | 8153398.77 | kcal/hr |
| LMTD | 35 | deg.C |
| Overall heat transfer coefficient | 1500 | kcal/hr.$m^2$ deg.C |
| Heat transfer area required | 155.30 | $m^2$ |
| | | |
| **Stripper vapour condenser** | | |
| Type of heat exchanger | Shell & Tube | |
| Mass flow rate of vapour entered to the condenser | 41134.75 | |
| Vapour inlet temperature to condenser | 120 | deg.C |
| Condenser outlet temperature | 40 | deg.C |
| Condenser heat load | 6385476.7 | kcal/hr |
| LMTD | 31.2692027 | deg.C |
| Overall heat transfer coefficient | 430 | kcal/hr.$m^2$ deg.C |
| Heat transfer area required | 474.91 | $m^2$ |
| Cooling water requirement | 798184.59 | kg/hr |
| | 798.18 | $m^3$/hr |

| RECOVERY OF CARBON-DIOXIDE FROM THE FLUE GAS BY 40% MDEA AQUEOUS SOLUTION | | |
|---|---|---|
| | | |
| **Gas precooling requirement** | | |
| Gas mass flow rate | 200000 | kg/hr |
| Gas temperature | 65 | deg.C |
| Gas heat capacity | 0.25 | kcal/kg dg.C |
| Gas temperature required | 40 | deg.C |
| Heat load required for the cooling | 3250000 | kcal/hr |
| Cooling water temperature difference | 8 | deg.C |
| Cooling water heat capacity | 1 | kcal/kg dg.C |
| Cooling water mass flow rate required | 406250 | kg/hr |
| Cooling water volumetric flow rate | 406.25 | $m^3$/hr |
| **Note:** | | |
| If we consider the quench tower, the cooling water flow rate will be increased, as the temperature difference decreases | | |