DAFTAR PUSTAKA

A. Cengel, Y., & A. Boles, M. (2015). *THERMODYNAMICS* (Y. A. cengel & M. A. Boles, Eds.; 8th ed.). McGraw-Hill Education.

Akasaka, R., Zhou, Y., & Lemmon, E. W. (2015). A Fundamental Equation of State for 1,1,1,3,3-Pentafluoropropane (R-245fa). *Journal of Physical and Chemical Reference Data*, *44*(1). https://doi.org/10.1063/1.4913493

ASY'ARI DARYUS. (2019). *TERMODINAMIKA TEKNIK VOLUME I (edisi e-book)* (asy'ari Daryus, Ed.; Vol. 1). Jurusan Teknik Mesin, Fakultas Teknik UNIVERSITAS DARMA PERSADA.

Candra, S. (2016). *Energy, Entropy and Engines : an introduction to thermodynamics*. John Wiley & Sons, Ltd.

DiPippo, Ronald. (2012). *Geothermal power plants : principles, applications, case studies, and environmental impact* (3 ed.). Butterworth-Heinemann.

Ermawati, T., & Negara, S. (2014). *Pengembangan Industri Energi Alternatif : Studi Kasus Panas Bumi Indonesia*. LIPI Press.

Gunadin Chaerah Indar. (2023). *Socialization of Design-Build Small-Scale Power Plant with Organic Rankine Cycle (ORC) System in Pincara, North Luwu Regency*. *6*(Technology Awareness for Tackling Community Issues). https://doi.org/https://doi.org/10.25042/jurnal_tepat.v6i1.373

Halliday, D., Resnick Robert, & Walker, J. (2011). *Fundamentals of Physics* (9 ed.). Jhon Wiley & Sons, Inc.

Irving, G., Alvarado, J., & Bluestein, M. (2015). *Thermodynamics and Heat Power* (9 ed.). CRC Press.

Kuppan, T. (t.t.). Heat exchanger design handbook. 2013. *Book*.

Kutz, M. (2014). *Mechanical Engineers' Handbook* (M. Kutz, Ed.; 4 ed.). John Wiley & Sons, Inc.

Natick, M. (2022). MATLAB (Version 2022a). *The MathWorks Inc*.

NIST, J. (2019). *Reference fluid thermodynamic and transport properties database (REFPROP)*.

Pikra, G., Rohmah, N., Pramana, R. I., & Purwanto, A. J. (2015). The Electricity Power Potency Estimation From Hot Spring in Indonesia With Temperature 70-80°C Using Organic Rankine Cycle. *Energy Procedia*, *68*, 12–21. https://doi.org/10.1016/j.egypro.2015.03.227

Rauf, S. B. (2020). *Thermodynamics Made Simple for Energy Engineers*. River Publishers.

Saari, J. (2010). Heat exchanger dimensioning. *Lappeenranta University of*. https://sistemas.eel.usp.br/docentes/arquivos/5817712/LOQ4086/saari__heat_exchanger_dimensioning.pdf

Shah, R. K., & Sekulic, D. P. (2003). *FUNDAMENTALS OF HEAT EXCHANGER DESIGN*. Jhon Wiley & Sons, Inc.

Sim, J.-B., Yook, S.-J., & Kim, Y. W. (2022). Performance Analysis of Organic Rankine Cycle with the Turbine Embedded in a Generator (TEG). *Energies*, *15*(1), 309. https://doi.org/10.3390/en15010309

Sumardi, O. E., Sundhoro, (2005). GEOLOGI DAERAH PINCARA, MASAMBA, KABUPATEN LUWUK UTARA, SULAWESI SELATAN. *Pemaparan Hasil Kegiatan Lapangan Subdit Panas Bumi*.

Tarrad, A. H. (2022). *What Every Engineer Should Know about the Organic Rankine Cycle and Waste Energy Recovery*. books.google.com. https://books.google.com/books?hl=en&lr=&id=E21_EAAAQBAJ&oi=fnd&pg=PR5&dq=what+every+engineer+should+know+about+the+organic+rankine+cycle+and+waste+energy+recovery&ots=VhgGyvAuyv&sig=Xzh6j49YzmbAsdxv_ogd_L4Sg4E

Tchanche, B. F., Lambrinos, G., Frangoudakis, A., & ... (2011). Low-grade heat conversion into power using organic Rankine cycles–A review of various applications. *... and Sustainable Energy ...*. https://www.sciencedirect.com/science/article/pii/S1364032111002644

Vega Nugraha, A., & Tk, B. F. (2015). DESAIN ALAT PENUKAR KALOR JENIS SHELL AND TUBE SEBAGAI EVAPORATOR UNTUK PEMBANGKIT LISTRIK TENAGA PANAS BUMI SUHU RENDAH DENGAN MENGGUNAKAN SISTEM ORGANIC RANKINE CYCLE (ORC). *Jurnal Teknik Mesin S-1*, *3*(3), 326–335.

Warokka, A., & Boedi, S. (2020). *TERMODINAMIKA TEKNIK*. Polmindo Press. www.polimdo.ac.id

Whu, C. (2007). *THERMODYNAMICS AND HEAT POWERED CYCLES : A COGNITIVE ENGINEERING APPROACH*. Nova Science Publishers, Inc. .

