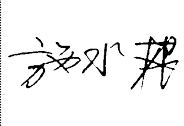
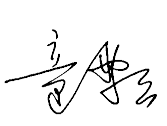
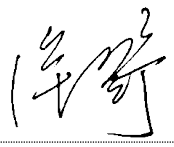
AIR COMPRESSORS 5701-K001A/B/C/D/E/F OPERATING PROCEDURE

Project Name:	HENGYI（BRUNEI）PMB PETROCHEMICAL PROJECT
Project Owner:	HENGYI INDUSTRIES SDN BHD
Project Package:	PACKAGE 12: AIR SEPARATION UNIT
Document Type:	TECHNICAL
Document Name:	AIR COMPRESSORS 5701-K001A/B/C/D/E/F OPERATING PROCEDURE
Document Number:	HYBN-T4-16-0010-2018-1
Revision Number:	1
Total Page Number:	40

Rev	Status	Date	Issued By	Checked By	Approved By
					
1	IFI	28/08/2018	Shi Shuigen（Deputy Department Manager）	Tong Xueyun（Deputy Chief Engineer）	Xu Ye（Deputy Director）

Revision History

Rev #	Date	Description
1	28/08/2018	This is the First Edition

Hengyi Industries Sdn Bhd
恒逸实业（文莱）有限公司

HYBN-T4-16-0010-2018-1

Air Compressors 5701-K001A/B/C/D/E/F Operating Procedure

空气压缩机 5701-K001A/B/C/D/E/F 操作规程

Issued Date：August 2018　　颁布日期：2018 年 8 月

Issued by: Shi Shuigen, Liang Jinbao, Mi Jianbin
编　写：施水根 梁金豹 米建彬

Checked by: Tong Xueyun
审　核：童雪云

Approved by: Xu Ye
批　准：徐 野

Contents 目录

1 Introduction 机组概况

1.1 Function and service 作用和任务

Air compressor 5701-K001 is served to pressurize the air from the self-cleaning filter. The pressurized air is diverted into two streams; one stream is sent to the Air Separation Unit, and the other stream is sent to the instrument air drying system to provide compressed air.
空气压缩机机组 5701-K001 是将自洁式过滤器来的空气加压后分为 2 路分别送到空分装置和仪表空气干燥系统，提供压缩空气。

1.2 Scope 管辖范围

The air compressor unit includes motor, centrifugal air compressor, inlet guide vane, outlet vent valve, control system, gearbox, lubrication system, seal system, inter-stage cooling and separation equipment and related process pipelines, pipe fittings, auxiliary lines, instruments, etc.
机组包括：电机、离心式空气压缩机、进口导叶、出口放空阀、控制系统、齿轮箱、润滑系统、密封系统、级间冷却及分离设备等设备设施；以及与它们相关的工艺管线、管件、辅助管线、仪表等。

1.3 Process overview 流程概述

1.3.1 Process gas 工艺气流程

The air from the self-cleaning filter enters Stage 1 impeller for compression via a temporary filter (for initial startup) and the inlet guide vane. The air from Stage 1 impeller is cooled and separated in Stage 1 intercooler; the water separated is directly discharged into the trench, and the air is sent to Stage 2 impeller for compression. The air from Stage 2 impeller is cooled and separated in Stage 2 intercooler; the water separated is directly discharged into the trench, and the air is sent to Stage 3 impeller for compression. The compressed air from Stage 3 is divided into two streams; one stream is discharged to the atmosphere through the pressure relief valve and the silencer to ensure operation safety of the compressor, and the other stream is sent to the compressed air header through the expansion joint and check valve for production use.
经自洁式过滤器过滤后的空气经临时过滤器（首次开车）、进口导叶进入压缩机的一级叶轮进行

压缩；压缩机一级叶轮出口气体经冷却分离一体的一级中间冷却器冷却、分离，分离的水直接排入地沟，空气进二级叶轮再次进行压缩；压缩机二级叶轮出口的气体经经冷却分离一体的二级中间冷却器冷却、分离，分离的水直接排入地沟，空气进压缩机三级叶轮再次进行压缩；经三级压缩的空气分两路送出，一路经泄压阀、消音器排放至大气中，保证压缩机的运行安全；一路经膨胀节、单向阀送入压缩空气总管网，供生产使用。

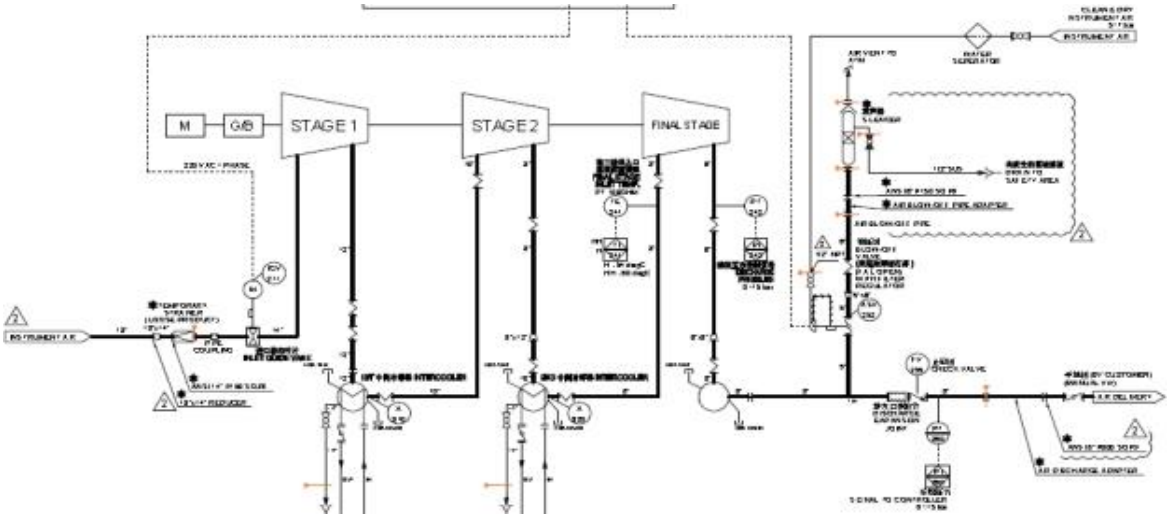


Figure 1 Gas flow diagram

图 1 气路流程图

1.3.2 Lube oil system 润滑油系统

1.3.2.1 The oil system of the air compressor unit is a forced oil supply system, which supplies lube oil to bearings, takes away the heat generated in friction, reduces friction, and flushes away the metal particles generated due to friction to ensure normal operation of the system.

