Contents

Chapter 1. Introduction

This manual is intended as a guide for application engineers, consultants, sales engineers, and HVAC designers to use Hanbell RT series centrifugal compressors. The copyright of content in 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.

Features

- **HFC-134a** - chlorine-free refrigerant Zero ODP）.
- **COP** - the highest-efficiency centrifugal compressor for HFC-134ain the market.
- **Maximum pressure** – designed for the high pressure up to17 bar.
- **Compressor** - semi-hermetic design.
- **Refrigerant cycle with -** high-efficiency two-stage compression with economizer.
  - High-efficiency motor.
- **Shaft** –made of high-strength alloy steel.
- **Impellers** –closed type made of high-strength aluminum.
- **Bearings** -durable for 50,000-hour operation without overhaul.
- **Semi-hermetic motor** –independent cooling by liquid refrigerant.
- **Gear** –less mechanical loss (JIS 0/ ISO Grade 4).
- **Enclosure -** IP54 protection.

Ambience

RT series compressors should be stored and operated within the following ambient temperature.

Storage: -10℃ to 70℃ (14℉ to 158℉)

Operation(Water-cooled): ET:-8℃~20℃ (17℉to 68℉);CT：20℃~50℃(68℉ to 122℉)

Operation(Heat pump): ET:-8℃~20℃ (17℉ to 68℉);CT：20℃~60℃(68℉ to 140℉)

Note: Please refer to “Application limits” in page 2 for allowable operating conditions and Hanbell selection software for detailed performance data.

Safety cautions

Safety cautions in this instruction manual are for users to take precaution measures in order to reduce risks of personal injury and equipment damage. Please read these instructions carefully before Installing, operating, and maintaining the equipment.

Danger: Indicates a personal safety hazard which, special precautions are required to prevent users from danger or injury. Dangerous or unsafe items will result in personal injury or death.

Warning: Indicates a personal safety hazard which, special precautions are required to prevent users from potential danger or injury. Failure to follow the instructions could result in personal injury or death.

Caution: Instructs user for general precautions. Failure to follow the instructions could result in personal injury and/or damage to the equipment.

Chapter 2. Basic design

2.1 Compressor nomenclature

RT–xxxx

- **Empty – Standard**
- **T – Dual-IGV**
- **E – High Efficiency**

- **0 – Air-conditioning** ΔT = 30°C
- **1 – Heat pump** ΔT = 40°C

- **Mod**

- **RT model—Centrifugal**

2.2 Application limits

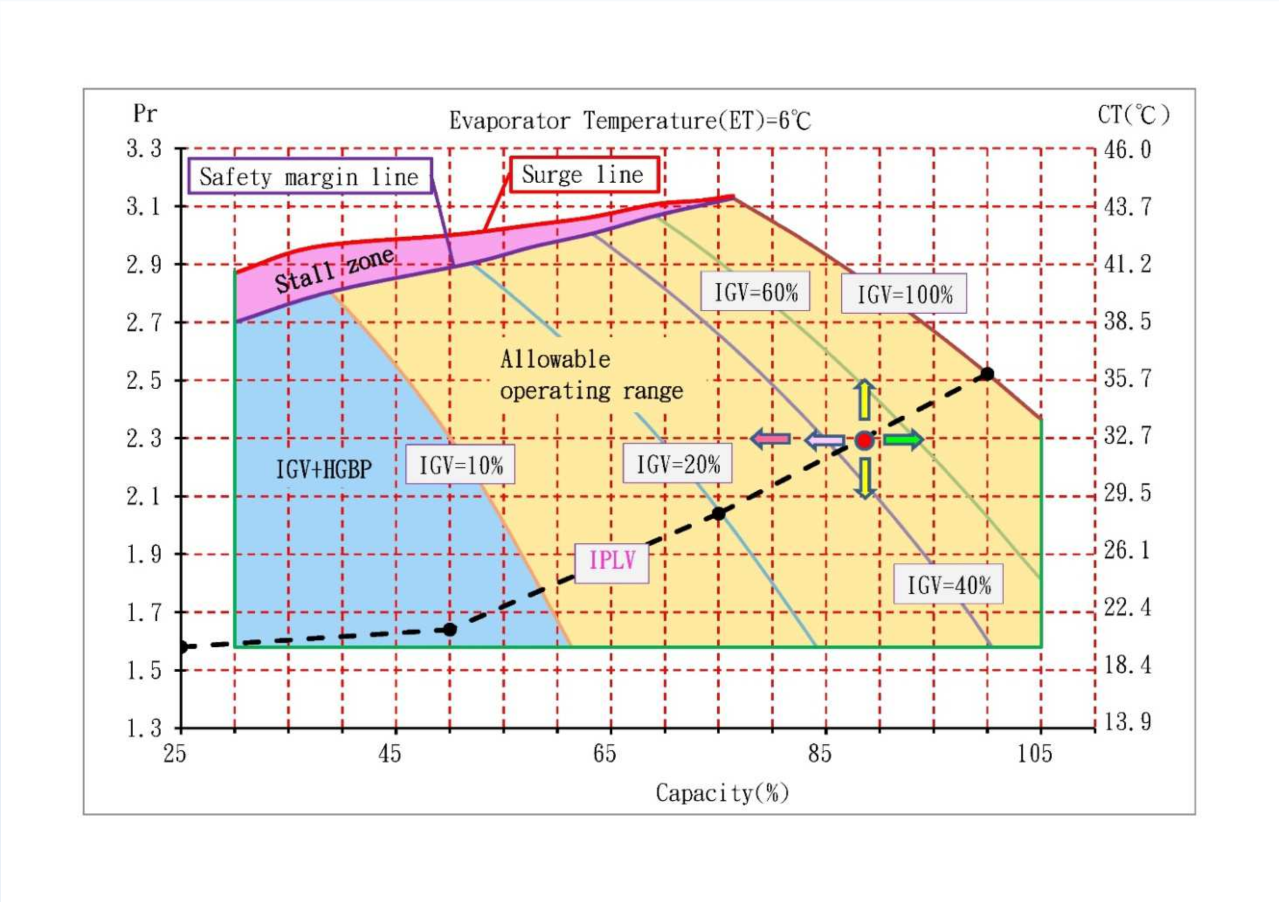


Figure 2.1 RT series application limits

1. Pressure ratio: the ratio of discharge pressure (abs.) over suction pressure (abs.). *pressure sensors should be installed on the compressor discharge and suction pipe. If the sensors are installed on condenser and evaporator, pressure drop need to be considered.Surge point:
2. Surge point: each IGV opening has a corresponding maximum pressure ratio surge point.
3. Surge line: the curve formed by connecting surge points of each IGV opening.
4. Safety margin line: the line formed by translating the surge line to a safety margin at the maximum upper limit of pressure ratio for each IGV opening.

5. Stall zone: Rotating stall is a local disruption of airflow within the compressor which continues to provide compressed air but with reduced effectiveness. Stall zone is defined to confine application of the compressor under unsteady flow with small volume flow.

6. Allowable operating range: ranging from the maximum IGV opening (100%) to the smallest IGV opening (10%),with the maximum operation load of (105%) and covering the operating range from safety margin line to the minimum pressure ratio

2.3 Compressor specifications

Model			RT-120 (E,T)		RT-130 (E,T)		RT-140 (E,T)	
Refrigerant			R134a					
Compressor	Type		Two-stage with speed-up gearing					
	Pressure ratio*		LP	HP	LP	HP	LP	HP
			1.63	1.55	1.63	1.55	1.63	1.55
	Mass flow rate*	kg/sec	11.95	13.54	13.01	14.73	13.43	15.21
	Volume flow (Suction)*	㎥/hr	2,466	1,740	2,684	1,893	2,711	1,954
	Rated speed	rpm	11,700		12,000		12,000	
	Inlet guide vane control	IGV1	10~100% continuous(standard, *2)					
	Inlet guide vane control	IGV2	10~100% continuous(optional, *3)					
Transmission	Type		Helical gear					
	Lubrication		Built-in oil pump					
	Lubricant charge	Liter	38					
Motor	Type		3 Phase, 2 Pole, Induction					
	Starting		Y-△ Starting, Direct starting					
	Voltage (50/60 Hz)	V	380~600,10k/6k/4k/3k					
	Insulation		Class F					
	Protection		PTC,Pt100/Pt1000					
Oil heater		kW	2x0.5					
Chamber heater		kW	2x0.3					
Maintenance butterfly valve			8” (optional)					
Dimension (LxWxH)		m	2.30 x 1.20 x 1.02					
Weight		kg	3,500					
Hydrostatic pressure test		kg/cm²g	22					

Table 2.1 Refrigeration Compressor specifications

1. Under CT/ET=36℃/6℃(refer to ASHRAE 90.1-2015)
2. Setting IGV1=5% applied only in startup, in regular operation should set IGV1≧10%, while for Dual IGV models IGV1≧5%.
3. IGV2 is optional, for Dual IGV models select RT-120T, RT-130T, RT-140T. These models have good part load efficiency with IPLV=7.0~7.4
4. The available motor voltage specification is as follows：

Voltage	RT-120~140(E,T)
380V~600V	○
3kV/3.3kV	○
6kV/6.6kV	○
10kV/11kV	○

Model			RT-160 (E,T)		RT-180 (E,T)		RT-200 (E,T)	
Refrigerant			R134a					
Compressor	Type		Two-stage with speed-up gearing					
	Pressure ratio*		LP	HP	LP	HP	LP	HP
			1.63	1.55	1.63	1.55	1.63	1.55
	Mass flow rate*	kg/sec	15.95	18.06	18.34	20.77	19.73	22.35
	Volume flow (Suction)*	m³/hr	3,291	2,321	3,784	2,669	4,071	2,872
	Rated speed	rpm	9,400		8,900			
	Inlet guide vane control	IGV1	10~100% continuous(standard, *2)					
	Inlet guide vane control	IGV2	10~100% continuous(optional, *3)					
Transmission	Type		Helical gear					
	Lubrication		Built-in oil pump					
	Lubricant charge	Liter	57					
Motor	Type		3 Phase, 2 Pole, Induction					
	Starting		Y-△ Starting, Direct starting					
	Voltage (50/60 Hz)	V	380~600,10k/6k/4k/3k					
	Insulation		Class F					
	Protection		PTC,Pt100/Pt1000					
Oil heater		kW	2x0.5					
Chamber heater		kW	2X0.3					
Maintenance butterfly valve			10" (optional)					
Dimension (LxWxH)		m	2.62 x 1.29 x 1.27					
Weight		kg	4,500					
Hydrostatic pressure test		kg/cm²g	22					

Table 2.2 Refrigeration Compressor specifications

1. Under CT/ET=36℃/6℃(refer to ASHRAE 90.1-2015)
2. Setting IGV1=5% applied only in startup, in regular operation should set IGV1≧10%, while for Dual IGV models IGV1≧5%.
3. IGV2 is optional, for Dual IGV models select RT-160T, RT-180T, RT-200T. These models have good part load efficiency with IPLV=7.0~7.4
4. The available motor voltage specification is as follows：

Voltage	RT-160~200(E,T)
380V~600V	○
3kV/3.3kV	○
6kV/6.6kV	○
10kV/11kV	○

Model			RT-240 (E)		RT-260 (E)		RT-280 (E)	
Refrigerant			R134a					
Compressor	Type		Two-stage with speed-up gearing					
	Pressure ratio*		LP	HP	LP	HP	LP	HP
			1.63	1.55	1.63	1.55	1.63	1.55
	Mass flow rate*	kg/sec	23.91	27.08	26.18	29.65	27.36	30.99
	Volume flow (Suction)*	㎥/hr	4,933	3,480	5,402	3,810	5,645	3,982
	Rated Speed	rpm	8,200					
	Inlet guide vane control	IGV1	10~100% continuous					
	Inlet guide vane control	IGV2	Not applicable					
Transmission	Type		Helical gear					
	Lubrication		Built-in oil pump					
	Lubricant charge	Liter	68					
Motor	Type		3 Phase, 2 Pole, Induction					
	Starting		Y-△ Starting, Direct starting					
	Voltage (50/60 Hz)	V	380~600,10k/6k/4k/3k					
	Insulation		Class F					
	Protection		PTC,Pt100/Pt1000					
Oil heater		kW	2x0.5					
Chamber heater		kW	2X0.3					
Maintenance butterfly valve			10” (optional)					
Dimension (LxWxH)		m	2.60 x 1.30 x 1.20					
Weight		kg	4,500					
Hydrostatic pressure test		kg/cm²g	22					

Table 2.3 Refrigeration Compressor specifications

1. Under CT/ET=36℃/6℃(refer to ASHRAE 90.1-2015)
2. Setting IGV1=5% applied only in startup, in regular operation should set IGV1≧10%,
3. Dual IGV structure is not available for this framework.
4. The available motor voltage specification is as follows：

Voltage	RT-240~280
380V~600V	Optional
3kV/3.3kV	○
6kV/6.6kV	○
10kV/11kV	○

Caution：This series of low-voltage motor specifications are only for motor A. Motor B with high evaporation conditions is not applicable due to low voltage start up and extremely large running current.

Model			RT-111		RT-161		RT-221	
Refrigerant			R134a					
Compressor	Type		Two-stage with speed-up gearing					
	Pressure ratio*		LP	HP	LP	HP	LP	HP
			1.91	1.73	1.91	1.73	1.91	1.73
	Mass flow rate*	kg/sec	9.83	11.74	17.03	20.35	19.66	23.48
	Volume flow (Suction)*	㎥/hr	2,028	1,296	3,515	2,246	4,056	2,592
	Rated Speed	rpm	12,000		9,400			
	Inlet guide vane control	IGV1	5~100% continuous(standard, *2)					
	Inlet guide vane control	IGV2	5~100% continuous(standard, *3)					
Transmission	Type		Helical gear					
	Lubrication		Built-in oil pump					
	Lubricant charge	Liter	33		57		57	
Motor	Type		3 Phase, 2 Pole, Induction					
	Starting		Y-△ Starting, Direct starting					
	Voltage (50/60 Hz)	V	380~600,10k/6k/4k/3k					
	Insulation		Class F					
	Protection		PTC,Pt100/Pt1000					
Oil heater		kW	2x0.5					
Chamber heater		kW	2x0.3					
Maintenance butterfly valve			8" (optional)		10" (optional)			
Dimension (LxWxH)		m	2.60 x 1.30 x 1.20					
Weight		kg	4,500					
Hydrostatic pressure test		kg/cm^2g	22					

Table 2.4 Heating Compressor specifications

1. Under CT/ET=36℃/6℃(refer to ASHRAE 90.1-2015)
2. Setting IGV1=5% applied only in startup, in regular operation should set IGV1≧10%,
3. All standard heat pumps include dual IGV structure.
4. The available motor voltage specification is as follows：

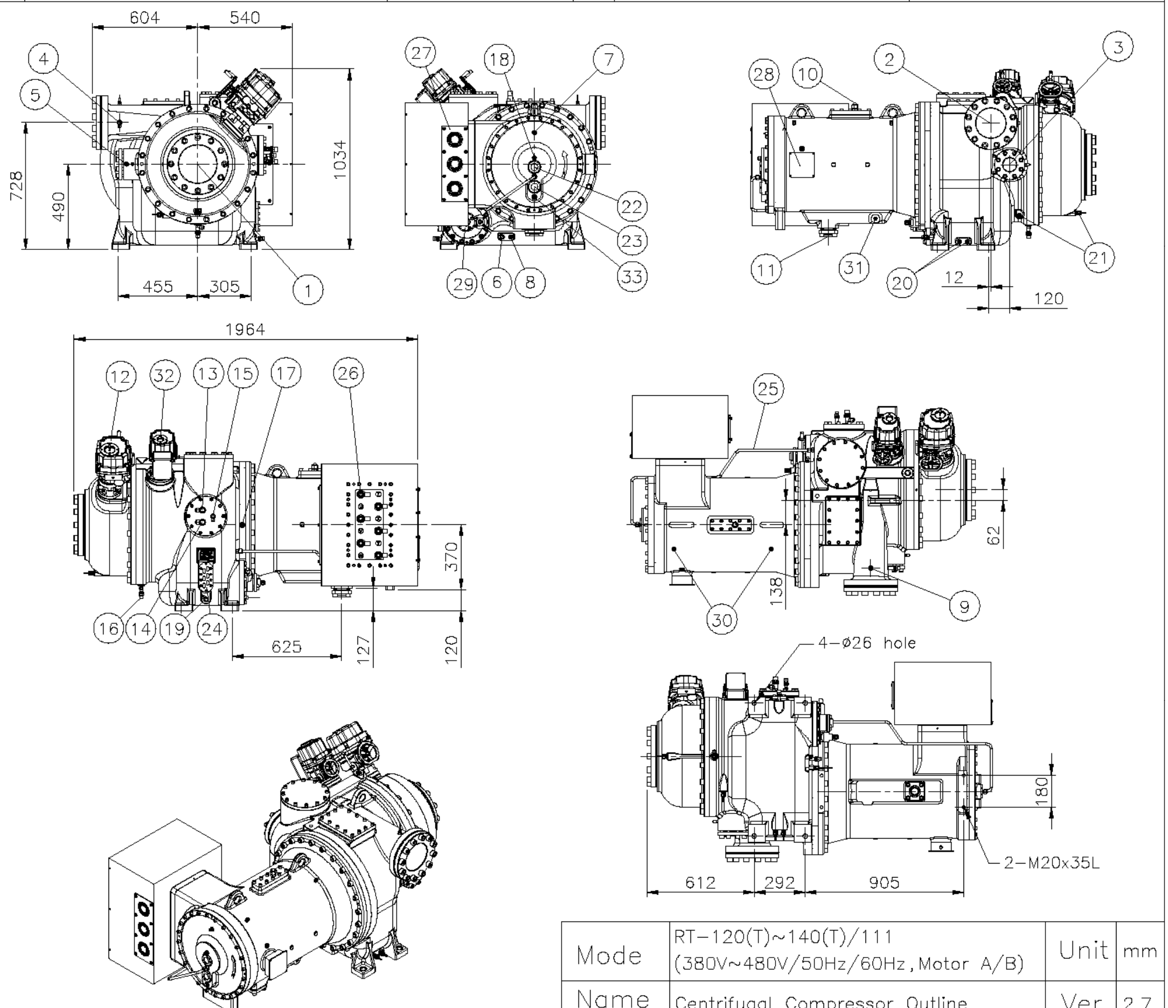
Voltage	RT-111 ~ 161	RT-221
380V~600V	○	Optional
3kV/3.3kV	○	○
6kV/6.6kV	○	○
10kV/11kV	○	○

Caution：RT-221 low-voltage motor is only for motor A. Motor B with high evaporation conditions (due to extremely large start up current) is not applicable.

2.4 Compressor outline

Low voltage compressor outline RT-120~140(E,T)/RT-111 (motor A&B)

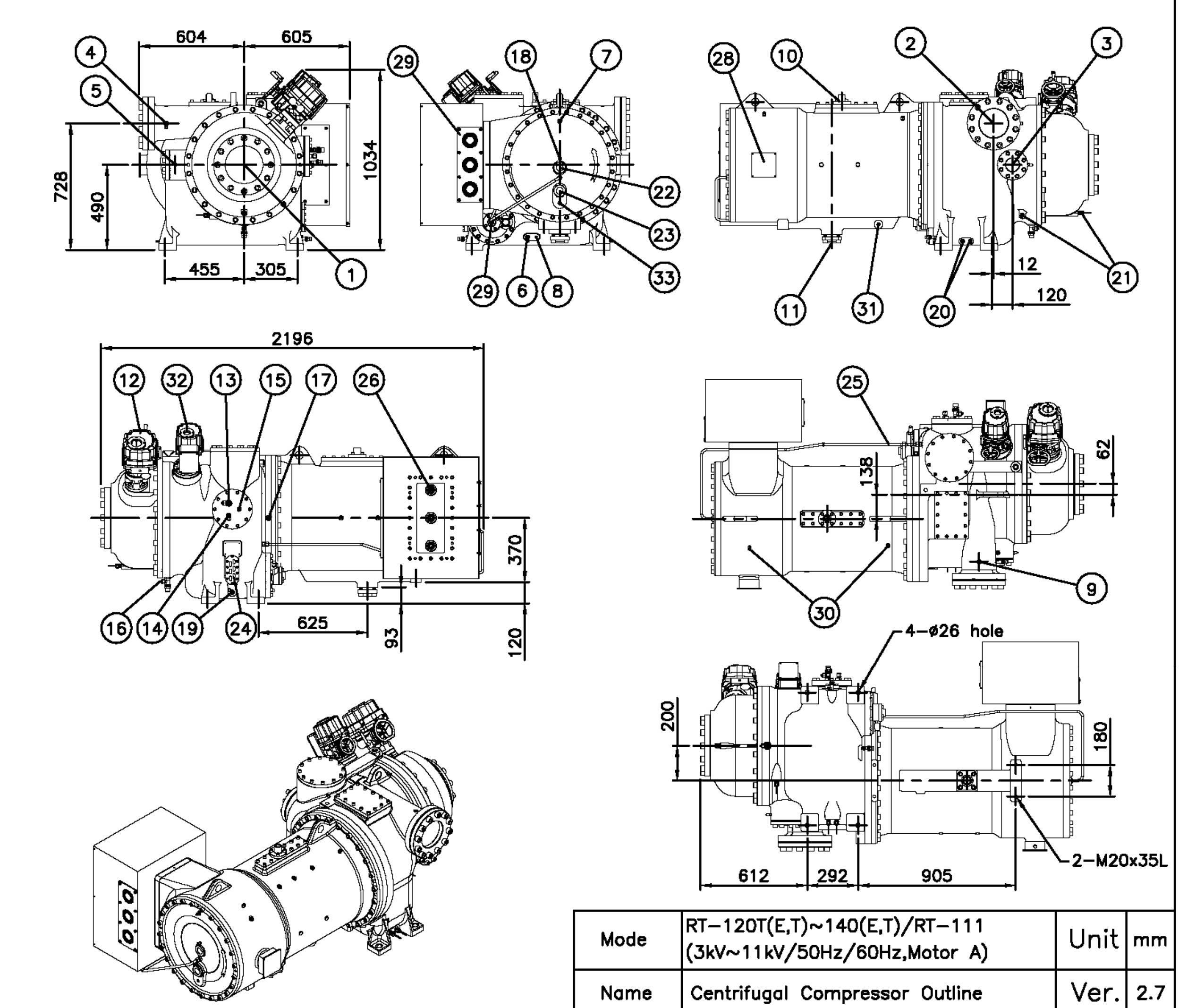
No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	6" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	2 1/2" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	PT100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC (optional)	26	Power bolt	5/8−11UNF/1 3/16−12UNC
10	Motor cooling connection (inlet)	3/4"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC,4*PT100/PT1000
12	Actuator (IGV1 volume control)	220V/1ø/50/60Hz	29	Oil pump outlet	1" steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	1/2"NPT
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2 volume control)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Optical level switch	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT−120(T)~140(T)/111 (380V~480V/50Hz,Motor A/B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

High voltage compressor outline RT-120~140(E,T)/RT-111 (motor A)

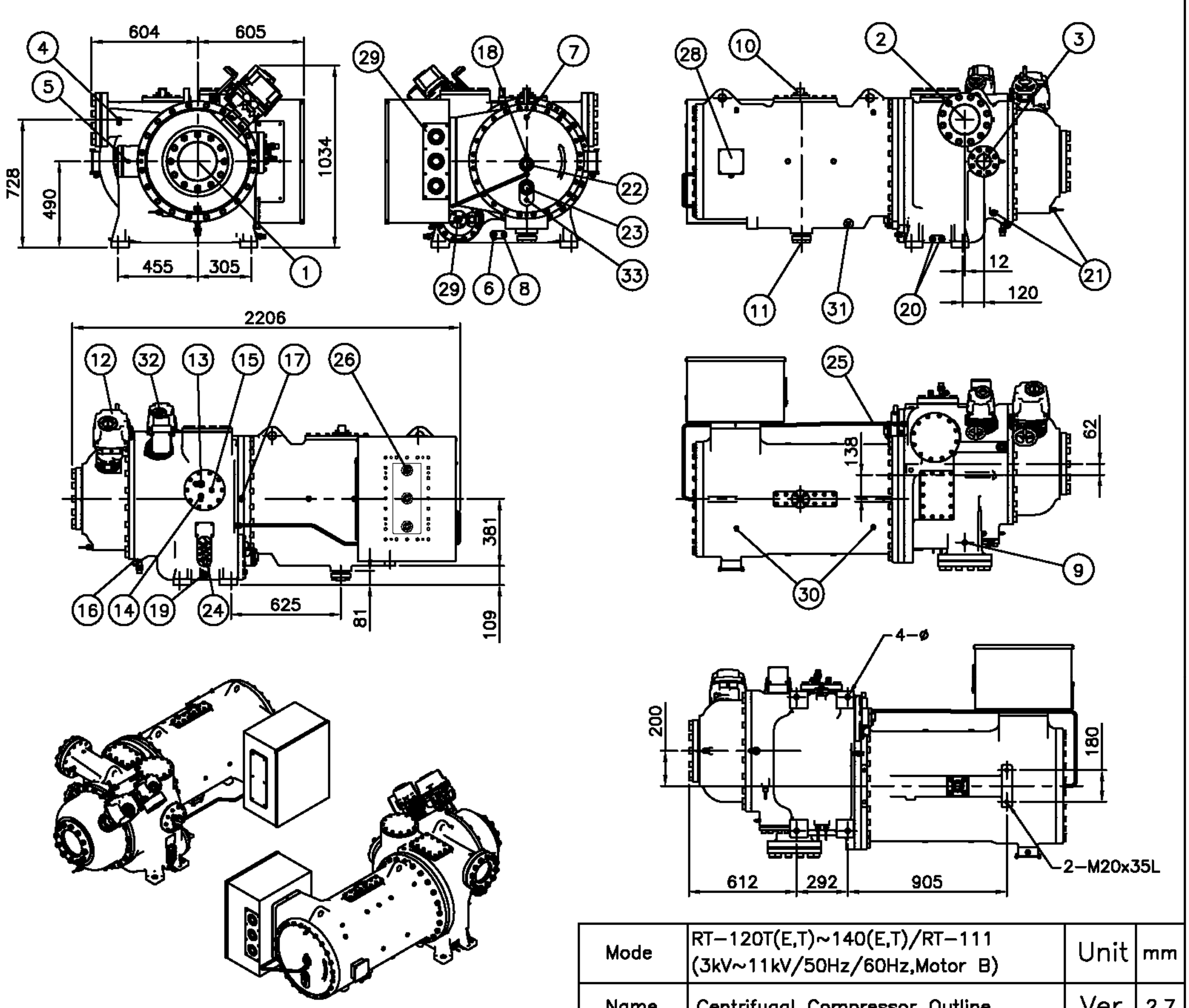
No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20k (JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	6" 20k (JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	2 1/2" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	9/16-18UNF
10	Motor cooling connection (inlet)	3/4"FL	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	3/8"FL	31	Secondary motor cooling outlet	1/2"NPT
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	3/8"FL			



Mode	RT-120T(E,T)~140(E,T)/RT-111 (3kV~11kV/50Hz/60Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

High voltage compressor outline RT-120~140(E,T)/RT-111 (motor B)

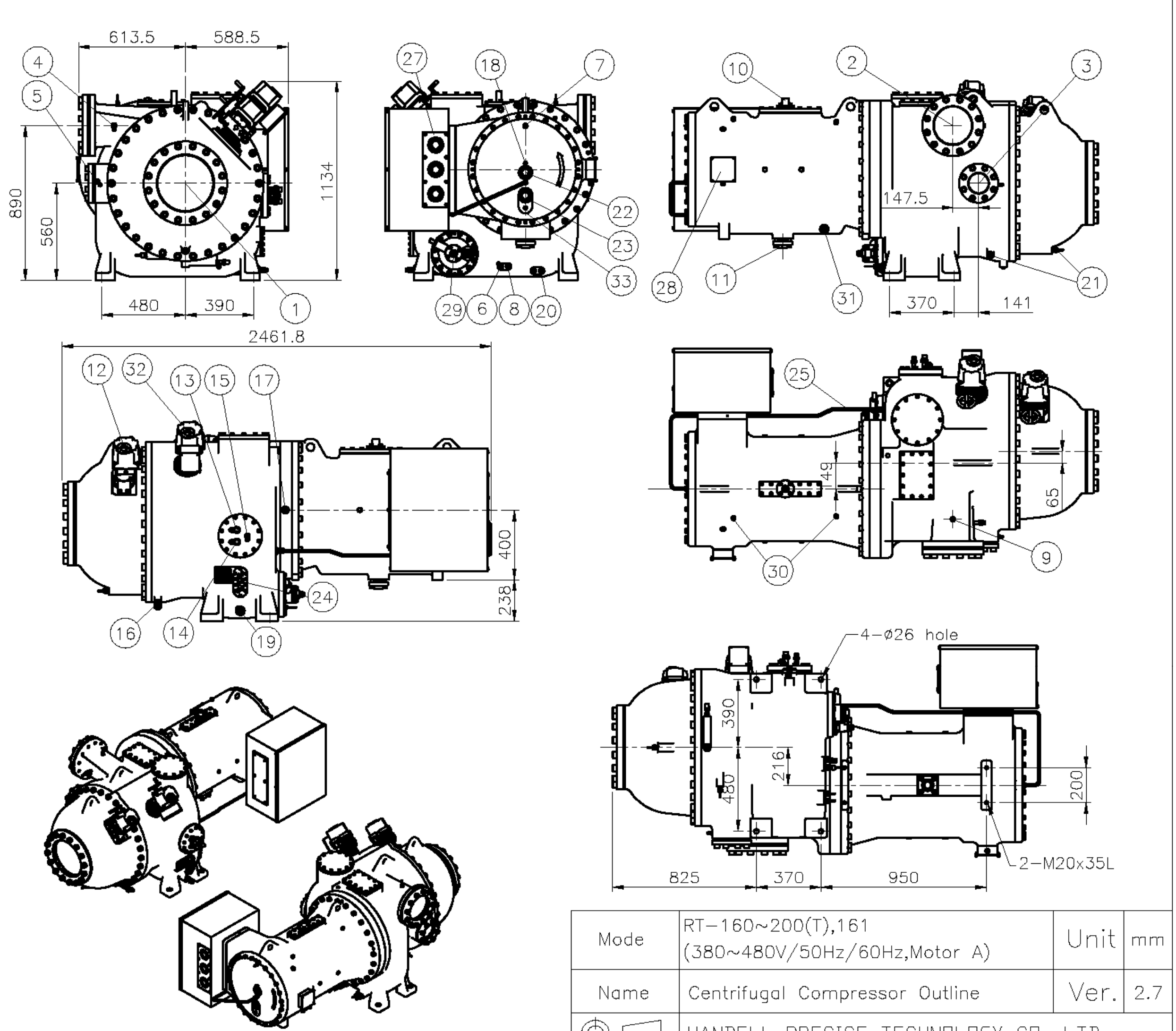
No.	Name	Specification	No.	Name	Specification
1	Suction flange	8" 20k (JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	6" 20k (JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	2 1/2" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	9/16-18UNF
10	Motor cooling connection (inlet)	3/4"FL	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1φ/50/60Hz	29	Oil pump outlet	1"steel/380V/3φ/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	3/8"FL	31	Secondary motor cooling outlet	1/2"NPT
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1φ/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1φ/50/60Hz
17	Oil connection (gearbox)	3/8"FL			



Mode	RT-120T(E,T)~140(E,T)/RT-111 (3kV~11kV/50Hz/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-160~200(E,T)/RT-221 (motor A)

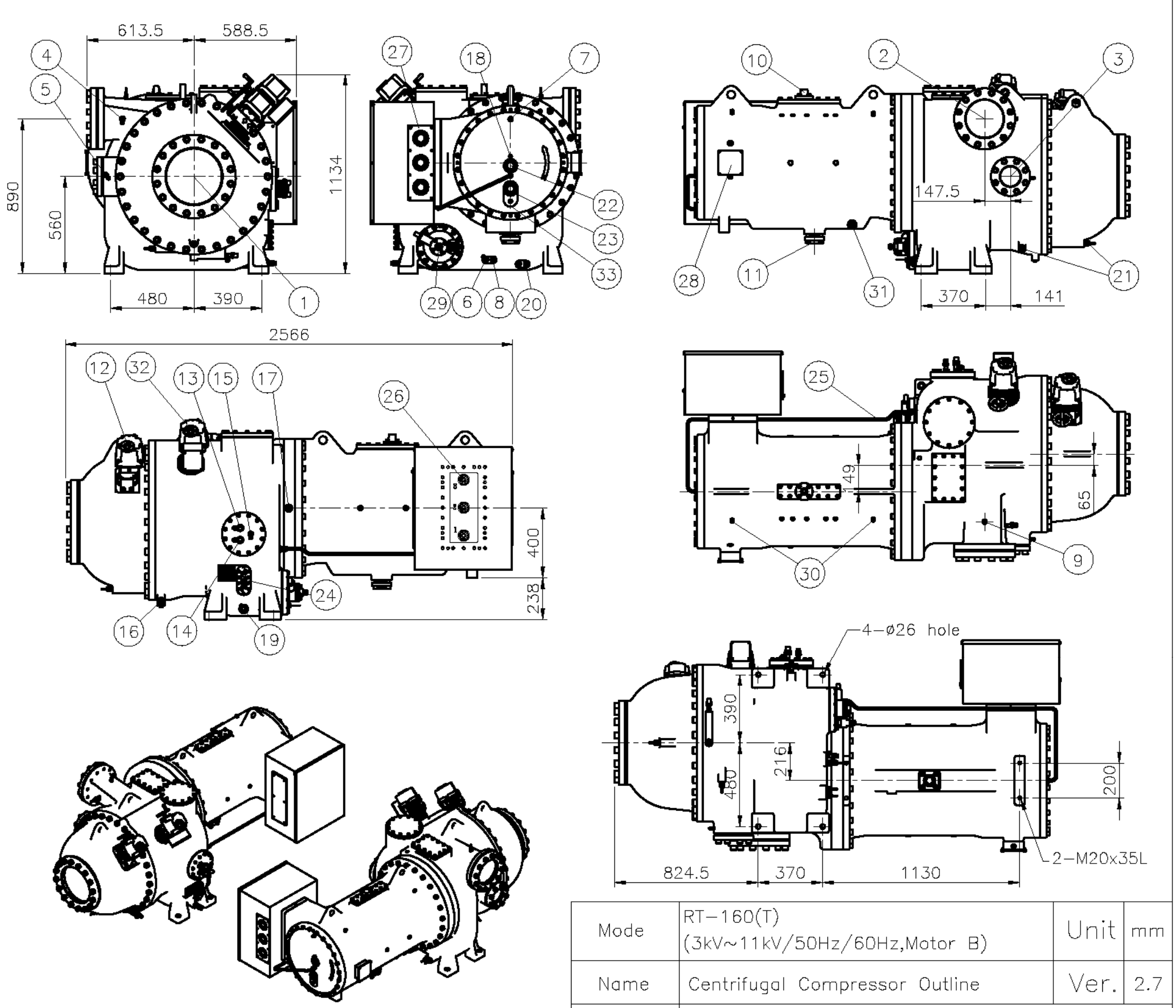
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT-160~200(T),161 (380~480V/50Hz/60Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

High voltage compressor outline RT-160(T)(motor B)

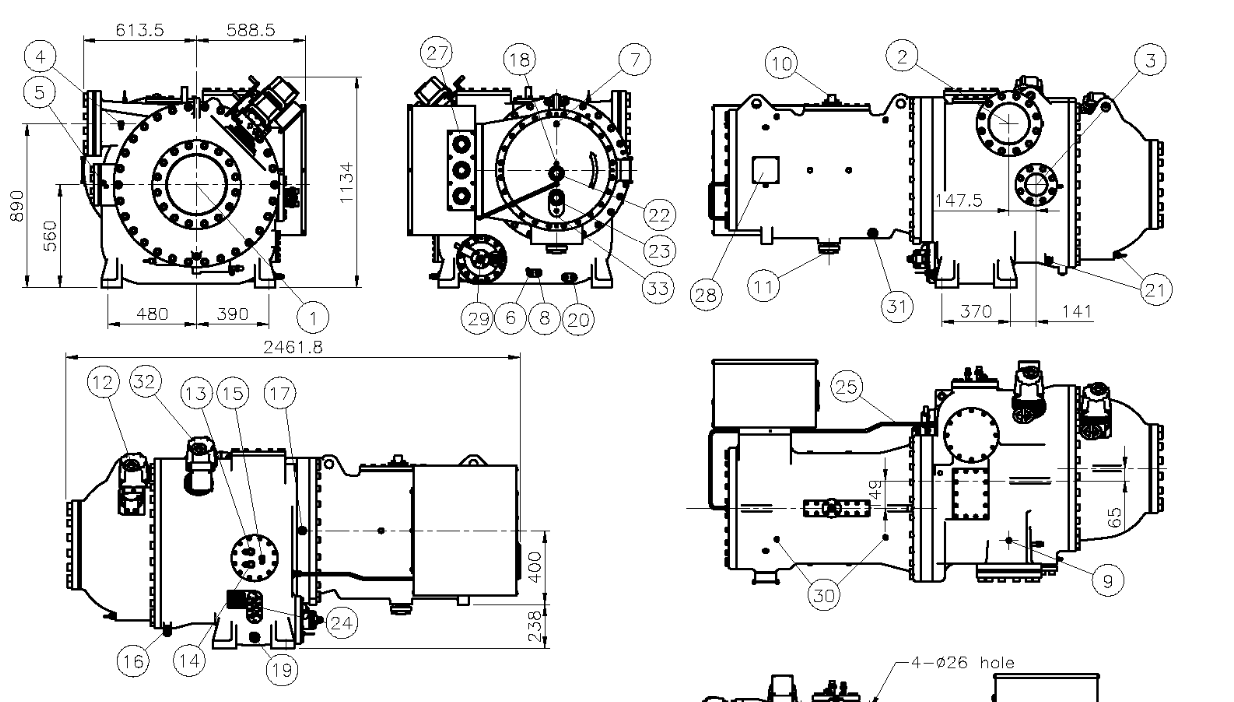
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			