Zohuri, B. (2017). Thermodynamics of Cycles. Dalam *Compact Heat Exchangers* (hlm. 291–313). Springer International Publishing. https://doi.org/10.1007/978-3-319-29835-1_6

LAMPIRAN

Lampiran 1. Dokumentasi Lapangan


PERMANDIAN
AIR PANAS


KOMETER
ELECTRO MAGNETIC FLOWMETER
KTM-800
C/CE

Metasol
ABS 54c
MCCB
OFF
50A
Metasol
ABS 53c
MCCB
OFF
30A
Metasol
ABS 32c
OFF
20A


SUNG SAN
MODEL SMG-100F
SER. NO.
TAG. NO.
MAX. TEMP. °C MAX. PRESS. kgf/cm²
OUTPUT SIGNAL DC 4 ~ 20mA
CONTACT FROM -SPST AC250V 1A
C TO C mm
SUNG SAN SENSOR
Tel : 02-2671-0018
www.sst21.co.kr


Germany
www.ifm.com
Made in Germany
74-07
AB K91
Window:
Laminated safety glass
Port: 1.4435
G1 Aseptoflex Vario
S/N 00014445200
KL.0,2
P Range
-1,00...10,00 bar
-14,5...145 psi
P max 50 bar/725 psi
PG2794
1: U
2: I A :4..20 mA
4: I out :<250 mA

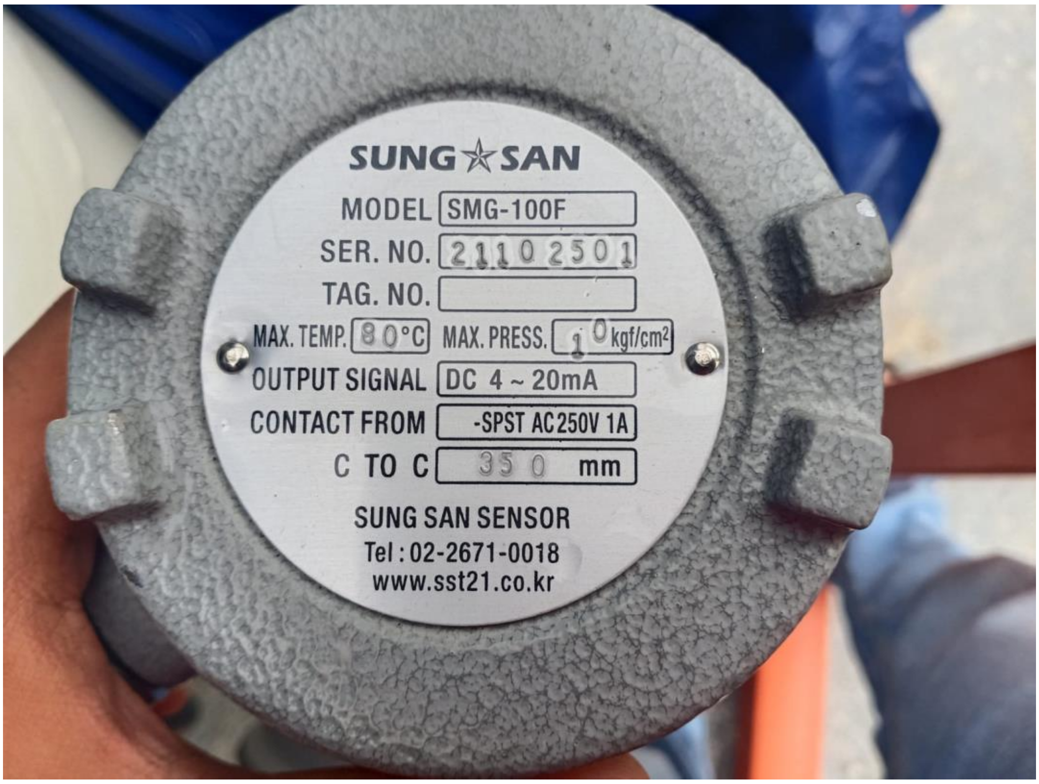

wilo
Type
Vertical Multistage Pump
Cert. No.
407
Model
HELIX V1606
1/16/E
7.5kW, 380V, 14.6A, 2P
Capacity
0.3 ㎥/min
ηp
67.3 %
Head
89 m
Bore
50 mm
Stage(s)
6
Date
21/06
Serial No.
210605055
SVC
1688-5890
WILO Pumps Ltd.
주 의 !
펌프 가동 전 펌프 내 공기를 완전히
제거하여 주십시요.
흡 ↓ 입
고효율기자재
수도용
위생안전기준