压缩机组的油系统为强制供油系统，为各部轴承提供润滑油，带走摩擦产生的热量、降低摩擦、冲刷带走摩擦产生的金属颗粒，保证系统的正常运行。

1.3.2.2 Before the air compressor is started, the lube oil in the tank is pressurized to 0.25 MPaG by the auxiliary lube oil pump and then cooled in the oil cooler, and the oil temperature is controlled using the oil temperature controller. After the lube oil flows through the duplex oil filter, the oil pressure controller on the outlet oil pipeline controls the oil pressure between 0.16-0.25 MPaG. The auxiliary oil pump will automatically start if the oil pressure is lower than 0.14 MPaG and stop if the oil pressure is higher than 0.21 MPaG. The oil is divided into three streams; two streams are used as the lube oil for the front and rear bearings of the motor and go back to the oil tank after lubricating the bearings, and the third stream enters the gearbox to lubricate the gear shaft bearings and go back to the oil tank. The oil pipeline after the oil filter is provided with oil pressure alarm and interlock. The low pressure alarm is set at 0.16 MPaG and interlock at 0.1 MPaG. The interlock uses a two-out-of-three voting logic.

空气压缩机启动前，空气压缩机油箱中润滑油由辅助润滑油泵升压到 0.25MPaG，经油冷却器冷却后由油温控制器控制油温。经过双联式油过滤器后，出口油管上设置了油压控制器，控制油压

在 0.16-0.25MPaG 之间，低于 0.14MPaG 辅助油泵自启动，高于 0.21MPaG 辅助油泵停；油路一共分为三路：第一、二路作为电机前后轴承的润滑油，润滑轴承后直接回到油箱；第三路进入齿轮箱润滑各齿轮轴的轴承后返回油箱。油过滤器后的油管路上设有油压报警、联锁，0.16MPaG 低报警、0.1MPaG 联锁，联锁为三选二。

1.3.2.3 After the air compressor is started, the main oil pump starts to run. After the main oil pump is running normally, stop the auxiliary oil pump and enable the automatic start interlock.
空气压缩机启动后，主油泵开始运转，在主油泵运行正常后，辅助油泵停运，并投自启动联锁。

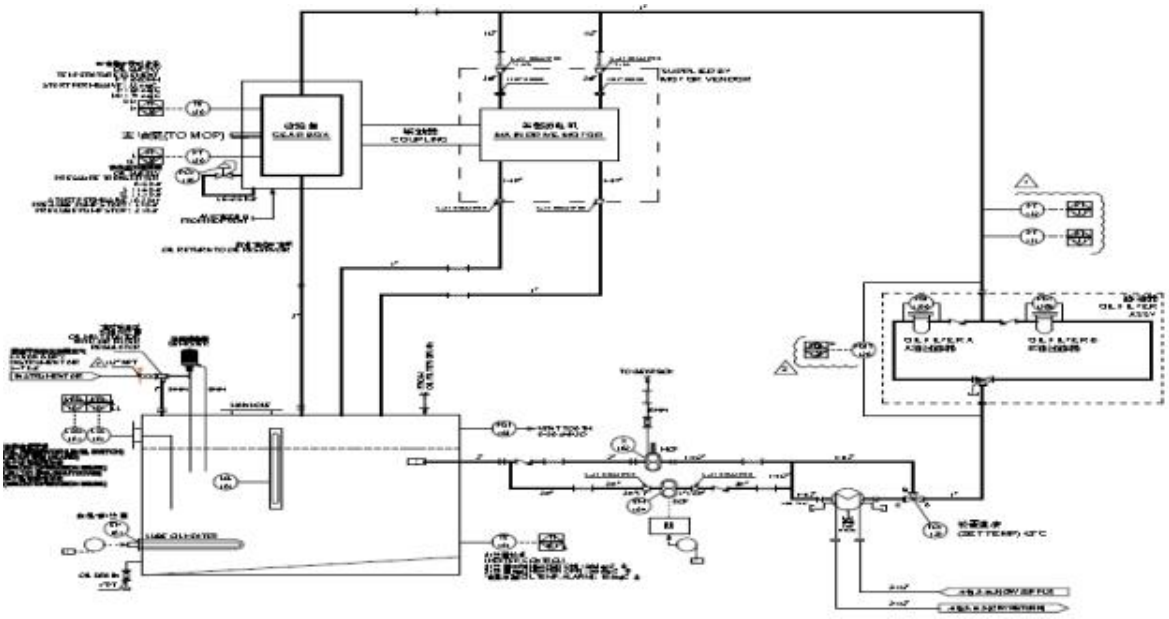


Figure 2 Oil flow diagram

图 2 油路流程图

1.3.3 Seal system 密封系统

1.3.3.1 The seal between the compressor and the gearbox is to prevent gas and lube oil leakage. During compressor operation, the core assembly piping is filled with high pressure gas. If the equipment has no seal system, high pressure gas will enter the oil line or the oil will enter the gas line, which would affect compressor performance, safety and gas quality.
压缩机与齿轮箱的密封是防止气体和润滑油的泄漏。压缩机运行中，核心总成的管道充满高压气体。如果设备没装密封，高压气体将进入油管道，或者润滑油将进入气体管道，这会影响压缩机性能、安全和气体的质量。

1.3.3.2 The compressor system uses a carbon seal to minimize gas and lube oil leakage. The discharge pressure of Stage 1/2/3 of the compressor is 0.23/0.48/0.85 MPaG, and the oil pressure is below 0.25 MPaG. During normal operation, the gas pressure is higher than the oil pressure, and a trace of gas leaks into the gearbox and is vented to the atmosphere through the breather valve at the top of the gearbox.
本压缩机系统采用碳环密封 (Carbon Seal)，在最大程度上减少了气体和润滑油的泄漏。压缩机

一、二、三级的排气压力分别是 0.23/0.48/0.85MPaG，油压在 0.25MPaG 以下，正常运行时，气体的压力高于油压，有微量气体泄漏进齿轮箱，经过齿轮箱顶部的呼吸阀排放至大气。

1.4 Main structural features and materials 机组的主要结构特征及材料

1.4.1 Configuration 机组配置

1.4.1.1 The air compressor unit is designed and manufactured by Hanwha, and the model is SM6000. It has three stages of compression and diaphragm disc couplings. The schematic diagram is shown below.