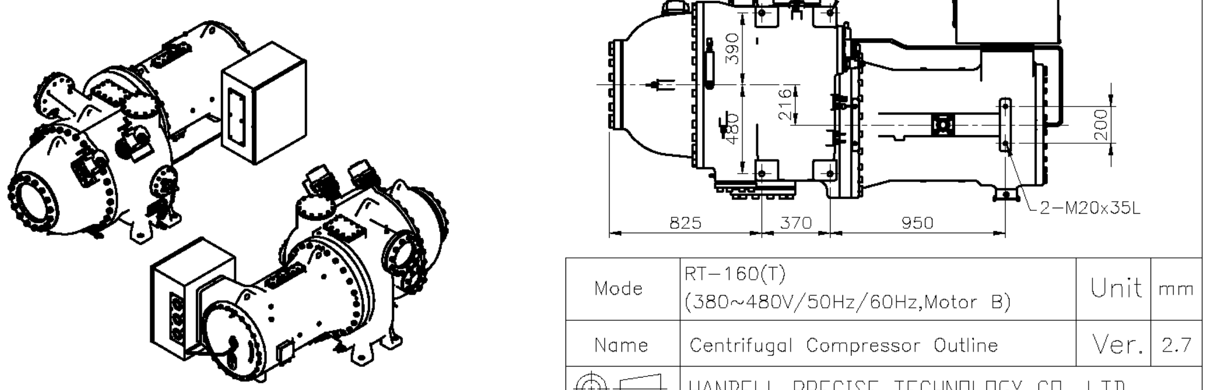


Mode	RT-160(T) (3kV~11kV/50Hz/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-160(T)(motor B)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			

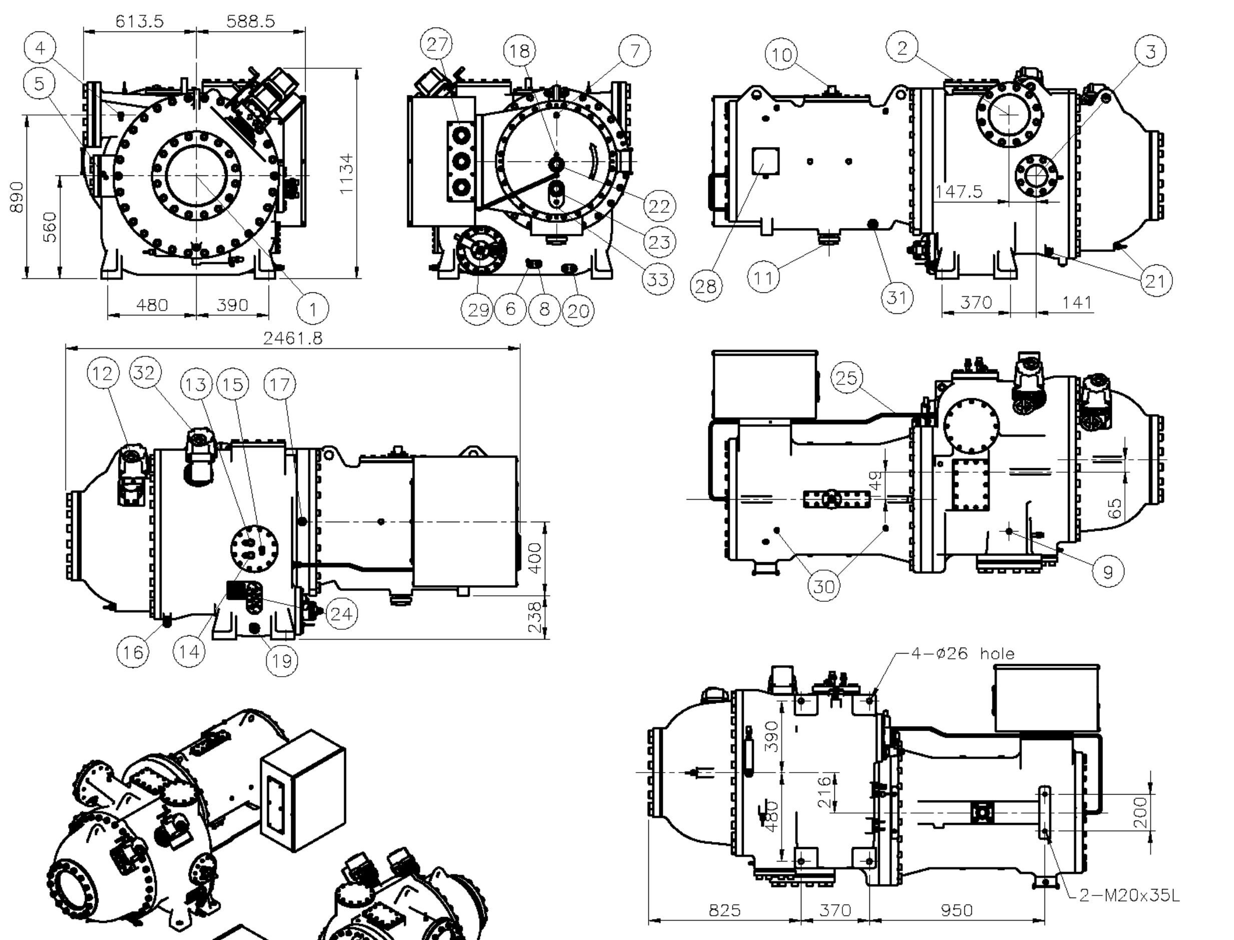




Mode	RT-160(T) (380~480V/50Hz/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-180(T),RT-161(60Hz) (motor B)

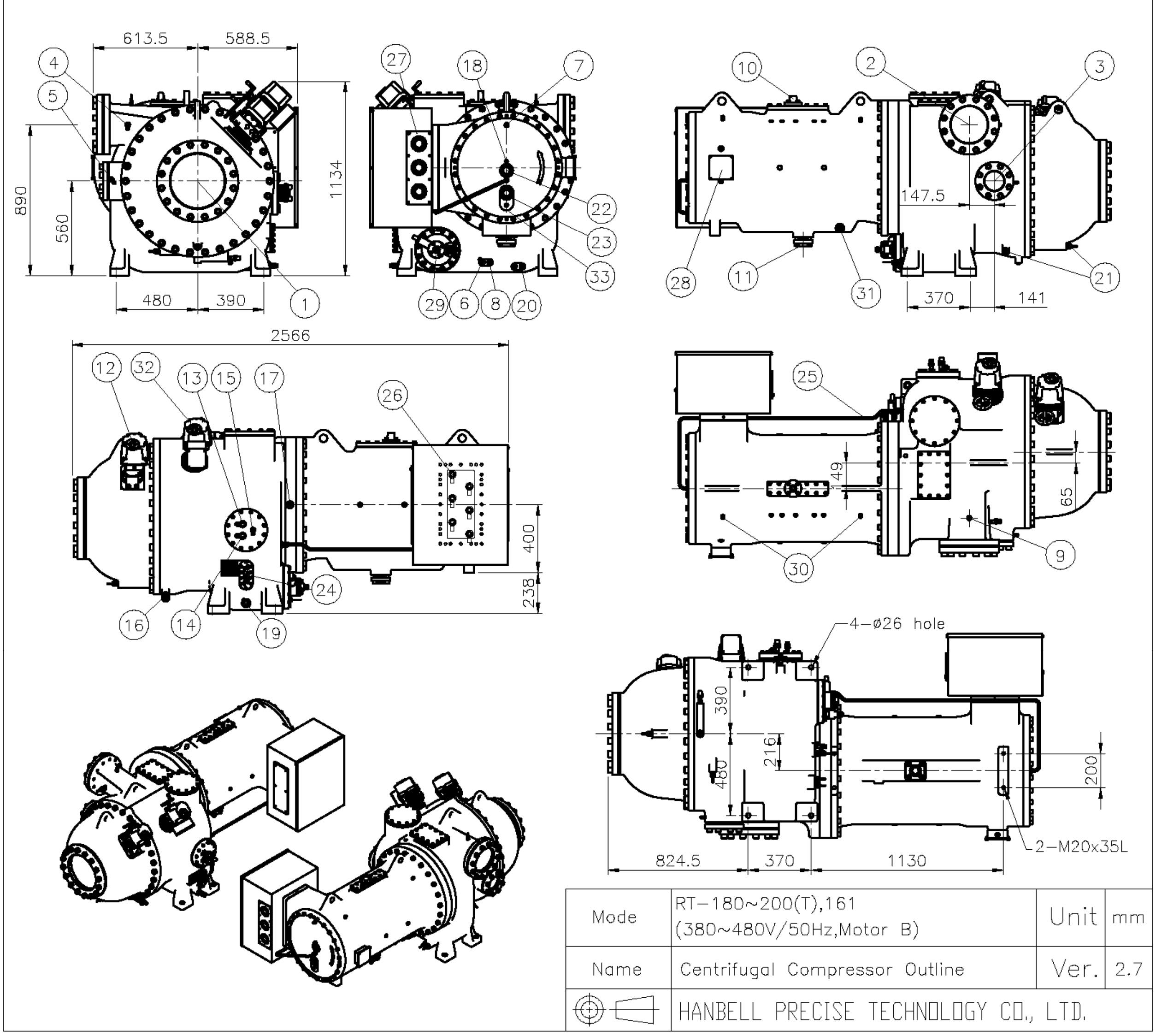
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8−14UNC/9/16−18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT−180(T),161 (380~480V/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

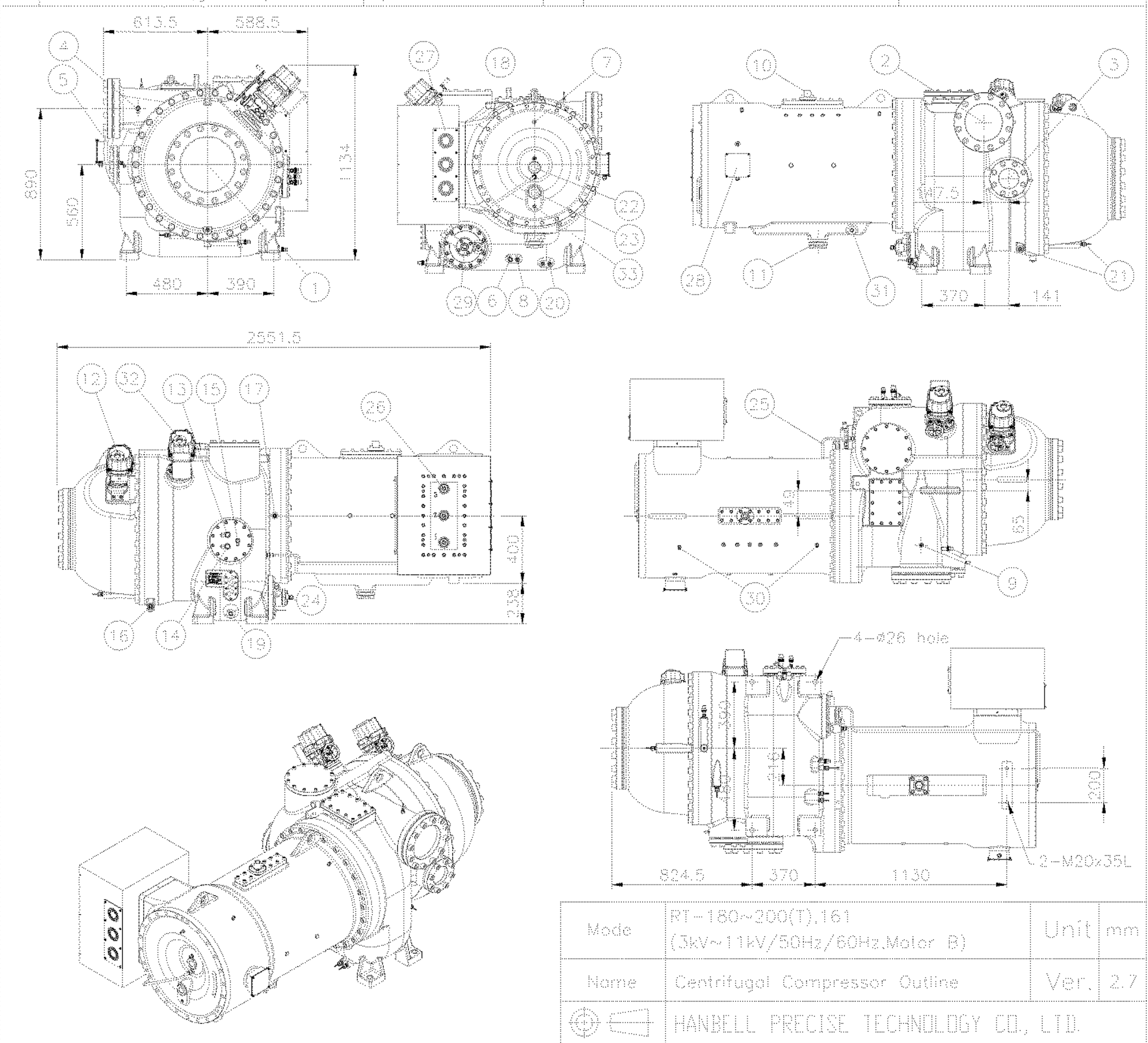
Low voltage compressor outline RT-180~200(T),RT-161(50Hz) (motor B)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



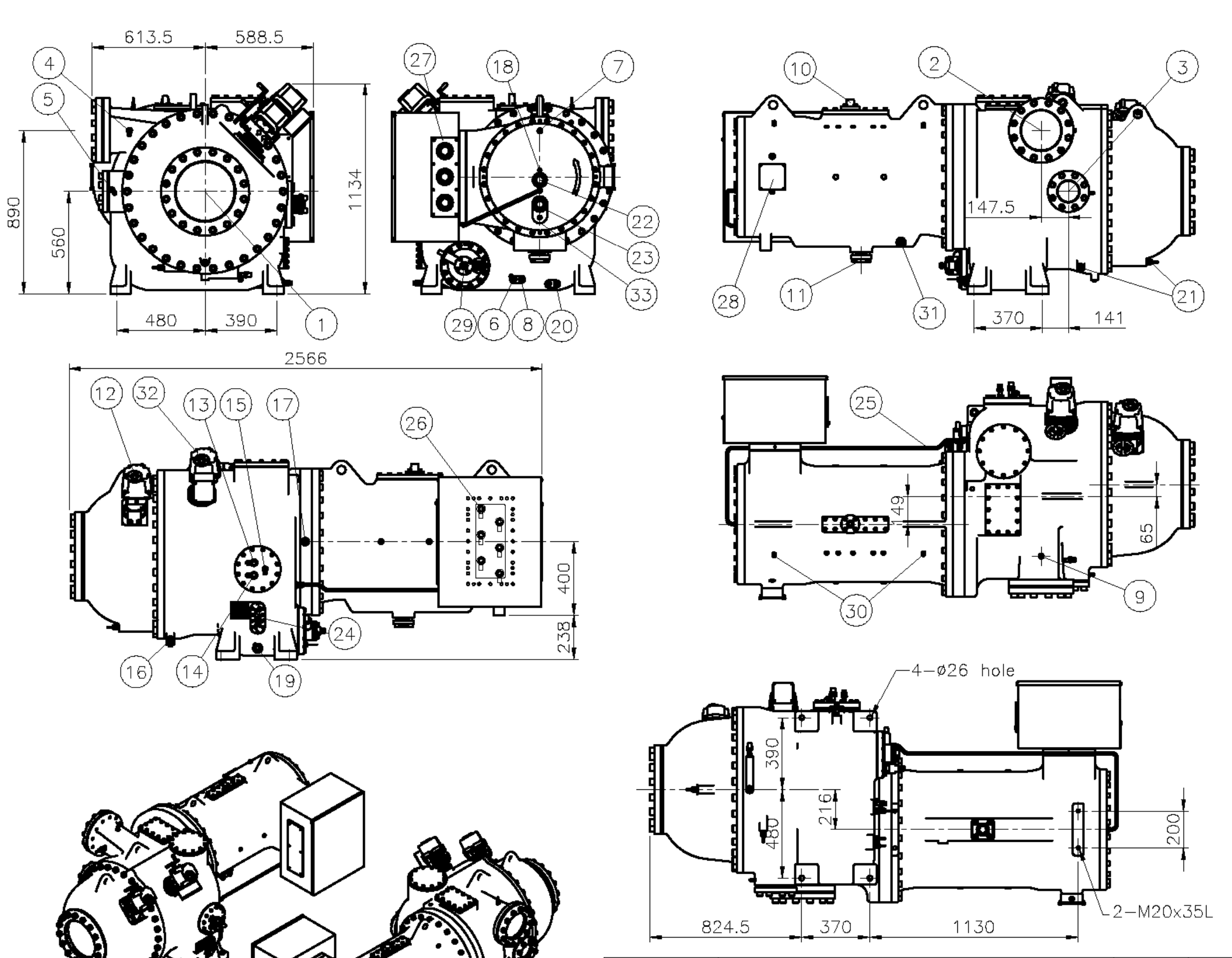
High voltage compressor outline RT-180~200(T),RT-161(50/60Hz) (motor B)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Low voltage compressor outline RT-200(T) (60Hz) (motor B)

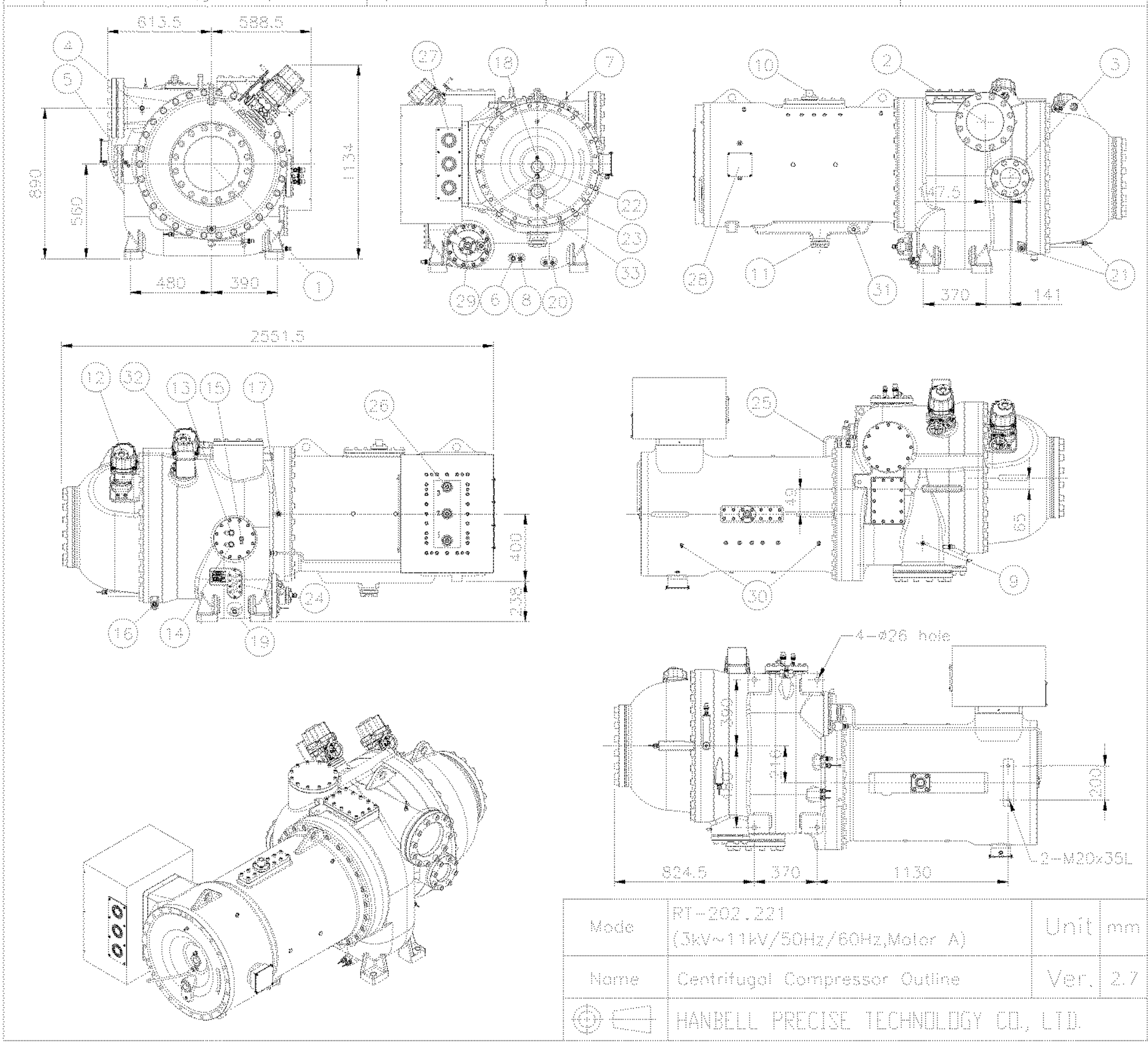
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT-200(T) (380~480V/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

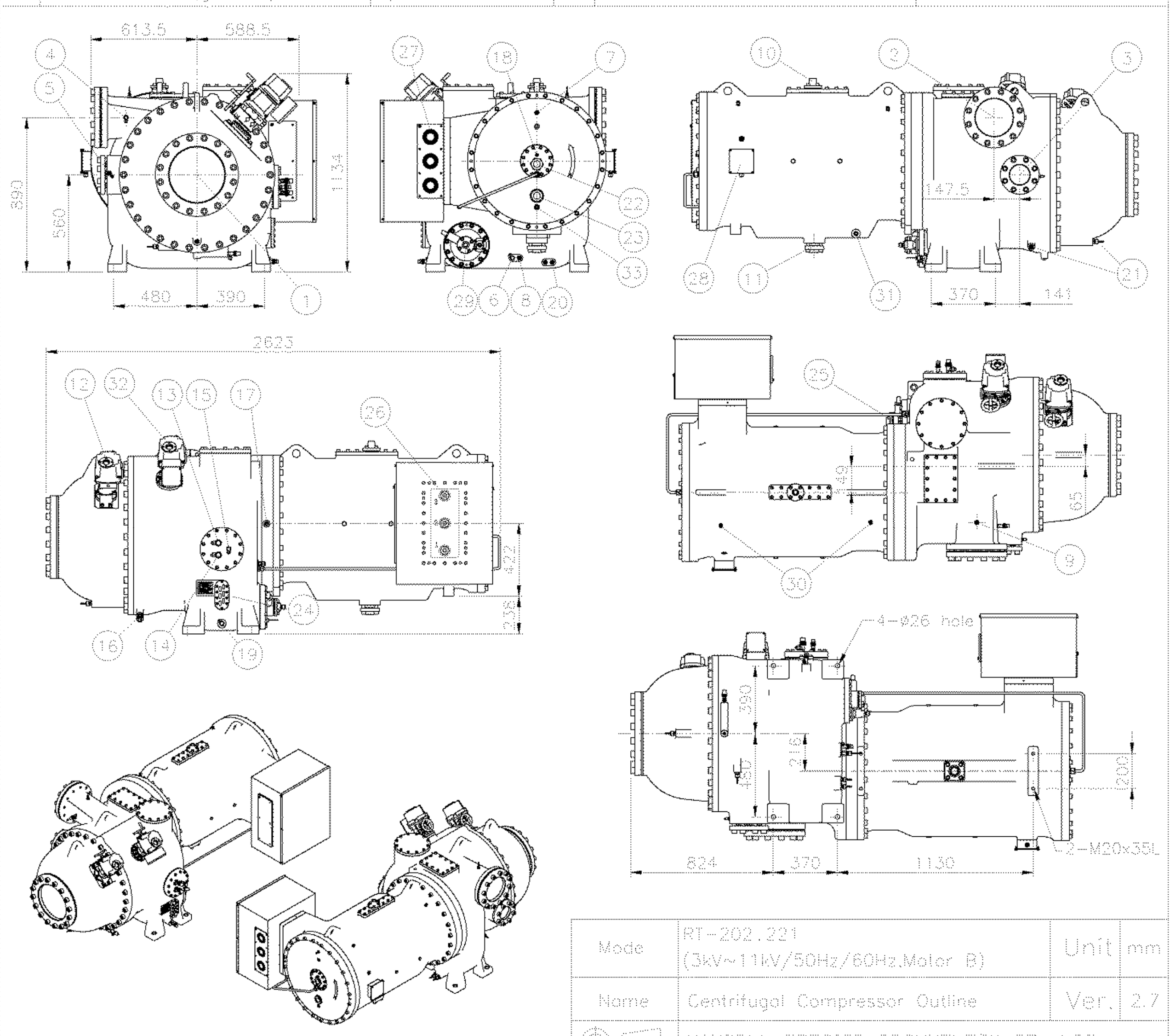
High voltage compressor outline RT-202,RT-221 (50/60Hz) (motor A)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1φ/50/60Hz	29	Oil pump outlet	1"steel/380V/3φ/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1φ/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1φ/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



High voltage compressor outline RT-202,RT-221 (50/60Hz) (motor B)

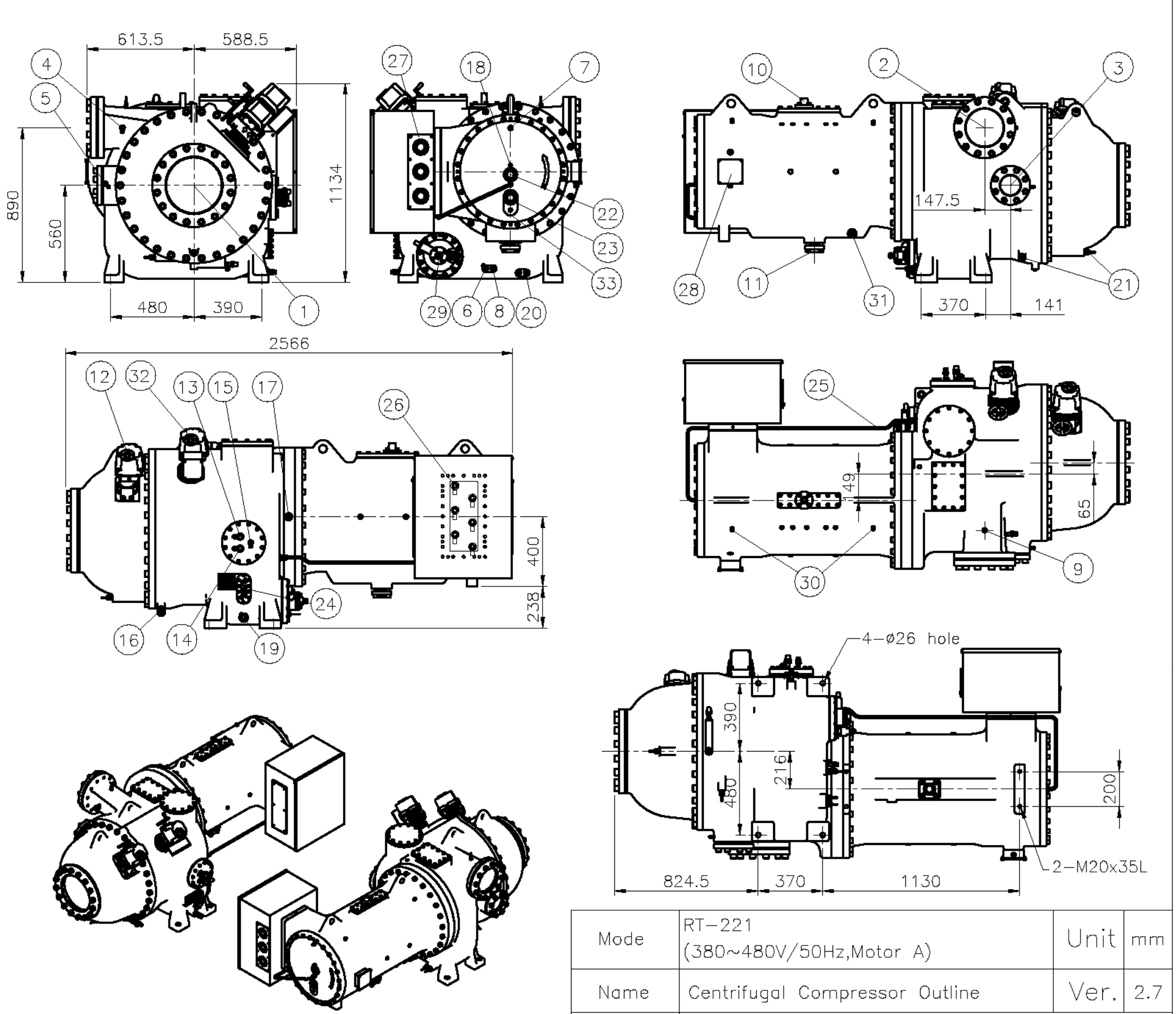
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1φ/50/60Hz	29	Oil pump outlet	1"steel/380V/3φ/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Evo. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1φ/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1φ/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT-202,221 (3kV~11kV/50Hz/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-221 (50Hz) (motor A)

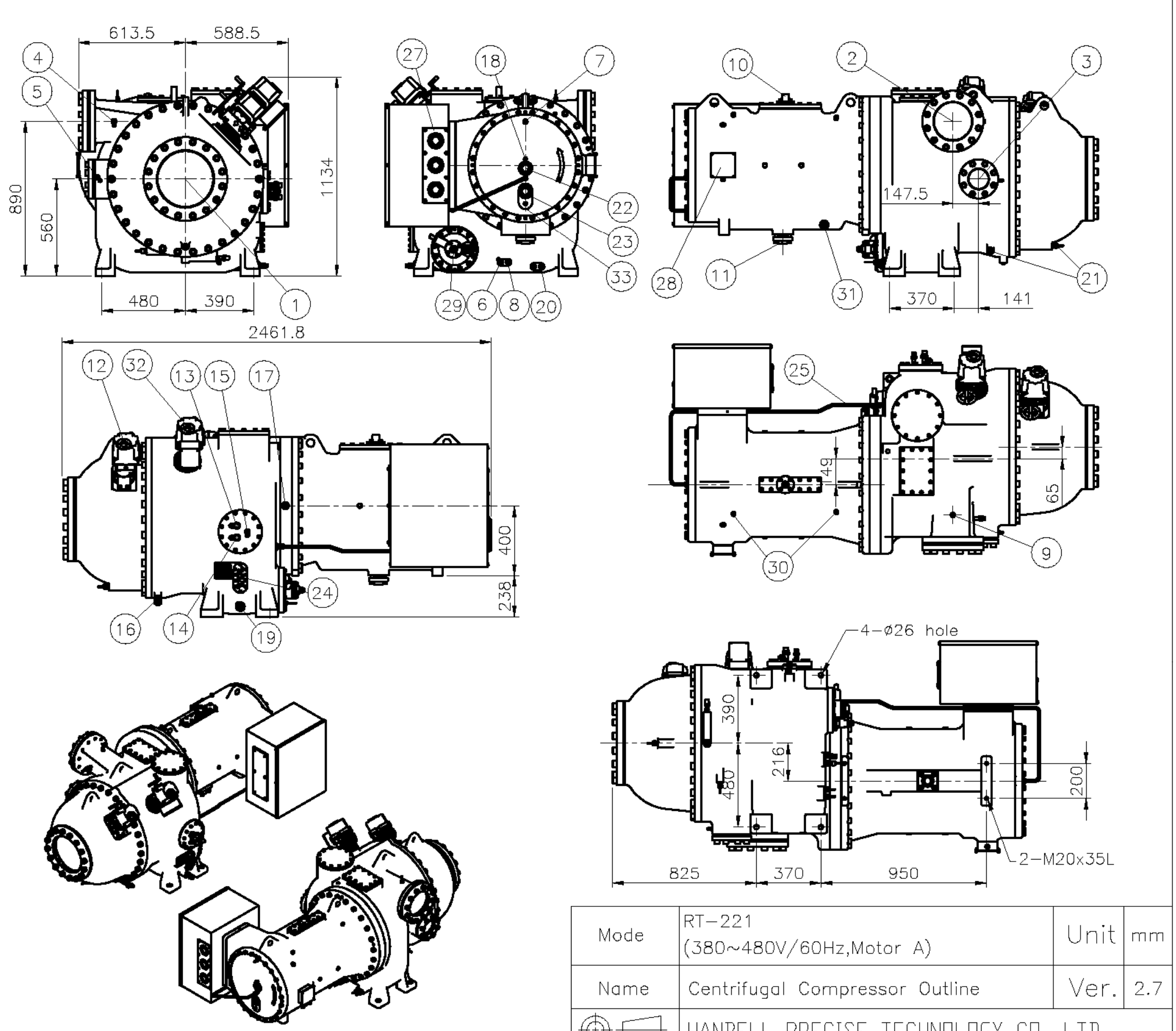
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT-221 (380~480V/50Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-221 (60Hz) (motor A)

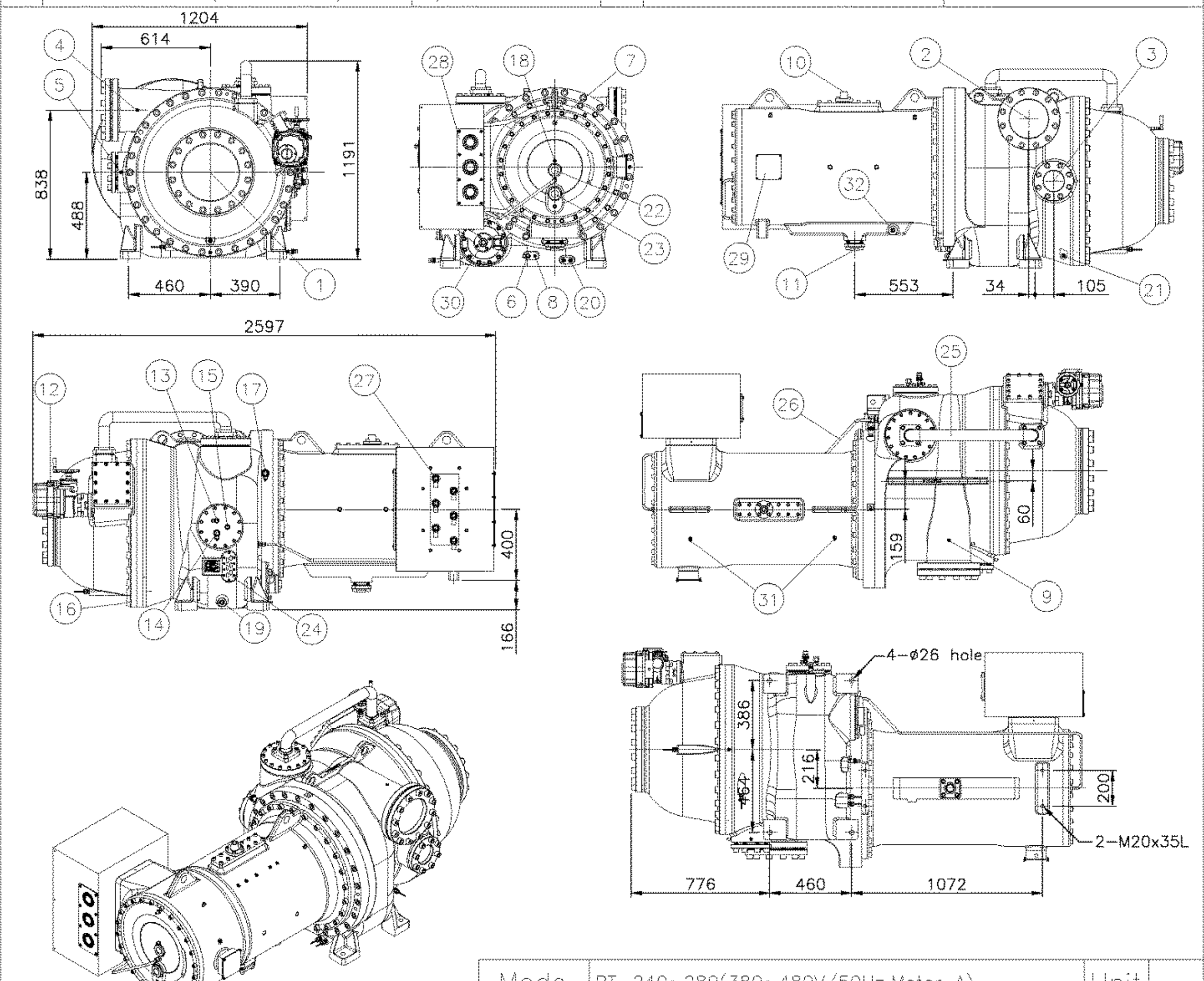
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil connection (motor)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain valve	1/4"FL
3	Economizer connection	4" 20k(JIS)	20	Oil heater (2x500W)	220V
4	Pressure connection (discharge)	1/4"FL	21	Refrigerant heater (2x300W)	220V
5	Pressure connection (ECO)	1/4"FL	22	Sight glass (motor)	
6	Pressure connection (oil tank)	1/4"FL	23	Sight glass (ref. level)	
7	Pressure connection (motor)	1/4"FL	24	Sight glass (oil level)	
8	Temperature sensor (oil tank)	Pt100	25	Oil return pipe	1/2"
9	Discharge temperature thermistor	PTC	26	Power bolt	7/8-14UNC/9/16-18UNF
10	Motor cooling connection (inlet)	7/8"copper	27	Cable box flange	430*150
11	Motor cooling connection (outlet)	1 5/8"copper	28	Motor temperature sensor	PTC&3*Pt100/Pt1000
12	Actuator (IGV1)	220V/1ø/50/60Hz	29	Oil pump outlet	1"steel/380V/3ø/50/60Hz
13	Angle valve	1/2"FL	30	Secondary motor cooling inlet	1/4"FL
14	Eva. oil return connection	1/2"FL	31	Secondary motor cooling outlet	3/4"FL
15	IGV oil return connection (inlet)	1/4"FL	32	Actuator (IGV2)	220V/1ø/50/60Hz
16	IGV oil return connection (out.)	3/8"FL	33	Refrigerant level monitoring(optional)	230V/1ø/50/60Hz
17	Oil connection (gearbox)	1/2"FL			