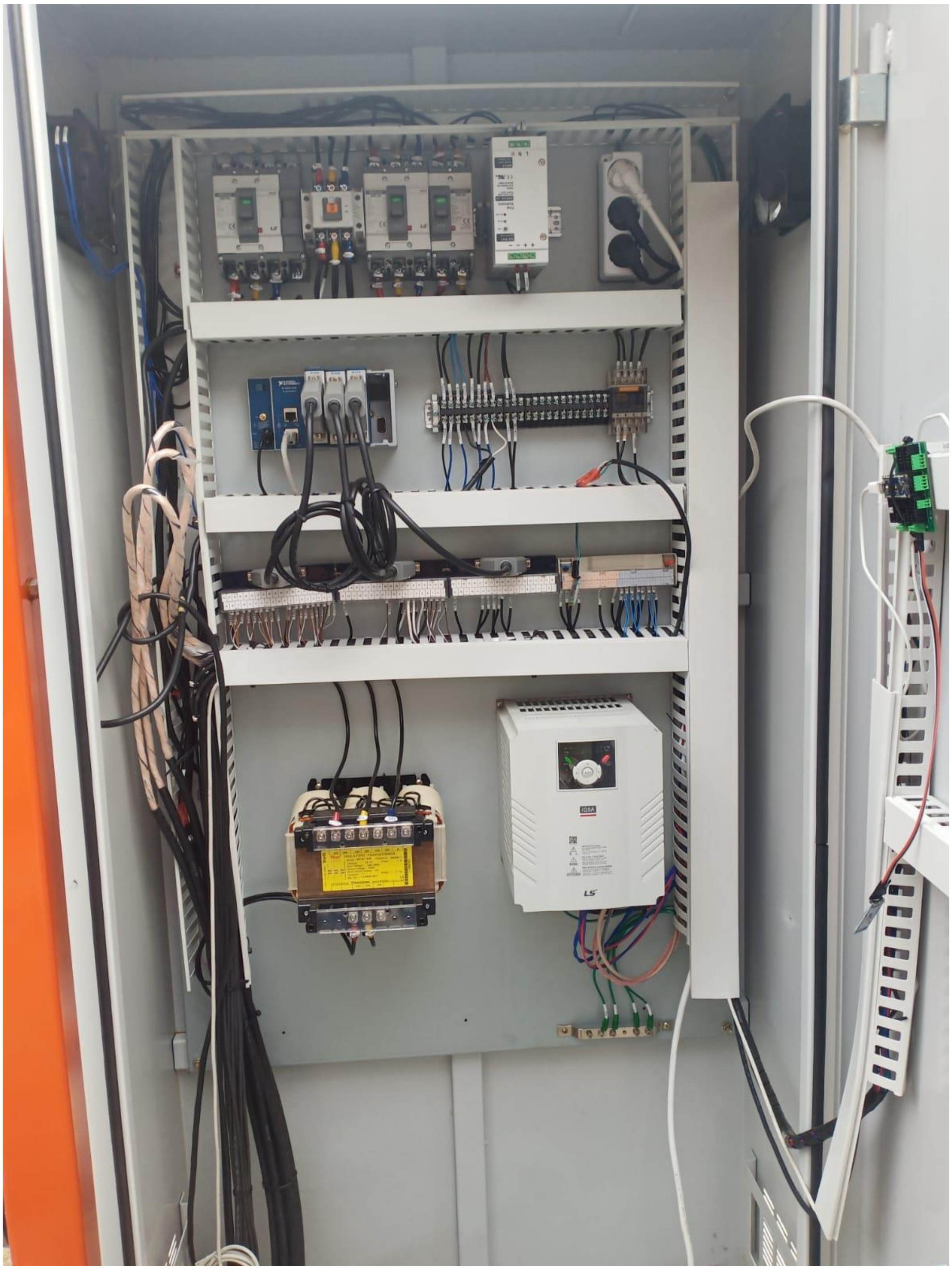

Metasol
ABS 54c
OFF
50A
LS
Metasol
ABS 53c
OFF
LS
Metasol
ABS 33c
OFF
20A
Fine
Suntronix
FDR240-24
INPUT
OUTPUT
L N


wilo
3~ Induction Motor
IE3_H7504K3_2P FRAME 132
380 V 60 Hz
7.5 kW 2 P
EFF. 90.2 % SPEED 3520 rpm
CURR. 14.6 A
AMB. 40°C INS. F
TYPE. TEFC
S.F 1.15 DUTY S1
ENCL. IP55
BEARING(D.E/ND.E) 6308ZZC3/6206ZZC3
DATE. 2021.06
S/NO. 210670618
IE3_H7504K1_2P Wilo Pumps Ltd.


거치대 볼트 길이 6mm 이하 사용


Kampus Merdeka
PROGRAM PENGABDIAN MASYARAKAT
UNIVERSITAS HASANUDDIN
RANCANG BANGUN PEMBANGKIT LISTRIK SKALA KECIL
SISTEM ORGANIC RANKINE CYCLE (ORC)
DI PINCARA KABUPATEN LUWU UTARA

