Micro Control Systems

HANBELL

RTM Series

TECHNICIAL MANUAL

Water-or Air-Cooled Chillers

Permanent Magnet Motor

Excellent energy efficiency

Low noise & vibration levels

R134a

Oil-free Magnetic Centrifugal Compressor

RTM Series

Hanbell's RTM series compressors, are certified with CE, UL, Lloyd's Register (Marine purpose), ATEX, and IECEx (Hazardous)

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Chapter 1 Introduction

This manual is intended as a guide for application engineers, consultants, sales engineers, and HVAC designers to use Hanbell RTM series centrifugal compressors. The copyright of this technical manual belongs to Hanbell Precise Machinery Co., Ltd.. Neither this publication nor any part of it may be reproduced or transmitted in any form or by any means without the prior permission of Hanbell Precise Machinery Co., Ltd..

1.1 Features

- Refrigerant – R134a
- Compressor – semi-hermetic design
- Shaft –made of high-strength alloy
- Impellers – closed type made of high-strength aluminum
- Bearings – magnetic bearings
- Motor –permanent magnet synchronous motor, independent cooling by liquid refrigerant
- Enclosure - IP54 protection

1.2 Ambience

RTM series compressors should be stored and operated within the following ambient temperature.
Storage: -25°C~55°C
Operation(Water-cooled):ET:2°C ~14°C;CT:15°C ~55°C

Note:

1. Please refer to “Application limits” in chapter 2 for allowable operating conditions and Hanbell selection software for detailed performance data.
2. For special application limits, please contact Hanbell.
3. Chapter 7 contains instructions for the use of other AC electrical components.
4. In a humid environment, the compressor housing and piping should be insulated to prevent condensation.
5. The joints of the compressor side magnetic controller control line, magnetic controller power line, Modbus, and Key pad using RJ-45 connectors need to be insulated to prevent the terminals from corroding due to low temperature condensation.

1.3 Vibration

It is different from tradition centrifugal compressor. RTM series compressor operates with a magnetic motor and the motor shaft is levitated during operation. The measurement of vibration level on compressor body cannot represent the vibration level of the motor shaft. The vibration level of the motor shaft is monitored by magnetic bearing controller (MBC). We call the anti-vibration function of magnetic bearing as UFRC.

MBC controls the position and movement of the motor shaft. When compressor operates in different working conditions or loadings, the motor shaft will generate forces toward the magnetic bearings. The unbalance from the bearing is regularly created and considered as loading. MBC has UFRC function and can avoid the vibration from compressor. When if having the high vibration which is not

able to be managed by MBC, MBC will send the alarm signal to the controller to decide whether making emergent stop or not. Therefore, there is no additional anti-vibration required under MBC control function.
The vibration level of the compressor body is lower than 1.0 mm/s (overall) when it is dispatched from HANBELL.

Note:

1. In the situation that when the bearing is not in well unbalanced position but still can be controlled by MBC, normally there is no high vibration happened and only the bearing running path is close to the limitation.
2. The measurement of frequency spectrum before the dispatch from HANBELL is to make sure there is no abnormal performance in running.

1.4 Abbreviation description

Abbreviation	Description
AC	Alternating current
AHRI	Air-Conditioning, Heating and Refrigeration Institute
ANSI	American National Standard Institute
CT	Condensing Temperature
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ET	Evaporating Temperature
GB	Guo Biao (National Standard of The PRC)
HGBP	Hot Gas Bypass
IGV	Inlet Guide Vane
IP	International Protection Marking
JIS	Japanese Industrial Standards
MBC	Magnetic Bearing Controller
Pr	Pressure Ratio
RTM	Magnetic Centrifugal Refrigeration Compressor
THD	Total Harmonic Distortion
UFRC	Unbalance Force Rejection Control
UL	Underwriter Laboratories Inc.
VDC	Voltage Direct Current
VFD	Variable-frequency Drive

Chapter 2. Basic design

2.1 Compressor nomenclature

RT M – XX X

2.2 Application limits

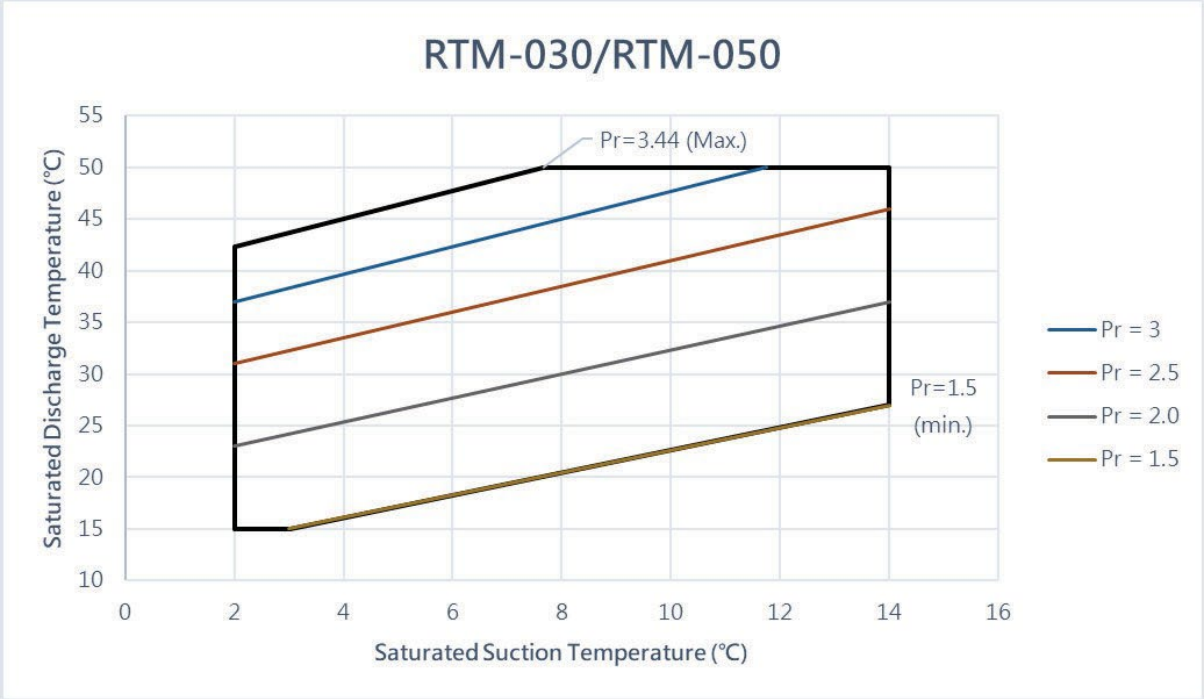


Figure 2.1 RTM-030/RTM-050 application limits (@IGV=100%)

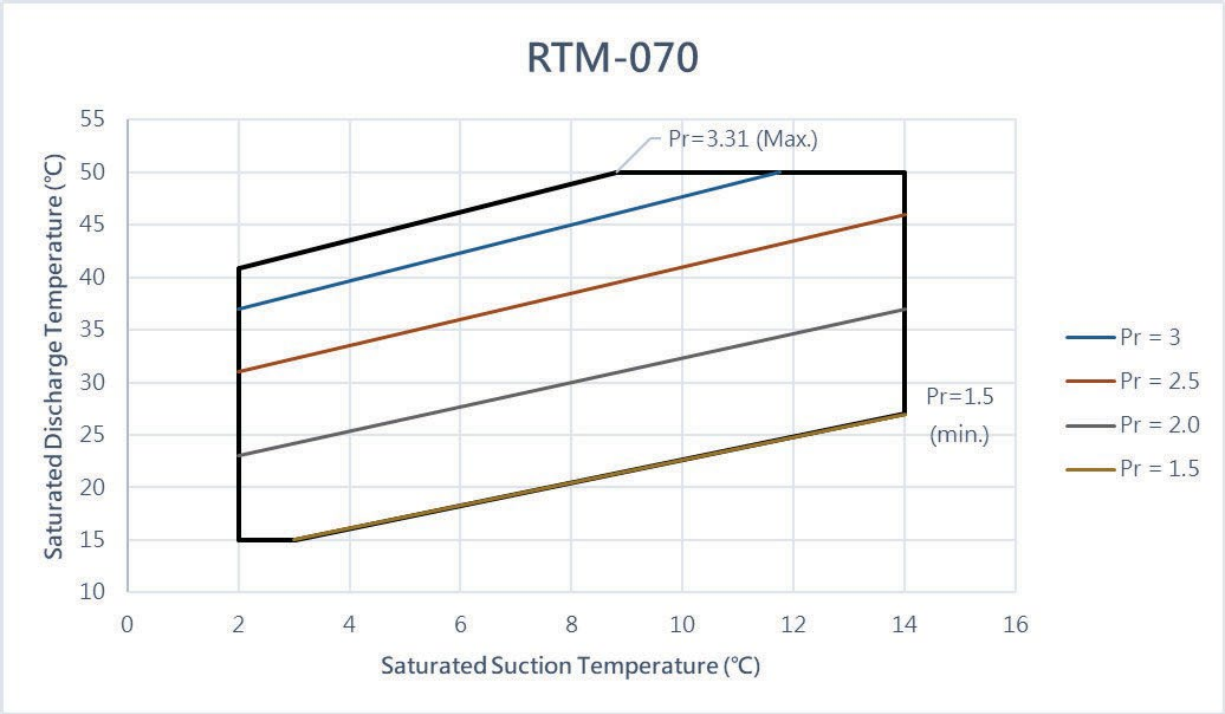


Figure 2.2 RTM-070 application limits (@IGV=100%)

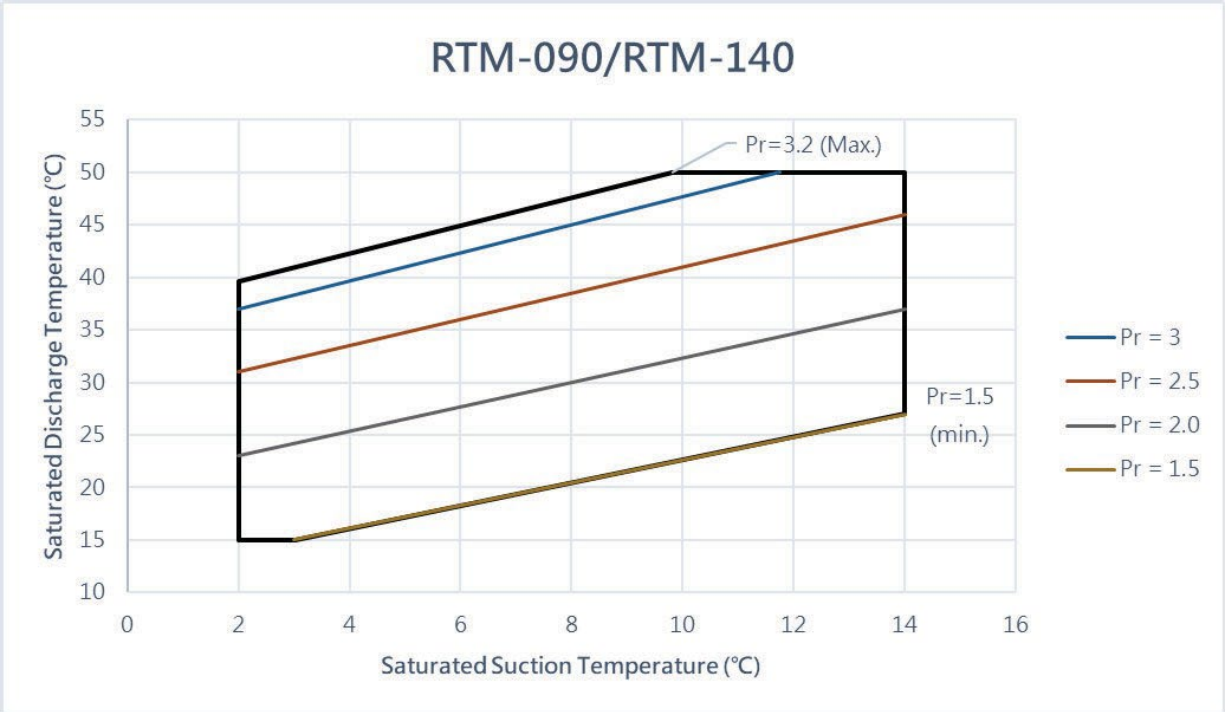


Figure 2.3 RTM-090/ RTM-140 application limits (@IGV=100%)

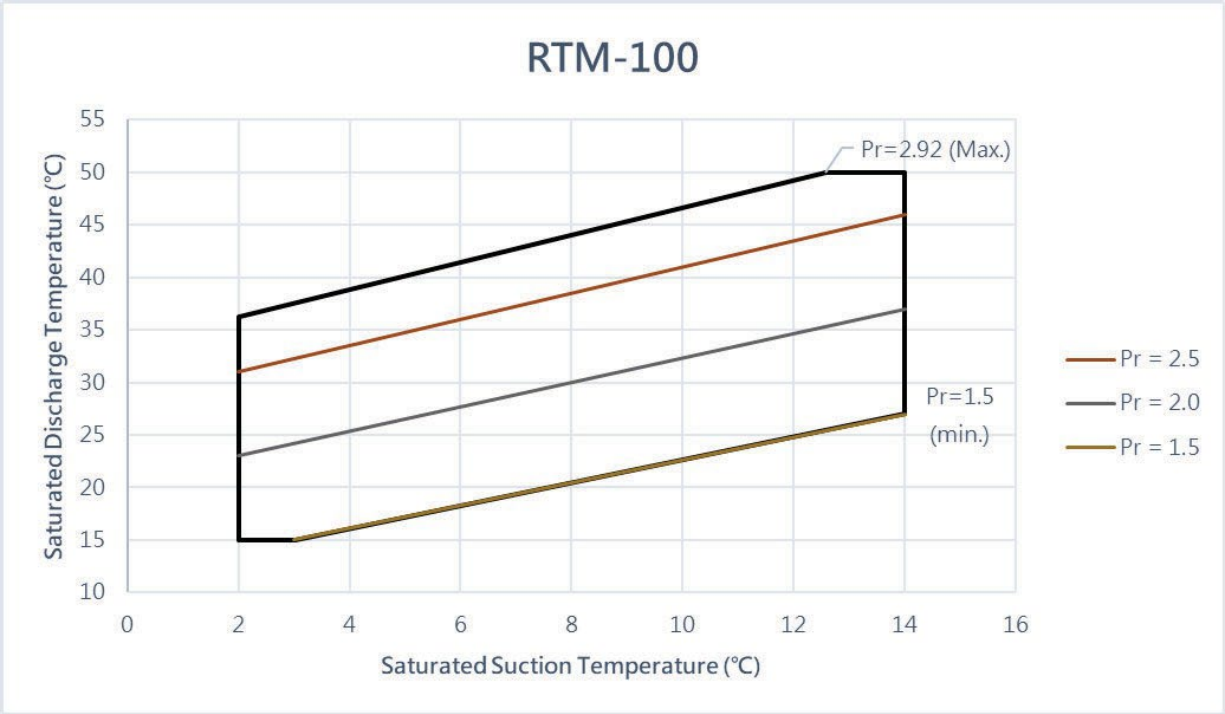


Figure 2.4 RTM-100 application limits (@IGV=100%)

Note:

1. This range represents the range of FLA at 380V, and the limits for maximum condensing temperature (SCT) and evaporating temperature (SST) are depending on the full load current and the axial thrust of the compressor.
2. Please refer to the latest compressor selection software for compressor capacity under specific working condition(s).

2.3 Compressor specifications

Model			RTM-030		RTM-050	
Refrigerant			R134a			
Compressor	Type		Two-stage compression			
	Max. pressure ratio		3.44			
	Nominal cooling capacity	USRT	125	150	200	250
	Rated Frequency	Hz	350	366.6	293.3	318.3
	Max. Frequency	Hz	383.3		321.7	
	Min. Frequency	Hz	210.0		176.0	
	Axial guide vane control	IGV	20%~100% continuous			
	Movable Diffuser Control		NA			
Transmission	Type		Direct-driven			
	Lubrication		Oil free			
Motor	Type		3 Phase, 2 Pole, Permanent magnet motor			
	Starting		By VFD			
	Power Voltage	V	380			
	Insulation		Class H			
Dimension (LxWxH)		m	1.02x0.62x0.53		1.13x0.74x0.59	
Weight		kg	395		573	
Hydrostatic pressure test		kg/cm²g	22			

Table 2.1 RTM-030/ RTM-050 Compressor specifications

Model			RTM-070		RTM-090	
Refrigerant			R134a			
Compressor	Type		Two-stage compression			
	Max. pressure ratio		3.31		3.2	
	Nominal cooling capacity	USRT	300	350	400	450
	Rated Frequency	Hz	230	240	216.6	225
	Max. Frequency	Hz	250.0		225.0	
	Min. Frequency	Hz	138.0		130.0	
	Axial guide vane control	IGV	20%~100% continuous			
	Movable Diffuser Control		NA			
Transmission	Type		Direct-driven			
	Lubrication		Oil free			
Motor	Type		3 Phase, 2 Pole, Permanent magnet motor			
	Starting		By VFD			
	Power Voltage	V	380			
	Insulation		Class H			
Dimension (LxWxH)		m	1.3x0.8x0.7			
Weight		kg	1,050		1,150	
Hydrostatic pressure test		kg/cm²g	22			

Table 2.2 RTM-070/ RTM-090 Compressor specifications

Model			RTM-100	RTM-140	
Refrigerant			R134a		
Compressor	Type		Two-stage compression		
	Max. pressure ratio		2.92	3.2	
	Nominal cooling capacity	USRT	500	600	700
	Rated Frequency	Hz	218.3	350	366.6
	Max. Frequency	Hz	218.3	383.3	
	Min. Frequency	Hz	131.0	210.0	
	Axial guide vane control	IGV	20%~100% continuous		
	Movable Diffuser Control		NA		
Transmission	Type		Direct-driven		
	Lubrication		Oil free		
Motor	Type		3 Phase, 2 Pole, Permanent magnet motor	3 Phase, 4 Pole, Permanent magnet motor	
	Starting		By VFD		
	Power Voltage	V	380		
	Insulation		Class H		
Dimension (LxWxH)		m	1.34x0.85x0.76	1.56x0.85x0.83	
Weight		kg	1,250	1,450	
Hydrostatic pressure test		kg/cm^2g	22		

Table 2.3 RTM-100/ RTM-140 Compressor specifications

Model			RTM-180	
Refrigerant			R134a	
Compressor	Type		Two-stage compression	
	Max. pressure ratio		3.2	
	Nominal cooling capacity	USRT	800	900
	Rated Frequency	Hz	291.5	299.8
	Max. Frequency	Hz		
	Min. Frequency	Hz		
	Axial guide vane control	IGV	20%~100% continuous	
	Movable Diffuser Control		NA	
Transmission	Type		Direct-driven	
	Lubrication		Oil free	
Motor	Type		3 Phase, 4 Pole, Permanent magnet motor	
	Starting		By VFD	
	Power Voltage	V	380	
	Insulation		Class H	
Dimension (LxWxH)		m	1.82x1.02x0.95	
Weight		kg	1,800	

Hydrostatic pressure test	kg/cm²g	22

Table 2.4 RTM-180 Compressor specifications

2.4 Compressor performance

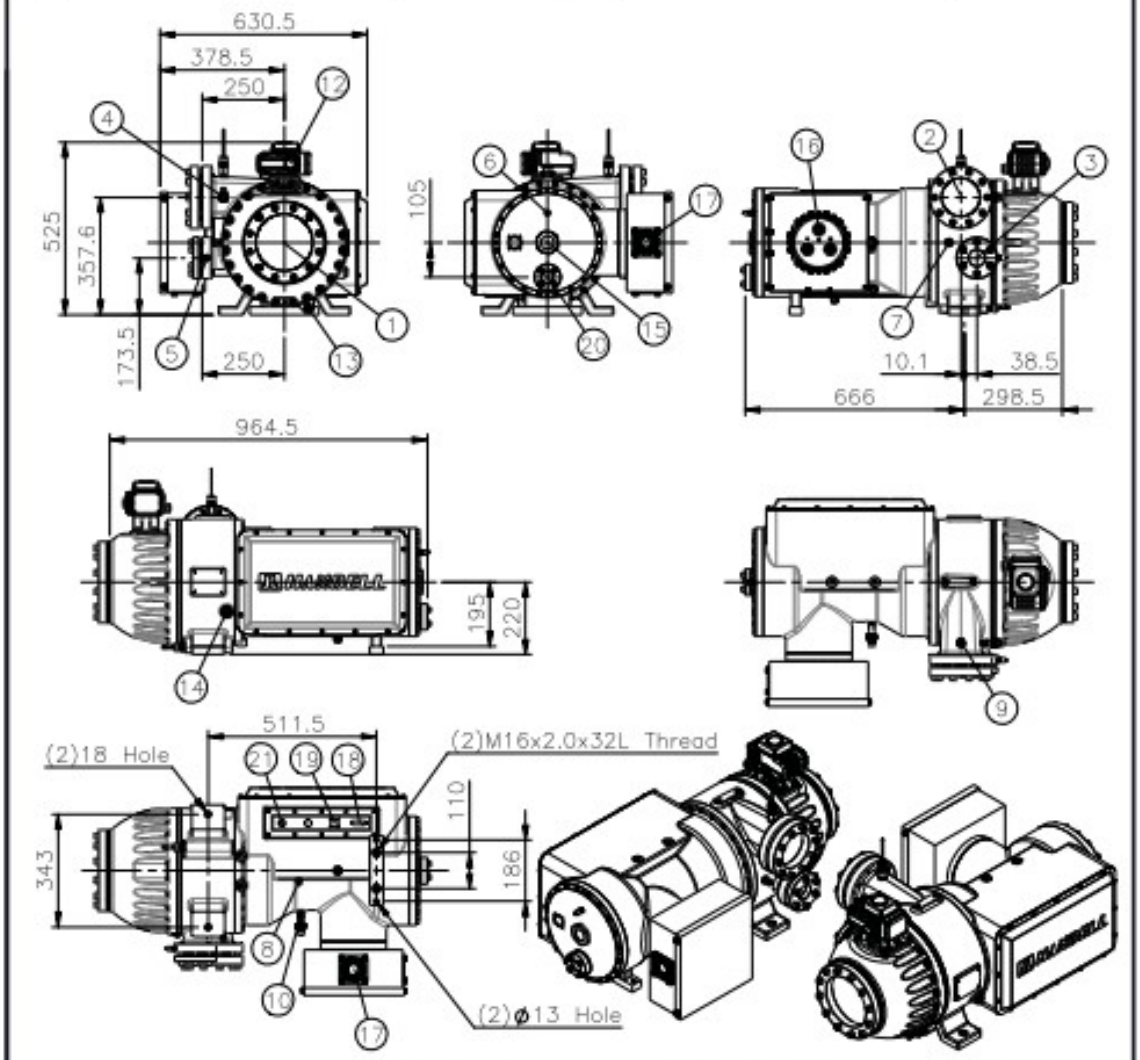
Model	USRT	COP	IPLV
RTM-030	125	6.37	10.23
	150	6.32	10.37
RTM-050	200	6.60	10.86
	250	6.52	11.00
RTM-070	300	6.54	10.37
	350	6.50	10.72
RTM-090	400	6.83	10.86
	450	6.67	10.96
RTM-100	500	6.92	11.61
RTM-140	600	6.61	10.39
	700	6.50	10.64

Table 2.5 Compressor performance

Note: The performance is based on AHRI-55X condition.
Working condition is based on SST: 6C SCT: 36C

