PREINSULATED PIPES FOR LOW TEMPERATURE UTILITIES FLEXIBLE PIPE SYSTEMS M -PEX

made acc. Standard PN-EN 13941 (EN 13941) " Design and installation of preinsulated bonded pipe systems for district heating" - Appendix D

MR-6/I-110 (180)

Output data:

flow pipeline temp. t_f=	70,00	°C
return pipeline temp. t_r=	50,00	°C
soil temp. t_s=	10,00	°C
pipeline axis depth (caunting from soil surface) Z=	0,69	m
counting from soil surface) z=	0,60	m
Corrected value of depth Z, so that the surface transition insulance Ro at the soil surface is included Zc=	0,77	m
Soil penetration coefficient λs =	1,20	W/mK
for wet soil from 1,5 W/(mK) to 2 W/(mK), for dry sand about . 1,0 W/(mK)		
Casing tube external diameter D_o=	0,1800	m
wall thickness of casing tube g_o =	0,0030	m
Insulation external diameter D_{iz}=	0,1740	m
Medium pipe diameter PEX D_{z1} =	0,1100	m
wall thickness of PEX tube g_1 =	0,0100	m
Distance in light between casing tubes a =	0,2000	m
Distance beetwen pipleine axises C =	0,3800	m
coefficient of thermal conductivity for PUR insulation systems M-PEX λiz=	0,0245	W/mK
coefficient of thermal conductivity for medium pipe PEX wg DIN 52612 λ_{PEX}=	0,3800	W/mK
coefficient of thermal conductivity for casing tube PE-LD λ_{PE-LD}=	0,4300	W/mK

Q_f - heat losses on flow pipeline
Q_r - heat losses on return pipeline

$$Q_f = U_1 \times (t_f - t_s) - U_2 \times (t_r - t_s)$$

$$Q_r = U_1 \times (t_r - t_s) - U_2 \times (t_f - t_s)$$

Overall heat loss is:

$$Q_f + Q_r = 2 \times (U_1 - U_2) \times (\frac{t_f + t_r}{2} - t_s)$$

gdzie:

U_1 i U_2 - heat loss coefficient

t_f i t_r - temp.in flow and return pipeline

t_s - undisturbed soil temp.at depth "z"

$$U_1 = \frac{R_s + R_i + R_{PEX} + R_{PE-LD}}{(R_s + R_i + R_{PEX} + R_{PE-LD})^2 - R_h^2} \qquad U_2 = \frac{R_h}{(R_s + R_i + R_{PEX} + R_{PE-LD})^2 - R_h^2}$$

The overall heat loss coefficient:

$$U_1 - U_2 = \frac{1}{R_i + R_s + R_{PEX} + R_{PE-LD} + R_h}$$

where:

R_i - insulance of insulating material

$$R_{iz} = \frac{1}{2\pi\lambda_{IZ}} \ln \frac{D_{iz}}{d_z}$$

R_{PEX} - insulance of medium pipe PEX

$$R_{PEX} = \frac{1}{2\pi\lambda_{PEX}} \ln \frac{D_z}{(D_z - 2 \times g)}$$

R_{PE-LD} - insulance of casing tube PE-LD

$$R_{PE-LD} = \frac{1}{2\pi\lambda_{PE-LD}} \ln \frac{D_o}{(D_o - 2 \times g_o)}$$

R_s - insulance of the soil

$$Rs = \frac{1}{2\pi\lambda_s} \ln \frac{4Z_c}{D_o}$$

gdzie: $Z_C = Z + R_o \times \lambda_{gr}$

Z_C - Corrected value of depth Z, so that the surface transition insulance Ro at the soil surface is included

$R_o =$ 0,0685 m^2K/W

R_h - insulance of heat exchange between flow and return pipe

$$R_h = \frac{1}{4\pi\lambda_s} \ln\left(1 + \left(\frac{2Z_c}{C}\right)^2\right)$$

Heat loss of pipeline laying directly in the ground

$$R_{iz} = \frac{1}{2 \times 3{,}1416 \times 0{,}0245} \ln \frac{0{,}1740}{0{,}1100} = 2{,}9790 \text{ mK/W}$$

$$R_{PE\text{-}LD} = \frac{1}{2 \times 3{,}1416 \times 0{,}4300} \ln \frac{0{,}1800}{0{,}1740} = 0{,}0125 \text{ mK/W}$$

$$R_{PEX} = \frac{1}{2 \times 3{,}1416 \times 0{,}3800} \ln \frac{0{,}1100}{0{,}0900} = 0{,}0840 \text{ mK/W}$$

$$R_h = \frac{1}{4 \times 3{,}1416 \times 1{,}2000} \ln \left(1{,}00 + \left(\frac{2 \times 0{,}7700}{0{,}3800} \right)^2 \right) = 0{,}1895 \text{ mK/W}$$

$$R_s = \frac{1}{2 \times 3{,}1416 \times 1{,}2000} \ln \left(\frac{4 \times 0{,}7700}{0{,}1800} \right) = 0{,}3766 \text{ mK/W}$$