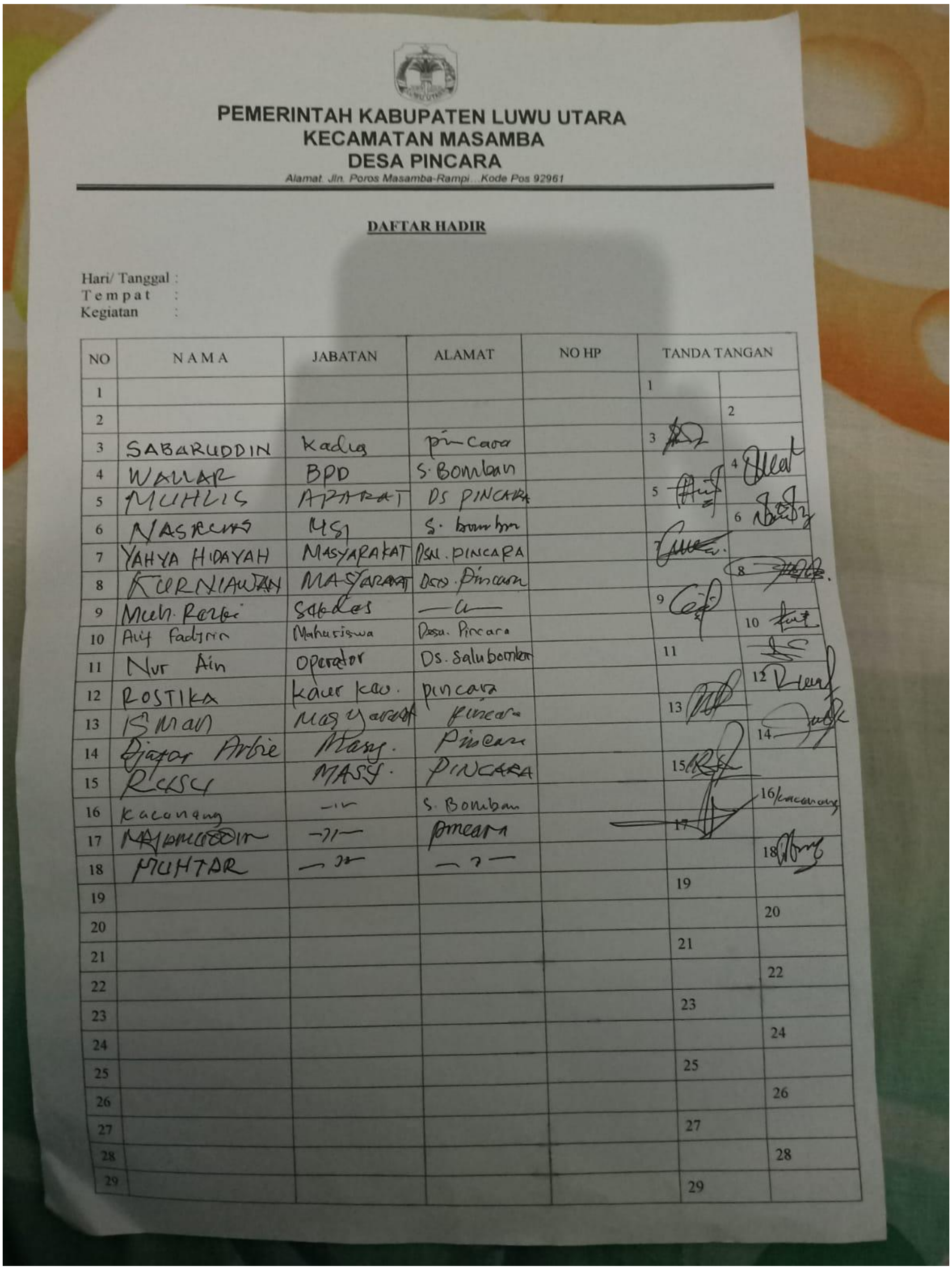

SUNG SAN
MODEL SMG-100F
SER. NO. 21102501
TAG. NO.
MAX. TEMP. 80°C MAX. PRESS. 10 kgf/cm2
OUTPUT SIGNAL DC 4 ~ 20mA
CONTACT FROM -SPST AC250V 1A
C TO C 350 mm
SUNG SAN SENSOR
Tel : 02-2671-0018
www.sst21.co.kr




Kampus Merdeka
INDONESIA JAYA
PROGRAM PENGABDIAN MASYARAKAT
UNIVERSITAS HASANUDDIN
RANCANG BANGUN PEMBANGKIT LISTRIK SKALA KECIL
SISTEM ORGANIC RANKINE CYCLE (ORC)
DI PINCARA KABUPATEN LUWU UTARA
22 Agustus 2022


Kampus Merdeka
INDONESIA JAYA
PROGRAM PENGABDIAN MASYARAKAT
UNIVERSITAS HASANUDDIN
RANCANG BANGUN PEMBANGKIT LISTRIK SKALA KECIL
SISTEM ORGANIC RANKINE CYCLE (ORC)
DI PINCARA KABUPATEN LUWU UTARA


Kampus Merdeka
PROGRAM PENGABDIAN MASYARKAT
UNIVERSITAS HASANUDDIN
RANCANG BANGUN PEMBANGKIT LISTRIK SKALA KECIL
SISTEM ORGANIC RANKINE CYCLE ORC
DI PINCARA KABUPATEN LUWU UTARA



PEMERINTAH KABUPATEN LUWU UTARA
KECAMATAN MASAMBA
DESA PINCARA
Alamat: Jln. Poros Masamba-Rampi... Kode Pos 92961

DAFTAR HADIR

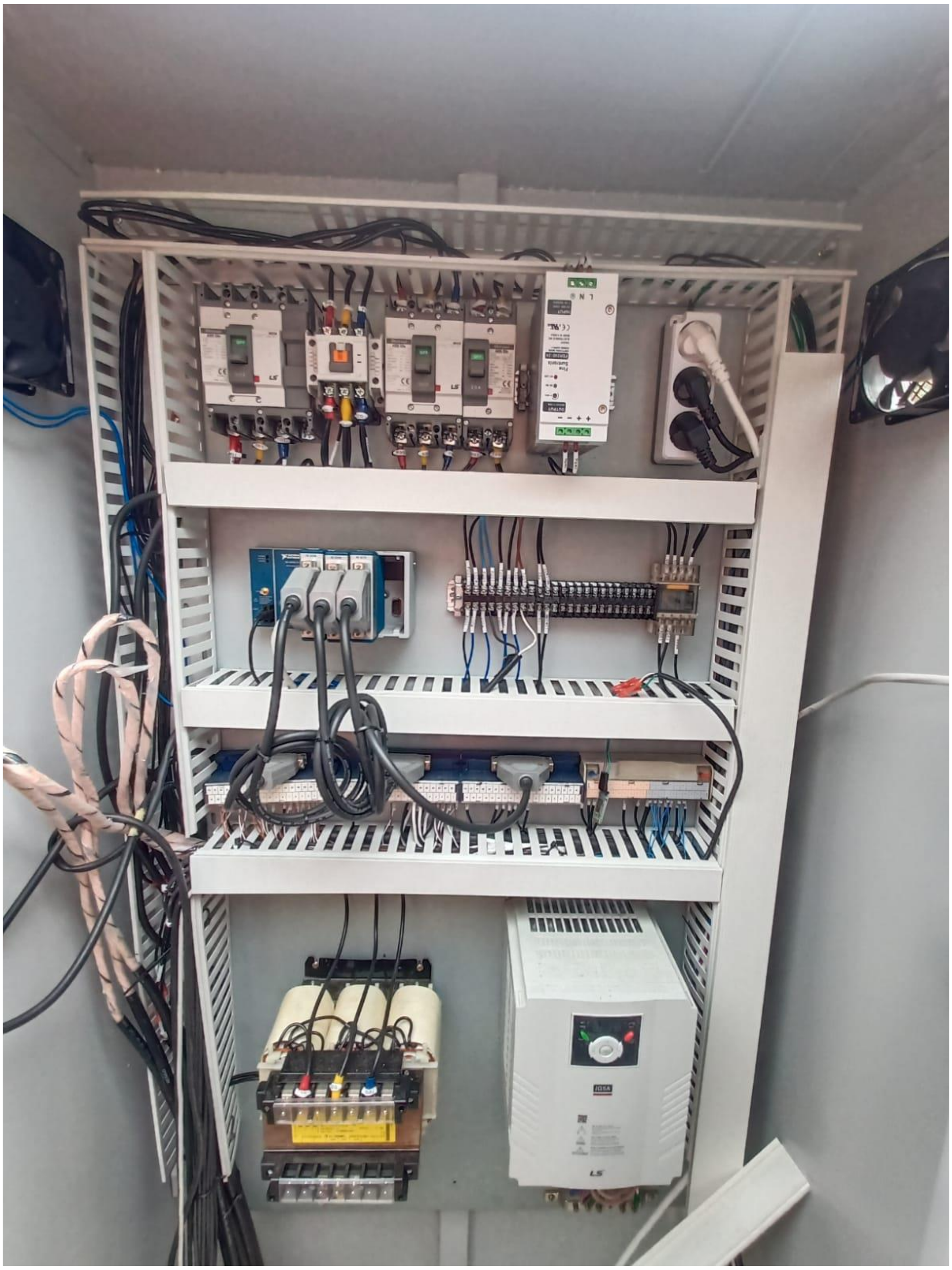
Hari/ Tanggal :
Tempat :
Kegiatan :