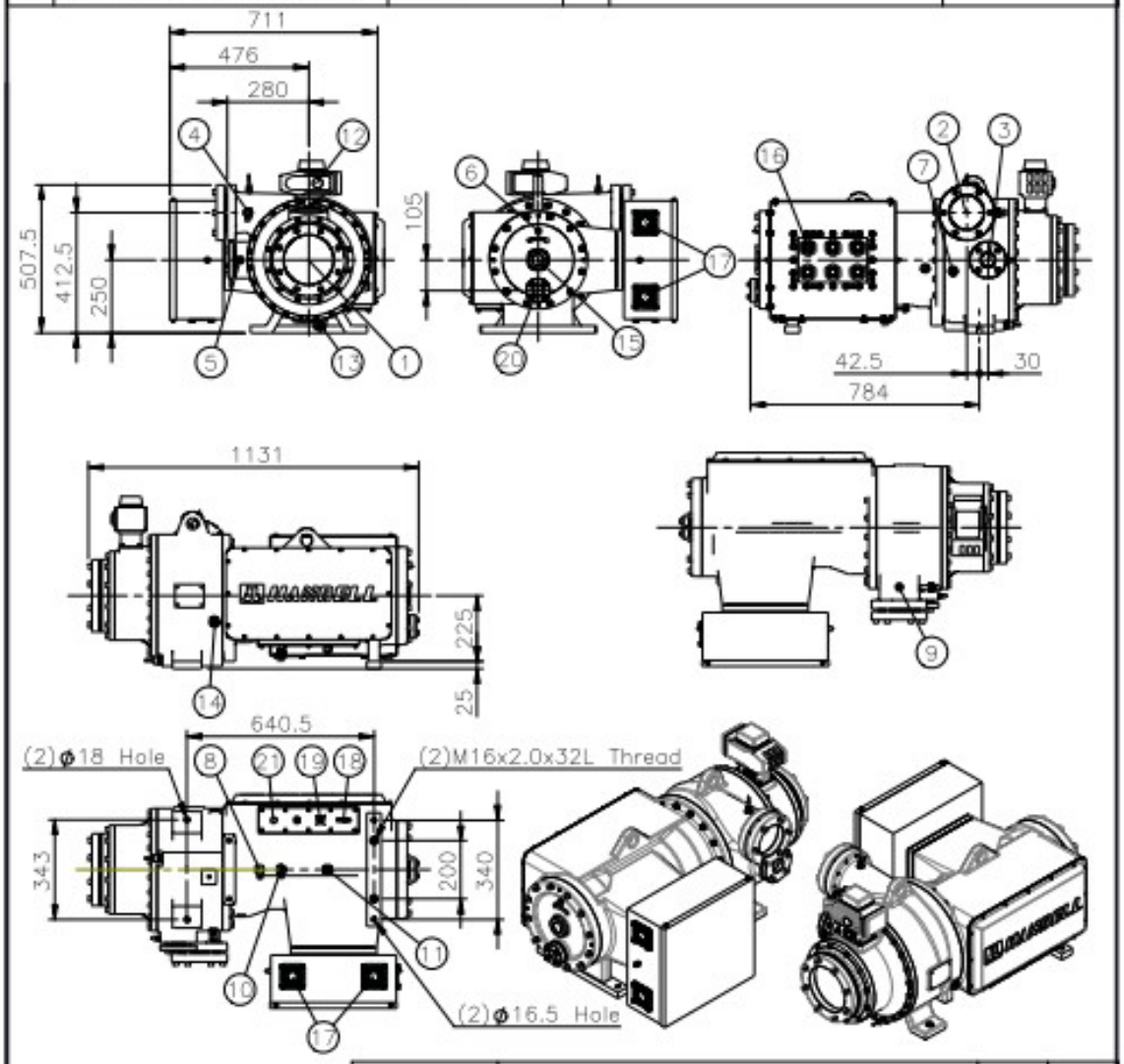
2.5 Compressor Outline

No.	Name	Specification	No.	Name	Specification
1	Suction flange	6" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	4" 20K	13	Refrigerant heater	220V,150W
3	Economizer flange	1 1/2" 20K	14	Sight glass(refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	M16,380V
6	Pressure connection,Motor	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet(air+liquid)	1/2"FL	18	Control & sensor port	6*PT-100
8	Bearing cooling oulet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling oulet	1 1/4"FL
10	Motor cooling inlet(liquid)	1/4"FL	21	Modbus port	RJ45
11	Motor cooling outlet(liquid)	1/2"FL			



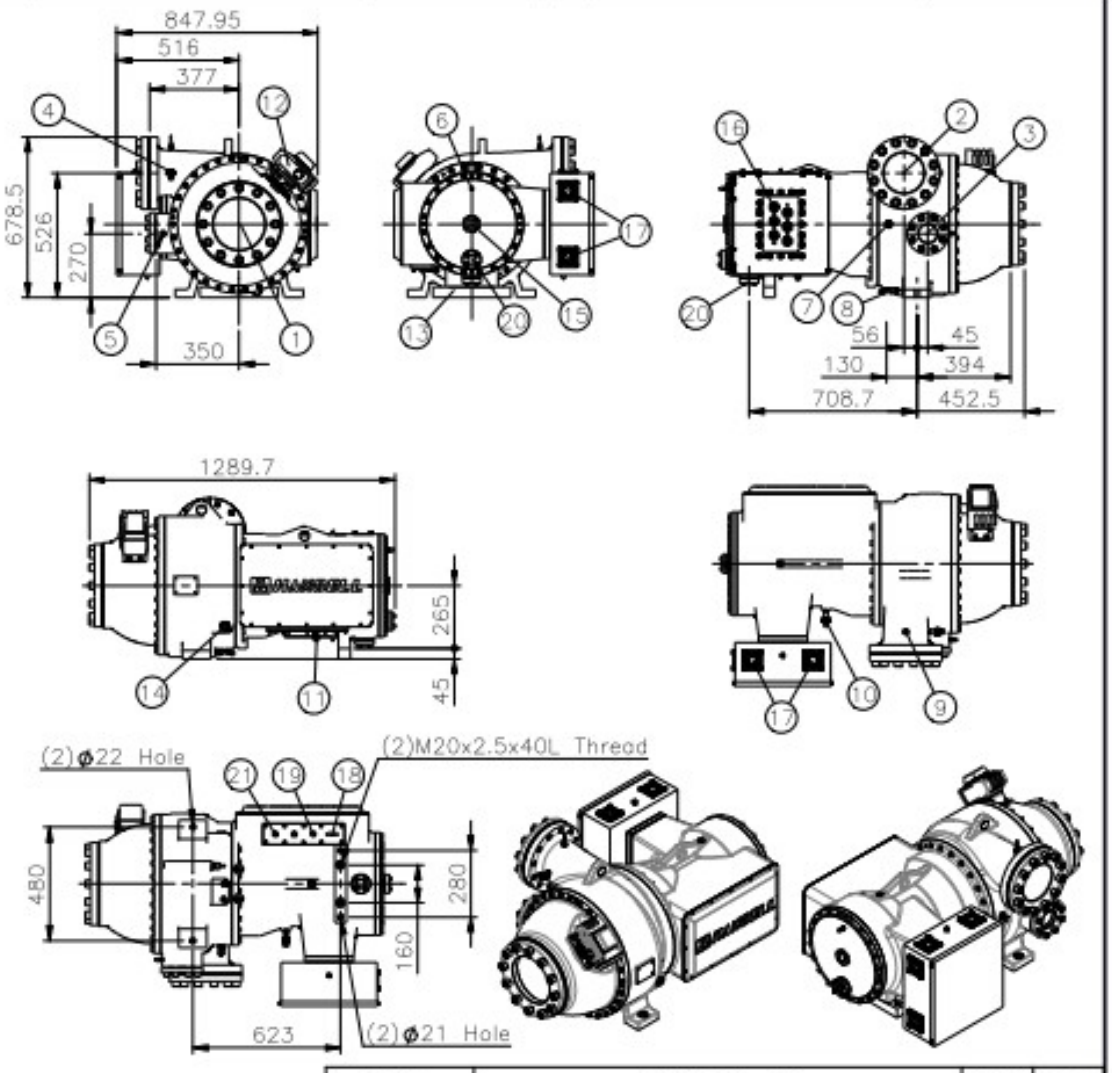
Mode	RTM-030 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	1.2
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	6" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	4" 20K	13	Refrigerant heater	220V,300W
3	Economizer flange	1 1/2" 20K	14	Sight glass(refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	M16,380V
6	Pressure connection,Motor	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet(air+liquid)	1/2"FL	18	Control & sensor port	
8	Bearing cooling oulet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling oulet	1 1/4"FL
10	Motor cooling inlet(liquid)	1/4"FL	21	Modbus port	RJ45
11	Motor cooling outlet(liquid)	1/2"FL			



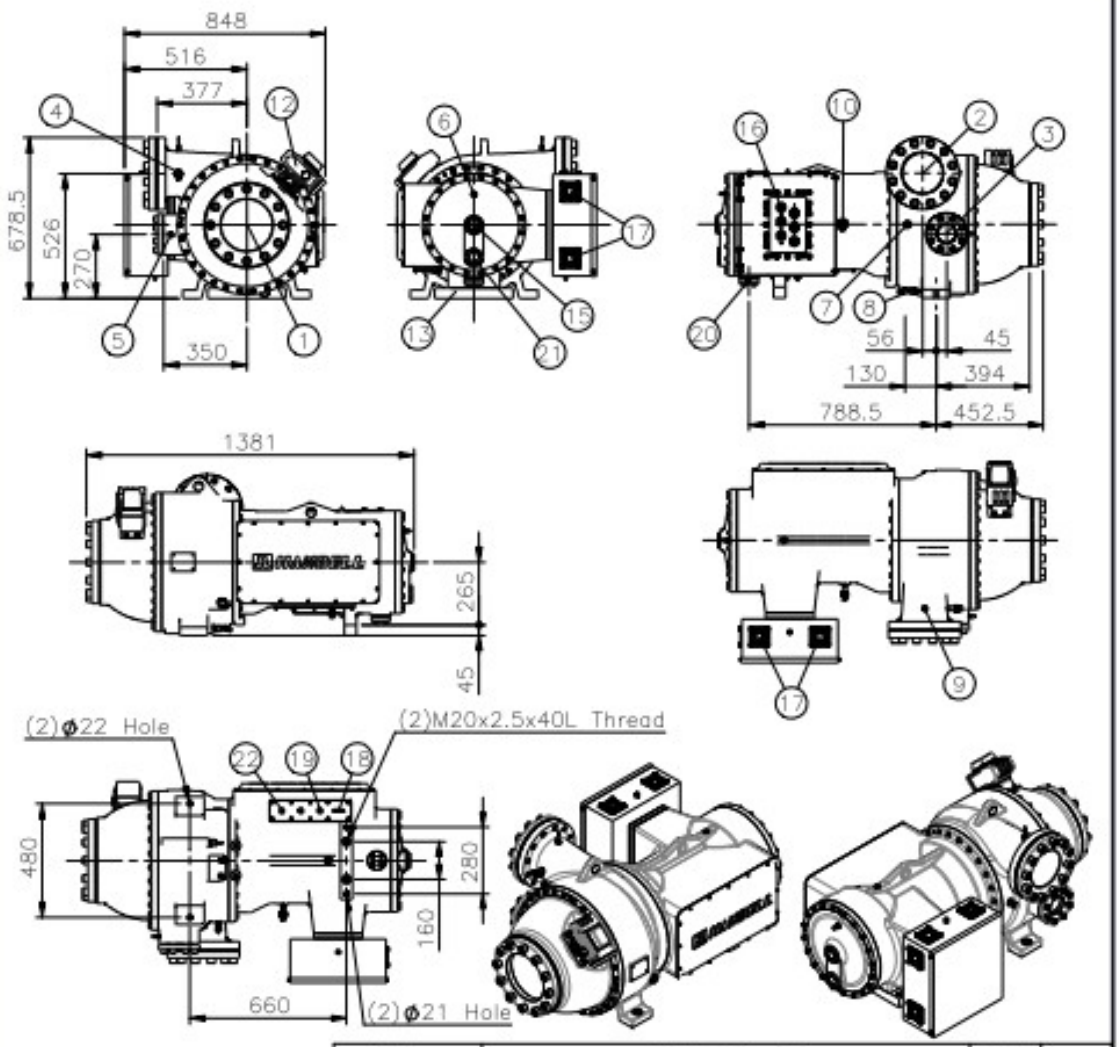
Mode	RTM-050 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	1.3
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	6" 20K	13	Refrigerant heater	220V,300W
3	ECO flange	2 1/2" 20K	14	Sight glass(Refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	5/8-11UN-6g
6	Pressure connection,Pmo	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet	1/2"FL	18	Control & sensor port	
8	Bearing cooling outlet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling outlet	1-1/4"FL
10	Motor cooling inlet	1/4"FL	21	Modbus port	RJ45
11	Motor cooling outlet	1/2"FL			



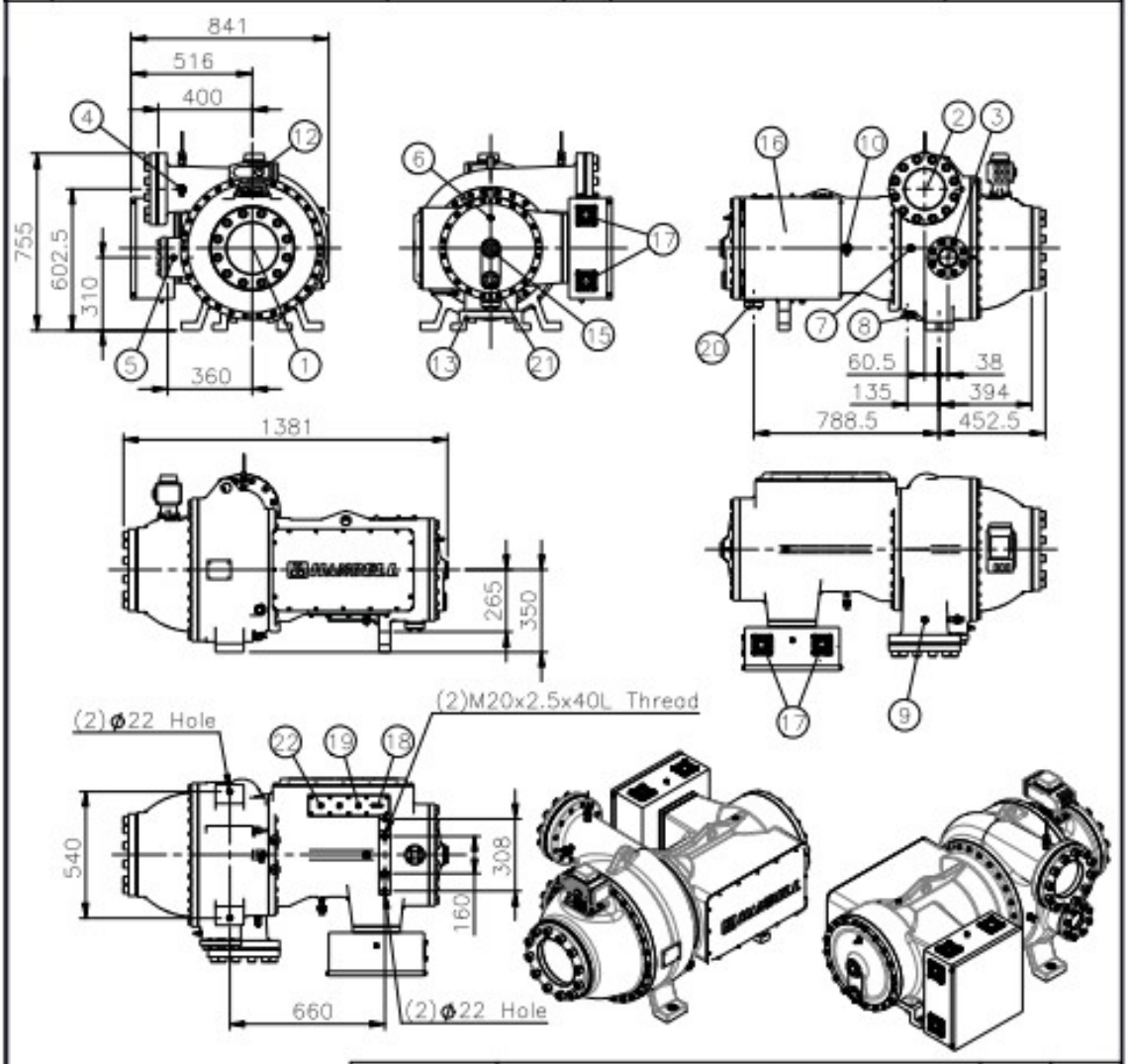
Mode	RTM-070 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	2.1
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	6" 20K	13	Refrigerant heater	220V,300W
3	ECO flange	2 1/2" 20K	14	Sight glass(Refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	5/8-11UN-6g
6	Pressure connection,Pmo	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet	1/2"FL	18	Control & sensor port	
8	Bearing cooling outlet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling outlet	1-1/4"FL
10	Motor cooling inlet	1/4"FL	21	Sight glass(Refrigerant)	
11	Motor cooling outlet	1/2"FL	22	Modbus port	RJ45



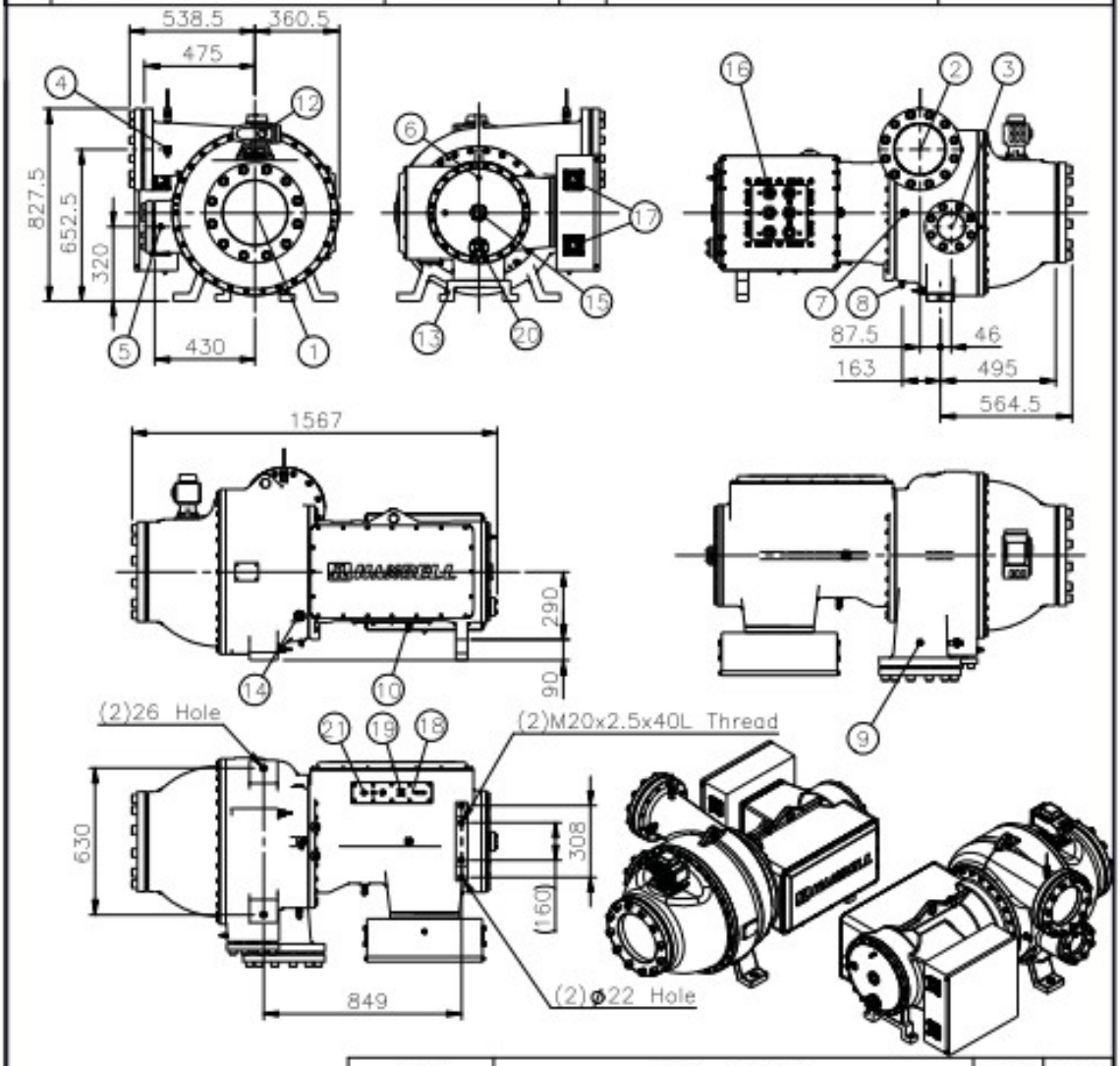
Mode	RTM-090 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	2.1
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	6" 20K	13	Refrigerant heater	220V,300W
3	ECO flange	2 1/2" 20K	14	Sight glass(Refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	5/8-11UN-6g
6	Pressure connection,Pmo	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet	1/2"FL	18	Control & sensor port	
8	Bearing cooling outlet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling outlet	1-1/4"FL
10	Motor cooling inlet	1/4"FL	21	Sight glass(Refrigerant)	
11	Motor cooling outlet	1/2"FL	22	Modbus port	RJ45



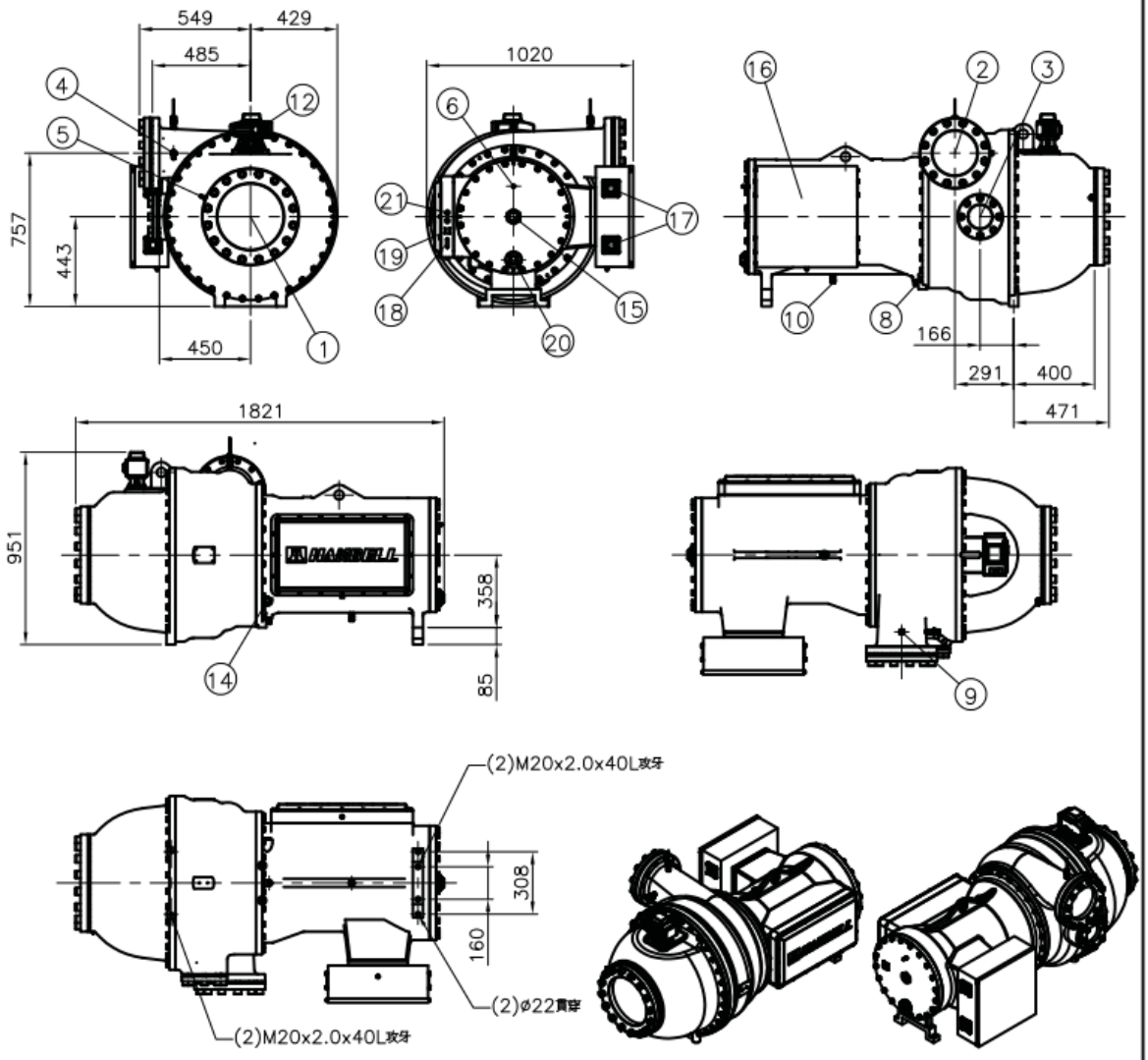
Mode	RTM-100 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	1.1
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	10" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	8" 20K	13	Refrigerant heater	220V,300W
3	ECO flange	4" 20K	14	Sight glass(Refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pe	1/4"FL	16	Cable connector	7/8-14UN-6g
6	Pressure connection,Pmo	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet	1/2"FL	18	Control & sensor port	
8	Bearing cooling outlet	1/4"FL	19	Power cable connector	
9	Temperature sensor port,Td	PT-100	20	Bearing cooling outlet	1-1/4"FL
10	Motor cooling inlet	1/2"FL	21	Modbus port	RJ45
11	Motor cooling outlet	N/A			



Mode	RTM-140 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	1.2
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20K	12	Actuator	220V,50/60Hz
2	Discharge flange	8" 20K	13	Refrigerant heater	N/A
3	ECO flange	4" 20K	14	Sight glass(Refrigerant)	
4	Pressure connection,Pd	1/4"FL	15	Sight glass(motor direction)	
5	Pressure connection,Pi	1/4"FL	16	Motor power terminal	7/8-14UN-6g
6	Pressure connection,Pmo	1/4"FL	17	Cable box flange	86x86
7	Bearing cooling inlet	N/A	18	Control & sensor port	
8	Bearing cooling outlet	1/4"FL	19	AMB power cable connector	
9	Temperature sensor port,Td	PT-100	20	Motor&Brg. cooling outlet	1-1/2"
10	Motor cooling inlet	1/2"FL	21	Modbus terminal	RJ45
11	Motor cooling outlet	N/A			



Model	RTM-180 DT	Unit	mm
Name	AMB Centrifugal Compressor Outline	Ver.	1.1
	HANBELL PRECISE MACHINERY CO., LTD.		