Mode	RT-221 (380~480V/60Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-240~280 (50Hz) (motor A)

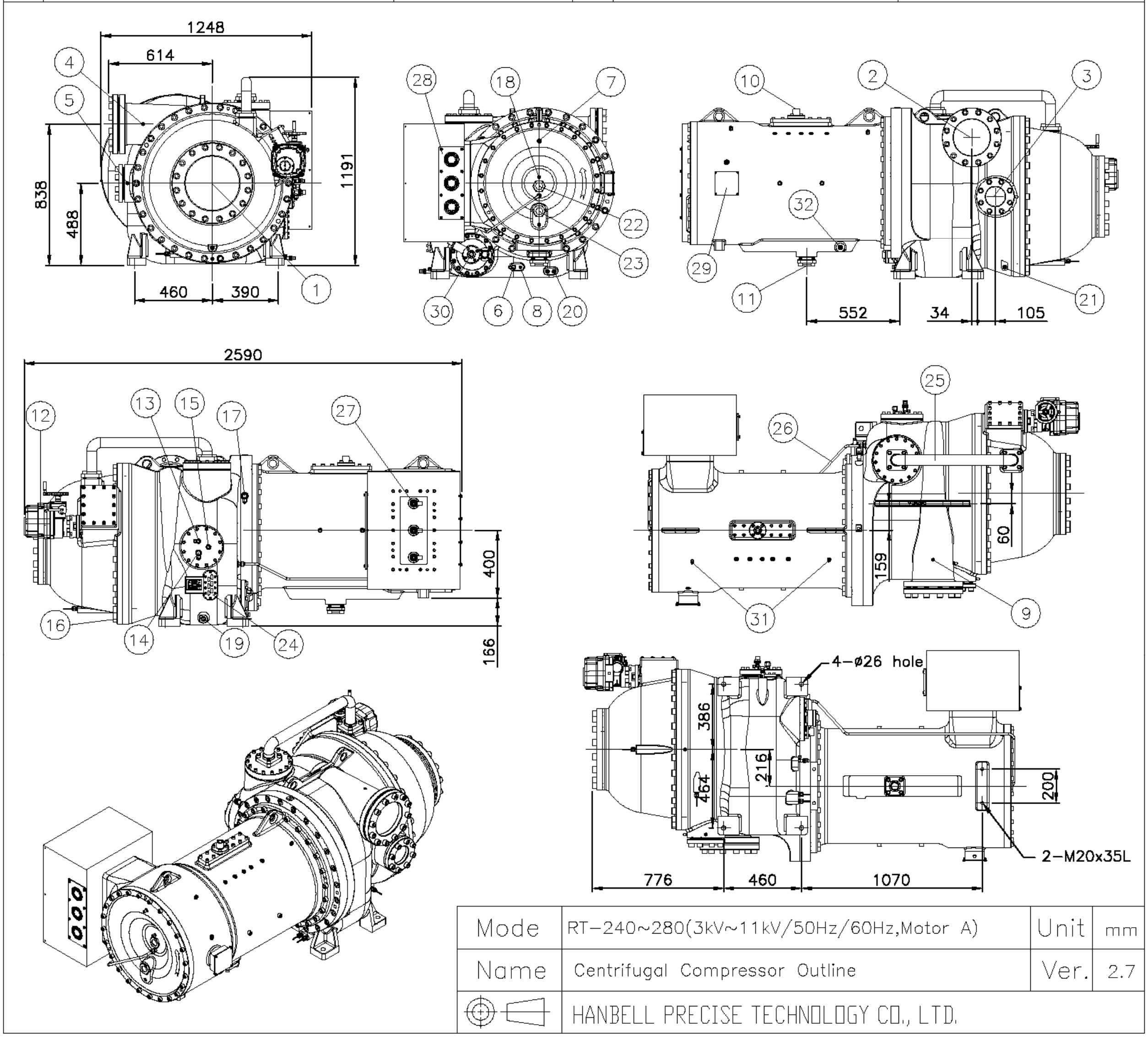
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil Lubricant Inlet(Motor side)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain	1/4"FL
3	Economizer connector	4" 20k(JIS)	20	Oil heater(2x500W)	220V
4	Pressure detector(discharge)	1/4"FL	21	Ref. heater(2x300W)	220V
5	Pressure detector(ECO.)	1/4"FL	22	Sight glass(motor direction)	
6	Pressure detector(Oil tank)	1/4"FL	23	Sight glass(ref. level)	
7	Pressure detector(motor)	1/4"FL	24	Sight glass(oil level)	
8	Temperature sensor(Oil tank)	PT100	25	Ref. recycling pipe	2" steel
9	Discharge Temperature protector	PTC (optional)	26	Lub. recycling pipe	1/2"
10	Motor Liquid injection(inlet)	7/8"copper	27	Power bolt	5/8-11UNC/9/16-18UNF
11	Motor Liquid injection(outlet)	1 5/8"copper	28	Cable box flange	2*3"
12	Actuator (IGV Volume control)	220V/1ø/50/60Hz	29	Cable box flange	380*80
13	Oil sep. oil recycling inlet	1/2"FL	30	Motor temp. sensor	PTC,3*PT100/PT1000
14	Eva. oil recycling connector	1/2"FL	31	Oil pump outlet	1" steel/380V/3ø/50/60Hz
15	IGV oil recycling(inlet)	1/4"FL	32	Motor Liquid injection(inlet)	1/4"FL
16	IGV oil recycling(outlet)	3/8"FL	33	Motor Liquid injection(outlet)	3/4"FL
17	Oil Lubricant Inlet(Gearbox side)	1/2"FL			



Mode	RT-240~280(380~480V/50Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

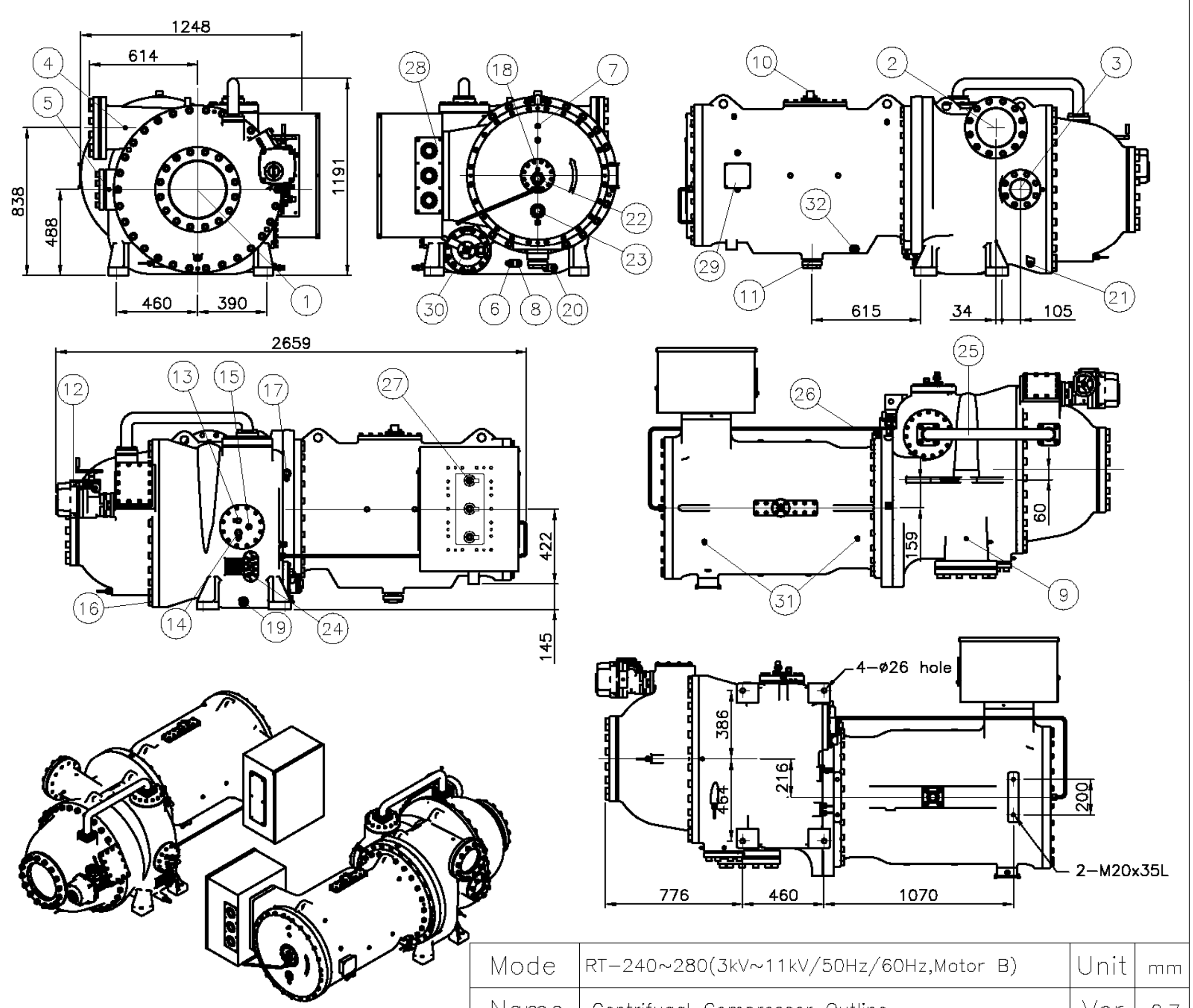
High voltage compressor outline RT-240~280 (50/60Hz) (motor A)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12” 20k(JIS)	18	Oil Lubricant Inlet(Motor side)	1/4”FL
2	Discharge flange	8” 20k(JIS)	19	Oil drain	1/4”FL
3	Economizer connector	4” 20k(JIS)	20	Oil heater(2x500W)	220V
4	Pressure detector(discharge)	1/4”FL	21	Ref. heater(2x300W)	220V
5	Pressure detector(ECO.)	1/4”FL	22	Sight glass(motor direction)	
6	Pressure detector(Oil tank)	1/4”FL	23	Sight glass(ref. level)	
7	Pressure detector(motor)	1/4”FL	24	Sight glass(oil level)	
8	Temperature sensor(Oil tank)	PT100	25	Ref. recycling pipe	2” steel
9	Discharge Temperature protector	PTC (optional)	26	Lub. recycling pipe	1/2”
10	Motor Liquid injection(inlet)	7/8”copper	27	Power bolt	5/8−11UNC/9/16−18UNF
11	Motor Liquid injection(outlet)	1 5/8”copper	28	Cable box flange	2*3”
12	Actuator (IGV Volume control)	220V/1ø/50/60Hz	29	Cable box flange	380*80
13	Oil sep. oil recycling inlet	1/2”FL	30	Motor temp. sensor	PTC,3*PT100/PT1000
14	Eva. oil recycling connector	1/2”FL	31	Oil pump outlet	1” steel/380V/3ø/50/60Hz
15	IGV oil recycling(inlet)	1/4”FL	32	Motor Liquid injection(inlet)	1/4”FL
16	IGV oil recycling(outlet)	3/8”FL	33	Motor Liquid injection(outlet)	3/4”FL
17	Oil Lubricant Inlet(Gearbox side)	1/2”FL			



High voltage compressor outline RT-240~280 (50/60Hz) (motor B)

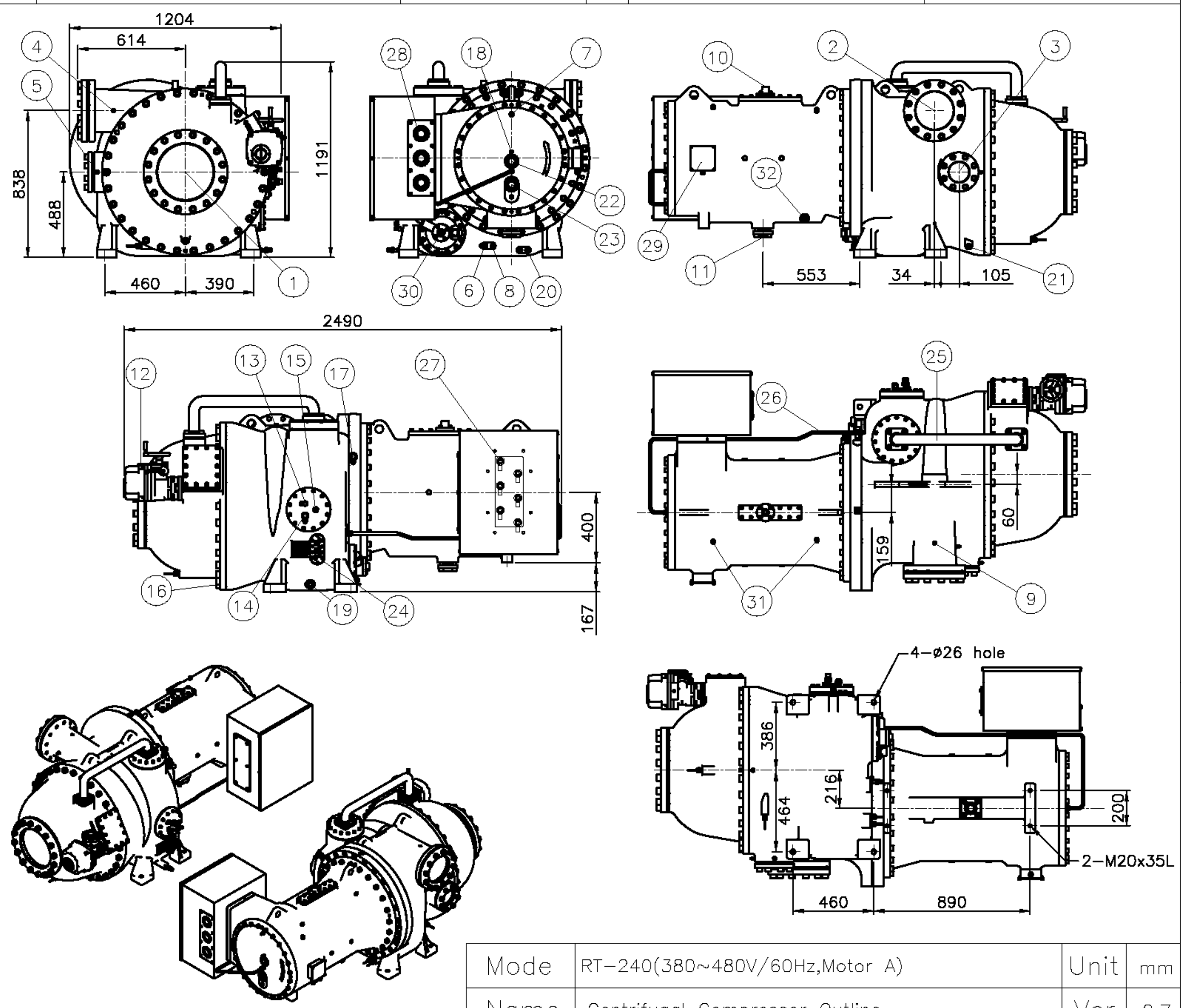
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil Lubricant Inlet(Motor side)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain	1/4"FL
3	Economizer connector	4" 20k(JIS)	20	Oil heater(2x500W)	220V
4	Pressure detector(discharge)	1/4"FL	21	Ref. heater(2x300W)	220V
5	Pressure detector(ECO.)	1/4"FL	22	Sight glass(motor direction)	
6	Pressure detector(Oil tank)	1/4"FL	23	Sight glass(ref. level)	
7	Pressure detector(motor)	1/4"FL	24	Sight glass(oil level)	
8	Temperature sensor(Oil tank)	PT100	25	Ref. recycling pipe	2" steel
9	Discharge Temperature protector	PTC (optional)	26	Lub. recycling pipe	1/2"
10	Motor Liquid injection(inlet)	7/8"copper	27	Power bolt	5/8-11UNC/9/16-18UNF
11	Motor Liquid injection(outlet)	1 5/8"copper	28	Cable box flange	2*3"
12	Actuator (IGV Volume control)	220V/1ø/50/60Hz	29	Cable box flange	380*80
13	Oil sep. oil recycling inlet	1/2"FL	30	Motor temp. sensor	PTC,3*PT100/PT1000
14	Eva. oil recycling connector	1/2"FL	31	Oil pump outlet	1" steel/380V/3ø/50/60Hz
15	IGV oil recycling(inlet)	1/4"FL	32	Motor Liquid injection(inlet)	1/4"FL
16	IGV oil recycling(outlet)	3/8"FL	33	Motor Liquid injection(outlet)	3/4"FL
17	Oil Lubricant Inlet(Gearbox side)	1/2"FL			



Mode	RT-240~280(3kV~11kV/50Hz/60Hz,Motor B)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-240 (60Hz) (motor A)

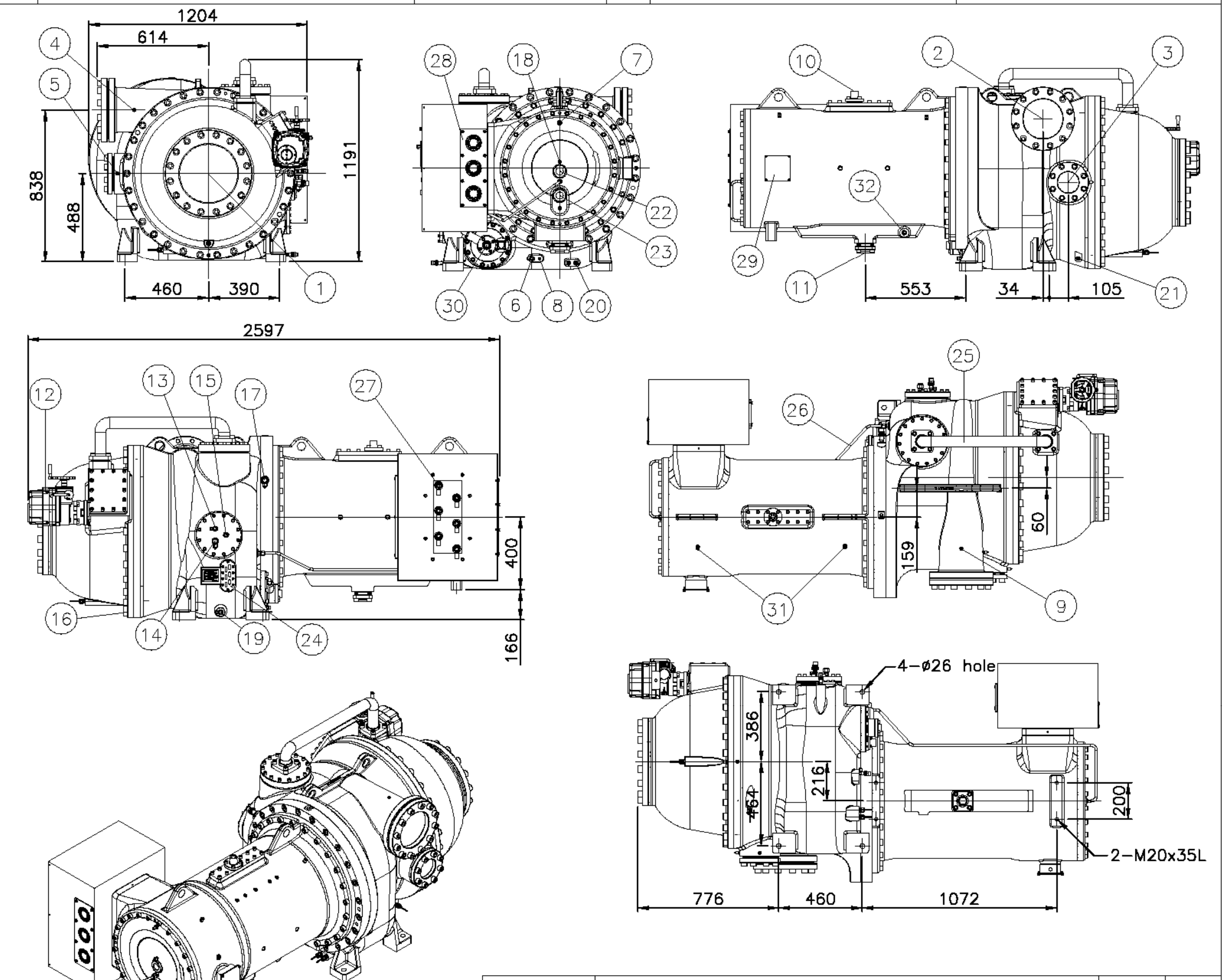
No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil Lubricant Inlet(Motor side)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain	1/4"FL
3	Economizer connector	4" 20k(JIS)	20	Oil heater(2x500W)	220V
4	Pressure detector(discharge)	1/4"FL	21	Ref. heater(2x300W)	220V
5	Pressure detector(ECO.)	1/4"FL	22	Sight glass(motor direction)	
6	Pressure detector(Oil tank)	1/4"FL	23	Sight glass(ref. level)	
7	Pressure detector(motor)	1/4"FL	24	Sight glass(oil level)	
8	Temperature sensor(Oil tank)	PT100	25	Ref. recycling pipe	2" steel
9	Discharge Temperature protector	PTC (optional)	26	Lub. recycling pipe	1/2"
10	Motor Liquid injection(inlet)	7/8"copper	27	Power bolt	5/8–11UNC/9/16–18UNF
11	Motor Liquid injection(outlet)	1 5/8"copper	28	Cable box flange	2*3"
12	Actuator (IGV Volume control)	220V/1ø/50/60Hz	29	Cable box flange	380*80
13	Oil sep. oil recycling inlet	1/2"FL	30	Motor temp. sensor	PTC,3*PT100/PT1000
14	Eva. oil recycling connector	1/2"FL	31	Oil pump outlet	1" steel/380V/3ø/50/60Hz
15	IGV oil recycling(inlet)	1/4"FL	32	Motor Liquid injection(inlet)	1/4"FL
16	IGV oil recycling(outlet)	3/8"FL	33	Motor Liquid injection(outlet)	3/4"FL
17	Oil Lubricant Inlet(Gearbox side)	1/2"FL			



Mode	RT–240(380~480V/60Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

Low voltage compressor outline RT-260~280 (60Hz) (motor A)

No.	Name	Specification	No.	Name	Specification
1	Suction flange	12" 20k(JIS)	18	Oil Lubricant Inlet(Motor side)	1/4"FL
2	Discharge flange	8" 20k(JIS)	19	Oil drain	1/4"FL
3	Economizer connector	4" 20k(JIS)	20	Oil heater(2x500W)	220V
4	Pressure detector(discharge)	1/4"FL	21	Ref. heater(2x300W)	220V
5	Pressure detector(ECO.)	1/4"FL	22	Sight glass(motor direction)	
6	Pressure detector(Oil tank)	1/4"FL	23	Sight glass(ref. level)	
7	Pressure detector(motor)	1/4"FL	24	Sight glass(oil level)	
8	Temperature sensor(Oil tank)	PT100	25	Ref. recycling pipe	2" steel
9	Discharge Temperature protector	PTC (optional)	26	Lub. recycling pipe	1/2"
10	Motor Liquid injection(inlet)	7/8"copper	27	Power bolt	5/8−11UNC/9/16−18UNF
11	Motor Liquid injection(outlet)	1 5/8"copper	28	Cable box flange	2*3"
12	Actuator (IGV Volume control)	220V/1Ø/50/60Hz	29	Cable box flange	380*80
13	Oil sep. oil recycling inlet	1/2"FL	30	Motor temp. sensor	PTC,3*PT100/PT1000
14	Eva. oil recycling connector	1/2"FL	31	Oil pump outlet	1" steel/380V/3Ø/50/60Hz
15	IGV oil recycling(inlet)	1/4"FL	32	Motor Liquid injection(inlet)	1/4"FL
16	IGV oil recycling(outlet)	3/8"FL	33	Motor Liquid injection(outlet)	3/4"FL
17	Oil Lubricant Inlet(Gearbox side)	1/2"FL			



Mode	RT−260~280(380~480V/60Hz,Motor A)	Unit	mm
Name	Centrifugal Compressor Outline	Ver.	2.7
	HANBELL PRECISE TECHNOLOGY CO., LTD.		

2.5 Connections

2.5.1 Suction/discharge/economizer flange size

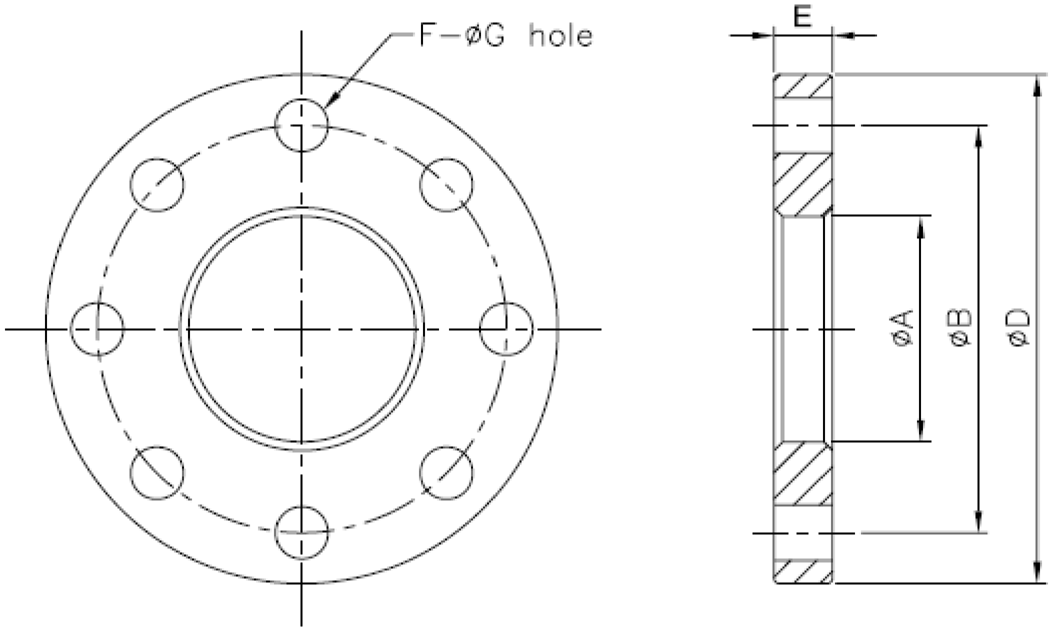


Figure 2.2 Flange size

Position		Size	A		B	D	E	F	G	Piping thick
			(JIS)	(GB)						(GB)
RT-120~140 RT-111	Suction	8"	218	221.5	305	350	30	12	25	11
	Discharge	6"	167	170.5	260	305	28	12	25	10.5
	Mid.-press. (Eco.)	2 1/2"	77.5	77.5	140	175	20	8	19	7
RT-160~280 RT-161, RT-221	Suction	12"	320	327.5	430	480	36	16	27	14
	Discharge	8"	218	221.5	305	350	30	12	25	11
	Mid.-press. (Eco.)	4"	116	116	185	225	24	8	23	8.5
Remarks		※ Material-standard JIS 20 kg/cm^{2}g steel unit: mm								
		※ thickness must be equal to the standard or larger								

Table 2.5 Flange dimensions

Note：

1. Please weld steel pipes onto flanges by butt-welding and make sure debris has been cleaned, otherwise the compressor might be damaged badly during running. Flow velocity in the discharge side of the compressor could be as high as 15~20m/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.

2. The discharge and suction piping is recommended to be one size larger than that of discharge and suction flanges 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 2.3&2.4.
3. To make the compressor maintenance easier, it is recommended to install butterfly valve on the pipe between compressor discharge port and condenser. Therefore, the remaining gas inside compressor can be led to the condenser without additional refrigerant recovery procedure.

Model	Dimension (inch)	Flow Resistance Coefficient (K)	Density (kg/m^3)	Flow Speed (m/s)	Pressure Drop (kPa)
RT-120	8″	0.5	45	14.69	2.43
RT-130	8″	0.5	45	15.98	2.87
RT-140	8″	0.5	45	16.49	3.06
RT-160	10″	0.51	45	12.70	1.9
RT-180	10″	0.51	45	14.61	2.4
RT-200	10″	0.51	45	15.72	2.8
RT-240	10″	0.51	45	19.05	4.2
RT-260	10″	0.51	45	20.85	5.0
RT-280	10″	0.51	45	21.80	5.5
RT-111	8″	0.5	59	10.94	1.77
RT-161	10″	0.51	59	12.29	2.27
RT-221	10″	0.51	59	14.19	3.03

※ 1.Density & volume flow operation condition: water-cooling machine CT/ET=36/6℃, Heat pump CT/ET=46/6℃ .
※ 2.Install the butterfly valve close to the condenser inlet end.

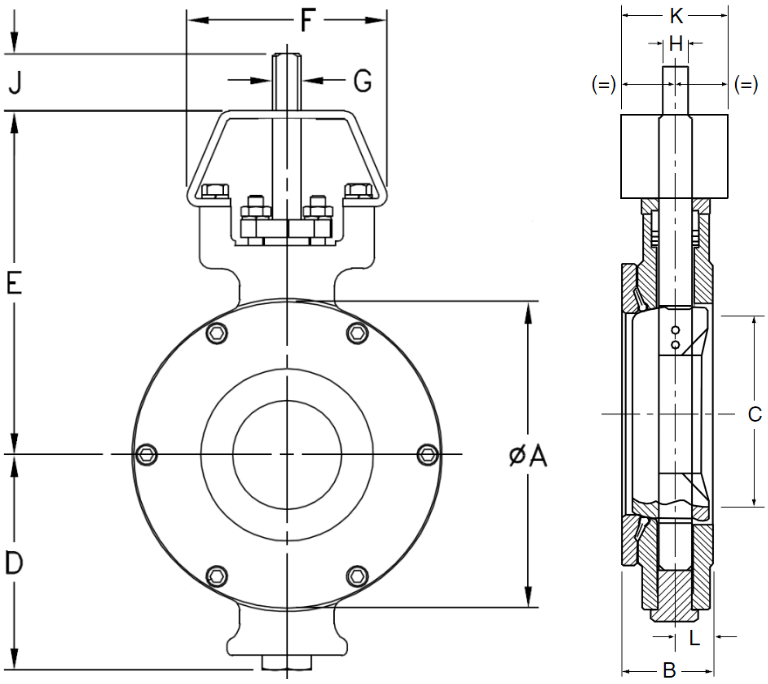


Figure 2.2.1 Outline of butterfly valve

Butterfly valve dimensions		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
Remarks		※Size ”C” is the minimum size when the valve is fully open. **[unit：mm]**										
		※Operating Temperature: -29℃~260℃. Operating Pressure: 1480psi.										
		※Material: Valve body is conformed to the standard of ASTAM351 GR CF8M stainless steel; pressure rating is ASME 150.										
		※The butterfly valve is of wafer type butterfly valve and installed in between ANSI class 150 flanges.										

Table 2.5.1 Specifications of flange

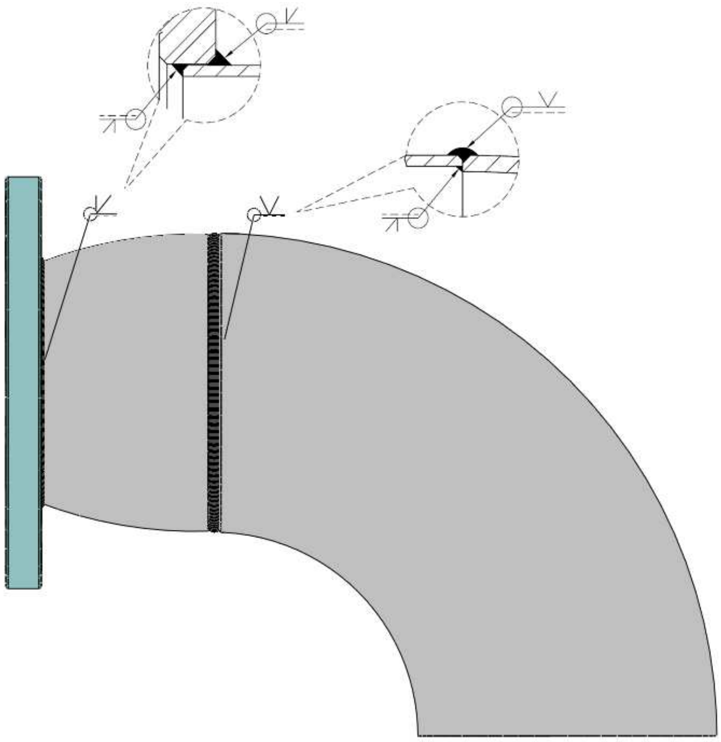


Figure 2.3 Discharge and suction piping

Caution: Residue from welding might damage the compressor seriously.

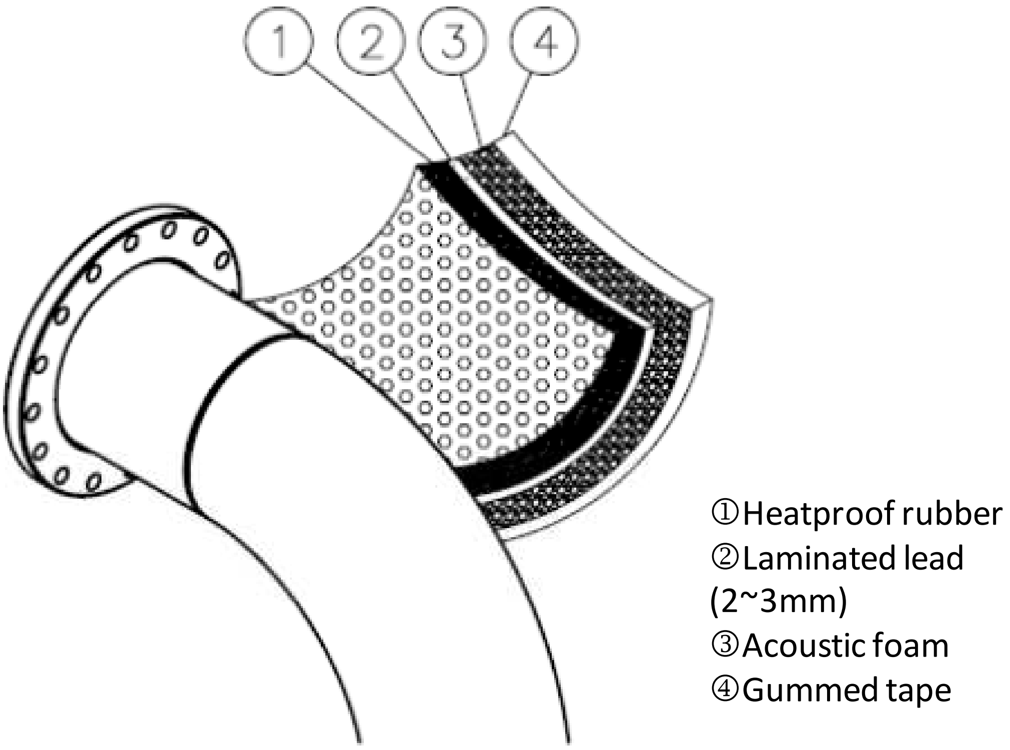


Figure 2.4 Enclosure of piping connection

Note 4：As the pipeline is susceptible to stress deformation after welding which will lead to the incapability connection of compressor after dismantling. Thus, connection of the evaporator and condenser pipe outlet should be equipped with a pair of locking flange in order to increase the assembling clearance. These two flanges on evaporator and condenser need to be released during the connection of the compressor so as to reduce the effect of welding pipe deformation.

Caution：Sometimes in order to prevent leakage at the connections of compressor, the overtightening of flange bolts can happen. This could cause the suspension of the compressor in the air, leading to excessive vibration and damage of the compressor. Thus, please follow the instructions on compressor mounting (refer to 6.2 Installation and fixation of the compressor) and the advice of using flange connections.

2.5.2 Size of bushings for motor liquid injection

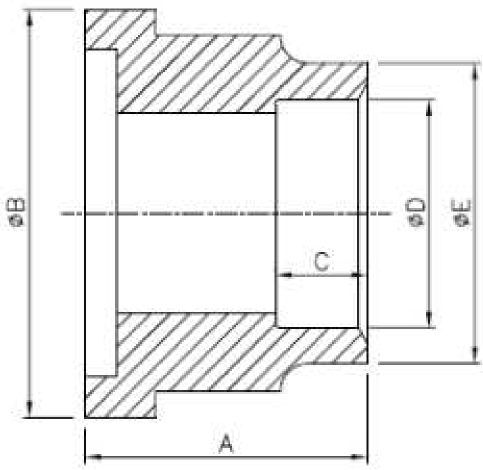


Figure 2.5 Size of bushings

Mode		Size		A	B	C	D	E	F
RT-120~140 RT-111	Liquid injection inlet	3/4"	Flare						
	Liquid injection outlet	1 1/8"	Copper	52	75	35	28.8	42	12
RT-160~280 RT-161, RT-221	Liquid injection inlet	7/8"	Copper	52	60	35	22.6	42	12
	Liquid injection outlet	1 5/8"	Copper	52	75	35	41.6	52	12
Remarks		unit: mm							

Table 2.6 Dimensions of bushings

Note：To effectively control motor temperature, some service valve can be installed in the piping before the bushing for motor liquid injection to provide adequate amount.