空气压缩机组由韩华公司设计制造，压缩机型号为 SM6000，分为三级压缩，通过膜盘式联轴器联接。机组配置示意图如下：

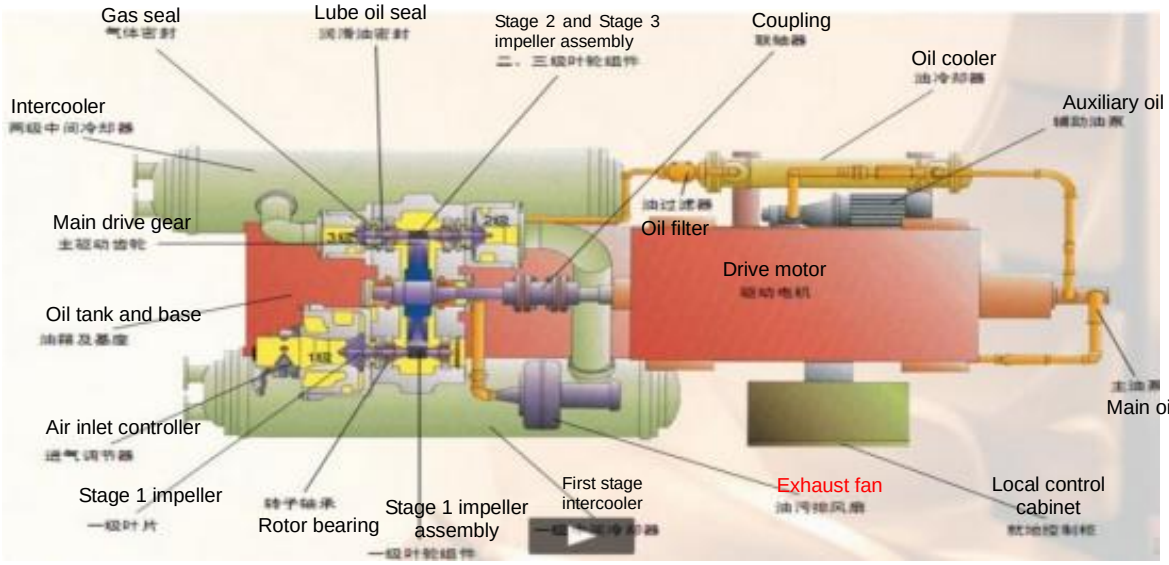


Figure 3 Schematic diagram of air compressor

图 3 空气压缩机结构示意图

1.4.1.2 The air compressor unit is skid-mounted and placed on the first floor of the compressor house. In addition, a 10t double girder bridge crane is provided for compressor maintenance.

机组为撬装式，布置在压缩机厂房一层。另外，设有 10t 检修用双梁桥式起重机 1 台。

1.4.2 Compressor 压缩机

1.4.2.1 Compressor configuration 压缩机组成

（1）The SM6000 centrifugal air compressor has a radially split structure. Stage 1 impeller and Stage 2 impeller are installed on 1# rotor and arranged back to back on both sides of the gearbox. Stage 3 impeller is installed on one side of 2# rotor gearbox.

SM6000 型的离心式空气压缩机采用径向剖分结构。一级叶轮与二级叶轮在 1#转子上，在齿轮箱

两侧按照背靠背进行布置。三级叶轮安装在 2#转子的齿轮箱的一侧。

（2）The compressor consists of stator (casing, flow channel, seal, etc.), rotor (shaft, impeller, bushing, balance drum, etc.), bearings, seal, etc. The detailed configuration is shown in the table below.

压缩机由定子（机壳、流道、密封等）和转子（轴、叶轮、轴套、平衡鼓等）及轴承、密封等组成。详细配置情况如下表所示：

Table 1 Compressor configuration

表 1 压缩机结构组成表

Compressor model 压缩机型号		SM6000		
Stage No. 压缩机级号		Stage 1 一级	Stage 2 二级	Stage 3 三级
Casing 机壳	Type 形式	Radially split 径向剖分	Radially split 径向剖分	Radially split 径向剖分
	Material 材料	Cast iron/GC250 铸铁/GC250	Cast iron/GC250 铸铁/GC250	Cast iron/GC250 铸铁/GC250
Impeller 叶轮	Number of stage 级数	1	2	3
	Type 形式	Open type integrally milled 开式整体铣制	Open type integrally milled 开式整体铣制	Open type integrally milled 开式整体铣制
	Material 材料	17-4PH	17-4PH	17-4PH
Shaft 轴	Type 形式	Integrally forged 整体锻造	Integrally forged 整体锻造	Integrally forged 整体锻造
	Material 材料	SCM440	SCM440	SCM440
Coupling 联轴器	Type 形式	Disc 碟片式	Disc 碟片式	Disc 碟片式
	Supplier 供货商	Hanwha 韩华	Hanwha 韩华	Hanwha 韩华
Bearing 轴承	Support bearing 支撑轴承	Tilting pad 可倾瓦	Tilting pad 可倾瓦	Tilting pad 可倾瓦
	Thrust bearing 推力轴承	Double acting, self-equalizing 双作用自平衡型	Double acting, self-equalizing 双作用自平衡型	Double acting, self-equalizing 双作用自平衡型
Seal 密封	Type 形式	Carbon seal 碳环密封	Carbon seal 碳环密封	Carbon seal 碳环密封
	Supplier 供货商	Hanwha 韩华	Hanwha 韩华	Hanwha 韩华

1.4.3 Motor 电机

The motor is manufactured by ABB. It uses a forced lube oil system together with the compressor.
电机是 ABB 公司制造。与压缩机一起由润滑油强制润滑。

1.4.4 Lube oil system 润滑油系统

1.4.4.1 The lube oil unit is provided by the air compressor manufacturer together with the air compressor. It consists of lube oil tank, oil pump, oil cooler, duplex filter, pressure regulator, temperature regulating valve, electric heater, oil mist system, valves and pipe fittings, etc., which are all mounted on the same base. All oil inlet and outlet manifolds and branches are carbon steel flexible pipes.
机组的润滑油站由空气压缩机厂家成套提供，由润滑油箱、油泵、油冷却器、双联过滤器、调压阀、调温阀、电加热器、油雾系统、阀门及管件等组成，这些设备都安装布置在同一个底座上。所有进、排油集合管及支管材质均为碳钢和软管。
1.4.4.2 The lube oil tank provides necessary oil replenishment. The oil mist system is driven by instrument air and a certain degree of vacuum is maintained in the oil tank to suck out the oil-containing air in the oil tank. The air is filtered and then discharged. The filtered lube oil returns to the oil tank. The oil tank has a built-in electric heater. The level of the oil tank is maintained at 80% between the high and low level alarm set points of the sight glass.
润滑油箱提供必要的补油，油雾系统以仪表空气做动力，保持油箱内一定的真空度，将油箱内的含油空气吸出，经过滤后，空气排出，过滤的润滑油返回油箱。油箱内置电加热器，油箱的油液位在视镜的高报与低报之间 80%的位置。
1.4.4.3 The lube oil unit has two lube oil pumps. The main oil pump is a gear pump connected to the main shaft of the gearbox through the coupling and is started together with the compressor. The auxiliary oil pump is a motor-driven screw pump and is provided with automatic start control.
润滑油站设两台润滑油泵，主油泵为齿轮泵与齿轮箱的主轴通过联轴器连接在一起，与压缩机一起启动；辅助油泵为螺杆泵，由电动机驱动。辅助油泵设置有自启动控制。