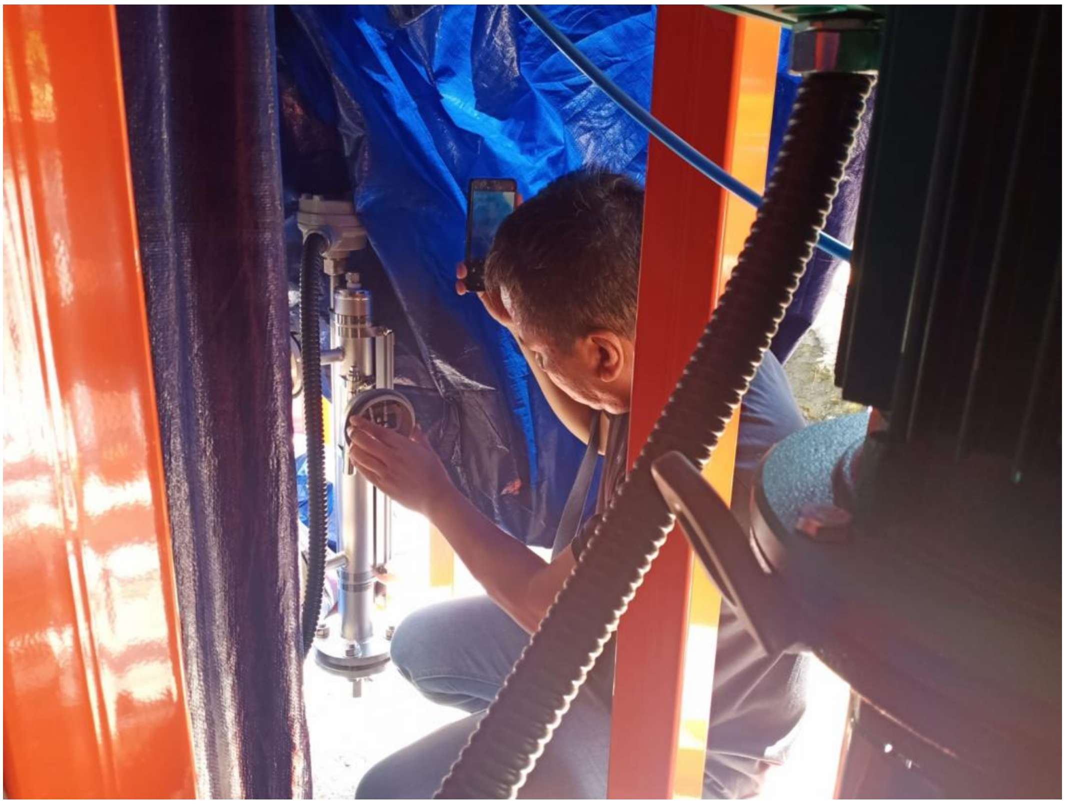
NO	NAMA	JABATAN	ALAMAT	NO HP	TANDA TANGAN
1					1
2					2
3	SABARUDDIN	Kadus	pincara		3
4	WAHAR	BPD	S. Bomban		4
5	MUHLIS	APARAT	DS PINCARA		5
6	NASRUN	MSI	S. bomban		6
7	YAHYA HIDAYAH	MASYARAKAT	DSN. PINCARA		7
8	KURNIAWAN	MASYARAKAT	Des. Pincara		8
9	Muh. Rezki	Sekdes	—ıı—		9
10	Arif Fadjrin	Mahasiswa	Desa. Pincara		10
11	Nur Ain	Operator	Ds. Salubomban		11
12	ROSTIKA	Kaur keu.	pincara		12
13	ISMAN	Masyarakat	Pincara		13
14	Djafar Arbie	Masy.	Pincara		14
15	Resky	MASY.	PINCARA		15
16	kaconang	—ıı—	S. Bomban		16/kaconang
17	MAHMUDDIN	—ıı—	pincara		17
18	MUHTAR	—ıı—	—ıı—		18
19					19
20					20
21					21
22					22
23					23
24					24
25					25
26					26
27					27
28					28
29					29


MAAF!!