2.6 Compressor structure

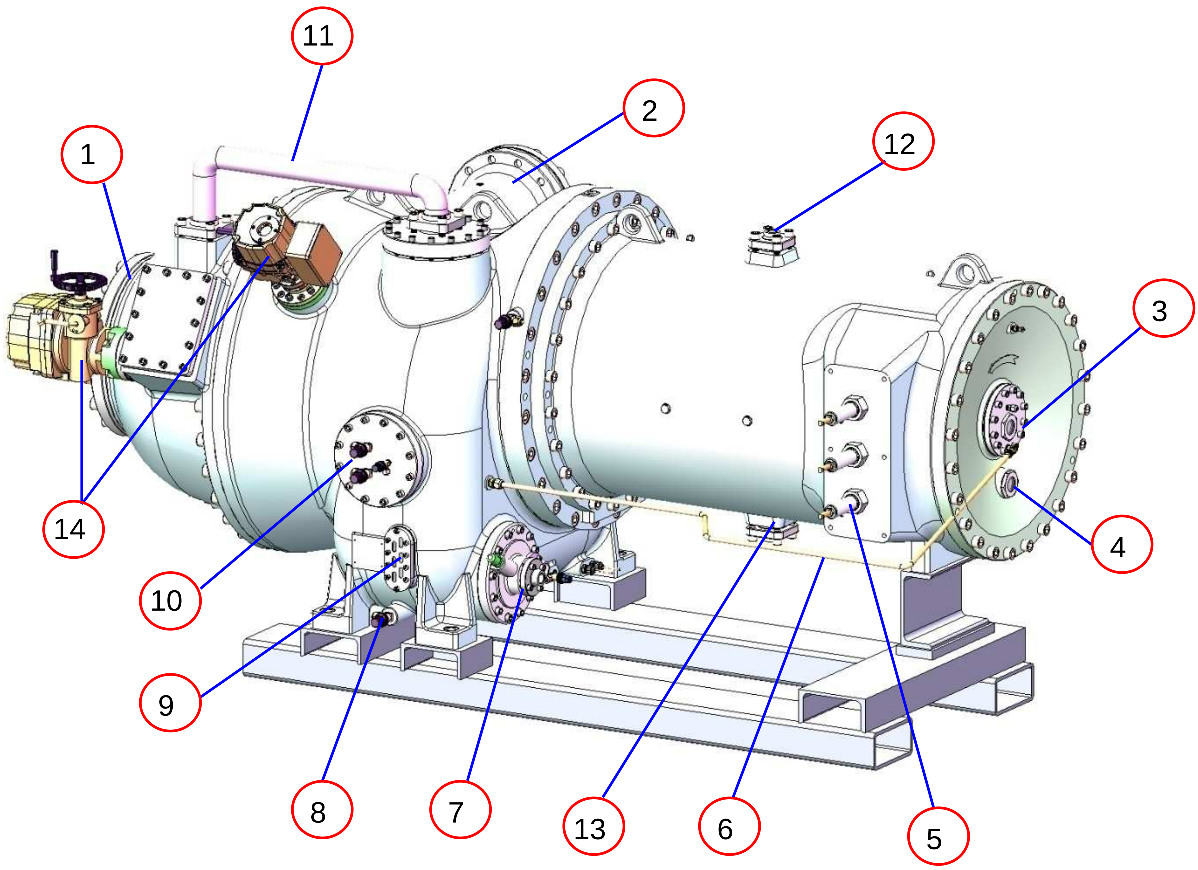


Figure 2.6 Compressor structure

NO.	Description	NO.	Description
1	Suction	8	Oil drain valve
2	Discharge	9	Sight glass (oil level)
3	Sight glass (motor)	10	Oil return flange
4	Sight glass (refrigerant level)	11	Gas return pipe
5	Power bolt	12	Inlet flange for motor cooling
6	Oil return connection	13	Outlet flange for motor cooling
7	Oil pump	14	Actuator

Chapter 3. Capacity control system

3.1 Inlet guide vanes

The cooling capacity of RT Series centrifugal compressors are modulated with change in angles of inlet guide vanes. Before refrigerant reaches the 1st impeller for compression, a pre-rotation angle has developed for changing in adiabatic head for control of its cooling capacity.

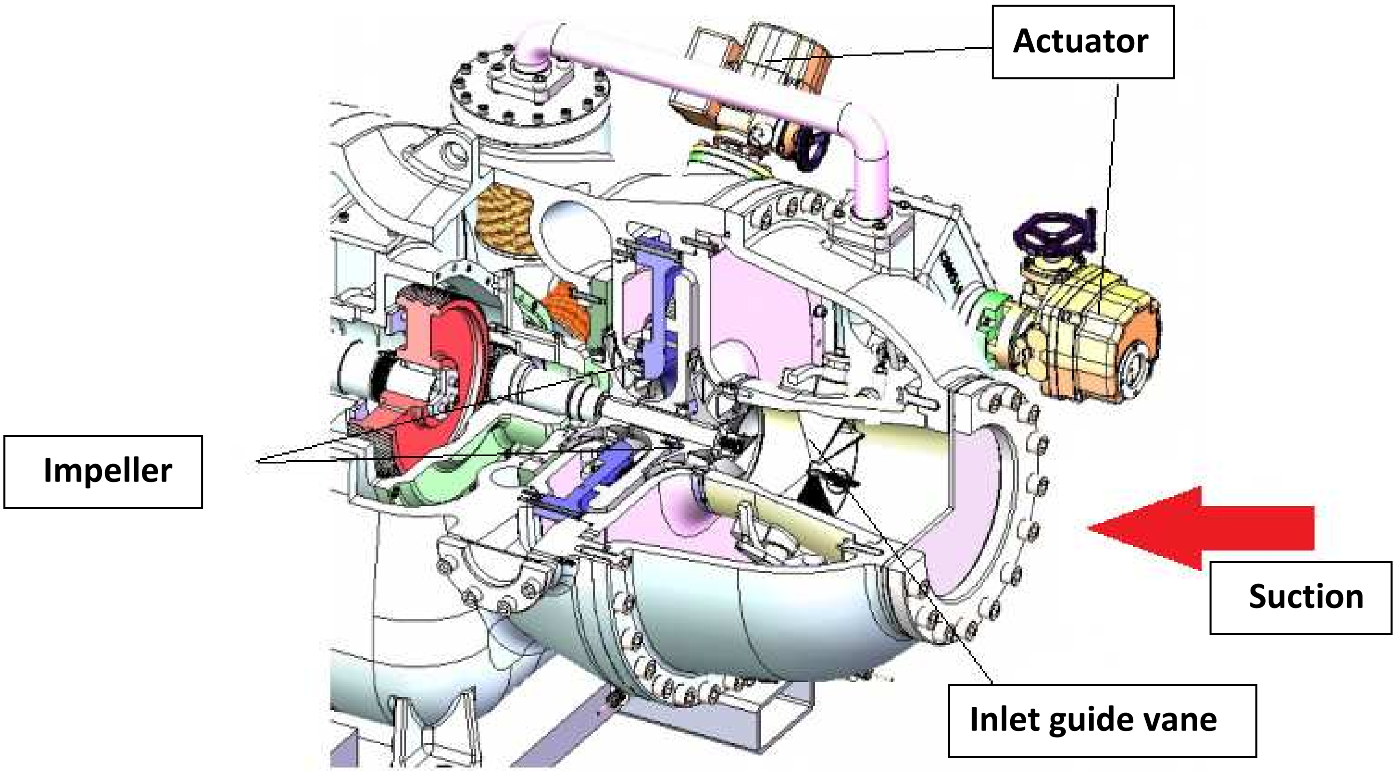


Figure 3.1 Compressor inlet

As illustrated in Figure 3.1, RT series standard water-cooled compressors have first inlet guide van (IGV1). Refrigerant gas from the evaporator outlet flows through the suction nozzle to the compressor suction inlet. After the inlet nozzle, gas flow velocity increases due to the narrow passage. By changing angles of IGV1, refrigerant gas enters with a pre-rotation angle into impellers. Both gas flow speed and pressure will increase with rotation of impellers.

Double guide vane performance

Impeller of each stage in front of IGV can only control energy change of that particular stage. In order to get wider energy change and larger operating range, addition of IGV2 structure at the second stage is necessary. IGV2 is the variable radial guide vanes located before the inlet of second stage impeller, which can be controlled together with IGV1 to achieve a greater unloading capacity, equivalent to better IPLV value. Currently in Hanbell, all standard RT-120T~200T and heat pumps include dual IGV design.

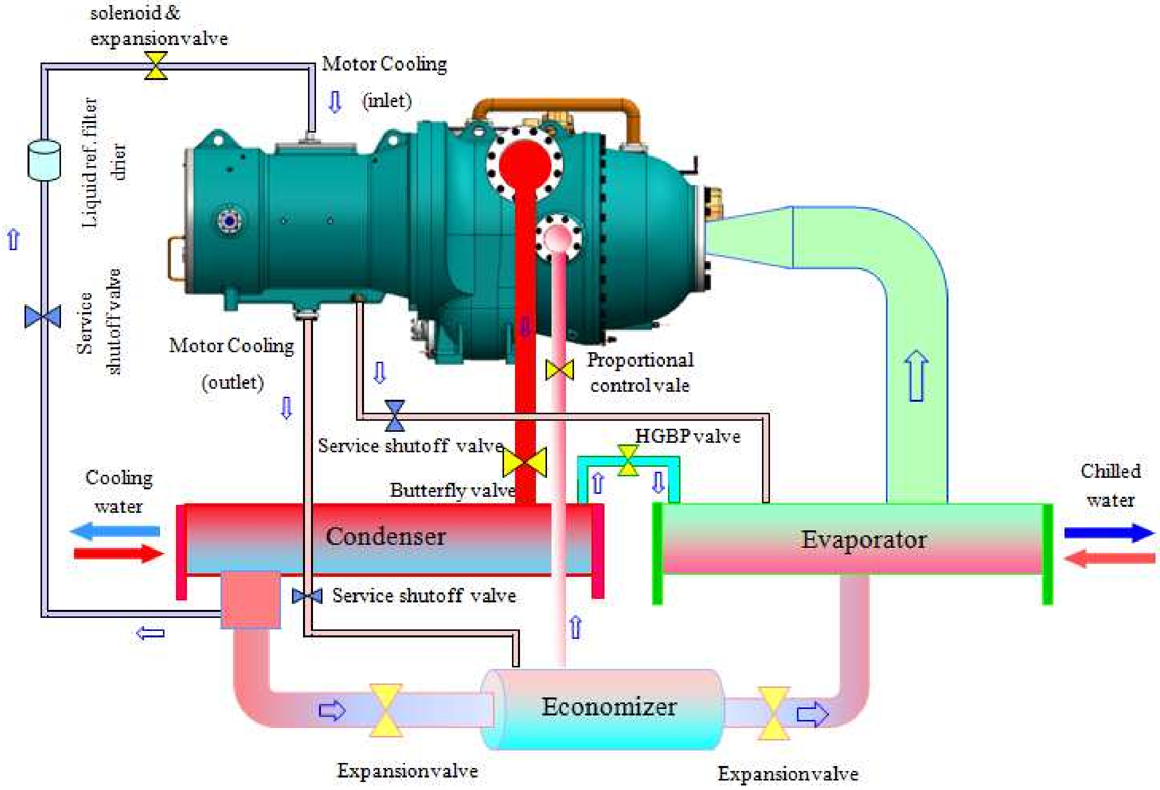


Figure 3.2 System with an economizer

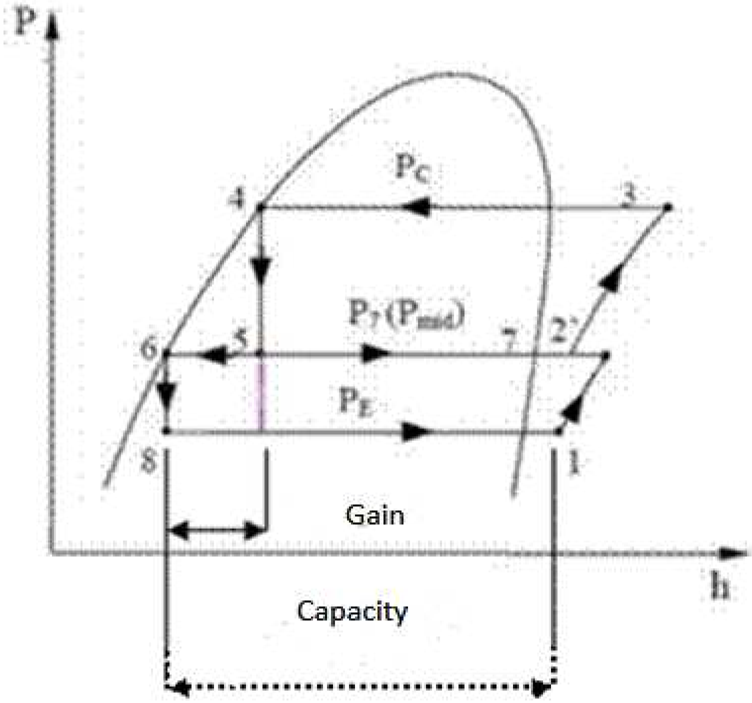


Figure 3.2.1

Figure 3.2.1 Refrigerant cycle diagram with economizer contributes to higher efficiency and this is due to an approximately 7% capacity gain occurs between point 5 & point 6.

3.1.1 Control of inlet guide vanes

Angles of inlet guide vanes are automatically controlled through a vane actuator with a lever arm. Automatic adjustment of angles of guide vanes is made with loading, from full load with vanes widely opened to minimum load with guide vanes completely closed.

The percentage of Actuator opening and the controlling current (pressure) signal are linearly proportional. But the angle change of the inlet guide vane does not show a relationship with the capacity change, so the percentage of Actuator opening is not equivalent to the percentage of frozen capacity load.

1. When IGV1 is fully close, a small opening is formed in the central portion to maintain the basic flow of refrigerant to the compressor. The refrigerant flow is at minimum when the inlet flow guide vane is completely closed. The freezing capacity at this point is also at the minimum, but often in the surge zone which cannot be used. Normal operation IGV1 ≧ 10% uses (T series IGV1 ≧ 5%).

Note 2: The lower pressure ratio stands for the lower minimum unloading capacity. Therefore, it is NOT applied to all operation conditions that opening of the vane Actuator could be set less than10%. Please refer to HANBELL selection software for details of opening of guide vanes in percentage before operation.

3. When the inlet guide vane of the compressor inlet is fully close, the Actuator motor will continue to output torque while the Actuator micro switch has not yet functioned. At this point as the transmission mechanism (guide vain mechanism) has been fully close, the Actuator motor is locked rotor leading to the temperature protection jump-off (overload phenomenon), and long-term operation will cause adverse effects on the Actuator. In order to solve this problem, the Actuator is set from the factory to operate range from 0% to 100% (input signal is 4mA ~ 20mA). Please set to 5% ~ 100% (4.8mA ~ 20mA) after the unit is switched on with self-test. Please set to 5 % (4.8mA) when starting and turning off the unit to avoid operations below 5%.

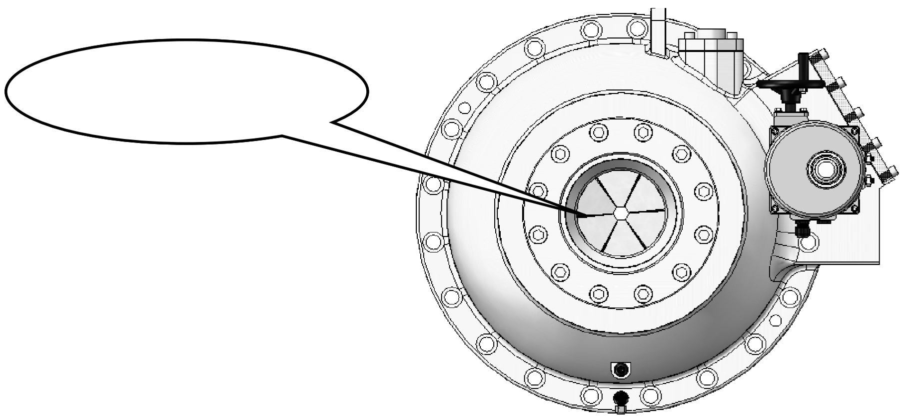


Figure3.3CloseInlet guide vanes completely

3.2 Vane Actuator control

3.2.1 Actuator data

Power Supply	220V AC 1PH, 50/ 60Hz, ±10%
Power control	220V AC 1PH, 50/ 60Hz, ±10%
Working Cycle(modulating)	70%, Max. 180 starts per hour
Motor	Induction Motor
Motor operating temperature	Built-in temperature protection, on 150±5℃ / off 97±5℃
Cable inlet	Three 3/4”PF tap
Operating Temperature	-10℃~+70℃
Operating humidity	90％ RH Max.(non-condensing)
Enclosure and protection class	IP67/NEMA4
Control signal	Input, output 4~20mADC,0~5VDC,0~10VDC,1~5VDC
Torque switch	Open/close SPDT, 250VAC 10A Rating
Chamber heater	10W(HQ-015) / 5W(HQ-010) ceramic housed

Table 3.2.1 Actuator data

Type	Model	Maximum output torque	Operation time (second)	Rated current(A)	Duty type
		kg・m	50/60Hz	50/60Hz	
Actuator 1(for IGV1)	HQ-015	15	21/25	0.72/0.84	70%
Actuator 2(for IGV2)	HQ-010	10	17/20	0.47/0.46	70%

Note1. Please contact technicians from Hanbell if explosion-proof is required.
Note2. Started from 2017, standard version of actuator is in yellow color. Please contact service center of Hanbell for other color requirements.

3.2.2 Proportional control board setting

The following picture is the appearance of the proportional board. All settings have been completed in the factory. Please contact technicians from Hanbell for special setting requirements.

Caution：Only authorized and certified technicians are allowed to change the settings.

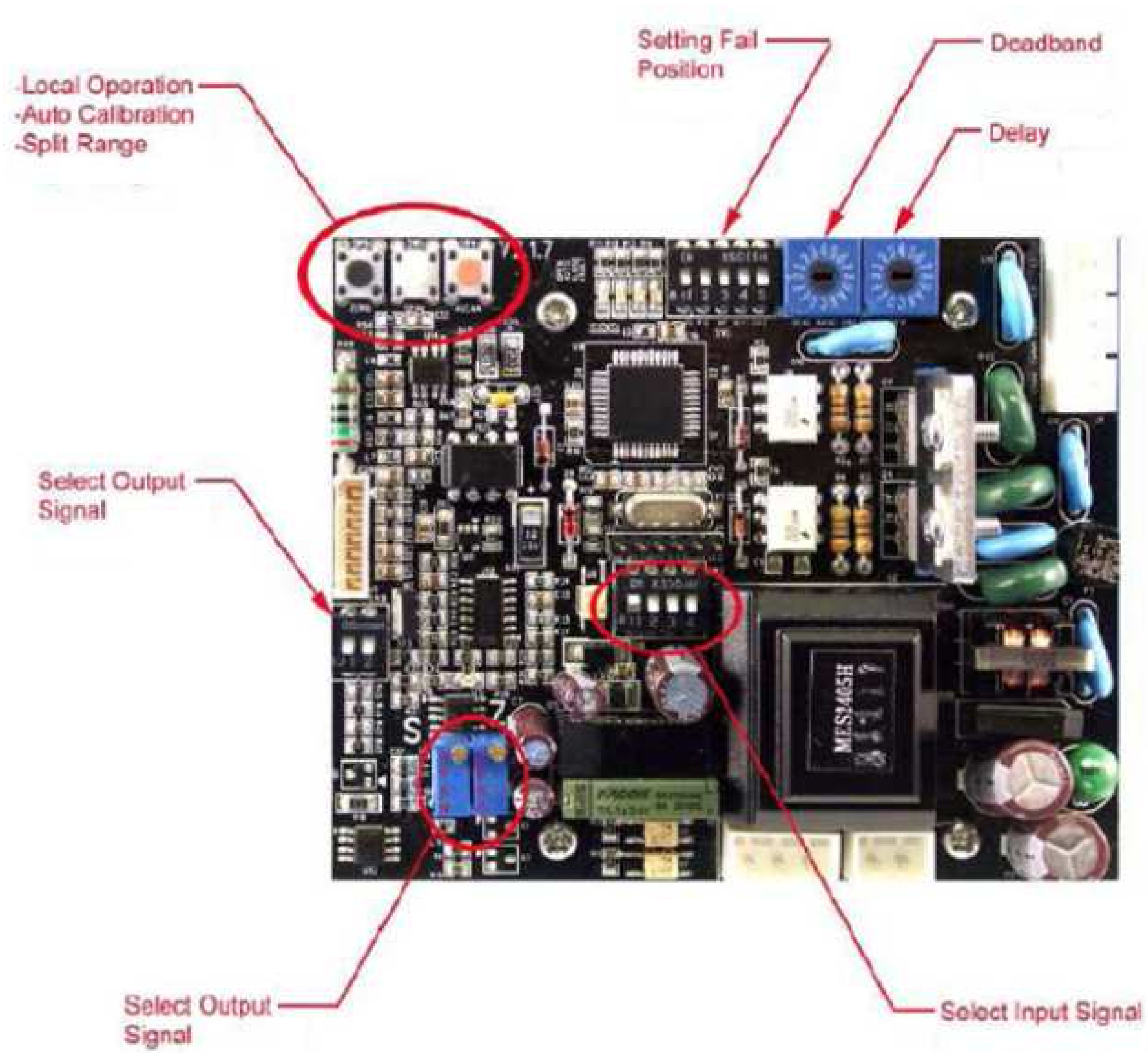
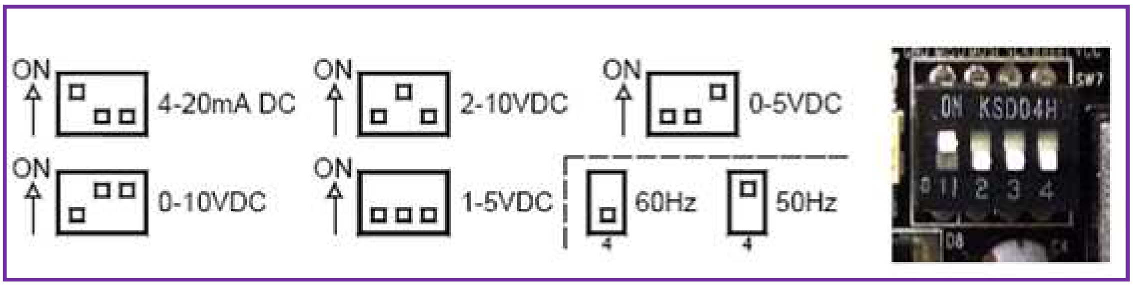


Figure 3.5 Control board of the Actuator

3.2.3 Digital BCD switch setting

Selection of input signal

User can select input signal type by adjusting DIP switches as follows:

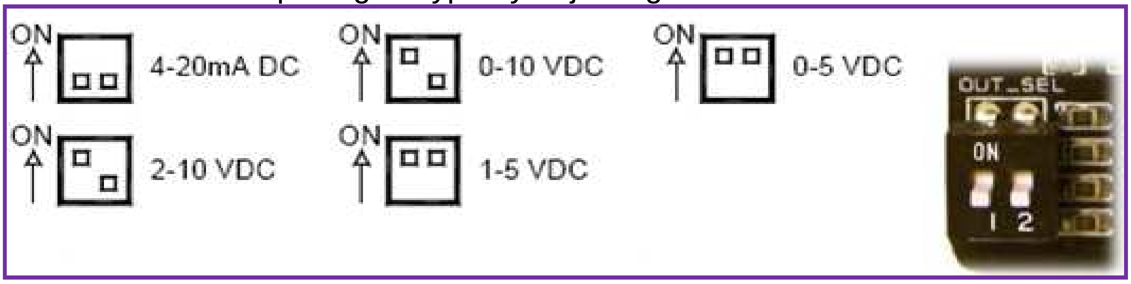


Note：Actuator IGV1: terminal #15(+ve)，terminal #16(-ve)；Actuator IGV2: terminal #10(+ve)，terminal #11(-ve).

Caution：Do not adjust DIP switch when power is supplied to the actuator!

Selection of output signal

User can select output signal type by adjusting DIP switches as follows:

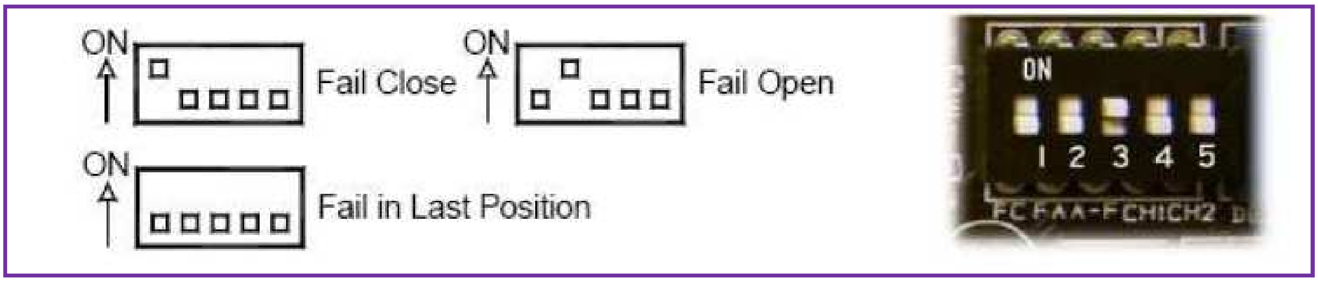


Note：Actuator IGV1: terminal #17(+ve)，terminal #18(-ve)；Actuator IGV2: terminal #12(+ve)，terminal #13(-ve).

Caution：Factory default setting of input signal is 4-20mA DC; output signal is 4-20mA DC; Signal for valve body fully open is 20mA.

When necessary, adjust the key of ZERO or SPAN to match the input signal

When the Control signal is out of order, please adjust DIP switch to recover signal setting.



Note：Factory default setting is at the off position.

Delay working time

Delay setting is to avoid excess continuous operation of the actuator, which would result in the overheating of the actuator motor. Delay time ranges from 0~7.5 seconds, and is adjusted to 15 stages, with 0.5 seconds at each stage. Factory default setting scale 4 is 2 seconds.

Seconds	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Dial	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Warning：Only authorized and certified technicians are allowed to change this setting.

Deadband

When using 4 ~ 20mA as the input signal, if the dead band value (sensitivity) is set to 1%, the input current changes need to be over 16/100 = 0.16mA to make a 1% movement.

Factory default setting of the dead band value is 2%, therefore an input current change of 0.32mA (2%) is required to make minimum movement.

%	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Dial	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Deadband value (sensitivity) setting: The lower the set value, the more sensitive it will be. Excessive sensitivity will cause actuator “hunting” (moving up and down while unable to positioning). But if the deviation range on operation settings of the system unit controller is too small, it will also lead to the same “hunting” problem. Therefore, when “hunting” occurs, please make sure that both settings are appropriate.

Warning：Setting of extremely low dead band value may cause actuator “hunting”.

Warning：Only authorized and certified technicians are allowed to change this setting.

3.2.4 Duty cycle

This setting could be used as periodic setting. The settings for operating time and rest time of the actuator are based on the standards of IEC (International Electrotechnical Commission), IEC34-1 as follows:

Start frequency=operating time/(operating time + rest time)*100%

Rest time=operating time*(1-start frequency)/start frequency

✧ Example: Actuator duty cycle (start frequency) on the compressor of 50 Hz is 70%, the operating time is 21 seconds:
Rest time = 21 * (1-70%) / 70% = 9 seconds, so when the controller is under command to carry out:

1. Full capacity control (IGV=0%→100% or 100%→0%), time interval should be at least 21+9=30 seconds.
2. Partial capacity modulation, the interval time is:
   Interval time= | Capacity difference% | *(21 +9)

   ➢ Example :IGV=65%→55%   interval time=｜65%-55%｜*(21+9)=3 seconds

Note：It is complicated to split command time into many parts in control logic. Therefore, if the operation opening for chilled water control is ≦10% for each operations, and the chilled water response cycle is about 30~60seconds, then an operating time interval of 30 seconds can be used.

Caution：In order to prevent accumulated heating of the motor due to frequent operations, it is advisable to set the start frequency to maximum 3 times/minute.

Local Operation Mode

This feature allows for temporary local operation by use of the Zero/Close and Span/Open buttons on the PCU board to open and close the guide vanes. To access this feature, simultaneously push the Zero and Span buttons, hold for two seconds, and release. The yellow Fault LED will be lit to indicate Local operation mode. (If there is no operation occurs within 15 seconds, the PCU will default to setpoint control).

Automatic Calibration

This feature allows for automatic calibration of the PCU card to the preset limits, without the need for a signal generator. To access this feature, press the A-Scan button one time. The white Auto Scan LED will flash. The unit will then automatically stroke to the close limit, pause, then stroke to the open limit and stop. The PCU will now be calibrated.

Note：1. Actuator is calibrated at the factory, and settings are stored in non-volatile memory. No recalibration required unless the limits are changed.

2. When Actuator is in operation, the operating mode is repositioned to automatic mode. Do not use Manual mode unless under troubleshooting situations. Using manual mode is not recommended at normal conditions.

Split Range

This feature allows a range of set points for full open and full close positions.

Close: 3 to 8mA DC
Open: 16 to 21mA DC

For example: If the user would like to assign 5mA to the fully closed position, supply a 5mA signal and then allow the actuator to move to the corresponding position. Move switch 4 (CH1) to the on position, and press the Zero button one time. The actuator acknowledges that position as fully closed and transmits 4mA. Push the Span button to set the fully open position. Once the setting is complete, move switch 4 down to the off position.

Reverse Acting

Standard operation is clockwise rotation of the actuator to close. When reverse action, or counterclockwise rotation to close is required, move switch 5 (CH2) to the on position (up). Move actuator to mid position and push A-scan button. Supply signal and check rotation.

Switch 5 on (up) = 20mA Full Close	Switch 5 off (down) = 4mA Full Close
4mA Full Open	20mA Full Close

3.2.5 Wiring

The terminals of the control elements in the actuator are connected inside the housing. Remove the housing and connect the cable to the terminals. The connection method is shown in Figure 3.4 and Figure 3.4.1. Please check if the power supply is in proper voltage. When all terminals are properly connected, please adjust to half open level with manual control and test the grounding.

Caution：Please turn off all power services before attempting to perform maintenance and wiring of actuator. Before dismantling the actuator, make sure that the IGV is in fully close and not pressurized condition.

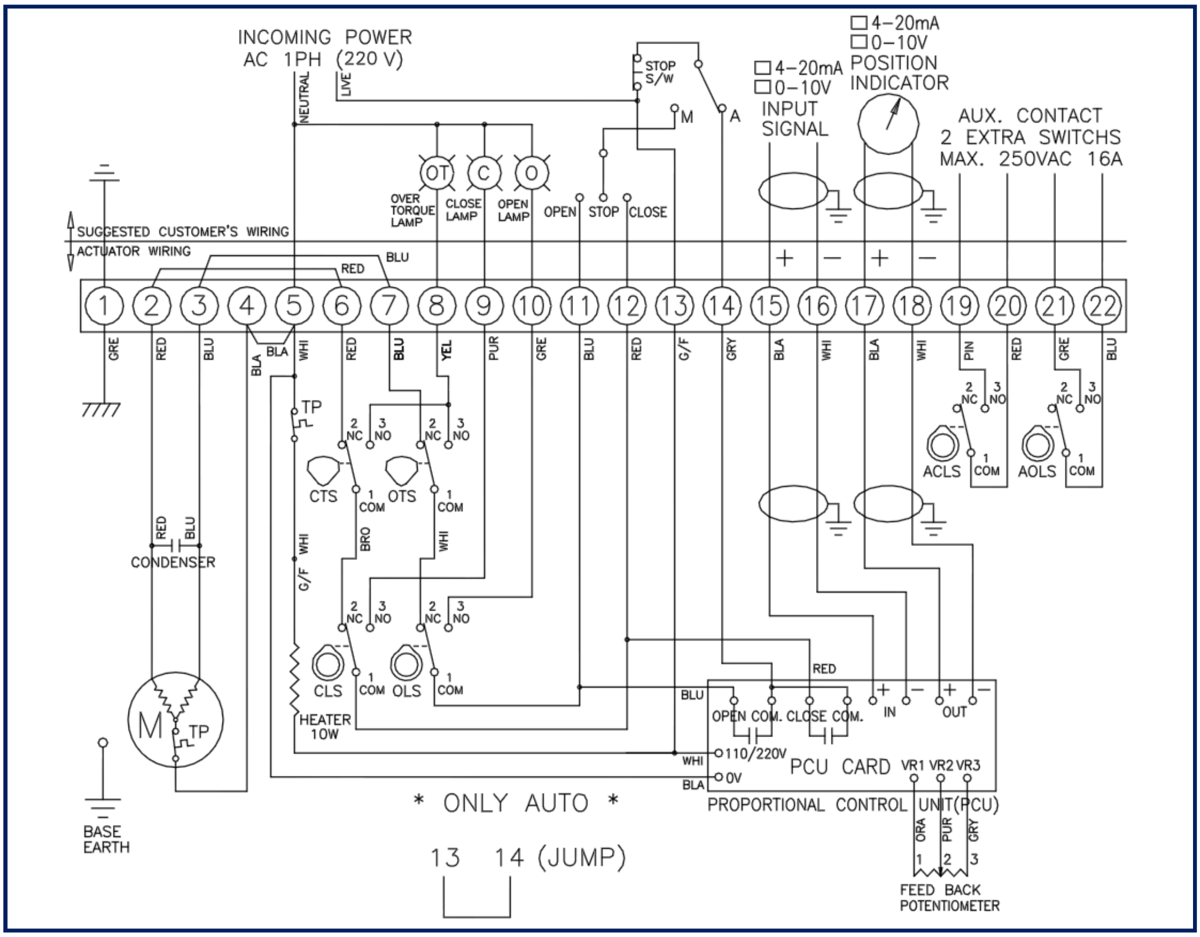


Figure 3.4 Actuator1 wiring diagram (for IGV1)

1. Input signal #15(+ve) & #16(-ve)：4~20mA DC,0~5V DC,0~10V DC,1~5V DC，Factory setting is 4-20mA DC
   Output signal #17(+ve) & #18(-ve)：4~20mA DC,0~5V DC,0~10V DC,1~5V DC，Factory setting is 4-20mA DC

Caution：All control signal wires need to be in shielded (isolated) wiring to avoid interference. Length of the signal wire should not exceed more than 30m.

2 Power connecting point (220V AC 1PH,50/60Hz) #5 & #13：

Caution：An independent power supply is required for actuator power supply. Power source should not be used in conjunction with other electrical equipment (particularly not use in connection with two-phase power from compressor motor main power source), and "isolation transformer" and "electric filter" have to be installed to avoid voltage fluctuation (within 10% of permissible fluctuation) and noise interference which will cause damage to the actuator board.

Caution：It is required to install 2A fuse at the input end of the main power source to protect the actuator.

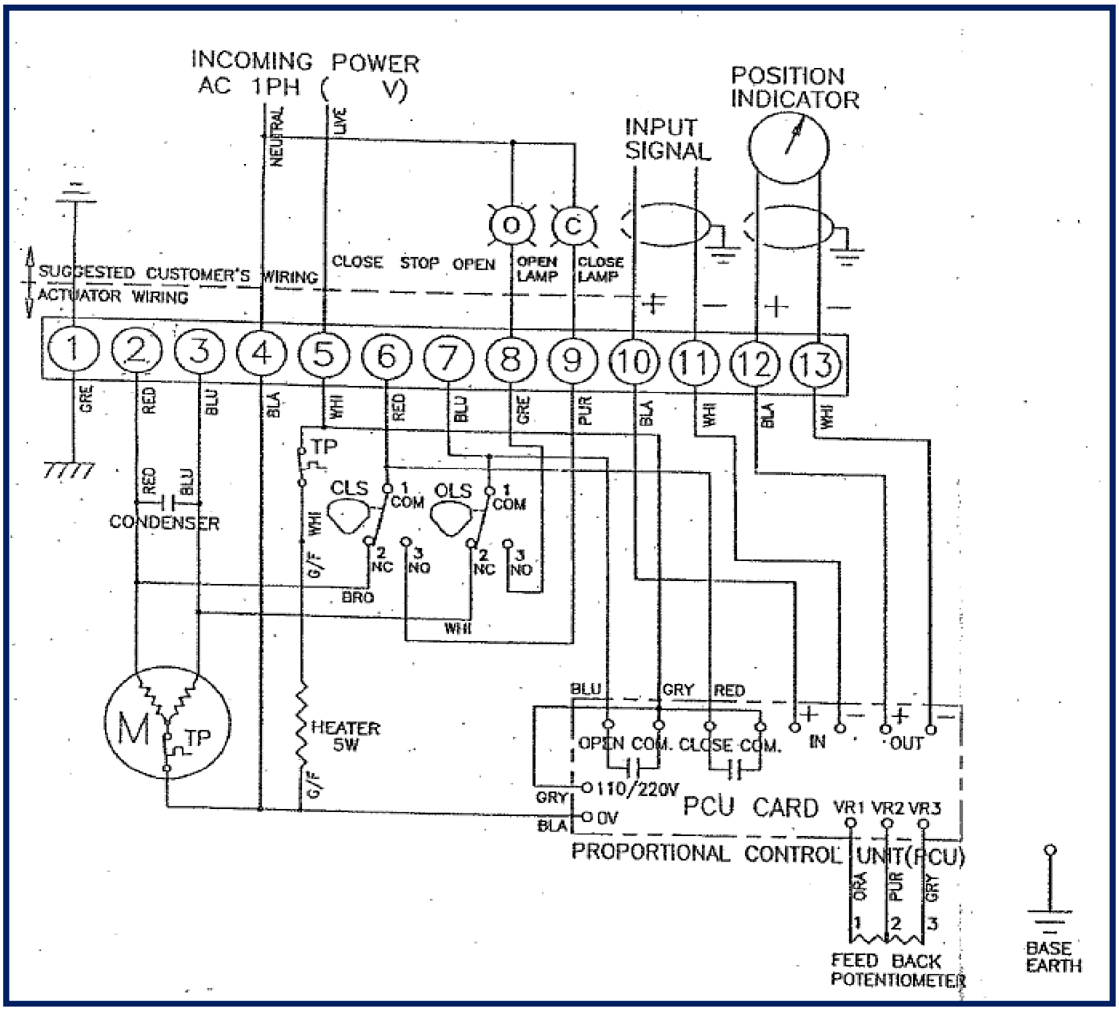


Figure3.4.1 Actuator2 Wiring Figure (for IGV2)

1. Input signal #10(+ve) & #11(-ve)：4~20mA DC,0~5V DC,0~10V DC,1~5V DC，Factory setting is 4-20mA DC
   Output signal #12(+ve) & #13(-ve)：4~20mA DC,0~5V DC,0~10V DC,1~5V DC，Factory setting is 4-20mA DC

2. Power connecting point(220V AC 1PH,50/60Hz) #4 & #5：

Note：Actuator 2 is used in heat pump models and T series (dual IGV), not for standard compressor models.