2.6 Connections:

2.6.1 Suction/discharge/economizer flange size:

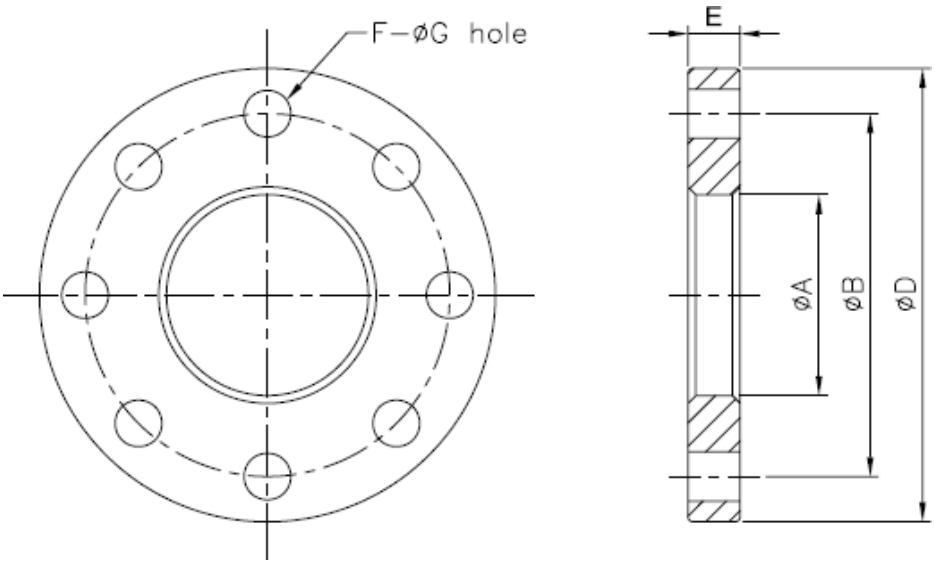


Figure 2.3 Flange

y伋		Size	A			B	D	E	F	G	护簹::
			GB	JIS	AMSE						
RTM-070 RTM-090 RTM-100	Suction	8"	221.5	218	223.1	305	350	30	12	25	>8.2
	Discharge	6"	170.5	167	172.3	260	305	28	12	25	>7.1
	ECO. port	2 1/2"	77.5	77.5	77	140	175	20	8	19	>5.2
RTM-030 RTM-050	Suction	6"	170.5	167	172.3	216	247	27	12	14	>7.1
	Discharge	4"	116	116	118.3	160	190	30	10	14	>6
	ECO. port	1 1/2"	50	50	52.3	95	125	20	6	14	>3.7
RTM-140	Suction	10"	276.5	270	277	380	430	34	12	27	>9.3
	Discharge	8"	221.5	218	223.1	305	350	30	12	25	>8.2
	ECO. port	4"	116	116	118.3	185	225	24	8	23	>6
RTM-180	Suction	12"	327.5	320	332.8	430	480	36	16	27	>10.3
	Discharge	8"	221.5	218	223.1	305	350	30	12	25	>8.2
	ECO. port	4"	116	116	118.3	185	225	24	8	23	>6

i t	*Material- standard JIS 20kg/cm²g steel Unit: mm
	*Thickness must be equal to the standard or larger. Note: The increased thickness of piping can lead to the noise reduction.
	*The RTM-030 and RTM-050 models feature custom-made flanges, not standard off-the-shelf flanges available in the market.
	*The internal diameter of flanges specified in the GB standard table can be paired with flange gaskets for use.
	*Please refer to the specifications of each standard for the outer diameter of the

flange gaskets listed in the table above.

Table–1 Flange dimensions

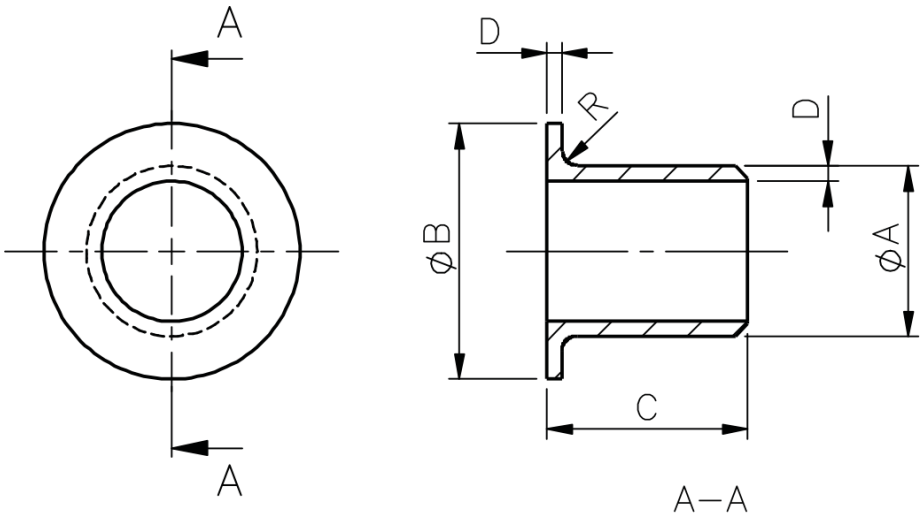


Figure -1 Flange bushing

Size	A	B	C	D	R
1 1/2"	48.6	73	50	3	3
2 1/2"	76.3	105	65	3.5	4
4"	114.3	157	75	4	5
6"	165.2	216	90	5	5
8"	216.3	270	100	6.5	5
10"	267.4	324	125	6.5	5
Note	*Material- SUS304		Unit: mm		

Table 2-6 Bushing dimension

Note1. Please weld steel pipes onto flanges by butt-welding and make sure debris has been cleaned, otherwise the compressor might be damaged during operation. Flow velocity on the discharge side of the compressor could be as high as 15~20 m/sec. High-speed discharge gas will make noise in discharge connection. In order to decrease the noise level, it's recommended to round sharp edges of joints of piping as shown in Figure 2.13。

Note2. The discharge and suction piping is recommended to be one size larger to reduce pressure drop and noise level. If the noise level is high in discharge side, it is suggested to increase the piping thickness or enclose with acoustic foam shown in Figure 2.14。

Note3. The flange bushing is made by stainless steel, and the steel pipe is made by carbon steel. When welding with different materials, please select appropriate solder to avoid fracture due to insufficient welding strength.

Note4. Outline drawings in chapter 2.5 is without flange bushing. Please refer to the table 2-6 for the bushing size.

Note5. The flange gaskets need to be paired with flanges specified in the GB standard listed in Table 2-5.

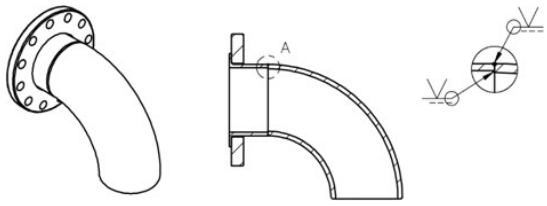


Figure-2 Discharge and suction piping

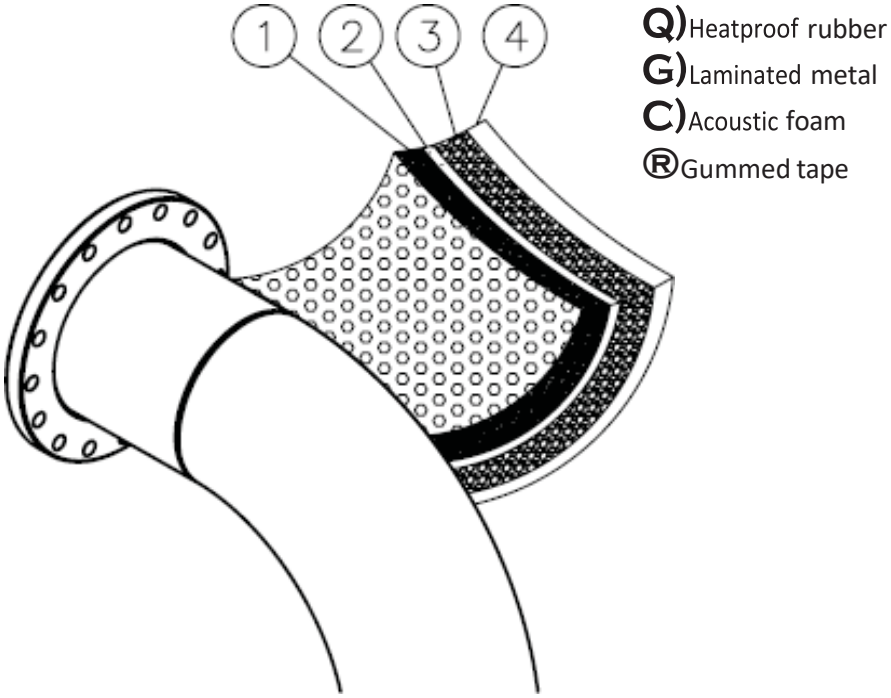


Diagram-3 Discharge acoustics enclosure

2.6.2 Discharge stop valve/butterfly type (optional):

For maintenance, the stop valve can be installed in condenser inlet and liquid line. When installing butterfly valve, the pipe must also be enlarged one size to effectively reduce the pressure drop. The pressure drop of the butterfly valve is listed as table below:

Model	Size (inch)	Hydraulic Resistance (K)	Density (kg/m^3)	Velocity (m/s)	Pressure Drop (kPa)
RTM-030	6"	0.64	42.6	6.7	0.61
RTM-050	6"	0.64	42.6	11.1	1.69

RTM-070	8"	0.5	42.6	9.1	0.88
RTM-090	8"	0.5	42.6	11.7	1.46
RTM-100	8"	0.5	42.6	13.0	1.80
RTM-140/180	10"	0.51	42.6	11.6	1.47

Table–2 Pressure drop

Note: The density and velocity and based on following working condition CT/ET=36/6℃;
The pressure drop of the selected butterfly valve is recommended to be <0.1bar.

Butterfly valve size		A	B	C	D	E	F	G	H	J	K	L
2 1/2”	65mm	121	48	58	97	162	111	16	11	32	64	20
3”	80mm	133	48	73	104	168	111	16	11	32	64	20
4”	100mm	171	52	94	120	191	111	16	11	32	64	19
5”	125mm	191	57	122	129	191	130	19	13	32	114	24
6”	150mm	219	57	149	141	203	130	19	13	32	114	24
8”	200mm	273	61	198	176	241	130	22	16	32	114	24
10”	250mm	332	70	248	217	273	155	30	22	51	114	27
Remark		*Dimension C is minimum size when the valve is opened totally unit:mm										
		*Operation Temp.:-29℃~260℃;Operation Pressure:1480psi										
		*Material- ASTAM351 GR CF8M stainless steel. Pressure level: ASME 150										
		*The butterfly valve is of wafer plate valves. Use ANSI 150 standard flange										

Table–3 Flange size

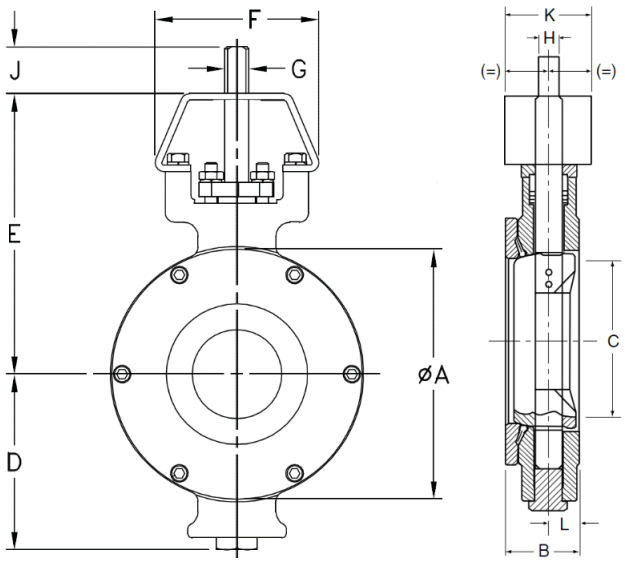


Figure -4 Outline of butterfly size

2.6.3 Discharge check valve：

To protect compressor from serious damage due to reverse rotation after emergency stop or shutdown, it is necessary to install the discharge check valve.

Warning：Discharge check valve is mandatory

Size		A(mm)	B(mm)	C(mm)	D(mm)
4"	100mm	64	156	112	53
6"	150mm	76	213	160	77
8"	200mm	89	267	210	102
10"	250mm	114	328	260	107
Remark		*The check valve is of wafer plate valve. Use ANSI 150 standard flange			

Table–4 Check valve size

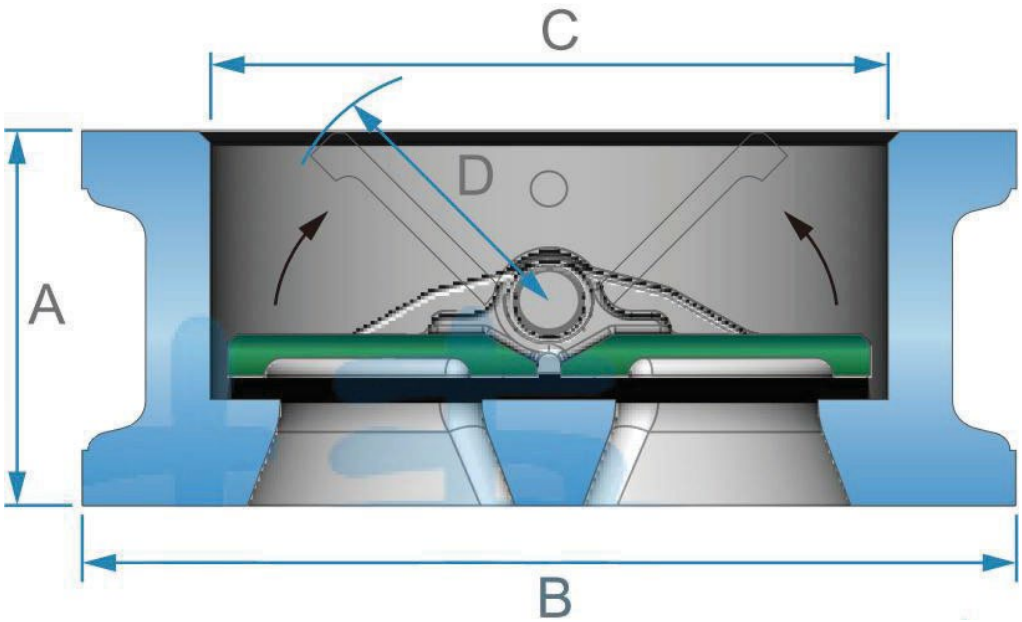


Figure-5 Dual plate discharge check valve

Chapter 3 Suction Structure

3.1 Inlet Guide Vanes：

The cooling capacity of the RTM compressor is mainly adjusted by changing the RPM (using a VFD), but this is limited in its range. Therefore, the RTM compressor is also equipped with an inlet guide vane (IGV) angle adjustment mechanism to increase the cooling capacity, as shown in Figure 3.1. The gas refrigerant enters the compressor through the evaporator and then passes through the IGV before entering the impeller. By adjusting the angle of the IGV, the gas flow angle entering the impeller is changed, causing the gas flow to generate pre-swirl. When the gas flow angle decreases, the cooling capacity also decreases. This allows for further adjustment of the capacity. For the difference between frequency adjustment and IGV control, please refer to Figure 3-8 in chapter 3.4.1."

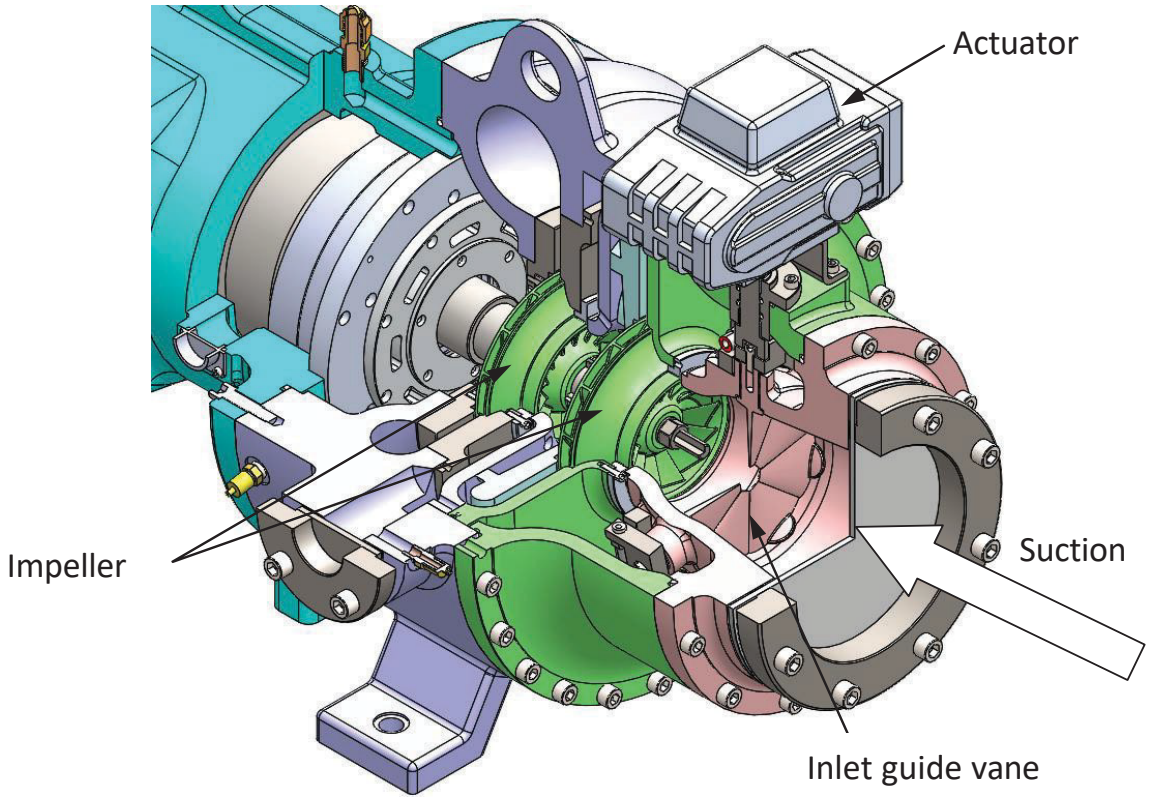


Figure-6 Compressor inlet guide vanes

3.1.1 Control of inlet guide vanes：

Angles of inlet guide vanes are automatically controlled through a vane actuator with a lever arm, and IGV opening ranges from 20% (minimum load) to 100% (full load).

Opening of the vane actuator in percentage (%) has a linear relation to the control signal. However, cooling capacity does not relate the angle changes of guide vanes. Therefore, vane actuator's opening in percentage (%) is not the same as the cooling capacity in percentage (%)

Note1:When inlet guide vanes are completely closed, a small hole will be formed in the middle to keep a basic amount of gas flow into the compressor. When inlet guide vanes are fully closed, only min. mass flow passes so the smallest cooling capacity will be established.

Note2:When the operating pressure ratio is lower, the lower minimum cooling capacity can be reached.

Note：

1. IGV should be fully opened before start up.
2. When HGBP opened before stop，please keep IGV fully opened.
3. IGV operating range is 20%~100%.
4. Actuator feedback window is shown as follows:

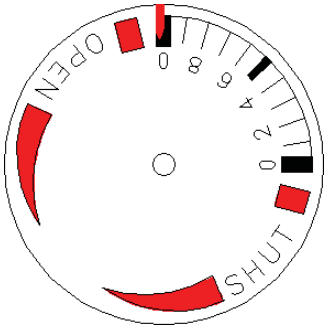


Figure-7 IGV OPEN

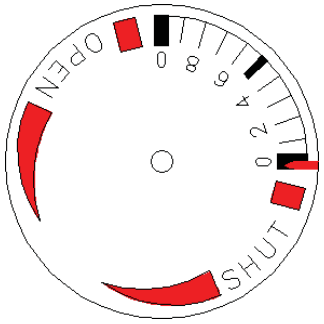


Figure-8 IGV SHUT

3.2 Actuator：

3.2.1 Actuator information：

RATED POWER	1Phase, AC 220V±10%(50/60Hz)
INPUT SIGNAL	4~20mA·DC;1~5V·DC;2~10V·DC
OUTPUT SIGNAL	4~20mA·DC
OUTPUT TORQUE	100N-m～50N-m(RTM-030 only)
OPERATION SPEED	30 sec(50Hz);25 sec(60Hz)
TRAVEL ANGLE	0~90°
RATED OPERATION TIME	Continuous (100%)
RESOLUTION	1%～minimum 0.16mA
DEAD ZONE	Max. 0.5%
PROTECTION	Motor thermal protector (120ºC)
AMBIENT TEMPERATURE	-30~60ºC
RATED CURRENT	0.35A(220V)
MOTOR	25W
INSULATION GRADE	Class E
INSULATION RESISTANCE	500V·DC / 100MΩ
WITHSTAND VOLTAGE	1500V·AC / 1 minute
WIRE INLET PORT	G1/2×2
ENCLOSURE PROTECTION	IP-67
WEIGHT	3kg

Table–5 Actuator data

Note:

1. When operating at ambient temperature under 0°C, optional space heater(optional) is required to keep the actuator inside dry. Otherwise, moisture may condense under low temperature and high humidity or parts may shrink at low temperature.
2. The standard input control signal is 4-20mA DC. If customers plan to apply to " 1-5V DC or 2-10V DC", please inform Hanbell beforehand. The controller version does not support to switch different input signals. The available specification of output feedback signal is 4-20mA DC only.

3.2.2 Electrical connections

The outer diameter of cable should be Φ9 ~ Φ11. If other size of wire is used, please select the correct cable gland otherwise the water may penetrate.

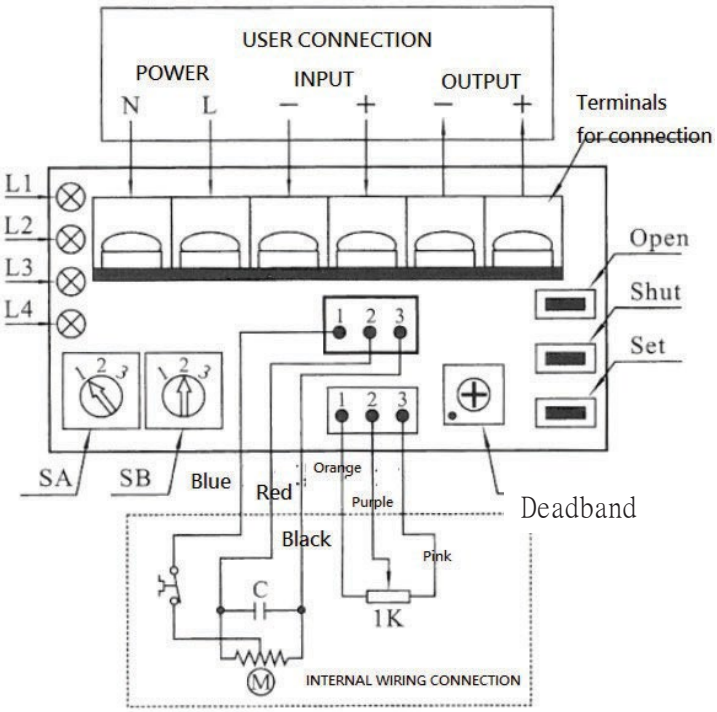


Figure 3-4 Wiring diagram (single phase, 220V)

Remark:1. 5A fuse or breaker should be installed at main power supply circuit. Voltage stabilizer is required to avoid the damage caused by the imbalance of voltage. (within 10%)

2. Signal wires should be shielded to prevent interference.
3. The actuator wiring shall not be parallel to the motor cables.