1.5 Technical parameters of main equipment 主要设备技术参数

1.5.1 Compressor 压缩机

1.5.1.1 Compressor data sheet 压缩机数据表

Table 2 Expander parameters

表 2 压缩机参数表

Operating conditions 操作条件			
Operating case 操作工况	100% capacity (rated) 100.%工况 1（额定）		
Compressor model 压缩机型号	SM6000		
Stage or stream in/out 段号或中间进/出物流号	1	2	3
Volumetric flow (0.1013MPaG & 0℃) (Nm^3/h) 体积流量（0.1013MPaG & 0℃）Nm^3/h	15000	15000	15000
Inlet conditions 入口条件			
Pressure (MPaA) 压力 MPaA	0.0990	0.23	0.48
Temperature (℃) 温度℃	37	40	40
Average molecular weight (%) 平均分子量%	28.96	28.96	28.96
Adiabatic exponent K 绝热指数 K	1.4		
Outlet conditions 出口条件			
Pressure (MPaA) 压力 MPaA	0.23	0.48	0.85
Temperature (℃) 温度℃	138	130	126
Adiabatic exponent K 绝热指数 K	1.4		
Shaft power (kW) 轴功率 kW	1568		
Driving power (kW) 驱动功率 kW	1800		
Speed (rpm) 转速 rpm	2970		

1.5.1.2 Medium composition 介质组成表

Table 3 Medium composition

表 3 空气的组成表

Medium 介质	Oxygen 氧气	Nitrogen 氮气	Rare gas 稀有气体	CO_2	Others 其他	Average molecular weight 平均分子量
Mol% 摩尔百分含量（%）	21	78	0.94	0.03	0.03	28.96

1.5.1.3 Expected performance curves 压缩机预期性能曲线

Customer requirements

Gas	Air	
Barometric Pressure	1.010	barA
Inlet Pressure	0.990	barA
Inlet Temperature	36.80	oC
Relative Humidity	85	%
Coolant Temperature	33.00	oC
C/W Temperature Rise	10.00	oC

Performance

Flow	15000.00	Nm3/hr(Dis)
Discharge Pressure	0.8500	MPaG
Shaft Power	1568.43	kW
Turn-Down Ratio	31	%
Discharge Temperature	126.14	oC
C/W Consumption	181.54	m3/hr
Motor Frequency	50	Hz

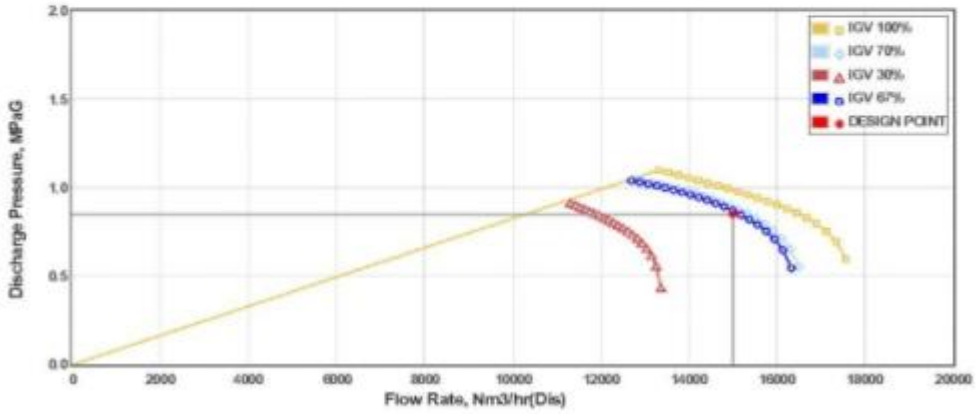


Figure 4 Flow-pressure curve

图 4 压缩机的流量、压力工作区域曲线图

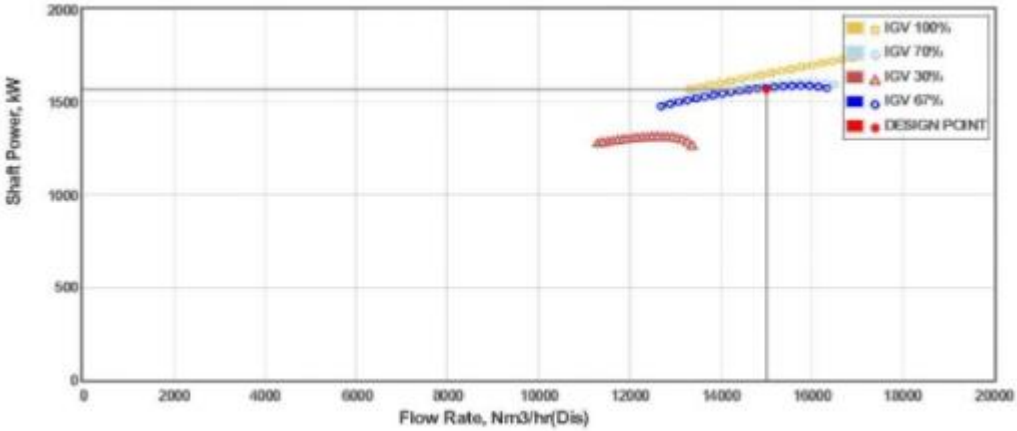


Figure 5 Flow-power curve

图 5 压缩机的流量、功率工作区域曲线图

1.5.2 Motor 电机

Table 4 Main motor parameters

表 4 主电机参数表

Manufacturer		ABB	
Degree of protection		IP55-IC611	
Insulation class		F(105℃)	
Temperature rise class	℃	B(80℃)	
Working system		Continuous	
Service factor		1.15	
Voltage	V	10kV	
Power	KV	1,800	
Bearing		Sliding	
Lubrication		OIL	
Noise	dB(A)	87	No-load
Vibration	nn/sec	2.0(0-Peak)	No-load

制造商		ABB	
保护等级		IP55-IC611	
绝缘等级		F(105℃)	
温升等级	℃	B(80℃)	
工作制		连续工作制	
服务系数		1.15	
电压	V	10kV	
功率	KV	1,800	
轴承		滑动	
润滑		OIL	
噪声	dB(A)	87	无负载条件
振动	nn/sec	2.0(0-Peak)	无负载条件

1.5.3 Lube oil system 润滑油系统

1.5.3.1 Main parameters of lube oil system 润滑油系统的主要参数

Table 5 Lube oil parameters

表 5 润滑油参数表

Grade 油牌号	32# turbine oil 32#涡轮机油	
Oil output 输出油量	l/min	231.4

Table 5 Lube oil parameters（Continued）

表 5 润滑油参数表（续）

Output oil pressure 输出油压	MPaG	0.16~0.245

1.5.3.2 Lube oil tank 润滑油箱

Table 6 Lube oil tank parameters

表 6 油箱参数表

Nominal volume 公称容积	m^3	0.6
Oil capacity 注 油 量	m^3	0.546
Material 材质	SS400	

1.5.3.3 Lube oil pump (motor-driven) 润滑油泵（电机驱动）

Table 7 Oil pump parameters

表 7 油泵参数表

Type 油泵型号	Screw 螺杆型	
Flow 油泵流量	m^3/h	9.9
Pressure 压力	MPaG	0.7
Motor power 电机功率	kW	1.5
Motor voltage 电机电压	V	380
Explosion-proof rating 防爆等级	dIICT4	