3.2.6 LED indicator lights

LED	Indication
Blue light	Power on
Flickering Blue light	Auto calibrating
Green light	Fully closed
Flickering Green light	Closing
Red light	Fully open
Flickering Red light	Opening
Yellow light	Manual mode
Flickering Yellow light	Error indicator for one of the following situations : No input signal; 4-20 mA polarity error; Reversal of equipotential line.

Table 3.2.6 LED Indicator lights

3.2.7 Manual operation

To manually operate the actuator, pull the manual declutch lever towards the handwheel until it remains in position. Turn the handwheel until the guide vanes reaches the desired angle. Turn clockwise to close and counterclockwise to open.

Note：When the actuator is in power, manual mode will automatically switch to automatic mode.

3.2.8 Overload protection

Overload protection device which detects the variation of torque during operation is installed for preventing damage of valve and actuator under overload condition. Once the operational torque exceeds the setting value, torque switch is tripped and actuator will be stopped immediately.

Warning：Do not set the overload trip higher than the recommended maximum torque value.

3.2.9 Troubleshooting

PROBLEMS	Checking Methods
Actuator does not respond	Check the power supply of actuator.
	Check that the voltage matches the rating on the actuator nameplate.
	Check internal wiring against actuator wiring diagram.
	Check the limit switch cams.
Actuator is receiving power but does not operate	Check the power supply of actuator.
	Check actuator torque to see if it is greater than the valve torque.
	Check the limit switch cams.
	Check that the torque switches have not tripped.
	Check mechanical travel stop adjustment.
	Verify the actuator against valve rotation (standard units are counterclockwise open).
	Check internal wiring.
	Check for corrosion or condensation.
	Verify coupler/bracket are correctly installed and is not causing binding.
Actuator runs erratically	Check ambient temperature.
	Verify that the duty cycle has not been exceeded.
	Check the position of manual operation lever.
IGV position indicator	Check resistance value.
	Check whether the transmission gear is interfered.
	Check board for damage.
Current / IGV position converter	Verify input signal.
	Check DIP switch configuration.
	Check board for damage.

Table 3.2.9 Actuator troubleshooting

3.2.10 Actuator capacity control

When adjusting the compressor towards the target water temperature, as IGV1 opening is not linearly proportional to the capacity change, it is recommended to refer to the following example in Table 3.4 for IGV1 adjustment range. Generally, when IGV opening is adjusted from 100% to 40%, the capacity change is only about 21%, but when the opening is adjusted from 40% to 10%, there will be a 34% capacity change.

	Target chilled water temperature (CHWT), 7℃				
Range	＜6℃	6~6.7℃	7±0.3℃	7.3~8℃	＞8℃
Loading mode	fast unloading	normal unloading	Neutral zone	normal loading	fast loading
When IGV≧40%	IGV-10%	IGV-5%	no action	IGV+5%	IGV+10%
When IGV＜40%	IGV-5%	IGV-3%	no action	IGV+3%	IGV+5%

Table 3.4 Capacity control table

Caution：1. Although under standard condition (CT/ET=36/6℃), the typical target chilled water temperature (CHWT) is 7℃, the target CHWT can be set to the desired temperature by the user. If the neutral zone is too small (<±0.3℃), it can be difficult to obtain a stable target CHWT. The reason for this issue is due to the deadband of actuator being set to 2%.

Caution：2. The adjustment for the target CHWT should be mainly based on the input signal as the output signal is often susceptible to noise and harmonic interference which could cause significant deviation between output and input signal. Therefore, it is recommended to cancel output signal feedback during capacity control, which can also avoids heavy duty cycle due to feedback "hunting".

Caution：3. Each IGV1 opening has a corresponding limit pressure ratio. During the loading and unloading capacity control process, the pressure ratio must be monitored that it's within the limit pressure ratio to ensure no surge occurred. Please refer to 3.3.1 safety margin formula section for more information.

3.3 Surge and Stall phenomenon

【Definition】

- ✧ Surge: When the flow rate continues to decrease after stalling, further breakdown of steady through flow will occur which ultimately, leads to complete expansion of separation zone in the flow path. This results in significant drop in discharge pressure and when the discharge pressure is lower than the backpressure, reversal of flow will take place. Such phenomena are periodic and detrimental due to heavy vibrations of compressor.
- ✧ Surge point：Each IGV opening has a corresponding maximum pressure ratio surge point.
- ✧ Surge line：The curve formed by connecting surge points of each IGV opening.
- ✧ Stall: When the flow rate decreases, the incidence angle increases, causing more severe flow separation as well as larger separation zone and at this point, the performance of compressor is significantly deteriorated. This phenomenon is known as stalling.
- ✧ Stall zone：Rotating stall is a local disruption of flow within the compressor at low flow rates which limits the operating range of the compressor.
- ✧ Allowable operating range：Ranging from the maximum IGV opening (100%) to the smallest IGV opening (10%),with the maximum operation load of (105%) and covering the operating range from safety margin line to the minimum pressure ratio.
- ✧ Safety margin line：The curve is formed by translating the surge line to a safety margin at the maximum upper limit of pressure ratio for each IGV opening.
- ✧ Pressure ratio：Pressure ratio is the absolute pressure ratio between compressor discharge and suction inlet.

When the centrifugal compressor is operating at part load, the angle of guide vanes will become smaller, and the flow rate of refrigerant entering the compressor will also become smaller. The surging and stalling phenomena occur when the flow rate is reduced beyond a critical limit. As shown in Figure 3.5, when compressor operates above the surge line, stalling or surging may occur. When surging occurs, the discharge pressure of compressor will reduce drastically, lower than the pressure in condenser, and as a result, high pressure gas flows reversely back into the compressor and the airflow inside the compressor becomes unsteady and turbulence which leads to heavy vibrations and noise. During surging, high speed shaft can be damaged due to heat accumulation inside the compressor. In addition, the rotating parts will experience an alternating stress induced by periodically varying pressure due to reversal of flow which increases the loads on bearings and may destroys the bearings. Therefore, the operation of compressor must be limited within the allowable operating range under the safety margin line.

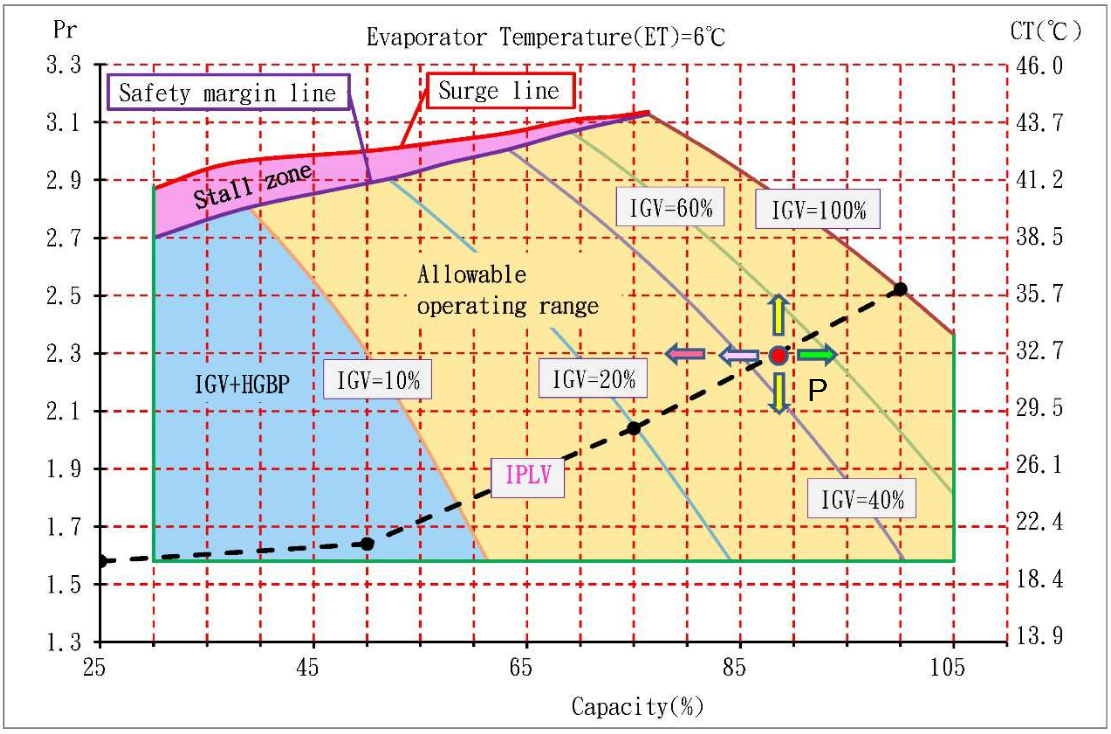


Figure 3.5 illustrates the operating range of a fixed-frequency water-cooled compressor.

Surge occurred due to dramatic change of working condition can be detected by measuring the current value of motor as the compressor will be in a state of unsteady loading due to the reversal of flow during surging. With an approximately 5 seconds/cycle of surge frequency, the compressor can be considered as surging when three consecutive peak current differential is 10% higher than the average current within 15 seconds (except during loading control of the compressor). Please refer to section 3.3.1 for surge protection strategy (mechanism).

Note：RT series compressors use rigid bearings and are capable of withstanding short-term surge up to 15 seconds. However, the compressor cannot withstand long-term surge, thus using only current detection for surge protection is not allowed. Safety margin line formula should always be used as primary surging protection.

Warning：Once surging occurred, labyrinth seal gaps will become larger, which increases the leakage of labyrinth seals. In addition, the vibration of compressor will also become larger due to greater imbalance. Such effects are detrimental and should be avoided.

Warning：Normal operations of compressor should always be within the allowable operating range. Current detection is mainly used when surging occurred due to dramatic change of working condition.

3.3.1 Fixed-frequency capacity control and surge protection strategy

The capacity control of a fixed-frequency compressor is generally divided into constant pressure ratio modulation and constant load modulation.

【Constant pressure ratio modulation】Taking point P of Figure 3.5 at a certain constant pressure ratio as an example, if the outlet temperature of the chilled water (CHWT) is higher than the target temperature, then the loading should be increased by increasing IGV opening (P shifts right) until reaching the temperature at target CHWT±0.3℃. If the outlet temperature of the chilled water (CHWT) is lower than the target temperature, then the loading should be reduced by decreasing IGV opening (P shifts left) while making sure that the operating pressure ratio does not exceeds the limit. If further reduction of IGV opening is required when the pressure ratio reaches the limit, then hot gas bypass valve should be opened to balance the system.

【Constant load modulation】Taking point P of Figure 3.5 at a certain constant load as an example, if the pressure ratio is required to be increased (P shifts upward) when the outlet temperature of cooling water increases, then IGV opening should be increased while making sure the operating pressure ratio does not exceeds the limit during the process. Start surge protection if the outlet temperature of cooling water rises continuously. If the outlet temperature of cooling water drops, then IGV opening should be decreased to reduce the pressure ratio (P shifts downward), this process

Surge protection mechanism of a fixed-frequency compressor is generally divided into two modes: unloading mode and loading mode

【Unloading mode】If surge occurs during unloading mode of cooling water, then open the hot gas bypass valve for 1-2 minutes to reduce the operating pressure ratio (raising the lower pressure). The system can return to normal operating mode after the hot gas bypass valve is closed.

【Loading mode】If surge occurs during loading mode of cooling water, then increase the opening of IGV by 5-10% each increment. If compressor surge still persists when the IGV opening is increased to 100% then the system should be shut down.

Caution：The timing of compressor surge should be flagged, typically for 10 minutes, if there are three consecutive surge occurrences during this period, then the compressor must be shut down and investigation is required to identify and eliminate the cause(s), e.g. high cooling water outlet temperature due to inefficient in heat exchange of the condenser, then cleaning of the condenser is required. Otherwise, temporarily increase the target outlet temperature of cooling water (reduce operating pressure ratio) to allow temporary operation of the compressor until cleaning is completed.

Fixed-frequency unit safety margin line formula

Fixed-frequency compressor allowable operating range：Ranging from the maximum IGV opening (100%) to the smallest IGV opening (10%),with the maximum operation load of (105%) and covering the operating range from safety margin line to the minimum pressure ratio.

The safety margin line formula is a polynomial of IGV opening and should be monitored when the compressor is under capacity control to avoid operating pressure ratio from exceeding the precaution safety margin line.

Pr=*pressure ratio (safety margin line)* =y=a+bx+cx^2+dx^3+ex^4
Where a, b, c, d, e are constants and x is the IGV opening.

Model										
Model	$Pr=a+bx+cx^2+dx^3+ex^4$									
	x=IGV opening(10~100) y=Pr (Max.safety pressure ratio)									
RT-120(E)	$y=2.69848+1.23309E-02x-1.28291E-04x^2+3.21830E-07x^3+1.58931E-09x^4$									
	constant	a		b		c		d		e
		2.69848E+00		1.23309E-02		-1.28291E-04		3.21830E-07		1.58931E-09
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	3.13	3.11	3.09	3.08	3.07	3.04	3.01	2.96	2.90	2.81
RT-120T	$y=2.44328+1.70194E-02x-1.69203E-04x^2+7.33557E-07x^3-6.12448E-10x^4$									
	constant	a		b		c		d		e
		2.44328E+00		1.70194E-02		-1.69203E-04		7.33557E-07		-6.12448E-10
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	3.13	3.10	3.07	3.04	3.01	2.96	2.90	2.82	2.72	2.60
RT-130(E) RT-140(E)	$y=2.77262+1.25863E-02x-1.31003E-04x^2+3.29367E-07x^3+1.61811E-09x^4$									
	constant	a		b		c		d		e
		2.77262E+00		1.25863E-02		-1.31003E-04		3.29367E-07		1.61811E-09
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	3.21	3.19	3.18	3.16	3.15	3.13	3.09	3.04	2.97	2.89
RT-130T RT-140T	$y=2.51204+1.73806E-02x-1.72966E-04x^2+7.51568E-07x^3-6.36018E-10x^4$									
	constant	a		b		c		d		e
		2.51204E+00		1.73806E-02		-1.72966E-04		7.51568E-07		-6.36018E-10
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	3.21	3.18	3.15	3.12	3.09	3.04	2.98	2.90	2.80	2.67
RT-160(E) ~ RT-280(E)	$y=2.55474+1.18314E-02x-1.22987E-04x^2+3.07100E-07x^3+1.53292E-09x^4$									
	constant	a		b		c		d		e
		2.55474E+00		1.18314E-02		-1.22987E-04		3.07100E-07		1.53292E-09
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	2.97	2.95	2.93	2.92	2.91	2.89	2.85	2.81	2.74	2.66
RT-160T ~ RT-280T	$y=2.3101+1.6313E-02x-1.6185E-04x^2+6.9836E-07x^3-5.6646E-10x^4$									
	constant	a		b		c		d		e
		2.31010E+00		1.63130E-02		-1.61850E-04		6.98360E-07		-5.66460E-10
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	2.96	2.94	2.91	2.88	2.85	2.80	2.75	2.67	2.58	2.46
RT-111 RT-161 RT-221	$y=2.27349+4.16545E-02x-3.06201E-04x^2-1.38454E-06x^3+1.66588E-08x^4$									
	constant	a		b		c		d		e
		2.27349E+00		4.16545E-02		-3.06201E-04		-1.38454E-06		1.66588E-08
	IGV(%)	100	90	80	70	60	50	40	30	20	10
	Pr	3.66	3.63	3.62	3.61	3.59	3.52	3.40	3.22	2.98	2.66

Table 3.5 Fixed-frequency compressor safety margin line formula

Warning：Safety margin line formula is the primary protection of compressor surge, DO NOT use current detection only for surge protection as it only passively activated when surge occurs. Compressor will be seriously damaged by repeating occurrence of surge.

Dual IGV relationship for different models

Both RT series and heat pump are equipped with double IGV mechanism. The actuators are set up separately while the operations of IGV1 and IGV2 are coupled. The formula is as follows:

Model	1.When 100≧IGV1≧70，IGV2=100									
Model	2.When 70＞IGV1＞0， $y=a+bx+cx^2+dx^3+ex^4$,其中 x=IGV1,y=IGV2									
RT-120T RT-130T RT-140T RT-111	$y = 7.849 + 2.320x - 1.440E{-}02x^2$									
	constant	a		b		c		d		e
		7.849E+00		2.320E+00		-1.440E-02		0.000E+00		0.000E+00
	IGV1	100	90	80	70	60	50	40	30	20	10
	IGV2	100	100	100	100	95.2	87.8	77.6	64.5	48.5	29.6
Model	1.When 100≧IGV1＞90，IGV2=100									
Model	2.When 90≧IGV1＞0, $y=a+bx+cx^2+dx^3+ex^4$,其中 x=IGV1,y=IGV2									
RT-160T RT-180T RT-200T RT-161	$y = 5.464E{+}00 + 3.317E{+}00x - 5.588E{-}02x^2 + 5.023E{-}04x^3 - 1.808E{-}06x^4$									
	constant	a		b		c		d		e
		5.464E+00		3.317E+00		-5.588E-02		5.023E-04		-1.808E-06
	IGV1	100	90	80	70	60	50	40	30	20	10
	IGV2	100	98.9	96.3	92.7	88.4	83.1	76.3	66.8	53.2	33.5
Model	$y = 5.5 + 1.969x - 1.020E{-}02x^2$ ，其中 x=IGV1, y=IGV2									
	constant	a		b		c		d		e
RT-221		5.500E+00		1.969E+00		-1.020E-02		0.000E+00		0.000E+00
	IGV1	100	90	80	70	60	50	40	30	20	10
	IGV2	100	100	97.7	93.4	86.9	78.5	67.9	55.4	40.8	24.2

Table 3.3.1 Equations describing the relationship between the two IGVs

3.3.2 Energy savings with variable frequency compressor

Centrifugal compressors are equipped with a motor which drives the high speed shaft through speed-up gears. Refrigerant gas is compressed and accelerated by the centrifugal effect of the impellers which rotating at high speed. In the diffuser, most of the kinetic energy gained is converted into pressure energy.

Obviously, the energy gained from the impeller is ultimately applied by the motor. Compressor Input power is as follows:

$$P = H \cdot \dot{m} / \eta$$

P = compressor input power
H = energy head
$\dot{m}$ = mass flow rate of refrigerant
η = motor efficiency

According to the Laws of Similarity in fluid mechanics:

$$\frac{\dot{m}_1}{\dot{m}_2} \propto \frac{N_1}{N_2}$$

$$\frac{H_1}{H_2} \propto \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{P_1}{P_2} \propto \left(\frac{N_1}{N_2}\right)^3$$

ṁ = mass flow rate of refrigerant
H = compressor head (enthalpy difference)
P = compressor input power

Combining compressor input power and similarity laws shows that H is proportional to the square of the speed, ṁ is proportional to the speed, while motor power is proportional to the cube of motor rotational speed. Thus, by reducing the rotational speed, power input will be greatly reduced and as a result, improving the efficiency of the compressor and reducing the power consumption of the chiller system (Refer to Figure 3.6, for the capability of fixed/variable frequency unit and shaft power map).

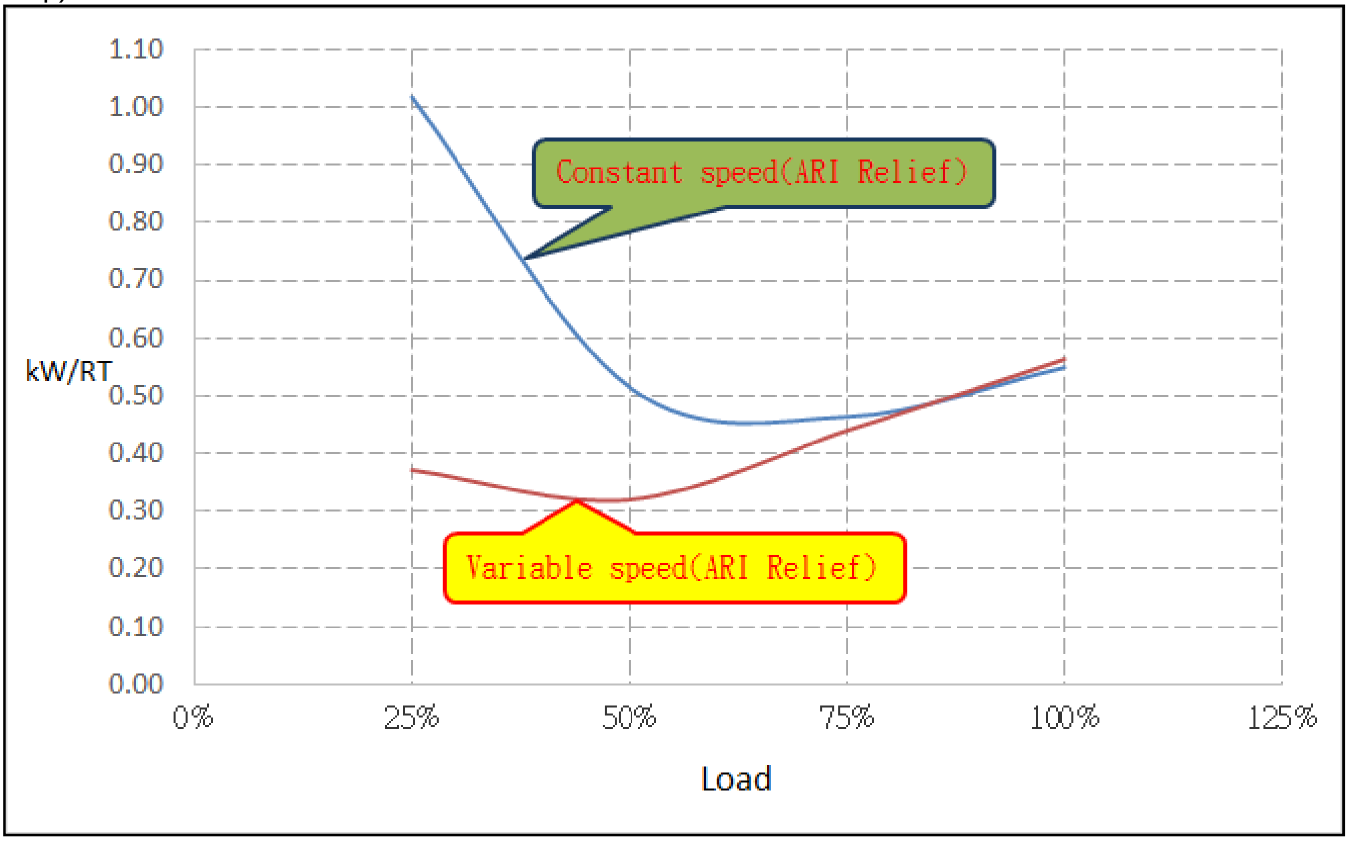


Figure 3.6 Performance map of a fixed/variable frequency unit

Chilled water temperature modulation

The VSD inverter optimizes the rotational speed of the motor and the opening of IGVs based on the chilled water outlet temperature and the compressor head (pressure ratio), so that the unit always operates under the best condition.

The basic parameter of VSD control is the temperature difference between the actual value of the chilled water outlet temperature and the set value.

1. When the unit is operating at full load, the IGVs are fully opened and the motor rotational speed control logic is completely based on the temperature difference. As the cooling load decreases, the motor rotational speed decreases. The motor rotational speed is controlled by the compressor head (pressure ratio) and the system minimum allowable rotational speed, until the rotational speed reaches the minimum value. At this point, motor will remain at minimum speed.
2. When the load demand reduces, motor rotational speed will provide signal for the logical control of the IGVs so that IGV opening can be decreased. As the cooling load continues to drop, speed signal from the compressor continues to turn off the guide vanes and increase motor rotational speed.

VSD capacity modulation strategy & variable frequency surge formulae

VSD capacity control takes variable speed as priority and IGV as auxiliary for modulation to reach the optimum efficiency. Thus, VSD compressor surge formulae mainly control the compressor frequency. The expressions are as follows:

:

$Z=a+bx+cy+dx^2+ey^2+fxy+gx^3+hy^3+ixy^2+jx^2y$

where a、b、c、d、e are constants (refer to Table 3.7 VSD compressor surge formula);

x=IGV(%) opening (10~100);

y=pressure ratio, Pr;

Z (minimum allowable operating frequency) = Frequency (Hz)

※Insert the value of y (pressure ratio) and x (IGV opening) at the operating point into the formula to obtain the minimum allowable operating frequency. The recommended compressor operating frequency is Z+1 to 1.5Hz in order to reach the maximum efficiency. Reasons for setting value range of +1 ~ 1.5Hz is:

a. To avoid forced increase in frequency at small IGV openings when IGV opening value is inserted into the formula (could cause fluctuation of chilled water temperature).

b. To avoid surge formula deviation or inaccurate measuring sensor;

c. This formula does not have safety margin.

Model	$Z= a+bx+cy+dx^2+ey^2+fxy+gx^3+hy^3+ixy^2+jx^2y$				
	x=IGV opening(10~100%)，y=pressure ratio Pr，Z=Frequency (Hz)				
RT-120E	a	b	c	d	e
	-3.99639E+01	-5.25339E-02	7.47371E+01	1.28399E-03	-2.21462E+01
	f	g	h	i	j
	-2.20465E-02	-8.07113E-06	2.51895E+00	-1.42502E-03	1.35207E-04
RT-130E RT-140E	a	b	c	d	e
	-2.10165E+01	1.11192E-01	4.57809E+01	-7.54248E-04	-1.00315E+01
	f	g	h	i	j
	-5.47750E-02	-6.23802E-06	1.06767E+00	-1.95358E-02	9.99493E-04
RT-160E~ RT-280E	a	b	c	d	e
	-3.28481E+01	-1.40837E-02	6.87195E+01	2.73888E-04	-2.00618E+01
	f	g	h	i	j
	-3.93628E-02	-9.02008E-07	2.22521E+00	3.62232E-03	1.55530E-04

Table 3.7 VSD compressor (50Hz) surge formula (without safety margin)

1. Start-up frequency: As high and medium pressure has not been established before start-up, it is impossible to calculate the required minimum rotational speed based on the pressure ratio when the compressor starts, therefore it is necessary to estimate the condensing temperature by using cooling water inlet temperature plus a temperature difference (7~8K) to obtain the expected condensing pressure. Then, using chilled water outlet temperature minus a temperature difference (1~2K) as the expected evaporation temperature to obtain the evaporation pressure. Finally, insert the pressure ratio based the estimated pressures and IGV=10% into the formula to calculate the minimum operable frequency+1Hz; otherwise start-up with the highest operating frequency.

※It is suggested to complete the accelerating time within 20 seconds for start-ups (0 to rated speed time). Excessive accelerating time can easily lead to discontinuity of gear thrust which will cause crash and bearing damage from slippage due to excessively low bearing loading. The compressor will also stay longer in the surge zone.

2. Unloading: Frequency control in priority, when the frequency drops continuously to below (Z+1) Hz into zone A, the compressor needs to start unloading. It is recommended that each decline for IGV≤20% is 2%, for 20<IGV<50% is 5%,and for IGV ≧ 50% is 8%.
3. Loading: When the frequency is increased to Z+2~3Hz, the compressor needs to start increasing the loading. Load increment is recommended as mentioned above.
4. For a 60Hz VSD compressor, please apply Table 3.7 VSD compressor (50Hz) surge formula and multiply the calculated value by 1.2.

VSD allowable operating range: as shown in Figure 3.7, the allowable operating range of a VSD compressor is formed by the maximum operable capacity (105%), VSD surge formula and pressure ratio, IGV opening and surge line.

※Surge line: Insert Z = 50Hz (fixed frequency), IGV opening (10-100%) into VSD surge formula, the values of y (pressure ratio) obtained forms the surge line, alternatively, it can also be obtained by using fixed frequency safety margin line formula.

Warning: The maximum operable frequency is the rated frequency of the compressor. Do not overclock for higher compressor capacity. Overclocking to a critical speed will cause structural collapse of high-speed shaft due to resonance.

Warning: The minimum operable rotational speed of the compressor is 60% of its rated speed. Excessively low speed will cause inefficient discharge of motor cooling liquid, oil leakage and bearing slippage due to low loading, in extreme cases, can lead to catastrophic failure of compressor.

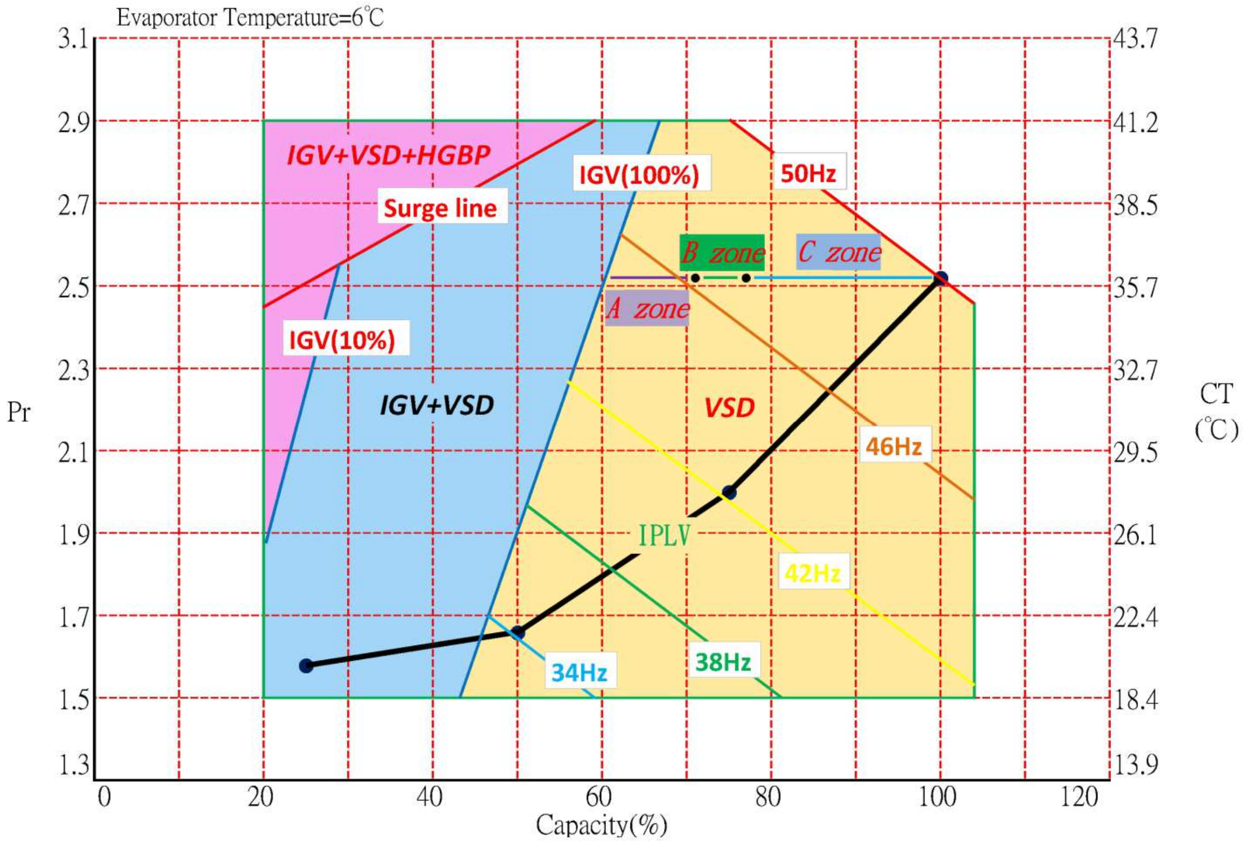


Figure 3.7 A schematic diagram of inverter operating range

Adjustment of inverter's frequency for capacity modulation

1. The increment and decrement of inverter frequency is differentiated according to the loading mode. When the output cycle time arrives (for example, 30 second), determine the adjustment of frequency based on the difference between current CHWT and target CHWT.

※Taking 800RT as an example, 1Hz is approximately 7.2% (58RT) of cooling capacity change rate.

2. Assuming that the set value of cooling water output temperature is 7°C, neutral zone temperature difference is ± 0.2°C, output cycle time is 30 seconds, rapid loading and unloading frequency is 1 Hz. Normal loading and unloading temperature difference is 0.5°C and frequency increase and decrease is 0.5Hz. Change of CHWT and inverter output are listed in the following table

	Target chilled water temperature (CHWT), 7℃				
Range	＜6.8℃	6.5~6.8℃	6.8~7.2℃	7.2~7.5℃	＞7.5℃
Loading mode	fast unloading	normal unloading	Neutral zone	normal loading	fast loading
Inverter output	-1Hz	-0.5Hz	no action	+0.5Hz	+1Hz

3.4 Hot gas bypass (HGBP)

Centrifugal compressors are of non-positive displacement types. They raise pressure and temperature of refrigerant by converting kinetic energy into an increase in static pressure. Hot gas bypass is to bypass or liquid refrigerant from condenser into evaporator through a proportional valve.

Function 1: 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 compression ratio.

Function 2: Apply during start up to lower starting current.

Function 3: Unloading modulation

Because hot gas bypass method is to transfer compressed gas from the condenser (high-pressure side) to the evaporator (low-pressure side), it should be noticed that this volume flow might make enormous noise. 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 at suction side. Setting the piping on suction pipe can also prevent liquid strike.

Besides, a muffler should be installed at the evaporator. Hot gas bypasses to the evaporator should be prevented from liquid refrigerant inside the evaporator. If liquid refrigerant splashes and sucks into the compressor, it will result in liquid compression, which damages the compressor.

Note1: The system with hot gas bypass is inefficient. It should be avoided whenever possible. Many system applications still require hot gas bypass in order to avoid surge or maintain constant chilled water temperatures from zero 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 opening and cooling capacity is 50%, and end user needs 20%. The pipe diameter and flow need to be considered based on the 30% difference.

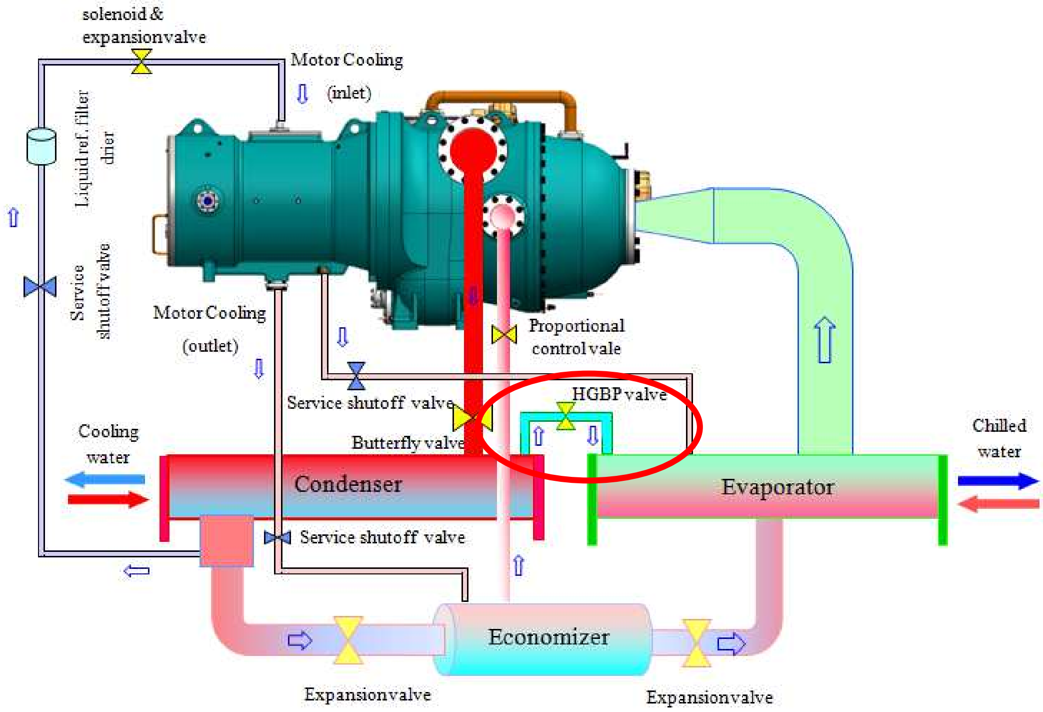


Figure 3.7 Refrigerant Circuit & Motor Cooling systems

3.5 Proportional valve

Single IGV model:
When the compressor operates at low pressure ratio with IGV1≤10%, the inlet flow will have higher pressure loss due to the angle of IGVs. As shown in Figure 3.8(a), from point to 9 to 1 the pressure loss becomes larger, leading to a lower intermediate pressure closing to evaporation pressure and the economizer may have higher liquid level due to higher difficulty in controlling expansion valve and orifice plate at low pressure end. As a result, liquid refrigerant may be drawn into compressor intermediate inlet (ECO port). Therefore, it is recommended to install an intermediate pressure valve between ECO port and economizer, near the compressor. Close the intermediate pressure valve when IGV's opening <10%, while fully open the valve when IGV opening is ≥10%.