3.2.3 Electrical Wiring

Make effective protection when using cable gland and vinyl tube. Please refer to figure 3.5.

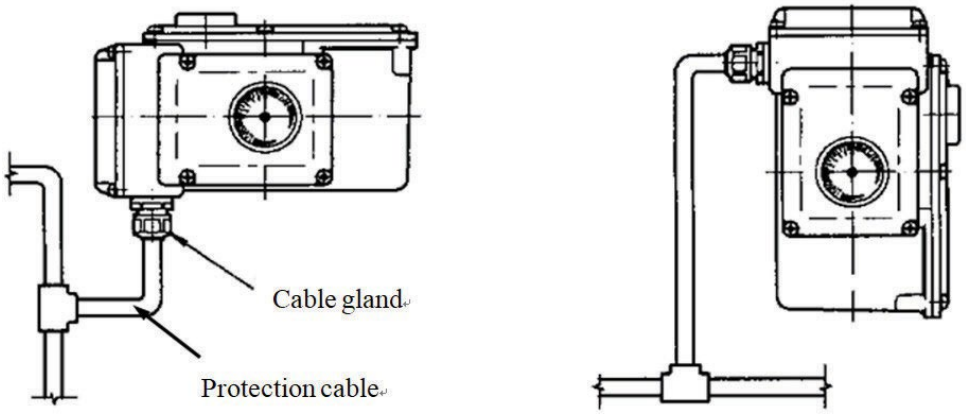


Figure.9 Illustration of electrical wiring

3.2.4 Setting of Control

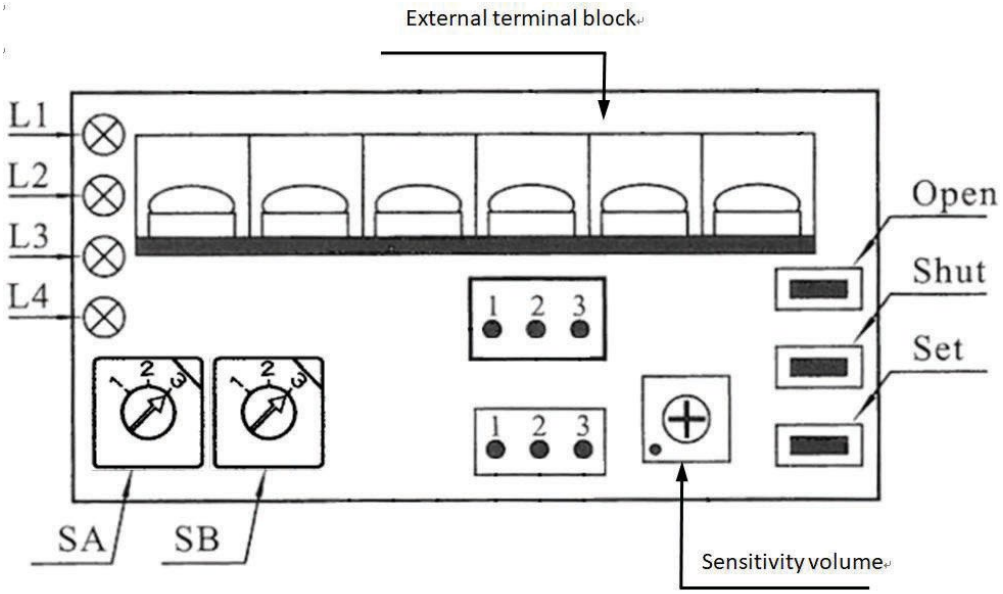
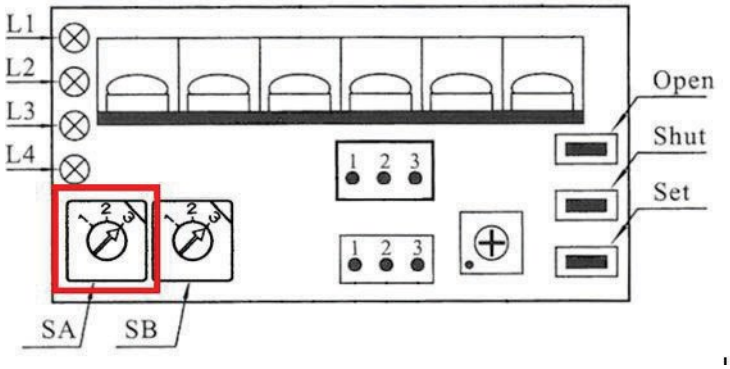


Figure.10 Switcher

3.2.4.1 Setting of Input/Output Signal



Selection mode of SA knob:

 Direct Action

When the knob is selected to 1 (Direct Action), the input and output signal will be the same. For example, if the input signal is 4mA, the output signal will be 4mA.

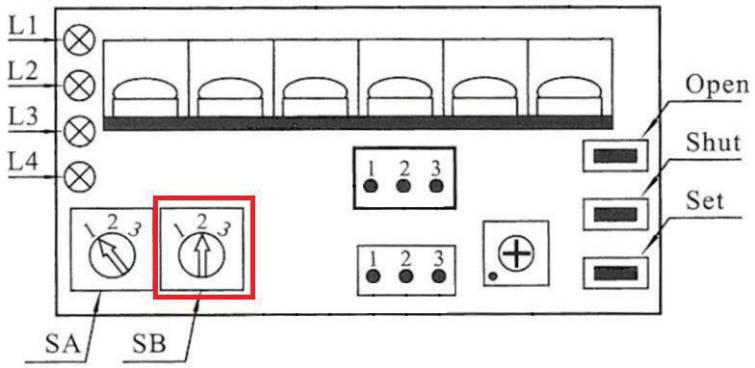
 Manual Mode

When the knob is selected to 2 (Manual Mode), the switcher can be operated manually (please follow the Hanbell's instruction for the operation of this mode).

 Reverse Action (Default)

When the knob is selected to 3 (Reverse Action), the input and output signal will be opposite. For example, if the input signal is 20mA, the output signal will be 4mA.

3.2.4.2 Setting of Signal Interruption



Selection mode of SB knob:

Close Action

The actuator is judged to fully close the guide vane.

Stop Action

The actuator is judged to keep the guide vane at the same position as before stop

Open Action (Default)

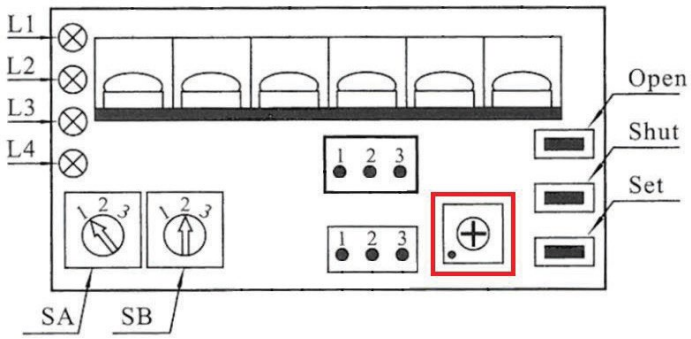
The actuator is judged to fully open the guide vane.

Note:When the input signal is less than 2.5mA or higher than 22mA, the actuator is judged to be interrupted and transferred to the specified state, so the control device and signal 4 to 20mA must be adjusted correctly.

* If the aperture of IGV decreased rapidly, the compressor might operate into surge area which might lead to the loss control of magnetic bearings and cause the damage of the mechanism. Therefore, when the control signal is malfunctioned, the IGV should be set as fully open to prevent surging during the compressor restart.

3.2.4.3 Setting of Sensitivity Volume

Sensitivity Volume Setting



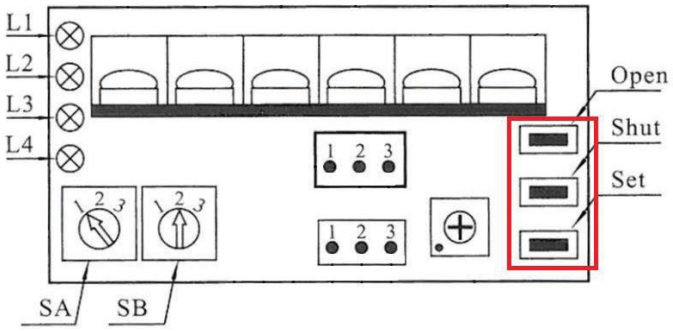
Volume	1	2	3	4	5	6	7	8	9	10
Sensitivity	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%

Table 3.2 Comparison of sensitivity volume

Note:

1. The default volume is set as 2 (1.0%)
2. The actuator might be malfunctioned due to the false adjustment of sensitivity volume. Please check with Hanbell if any adjustment of sensitivity volume needed to be implemented.

3.2.4.4 Procedure of Manual Setting



- Manual Setting Procedure for Close Action
  1. Adjust SA knob to 2 for the manual setting mode.
  2. Adjust the aperture of guide vane by actuator until it is closed fully.
  3. Hold the button of “Shut” and “Set” for 4 seconds simultaneously until the signal of L2 is light on. After that, the procedures for manual setting of close action are completed.

- Manual Setting Procedure for Open Action
  1. Adjust SA knob to 2 for the manual setting mode.
  2. Input signal with 20mA.
  3. Adjust the aperture of guide vane by actuator until it is opened fully. Hold the button of “Open” and “Set” for 4 seconds simultaneously until the signal of L2 is light on. After that, the procedures for manual setting of open action are completed.

- Completed Setting
  After completing the procedures of manual setting of open/close action, adjust SA knob to 3.

Note:

1. Please follow the same procedures above for reverse action.
2. The aperture of IGV is only controlled by the input signal.
3. When adjust IGV manually, please follow the manual setting procedures of close action then open action.

3.2.4.5 The Procedures of Feedback Signal Correction

Check the feedback ampere by multimeter at the position of fully opened and closed. If the tolerance of ampere exceeds 1%, please follow the procedures below for the correction.

1. Adjust SA knob to 2 to setting mode.
2. Hold “Set” button first then press “Open” and “Shut” buttons simultaneously until L2 signal is lighted on. Once L2 signal is lighted on, all the buttons can be released. After this procedure, the feedback signal correction mode of fully closed position (4mA) will be started.
3. In the feedback signal correction mode, the feedback ampere can be adjusted by “Open (Increase)” and “Shut (Decrease)” button. Adjust the feedback ampere by “Open” and “Shut” button then observe the variation on multimeter until the feedback ampere reaches 4±0.02mA.
4. Light off L2 signal by pressing the “Set” button, then re-press the “Set” button continually until L2 signal is lighted on again. Once L2 signal is lighted on, the “Set” button can be released. After this procedure, the feedback signal correction mode of fully opened position (20mA) will be started.
5. Same as procedure 3, adjust the feedback ampere by “Open” and “Shut” button then observe the variation on multimeter until the feedback ampere reaches 20±0.02mA.
6. Light off L2 signal by pressing the “Set” button, then re-press the “Set” button continually until L2 signal is lighted on again. Once L2 signal is lighted on, the “Set” button can be released. After this procedure, the feedback signal correction is completed.

Note:The actuator is set completely when dispatching from Hanbell. Please contact Hanbell representative before any adjustment.

3.2.5 Description of Blink Code

The signal of L1 to L4 will be lighted up accordingly when different failure conditions are encountered.

Signal	Color	Condition	Reason
L1	Green	Signal of power supply	Will be lighted up if the connecting point of L and N is connected correctly
L2	Red	Input signal failure	1. Will be lighted on if the input signal is detected below 2.5mA or higher than 22mA. This might caused by the open or short circuit of the wire of input signal. 2. If signal is still existed after confirming the situation above is fixed, please check the functionality of actuator.
L3	Red	Potentiometer failure	1. Will be lighted on if the wire of potentiometer is open/short circuit or leakage. The voltage will be approximately 4V under normal situation. 2. If signal is still existed after confirming the situation above is fixed, please check the functionality of actuator.
L4	Red	Mechanism failure	1. Will be lighted on if the mechanism is malfunctioned. Please check if the motor is connected appropriately and check if the mechanism is stuck by tools. 2. If signal is still existed after confirming the situation above is fixed, please check the functionality of actuator.
NA	NA	1. The signal of input and output does not match 2. IGV does not finish its operation range	1. Wrong signal input during the settings of open action. 2. The input/output signal is incorrect. The situation above can be solved by re-setting. If the issue cannot be addressed by reset of open function, the malfunctioning of actuator should be considered.
NA	NA	The feedback signal does not match the aperture of IGV	1. The failure of potentiometer or circuit problem (open circuit, short circuit or leakage in the wiring), the L3 indicator will light up. 2. If signal is still existed after confirming the situation above is fixed, please check the functionality of actuator.

Table 3.3 Description of blink code

3.2.6 Trouble Shooting

TROUBLE	PROBABLE CAUSE	SOLUTION
Motor does not start up	The power is not connected	Connect the power correctly
	Signal failed or terminals dropped	Reconnect the terminal correctly
	The wire is broken	Change or repair the wire
	Wrong input voltage or the voltage is too low	Check the input voltage
	Thermal protector is functioned because of mechanism stuck or high ambient temp.	Cool down the ambient temp. and check if the mechanism is stuck manually
Action mode indicator does not function	Action mode indicator damaged	Change the Action mode indicator
Water damage of actuator	Cable does not meet the water-proof standard	Contact Hanbell for the repair service
	Actuator feedback window is damaged	
	The casing is damaged or o-ring is not sealed properly	

Table 3.4 Description of trouble shooting

3.3 Capacity Modulation of Chiller

3.3.1 Capacity Modulation

To achieve the best performance, please follow the equation of safety margin line (refer chapter 3.4.2). The compressor loading/unloading will work with the control of IGV:

1. Speed Control:
   The cooling capacity of a compressor is directly proportional to its motor speed and the power consumption is directly proportional to the cube of motor speed, therefore cooling capacity can be adjusted by motor speed and lower motor speed generates higher operating efficiency. By PID control, the cooling capacity of the compressor can be changed to achieve the requested water temperature setting.

2. IGV Control:
   When the motor speed decreases to the lowest operable frequency, further reduction is not possible, therefore IGV (Inlet Guide Vanes) control is a secondary method. The minimum operable frequency needs to be calculated by inputting the compressor operating pressure ratio & IGV opening % into the Hanbell variable frequency resonance equation. For more details, please refer to section 3.4.2.

3. Hot Gas Bypass (HGBP):
   When operating conditions become extremely, the compressor cannot be operated in good condition by motor speed and IGV opening %, the hot gas bypass needs to be activated. This action reduces the compression ratio to make the compressor continue operating steadily. It is strongly recommended to install the external line of hot gas bypass with compressor to ensure that it can operate under partial load reliably.

Note:
Hanbell RTM series has dedicated control logic, which includes cooling capacity modulation and protection control logic. If customer has any concern of development of chiller control program, please contact Hanbell.

3.3.2 Power Consumption Efficiency of RTM with VFD

RTM series is designed as direct-driven mechanism with variable frequency. This consumption efficiency design is widely applied to different turbine product and can be explained by similarity principle.

Please refer to the similarity principle below:

Similarity Principle	Description
Q α N	Q : Cooling capacity Pr : Pressure ratio P : Power consumption N : Rotation speed
Pr α N^2	
P α N^3	

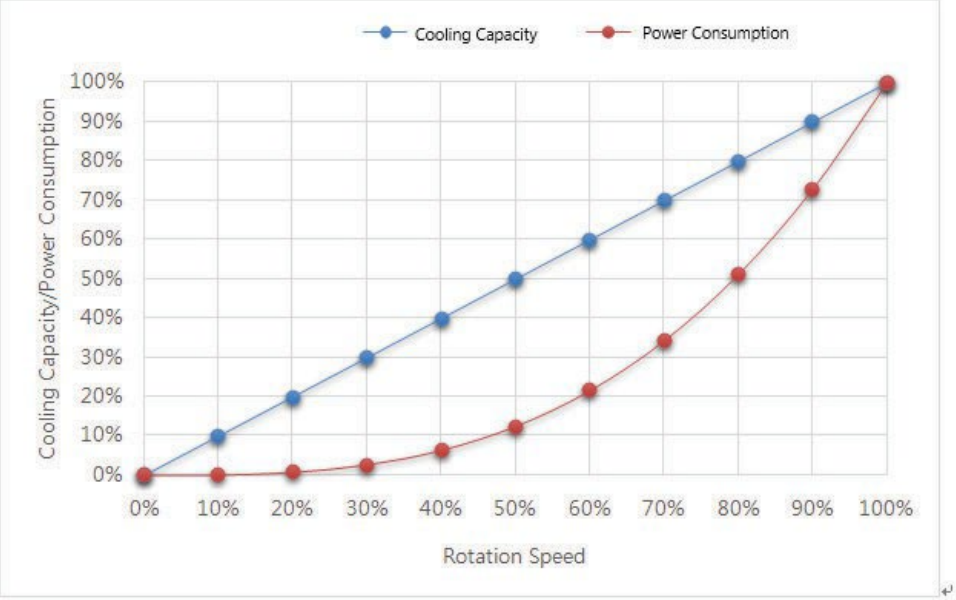


Figure 3.7 Similarity principle of cooling capacity and rotation speed

According to the diagram above, when the rotation speed decelerates to 50%, cooling capacity will decrease to 50% simultaneously. Under this scenario, power consumption will be approximately 13% due to it is proportional to the cube of rotation speed. This means the power consumption of variable frequency design is roughly 37% lower than fixed frequency design.

*The cooling capacity is proportional to the power consumption with fixed frequency design

3.4 Operation Range

3.4.1 IGV Capacity Control with VFD

When the centrifugal compressor is at part load, the angle of guide vane becomes smaller and refrigerant volume entering compressor also reduces; when the volume flow decreases to a certain extent, surge and stall may occur. When the compressor surges, discharge pressure drops suddenly lower than the pressure in condenser so high-pressured gas flows reversely to the compressor; therefore, gas flows inside the compressor turbulently and it causes higher vibration and noise. In addition, the magnetic bearing may cause high axis current which will lead to compressor emergency stop. Therefore, compressor's operating map must be confined below the Surge Line.

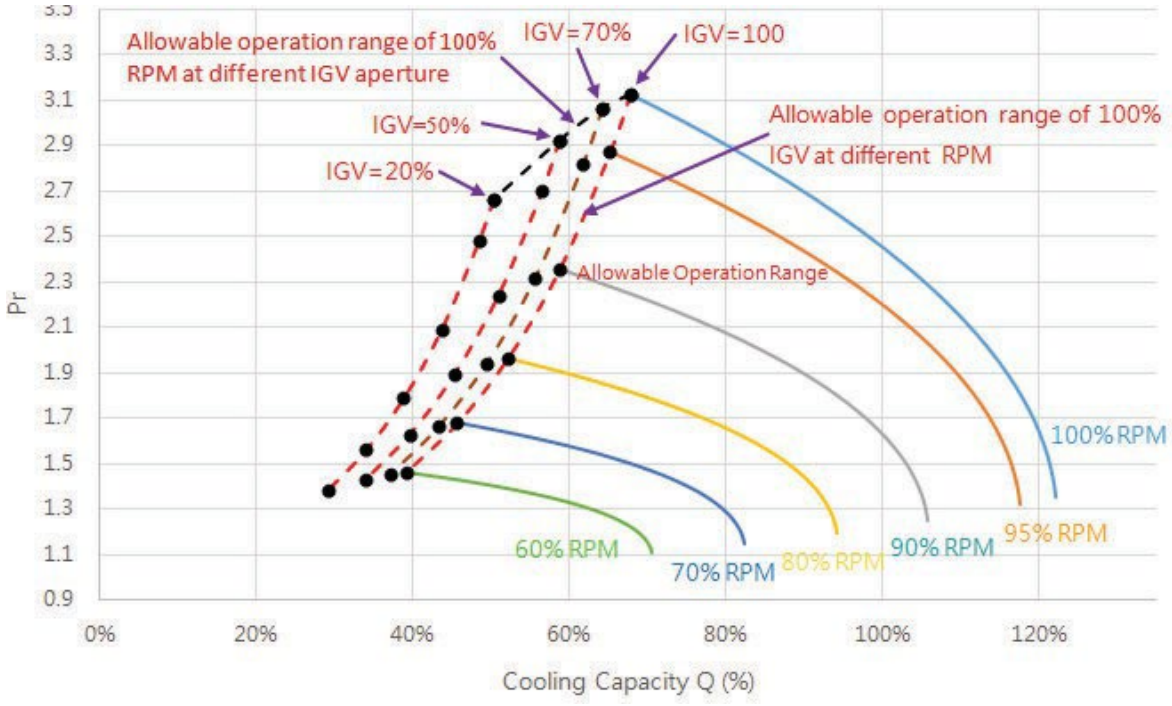


Figure 3.8 IGV Operating range

3.4.2 Equation of Surge Line

Equation of Surge Line is consisted of IGV aperture, pressure ratio and frequency. The equation should be monitored strictly during the capacity modulation of compressor to prevent the frequency is operated out of the limit of the equation.

Parameter	Description
x	IGV aperture, the input value is from 20 to 100.
y	Pressure ratio
z	Frequency Hz (RPM/60)

Model	Equation				
	$z=a+b/x+c/y+d/x^2+e/y^2+f/(xy)+g/x^3+h/y^3+i/(xy^2)+j/(x^2y)$				
	Coefficient				
RTM-030	a	b	c	d	e
	5.71863E+02	1.55999E+03	-8.60058E+02	-1.48060E+04	7.69278E+02
	f	g	h	i	J
	-9.62103E+02	7.06646E+04	-4.26526E+02	3.45306E+00	3.34200E+03
RTM-050	a	b	c	d	e
	4.80099E+02	1.74431E+03	-7.80175E+02	-1.14829E+04	7.87220E+02
	f	g	h	i	j
	-1.73516E+03	-9.34480E+04	-4.47060E+02	1.11438E+02	1.65811E+04
RTM-070	a	b	c	d	e
	3.77182E+02	1.89012E+02	-5.75815E+02	4.47873E+03	5.33694E+02
	f	g	h	i	j
	-2.82460E+02	-1.97711E+04	-2.97779E+02	3.10561E+01	-1.22848E+03

Model	Equation				
	$z=a+b/x+cy+d/x^2+ey^2+fy/x+g/x^3+hy^3+iy^2/x+jy/x^2$				
	Coefficient				
RTM-090	a	b	c	d	e
	-1.60028E+02	-3.74063E+02	3.12403E+02	8.16364E+03	-9.48668E+01
	f	g	h	i	j
	3.51605E+02	-8.34076E+04	1.07788E+01	-4.30710E+01	-7.34911E+02
RTM-100	a	b	c	d	e
	-1.94650E+02	-1.08157E+02	3.63203E+02	4.86017E+02	-1.18810E+02
	f	g	h	i	j
	2.85768E+02	-1.90493E+03	1.45014E+01	-2.86582E+01	-8.76373E+02

Model	Equation				
	$z=a+bx+c/y+dx^2+e/y^2+fx/y+gx^3+h/y^3+ix/y^2+Jx^2/y$				
	Coefficient				
RTM-140	a	b	c	d	e
	6.75376E+02	-2.95506E+00	-9.26916E+02	3.26782E-02	7.60226E+02
	f	g	h	i	J
	1.58876E+00	-1.17040E-04	-4.26479E+02	1.39979E-01	-1.10182E-02

Table 3.6 Safety margin line of each model

Note1: The calculation result of minimum frequency operation reaches surging line, therefore, the frequency of the control logic should be considered to add 2 to 3 Hz based on the calculation value for safety factor.

3.5 Hot Gas Bypass (HGBP)

Hot gas bypass is to bypass gas refrigerant or liquid refrigerant from condenser into evaporator through a proportional valve.