$$U1 = \frac{2{,}9790 + 0{,}0125 + 0{,}0840 + 0{,}3766}{(0{,}3766 + 2{,}9790 + 0{,}0125 + 0{,}0840)^2 - (0{,}1895)^2} = 0{,}2906 \text{ W/mK}$$

$$U2 = \frac{0{,}1895}{(0{,}3766 + 2{,}9790 + 0{,}0125 + 0{,}0840)^2 - (0{,}1895)^2} = 0{,}0159 \text{ W/mK}$$

$$U1\text{-}U2 = \frac{1}{2{,}9790 + 0{,}0125 + 0{,}0840 + 0{,}1895 + 0{,}3766} = 0{,}2746 \text{ W/mK}$$

Heat losses in flow pipeline:

Qf= $0{,}2906 \times (70{,}00 - 10{,}00) - 0{,}0159 \times (50{,}0000 - 10{,}00) =$ **16,8000 W/m**

Heat losses in return pipeline:

Qr= $0{,}2906 \times (50{,}00 - 10{,}00) - 0{,}0159 \times (70{,}00 - 10{,}00) =$ **10,6700 W/m**

Heat loss in both pipelines:

Qf+Qr = 27,4700 W/m

The overall heat loss:

Qf+Qr = $2{,}00 \times (0{,}2906 - 0{,}0159) \times \left(\frac{70{,}00 + 50{,}00}{2} - 10{,}00 \right) =$ **27,4700 W/m**

made acc. Standard PN-EN 13941+ A1 (EN 13941:2009+A1:2010) " Design and installation of preinsulated bonded pipe systems for district heating" - Appendix D

MR-6/I-110(180)

flow pipeline temp. t_f=	**70,00**	°C
return pipeline temp. t_r=	**50,00**	°C
soil temp. t_s=	**10,00**	°C
counting from soil surface z=	**0,60**	m
pipeline axis depth (caunting from soil surface) Z=	**0,69**	m
Corrected value of depth Z, so that the surface transition insulance Ro at the soil surface is included Zc=	0,77	m
Soil penetration coefficient λs =	**1,20**	W/mK
for wet soil from 1,5 W/(mK) to 2 W/(mK), for dry sand about . 1,0 W/(mK)		
Casing tube external diameter D_c=	**0,1800**	m
wall thickness of casing tube g_o =	**0,0030**	m
Insulation external diameter D_{PUR} =	0,1740	m
Medium pipe diameter d_o=	**0,1100**	m
Distance in light between casing tubes a =	**0,2000**	m
Distance beetwen pipleine axises C =	0,3800	m
coefficient of thermal conductivity for PUR insulation λ_i=	**0,0245**	W/mK

Q_f - heat losses on flow pipeline

Q_r - heat losses on return pipeline

$$Q_f = U_1 \times (t_f - t_s) - U_2 \times (t_r - t_s) \qquad Q_r = U_1 \times (t_r - t_s) - U_2 \times (t_f - t_s)$$

Overall heat loss is:

$$Q_f + Q_r = 2 \times (U_1 - U_2) \times (\frac{t_f + t_r}{2} - t_s) \qquad U_1 - U_2 = \frac{1}{R_s + R_i + R_h}$$

where:

U_1 i U_2 - heat loss coefficient

t_f i t_r - temp.in flow and return pipeline

t_s - undisturbed soil temp.at depth "z"

$$U_1 = \frac{R_s + R_i}{(R_s + R_i)^2 - R_h^2}$$

$$U_2 = \frac{R_h}{(R_s + R_i)^2 - R_h^2}$$

where:

R_i - insulance of insulating material

$$R_i = \frac{1}{2\pi\lambda_i} \ln \frac{D_{PUR}}{d_o}$$

R_s - insulance of the soil

$$R_s = \frac{1}{2\pi\lambda_s} \ln \frac{4Z_c}{D_c}$$

where: $Z_C = Z + R_o \times \lambda_s$

Z_C - Corrected value of depth Z, so that the surface transition insulance Ro at the soil surface is included

R_o = 0,0685 m^2K/W

R_h - insulance of heat exchange between flow and return pipe

$$R_h = \frac{1}{4\pi\lambda_s} \ln\left(1 + \left(\frac{2Z_c}{C}\right)^2\right)$$