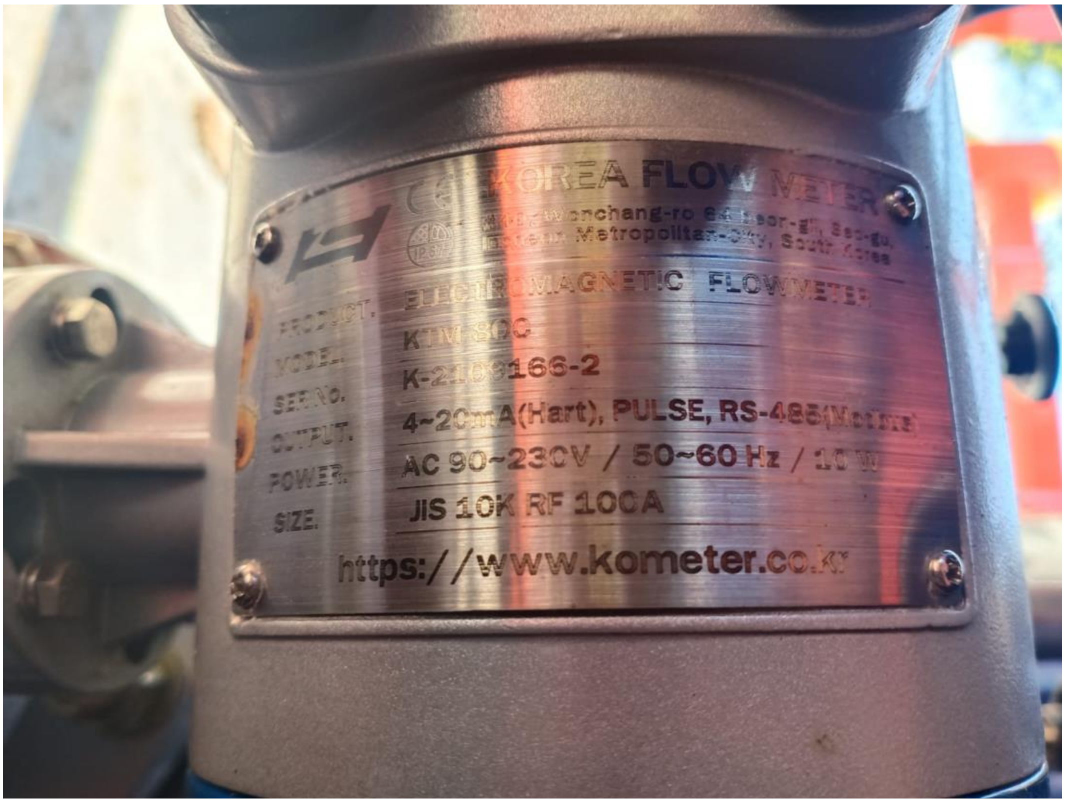

MAAF!!


Model : AKP90D-10BFHPM100A
Type : Pneumatic SUS H-P B/F Valve
Size : AKP90D
Action : ON/OFF
Power :
Serial no. : 1611B1-04
Size : 100A(4")
Connection : WAFER(JIS10K)
Material(Body/seat) SUS304/RTFE
Max temp. : 150℃
Max pressure : 10BAR
Direction : 2WAY






ACTS VALVE
www.actsvalve.com
Model : AKP90D-10BFHPM100A
[Actuator]
Type : Pneumatic SUS H-P B/F Valve
Size : AKP90D
Action : ON/OFF
Power :
Serial no. : 1611B1-04
[Valve]
Size : 100A(4")
Connection : WAFER(JIS10K)
Material(Body/seat) : SUS304/RTFE
Max temp. : 150℃
Max pressure. : 10BAR
Direction : 2WAY


KOREA FLOW
SIZE.
JIS 10K RF 100A
https://www.kometer.co.kr


KITECH
한국생산기술연구원
Key-tech power technologies


PEMERINTAH KABUPATEN LUWU UTARA
DINAS PEMUDA OLAHRAGA DAN
1. Dilarang melakukan
pengrusakan fasilitas pada
2. Penyerobotan dan
merupakan tindak pidana
TERIMA KASIH
ATAS
KUNJUNGAN ANDA
DILARANG
Mengambil apapun kecuali Foto
Meninggalkan apapun kecuali jejak


3~ Induction Motor
wilo
IE3_H7504K3_2P
FRAME 132
7.5 kW 2 P 380 V 60 Hz
CURR. 14.6 A EFF. 90.2 % SPEED 3520 rpm
TYPE. TEFC AMB. 40°C INS. F
ENCL. IP55 S.F 1.15 DUTY S1
BEARING(D.E/ND.E) 6308ZZC3/6206ZZC3
S/NO. 210670618 DATE. 2021.06
IE3_H7504K1_2P
Wilo Pumps Ltd. MADE IN KOREA

