CMP ARLES
Constructions Métalliques
et Préfabrication d'Arles

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**Dossier CMP Arles : 783**

Page/*Sheet* 0.1

**Client** / *Customer* : **MESSER**

*Engineered System N°* :

# 1 RESERVOIR DE STOCKAGE LOX 1800MT

## *1 x 1800MT LOX STORAGE TANK*

# NOTE DE CALCUL THERMIQUE

## *THERMAL LOSSES CALCULATION NOTE*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 28/07/04 | HULIN | | 28/07/04 | GABRELLI | | 28/07/04 | LEBOUCQ | | |
| EDITION *EDITION N°* | REFERENCE *CLIENT REF.* | DATE | NOM *NAME* | SIGN. | DATE | NOM *NAME* | SIGN. | DATE | NOM *NAME* | SIGN. | ETAT D'AVANC. *STATUS* |
| | | REDACTEUR *DRAWN UP BY* | | | VERIFICATEUR *CHECKED BY* | | | APPROBATEUR *APPROVED BY* | | | |

Projet : ASU KOSICE
*Project*

Classement CMP Arles : 783-NC03
*CMP Arles document N°*

CMP ARLES

N° CMP arles : 783 - NC 03

Item : 1 x 1800 MT LOX

Rev: 0

Page 0.2

Appareil / Item : 1 x 1800 MT LOX

Client : MESSER

| Page | DESIGNATION *Desription* | INDICE DE REVISION *Revision number* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | A | B | C | D | E | F | G | H |
| 0.1 | Page de garde / Front page | 1 | | | | | | | | |
| 0.2 | Fiche d'état de révision / List of current revisions | 1 | | | | | | | | |
| 1 | objets des modifications / Subject of modification | 1 | | | | | | | | |
| 2 | Data | 1 | | | | | | | | |
| 3 | Results | 1 | | | | | | | | |
| 4 | Results | 1 | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
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| 37 | | | | | | | | | | |
| 38 | | | | | | | | | | |
| 39 | | | | | | | | | | |
| 40 | | | | | | | | | | |
| 41 | | | | | | | | | | |

CMP ARLES

N° CMP arles : 783 - NC 03

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Rev: 0



## OBJET DES MODIFICATIONS :

(subject of modifications)

| INDICE DE L'EDITION Edition n° | OBJET DE LA MODIFICATION (subject of modifications) |
|---|---|
| 1 | Premiere diffusion / First issue |
| | |
| | |

DATA :

| | | | |
|---|---|---|---|
| Liquide : | Product : | | Oxygen |
| | Temperature : | T1 = | -183 deg.C |
| | Density: | W = | 1140 kg/m$^3$ |
| Heat of vaporisation : | | L = | 213 kJ/kg |
| External temperature : | | T2 = | 15 deg.C |
| Inner vessel : | Shell internal diameter : | D1 = | 12.550 m |
| | Shell height : | H1 = | 13.210 m |
| | Liquid height : | LH = | 12.895 m |
| | Shell average thickness : | E1 = | 0.006 m |
| | Roof external radius : | R1 = | 11.006 m |
| | Roof height : | G1 = | 1.964 m |
| Insulation Jacket : | Shell internal diameter : | D2 = | 14.750 m |
| | Shell height : | H2 = | 14.770 m |
| | Roof internal radius : | R2 = | 12.100 m |
| | Roof height : | G2 = | 2.507 m |
| Perlite thickness in the shell interspace : | | E3 = | 1.094 m |
| Perlite thickness in the roof interspace : | | Er = | 1.094 m |
| Foamglas thickness : | In the center : | E4 = | 0.800 m |
| | At the periphery : | E'4 = | 0.700 m |
| Foamglas external diameter : | | D4 = | 13.250 m |
| | | D'4 = | 11.650 m |
| Width of the reinforced concrete ring : | | Lb = | 0.800 m |
| Perlite specific gravity : | | W3 = | 56 kg/m3 |
| Foamglas specific gravity : | | W4 = | 130 kg/m3 |
| Number of inner vessel anchor bolt ( or straps ) : | | Na = | 40 |
| Area of one anchor bolt ( or strap ) : | | Sa = | 0.001 m² |
| Internal shell stiffeners : | Number : | Nr = | 6 |
| | External diameter : | Dr = | 12.939 m |
| | Height : | Hr = | 0.100 m |
| Outer shell stiffeners : | Number : | Ns = | 3 |
| | External diameter : | Ds = | 14.450 m |
| | Thickness : | Hs = | 0.020 m |