Heat loss of single pipeline laying directly in the ground

$$R_i = \frac{1}{2{,}00 \times 3{,}1416 \times 0{,}0245} \ln \frac{0{,}1740}{0{,}1100} = 2{,}9790 \text{ mK/W}$$

$$R_s = \frac{1}{2{,}00 \times 3{,}1416 \times 1{,}2000} \ln \frac{4 \times 0{,}7722}{0{,}1800} = 0{,}3770 \text{ mK/W}$$

$$R_h = \frac{1}{4{,}00 \times 3{,}1416 \times 1{,}2000} \times \ln \left[1{,}00 + \left(\frac{1{,}54}{0{,}38} \right)^2 \right] = 0{,}1899 \text{ mK/W}$$

$$U_1\text{-}U_2 = \frac{1}{0{,}3770 + 2{,}9790 + 0{,}1899} = 0{,}2820 \text{ W/mK}$$

$$U_1 = \frac{0{,}3770 + 2{,}9790}{(0{,}3770 + 2{,}9790)^2 - 0{,}1899^2} = 0{,}2989 \text{ W/mK}$$

$$U_2 = \frac{0{,}1899}{(0{,}3770 + 2{,}9790)^2 - 0{,}1899^2} = 0{,}0169 \text{ W/mK}$$

Heat losses in flow pipeline:

$$Q_f = 0{,}30 \times [70{,}00 - 10{,}00] - 0{,}02 \times [50{,}00 - 10{,}00] = \mathbf{17{,}26} \text{ W/m}$$

Heat losses in return pipeline:

$$Q_r = 0{,}30 \times [50{,}00 - 10{,}00] - 0{,}02 \times [70{,}00 - 10{,}00] = \mathbf{10{,}94} \text{ W/m}$$

Heat loss in both pipelines:

$Q_f + Q_r =$ **28,2021 W/m**

$$U_1 \text{ - } U_2 = \frac{1{,}00}{0{,}3770 + 2{,}9790 + 0{,}1899} = 0{,}2820 \text{ W/mK}$$

Overall heat loss:

$$Q_f + Q_r = 2{,}00 \times (0{,}30 - 0{,}02 \times [\frac{70{,}00 + 50{,}00}{2} - 10{,}00] = \mathbf{28{,}20} \text{ W/m}$$

wykonane wg normy PN-EN 15698-1 luty 2009 (EN-15698-1:2009), PN-EN 15698-1:2008

Rura MR-6/I-2x50(160)

Temperatura rurociągu zasilającego $T_{1=}$	70	°C
Temperatura rurociągu zasilającego $T_{2=}$	50	°C
Temperatura gruntu $T_{0=}$	10	°C
Połowa odstępu pomiędzy środkami rur D	0,03	m
Średnica rury osłonowej D_z	0,16	m
Grubość ścianki rury osłonowej g_z	0,003	m
Średnica rury przewodowej D_{p1}	0,05	m
Grubość ścianki rury przewodowej g_{p1}	0,0046	m
Średnica rury przewodowej Dp_2	0,05	m
Grubość ścianki rury przewodowej g_{p2}	0,0046	m
Odległość pomiędzy rurami przewodowymi s	0,01	m
Promień rury osłonowej r_1	0,077	m
Promień rury przewodowej r_2	0,0204	m
Promień rury przewodowej r_3	0,0204	m
Przewodność pianki PUR λ_{PU}	0,0245	$W*m^{-1}*K^{-1}$

Liniowy współczynnik przenikania ciepła (U) można opisać w następujący sposób:

$$U \frac{q_{całkowity}}{\left(\frac{T_1 + T_2}{2} - T_0\right)} \qquad [W*m^{-1}*K^{-1}]$$

Przewodność cieplną λ_{PU} można wyrazić następująco:

$$q_{całkowity} = 4\pi * \lambda_{PU} * h_s * \left(\frac{T_1 + T_2}{2} - T_0\right) \qquad [W*m^{-1}]$$

Przy tym:

$$h_s^{-1} = \ln\left(\frac{r_1^2}{2D * r_2}\right) - \ln\left(\frac{r_1^4}{r_1^4 - D^4}\right) - \frac{\left(\frac{r_2}{2*D} + \frac{2r_2 * D^3}{r_1^4 - D^4}\right)^2}{1 + \left(\frac{r_2}{2D}\right)^2 - \left(\frac{2r_2 * r_1^2 * D}{r_1^4 - D^4}\right)^2}$$

Obliczenie współczynnika utraty ciepła

$$h_s^{-1} = \ln \frac{0{,}00593}{0{,}00122} - \ln \frac{0{,}00003515}{0{,}00003434} - \frac{\left(\frac{0{,}02040}{0{,}06000} + \frac{0{,}00000110}{0{,}00003434}\right)^2}{1 + \left(\frac{0{,}02040}{0{,}06000}\right)^2 - \left(\frac{0{,}00000726}{0{,}00003434}\right)^2} =$$

$$= 1{,}58117 - 0{,}0233138 - \frac{0{,}13841}{1{,}07090} = 1{,}4286$$

Obliczenie utraty ciepła

$$q_{całkowity} = 12{,}5664 * 0{,}0245 * 0{,}7000 * \left(\frac{120}{2} - 10\right) = 10{,}7757 \quad [W*m-1]$$

Obliczenie liniowego współczynnika przenikania ciepła

$$U = \frac{10{,}7757}{\left(\frac{120}{2} - 10\right)} = 0{,}2155 \quad [W*m-1*K-1]$$