Lampiran 2. Kode pemrograman matlab r2023a dalam analisis termal dan parameter simulasi

```
% Thermodynamic Properties Table R245fa
R245faTables = twoPhaseFluidTables([180,493],[0.05,4],50,50,100,...
'R245fa','C:\Program Files\REFPROP');


% Thermal Analysis


% Input
RP = py.ctREFPROP.ctREFPROP.REFPROPFunctionLibrary('C:\Program
Files\REFPROP');
Unit = RP.GETENUMdll(int8(0),'MASS BASE SI').iEnum; % Satuan Unit SI
Fluids = 'R245fa';
iMass = int8(1); % 0: molar fractions; 1: mass fractions
iFlag = int8(0); % 0: don't call SATSPLN; 1: call SATSPLN
z = {1.0}; % Cairan Murni, mole fraction = 1.0
T_Cndsr = Data_Temperature_Air_Sungai; % Kelvin
T_Evptr = Data_Temperature_Geotermal; % Kelvin
nIs_Trbn = 0.95; % Percent
nIs_Pump = 0.67; % Percent
P_Gas = RP.REFPROPdll(Fluids,'TQ','P',Unit,iMass,iFlag,T_Evptr,1,z);
P_Gas = double(P_Gas.Output);
P_Gas = P_Gas(1) % Pa
P_Work = 0.73;% Mpa


% Point 1 (Condensor Outlet - Pump Inlet)
P_Cndsr =
RP.REFPROPdll(Fluids,'TQ','P',Unit,iMass,iFlag,T_Cndsr,0,z);
P_Cndsr = double(P_Cndsr.Output);
P_Cndsr = P_Cndsr(1); % Pa
P1 = P_Cndsr;
h1 = RP.REFPROPdll(Fluids,'TP','H',Unit,iMass,iFlag,T_Cndsr,P1,z);
h1 = double(h1.Output);
h1 = h1(1); % J/Kg
s1 = RP.REFPROPdll(Fluids,'TH','S',Unit,iMass,iFlag,T_Cndsr,h1,z);
s1 = double(s1.Output);
s1 = s1(1); % J/Kg


% Point 2 (Pump Outlet - Evaporator Inlet)
P2 = P_Work * 1.0e6; % Pa
P_Evptr = P2; % Pa
s2_s = s1; % J/Kg
```

```
h2_s =
RP.REFPROPdll(Fluids,'PS','H',Unit,iMass,iFlag,P_Evptr,s2_s,z);
h2_s = double(h2_s.Output);
h2_s = h2_s(1); % J/Kg
h_1 = h1 * 0.001; % kJ/Kg
h_2s = h2_s * 0.001; % kJ/Kg
h_2 = h_1 + (h_2s - h_1) / nIs_Pump; % kJ/Kg


% Point 3 (Evaporator Outlet - Turbine inlet)
P3 = P_Evptr;
h3 =
RP.REFPROPdll(Fluids,'TPvap','H',Unit,iMass,iFlag,T_Evptr,P_Evptr,z)
;
h3 = double(h3.Output);
h3 = h3(1); % J/Kg
u3 =
RP.REFPROPdll(Fluids,'TPvap','E',Unit,iMass,iFlag,T_Evptr,P_Evptr,z)
;
u3 = double(u3.Output);
u3 = u3(1); % J/Kg
V3 =
RP.REFPROPdll(Fluids,'TPvap','v',Unit,iMass,iFlag,T_Evptr,P_Evptr,z)
;
V3 = double(V3.Output);
V3 = V3(1); % m^3/Kg
s3 =
RP.REFPROPdll(Fluids,'PT','S',Unit,iMass,iFlag,P_Evptr,T_Evptr,z);
s3 = double(s3.Output);
s3 = s3(1); % J/Kg


% Point 4 (Turbine Outlet - Condensor Inlet)
s4 = s3; % J/Kg
P4 = P1; % Pa
h4_s = RP.REFPROPdll(Fluids,'SP','H',Unit,iMass,iFlag,s4,P4,z);
h4_s = double(h4_s.Output);
h4_s = h4_s(1); % J/Kg
h_3 = h3 * 0.001; % kJ/Kg
h_4s = h4_s * 0.001;
h_4 = h_3 - nIs_Trbn * (h_3 - h_4s); % kJ/Kg
Turb_Isentropic = (h_3 - h_4)/(h_3 - h_4s ); % Percent


% Working Fluid Mass Flow Rate
m_dot = 0.0627777778;
h_g = RP.REFPROPdll(Fluids,'QT','H',Unit,iMass,iFlag,1,T_Evptr,z);
h_g = double(h_g.Output);
h_g = h_g(1); % J/Kg
h_gas = h_g * 0.001; % kJ/Kg
```

```
m_dotTemp = 31 / (h_gas - h_2); % Kg/s


% Evaporator Extracted Load
Q_Evptr = m_dotTemp * (h_3 - h_2);


% Condenser Rejected Load
Q_Cndsr = m_dotTemp * (h_4 - h_1);


% Turbine Power Output
W_Trbn = nIs_Trbn * m_dotTemp * (h_3 - h_4);


% Pump Consumed Power
W_Pump = m_dotTemp * (h_1 - h_2);


% Cycle Net Power Output
W_net = W_Trbn + W_Pump;


% Cycle Net Thermal Efficiency
n_Thermal = (W_net / Q_Evptr) * 100;


% PHE Geometry for Heat Transfer
Tank_Fluid_Volume = 0.2; % m^3
N_Plate = 80;
Gap_Plate = 0.004; % m
Length_Plate = 1; % m
Width_Plate = 0.4;% m
Thicknes_Plate = 0.01; % m
Internal_Surface_Roughnes = 3.6e-6; % m
Brass_Thermal_Conductivity = 125; % W/m*K
Cross_Sectional_Channel = Gap_Plate * Width_Plate; % m^2
Wetted_Perimeter = 2*(Gap_Plate + Width_Plate); % m
Cross_Section_HT = 2*(Gap_Plate + Width_Plate); % m
Fouling_Factor_TL = 0.0004; % K*m^2/W
Fouling_Factor_Rfgrnt_Vap = 0.0004; % K*m^2/W
Fouling_Factor_Rfgrnt_Liq = 0.0002; % K*m^2/W
Thermal_Resistance = (Thicknes_Plate /(Brass_Thermal_Conductivity *
Cross_Sectional_Channel)) / 1000; % K/kW
Delta_K_Subcooling = 0; % K
Delta_K_Superheat = 0; % K
```

```
% Output

disp('At state point 1 (Condenser Outlet - Pump Inlet):')
fprintf('P1 = %.3f MPa',P1 * 1.0e-6)
fprintf('T1 = %.1f °C',T_Cndsr - 273.15)
fprintf('H1 = %.2f kJ/kg',h_1)
fprintf('S1 = %.3f kJ/kg',s1 * 0.001)


disp('At state point 2 (Pump Outlet - Evaporator Inlet):')
fprintf('P2 = %.3f MPa',P_Evptr * 1.0e-6)
fprintf('T2 = %.1f °C',T_Evptr - 273.15)
fprintf('H2s = %.2f kJ/kg',h_2s)
fprintf('H2 = %.2f kJ/kg',h_2)
fprintf('H Gas = %.2f kJ/kg',h_gas)
fprintf('S2s = %.3f kJ/kg',s2_s * 0.001)


disp('At state point 3 (Evaporator Outlet - Turbine Inlet):')
fprintf('P3 = %.3f MPa',P3 * 1.0e-6)
fprintf('T3 = %.1f °C',T_Evptr - 273.15)
fprintf('H3 = %.2f kJ/kg',h_3)
fprintf('S3 = %.3f kJ/kg',s3 * 0.001)


disp('At state point 4 (Turbine Outlet - Condenser Inlet):')
fprintf('P4 = %.3f MPa',P4 * 1.0e-6)
fprintf('T4 = %.1f °C',T_Cndsr - 273.15)
fprintf('H4s = %.2f kJ/kg',h_4s)
fprintf('H4 = %.2f kJ/kg',h_4)
fprintf('S4 = %.3f kJ/kg',s4 * 0.001)


fprintf ('Working Fluid Mass Flow Rate = %.4f kg/s%',m_dotTemp)
fprintf ('Evaporator Extracted Load = %.2f kW%',Q_Evptr)
fprintf ('Condenser Rejected Load = %.2f kW%',Q_Cndsr)
fprintf ('Turbine Power Output = %.2f kW%',W_Trbn)
fprintf ('Pump Consumed Power = %.2f kW%',W_Pump)
fprintf ('Cycle Net Power Output = %.2f kW%',W_net)
fprintf ('Thermal Efficiency = %.1f %%',n_Thermal)
```