Dual IGV Model:
For dual IGV models, IGV2 is adjustable radial guide vane. IGV2 opening can be used to control the pressure in the economizer to maintain a certain pressure difference between intermediate pressure and low pressure when operating in low pressure ratio. Thus, the intermediate inlet is less likely to suffer from the phenomenon of liquid absorption, as shown in Figure 3.8(b), so double IGV model users do not need additional intermediate pressure valve.

Note: 1. For dual IGV models, intermediate inlet is less likely to have liquid absorption issue, thus the minimum operating opening is ≥5%. The link relationship between IGV1 and IGV2 should be applied by Hanbell to ensure that the compressor intermediate pressure control is at the best point.

2. Intermediate pressure valve: Due to part load requirements (such as pure orifice plate expansion valve unit), some unit designs require lower economizer (flash tank) pressure to ensure smooth discharge of motor cooling liquid. In this case, the intermediate pressure valve requires proportional control and thus, a proportional valve should be used. Otherwise, an ON-OFF type shut-off valve is applicable.

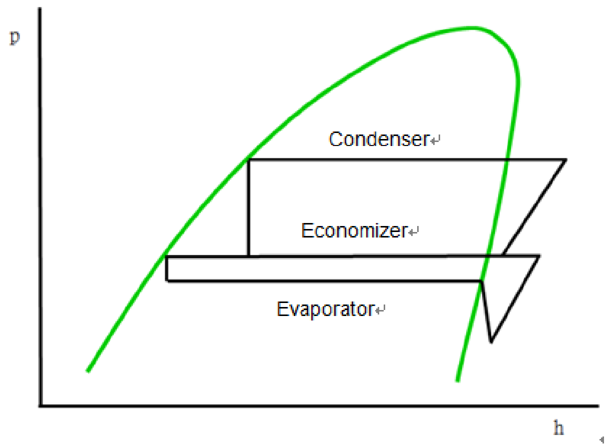


Figure 3.8 (a) Single IGV enthalpy diagram of 2-stage compression

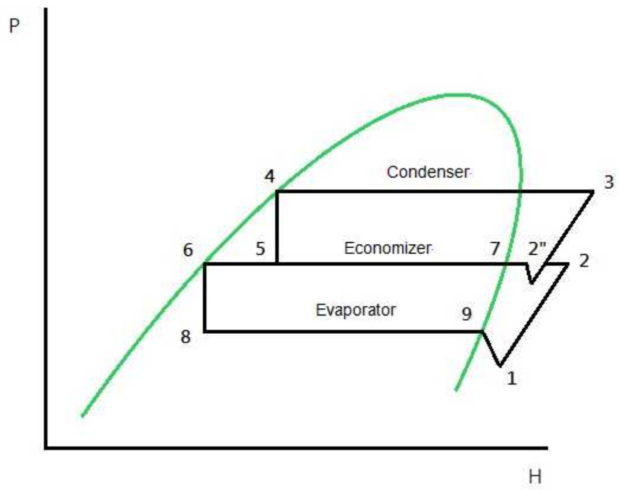


Figure 3.8 (b) Dual IGV enthalpy diagram of 2-stage compression

Compressor medium pressure formula

1. Water-cooled compressor intermediate pressure (absolute pressure) relationship

1. RT-120~280

When IGV>0,

Pm= 1.025*(IGV%/IGV100%)^0.08*(Pe*Pc)^0.5

When IGV=0,

Pm= 1.025*0.82*(Pe*Pc)^0.5

E.g.,

Pe=	3.62 bar	where,	
Pc=	9.63 bar		Pe=evaporator pressure
IGV=	100 %		Pc=condenser pressure
Pm=	6.05 bar		Pm=intermediate pressure

2. Heat pump compressor intermediate pressure (absolute pressure) relationship

1. RT-111

When IGV>0,

Pm= 1.025*(IGV%/IGV100%)^0.5*(Pe*Pc)^0.5+Pe/Pc*1.9

When IGV=0,

Pm= 1.025*0.82*(Pe*Pc)^0.5

E.g.,

Pe=	3.62 bar	where,	
Pc=	11.9 bar		Pe=evaporator pressure
IGV=	50 %		Pc=condenser pressure
Pm=	7.08 bar		Pm=intermediate pressure

2. RT-161,221

When IGV>0,

Pm= 1.025*(IGV%/IGV100%)^0.035*(Pe*Pc)^0.5+Pe/Pc*0.55

When IGV=0,

Pm= 1.025*0.9*(Pe*Pc)^0.5+Pe/Pc*0.55

E.g.,

Pe=	3.62 bar	where,	
Pc=	11.9 bar		Pe=evaporator pressure
IGV=	50 %		Pc=condenser pressure
Pm=	6.74 bar		Pm=intermediate pressure

Chapter 4. Lubrication system

4.1 Oil circuit

Lubricant is driven by built-in oil pump in the compressor. Oil passes front / back bearings of motors since gears and bearings are around the high-speed shaft for lubrication. The oil system consists of an oil pump, a relief valve, an oil filter, oil cooler and other control valves.

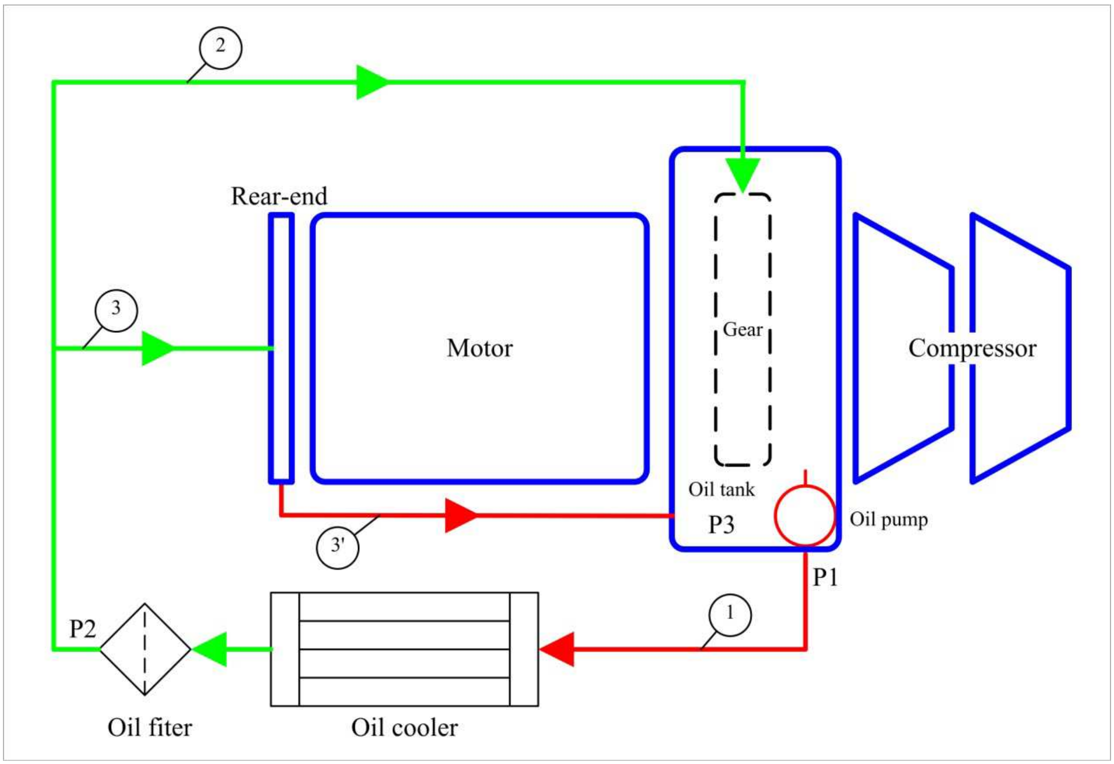


Figure 4.1 Schematic diagram of oil piping

After lubricant is pressurized by built-in oil pump, it passes the relief valve for modulation of pressure and flows through pipe 1. The oil circuit is then divided into two passages, Pipe 2 & 3, which is after the oil cooler and the oil filter. Oil in pipe 3 lubricates bearings in the back of the motor and returns to the oil tank by pipe 3'. Oil in Pipe 2 enters gear box on the top, and lubricates bearings in front of the motor, the gears, and the front/ back bearings, which are around the high-speed shaft, and returns to the oil tank finally.

Caution：RT-series centrifugal compressor uses positive displacement gear pumps which release pulsating wave at the discharge of the oil pump. Therefore, a buffer tube and a steel wire hose (length> 40cm) should be added at the outlet of the oil pump to absorb the shock.

Definition:

✧ R1: Resistance in pipe, R1=P1-P2. It includes pressure drop in pipe itself, oil cooler, and oil filter. Please pay attention to the pressure sensor installing point.

✧ R2：Internal resistance in compressor. Its fixed value 2.0~2.2 bar indicates the necessary pressure difference for compressor lubrication.

Pipeline resistance (R1) protection

Oil filter is the only component in the pipeline that has variable resistance while the rests are constants, thus the pressure difference of P1-P2 should be monitored to prevent lack of lubrication caused by oil filter blockage.

R1=P1-P2 ≥ 1.0 bar warning
R1=P1-P2 ≥ 1.5 bar shut down

Note：
1. Unexpected power trip often occurs in many areas, causing the system to shut down abnormally and compressor shuts down when the oil pump is stopped. For compressors using hydrodynamic bearings, lack of lubrication can cause jamming and damage of the rotor. Hanbell RT-series compressors use rigid bearings which does not require additional power trip protection as the residual oil can be used for free rotating shut down.
2. Compared to hydrodynamic bearings, rigid bearings have the advantage of less mechanical loss and less lubrication required.
3. Pressure sensor installation point: Pressure sensing point P1 should to be installed behind the buffer tube, while P2 should installed before the inlet of gearbox lubrication.

4.2 Oil pump

4.2.1 Specifications of the oil pump

The built-in oil pumps of RT series centrifugal compressors are of the positive displacement gerotor type.

	Item		Specifications			
Oil pump	Flow rate	L/min.	26~30		32~36	
	Pressure difference operating range	bar	2~4.5			
motor	Output	W	446		560	
	Voltage	V	3ψ/220V/50Hz	3ψ/380V/50Hz	3ψ/220V/60Hz	3ψ/380V/60Hz
	Max. operating current	A	3.6	2.1	3.5	2
	LRA	A	19.1	11.06	17.6	10.2

Table 4.1 Specifications of the oil pump

Note：Voltage Specifications: 3ψ/220V 50Hz & 60Hz are shared oil pump. With different power supply frequencies, the motor output and oil flow rate will also be different. This is similar for 3ψ/380V 50Hz & 60Hz. However, the internal windings of oil pump motor for 220V and 380V are different, therefore please contact Hanbell service technicians for different power supply voltage.

4.2.2 Features of oil pump

The primary function of the oil pump is to provide enough lubricant for lubrication and cooling of the bearings and gear, and the flow rate of lubricant and the temperature of bearings and gear after cooling are the decisive factor. Thus, protection mechanism is necessary to ensure the oil pump overcomes the internal resistance of compressor (R2) and provides adequate flow rate of oil.

Compressor internal resistance (R2) protection

Hanbell RT-series centrifugal compressor has been tested and verified that the optimum flow rate of oil is 20~25L/min. in the form of oil-jet and ensures the bearing outer ring temperature to be less than 80°C after cooling. Therefore, the pressure difference between oil pressure before entering the compressor P2 and oil tank pressure P3 is the key to overcome compressor internal resistance R2.

P2-P3<2.5kg/cm² warning
P2-P3≤2.0kg/cm² shutdown

Note：1. This oil pump internal resistance (R2) protection is based on the current specifications of 3/4HP oil pump (@60Hz). Please contact Hanbell technicians for other specification configuration requirements.
2. Bearings used by RT series compressor require stable supply of lubricant.
3. Before / after compressor start-up, the start-up and shut down of oil pump must be advanced and delayed by 3 seconds to provide sufficient lubrication.
4. Excessive lubricating oil will lead to rapid rise of bearing temperature while insufficient oil will lead to lack of cooling and lubrication, thus the oil pump flow rate should not be arbitrarily adjusted.

Warning：Only authorized and certified technicians are allowed to modify the oil pump setting.
Warning：Oil pump flow rate decreases as outlet pressure decreases (non-linear). Thus, do not adjust the pump outlet pressure to deactivate the oil filter alarm (filter pressure-drop will be smaller as oil pump outlet pressure becomes smaller) as the reduction in oil flow rate will lead to inadequate lubrication of bearings and gears and will result in burning.

4.3 Oil cooler

The system must be equipped with external oil cooler. As built-in oil pump is used in all models and the oil flow rate is fixed at 20~25L/min., the oil cooler should be the same for all models (excessive oil discharged will be bypassed back into the oil tank through an internal valve). Taking highest oil tank temperature as the temperature of oil entering the oil cooler, while the temperature of cooled oil needs to be around 30~40°C and it is recommended to use refrigerant for the cooling so that no further maintenance is required, then:

$$Q = \dot{m} C_p \Delta T \rho_r ,$$

Specific gravity=Please refer to section 4.6.1
Specific heat capacity=0.45 kcal/kg°C

Oil temperature settings for the oil cooler

After the oil in the oil tank is compressed by the built-in oil pump, it enters into the oil cooler and cooled down to a temperature between 30 and 45°C. Filtered by a high-density oil filter, the oil lubricates the bearings and gear in the form of oil-jet, and finally returns to the lower pressure oil tank. The cooling medium can either be the liquid refrigerant from the condenser or the liquid refrigerant from the outlet motor cooling. A temperature sensor must be installed at the oil cooler outlet to control the refrigerant flow and to maintain oil temperature of the oil cooler (Tco) between 30 ~ 40 ℃. The gaseous refrigerant in the heat exchanger can be directed back to the economizer for reuse.

Tco>45℃ or Tco< 25℃ alarm

Tco>50℃ or Tco< 20℃ shut down

Note：Refer to Hanbell selection software for heat load of the oil cooler.

4.4 External oil filter

The external oil filter is a must in the oil circuit. It should be installed in the oil line after the oil cooler. The function of external oil filters is to filter out debris so it does not act as abrasive when oil re-circulates. The filter shell should be able to withstand oil pressure as high as 12 to 15 bars.

Hanbell external oil filter must be used. Its filtering material could be **cellulose (paper)** or **synthetic fiber** (15~25μm). Paper can withstand flow of high-pressured oil without being torn apart. The material has to be able to block small debris without restricting oil flow too much. **Cellulose (paper)** as filter material is economical and works fine. Cellulose as the filter may block particles while allowing oil to pass through. There is synthetic fiber for high-end filters that has smaller passages to block smaller particles but still make fluid pass it through. There is also a kind of material that is a blend of these two materials.

HANBELL provides oil filter with spec. below:
Working pressure：15bar
Working temperature：-20~100℃
Filter accuracy：15~20μm
Rated flow：100L/min

Note：The centrifugal compressor is of delicate type. It is a must to use above materials for filtering.

Caution：If the filter material is a non-precision graded metal, the particles may get into the compressor and cause serious damage to the bearings.
Caution：In addition to the pressure difference judging as a protection system program, mechanical differential pressure switch can also be added as protection.

4.5 Oil & refrigerant circuits

In the compressor, oil is sealed and separated from the discharge volute and the motor by labyrinth ring assembly. A labyrinth ring is a non-contact ring so some amount of gas may still leak to the low-pressured oil tank. Two oil heaters are equipped in the bottom of the oil tank for heating to separate liquid refrigerant from oil. Thereafter, gas reaches the internal oil separator for the second oil separation. Purified gas then returns to the suction casing through the refrigerant return pipe.

The other possible oil leak is in lubricant circuits. When the compressor starts, oil for lubrication of front & back bearings around the motor shaft might lead to the motor casing because medium pressure in the motor has not been built up completely. Leaked oil will accumulate in the evaporator. In general, an ejector is applied to recirculation of leaked oil. Power of ejection comes from high pressure in the condenser or middle pressure in the economizer. Gas with oil will be separated firstly by internal oil separator in the oil tank, and gas will re-circulate stably without fluctuation of oil level. For better evaporation of liquid refrigerant in the oil tank, oil heaters in the bottom of the oil tank are used for heating.

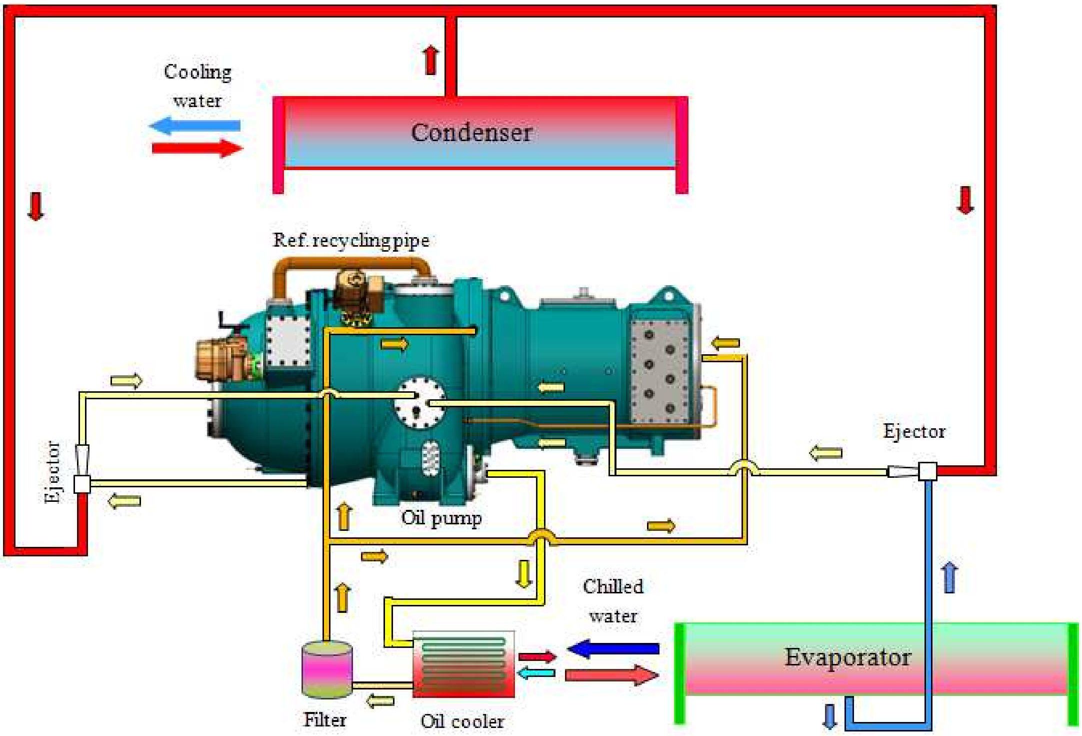


Figure 4.3 Schematic diagrams of oil & refrigerant circuits

Some amount of oil might mix with suction gas and would flow to the compressor from the evaporator. After the inlet nozzle, there is a mechanism which can bring oil to the bottom of suction casing for oil separation. An ejector should be applied to oil recirculation from the suction casing to the oil tank as shown in Figure 4.3. Power of ejection comes from high pressure in the condenser or middle pressure in the economizer.

Note：RT series compressors are equipped with ball and radial bearings. Therefore, the amount of lubricant need is much lesser. This design minimizes possibility of oil leakage to the system.

4.5.1 Oil temperature control in the oil tank

Oil temperature should be kept above ET+20°C by oil heater to avoid the liquid refrigerant remains in the oil tank. If the concentration of refrigeration dissolved in the lubricant is too high, then it will reduce the viscosity and effectiveness of the lubricating oil and the bearings will be more easily damaged. Therefore, the heater must be used to evaporate the liquid refrigerant and recirculate back into the system. By using temperature sensor, the oil temperature inside the tank can be controlled and when the oil temperature is lower than ET+20°C, the heaters should be turned on to evaporate the liquid refrigerant; when the oil temperature is higher than 45°C, the heater is turned off. In general, when the compressor is running, the heat generated by the rotating parts can help maintaining the oil temperature.

T3＜ET+20°C	turn on oil heater	Compressor running is strictly prohibited
T3＞45°C	turn off oil heater	
T3＞CT+10°C	warning	
T3＞CT+15°C	shut down	

Note：

1. ET is the evaporation temperature of the system during operation and shut down. Saturated temperature can be obtained by using the evaporator pressure.
2. CT is the condensation temperature of the system during operation. Saturated temperature can be obtained by using the condenser pressure.
3. The oil heater must be controlled independently and needs to be turned on during temporary shut down or 24 hours before restart. Oil temperature control stated above is still required during operation.

Warning：Do not start the machine when the oil temperature is lower than ET + 20 ℃！

Warning：Excessively high oil temperature indicates insufficient oil for compressor circulation or heat imbalance. Continuous running will cause damage to the machine.

Oil heater specifications

Two UL approved 500W oil heaters have been equipped in the oil tank as standard accessories. Specifications：500W/ 220V; IP 54; UL approved

Note1: The oil temperature inside the oil tank could be kept in normal range because heat is transferred to oil from bearings and gear during running. But if large amount of oil is returned from the evaporator or ambient temperature is low, oil temperature might be insufficient. Hence, oil heaters should be used to make sure the oil from oil pump is free of liquid refrigerant and temperature in oil tank is in safe range.

Warning：If lubricant mixes with liquid refrigerant, bearings and gears cannot be lubricated effectively. This will result in damage to the compressor.

Note2: There are oil separators installed for effective oil separation at oil return and refrigerant return ports in RT series compressors. Please refer to item 13&14 in Figure 4.4. Besides, gears are installed in the gear casing to efficiently minimize fluctuation of oil level due to high-speed rotation. Furthermore, the gear casing also reduces oil to mix with refrigerant flow so oil flow from the compressor to the system could be minimized.

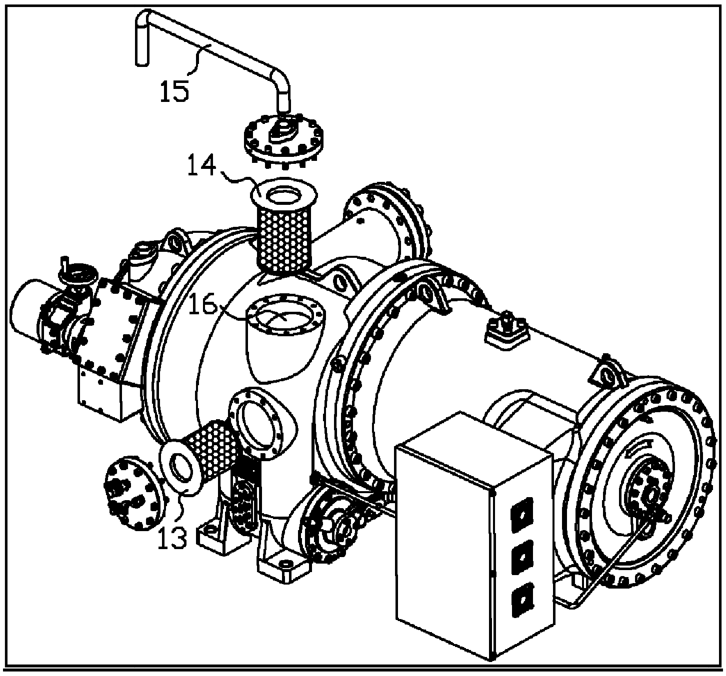


Figure4.4 Oil separator

Refrigerant heater specifications

Two UL approved 300W oil heaters have been installed in the compressor casing. Before restart of the compressor after shutdown for a long time, please turn on refrigerant heaters at least 24 hours to make temperature inside the compressor higher than system temperature and ambient temperature. Therefore, it can prevent condensation of refrigerant inside the compression chamber.

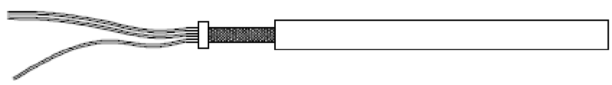


Figure 4.5 Refrigerant heater

Specifications： 300W; 110V or 220V; IP 54; UL approved

Note: If ambient temperature is low, it is recommended to turn on refrigerant heaters during stop of compressors.

Oil pressure in the oil tank

Pressure in the oil tank must be kept as low as possible for oil return to the oil tank finally. A pipe is connected between the oil tank and the suction casing (item 15 in Figure 4.4). Therefore, in normal condition the pressure difference between oil tank and suction side is-0.2~0.5bar.

Note：1. If oil pressure is abnormal inside the oil tank, the possible cause might be that the labyrinth ring for separating high/ low pressure is damaged and a large amount of refrigerant leak as shown in Figure 4.6.

2. When the oil tank pressure (P3) is 0.6 kg/cm² higher than the suction pressure (Ps), system should provide an alarm signal to users. When the oil tank pressure is 0.8 kg/cm² higher than the suction pressure, system should be stopped for protection and troubleshooting.

P3-Ps ≧ 0.6kgf/cm²alarm
P3-Ps ≧0.8kgf/cm²shut down

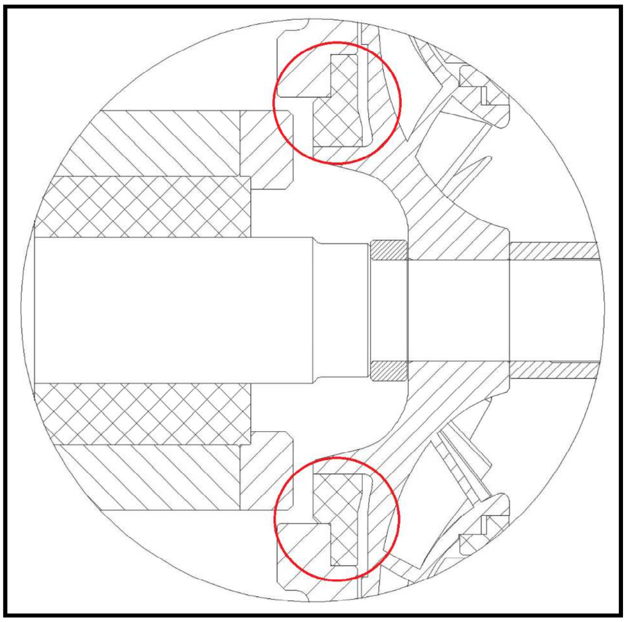


Figure 4.6 Labyrinth ring

RT series compressors are equipped with rigid bearings and fine oil separators. Therefore, oil carry-over in the system is much less. For oil return from the evaporator, orifice size of the oil return outlet of the evaporator should be confined. Suggested orifice sizes are shown as the table as below. Too much liquid refrigerant will cause poor lubrication for bearings resulting in serious damage to the compressor.

Model	Size of orifice
RT-120~140 RT-111	φ2
RT-160~200 RT-221, 161	φ3
RT-240~280	φ4

Unit: mm

4.6 Lubricants

The main functions of lubricant in the centrifugal compressor are lubrication and cooling. Bearings used in RT series compressors require a small but steady volume of oil for lubrication. Please pay more attention to oil temperature which is crucial to compressor bearing life. High oil temperature will reduce oil viscosity and result in poor lubrication and heat dissipation in the compressor as well. It is recommended to keep oil temperature between 30~40℃.

4.6.1 Lubricant table

Type		HBR-B12	HBR-B05	Unit
Specific gravity		0.944	0.955	*g/ml*
Viscosity	@40℃	32	68	mm^2/sec **(**cst)
	@100℃	5.3	8.5	
Flash point		215	255	℃
Pour point		-48	-39	℃
Acid number		0.01	0.01	mg KOH/g
Water content		<50	<50	ppm

Table 4.2 Specifications of lubricants

Note: 1. Use of lubricant other than the specified lubricant will result in HANBELL's non-warranty.
2. Standard lubricant model is HBR-B12. If the operating condition of evaporation temperature is > 14 degrees, then the concentration of refrigerant inside the lubricant will be higher resulting in lower oil viscosity. Therefore, please use HBR-B05 oil instead.

4.6.2 Precautions in changing of oil

1. Use HANBELL approved oil and does not mix different brands of oil together. Choices of oil should match characteristics of refrigerant. Some types of synthetic oil are incompatible with mineral oil. Oil in the compressor should be totally cleaned up in the system before charging different brands of oil. Charge the compressor with oil for the first start to ensure that there is no mix at all.
2. When using polyester oil for chiller systems, please make sure that oil does not expose to the atmosphere for prevention of change in its quality. Therefore, it is necessary to vacuum the system completely when installing the compressor.
3. In order to secure no moisture in the system, it is suggested to clean the system by charging it with dry Nitrogen and then vacuum it repeatedly as long as possible.

Note: When vacuuming the system, please notice that into consideration "When pressure is low, moisture will be condensed sore charge of some dry Nitrogen is necessary.

4. If the motor has burned out, acid debris may still remain inside the system and the oil becomes acid which will deteriorate the insulation of the motor. Therefore, it is a must to change oil and clean the system when changing the motor. Please follow the procedures mentioned above to change oil in the system. Check acidity of oil after 72 hours of operation and then change it again until acidity of oil becomes normal.

5. Please contact Hanbell local distributors/agents for choices of oil.

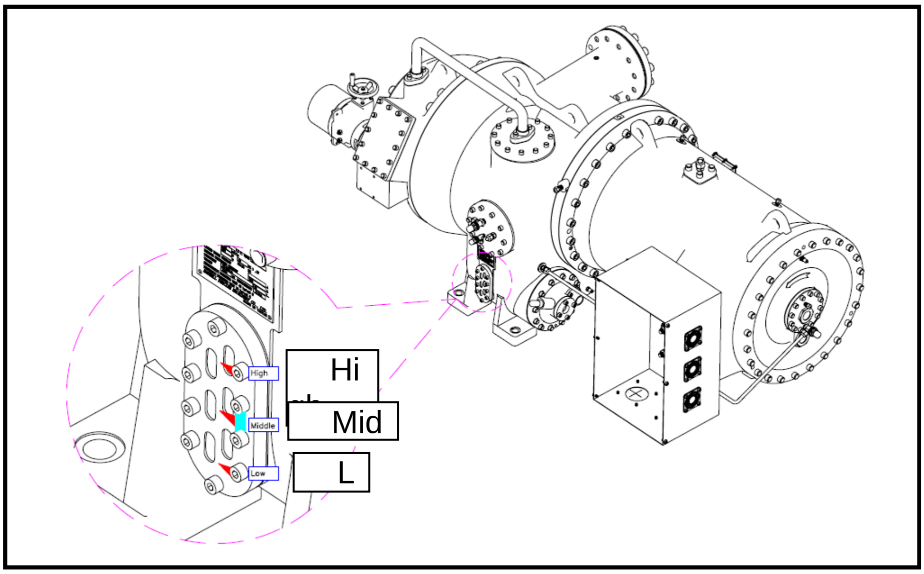


Figure 4.6Oil sight glass (Oil level)

Note: Users can refer to Figure 4.4 for charging of oil. After opening the oil separator flange, oil can be charged at the port, item16; or oil could be charged by vacuuming the angle valve, item13.

Warning：When the compressor is running, please check white floating ball inside as oil level indicator and it's recommended to maintain oil level between High and Middle; if the level is higher than High, oil must be drained to keep the level below the bottom of gears; if the level is between Middle and Low, oil return must be done or oil charge must be replenished; else if the level is lower than Low, the compressor must be stopped emergently to prevent dry wear of oil pump and bearing failure.

4.6.3 Oil change

Check oil periodically lubricant every 10,000-hour running. For the first operation of the compressor, it is recommended to change oil and the external oil filter after 2,000 -hour running. Check the system whether clean or not and then change oil every 20,000 hour or after 3-year continuous running under good condition.

Item	Maintenance(hr)	Note
Change oil and external filter	2,000hrs	After the first operation
Check oil	10,000hrs	After continuous running
Change oil	20,000 hrs or 3 years	After continuous running

Table 4.2 Maintenance for oil change

In order to avoid debris in the oil filter which may lead to bearing failure, the oil pressure differential switch is recommended to be installed. The switch will sense when oil pressure differentials between the primary and secondary sides exceeds the critical point. Then the compressor will be shut down automatically to prevent bearings from damage due to oil loss

Note1: Pressure gauges should be installed separately at P1 (the outlet of the oil pump) and P2 (the outlet of the oil filter). An oil pressure differential switch should be installed on piping in between for prevention of oil loss. (Please refer to the Figure 4.1 Schematic diagram of oil piping)

Note2: It is recommended replacing the external oil filter core after test of the chiller in the factory. Otherwise, debris might clog up the external oil filter.

Note3: It is not necessary to fill additional oil when compressor working in chiller normally. Unless there is oil carry-over or oil pumps maintenance. To fill the refrigeration oil, the oil pump should be connected to the service valve beneath compressor oil tank. (The amount of the oil should be ensured before restart the chiller.

Note4: Using refrigeration oil incorrectly, including using non-dedicated HANBELL oil, over filling, inferior quality filter, improper mesh specification and improper operation might damage the compressor. Only trained technicians are allowed to finish the maintenance work. Any proper service requirement, please contact HANBELL technicians.

Chapter 5. Motor

5.1 Motor cooling

The motor in RT series compressor is cooled by liquid refrigerant that comes from the condenser. Solenoid valves, expansion valves, or orifices should be installed on piping before the suction flange as a throttle for inflow control. In order to keep the motor temperature between30~90℃, it is estimated that heat exchange is equal to around 6~10% of motor power input for motor cooling.

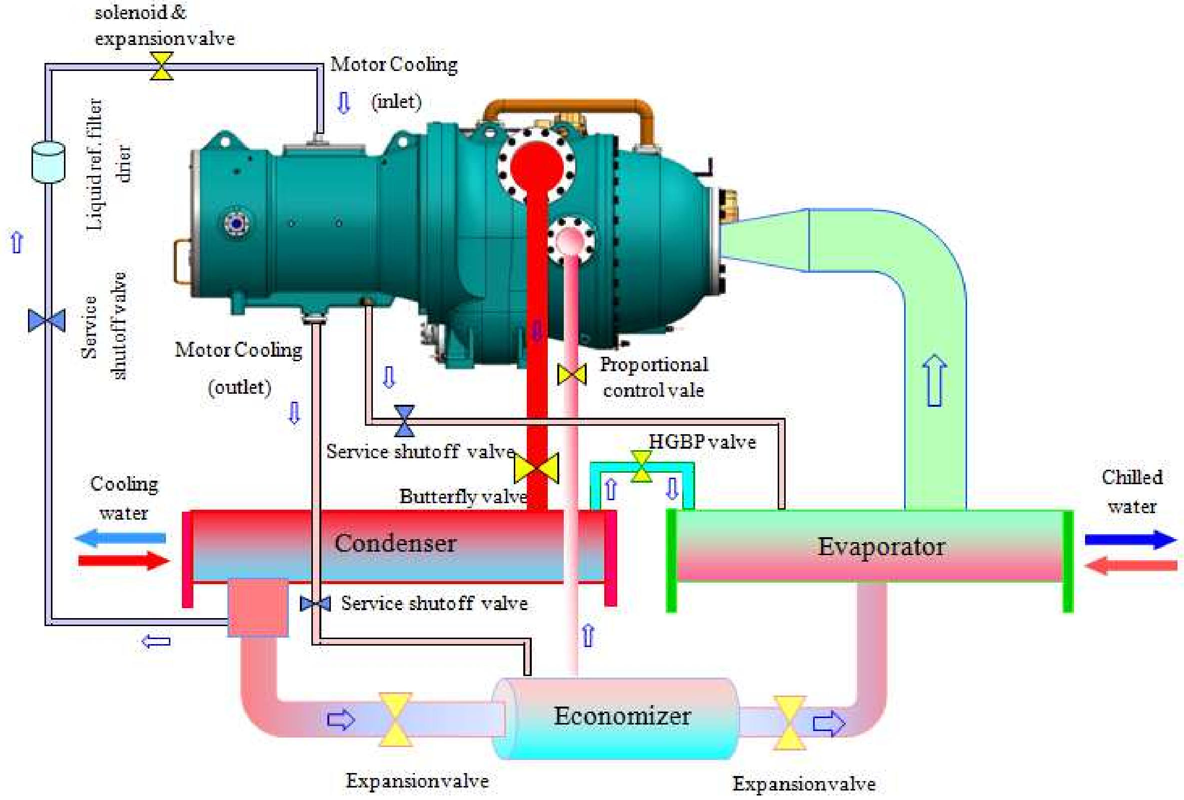


Figure 5.1Motor cooling system

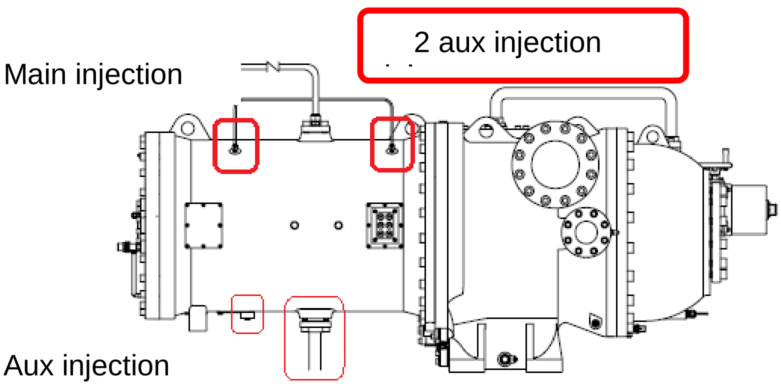


Figure 5.2 Two aux inlets for cooling

Note1: Two auxiliary injection inlets on the motor casing are the main source of motor coil cooling; please make sure both of them are connected.