Function: When the load reaches certain value the surge would happen. To continue the low load operation, the hot gas by pass valve can be opened to increase suction pressure and lower discharge pressure as well as compression ratio.

Because hot gas bypass is to transfer compressed gas from the condenser (high-pressure side) to the evaporator (low-pressure side), enormous noise may occur. It is recommended to enlarge the inner diameter of piping after the HGBP valve to keep flow speed under 10 m/sec.
In piping, the proportional valve should be installed as close as possible to the evaporator, and also at another side of suction entry (motor side) to lower the noises.
Besides, a muffler or shield should be installed at the evaporator to prevent splashed liquid refrigerant, which may damage the compressor.

Warning:Do not apply solenoid valve for HGBP to prevent system efficiency because of the high resistance.

Note1: HGBP will lead to the inefficiency of system, it should be avoid during the capacity modulation. However, in many applications, HGBP is still required for avoiding surging or maintaining the water temp. During minimum load to full load.
Note2: Required flow for HGBP depends on the difference between required minimum cooling capacity and the minimum load compressor can reach. If the IGV is at minimum aperture and cooling capacity is 50%, and end user needs 20%. The pipe diameter and flow need to be considered based on the 30% difference.
Note3: It is recommended to select appropriate piping size according to actual application.
Note4: The velocity and noise should be considered during HGBP application.
Note5: Please contact Hanbell representative for parallel design application.

3.6 Economizer Stop Valve

In parallel design application, the refrigerant in flash tank might flow back to the compressor from economizer port which might lead to the shaft reversed and auxiliary bearing damaged. Therefore, it is recommended to install economizer stop valve to prevent the refrigerant reversed.

Note1: It is not mandatory to install economizer stop valve in single compressor unit.
Note2: Motor driven control valve is applicable for economizer stop valve
Note3: Economizer stop valve is not allowed to be replaced by solenoid valve, this might caused severe pressure dropped and lead to the capacity reduction and malfunction of compressor.

Chapter 4 Motor

4.1 Motor cooling

There are two parts of magnetic centrifugal compressor need to be cooled, one is motor stator and another is motor rotor and magnetic bearing.

For the motor stator, it is cooled by high-pressured liquid refrigerant coming from the condenser. The inlet and outlet ports are shown as the "Motor cooling inlet (liquid)" and the "Motor cooling outlet" below.

For the cooling of the motor rotor and the magnetic bearing, it is mainly cooled by the medium-pressured gas coming from the economizer. The inlet and outlet ports are shown as the "Bearing cooling inlet (liquid + gas)" and "Bearing cooling outlet" as below.

It should be noted that when the motor and bearing's temperature reach alarm value (see Chapter 4.3 for alarm values), the auxiliary liquid refrigerant (from the condenser) can be turned on to mix with the medium-pressured gas to cool the magnetic bearing or motor rotor (as the 4.4 pipeline diagram). Meanwhile, open the "Auxiliary outlet of the bearing cooling" can prevent refrigerant be flooded.

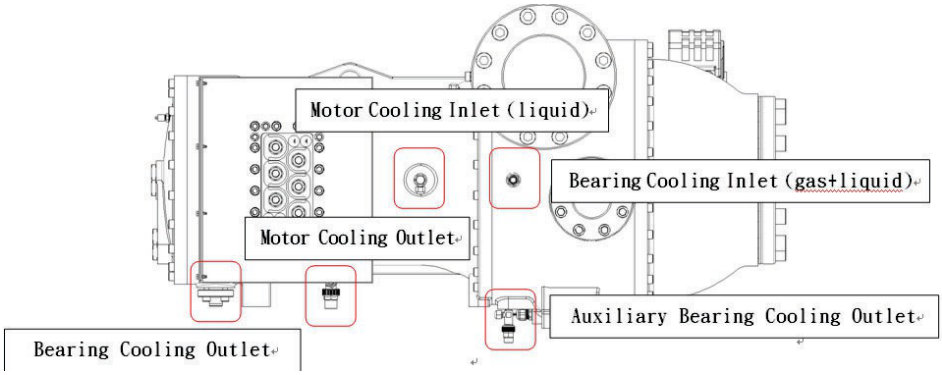


Figure 4.1 Magnetic motor & bearing cooling

4.2 Liquid returned from motor and bearings

4.2.1 Connection of Cooling Pipes (RTM-030 to RTM-100):

- Motor cooling inlet: Connected from the high pressure liquid line after condenser
  - Major motor cooling pipe:
    Ball valve (No. 10) in major motor cooling pipe should be normal opened. It should be adjusted according to motor and bearing temp. and Ke value at rated working condition to avoid excessive refrigerant.

  - Ball valve (No. 11) in auxiliary motor cooling pipe should be adjusted according to motor and bearing temp. and Ke value at maximum loading to avoid excessive refrigerant. This path is controlled by a normal closed solenoid valve (No. 9). It should be opened according to motor and bearing temp. and Ke value at maximum loading.

- Motor Cooling Outlet is connected to Bearing Cooling Inlet Port
- Bearing Cooling Outlet is connected to bottom part of Evaporator

Note 1: Bearing Cooling Outlet is connected to Evaporator, to reduce the pressure inside motor chamber which might lead to alarm of magnetic bearings.

Note 2: Please refer to Chapter 4.3 for the setting of auxiliary liquid injection solenoid valve (No. 9)

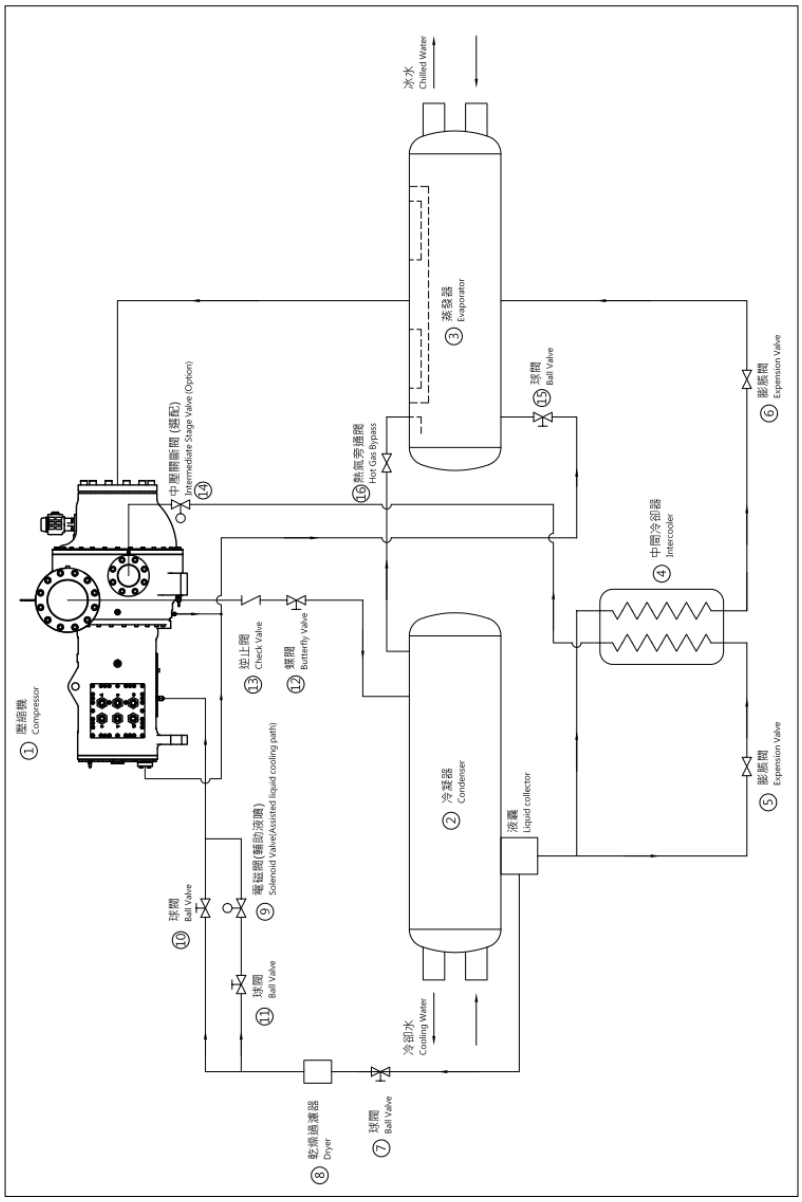


Figure 4.2 Cooling system of RTM series (flash tank)

Note 1: It is recommended to apply butterfly valve as discharge service valve (No.12) to prevent pressure drop which may influence chiller performance.

Note 2: Intermediate service valve is necessary to be installed in parallel system. It is not mandatory in single unit chiller.

4.2.2 Connection of Cooling Pipes (RTM-140):

Due to RTM-140 has built-in cooling pipeline, it's not necessary to connect external pipes to the motor cooling outlet or the bearing cooling inlet. Therefore, its figure is different from the figure of RTM-030 to RTM-100.

- Motor cooling inlet: connected with condenser high-pressure liquid.
  - Valve No. 10 is the main cooling pipe, which keeps opening all the time. It is necessary to adjust the ball valve to reduce the flow rate to meet motor temperature & bearing

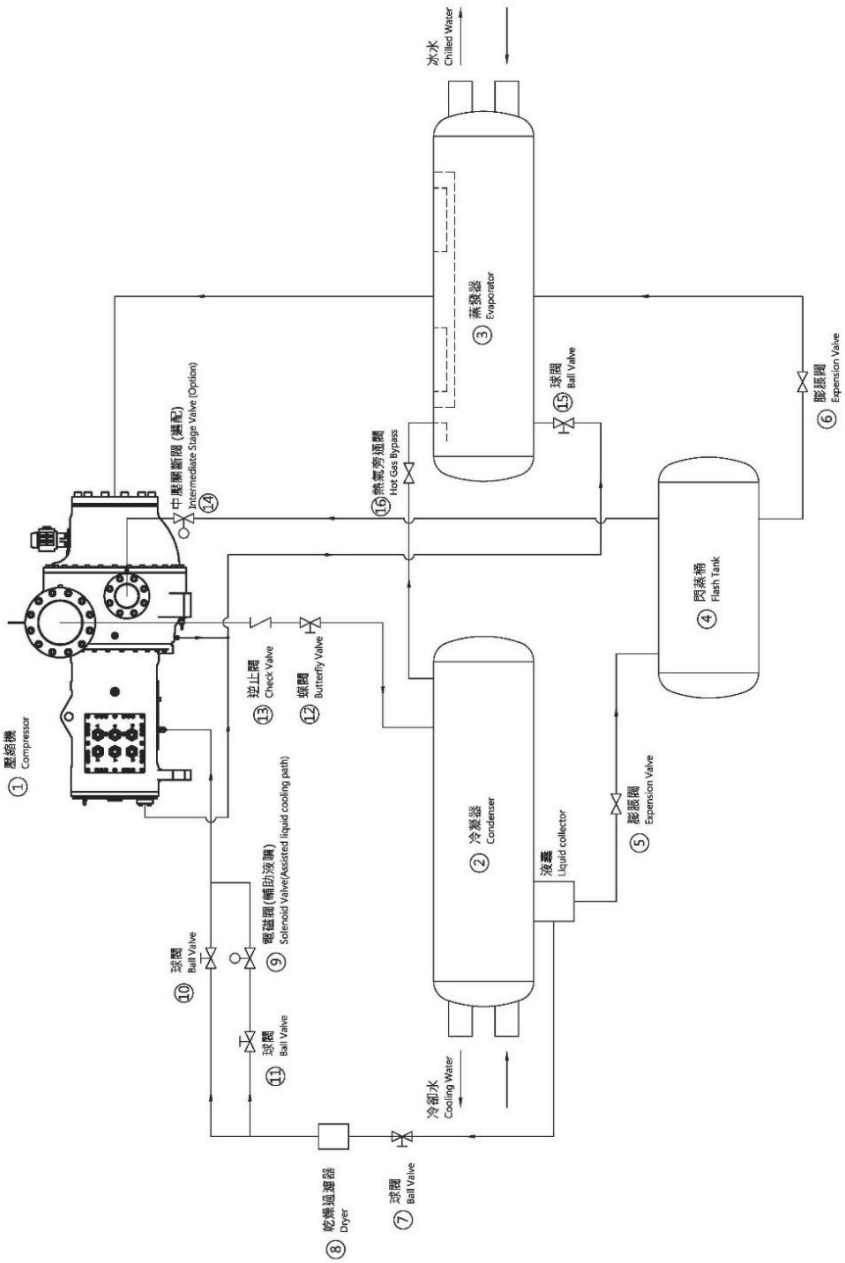
temperature and KE values under "rated conditions". In doing so, it can avoid the injection of excessive refrigerant to keep good operation performance.

- Valve No. 11 is the auxiliary cooling pipe. It is necessary to adjust the ball valve to reduce the flow rate to meet motor temperature & bearing temperature and KE values under "maximum load". In doing so, it can avoid the injection of excessive refrigerant to keep good operation performance. It's controlled by the solenoid valve No. 9 (N.C. Type).

- Bearing cooling outlet & auxiliary bearing cooling outlet: connected to the bottom of the evaporator.

Note:

The bearing liquid/gas outlet must be connected to the evaporator. Otherwise, the pressure in the



motor casing will increase and leads to excessive axial force even triggering an alarm of magnetic bearings.

Figure 4-4 Cooling system of RTM series (flash tank)

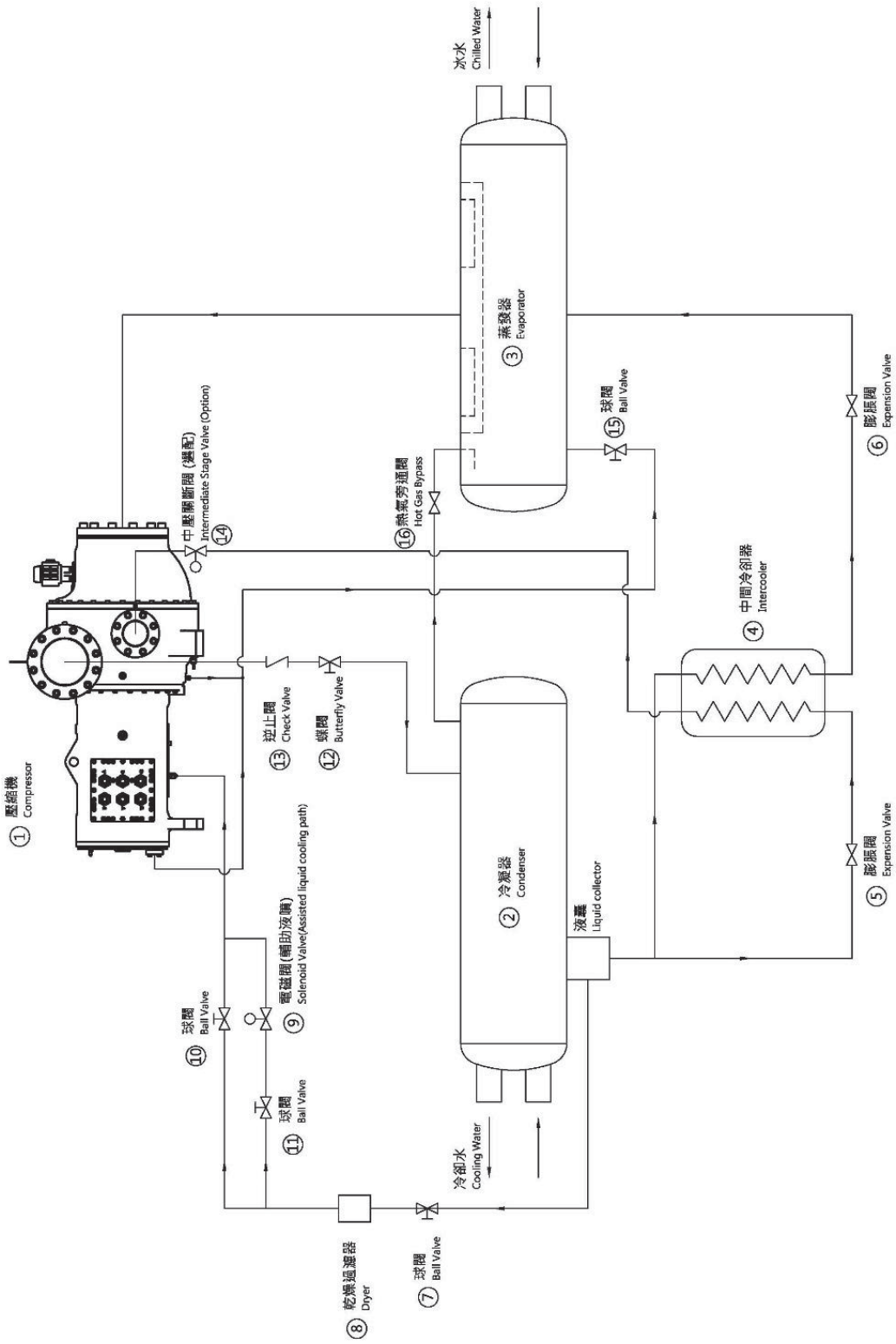


Figure 4-5 Schematic Diagram of Intercooler Piping for Unit Assembly

Note 1: Valve 12 in the above diagram is the exhaust pipe maintenance valve. It is recommended to use a butterfly valve to reduce the impact on performance due to pressure drop.

Note 2: Valve 14 in the above diagram is the intermediate pressure shut-off valve, and it is optional. It is only necessary to choose it for units with dual compressors or more. The intermediate pressure shut-off valve is used to prevent compressor reversal due to pressure differences when the compressor is stopped and waiting to restart. For typical single-compressor units, the installation of the intermediate pressure shut-off valve may not be necessary.

4.3 Protection Set Point

There are totally 8 pieces of Pt100 installed in motor winding (4 pieces) and magnetic bearings (4 pieces) to monitor motor temperature and suggested control logics are listed below:
Motor Temperature:

Set point	Temperature
Solenoid valve of auxiliary liquid pipe off	65°C
Solenoid valve of auxiliary liquid pipe open	80°C
Tripping point	90°C

Table 4-1: Motor temp. Protection set point

Bearing Temperature:

Set point	Temperature
Solenoid valve of auxiliary liquid pipe off	55°C
Solenoid valve of auxiliary liquid pipe open	70°C
Tripping point	85°C

Table 4.2: Bearing temp. Protection set point

Ke value of back emf:

Model / Set point	RTM-030		RTM-050			RTM-070	RTM-090 RTM-100	RTM-140
Electric Motor (Rotating Part) Version	A	B	A/B	C	D	A	A	A
Ke setting value of inverter	7.5	7.5	10.2	9.8	10.2	14.4	15.9	17.6
Solenoid valve of auxiliary liquid pipe off	6.56	7.30	9.10	8.70	8.79	12.59	13.67	16.80
Solenoid valve of auxiliary liquid pipe open	6.44	7.17	8.90	8.60	8.63	12.36	13.43	16.50
Tripping point	6.32	7.04	7.90	7.80	8.48	12.14	13.19	16.20

Table 4.3: Protection set point of Ke value of motor

Note1: If the temperature of motor rotor and magnetic bearings or Ke value reaches the alarm value, solenoid valve of auxiliary liquid pipe should be opened.
Note2: The Ke value of back emf can be accessed only by the communication of Modbus from inverter. Please refer to Chapter 5.3 for Communication.
Note3: The vapor cooling valve of bearing cooling inlet should be opened consistently when the compressor is operated.

Note 4: During the startup acceleration process, there may be significant fluctuations of Ke value, which may easily trigger alarms and shutdowns then resulting in startup failures. Therefore, it is recommended to temporarily disable Ke value protection during the startup acceleration process and resume Ke value monitoring after the startup is completed.

4.4 Motor Connection

4.4.1 Voltage & Frequency

Below table is the allowable operation range of input voltage and frequency of inverter which is tested by Hanbell. It might lead to the damage of inverter if operated out of limit.

Model	Brand of Inverter	Range of rated voltage
RTM-030 to RTM-140	Delta	360V~480V

Table.6: First side input voltage of inverter

Range of frequency
50 Hz±3Hz
60 Hz±3Hz

Table 4.5: Range of rated frequency

Warning:

Note1: The range of frequency is only suitable for the frequency of supply power instead of the compressor.

Note2: The operation range of rated voltage is based on the voltage input of compressor motor instead of the inverter.

Note3: Above specification is only applicable to Delta inverter. For other brands of electrical components, please contact Hanbell representatives.

4.4.2 Inverter Components

The connection of inverter is showing in figure 4.3 :

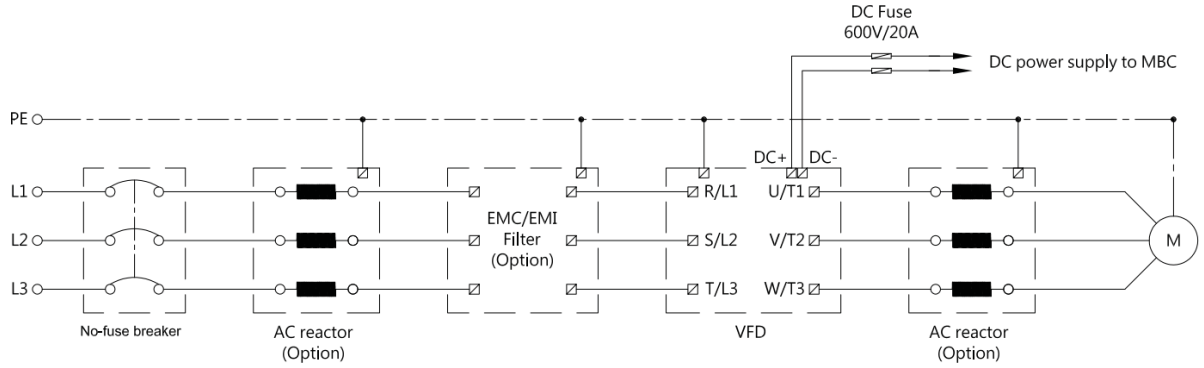


Figure 4.3 Connection of Inverter

4.4.2.1 Inverter

Inverter is used for driving motor and supply the power to AMBC.

Below is the specification of inverter with RTM developed model

Model	Inverter specification								
	Brand	Model of Inverter	INPUT		OUTPUT				Firmware
			V	A	HP	V	KVA	kW	
RTM-030	Delta	VFD1100C43A-HS	360-480	207	150	0-480	175	110	1.07
RTM-050		VFD2200C43A-HS	360-480	400	300	0-480	367	220	
RTM-070		VFD3550C43A-HS	360-480	625	475	0-480	544	355	
RTM-090		VFD3550C43A-HS	360-480	625	475	0-480	544	355	
RTM-100		VFD3550C43A-HS	360-480	625	475	0-480	544	355	
RTM-140		VFD2200C43A-HS*2	360-480	400*2	300*2	0-480	367*2	220*2	
RTM-180		VFD3550C43A-HS*2	360-480	625*2	475*2	0-480	544*2	355*2	

Table 4.6: Specification of inverter

Note1: Please refer to the version which can be found on the nameplate of inverter before utilizing Table 4.6. If the version is different from this table, please contact Hanbell representative for the updated information.

4.4.2.2 MCCB

To protect an electrical circuit from damage caused by excess current, the selection of the MCCB shall be based on the current under full load condition.

4.4.2.3 AC Reactor

AC reactor is recommended to install at input side of inverter due to the benefits listed below:

1. Increase the wire resistance
2. Improve power factor
3. Decrease the input current
4. Increase the capacitance of power system
5. Mitigate the interference of total harmonic distortion (THD) from inverter
6. Mitigate the transient voltage and current surge from main power
7. Protect the inverter from the voltage and current surge (the transient voltage might lead to the damage of inverter electrical circuit)

Warning:

Note1: Please refer to Figure 4.3 for AC reactor installation.

Note2: The temperature of AC reactor will be high during operation, therefore, cooling solution such as the installation of forced draft fan is recommended.

4.4.2.4 EMC/EMI Line Filter

In order to mitigate the interference of electromagnetic which can influence the performance of compressor significantly, applying certified line filter is strongly recommended. However, if EMC/EMI line filter is not applicable to certain circumstance, alternative solution which meet the regulations of EMC should be implemented.