1.5.3.4 Oil cooler 油冷却器

Table 8 Oil cooler parameters

表 8 油冷器参数表

Type 型式	Shell & Tube (Water - in - Tube)	
Tube bundle specification 管束规格	O.D.×thickness×length mm 外径×厚度×长度 mm	9.52×0.7×1300 (60 tubes) 9.52×0.7×1300（60 根）
Material 材质	Shell: carbon steel; shell O.D.: 165.2 壳体：碳钢； 壳体外径：165.2	

Table 8 Oil cooler parameters（Continued）

表 8 油冷器参数表（续）

	Tube bundle: copper (C1220T) 管束：铜（C1220T)
Design pressure 设计压力	Tube/Shell:0.65/1.0MPaG 管/壳:0.65/1.0MPaG
Design temperature 设计温度	Tube/Shell:100/100℃ 管/壳:100/100℃

1.5.3.5 Duplex filter 联过滤器

Table 9 Oil filter parameters

表 9 油过滤器参数表

Precision 过滤精度	μm	10
Filter element material 滤芯材质	Filter element: fiberglass 滤芯：玻璃纤维	
	Housing: Lightweight aluminum 壳体：轻量铝	

1.6 Utility consumption list 公用工程消耗表

Table 10 Utility consumption list

表 10 公用工程消耗表

Item 项目	Conditions 条件	Service 用途	Normal value 正常值	Remarks 备注
Electricity 电	380V，50Hz	Auxiliary oil pump motor 辅助油泵电机	1.5kW	
		Electric lube oil heater 润滑油电加热器	4kW	
	220V，50Hz	Motor heater 电机加热器	0.2kW	
		Control cabinet 控制柜	1kW	
	10kV，50Hz	Main motor 主电机	1800kW	
Cooling water 循环水	P_{in}=0.45MPaG,t_{in}=33℃ P_{out}=0.3MPaG，t_{out}=43℃	Lube oil cooler 润滑油冷却器	14.3t/h	181.54t/h
		Intercooler 中间冷却器	119t/h	
		Aftercooler 后冷却器	48t/h	

Table 10 Utility consumption list（Continued）

表 10 公用工程消耗表（续）

Instrument air 仪表风	P=0.5-0.7MPaG	Valve 阀门	1m^3/h	
		Oil tank 油箱	20m^3/h	
Lube oil 润滑油	Lube oil VG32 润滑油 VG32	Oil tank 油箱	546L	

1.7 Compressor control system 机组控制系统

1.7.1 Alarm & interlock set points 机组报警联锁设定值

Table 11 List of alarm & interlock set points

表 11 机组报警联锁设定值一览表

S/N 序号	Instrument Tag No. and description 仪表位号及描述		Unit 单位	Operating point parameter 操作点参数	Alarm 报警值		Interlock 联锁值		Remarks 备注
	Description 描述	Tag No. 仪表位号			AH	AL	SH	SL	
1	Oil filter differential pressure transmitter 油过滤器压差变送	PDIT120	PSTD	Max1.5	--	--	1.75	--	
2	Stage 3 inlet temperature 三级进口温度	TE241	℃	Max54	54	--	60	--	
3	Oil tank temperature 油箱温度	TE101	℃	Min36	--	16	--	--	
4	Oil supply temperature 供油温度	TE130	℃	32~60	60	--	74	--	
5	Motor winding temperature 电动机绕组温度	TE150R	℃	Max145	145	--	155	--	2oo3 interlock 温度三取二联锁
6	Motor winding temperature 电动机绕组温度	TE150S	℃	Max145	150	--	155	--	

Table 11 List of alarm & interlock set points（Continued）

表 11 机组报警联锁设定值一览表（续）

S/N 序号	Instrument Tag No. and description 仪表位号及描述		Unit 单位	Operating point parameter 操作点参数	Alarm 报警值		Interlock 联锁值		Remarks 备注
	Description 描述	Tag No. 仪表位号			AH	AL	SH	SL	
7	Motor winding temperature 电动机绕组温度	TE150T	℃	Max145	150	--	155	--	
8	Motor bearing drive end temperature 电机轴承驱动端温度	TE151	℃	Max85	85	--	90	--	
9	Motor bearing non-drive end temperature 电机轴承非驱动端温度	TE152	℃	Max85	85	--	90	--	
10	Oil supply pressure 供油压力	PT130	MPaG	0.16~0.245	--	0.163	--	0.103	2oo3 interlock 供油压力三取二联锁
11	Oil supply pressure 供油压力	PT131	MPaG	0.16~0.245	--	0.163	--	0.103	
12	Oil supply pressure 供油压力	PT132	MPaG	0.16~0.245	--	0.163	--	0.103	
13	Stage 1 vibration 一级振动	VT131X	μm	Max35.3	37	--	53	--	
14	Stage 2 vibration 二级振动	VT132X	μm	Max35.3	37	--	53	--	
15	Stage 3 vibration 三级振动	VT133X	μm	Max30.8	32	--	45	--	
16	Motor current transmitter 电机电流变送器	CT150	--	--	149.5	--	--	--	

Table 11 List of alarm & interlock set points（Continued）

表 11 机组报警联锁设定值一览表（续）

S/N 序号	Instrument Tag No. and description 仪表位号及描述		Unit 单位	Operating point parameter 操作点参数	Alarm 报警值		Interlock 联锁值		Remarks 备注
	Description 描述	Tag No. 仪表位号			AH	AL	SH	SL	
17	Auxiliary oil pump 辅助油泵	EM104	MPaG	0.4	--	--	0.21	0.14	According to PT130 measuring points, the auxiliary oil pump automatically stops when the pressure is ≥0.21 MPaG and starts automatically when the pressure is ≤0.14 MPaG. 根据 PT130 测点，≥0.21 自停，≤0.14 自启
18	Oil heater 油加热器	EH101	℃	36-45	45	36	--	--	The oil heater automatically starts when the oil temperature is below 36℃and stops when the oil temperature is above 45 ℃. 低于 36 自启，高于 45 停止
19	Motor space heater 电机空间加热器	EH150	--	--	--	--	--	--	The heater starts when the motor stops and the heater stops when the motor starts. 电机停加热器启动 电机启加热器停止

2 Test run 机组试车

2.1 Preparations before test run 试车前的准备工作

2.1.1 Keep the floor and equipment clean and remove obstacles.

搞好地面和设备卫生，清除障碍物。

2.1.2 All electrical and instrumentation systems have been confirmed by electrical and instrumentation personnel and have been calibrated and are functioning properly.