Note2：Change of the two auxiliary liquid injection connectors is prohibited.

Liquid returned from motor:

In heat pump, VFD application, or low compression ratio system, the liquid refrigerant might accumulate inside the motor casing. This is because in low compression ratio condition, the pressure difference between Economizer (P_{ECO}) and motor casing (P_{motor}) is not enough to cover the pressure drops in the piping line and the liquid refrigerant could accumulate in motor casing. Auxiliary injection outlet should be connected to the evaporator to prevent possible liquid flooding.

It is a must to install the auxiliary injection outlet in the working conditions below and use angle valve to control the flow rate to the evaporator.

1.Low compression ratio: Working condition is CT-ET<15℃
2.VFD system：Operational frequency is lower than 60%~80%of rated frequency
3. Heat pump system

Single-stage compression system (Without Economizer):

In single-stage compression system, the outlet of motor injection port is connected with evaporator. The pressure in motor casing is similar to evaporating pressure and this will cause condensation on the surface and deteriorate the insulation of main power terminals. In addition, when the motor casing pressure is lower than bearing housing pressure, the lubricant will flow into the motor casing and then enter the evaporator. Therefore, it is a must to install MPV (Minimum Pressure Valve) in the main motor injection outlet pipes and make sure to keep the standard below:

$$1\text{kgf/cm}^2 \leqq \text{Motor Pressure}(P_{motor}) - \text{Evaporating pressure}(P_s) \leqq 1.5\text{kgf/cm}^2$$ 。

Temp. Sensors Pt100 or Pt1000 – for motor coil temp. monitoring

There are 4sets of Pt100 or Pt1000 temperature sensors mounted in the motor coil. Adjust flow of liquid injection to motor by temperature feedback of these sensors. Choose the highest temperature among these four sensors for controlling the motor coil temperature between30~90℃.

Note: When temperature in any set of Pt100 or Pt1000 temp sensor reaches 90℃, the controller should raise the alarm. When the temperature reaches 95℃, the compressor should stop until the cause of high temperature has been eliminated.

Tmo> 90℃alarm

Tmo> 95℃ shut down

Warning：Motor temperature after cooling should be higher than ambient temperature to prevent condensing water which might cause insulation failure of wiring terminals.

Protector connect method: 1 & 2 are PTC protector contact, A & B are concurrent, O1 is contact for 2 pairs of Pt100, C& D are concurrent, O2 is contact for the other 2 pairs of Pt100.

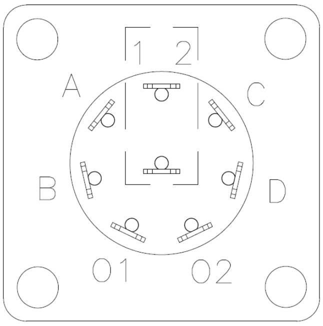


Figure 5.3 Protection terminal plates.

Specifications: Pt100 sensor

- Recommended max. meas. Current for heat coefficient <0.1K – DC1 ~ 3 mA
- Heating coefficient - 10mΩ/K
- Sensor resistance at 0℃ - 100Ω±0.12Ω
- Change of resistance 0 ~ 100℃ - 0.385Ω/K
- Insulation test voltage U is – AC 1.5kV

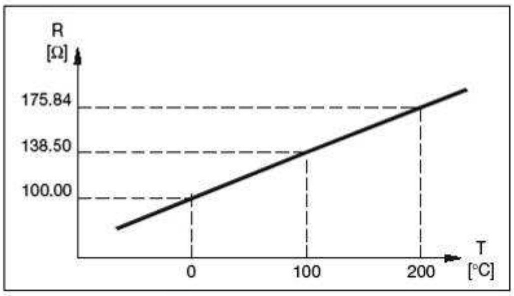


Figure 5.4Pt100 sensor

Specifications: Pt1000 sensor

- Recommended max. meas. Current for heat coefficient < 0.1K –DC0.2 ~ 2mA
- Sensor resistance at 0℃ - 1000Ω±1.20Ω
- Change of resistance 0 ~ 100℃ - 3.85Ω/K
- Insulation test voltage U is – AC 1.5kV

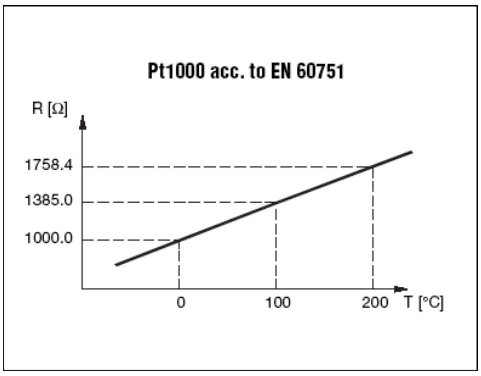


Figure 5.5 Pt1000 sensor

1. Please specify Pt100 or Pt1000 sensors when placing orders to Hanbell. In addition, all models can be equipped with Pt100 or Pt1000 sensors to precisely measure motor coil temperatures for control of motor cooling.

2. If the compressor is for high voltage or VFD application, the shielded wire need to be used in signal wire to avoid signal interferences.

5.2 Motor protector

In order to protect the compressors, the RT series compressors have been equipped with three PTC temperature sensors on the motor coil. The temperature sensors can be connected to the INT69HBY temperature control module to monitor the temperature change of the motor coil. When the coil temperature exceeds the set temperature causes PTC thermostat resistance increase and leads the INT69HBY temperature control to module trip in order to achieve protection. For the first trip, the protector will recover in five minutes, for the second trip, the protector will recover in sixty minutes. Force lock will take place if three trips occur and reset after 24 hours.

Technical data of INT69HBY

INT69HBY motor protector monitors phase loss, phase sequence, motor temperatures, and discharge temperatures with manual reset.

- Supply voltage
  AC 50/60 Hz 115/120V-15.....+10% 3VA
  AC 50/60 Hz 230/240V-15.....+10% 3VA
- Relay output
  Max. AC 240V, Max. 2.5A, C300
  min. ＞ 24V AC/DC, >20 mA
- Ambient temperatures
  -30 ~ +70 ℃
- Phase sensor
  3 AC, 50/60Hz, 200 ~ 575 V±10%

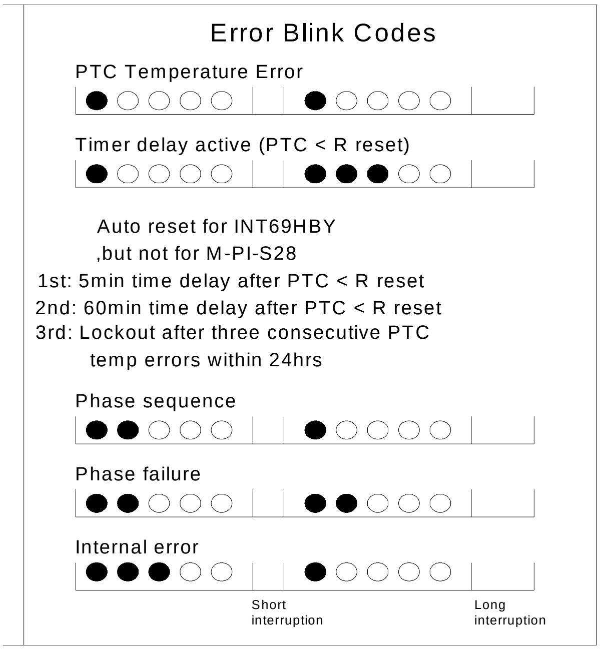


Figure 5.6Blink code of INT69HBY

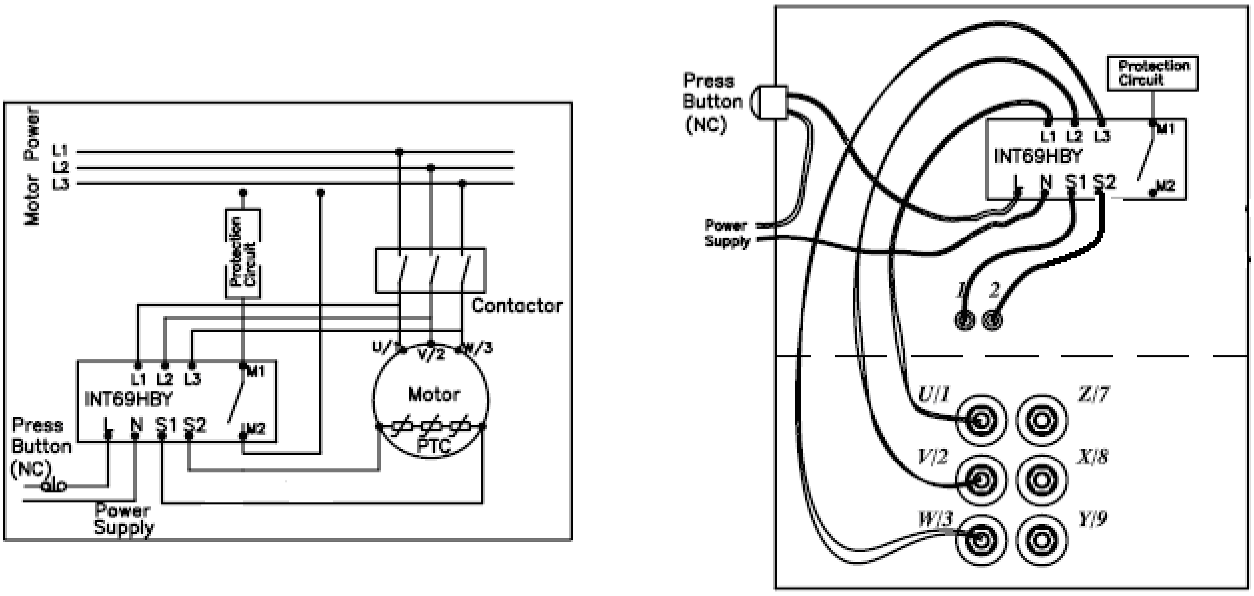


Figure 5.7 INT69HBY & PTC thermostats connection diagram

Phase loss and phase sequence

1. The phase monitoring of phase loss & phase sequence works after the motor starts 1 second (power on L1-L2-L3), and lasts 10 seconds (t_0 + 1sec to t_0 + 11sec)
2. If one of these parameters is incorrect, the relay locks out (M1-M2 is open).
3. The lockout can be cancelled by main reset of approx. 5 seconds (disconnect L-N)

Note: In order to make sure phase loss and phase sequence protection function well, please connect L1, L2, and L3 to the motor side as Figure5.6 shown.

Motor temperature

The motor temperature is constantly measured by thermostat (PTC) loop connected on S1-S2. If detected temperature exceeds setting its resistance will increase above the trip point then the output relay trips (M1-M2 is open). After cooling down below the response temperature, 5-minute delay is activated. After delay has elapsed, the relay pulls in again (M1-M2 is closed).The time delay can be cancelled by main reset of approx. 5 seconds (disconnect L-N).

Other major functional descriptions are as below:

1. After the supply voltage has been connected, a three second initialization period follows. Provide the PTC chain resistance is below the reset threshold (2.75kΩ), the relay trips after these 3 seconds have expired.
2. 1 to 9 PTC thermostats with different nominal response temperature may be connected serially to the PTC input.
3. If any thermostat resistance increases above trip level the relay drops out. This failure results in a lockout. (5 minutes delay for 1st PTC failure, 60 minutes delay for 2nd failure, lockout for 3rd failure.)
4. If a rapid temperature increase is detected (locked rotor condition), the output relay drops out. This failure results in a lockout.
5. The phase monitoring of the three phase motor voltage becomes active 1 second after motor has started, for duration of 10 seconds. In case of a wrong phase sequence or a phase failure, the relay switches of and locks.
6. The Lock-out and delay time may be lifted by cycling the power off for approx. 5 seconds.
7. To avoid nuisance tripping due to reverse running after shutdown (pressure equalization), the phase monitoring function is only re-enabled approx. 20 seconds after motor stop.
8. A dual LED (red / green) provides additional information about the motor protector and compressor status.
9. The relay is fed out as an N/O dry contact, which is closed under good conditions.
10. Sensor and supply circuits are galvanic isolated.
11. The motor protector is not suitable for application of frequency converters.

5.3 Electrical data and design

5.3.1 Motor design：Y-∆ Starting

The Y-∆ motor connects the motor coil by Y connection during starting therefore reducing voltage on coils to $1/\sqrt{3}$ of input voltage and reconnects the motor coil by Δ connection after starting. In doing so, starting current can be thoroughly decreased. It is called voltage-drop starting.

The Y-∆ motor connection method is shown in the following motor wiring diagram: In Y connection, MCM, MCS are inductive while the motor leads Z, X, Y are tied together as neutral connecting as letter Y. After timer set period (till peak value decreases), MCM, MCS become deductive. Around 0.25 sec later, MCM, MCD are inductive, they turn out Δ connection.

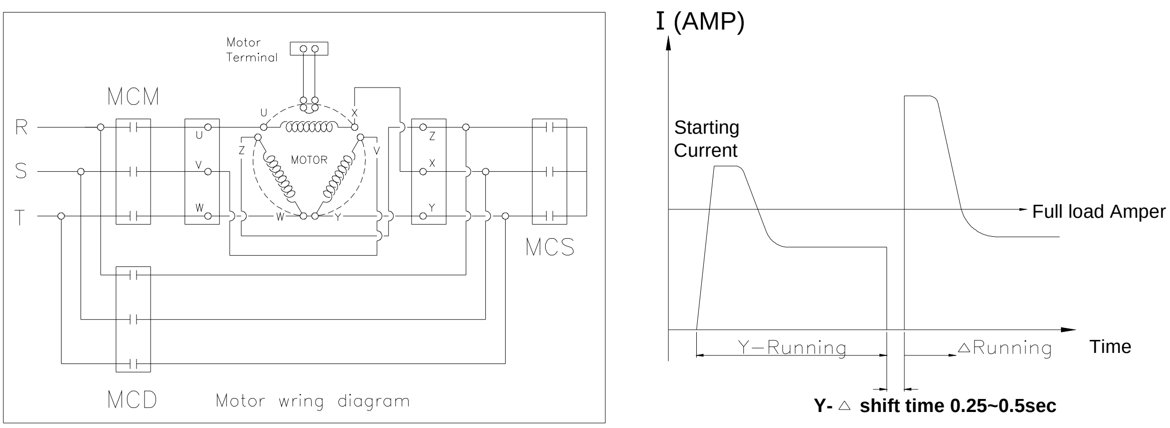


Figure 5.8Y-∆ starting diagram

Attention : After Y start, MCM & MCS are deductive for 0.25sec and then MCM & MCD are inductive for∆ run. Within transient 0.25sec, a pseudo short circuit might occur due to inappropriate action of contactors then causing compressor trip. When it occurs, we recommend you use adjustable Y-∆ timer to lengthen the time span for MCM, MCS deduction - MCM, MCD re-induct from 0.25sec to 0.5sec directly in the micro controller or the PLC program. Please refer to Y-∆ shift time diagram for details. Because the motor is not powered during Y-∆ shift. A shorter Y-∆ shift span is suggested to prevent the second start due to decreasing rotation speed. However, if the Y-∆ shift span is too short, the aforementioned pseudo short circuit might occur.

5.3.2 Characteristics of Starting

●Y-Δ

1. Starting current in Y connection is 1/3 of lock rotor ampere.
2. Starting torque in Y connection is 1/3 of lock rotor torque.
3. Acceleration of the motor rotor becomes smaller at full-load starting. Therefore compressors require starting at partial load (=Actuator 0%).

● Soft-start features

1. Starting current is 3 times higher of rated current ampere.

2. Soft-starter could set up the starting time, longer the starting time, less the ampere it has. For more details, please refer to technical documents of each manufacturer.

●Direct start
1. When the high voltage motor adopts full voltage starting, the starting current is about 6~7 times of the motor rated current.

●Step-down start
1. High voltage motor could operate with high voltage step-down transformer. Any technical advice, please contact Hanbell.

5.3.3 Motor design：Direct on line start/soft start/inverter start

RT series compressors with high voltage motors can start by direct start as below shown.

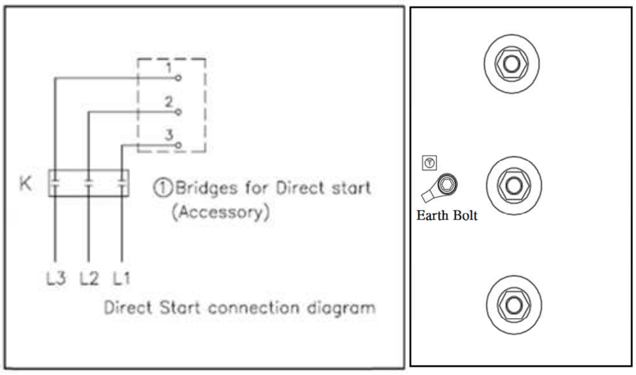


Figure 5.9 Wiring for high voltage

RT series compressors with low voltage motors can start by Y-Δ start, soft start and inverter start as below shown.

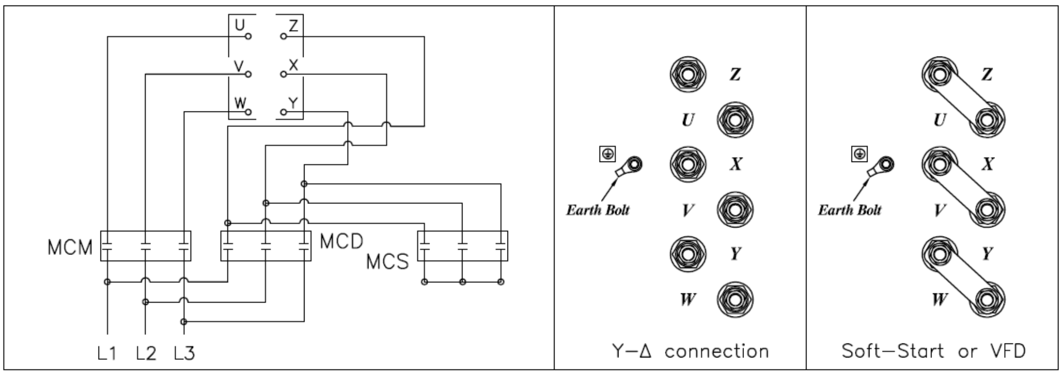


Figure 5.10 Wiring for low voltage

Note: In case of soft start and inverter start, bridges must be installed for wring of the same phase to prevent current imbalance.

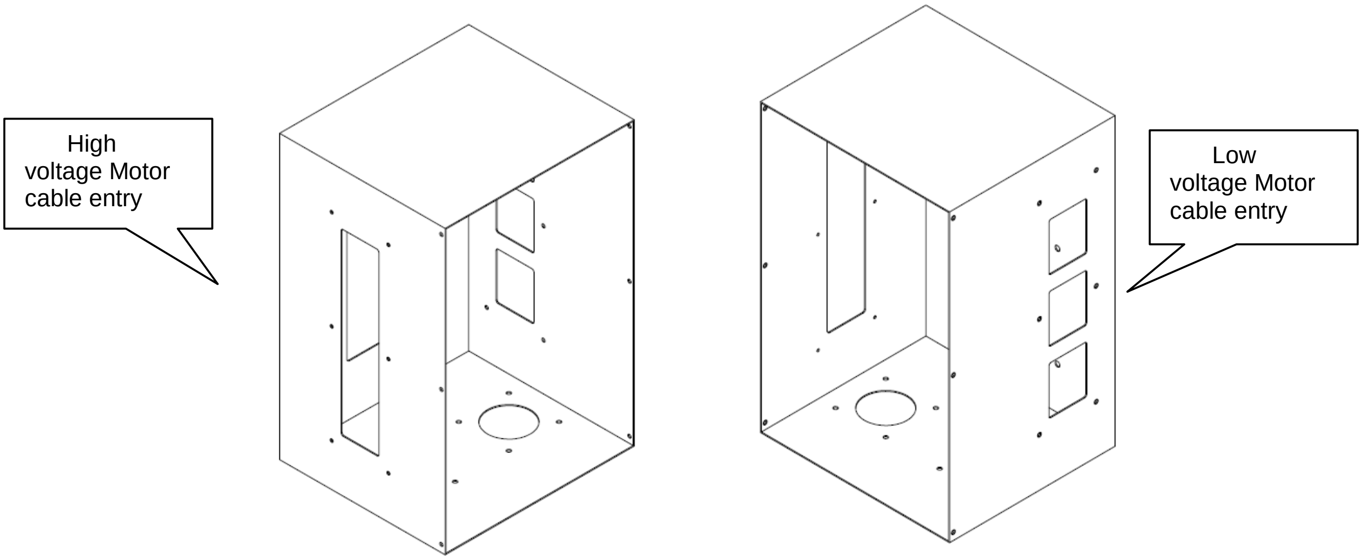


Figure5.11Cable inline location diagram

Warning：High voltage wiring entry should not take the entry of low voltage cable wiring. When taking the low voltage cable entry, the magnetic induction produced among phases will cause heat to the wiring box. Both entrances are applicable for low voltage wiring.

5.3.4 MCC & LRA

Low voltage(Y-△)

Modle	50Hz						60Hz					
	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)
RT-120(E,T) RT-130(E,T) RT-140(E,T) RT-111	A	310	380	543	760	3,320	A	310	380	540	757	3,450
			400	511	716	2,870			575	356	499	2,090
			415	493	690	3,005		312	440	467	654	2,785
									460	448	627	2,945
									480	429	601	2,615
	B	360	380	626	876	3,780	B	360	380	625	876	4,195
			400	597	836	3,330			575	413	578	2,445
			415	576	807	3,510		372	440	557	780	3,555
									460	535	749	3,760
									480	510	714	2,935
RT-160(E,T)	A	410	380	720	936	4,680	A	410	380	721	938	4,665
			400	687	894	4,130			575	479	623	3,165
			415	667	868	4,355			440	621	808	3,925
									460	600	780	4,185
									480	564	734	3,560
	B	520	380	903	1,174	5,940	B	520	380	907	1,180	6,005
			400	861	1,119	4,825			575	596	775	3,915
			415	830	1,080	5,085		570	440	856	1,113	5,355
									460	823	1,070	5,680
									480	785	1,021	4,795
RT-240(E) RT-221	A	620	380	1,078	1,401	6,665	A	620	380	1,079	1,403	7,290
			400	1,030	1,339	5,710			575	717	933	4,375
			415	998	1,298	6,035		624	440	934	1,214	5,805
									460	895	1,163	6,160
									480	860	1,118	4,930

Modle	50Hz						60Hz					
	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)
RT-180(E,T) RT-161	A	475	380	829	1,078	5,485	A	475	380	828	1,077	5,465
			400	787	1,023	4,685			575	550	715	3,505
			415	760	988	4,920		492	440	742	965	4,565
									460	714	929	4,835
									480	686	893	4,225
	B	620	380	1,078	1,401	6,665	B	624	380	1,079	1,403	7,290
			400	1,030	1,339	5,710			575	717	933	4,375
			415	998	1,298	6,035		624	440	934	1,214	5,805
									460	895	1,163	6,160
									480	860	1,118	4,930
RT-200(E,T)	A	520	380	903	1,174	5,940	A	520	380	907	1,180	6,005
			400	861	1,119	4,825			575	596	775	3,915
			415	830	1,080	5,085		570	440	856	1,113	5,355
									460	823	1,070	5,680
									480	785	1,021	4,795
	B	720	380	1,255	1,632	6,985	B	720	380	1,251	1,626	7,960
			400	1,189	1,546	6,845			575	826	1,074	4,610
			415	1,151	1,496	7,185		744	440	1,112	1,446	6,455
									460	1,069	1,390	6,850
									480	1,029	1,337	5,805
RT-260(E) RT-280(E)	A	720	380	1,255	1,632	6,985	A	720	380	1,251	1,626	7,960
			400	1,189	1,546	6,845			575	826	1,074	4,610
			415	1,151	1,496	7,185		744	440	1,112	1,446	6,455
									460	1,069	1,390	6,850
									480	1,029	1,337	5,805

Table 5.1 MCC&LRA of low voltage models

Note：Cooler standard equipment Motor A, able to operate the maximum load condition is about CT / ET = 40/13 ℃, the heating machine operating condition is about CT / ET = 52/14 ℃, a slightly different from the actual horsepower during the motor design. The actual maximum continuous operation current (MCC) should be in accordance with the above table. When the actual operating conditions of the unit exceeds the MCC value, please use Motor B and state for Motor B on the purchasing order instead.

Caution1.This table stated rated current and LRA for Motor design performance are not referring to the compressor operating rated current.

Caution2.The value of MCC in this table is related to the maximum temperature rise (90 ° C) of the Motor and is irrelevant to motor power (size). Therefore, a voltage drop in the power supply will cause motor temperature rise (refer to 4 Motor Coil Temperature Sensor Pt100 or Pt100 Description).

High Voltage (Direct)

Modle	50Hz						60Hz					
	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)
RT-120(E,T)	A	330	6kV	38	45	215	A	330	3.3kV	69	83	443
			10kV	23	27	154			4.16kV	54	65	381
									6.6kV	34	41	231
									11kV	20	24	140
	B	440	6kV	50	60	322	B	440	3.3kV	91	109	636
			10kV	30	36	217			4.16kV	71	86	485
									6.6kV	45	54	303
									11kV	27	32	199
RT-130(E,T) RT-140(E,T) RT-111	A	360	6kV	41	49	254	A	360	3.3kV	75	90	526
			10kV	25	30	177			4.16kV	59	71	446
									6.6kV	37	45	256
									11kV	22	27	160
	B	440	6kV	50	60	322	B	440	3.3kV	91	109	636
			10kV	30	36	217			4.16kV	71	86	485
									6.6kV	45	54	303
									11kV	27	32	199
RT-160(E,T)	A	440	6kV	50	60	322	A	440	3.3kV	91	109	636
			10kV	30	36	217			4.16kV	71	86	485
									6.6kV	45	54	303
									11kV	27	32	199
	B	520	6kV	58	70	362	B	520	3.3kV	107	128	722
			10kV	35	42	249			4.16kV	84	101	595
									6.6kV	53	63	341
									11kV	31	38	228
RT-180(E,T) RT-161	A	520	6kV	58	70	362	A	520	3.3kV	107	128	722
			10kV	35	42	249			4.16kV	84	101	595
									6.6kV	53	63	341
									11kV	31	38	228
	B	620	6kV	69	83	417	B	620	3.3kV	126	152	812
			10kV	41	50	256			4.16kV	100	120	650
									6.6kV	63	75	394
									11kV	37	45	233
RT-200(E,T)	A	560	6kV	63	76	430	A	560	3.3kV	115	138	418
			10kV	38	46	263			4.16kV	91	109	628
									6.6kV	57	68	365
									11kV	34	41	240
	B	720	6kV	80	97	473	B	720	3.3kV	146	175	924
			10kV	48	58	296			4.16kV	116	139	764
									6.6kV	73	87	470
									11kV	43	52	273

Modle	50Hz						60Hz					
	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)	Motor	Power (kW)	Voltage (V)	Rated current(A)	MCC (A)	LRA (A)
RT-240(E)	A	660	6kV	73	88	440	A	660	3.3kV	136	163	917
			10kV	44	53	253			4.16kV	106	127	675
									6.6kV	67	81	445
									11kV	40	48	230
	B	820	6kV	92	110	668	B	820	3.3kV	168	202	1,235
			10kV	54	65	342			4.16kV	132	158	952
									6.6kV	83	99	591
									11kV	49	59	314
RT-260(E) RT-280(E)	A	720	6kV	80	97	473	A	720	3.3kV	146	175	924
			10kV	48	58	296			4.16kV	116	139	764
									6.6kV	73	87	470
									11kV	43	52	273
	B	900	6kV	100	121	681	B	900	3.3kV	182	218	1,269
			10kV	60	72	369			4.16kV	145	174	1,016
									6.6kV	91	109	629
									11kV	54	65	338
RT-221	A	720	6kV	80	97	473	A	720	3.3kV	146	175	924
			10kV	48	58	296			4.16kV	116	139	764
									6.6kV	73	87	470
									11kV	43	52	273
	B	820	6kV	92	110	668	B	820	3.3kV	168	202	1,235
			10kV	54	65	342			4.16kV	132	158	952
									6.6kV	83	99	591
									11kV	49	59	314
RT-301	A	960	6kV	107	129	748	A	960	3.3kV	194	233	1,348
			10kV	63	76	407			4.16kV	154	184	1,096
									6.6kV	97	116	692
									11kV	57	69	373
	B	1,100	6kV	123	147	802	B	1,100	3.3kV	222	267	1,547
			10kV	74	89	502			4.16kV	176	212	1,178
									6.6kV	111	133	743
									11kV	66	79	456

Table 5.2 MCC&LRA of low voltage models

Note：Cooler standard equipment Motor A, able to operate the maximum load condition is about CT / ET = 40/13 ℃, the heating machine operating condition is about CT / ET = 52/14 ℃, a slightly different from the actual horsepower during the motor design. The actual maximum continuous operation current (MCC) should be in accordance with the above table. When the actual operating conditions of the unit exceeds the MCC value, please use Motor B and state for Motor B on the purchasing order instead.

Caution：1. This table stated rated current and LRA for Motor design performance are not referring to the compressor operating rated current.

Caution：2. The value of MCC in this table is related to the maximum temperature rise (90 °C) of the Motor and is irrelevant to motor power (size). Therefore, a voltage drop in the power supply will cause motor temperature rise (refer to Motor Coil Temperature Sensor Pt100 or Pt100 Description).

5.3.5 Grounding

Grounding point in electric system normally is a neutral point. 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 recommends to ensure the grounding during installation.

Suggestion:

a. Dedicated M12 grounding screw (instructed in terminal box) should be reliably connected with grounding wire.

b. Metal sheath of power cable, palpable threading pipe, cable metal trucking, and cable trays should be grounded.

c. Metal sheath of armored control cable, non-armored or non-metallic sheathed cable should be grounded.

d. Power cable grounding wire should use copper wire or tinned copper braided wire, and the cross-sectional area should follow below table:

Power cable (mm2)	Grounding wire(mm2)
120 and lower	16
150 and higher	25

Note：Resistance of grounding should not be higher than 8Ω.

5.3.6 Insulation for high voltage main terminals

5.3.6.1 Method 1:

After checking the phase sequence and the rotation direction of the motor, insulation work must be done on main terminals for voltage higher than 6000V.

MATERIALS:

1. LOCKTITE Cleaning liquid
2. 3MSCOTCHFIL gray electrical insulation materials
3. 3MSCOTCHKOTE paints
4. Plastic insulation tapes

HANBELL will not provide the materials above because all of them can be sourced locally.

Steps：

1. Shut down the power of the compressor.
2. Clean the dust, water, and oil on terminals by cleaning liquid.
3. Apply 3MSCOTCHFIL gray electrical insulation materials on the joint parts to make it smooth.
4. Apply 3MSCOTCHKOTE paints on the ceramic parts of power bolts up to 1/2”position. Apply 3MSCOTCHKOTE on the power bolts where gray electrical insulation materials had been applied and the on cable for 10”long from power bolts. Then, apply SCOTCHFIL gray electrical insulation materials on the surface again.
5. Use plastic insulation tapes to stick the whole painting layers.
6. Use 3MSCOTCHKOTE paints again for moisture prevention

5.3.6.2 Method2:

Use Hanbell RITA- CBTM 2050 Heat shrinkable tube and insulate the wiring terminals with for voltage higher than 6000V.

Materials：

1. High voltage insulation tapes
2. RITA- CBTM 2050 Heat shrinkable tube
3. Heating by blowlamp

Steps:

1. Put heat shrinkable tube into high voltage cable and tighten R type clip based on regulation.
2. Move pre-inserted heat shrinkable tube to proper position (The heat shrinkable tube should cover more than 30mm of white ceramic part of the terminal, and the cable and terminal joint part is not allowed to be exposed.)
3. Use blowlamp to heat up heat shrinkable tube to make the surface becomes tight. (Heating temperature is above 110°C) 。

4. Use high voltage insulation tapes to wrap both side of heat shrinkable tube to prevent it from moisture (As figure 35 below) 。

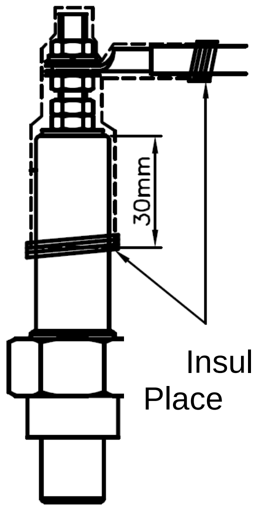


Figure 5.11Heat-Shrink Tube Diagrammatic Sketch for Covering

5.3.7Protective measures of electric shock

To prevent electric shock accident, compressor operating under electrified condition or electrified while shutting down, please follow the protective measure:

1. Around electrified part should place mark of awareness like “HIGH-VOLTAGE, DANGER”.
2. Using railing and partition to prevent unconscious personnel get close to electrified area. Barriers do not required to be locked, but need to be set and cannot be moved unconsciously.
3. Establishing protective fence surrounding the compressors and the units with 1.5m safe distance to prevent direct contact of electrified device.

Suggestion:

1. Regular setting of leakage protection should higher than 50mA, in humid region, 25mA will be more proper.
2. Terminal connecting voltage should not larger than 50V, in humid region: 25V.
3. Grounding resistance should not larger than 500Ohm.
4. Air cut board (ACB) normally placed with leakage breaker; please refer to relative operating setting.
5. Once leakage breaker launched, please check if the insulation of every device and wiring setting are correct, Please launch the system after check. Please contact device supplier of there is any problems.

Note:

1. Between motor casing and ground, resistance = 0Ω, potential difference = 0V.
2. Between device casing and ground, resistance = 0Ω, potential difference = 0V.
3. Between drive and device casing, resistance = 0Ω, potential difference = 0V.

5.4 Compressor Electrical and Safety Practices

5.4.1 Electrical Safety Precautions:

1. Once connected to the compressor, the power supply of the voltage would get very dangerous. Only qualified electricians and electrical engineers are allowed to the work installation. It shall be in strict accordance with the manual operation of the program as well as national regulations and safety codes before installation.
2. Users and installers shall be in accordance with the National Electrical Code as standard to provide grounding and install a protective circuit.
3. Before performing any maintenance operation, make sure the power switch is turned off to avoid accidents.
4. Before normal operation of the compressor or unacknowledged power is off, do not open the compressor terminal box to avoid danger.
5. After confirming the direction of rotation of the motor while the terminal without insulation protection, make sure to stay away from the compressor and assembling unit, to avoid the risk of electric shock.
6. When doing compressor maintenance work, inspection or parts replacement, it is a must to cut off the main power supply to the terminal discharge in order to avoid the risk of electric shock.

5.4.2 The Inspection and Preparation before Electrical Wiring

5.4.2.1 Inspection of Unpacking

1. All compressors have been passed the strict test by Hanbell. Users are unauthorized to disassemble to inspection, if necessary, please contact Hanbell Company.
2. Check the motor terminal box of compressor firstly when unpacking if there is damage, collision or deformation.
3. After first or a long time running, when compress start-up, it must uses DC2500V meg - ohmmeter to measure motor terminal box of the main terminal and the chamber cold insulation resistance test, the insulation value shall not less than the value determined by the formula as followed.

$$R=\frac{U_N}{1000+\frac{P_N}{100}}$$

In the formula: R — Motor Winding Insulation of Resistance (MΩ)
UN — Rated Insulation Voltage (V)
PN— Motor Power Rating (KW)

When the motor is damp or the insulation resistance is lower than the calculated values, it shall take action of drying motor stator, drying temperature must not exceed 120 ℃.

NOTE: Hanbell compressor has been test passed by national standards withstanding voltage testing. Users and installation contactor are not allowed to do the testing. If necessary, please contact with Hanbell Company.

5.4.2.2 Cable Selection:

1. Selection of high-voltage cables shall comply with IEC183 and DL401 "high voltage cable guide for the selection" standard.
2. Low voltage cable should meet the IECA S-19-81standard, 600V insulated wire, insulation-Haipa Dragon (Hypalon).
3. 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 requirements for use.
4. Location-site installation wiring and cable wires on-site installation of each device must be without prejudice to the vicinity of the device readings, adjustor repair any part of the operation.
5. Any damage to the installation were to incorrect wiring between the starter and the compressor caused responsible.

5.4.3 Power Wiring Detail:

5.4.3.1 Caution for wiring

a. Verify the nameplate ratings are compatible with the power supply characteristics and the electrical data on the nameplate. Use copper conductors to connect to power supply.
b. High voltage cable must fulfill national regular and standard.
c. User and contractor are not allowed to change the shape and dimension of cable box.
d. The material of armature terminal is brass; therefore armature terminal cannot stand the weight of high voltage cable. Installer must apply external cable shelve or tension-ease device to stand the high voltage cable. HANBELL will not provide wiring terminals.
e. 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 5.2. And elastic wire is required to make the maintenance easier and decrease transmission of vibration.
f. When tightening the cable connector of armature terminal (tighten bolt A&B), use torque wrench with the torque lower than 700kgf-cm (5/8” & 9/16” copper nut). Please refer to the figure 5.12.
g. Cable wiring and construction inspection rules must follow GB50168-92.