4.4.3 Grounding

Grounding in electric system is a must. Exposed compressor conductor should not be electrified in normal use. But there is possibility that the compressor is electrified under malfunction condition. For security purpose, HANBELL strongly ask grounding of below devices during installation:

1. M12 grounding screw in motor terminal box should be reliably connected with grounding wire.
2. All the metal part of the electronic components
3. Electronic component, metal sheath of power cable, palpable threading pipe, cable metal trunking, and cable trays should be grounded.
4. Power cable grounding wire should use copper wire or tinned copper braided wire, and the cross-sectional area should follow or larger than below table

Power Cable (mm^2)	Grounding Wire(mm^2)
120 and lower	16
150 and higher	25

Table 4.7 Power cable cross-sectional area

5. Please follow local electrical safety regulation for grounding
6. TN-S connection is recommended

Note:It is suggested that resistance of grounding should not be higher than 10Ω. However, please follow local electrical regulation before the value is determined.

4.4.4 Cable of main power input

Main power cable should meet local electrical safety regulation. Please choose wiring size of power supply under 1.25 safety margin of maximum load. Wire diameter, cross-sectional area, and current can refer to table 4.8.

- All on-site supply of cables and wires, equipment and field wiring, cable wire terminals and equipment are necessary to comply with various regulations and engineering requirement.
- Power cables shall be with braid sleeve and able to avoid the interference with others. Please refer to diagram 4.4 for the connection.
- Please double check the phase sequence when wiring.

Note:

1. The power cable gland should be insulated properly with heat shrinking tube
2. The power cable shall sustain the maximum permissible current under 90℃ (40℃ ambient temperature)
3. The maximum operating ampere (table 4.9) for first and secondary side of inverter should be considered when selecting power cable.

4. Please follow local electrical regulation for the specification selection.

600V Hypalon Cable (*1C)			
Section Area	Maximum	Section Area	Maximum

(mm^2)	Permissible current(A)	(mm^2)	Permissible current(A)
50	200	150	410
60	230	200	500
80	280	250	570
100	330	325	670
125	370	400	760

Table 4.8 600V Hypalon maximum permissible current

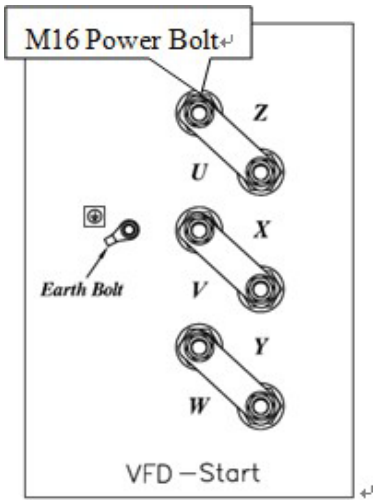


Figure 4.4 Connection of terminal plate

4.4.5 Connection notice

1. Check the power supply characteristics in line with the nameplate. The power cable must be made of copper and follow local electrical regulations.
2. It is not allowed to change the shape and dimension of cable box.
3. The power bolts are made of brass, which cannot sustain the weight of high voltage cables. External cable shelves or tension-ease devices to support the high voltage cables must be applied. HANBELL does not provide wiring terminals.
4. When tightening the terminals of power bolts, use torque wrench with the torque 300kgf-cm.
5. Cable wiring and construction and inspection must follow local electrical regulations.
6. Shielded wire should be used in control cables and proper distance in between power cables and control cables should be maintained to avoid signal interference.
7. The three-phase cables of the motor must be divided into a group of U/V/W and a group of X/Y/Z. Each cable box entry hole can only enter one group of power cable to prevent high temperature around the wiring entry, cable slot, or terminal box caused by harmonic.

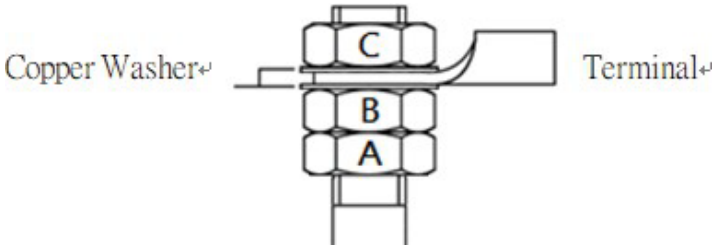


Figure 4.6 Power bolt connection

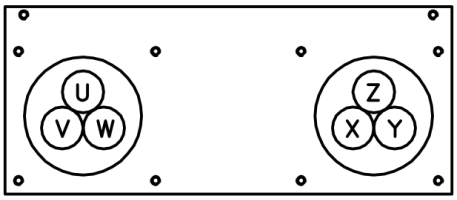


Figure 4.7 Cable box wiring entry and cables

4.5 MCC (Maximum Continuous Current) of motor

MCC of Primary and Secondary of VFD Inverter at Rated Voltage

Model	Voltage(V)	Power(kW)	Primary MCC(A)	Secondary MCC(A)
RTM-030	380	100	189	210
RTM-050	380	180	306	340
RTM-070	380	220	387	430
RTM-090	380	285	486	540
RTM-100	380	300	522	580
RTM-140	380	220*2	414*2	420*2
RTM-180	380	630	1035	1150

Note.1 Above is follow table 4.6 VFD Inverter Specification

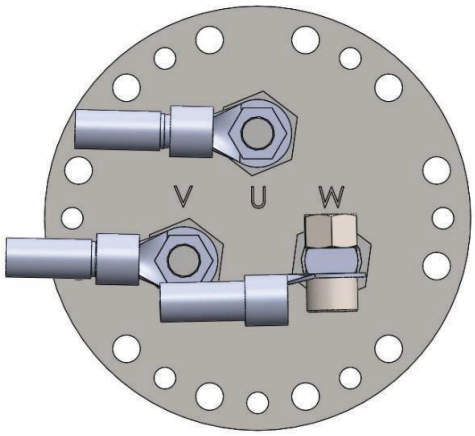
Note.2 Above primary current is follow input 380V. The primary current will be different if input voltage is different.

Note.3 The Secondary MCC is constancy.

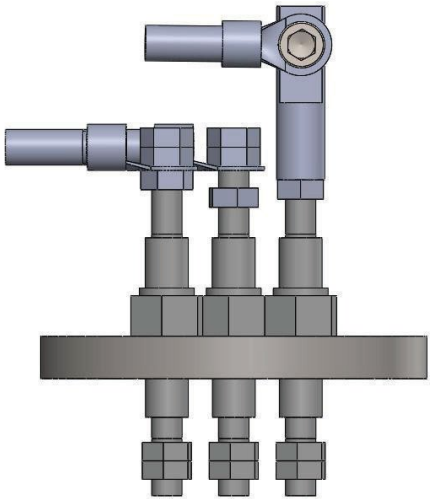
4.6 RTM-030 Terminal connection notice

The shape of terminal cover plate for RTM-030 is circle, power bolts position is shown below. The adapter is provided for different direction of cable entry. The connection instruction is recommended as below.

4.6.1 Side connection

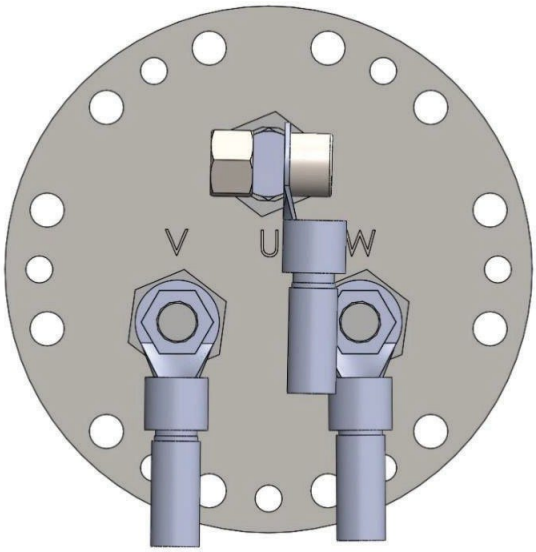


Side connection front view

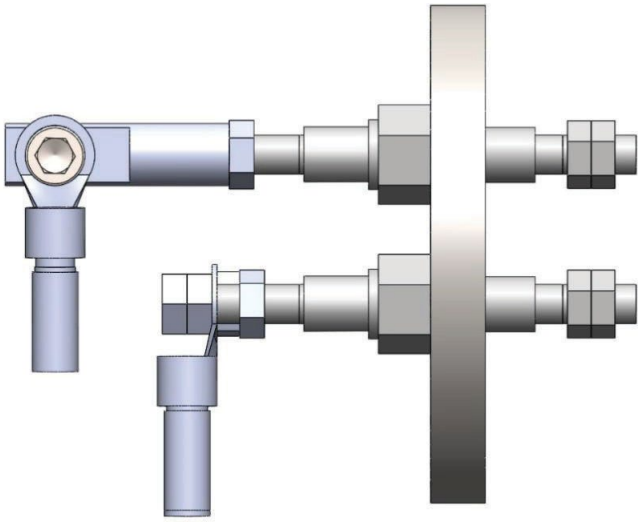


Side connection side view

4.6.2 Bottom connection



Bottom connection front view



Bottom connection side view

Chapter 5 Description of main component (VFD, AMBD)

5.1 Compressor and main components connection

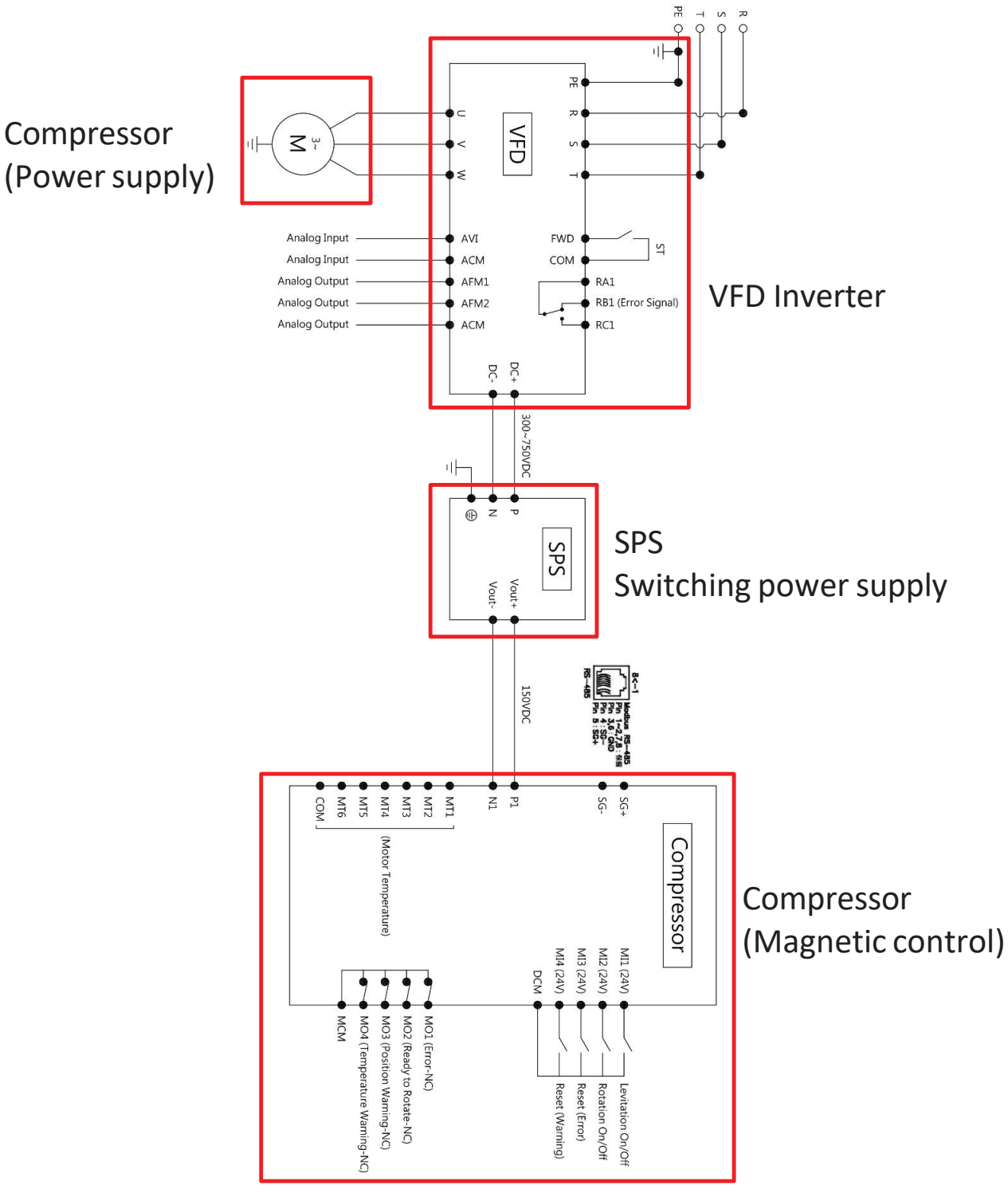


Figure 5.1 Compressor control connection

5.2 Active Magnetic Bearing Drive (AMBD) Information:

AMBD including 2 parts, controller module (AMBD) and power module (SPS).

Model	VFDC1012P00123K00A	VFDDD1012C205D-0A
Items	Controller module (AMBD)	Power module (SPS)
Firmware	1.02	1.02
Length (mm)	266	268
Width (mm)	260	503
Height (mm)	57	101
Weight (kg)	2.4	7
IP protection code	IP 00	IP 20
Operation Temp. (°C)	-10°C~+50°C (Natural convection)	-10°C~+50°C (Natural convection)
Relative humidity (%)	Max. 90%	Max. 90%
Storage Temp. (°C)	-40°C~+70°C	-40°C~+70°C
Power	145~155VDC	250~600VDC
Maximum loss power	3000	3000
Relay dry contact output	250 VAC / 0.25A max 30 VDC / 2A max	N/A
Protocol	Modbus RS485 Cable length<10m	N/A

Table 5-1. Magnetic bearing controller specification

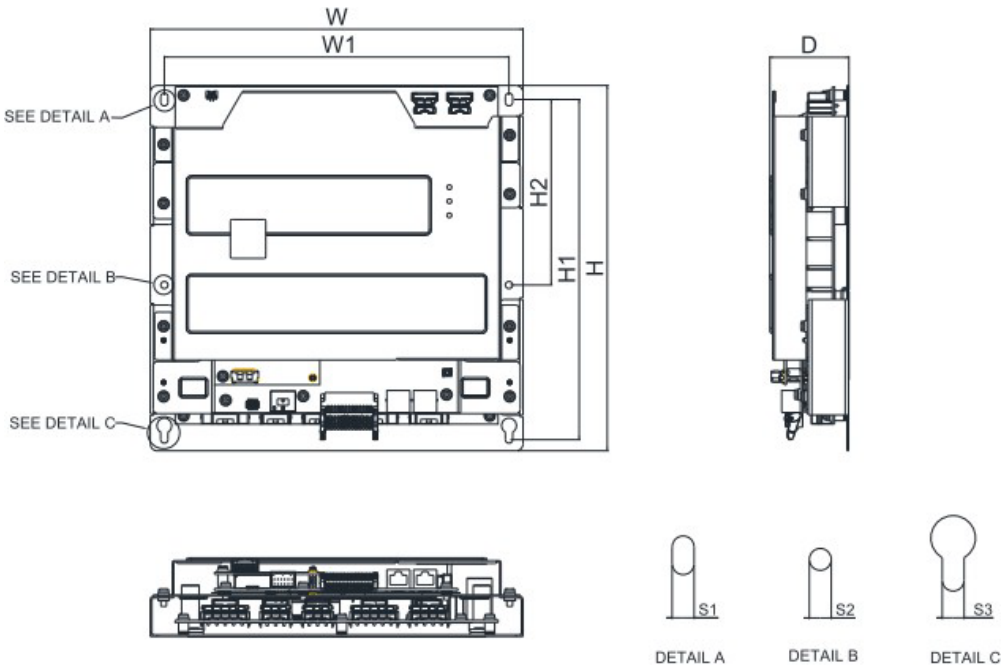
Note :

1. The signal lines should be shielded to avoid interference.
2. Signal lines must not be placed in the same conduit as power lines to prevent signal interference.
3. If the product is to be installed in harsh environments such as condensation, dust, etc., please install the product in an IP54-rated environment, such as a cabinet.
4. Please download the original manufacturer's technical manual from the official Delta Electronics website.

item	Content
File Name	DELTA_IA-MDS_C2000-HS_UM_EN_20210729.pdf
Language	English
File URL	https://filecenter.deltaww.com/Products/download/06/060101/Manual/DELTA_IA-MDS_C2000-HS_UM_EN_20210729.pdf

5.2.1 Controller module

5.2.1.1 Controller module (MBC) outline:



DIMENSION: UNIT: mm [inch]

W	H	D	W1	H1	H2	S1	S2	S3
266 [10.48]	260 [10.24]	57 [2.25]	245.4 [9.67]	242.0 [9.53]	132.0 [5.20]	5.2 [0.21]	5.2 [0.21]	5.2 [0.21]

Figure 5-2. controller module outline and dimension

Note. Controller module (AMBD) installed in compressor

5.2.1.2 Controller module (AMBD) connection overview:

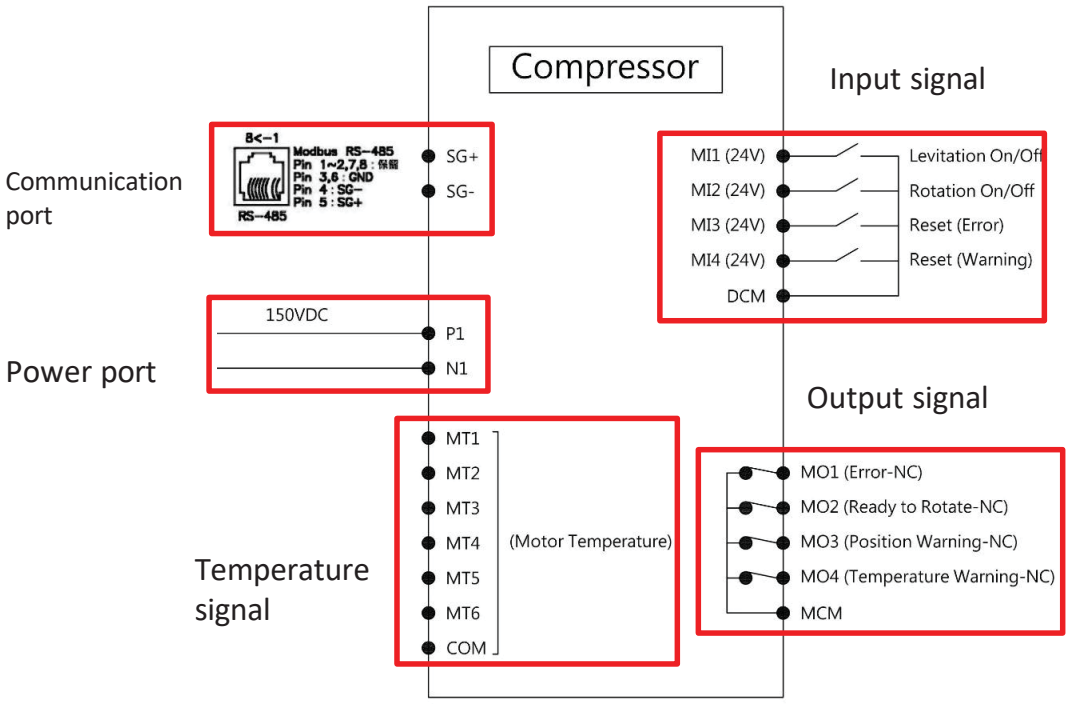


Figure 5-3. Controller module (AMBD) connection port

5.2.1.3 Signal input port (MI):

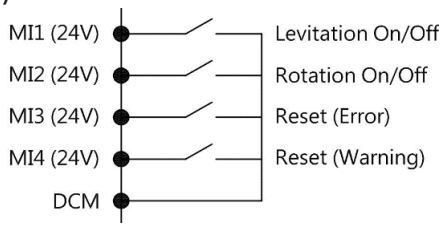


Figure 5-4. Controller module (AMBD) MI connection port

Item	Port	Port condition	Bearing condition
Levitation	MI1 DCM	Open	Non-Levitation
		Close	Levitation
Rotation	MI2 DCM	Open	Non-Rotation
		Close	Operation (Protection on)
Reset	MI3(MI4) DCM	Trigger for 1 second	Reset (error/warning)

Table 5-2. Controller module (AMBD) MI port information

5.2.1.4 Signal output port (MO):

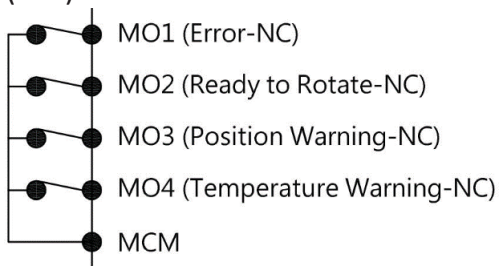


Figure 5-5. Controller module (AMBD) MO connection port

Note. I/O signal are dry contact output.

Item	Port	Port condition	Bearing condition
Error	MO1 MCM	Open	Error / Alarm
		Close	Normal
Ready to Rotate	MO2 MCM	Open	Unallowable for Rotation
		Close	Ready to rotate
Position Warning (It can be ignored)	MO3 MCM	Open	Position warning
		Close	Normal
Bearing Temperature Warning (It can be ignored)	MO4 MCM	Open	High-temp. alarm
		Close	Normal

Table 5-3. Controller module (AMBD) MO port information

Note.1: MO3 is for bearing position warning only and this port can be ignored. Compressor tripping is following MO1.

Note.2: MO4 is for reference of high bearing temperature. The function of high bearing temperature protection is covered by MO1, hence, MO4 can be ignored.

5.2.1.5 Controller module (AMBD) Modbus communication parameter

Item	AMBD Parameter	Default	Setting Range
Communication address	09-00	1	1----254
Transmission speed	09-01	9.6	4.8~115.2Kbps
time-out detection	09-03	0.0	0.0~100.0 Sec
communication protocol	09-04	13	1:7,N,2(ASCII) 2:7,E,1(ASCII) 3:7,O,1(ASCII) 4:7,E,2(ASCII) 5:7,O,2(ASCII) 6:8,N,1(ASCII) 7:8,N,2(ASCII) 8:8,E,1(ASCII) 9:8,O,1(ASCII) 10:8,E,2(ASCII) 11:8,O,2(ASCII) 12:8,N,1(RTU) 13:8,N,2(RTU) 14:8,E,1(RTU) 15:8,O,1(RTU) 16:8,E,2(RTU) 17:8,O,2(RTU)
Communication response delay time	09-09	2.0	0.0~200.0ms

Table 5-4. Controller module (AMBD) Modbus communication parameter

Note. Above settings can be adjusted as per application requirement by keypad.