所有电气系统及仪表系统经电气、仪表人员确认，调校、投用正常。

2.1.3 Make sure the cooling water, electricity, air, etc. are ready.

确认循环水水、电、风等具备使用条件。

2.1.4 Make sure the grade and amount of lube oil comply with the compressor specifications and requirements, the oil tank level is at 80% between “H” and “L” of the oil meter on the side of the oil tank, and the lube oil pipeline has been flushed with oil to remove foreign matters inside (cover the head and motor when flushing for initial startup). Make sure the piping, components

and sensors are correct. Make sure the auxiliary oil pump functions properly and the oil pressure is within the operating parameters. Make sure the oil system is cleaned in accordance with the specified requirements (after maintenance).

确认润滑油牌号与用量符合压缩机规格和需求。确认油箱油位在油箱侧面的油量计的‘H’与‘L’之间的 80%。确认润滑油管道已经用油进行冲洗去除管道内的异物（首次开车，冲洗时，用法兰盖住机头和电机进出口）。确认管道，构成部件及传感器是否正确。确认辅助油泵运行正常，油压在运行参数范围内。确认油系统清洗符合规定要求（检修后）。

2.1.5 Make sure the horizontal error during compressor installation is ≤0.5mm/m.

确认压缩机安装水平误差≤0.5mm/m。

2.1.6 Check the inside of pipes for cleanliness. Any foreign matter must be removed before operation.

确认管道内部是否干净。有异物时，运转前必须去除。

2.1.7 Check if the systems, equipment and pipelines have been properly installed.

检查机组系统设备、管线是否安装完好。

2.1.8 Make sure the inlet vane can open and close freely and has no foreign matter inside.

确认进口导叶开关灵活，内部无异物。

2.1.9 Manually rotate the shaft and make sure the rotor rotates freely without interference and abnormal sound.

手动盘车，转子无卡涩、无异常声音。

2.1.10 Make sure the instrument air pressure and flow of the system are normal (the auxiliary air compressor functions properly) and the instrument air piping/tubing is correct.

确认系统仪表空气压力、流量正常（辅助空压机运行正常），仪表风接管正确。

2.1.11 Make sure the anti-surge valve can open and close freely.

确认防喘振阀开关灵活。

2.1.12 The personnel are familiar with the test run plan and have passed the examination.

岗位人员熟悉试车方案并考试合格。

2.1.13 Check the specifications on the motor nameplate to confirm that it is the right equipment (for initial startup). Open the junction box of the main motor and check that the power cables are connected correctly (for initial startup or after motor maintenance). Make sure the earth line is connected to the motor properly.

确认电机铭板上的规格，确认是否是合适的设备（首次开车）。打开主电机的接线盒，确认各电源线连接一致（首次开车或电机检修后）。确认把接地线与电机接地部连接。

2.1.14 Make sure the main motor rotates in the same direction as the gearbox does.

确认主电机和齿轮箱的旋转方向一致。

2.1.15 Make sure the coupling and the guard have been properly installed and secured and are free from friction.

确认连轴器安装完好，防护罩安装完好，无松动、摩擦。

2.1.16 Make sure all parameters of the compressor unit have been set through the touch panel and debugged to be normal and the DCS is working normally.

确认机组各参数已经通过控制触摸屏设定完成，调试正常，DCS 系统已进入正常工作状态。

2.1.17 Make sure the anchor bolts of motor and pump and the connecting bolts of moving parts are tightened and not loose.

确认电机和泵地脚螺栓、各运动部件连接螺栓有无松动。

2.1.18 According to the list of alarm & interlock set points, make sure all alarms and interlocks of the compressor system have been tested and all of them meet the requirements and have been put into use. (Note: Each alarm and interlock signal shall be verified for 3 times, and the test values shall be basically the same; otherwise, it shall be re-verified. For alarms and interlocks that cannot be measured, contact the instrumentation personnel to turn off the transmitter signal and to send an analog signal which reaches the alarm and interlock set points for testing).

根据机组报警联锁一览表，确认机组系统所有报警及联锁已试验完成，全部符合要求，并已投用。（注意：每个报警联锁信号应校验 3 次，每次试验值要求基本一致，否则应重新校验。对于无法进行实测的报警联锁，联系仪表人员将变送器信号关闭，从变送器处由仪表人员发模拟信号达到报警联锁所需的设定值，对信号进行检验）。

2.1.19 Get thermometer, vibrometer, listening needle and other startup tools ready.

准备好温度计、测振仪、听针等开车工具。

2.1.20 Make sure the cooling water system of each cooler has been taken into service and is functioning properly.

确认机组冷却器循环水系统已经投用，并运行正常。

2.1.21 Contact the dispatcher for startup.

与调度联系完毕，准备开机。

2.2 Inspection before test run 试车前的检查工作

2.2.1 Check whether an alarm, warning or interlock message has been given via the touch panel of the control cabinet or the screens in the control room. If any, find out the cause and take appropriate measures to eliminate it.

通过控制柜的触摸屏或控制室的画面，确认是否发生报警或警告信息。若有警告，查出原因，并采取相应措施。

2.2.2 Vent the main oil pump. Open the vent valve on the main oil pump and then start the auxiliary oil pump. There shall be no air bubbles generated in the circulating lube oil.

进行主油泵排气作业。打开主油泵管道的排气阀门后，启动辅助油泵，循环润滑油上不生成气泡。

2.2.3 Make sure all instrument valves are in the same status as indicated on the P&ID (open/closed position).

确认所有仪表阀门的状态是否与 P&ID 相同。(打开/关闭位置)

2.2.4 Check that cooling water has been supplied.

检查是否已提供冷却水。

2.2.5 Inching test 进行点动测试

2.2.5.1 After completing all the pre-checks, press the start button on the control panel to start the compressor and wait for 2 seconds.
完成所有提前检查后，按下控制面板的开始按钮，启动压缩机后，等待 2 秒。
2.2.5.2 Press the stop button to stop the compressor.
2 秒后，按下停止按钮，停止压缩机。
2.2.5.3 Check the rotation direction of the motor, equipment vibration characteristics, and the starting condition when the compressor is stopped.
在压缩机停止时，确认电机的旋转方向、设备的振动特点、启动状况。