## RESULTS :

| | | | |
|---|---|---|---|
| Mass of liquid :<br>M = 0.99 x ( PI x D1² x LH / 4 ) x W | M = | 1800274 | kg |
| Inner shell average diameter :<br>Di = [ ( H1 - Nr x Hr ) x ( D1 + 2 x E1 ) + Nr x Hr x Dr ] / H1 | Di = | 12.58 | m |
| Outer shell average diameter :<br>Do = [ ( H2 - Ns x Hs ) x D2 + Ns x Hs x Ds ] / H2 | Do = | 14.74878 | m |
| Temperature difference :<br>delta_T = T2 - T1 | delta_T = | 198.00 | deg.C |
| Average temperature :<br>Tm = ( T1 + T2 ) / 2 | Tm = | -84 | deg.C |
| Stainless steel thermal conductivity : | Lambda = | 14 | W/m deg.C |
| Perlite thermal conductivity :<br>lambda3 = ( 1.292E-4 + 0.2564E-6 x Tm ) x (W3 + 400 ) - 0.019478 | Lambda3 = | 0.0296 | W/m deg.C |
| Foamglas thermal conductivity :<br>Foamglas quality : HLB1000 | Lambda4 = | 0.0320 | W/m deg.C |

## CALCULATION OF AVERAGE SURFACES :

| | | | | |
|---|---|---|---|---|
| Foamglas : | S4 = PI x D'4² / 4 | S4 = | 106.60 | m² |
| | ( if there is a concrete ring ) : | | | |
| | S'4 = PI x D4² / 4 - S4 | S'4 = | 31.29 | m² |
| Perlite : | Roof : | Sr = | 160.91 | m² |
| | Sr = [ ( 2 x PI R1 x G1 ) x ( 2 x PI x R2 x G2 ) ](1/2) | | | |
| | Shell : | S3 = | 600.56 | m² |
| | S3 = PI x 0.5 x ( Do + Di ) x 0.5 x ( H1 + H2 ) | | | |
| Bottom : | | SB = | 8.76 | m² |
| | SB = PI x [ ( 0.5 x ( Do + Di ) )² - D4² ] / 4 | | | |
| Anchor bolts ( or straps ) : | | S7 = | 0.04 | m² |
| | S7 = Na x Sa | | | |
| Foamglas stainless steel belt : | | S8 = | 0.02 | m² |
| | S8 = PI x D4 x 0.0005 | | | |
| Piping ( estimated ) : | | S6 = | 0.025 | m² |

## CALCULATION OF THERMAL LOSSES :

| | | | | |
|---|---|---|---|---|
| Foamglas : | | Q4 = | 1129 | W |
| | Q4 = lambda4 x ( S4 / E4 + S'4 / E'4 ) x delta_T | | | |
| Perlite : | | Q3 = | 4183.44 | W |
| | Q3 = lambda3 x ( Sr / Er + S3 / ( 0.5 x ( Do - Di ) ) + SB / E'4 ) x delta_T | | | |
| Anchor bolts ( or straps ) : | | Q7 = | 158.4 | W |
| | Q7 = lambda x S7 x delta_T / E'5 | | | |
| Foamglas belt : | | Q8 = | 82.42 | W |
| | Q8 = lambda x S8 x delta_T / E'5 | | | |
| Piping : | | Q6 = | 63.37 | W |
| | Q6 = lambda x S6 x delta_T / E4 | | | |
| Total : | | Q = | 5617 | W |
| | Q = Q3 + Q4 + Q6 +Q7 +Q9 | | | |

## CALCULATION EVAPORATION RATE PER DAY :

E = Q x 86400 / ( L x M x 1E3 )

E = 0.13%