Lampiran 3. Data sheet pompa

Helix FIRST V 1606

Data sheet

Product data

Product description	Helix FIRST V 1606

Hydraulic data

Maximum inlet pressure *p inl*	10 bar
Maximum operating pressure *PN*	25 bar
Discharge port	DN 50
Min. fluid temperature T_{min}	-20 °C
Max. fluid temperature T_{max}	120 °C
Min. ambient temperature T_{min}	-15 °C
Max. ambient temperature T_{max}	50 °C

Motor data

Voltage tolerance	±10 %
Rated power P_2	7.5 kW
Rated current I_N	13.8 A
Rated speed *n*	2923 1/min
Power factor $cos\ \varphi_{100}$	0.87
Motor efficiency 50% η_M *50%*	89.6 %
Motor efficiency 75% η_M *75%*	90.5 %
Motor efficiency 100% η_M *100%*	90.1 %
Protection class motor	IP55

Materials

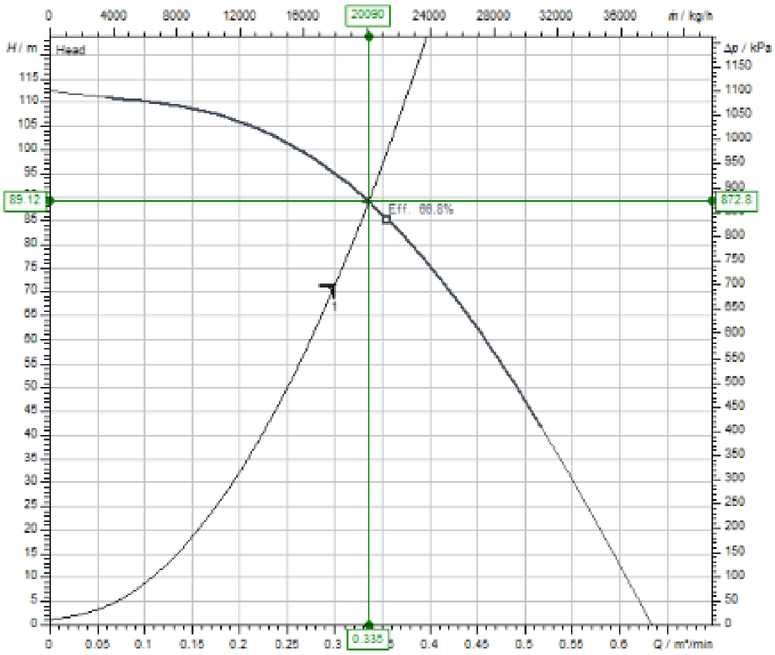
Pump housing	Grey cast iron
Impeller	Stainless steel
Shaft	Stainless steel
Mechanical seal	BQ1EGG
Gasket material	EPDM

Installation dimensions

Pipe connection on the suction side *DNs*	DN 50
Pipe connection on the discharge side *DNd*	DN 50

Helix FIRST V 1606

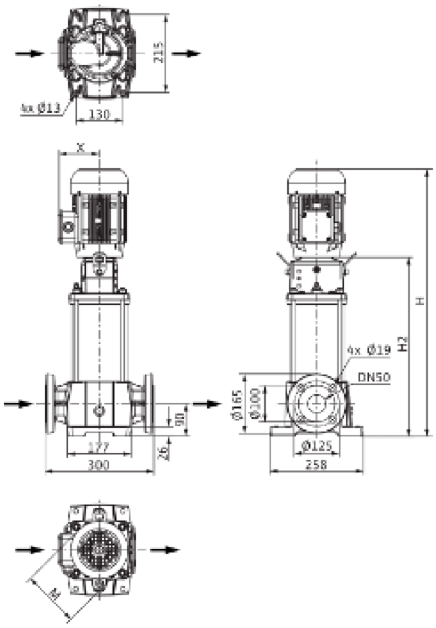
Pump curves



Fluid media	Water 100 %
Fluid temperature *T*	20.00 °C
Requested flow *Q*	0.30 m³/min
Delivery head (pressure unit)	71.49 m (700.00 kPa)
Delivered volume flow *Q @ OP*	0.34 m³/min
Delivery head (pressure unit) at the duty point *p @ OP*	89.12 m (872.69 kPa)
speed at duty point *n hydr. @ OP*	3569 1/min
Total electrical power consumption at the duty point *P1 @ OP*	8.14 kW
Total shaft power at the duty point *P2 @ OP*	7.34 kW
NPSH pump @ BP *NPSH pump*	2.08 m
Hydraulic efficiency at duty point *η hyd. @ OP*	66.66 %
Overall efficiency at the duty point *η tot. @ OP*	59.92 %

Dimensions and dimensions drawings

Helix FIRST V 16, PN 25



Dimensions *H*	1174 mm
Dimensions *H1*	152 mm
Dimensions *H2*	790 mm
Dimensions *L1*	150 mm
Dimensions *L2*	150 mm
Dimensions *L4*	130 mm
Dimensions *L5*	187 mm
Dimensions *L7*	0 mm
Dimensions *H3*	90 mm
Dimensions *H4*	850 mm
Dimensions *H5*	20 mm
Dimensions *H6*	429 mm
Dimensions *H7*	0 mm
Dimensions *L8*	183 mm
Dimensions *X*	196 mm