5.2.1.6 Controller module (AMBD) Modbus communication port description:

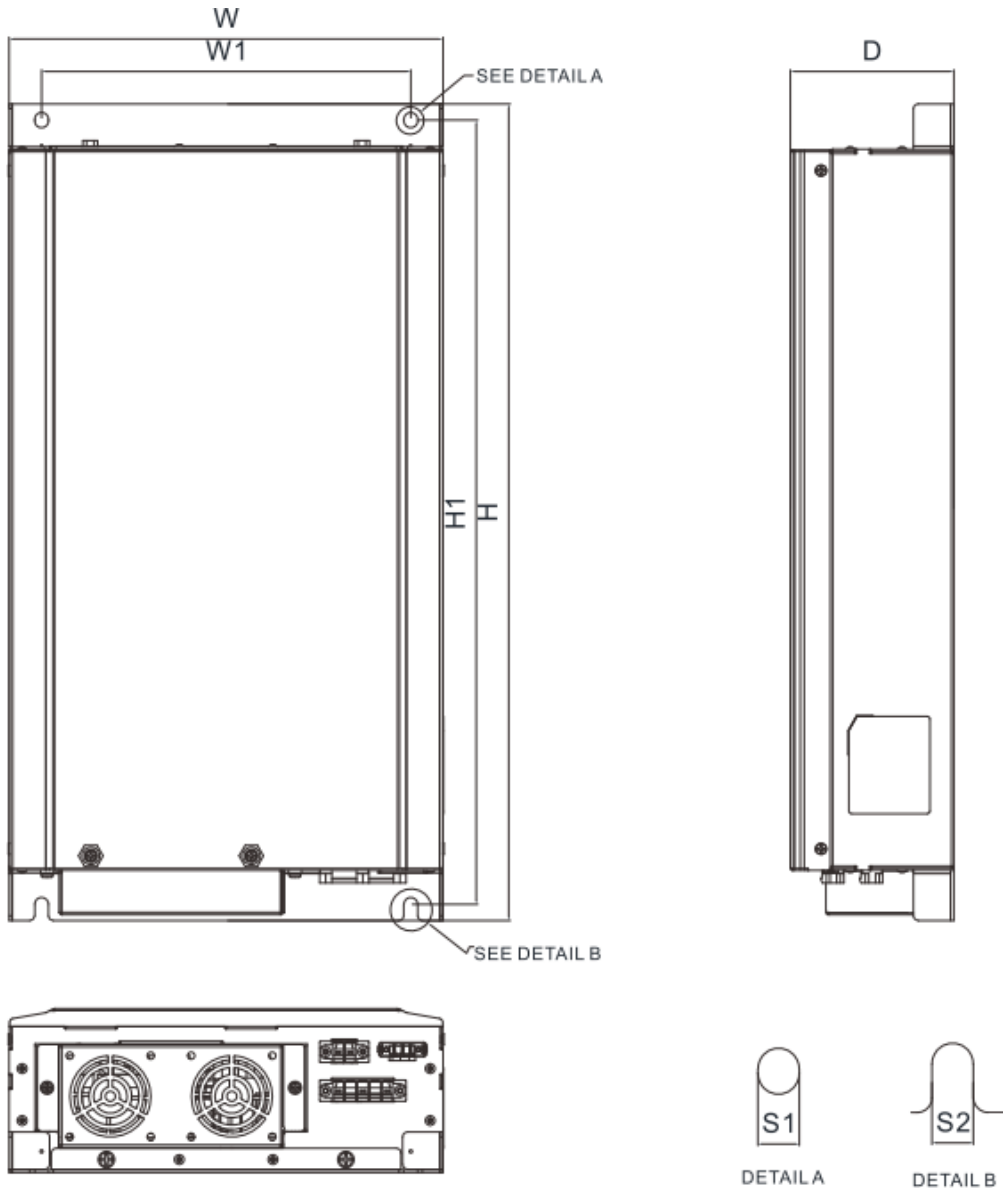
Type	Port Code	Description	
Control order	2000H	Bit1~0	00B : Non-function
			01B : Non-Levitation
			10B : Levitation
			11B : Non-function
		Bit5~4	00B : Non-function
			01B : Alarm clear
			10B : Alarm clear
			11B : Non-function
	2002H	Bit1	1 : Reset (Other bits should remain set to 0.)
Status information	2100H	High byte :Warn Code Low byte :Error Code	
	2101H	Bit1~0	00B : AMBD stops
			11B : AMBD in operation
	2108H	0 : Non-Levitation	
		1 : Levitation	
	2200H	Front bearing V: Position change of shaft (um)	
	2201H	Front bearing W: Position change of shaft (um)	
	2202H	Back bearing V: Position change of shaft (um)	
	2203H	Back bearing W: Position change of shaft (um)	
	2204H	Axial Position change of shaft (um)	
	2205H	Front bearing V1: Current (A)	
	2206H	Front bearing V3: Current (A)	
	2207H	Front bearing W1: Current (A)	
	2208H	Front bearing W3: Current (A)	
	2209H	Back bearing V2: Current (A)	
	220AH	Back bearing V4: Current(A)	
	220BH	Back bearing W2: Current (A)	
	220CH	Back bearing W4: Current (A)	
	220DH	Axial bearing Z1: Current (A)	
	220EH	Axial bearing Z2: Current (A)	
	220FH	Motor frequency (Hz)	
	2210H	DC bus voltage(V)	
	2212H	Switching element temperature (℃)	
	2215H	Front radial bearing temperature (℃)	
	2216H	Front axial bearing temperature (℃)	
	2217H	Back axial bearing temperature (℃)	
	2218H	Back radial bearing temperature (℃)	

Table 5-5. Controller module (AMBD) Modbus communication port list

Note 1: Modbus communication is half-duplex and cannot perform read and write operations simultaneously.

Note 2: Different bits at communication address 2002H have their respective functions. Therefore, when executing a reset, only Bit 1 can be commanded.

5.2.2 Power module (SPS) outline:



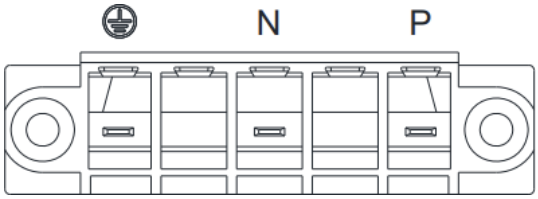
Frame	W	H	D	W1	H1	S1	S2
B	267.8 [10.54]	503.0 [19.81]	101.0 [3.82]	227.8 [8.97]	483.0 [19.02]	8.5 [0.35]	8.5 [0.35]

Unit: mm [inch]

Figure 5-6. Power module (SPS) dimension

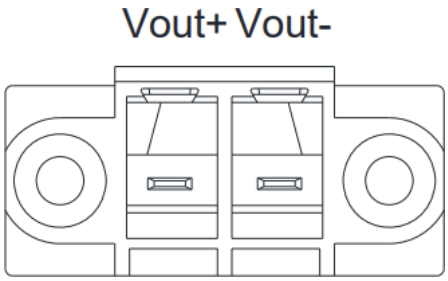
5.2.2.1 Power module connection:

Input Port:



Port Name	PIN	Description
Input Port	1	P
	3	N
	5	PE

Output Port:



Port Name	PIN	Description
Output Port	1	Vout-
	2	Vout+

Input port:
P terminal connect with VFD inverter DC+
N terminal connect with VFD inverter DC-

Output port:
Vout+ terminal connect with controller module (AMBD) P1 terminal
Vout- terminal connect with controller module (AMBD) N1 terminal

Note.1: Connection instruction as figure 5.1
Note.2: it's suggested add 20A fuse in input in order to avoid incorrect input which will cause power module damage.
Note 3: After the inverter is powered off, it must be fully discharged before next power on. Otherwise, DC bus current may increase suddenly then leading to burnt out of fuses or SPS.

5.3 Inverter (VFD) connection instruction and communication parameter

Inverter connection requirement and parameter setting as follow VFD technical manual. This is show Inverter and magnetic bearing controller connection and setting instruction.

5.3.1 Inverter (VFD) connection instruction and parameter setting

Controller module (AMBD) and inverter protection connection:

controller module (AMBD)		Inverter	
Port	Description	Port	Description
MO1	MBC abnormal alarm	MI1	Emergency stop
MO2	Operation allow	MI2	Enable drive
MO4	Bearing high temperature alarm	MI3	Base Block (B.B) input from external
MCM	Common point	DCM	Common point

Table 5-6. Controller module (AMBD) and inverter protection connection

Inverter (VFD) setting:

Item	Setting	Description
02-01	28	Emergency stop
02-02	49	Enable drive
02-03	11	Base Block (B.B) input from external
02-12	20	Open MI1 , MI2 , MI3 Port

Table 5-7. Inverter (VFD) protection parameter setting

Note1. If use Modbus communication protection, above all items setting zero and close MI port
Note 2: During manual startup of the inverter, please do not bypass the protection functions.

5.3.2 Inverter (VFD) Modbus communication parameter:

Parameter Name	Parameter	Default	Setting range
Communication address	09-00	1	1----254
COM1 transmission speed	09-01	9.6	4.8~115.2Kbps
COM1 transmission fault treatment	09-02	3	0: Warn and continue operation 1: Fault and ramp to stop 2: Fault and coast to stop 3: No warning, no fault and continue operation
COM1 time-out detection	09-03	0.0	0.0~100.0 Sec.
COM1 communication protocol	09-04	1	1:7,N,2(ASCII) 2:7,E,1(ASCII) 3:7,O,1(ASCII) 4:7,E,2(ASCII) 5:7,O,2(ASCII) 6:8,N,1(ASCII) 7:8,N,2(ASCII) 8:8,E,1(ASCII) 9:8,O,1(ASCII) 10:8,E,2(ASCII) 11:8,O,2(ASCII) 12:8,N,1(RTU) 13:8,N,2(RTU) 14:8,E,1(RTU) 15:8,O,1(RTU) 16:8,E,2(RTU) 17:8,O,2(RTU)
Communication response delay time	09-09	2.0	0.0~200.0 ms

Table 5-8. Inverter (VFD) Modbus communication parameter

Note. Above it can be adjust under application requirement, connection with controller module (AMBD) to setting, or inform HANBELL setting.

5.3.3 Inverter (VFD) Modbus communication port description:

	Modbus Address	Function	
Control Requirement	2000H	Bit1~0	00B : No function
			01B : Stop
			10B : Run
			11B : JOG + RUN
		Bit5~4	00B : No function
			01B : FWD
			10B : REV
			11B : Change direction
	2001H	Frequency command (XXX.XX Hz)	
	2002H	Bit1	1 : Reset (Other bits should remain set to 0.)
Status information	2100H	High byte : Warn Code Low byte : Error Code	
	2101H	Bit1~0	00B : Drive stops
			11B : Drive operating
	2102H	Frequency command (XXX.XX Hz)	
	2103H	Output Frequency (XXX.XX Hz)	
	2104H	Output current (XX.XX A). When current is higher than 655.35, it shifts the decimal as (XXX.X A). The decimal can refer to High byte of 211F.	
	2105H	DC bus voltage (XXX.X V)	
	2106H	Output voltage (XXX.X V)	
	210FH	Power output (X.XXX kW)	
	2200H	Display output current (A). When current is higher than 655.35, it shifts the decimal as (XXX.X A). The decimal can refer to High byte of 211F.	
	2202H	Actual output frequency (XXXXX Hz)	
	2203H	DC bus voltage (XXX.X V)	
	2204H	Output voltage (XXX.X V)	
	2206H	Display actual motor speed kW of U, V, W (XXXXX kW)	
	2224H	Carrier frequency of the drive (XX kHz)	
	223FH	Motor Ke value	

Table 5-9. Inverter (VFD) Modbus communication port list

Note 1:
Modbus communication is half-duplex and cannot perform read and write operations simultaneously.
Note 2:
Different bits at communication address 2002H have their respective functions. Therefore, when executing a reset, commands can only be sent to Bit 1.
Note 3:
For inverter firmware versions before v9.107, the Ke value reading needs to be done through channel 2236H. However, for some older firmware versions, the Ke value of the motor may not be read through channel 2236H. In this case, parameter 00-04 should be set to 54, and then channel 2116H can be used for reading. Alternatively, notify Hanbell service personnel to update the inverter firmware. For firmware versions v1.07 and later, the Ke value of the inverter can be read through channel 223FH. If any abnormalities occur when using inverter versions before v9.107, it is recommended to contact Hanbell personnel for firmware version update to resolve issues related to older firmware versions.

5.4 Inspection Method of Inverter

The capacitance might be fully discharged if the inverter is shut down for a long while. Hence, the component might be damaged if the inverter is inputted power without any inspection. Therefore, the inspection procedure is mandatory.

- Inspection Target: Inverter
- Inspection Tool: Multimeter with diode measurement function
- Inspection Procedure:
  1. Discharge the capacitance of inverter completely.
  2. Disconnect the power cable on point R, S, T on primary and U, V, W on secondary and DC bus.
  3. Switch to diode measurement mode.
  4. Use a multimeter to measure the continuity of the primary side R, S, T points and the secondary side U, V, W points with the direct current bus P, N points. The diagram below is a simplified circuit diagram of the inverter for reference.

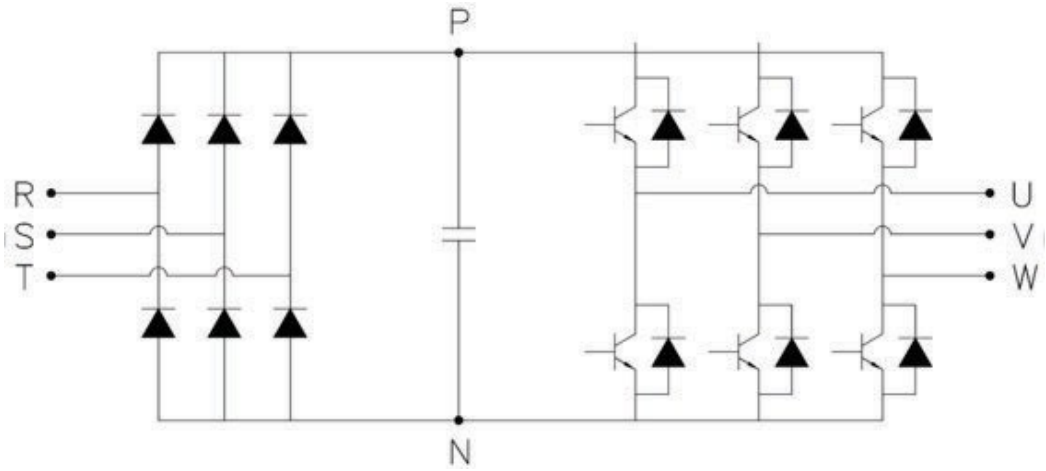


Figure 5.7 Inverter electrical circuit

5. Measure the port as the following table:

Primary			Secondary		
Polarity		Status	Polarity		Status
Positive(+)	Negative(-)		Positive(+)	Negative(-)	
R	P	Close	U	P	Close
S	P	Close	V	P	Close
T	P	Close	W	P	Close
R	N	Open	U	N	Open
S	N	Open	V	N	Open
T	N	Open	W	N	Open
P	R	Open	P	U	Open
P	S	Open	P	V	Open
P	T	Open	P	W	Open
N	R	Close	N	U	Close
N	S	Close	N	V	Close
N	T	Close	N	W	Close

Table 5.10 Inverter inspection table

Figure 5.7 Inverter electrical circuit

5.5 Lifetime of Magnetic Bearing and AMBD

The lifetime of magnetic bearing and AMBD is designed for more than 10 years.
In order to make sure magnetic bearing and AMBD are working properly, it is required to do the dust cleaning every 3 year:

a. Clean the dust on the PCB board of AMBD to prevent the PCB gets short, and cause the AMBD high temperature.
b. Clean the dust on the AMBD fans and heat sink to prevent the fans stuck or poor heat dissipation and cause the AMBD high temperature.

Must follow the operation requirement of environment:

a. Operation temperature:+5℃ ~ +40℃ (free convection)
b. Relative humidity:30% ~ 70%
c. Altitude:Lower than 1,000 meters

5.6 Troubleshooting

Please contact Hanbell representative for AMBD troubleshooting.

5.7 Special Site-Specific Requirements:

5.7.1 High Power Factor and Low Harmonic Distortion Requirements:

Due to the application of VFD may decrease the power factor and generate harmonic distortion then affecting the quality of power supply, it is recommended to install active harmonic filters to improve power quality if there are power quality requirements at jobsites.

The RTM Series is recommended to be operated with Delta Electronics APF3000 Series active harmonic filters. The specifications are as shown below.

Model	APF Selection	CT Selection
RTM-030	130A	CT-C1000*3
RTM-050	130A	
RTM-070	170A	
RTM-090	130A+130A	
RTM-140	130A+200A	

Table 5-11: APF Selection Table

If there is a need for active harmonic filters, please contact Hanbell.

5.7.2 Unstable Power Quality Application:

The power supply of magnetic bearing controller is provided by the inverter, which is not only supplying power but also providing dEb protection function (deceleration energy backup). It prevents from sudden power failure then magnetic bearings falling suddenly at high speed.

However, when the power quality at sites is unstable or multiple large fixed-frequency units share the same power supply, the dEb protection function may be triggered by momentary voltage drops, then leading to VFD trips.

To avoid frequent triggering of dEb protection function, customers can install an external UPS (Uninterruptible Power System) instead of the dEb to provide power to the magnetic bearing controller to solve the problem.

UPS configuration can be referenced in the following diagram:

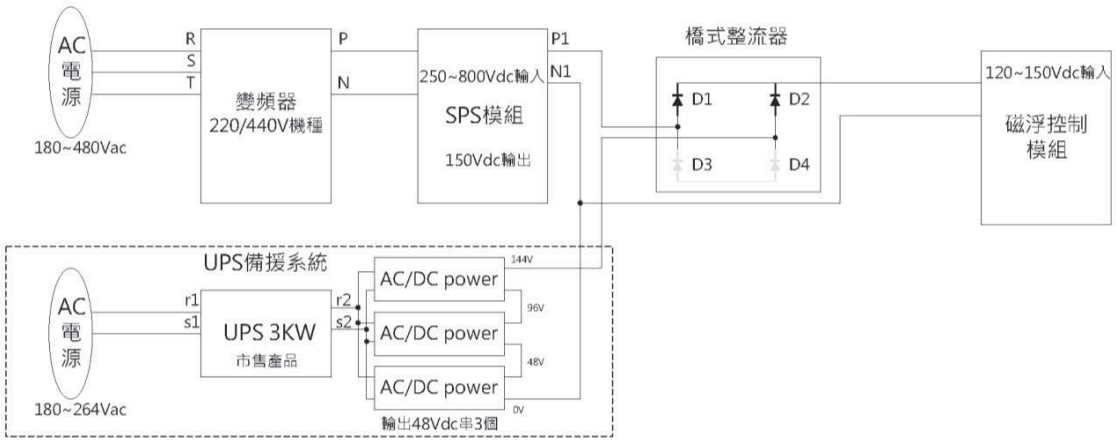


Figure 5-8: External UPS Circuit Configuration Diagram

After setting up the UPS system, the dEb function of the inverter needs to be disabled by setting the inverter parameter Pr 07-13=0 to turn off the dEb function.

For most of sites with unstable power quality, when compressor operation is affected by power quality issue, it can be adjusted by inverter parameters to solve problems of abnormal shutdowns. Please contact Hanbell all the time about the setting of inverter parameters . The compressor is out of warranty if the setting of inverter parameters without Hanbell's instruction.

Chapter 6 Compressor Control Sequence

6.1 Start Sequence

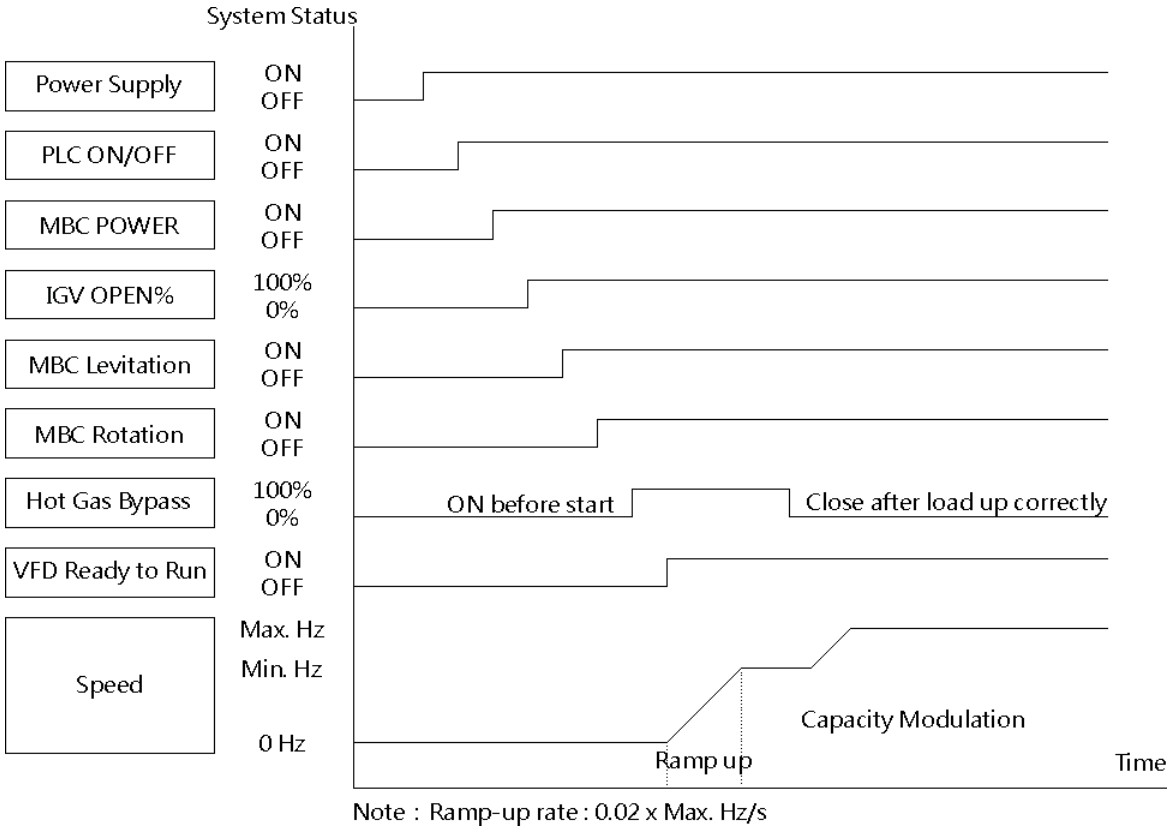


Figure -11 Start sequence

Note:

1. Please contact Hanbell representative for Hot Gas Bypass ON/OFF control logic.
2. Max. Hz is compressor rated motor speed, please refer chapter compressor specifications.
3. Min. Hz is for the minimum operational speed calculated through the surge equation. This minimum speed should not be lower than the minimum motor speed of each RTM model.

6.2 Shutdown Sequence

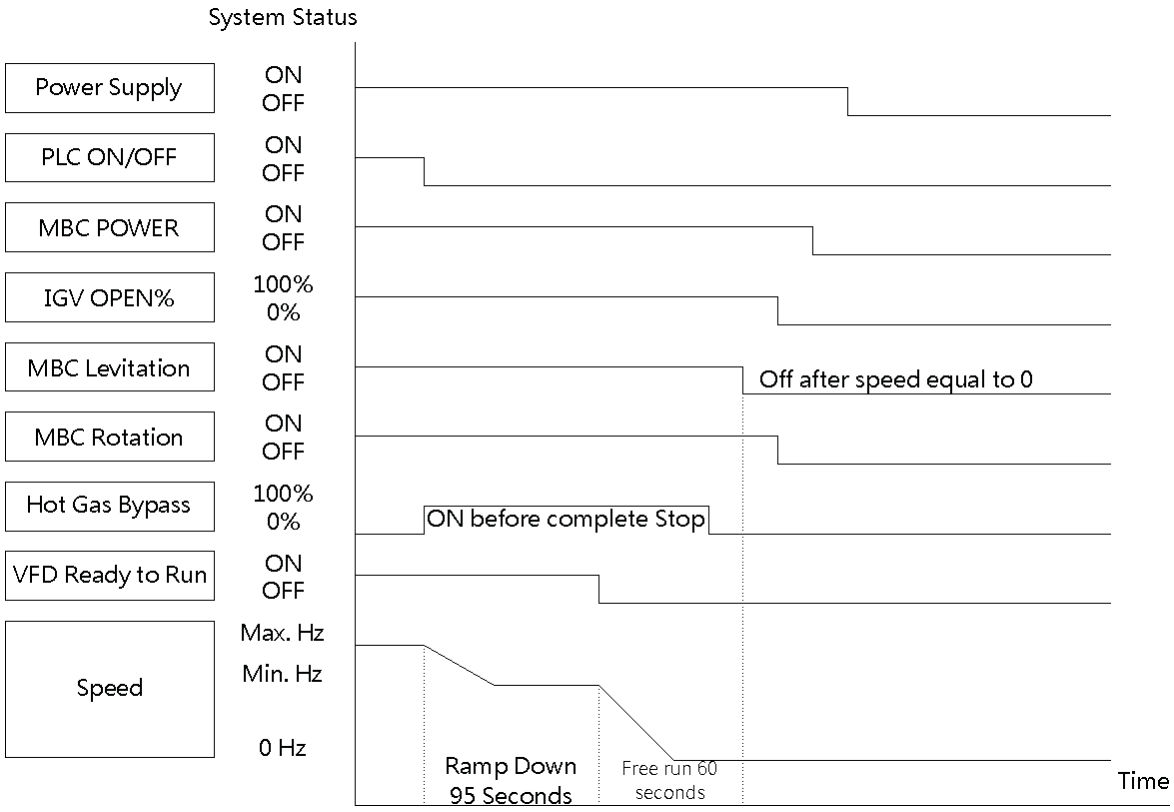


Figure-12 Shutdown sequence

Note:

1. AMBD Levitation can be OFF only after compressor shaft speed equal to 0Hz.
2. The recommended shutdown deceleration time is 95 seconds, which can be adjusted based on different conditions at jobsites. During the shutdown deceleration period, the compressor should reduce its speed as much as possible to shorten the free-run time. Once the deceleration time is completed, the inverter should terminate the speed command immediately to allow the compressor to free run then stop.
3. The compressor shutdown procedure should terminate the rotation command directly to allow the compressor to free run then stop. VFD is not allowed to receive direct command to reduce the motor speed to zero because the motor operating time may stay too long in the low-speed range to increase the risk of surge even resulting in shaft damage.
4. AMBD Levitation OFF has to be set at least 60 seconds after free run stop.
5. Adjust the IGV aperture to fully open to decrease the rotation speed to the minimum when the compressor shut down.