2.3 Test run 开机调试

Start the test run after completing the pre-checks and confirming that there is no problem with the operation of the equipment. During the test run, it is required to check the components, temperature, pressure, abnormal noise/vibration and leakage of gas/oil/cooling water.
完成提前检查，确认设备运转上没有问题后，开始进行调试。调试时，必须确认部件、温度、压力、各部位是否发生异常噪音及振动，是否有漏油、气体泄漏及冷却水漏水现象。
2.3.1 Check the oil level and oil temperature in the oil tank.
确认油箱内的油位与油温。
2.3.2 Check the supply of control power.
确认供应控制电源。
2.3.3 The oil heater automatically starts when the oil temperature is below 36℃.
油温为 36℃以下时，油加热器自启动。
2.3.4 Start to supply the instrument air (seal) and check the settings.
开始供应仪表气（Instrument Air）（密封），确认设定。
2.3.5 Check that the cooling water for the intercooler and oil cooler is functioning properly.
确认中间冷却器和油冷却器冷却水投运正常。
2.3.6 Check that the auxiliary oil pump (AOP) is started.
确认辅助油泵（AOP）启动。
2.3.7 Check the pipes for leaks and eliminate the leaks (if any).
检查各管道是否漏泄，消除漏点。
2.3.8 Check the oil temperature and stop starting if the oil temperature cannot be adjusted automatically.
确认油温，若发现无法自动调节油温则停止启动。
2.3.9 Check the oil pressure and adjust the set point (if necessary).
确认油压，调整设定值（若必要）。
2.3.10 Check that the inlet guide vane (IGV) and BOV drive are at the START position.
确认进口导叶 (IGV)、BOV 驱动器是否位于开始位置。

2.3.11 Press the START button to start the compressor.

按下“启动”按钮，启动压缩机。

2.3.12 Monitor the stability after the peak starting current of the main motor is reached. Check the components, temperature, pressure, abnormal noise/vibration and leakage of gas/oil/cooling water.

监控主电机的电流值达到启动峰值后的稳定状态。确认部件、温度、压力、各部位是否发生异常噪音及振动，检查是否有漏油、气体泄漏及冷却水漏水现象。

2.3.13 Load and continue running the compressor until it is running normally, and record the measurements of all measuring points.

加载，持续运行至达到正常状况，记录所有测定点的测值。

2.3.14 Stop the compressor after all the temperature values are stable and the compressor is running normally for 5 minutes.

在所有温度值保持稳定的状况下，确认压缩机运行正常 5min 后，停止压缩机。

2.3.15 Press the STOP button to stop the compressor.

按下“停止”按钮，让压缩机停止运转。

2.4 Oil system test run 油路系统试运转

2.4.1 Oil system alarm and interlock test 油路系统报警联锁试验

Note: Each alarm and interlock signal shall be verified for 3 times, and the test values shall be basically the same; otherwise, it shall be re-verified. For alarms and interlocks that cannot be measured, contact the instrumentation personnel to turn off the transmitter signal and to send an analog signal which reaches the alarm and interlock set points for testing.

注意：每个报警联锁信号应校验 3 次，每次试验值要求基本一致，否则应重新校验。对于无法进行实测的报警联锁，联系仪表人员将变送器信号关闭，从变送器处由仪表人员发模拟信号达到报警联锁所需的设定值，对信号进行检验。

2.4.1.1 Lube oil pressure low low shutdown test (2oo3) 润滑油压力低低停车试验（3 取 2）

（1）Close the shutoff valve on PT-130 impulse tube and release the oil pressure in PT-130 to 0 (this can be achieved with the assistance of the drain valve).

关闭 PT-130 导压管切断阀，将 PT-130 中的油压释放到 0（可通过表头放油阀辅助实现）

（2）Slowly close the shutoff valve on PT-130 impulse tube, so that the pressure indication slowly drops, and observe the drop of oil pressure through PI-130.

慢慢关闭 PT-130B 导压管切断阀，使压力指示慢慢的下降，通过 PI-130 观察油压的下降。

（3）When the lube oil pressure reaches or approaches the low low value (0.10 MPaG), PALL-130 sends a pressure low low interlock signal for shutdown.

当压力达到或接近润滑油压力低低值 0.10MPaG 时，PALL-130 发出低低联锁停机信号。

（4）Open the shutoff valve on PT-131 impulse tube to restore the pressure of PI-130.

打开 PT-131 的导压管切断阀，恢复 PI-130 压力。

（5）Slowly close the shutoff valve on PT-132 impulse tube, so that the pressure indication slowly drops, and observe the drop of oil pressure through PI-130. When the lube oil pressure reaches or approaches the low low value (0.10 MPaG), PALL-130 sends a pressure alarm low low signal for shutdown.

慢慢关闭 PT-132 导压管切断阀，使压力指示慢慢的下降，通过 PI-130 观察油压的下降。当压力达到或接近润滑油压力低低值 0.10MPaG 时，PALL-130 发出低低报警信号。

（6）Open the shutoff valve on PT-132 impulse tube to restore the pressure of PI-130.

打开 PT-132 的导压管切断阀，恢复 PI-130 压力。

（7）After the pressure of PI-130 is restored, release the pressure of PT-131 to zero, and then test the action signals of PT-130 and PT-132 according to the above steps.

恢复后，释放 PT-131 表头中的压力到 0 后，按上述步骤试验 PT-130、132 的动作信号。

（8）After the pressure of PI-130 is restored, release the pressure of PT-132 to zero, and then test the action signals of PT-130 and PT-131 according to the above steps.

恢复后，释放 PT-132 表头中的压力到 0 后，按上述步骤试验 PT-130、131 的动作信号。

（9）Open the shutoff valve on the impulse pipe to restore the oil pressure. Repeat the above actions twice, record the values and observe whether they are consistent.

打开导压管切断阀，恢复油压，重复上述动作两次，记录并观察每次动作的值是否一致。

2.4.2 Normal shutdown test 正常停车试验

Follow the steps in 3.1.5.1 to check if the compressor is shut down as required.

按 3.1.5.1 的步骤，检查是否按要求停机。

3 Normal operation 机组正常运转操作

3.1 Operation 运转

All systems, including the compressor, must be ready before starting the compressor. The motor start interval must be more than 30 minutes.

启动压缩机前，包括压缩机在内的所有系统必须做好提前准备。电机启动间隔时间必须在 30 分钟以上。

3.1.1 Preparedness of utility conditions 公用条件预备

3.1.1.1 Make sure the local control cabinet and auxiliary equipment have been energized.

确认就地控制柜及附属设备的电源送电。

3.1.1.2 Check the instrument air (I/A) supply.

确认供应 I/A(仪表气)。

3.1.1.3 Make sure the safety facilities are functioning properly.

确认安全装置投运正常。

3.1.1.4 Check the position of the valves on the suction/discharge side and the position of all the manual valves (open/closed position).

确认安装吸气/排气侧的阀门位置，确认所有手阀的位置。(打开/关闭位置)

3.1.1.5 Check the position of drain valves and the status of interlocks.

确认排水阀的位置及联锁启动状况。

3.1.1.6 Make sure the oil tank has no condensate water and the lubrication system is functioning properly.

确认油箱无冷凝水，润滑系统运行正常。

3.1.1.7 Make sure the auxiliary oil pump functions normally.

确认辅助油泵运行正常。

3.1.1.8 Make sure the cooling water is put into service and the coolers are functioning normally.

确认循环水投运，各冷却器运行正常。

3.1.1.9 Make sure the alarms and interlocks are put into service and are functioning properly.

确认机组各报警联锁投运，运行正常。

3.1.2 Confirmation of operating conditions 确认运转条件

To start the compressor, the following conditions must be met. Check whether these conditions are met or not through the startup condition screen of the touch panel.