600V Hypalon cable (*1C)			
Area of section (mm^2)	Maximum permissible current (A)	Area of section (mm^2)	Maximum permissible current (A)
50	200	150	410
60	230	200	500
80	280	250	570
100	330	325	670
125	370	400	760

Table 5.2

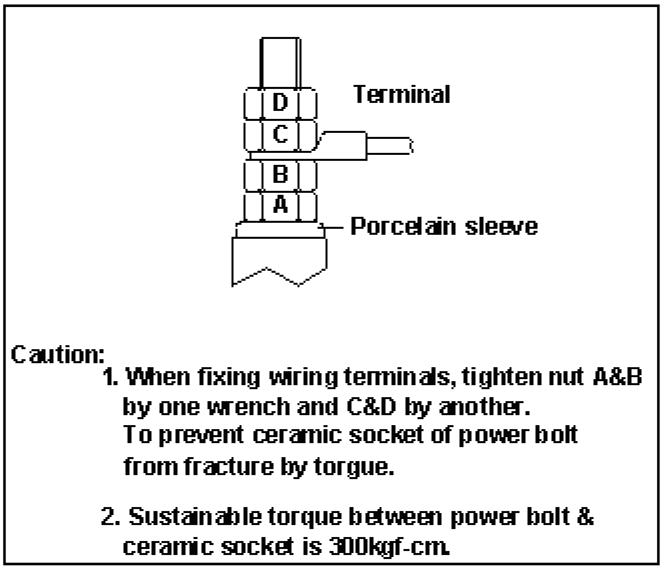


Figure 5.12 Connection of power bolts and terminals

5.4.3.2 Making of cable end and the connector

The making of cable end and the connector must be conducted by experienced personnel and follow working rules.
When making cable end and connector with the voltage higher than 6Kv outside, the Relative Humidity (RH %) must be around 70%. When relative humidity is high, heathen ambient temperature or cable.
When making plastic insulation cable end and connector, avoid the dust falling into the insulation and do not process during the fog or raining days.

Please follow the requirements below:

1. Type and specification must follow the cable type e.g. voltage, core numbers, protection layers, and environment.
2. The structure must be easy, compact for installation.
3. Materials and parts must meet the technical requirement.
4. Performance must follow current national standard.

The insulation materials should be not only aligned with demands, but also compatible with cable insulation. Hardness, expansion coefficient, tensile strength, and breaking extension of these two materials must be similar. Rubber insulation cable must apply high viscosity and elasticity materials as additional insulation.

When connecting core and amour clamp, must apply standard connecting tube and wiring, the inner diameter must be compatible with core and the intersecting surface must be 1.2~1.5 bigger than the intersecting surface of core. When press bond, coaxial cable press pliers and mold must meet the specification requirement.

Working Inspection：

Before making the end of cable and connector, must be familiar with working information for installation, ensure the inspection procedure, and meet the demands below:

1. Ensure the insulation of cable is in good condition without damping, and no moisture is allowed inside the plastic cable. Test the electronic performance which must be aligned with the standard.
2. The specification of accessories must be the same with cable, no injury parts, no damping of insulation materials, and sealing materials must work. Assemble

accessories of casing structure firstly, and the cleaning of inner tube, testing for the sealing, and dimension of structure must align with the requirement.

3. Working machine must be well prepared, easy to be operated, in clean condition, spare part are well prepared, and the solvent to clean the plastic insulation on the surface must follow working rules.
4. Testing the assembling if necessary

Requirement for cable processing:

When making wiring terminal and connector with starting from cutting the cable until finishing, shortening the insulation exposure lead-time is the must. When cutting the cable, do not injure core of conductor and preserved insulation layer.

When the fueling cable is inserted with cable, make the connector firstly, and if there are position difference, make the lower byte connector firstly.

The end of cable and connector must be insulated properly, sealed for damp-proof, and mechanical protection.

For the cable with the power higher than 6kV, the positive procedure to improve screened part of cable for central integration is the must and ensures the distance between terminals insulation and grounding insulation.

Wire terminal lugs

a. Use and size proper crimp type wire terminal lugs in the jobsite.
b. The main power bolt specification is M16. Electricity distribution should be performed by professional electrician to select the appropriate terminal diameter.
c. Use copper washers on power bolt connections.
d. Tighten each bolt by 300kgf-cm torque force
e. These connections should be under supervision of a qualified electrical engineer in compliance with NEC or local guidelines

AWG	mm^2	N	AWG	mm^2	N
30	0.05	6.7	3	26.670	712
28	0.08	8.9	2	33.620	801
26	0.13	13.4	1	42.410	890
24	0.2	22.3	1/0	53.49	1112.5
22	0.324	35.6	2/0	67.43	1235
20	0.519	57.9	3/0	85.01	1557.5
18	0.823	89	4/0	107.2	2002.5
16	1.310	133.5	250	127	2225
14	2.080	222.5	300	156	2447.5
12	3.310	311.5	350	177	2670
10	5.261	356	400	203	2892.5
8	8.367	400.5	500	253	3560
6	13.300	445	600	304	4005
4	21.150	623	700~2000	355~1016	4450

Table 5.2 Pull-out force of crimped connections

Note:

1. Refer to UL-486A for pull-out force standard of crimped connections.

2. Ensure power supply wiring and output motor wiring are connected to the proper terminals. Failure to do so will cause catastrophic failure of the motor.

5.4.4 Limitation of power supply

a. **Voltage limitation** b. **Frequency:**
1. Long term running: Low voltage±5%; High voltage±2%1. Rated frequency±2%
2. Instant running: Low voltage±10%; High voltage±4%
3. Unbalanced: Low voltage±3%; High voltage±2%

Power of some areas is unstable. Install an additional voltage protector with mentioned voltage limitation above to ensure safe operation of the compressor.

1. Unbalanced voltages :

Unbalanced voltages occur because of variations in load. When load on one or more of the phases are different from the other(s), unbalanced voltages will appear. This can be due to different impedances, type, and value of load on each phase. Unbalanced voltages can cause serious problems, particularly for the motor.

National Electrical Manufacture Association (NEMA) defines voltage unbalance as below:

$$\text{Percentage of unbalanced voltage} = 100 \times \frac{\text{maximum voltage deviation from average voltage}}{\text{average voltage}}$$

NEMA states that poly-phase motors shall operate successfully under running conditions at rated load when unbalanced voltage at the motor terminals does not exceed 1%. Furthermore, operation of a motor under above 5% unbalanced condition is not recommended. It probably results in motor damage.

Unbalanced voltages at motor terminals cause unbalanced phase current. This causes excessive heat to shorten motor life. If unbalanced voltage is too high, thereduced torque capability might not be adequate for the application and the motor will not attain rated speed and.

Some more common causes of unbalanced voltages are:
- ●Unbalanced utility supply
- ●Unequal transformer tap settings
- ●Transformer failure
- ●Open delta connected transformer banks
- ●Large single phase distribution transformer in the system
- ●Heavy reactive single phase loads such as welding machine
- ●Open phase on the primary of a 3-phase transformer in the distribution system
- ●Blowout fuse on the 3-phase bank of power factor improvement capacitors
- ●Unequal impedance in conductors of power supply wiring
- ●Unbalanced distribution of single phase load, such as lighting

A 3-phase unbalanced voltage protector is an optional accessory. Please contact Hanbell for more details.

Chapter 6 Compressor lifting and installation

6.1 Compressor lifting

After the compressor arrives at the warehouse, check the crate if it is in good condition and check all compressor accessories with shipping documents to see if there is any discrepancy.

Each HANBELL centrifugal compressor has been fully tested at the factory and all precautionary measures have been taken to make sure the compressor is in perfect condition during working. When lifting the compressor, it is recommended to use a steel chain, a steel cables as shown in the Figure 6.1as below, or a safety rope, which have loading capacity of 5,000kgf.

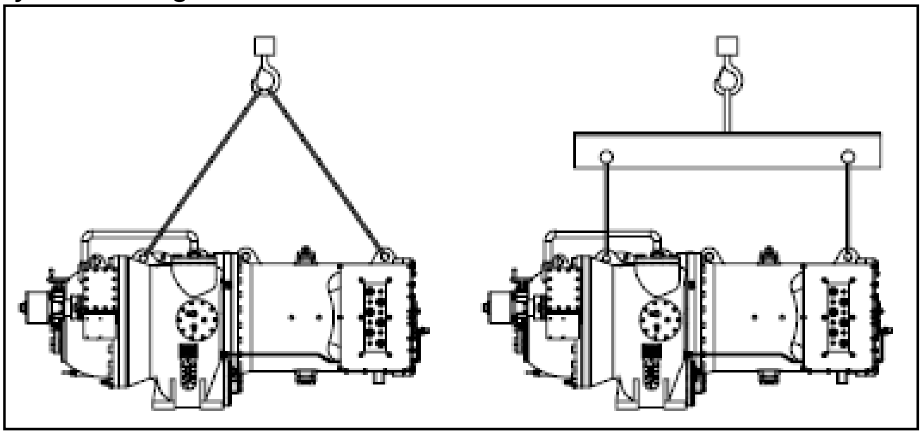


Figure 6.1 lifting the compressor with a steel chain or a steel cable

Make sure that the steel chain, steel cable, safety rope or other lifting equipment is properly positioned to avoid damage to the compressor and its accessories. Keep the compressor in a horizontal position when lifting to avoid crashing on the ground, hitting on the wall or any situation that may damage it and its accessories.

6.2 Compressor mounting

The position of the compressor in the refrigeration system should be accessible and makes sure that the chiller base or site is far enough from any heat source to prevent heat radiation. The compressor should also be installed as closer as possible to the power supply for easier connection. It is a must to keep good ventilation and low humidity condition in the site. Make sure that the supporter is strong enough to prevent vibration and noise while the compressor is operating.

The compressor must be installed horizontally. In order to prevent vibration when operating, cushions or mounting pads should be installed. The installation of mounting pads is shown in the Figure 6.2below. The tightening of bolt should still keep certain deformation tolerance on rubber pad.

※It is strongly recommended the position of the compressor is higher than the evaporator, and the compressor mounting pad is higher than the economizer refrigerant level (Figure 6.3).

※Please make sure to lock the mounting of the front side and back side, and it is no need to lock the mount in the middle shown in figure 6.2 below.

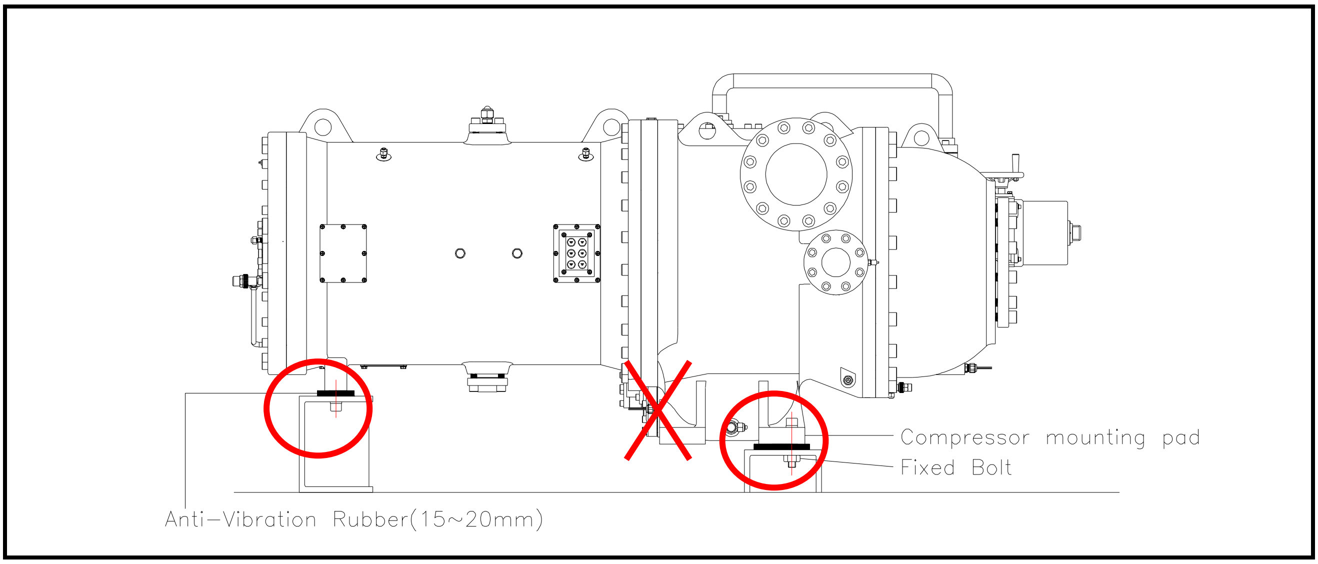


Figure 6.2 Installation of mounting pads

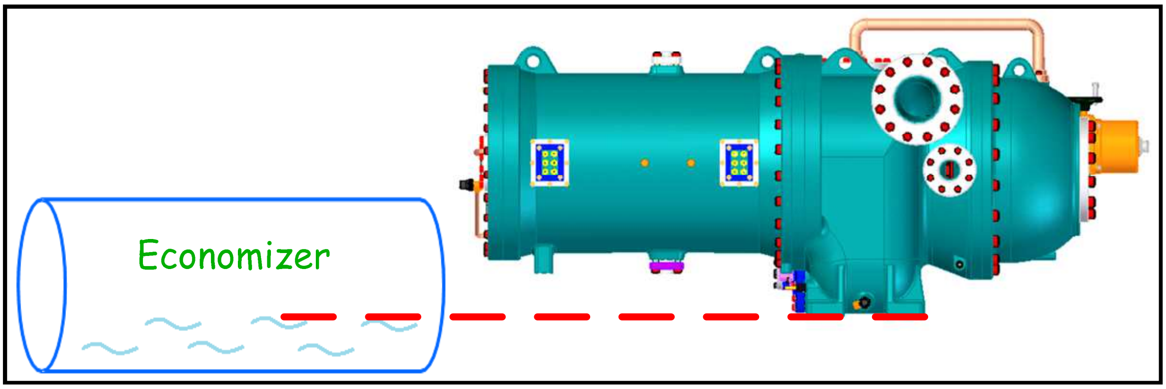


Figure 6.3 Installation of Economizer

Note1: It is suggested position of compressor should be higher than evaporator, and the compressor foot base should be higher than economizer liquid level (as figure 6.3) to prevent pressure loss of liquid return,
Note2: Compressor fixed bolts are required for 2 side of compressor. The middle one is not necessary.

6.3 Compressor protection device

Protection devices as below table are basic configuration (depends on the order). Must build up protection setting as this security requirement. You shall take their own risk if changes the setting without our permission.

Compressor device	Setting point	Note.
Compressor motor protector (PTC sensor)	Trip temp.:110℃, Return temp.:100℃	Standard
Reverse phase protection (protector INT69HBY)		Standard
phase failure protection (protector INT69HBY)		Standard
Oil filter pressure difference switch	Trip pressure: 1.5kg/cm^2	Optional
Motor temp. sensor Pt10/Pt1000(motor liquid injection usage)	Temp. control 30~90℃	Standard

- Manual reverse setting(recommended):

As compressor protection device. Compressor motor coil protection and compressor discharge temperature must connect with INT69HBY connector. In case it can react immediately when the temperature tripped. And set up the guiding light on control box. Turning on the compressor at shorted circuit to bypass protection module is not allowed, and Hanbell is not responsible for the damage.

6.4 Compressor accessories

Hanbell designs complete standard and optional accessories according to various application requirements for safe and steady operations well as the best performance.

● : Standard, ∆ : Optional

Accessory	RT
Suction/Discharge flange	●
Economizer flange	●
INT69HBYmotor protector	●
IP54 terminal box	●
Refrigerant heater(300W*2)	●
Oil heater(500W*2)	●
Oil drain valve	●
Motor PTC	●
Motor temperature sensor(Pt100 or Pt1000)	●
Oil tank temperature sensor(Pt100 or Pt1000)	●
Discharge temperature sensor(Pt100 or Pt1000)	●
Lubricant	●
External oil filter	△
Oil cooler(5RT)	△
Oil pressure differential switch	△
Mounting pad	△
Actuator heater	△
Ejector	△
Discharge valve	△

Table 6.1 Spare parts (Standard/Optional)

Note: The accessory chart is for purpose only. Actual specification and accessories enclosed might vary with different quotation and agreement respectively. If any optional accessory is required and out of above mentioned standard accessories, please contact Hanbell for detailed specification and quotation.

6.5 Operation and maintenance

6.5.1 Compressor start-up

The table below shows the required procedures and points before commissioning the compressor.

Items	Check Points	Remarks
Leakage test	1. Inject 13.5 bar of nitrogen. 2. No leakage within 12 hours. 3. Mark the confirmed pressure on the pressure gauge.	1. Close the service valve on the evaporator
Vacuum test	1. Vacuum pressure should below 750mmHg. 2. Maintain the vacuum state for 12 hours and confirm whether the degree of vacuum has changed or not.	1. High pressure gauge must be closed (no vacuum scale). 2. Do not conduct electrical testing under vacuum state.
Lubricant oil refilling	1.Use vacuum method and the angle valve on the return flange of compressor for filling lubricant oil 2. Fill the oil until oil display at H scale. Verify the oil level and refill (if necessary) after commissioning 3.Remove the wiring of the built-in oil pump to avoid malfunction of the oil pump due to insufficient oil which will result in damage to the oil pump 4.The oil heater should be powered on 24 ~ 48 hours before compressor started to ensure oil temperature is above "evaporation temperature " + 20 ℃"	1. The oil level should not be higher than the H scale on the oil display to avoid agitating the oil when the gear rotates. 2. Determine the lubricating oil heating time on condition like under high latitude or cold area.
Refrigerant refilling	1. Confirm whether the chilling water pump and the cooling water pump are running before refrigerant filling. 2. Firstly add the gaseous refrigerant to above saturation temperature 0 ℃. 3. Fill the gaseous refrigerant to 2bar (g) after connecting the oil pump power. 4. Then charge the liquid refrigerant to 80% of the standard amount.	1. Record the amount of refrigerant filled.
Motor fluid spray volume	1. Adjust firstly the angle valve opening of the motor housing to 2 cycles, and then open fully the outlet valve at the bottom of the motor housing.	1. Please adjust the opening of the valve according to the actual maximum load condition of the model and control the motor temperature at <90℃. 2. The present specifications are Pt100 (or Pt1000) a total of 4 groups, need to be connected to the control system to monitor motor temperature.
Control setting	1. Verify if the electrical specifications of the Actuator and hot gas bypass valve are correct. 2. Actuator: Control signal of 5% ~ 100% is 4.8 ~ 20mA (or 0.5 ~ 10V), check if the actuator indicator steering is rotating. 3. Actuator starting point is set to be 5% (for start-up program). 4. Hot gas bypass valve: check if movement from 0% ~ 100% is normal.	1. Make sure the Actuator is working properly.

Confirmation before start-up	1. Oil pump steering test: Use motor rear cap oil sight glass to observe whether there is intake of lubricating oil. 2. Motor Steering Test: After starting the push button, observe the motor rear cap oil sight glass. The steering direction should be in counterclockwise. 3.Check the following before starting the compressor : a. Actuator=5%. b. Hot gas bypass valve (HGBP)=100% c. Medium pressure valve =0%	1. Motor fluid spray volume can be observed from the display under the motor rear cap. The refrigerant level should not be higher than the coil to avoid oil agitating and spilling, and further cause damage of the motor coils. 2. During compressor stable operation, the oil level should be controlled between M ~ H scale on the oil display.
Start-up process test and check	1.Load test: a. After the previous start-up process is completed, actuator opening should be from 5 → 10%, medium pressure valve should be 0 → 100%, hot gas bypass valve will still maintain at 100%. b. Adjust the capacity according to the normal loading and unloading control logic. Then the hot gas bypass valve can be closed. c. Ensure that the lubricant oil temperature of the cooler outlet is 30 to 45 °C. Check the cooling medium flow if the temperature is not within the range. d. Make sure feedback motor temperature of Pt100 (or Pt1000) is at 30 ~ 90 ℃ to avoid condensation at the outer side of the motor. e. After flooded chiller is fully loaded, observe the condition of the refrigerant in the evaporator, the copper tubes must be slightly visible, and the bubbles created by evaporation of the refrigerant can be seen. f. Super heat temperature of discharge is appropriate and should be at Tc +5 ~ 10 ℃. g. Measurement and recording on vibration and noise h. Unloading test: Testing the load change is to test the relationship between hot gas bypass valve opening and safety margin line (or the inverter surge line).	1. The maximum liquid level of the liquid refrigerant in the economizer should not be exceeding 1/2 of the economizer muffler to avoid liquid compression (or to install addition liquid level protection switch or delay pressure valve turning on). 2. Medium pressure sensor (or external pressure gauge) and medium pressure inlet gas temperature sensor shall be provided to calculate super heat temperature of medium pressure inlet. It is recommended to be between 0 and 0.5 ℃ and observe the state of refrigerant in the gas inlet sight glass. 3. If the operating current is greater than the maximum continuous operating current during loading, the compressor should be unloaded (IGV ↓) to avoid overloading the compressor (over current protection). 4.Vibration measurement (new machine overall capacity) : Motor end： ≦1.8 mm/s Gear end： ≦0.8 mm/s Noise level： ＜88 dB(A) ＊＊Please refer to 6.7Compressor vibration measuring point
Shut down process test and check	1. Increase the temperature of chilling water and lower the temperature of the cooling water (can be determined and adjusted through pressure ratio change trends). a. Firstly turn on the hot gas bypass valve: 0% → 100% b. The Actuator is adjusted downward according to the capable operation pressure ratio Pr (max) obtained from safety margin equation. c. The oil pump will delay 3 seconds to turn off after shutdown of compressor. 2.Verify if the compressor motor stops rotating within 30 seconds; if not, please check whether pressure ratio is a little higher and adjust opening of the hot gas bypass valve as reference.	1. Time interval between re-start and shutdown should not be less than 20 minutes and ensure motor temperature should not exceed 70℃.

	3. Make sure Actuator opening is 5% and hot gas bypass is 100% after shut down, and record the oil level. 4. Re-confirm the oil level change and oil heater heating status after 2 hours shutdown.	

Table 6.1 Compressor unit first run check table

Some important issues as below before starting the compressor:

1. Before the initial start at the job site, check all auxiliary facilities which should be fixed firmly.
2. In the low ambient temperature, oil viscosity should be considered. Refrigerant and oil heaters are supposed to turn on if necessary.
3. Check all electronic equipment match the controller.
4. Check all stop valves in the system which should be opened.
5. The operating condition of the compressor after commissioning at the job-site should be adjusted; discharge temperature will be at least 5℃abovesaturated condensing temperature and suction vapor superheat should be within 1℃ comparing to saturated evaporating temperature.
6. Contact HANBELL or the local distributor if any abnormal vibration or noise is found at pipeline while the compressor is running.
7. Regularly check the chiller according to national regulations and the following items should also be checked:
   - -Operating data
   - -Oil level
   - -All compressor monitoring parts
   - -Check electrical cable connections and tightness

Note: During shipment of the compressor, all valves have been closed. After layout of all components in the system, make sure these valves are open.

6.5.2 Compressor control logic

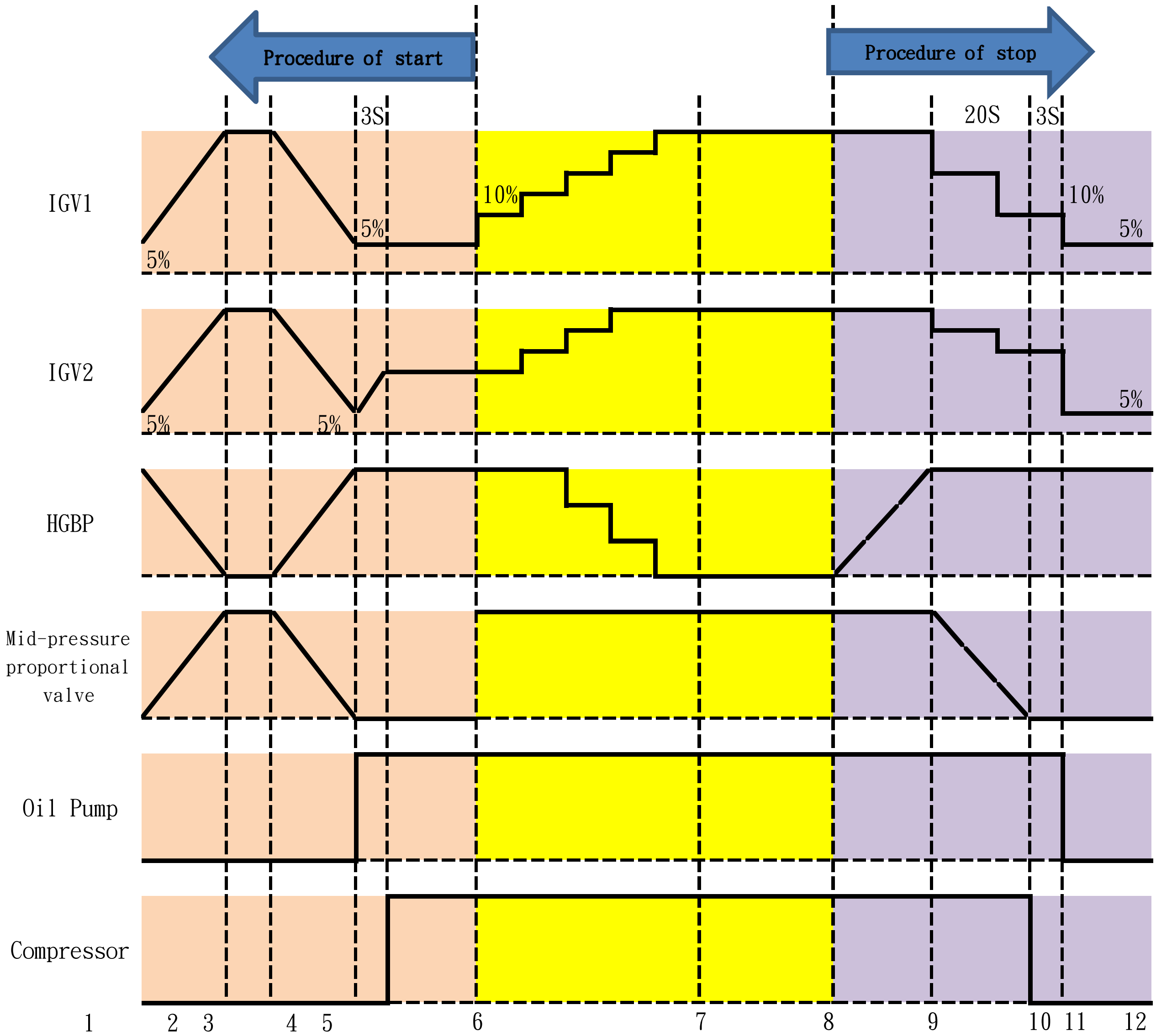


Figure 6.4 Control logic diagram of the start-stop

1. Time Zone 1-4: Actuator (IGV1 & IGV2), Hot Gas Bypass Valve (HGBP), and Medium Pressure Valve Self-test time zone require self-test procedure prior to each startup to prevent abnormal shut down or valve un-recovery failure.
2. Time zone 4-5: oil pump pre-open time 3 seconds; Actuator IGV2 pre-open to IGV1 = 10% of the corresponding position.
3. Time Zone 5-6: Number of seconds during compressor start-up process

   Note1：Time Table 6 Compressor Startup Completion Point, Actuator (IGV1) will immediately open to 10% position.
4. Time zone 6-7-8: The unit is free to load and unload according to the capacity control logic.
5. Time Zone 8-9: Time point 8 the shutdown command is issued and the heater bypass valve hits to fully open position.
6. Time Zone 9-10: The Actuator (IGV1) is still unloaded according to the safety margin equation; the medium pressure valve begins to close to fully close position.

   Note2：When the pressure ratio is high, IGV1 may not close to 10% position

   Note3：After the heater bypass valve is fully open, it will start to count about 20 ~ 30seconds. If the IGV1 still cannot be closed to 10% when the time is up, the compressor will need to be stopped (shutdown)
7. Time Zone 10-11: Pump Delay 3seconds shutdown area
8. Time Zone 11-12: Lower the Actuator (IGV1) opening to 5% while IGV2 is closed to 5% position

6.6 Troubleshooting

The table below shows some problems that might occur at the jobsite. This table will only be served as a guide for engineers to understand the situation once the problem occurs.

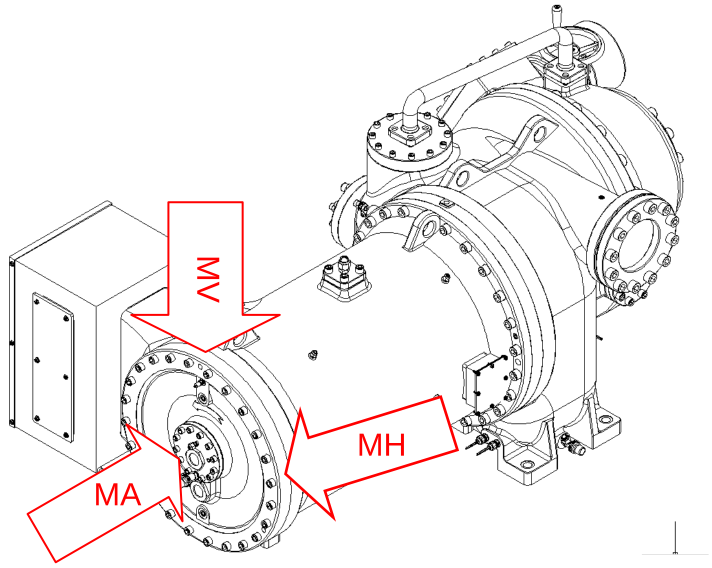
Problem	Possible cause	Action
Sudden trip of the motor thermostat /sensor	Refrigerant shortage	Charge refrigerant
	Unstable electricity system or power failure	Check power supply
	Motor overloaded	Check motor condition.
	Bad motor coil causing temperature rising rapidly.	Check the coil or the motor stator.
Poor insulation of the motor	Bad motor coil.	Check the coil or the motor stator.
	Motor power terminal or bolts are wet or frosty.	Check power bolt.
	Motor power terminal or bolts are bad or dusty.	Check power bolt.
	Acidified internal refrigeration system.	Clean the system.
	Motor coil running long time continuously under high temperature.	Check liquid injection condition.
Compressor starting failure or Y-Δ shifting failure	Voltage incorrect.	Check power supply
	Motor failure	Replace the motor
	Incorrect power supply connection.	Check and reconnect it
	Y-Δ timer failure.	Check or replace it
	Rotor jam	Check and repair it
	Protection device trip	Check devices
Abnormal vibration and noise of the compressor	Damaged bearings.	Replace bearings.
	Insufficient lubricant.	Check oil level of the compressor if enough, or add some oil if necessary.
	Working out of the operating limit (surge)	Check the operating range.
	Improper pipe system.	Check the system piping.
	Unbalanced motor rotor	Check and balance the rotor.
High discharge temperature	Insufficient refrigerant.	Check leakage. Charge additional refrigerant and adjust suction superheat less than 1℃
	Condenser problem due to low efficiency.	Check and clean the condenser.
	Refrigerant is overcharge.	Reduce refrigerant
	Air/moisture in the refrigerant system	Recover and purify refrigerant and vacuum system.
	Improper expansion valve using	Replace and adjust proper suction super-heat
Oil loss	Improper system piping	Check the oil pump
Low suction pressure	Lack of refrigerant	Check leakage. Charge additional refrigerant.
	malfunction of the expansion valve	Check and reset for proper superheat

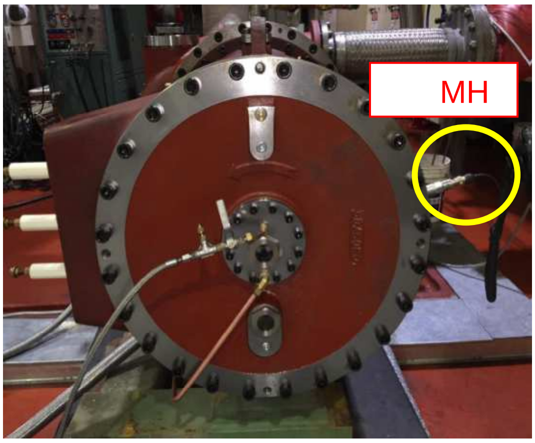
Note:

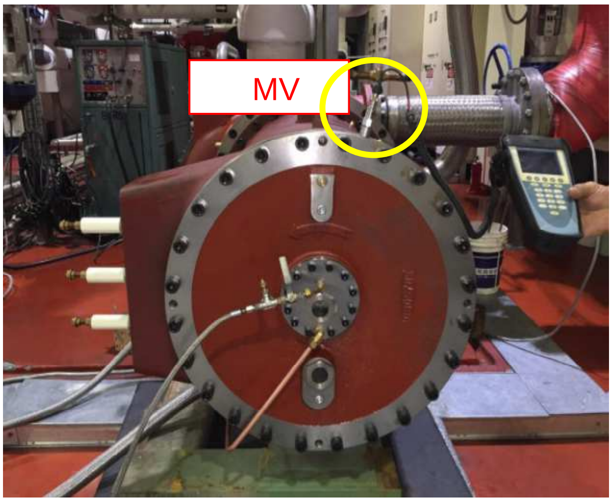
1. The replacement of compressor internal parts should be performed by qualified service technicians only.
2.When reclaiming liquid refrigerant, chilled water pump and cooling water pump can be off; when reclaiming , make sure chilled water pump and cooling water pump are running (or drain out chilled water or cooling water); when reclaiming refrigerant(liquid or gas), make sure start circuit of the compressor is open and oil heater must be powered. When reclaiming refrigerant till 1~2psi, it’s recommended to drain out refrigerant and charge nitrogen to establish positive pressure and during repair keep purging some amount of nitrogen; if the job of greater opening is done(dismantle gas return pipe of motor cover), it’s recommended to reclaim refrigerant and charge nitrogen to positive pressure, vacuum again (below 5 torr) and then charge nitrogen to positive pressure (within 8 hours, it cannot increase above 1.33torr) to ensure remain of refrigerant in the system to the minimum.

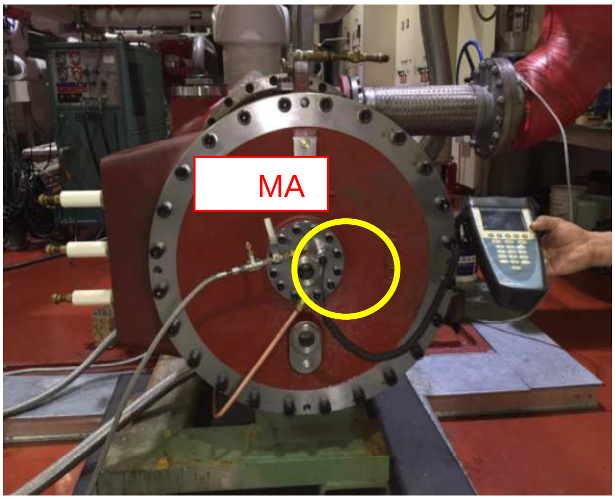
6.7Compressor vibration measuring point

1. Simple vibration measurement
   Motor rear parts：MV、MH & MA

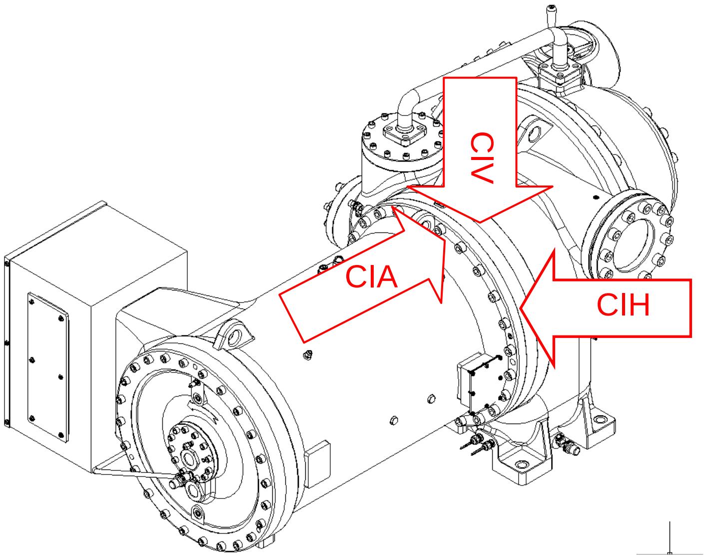


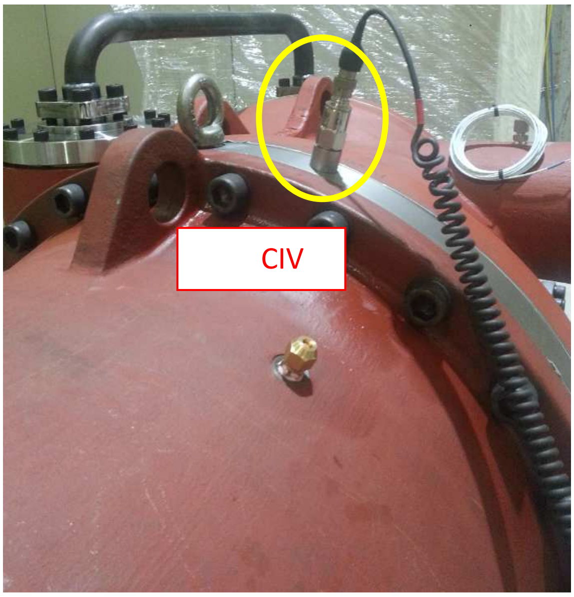






Gear Proximal parts：CIV、CIH、CIA





2.Spectrum measurement：Please contact service technicians for spectrum measurement settings.

Besides simple vibration meter point 6, additional measurement of the gear part distal: COV, COH, COA is necessary.