Chapter 7 Compressor lifting and installation

7.1 Compressor lifting

- When lifting compressor, it is recommended to use steel chain or cable as Figure 7.1, or other safety ropes with loading capacity 2,500kg.
- Making sure the steel chain or cable are properly positioned and keep the compressor in horizontal level to prevent damage in compressor and its accessories during lifting.

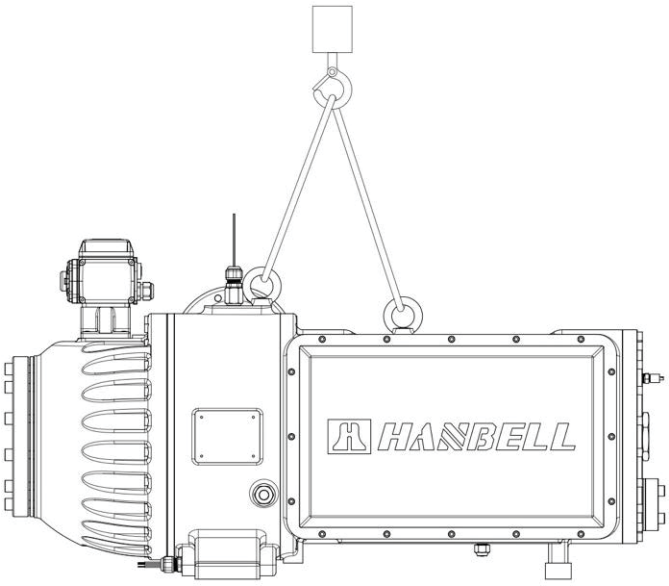


Figure 7-1 Lifting compressor

7.2 Compressor installation

- Compressor should be mounted close to power supply and keep it under proper ventilation and low humidity condition.
- Making sure the frame that supports compressor is strong enough to resist possible vibration and noise during operation and reserve at least 600mm service space around compressor.
- Compressor has to be installed in horizontal position and mounting pad is also recommended to be equipped, as Figure 6.2.

Remark:Compressor should be installed at higher position than evaporator and compressor-foot position should be higher than ECO liquid level in order to prevent pressure loss on liquid return.

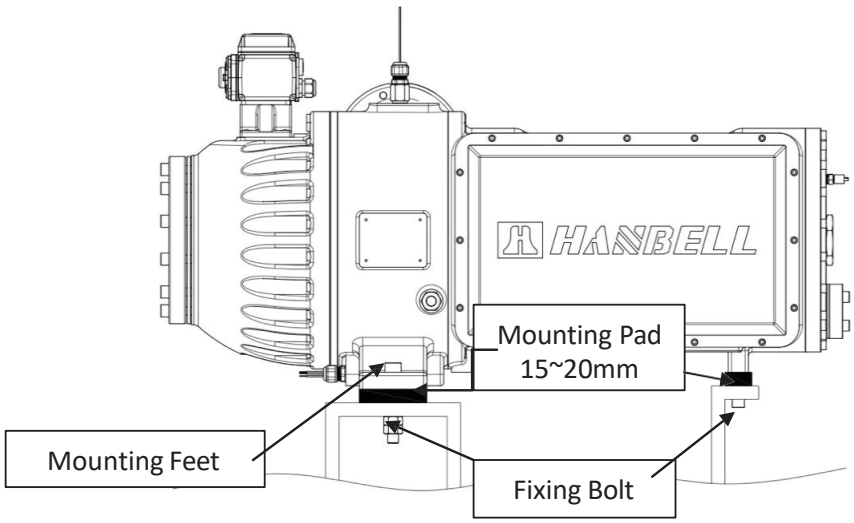


Figure -13 Compressor installation (without support rack)

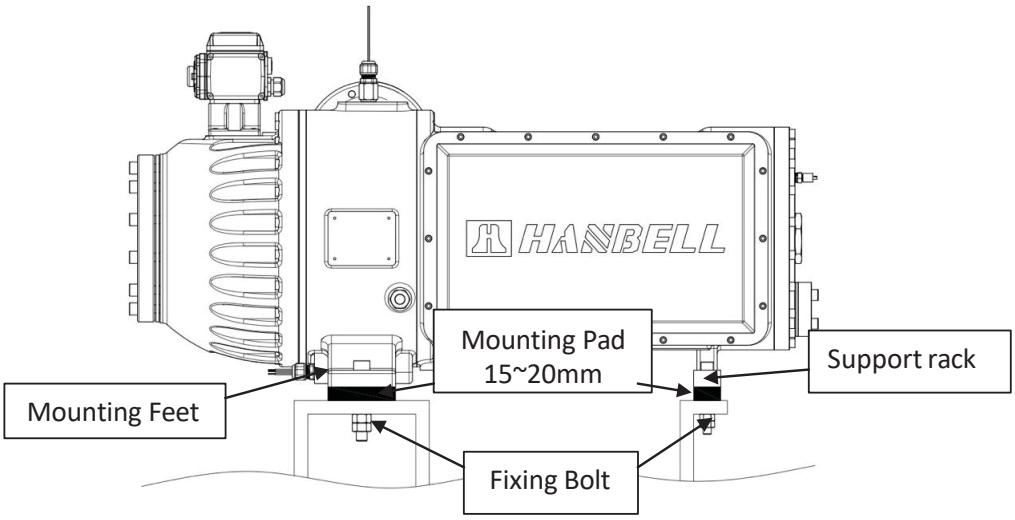


Figure -14 Compressor installation (with support rack)

Chapter 8 Instructions

8.1 Accessories

As a complete package of oil-free centrifugal compressor, HANBELL supplies both standard and optional accessories for variable applications to ensure the stability and efficiency of compressors in the field. When receiving the compressor package, please double check and make sure the accessories are included.

Models/Accessory	●:Standard △:Optional	Remark
Suction/Discharge flange*1	●	
Economizer flange*1	●	
IP54 Terminal Box*1	●	On compressor
Discharge Temperature Sensor(Pt100)	●	
Discharge Temperature Sensor(Pt1000)	△	
Mounting Pad	△	
Discharge Stop Valve(Butterfly type)	△	
VFD	●	
EMI/EMC filter	△	
AC Reactor	△	
DC/Fuse(600V/20A)	△	
APF Active Power Filter	△	
UPS Magnetic Controller Uninterruptible Power System	△	
Gasket Kit	●	For Suction, Medium pressure, Discharge, Motor cooling inlet/ outlet sides.

Table–7 Compressor Accessories

Remark:If there are any optional items required, please contact HANBELL to have further specification and prices information.

8.2 Valves

1. All kinds of valves installed on compressor are closed before delivery. Please make sure to open the valves before testing run.
2. Actuator power supply and opening test: test from 0 ~ 100% (input signal is 4~20mA or other spec). Before compressor startup, IGV shall be fully opened.
3. HGBP and Proportion Valve for Economizer opening test: test 0 ~ 100%. When start up, the opening at start point of HGBP is 100%, and 0% for proportion valve.

8.3 Testing Before Power Supply

1. Checking the voltage supply to compressor is correct.
2. Checking the voltage supplied to AMBD from VFD DC bus is correct (VDC 350~750V). If correct, perform static levitation test. Before shaft is levitated, make sure there is no alarm record.

Remark:

1. Do not run the compressor during checking process.
2. Do not perform any electric test on compressor under vacuum circumstance.
3. The motor shaft must be levitated at least 4 hours before startup if AMBD without power supply for a long period of time, and do not manually rotate the shaft. This is to ensure the electrical components are fully charged to operate correctly after long stop.
4. The voltage of capacitor inside VFD may drop after long-time without main power supply. It is suggested to charge these components 3 to 4 hours every 2 years. If there is no power supply to VFD for more than 2 years, it is required to charge electrical components with 70% to 80% rated voltage power for at least 1 hour, and then charge it with rated voltage power for at least 3 hours to ensure the electrical components are fully charged. (Do not run the compressor during charging period)
5. Please turn on refrigerant heater for at least 4 to 6 hours before compressor start after long time power off.

8.4 System requirement

1. System pipe has to keep clean. It can't be contaminated by welding debris or steel scrap, which can cause damage to compressor.
2. Proper size of check valve must be installed on discharge pipe and the pressure drop should be as small as possible. The pressure and temperature is high in discharge side, so the material and quality of check valve has to be reliable.
3. Compressor must be stocked properly under humid circumstance.
4. If compressor is shut-down for a long term, especially in the winter, refrigerant may condense inside compressor. Please check if refrigerant is accumulated in the compressor from sight glass before starting up the compressor. If necessary, open the valves in aux. liquid return line to drain out liquid refrigerant to evaporator.
5. If there is a need for maintenance, the compressor must be removed from the unit. After refrigerant recovery is completed, the compressor can only be removed when the temperature inside the unit is higher than the environmental dew point temperature. Otherwise, low temperatures may cause condensation inside the compressor and system, leading to rusting of the compressor and internal components of the unit.

8.5 Control requirement

1. In order to avoid motor over-heat, compressor is not allowed to start/stop frequently. The interval between start/stop should be at least 10 minutes.
2. When cutting primary side power supply to VFD, please ensure the residual power of the VFD is fully discharged before next power supply. This is to avoid the power impact to the electrical components of the VFD.
3. Discharge/Suction pressure value for calculating surge equation has to be read by the transmitter close to compressor Discharge/Suction port, not by the transmitter installed on evaporator or condenser shell.

Appendix：Koei (phase-out) Actuator Data

Actuator information:

RATED POWER	1Phase, AC 220V±10%(50/60Hz) 1Phase, AC 110V±10%(50/60Hz)
INPUT SIGNAL	4~20mA·DC;1~5V·DC
OUTPUT SIGNAL	4~20mA·DC
OUTPUT TORQUE	49N·m(5kgf·m)
OPERATION SPEED	15sec(50Hz);12.5 sec(60Hz)
TRAVEL ANGLE	0~90°
RATED OPERATION TIME	Continuous (100%)
RESOLUTION	Over 1/250
DEAD ZONE	Max. 0.5%
PROTECTION	Motor thermal protector (120ºC)
AMBIENT TEMPERATURE	Ambient temperature within: -25~55ºC
RATED CURRENT	0.4A(220V);0.7A(110V)
MOTOR	20W
INSULATION GRADE	Class E
INSULATION RESISTANCE	Between power terminal – case : 500V·DC / 100MΩ
WITHSTAND VOLTAGE	Between power terminal – case : 1500V·AC / 1 minute
WIRE INLET	G1/2×2
ENCLOSURE PROTECTION	NEMA-4X (IP-66)
WEIGHT	4.5kg

Table 3.1 Actuator data

Note:When operating at ambient temperature under 0℃, optional space heater is required to keep the actuator inside dry. Otherwise, moisture may condense under low temperature and high humidity or parts may shrink at low temperature.

Electrical connections

When using standard wire wiring, cable diameter should be Φ9 ~ Φ11; if other wire is used, please select the appropriate cable diameter, otherwise the water may penetrate.

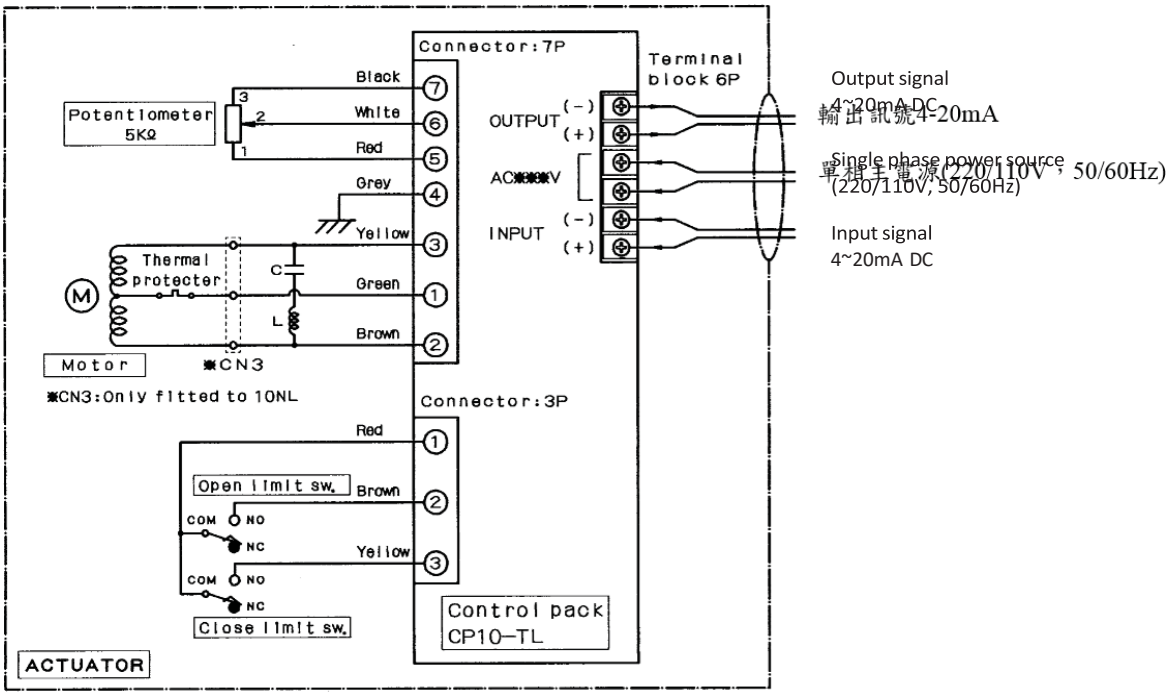


Figure 3.2 Wiring diagram (220/110V)

Remark:1. 5A fuse or breaker should be installed in main power supply. Voltage stabilizer is required to avoid the damage caused by the imbalance of voltage. (within 10%)

2. Signal wires for control should be shielded to prevent them from interference.
3. The actuator wiring shall not be parallel to the power cables.

Wiring

Make effective water proof if vinyl tubes or conduits are used:

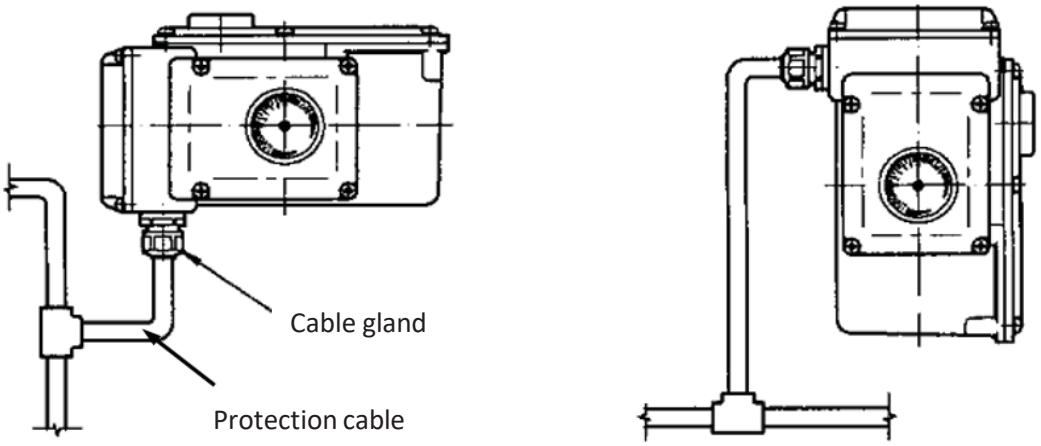


Figure 3.3 Wiring

Control info.

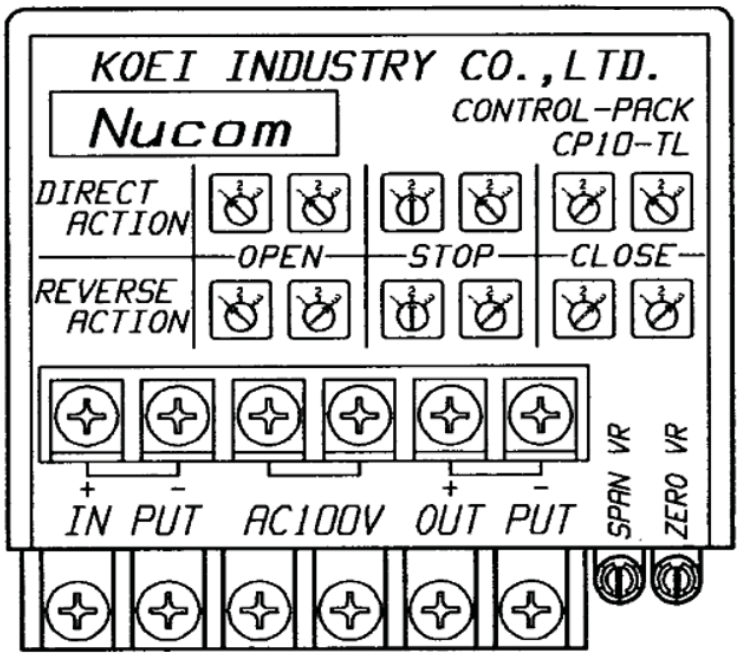


Figure 3.4 Control pack

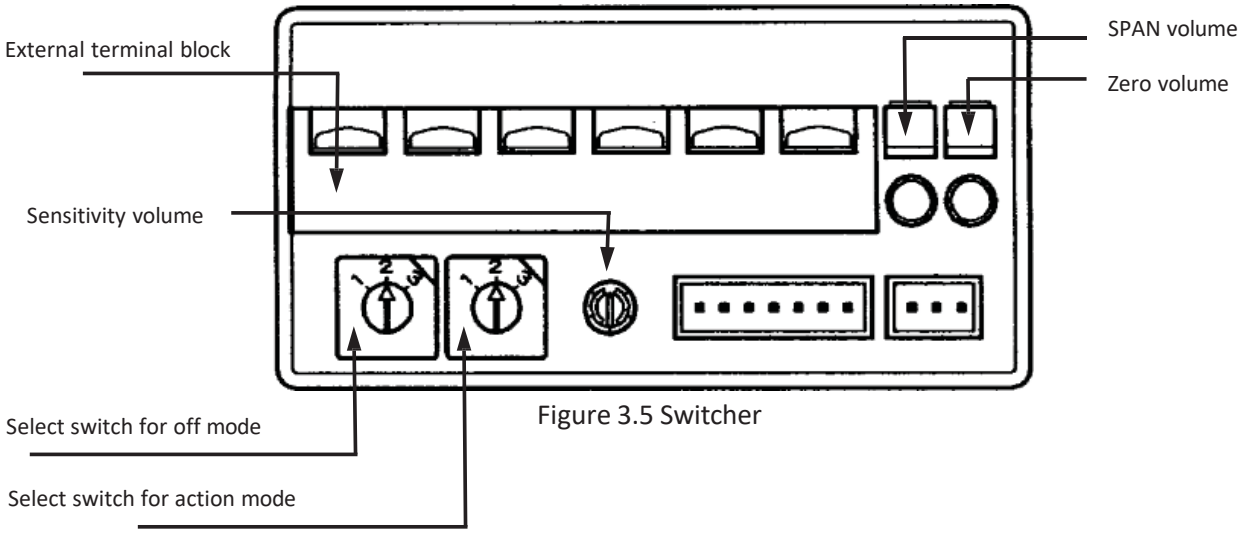
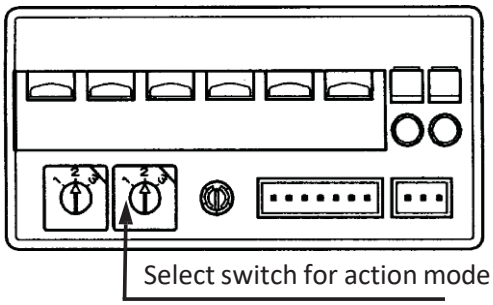
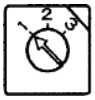


Figure 3.5 Switcher

※Direction mode

Either direct or reverse action is selectable at this switch.



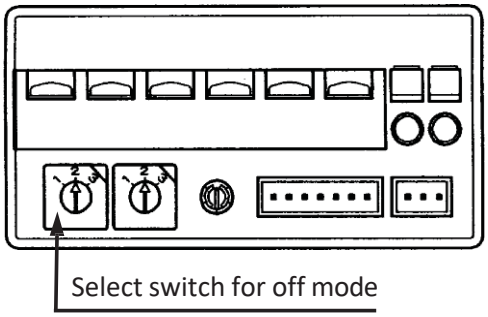


1 = Direct action
Input signal 20mA → Close
Input signal 4mA → Open

3 = Reverse action
Input signal 4mA → Open
Input signal 20mA → Close

※Selection of a mode during signal interruption:

A mode among open/stop/close is selectable at this switch in case of signal interruption.



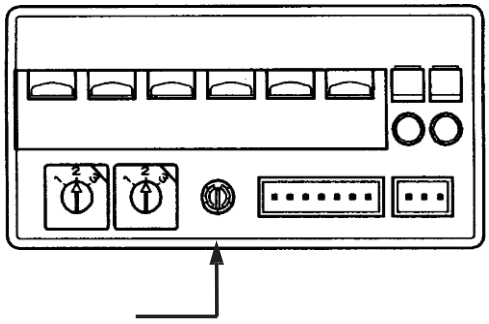
Select switch 1 = Close action (default)

Select switch 2 = Stop action

Select switch 3 = Open action

Note:When the input signal is less than 2mA, the actuator is judged to be interrupted and transferred to the specified state, so the control device and signal 4~20mA must be adjusted correctly.

※ Sensitivity volume:

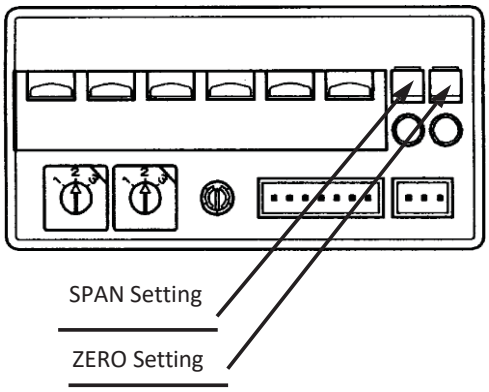


* Sensitivity volume
  Clockwise for higher
  Counter clockwise for lower

* Max. sensitivity:
  Resolution = 1/400

* Min. sensitivity:
  Resolution = 1/100

※ ZERO/SPAN Setting:



* ZERO volume
  CW = To increase (to OPEN direction)
  Adjustable range - 25 ~ +25 %

* SPAN volume
  CW = To increase (to OPEN direction)
  Adjustable range - 50 ~ +200 %

Remark:

1. Before the compressor is shipped out from the factory, the zero and span knobs have been adjusted to the best position. Do not adjust if not necessary. If adjustment is required, please use a small screwdriver to turn gently (excessive force will cause damage in the knob).
2. When adjusting IGV, turn to the fully-close position and then do fully-open position adjustment.

※Note:Because the forward turn of the actuator is opposite to the IGV connecting rod's, the zero knob is fully opened while the span knob is fully closed. To avoid risk, this adjustment should be done by qualified personnel.

Troubleshooting

TROUBLE	PROBABLE CAUSE	SOLUTION
Motor does not start up	1. Power failed or dropped 2. Signal failed or dropped 3. Wire broken or disconnected 4. Thermal protector functioned 5. Limit switches functioned at an intermediate position 6. Motor advancer defective 7. Control pack defective	1. Check and supply power 2. Check and input signals 3. Change the wire or re-connect the terminal 4. Lower the ambient temperature 5. Decrease duty rate 6. Eliminate overload at valve 7. Re-adjust the limit cam 8. Change advancer (condenser) 9. Change control pack
Aperture unfixable (Hunting)	1. Noise on signal line 2. Noise on potentiometer 3. Potentiometer and opening gear loose	1. Check input signal 2. Change potentiometer 3. Check the fixing screws
Aperture does not match input signal	1. A wrong signal input 2. Improper adjustment of ZERO/SPAN 3. Potentiometer slipped	1. Check the input signals 2. Re-adjust ZERO/SPAN 3. Re-adjust the aperture on the potentiometer
Aperture signal does not output	The opening signal is broken or poorly connected	Check the wiring connection

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