为了启动压缩机，必须满足如下条件。通过触摸屏的启动条件画面，可以确认是否符合这些条件。

3.1.2.1 Make sure there is no compressor shutdown signal.

确认无压缩机关机信号。

3.1.2.2 Make sure the compressor is ready (240 seconds after the compressor is stopped).

确认压缩机处于准备就绪状态。(停止压缩机后 240 秒)

3.1.2.3 Make sure the oil supply pressure is above 0.26 kg/cm^2 (AOP is running).

确认供油压力必须为 0.26kg/cm^2 以上。 (AOP 处于运行状态)

3.1.2.4 Make sure the oil supply temperature is above 30℃.

确认供油温度为 30℃以上。

3.1.2.5 Make sure the inlet guide vane (IGV) is completely closed. 确认进口导叶(IGV) 完全关闭状况。

3.1.2.6 Make sure the ASV is fully open.

确认 ASV 完全打开状况。

3.1.2.7 Do not press the normal shutdown, emergency shutdown, or remote shutdown button.

请勿按下一般停止、紧急停止、远程停止按钮。

Note: The compressor timer starts when a compressor shutdown signal (or emergency

shutdown signal) is detected. The compressor timer is set to 4 minutes (240 seconds of coast-down time) at the time of delivery. After the field test, the timer set value may be changed according to the actual motor stop time. The compressor cannot be started until the timer is stopped.

注意：检测到压缩机停止信号（或紧急停止信号）时，压缩机计时器开始打开。发货时，压缩机计时器设定为 4 分钟（240 秒滑行时间）。进行现场测试后，按照实际电机停止时间，可以变更计时器设定值。计时器停止前，不能启动压缩机。

3.1.3 Startup 启动

3.1.3.1 After the operating conditions in 3.1.2 are met, the operator presses the START button to start the motor.

确认 3.1.2 的运转条件后，操作人员按下“启动”键，电机启动。

3.1.3.2 During the start-up phase, the IGV is at the minimum flow opening and the ASV is fully open.

在启动阶段，IGV 在最小流量开度，ASV 处于全开状态。

3.1.3.3 Put the AUTO LOAD/UNLOAD switch of the control panel to AUTO LOAD to enter the loading phase.

将控制面板的“自动加载/卸载”开关调成“自动加载”时，进入加载阶段。

3.1.3.4 After the compressor is running normally, check if there is any alarm signal and if abnormal noise or vibration occurs.

压缩机运行正常后，确认有无报警信号，注意检查是否发生异常噪音或振动。

3.1.4 Shutdown 停机

3.1.4.1 The compressor can be shut down by pressing the stop button or emergency stop button of the controller or by sending a shutdown signal from the control room. If a shutdown signal is given due to any abnormality in operation, the compressor shall be shut down according to the corresponding steps.

若按下控制器的停止按钮及紧急停止按钮，或以远程控制发出停止信号，可以停止压缩机。由于在运行过程中出现异常，而发生停机信号时，压缩机按照相应步骤停止。

3.1.4.2 The shutdown steps differ depending on how the shutdown signal is sent, as detailed below.

依据发出停止信号的方式，停止步骤有所不同。详细内容如下。

3.1.4.3 Normal shutdown 正常停机

（1）Compressor under no-load

压缩机在无负荷状态。

1）Press the STOP button (on the field touch panel or via remote control).

按下“停止”按键（现场触摸屏或远程）。

2）The main motor stops after 100 milliseconds.

100 毫秒后，主电机停机。

3）The compressor starts to idle.

压缩机开始惰转。

4）The auxiliary oil pump starts automatically.

辅助油泵自动启动。

（2）Compressor under load

压缩机在负荷状态。

1）Press the STOP button (on the field touch panel or via remote control).

按下“停止”按键（现场触摸屏或远程）。

2）The compressor is switched to no-load after 100 milliseconds.

100 毫秒后，切换至无负荷状态。

3）The main motor stops after 100 seconds.

10 秒后主电机停机。

4）The compressor starts to idle.

压缩机开始惰转。

5）The auxiliary oil pump starts automatically.

辅助油泵自动启动。

3.1.4.2 Emergency shutdown 紧急停机

The compressor will stop urgently when the EMERGENCY STOP button is pressed or the shutdown condition is detected during operation. The emergency shutdown steps are as follows.

按下“紧急停止”按纽或运行压缩机中检测到“停机”状况时，压缩机会紧急停止。紧急停止顺序如下。

（1）An emergency shutdown signal is detected.

检测到紧急停止或停机（Shutdown）信号。

（2）Quickly open the BOV when the compressor is shut down.

压缩机停机时，快速打开 BOV。

（3）Stop the main motor.

主电机停机。

（4）If the operation signal of the main motor is off or an emergency shutdown signal occurs during normal operation, follow the following steps.

正常运转中若主电动机的运行信号是关闭或发生紧急停止信号，则开始下列动作。

（5）The compressor starts to idle.

压缩机开始惰转。

（6）The auxiliary oil pump starts automatically.

辅助油泵自动启动。

Note: An emergency shutdown alarm is given when the compressor is stopped due to an emergency shutdown signal. Press the RESET button to restart the compressor and release the emergency stop alarm.

注意：因紧急停止信号停止信号而压缩机停机时，发出紧急停止警报。按下“重启”按钮，压缩机重启，解除紧急停止警报。

3.2 Lube oil filter switchover 润滑油过滤器切换

3.2.1 Open the connecting valve.

打开连通阀。

3.2.2 Open the vent valve of the standby filter and close it after seeing the oil.

打开备用一组过滤器放空阀门，见油后关闭。

3.2.3 Turn the handle of the two-position three-way valve to put the standby filter into service in one step.

转动过滤器两位三通阀手柄至备用过滤器投用位置，转动时要用力一步到位。

3.2.4 Close the connecting valve.

关闭连通阀。

3.2.5 Before switching and cleaning the filter element, make sure there is no internal leakage. Otherwise, cleaning the filter cover may cause shutdown of the lube oil system due to pressure release.

在切换和清洗滤芯前，必须确认切换阀有无内漏。否则，在开清洗过滤器头盖时会引起润滑油系统泄压而停机。

3.2.6 When the pressure difference across the lube oil filter is greater than 0.1 MPaG, the filter shall be switched out and cleaned.

润滑油过滤器压差大于 0.1MPaG 时应切换清洗滤芯。

3.2.7 Switch the filter with a pressure difference greater than 0.1 MPaG to standby.

将压差大于 0.1MPaG 的过滤器切换至备用。

3.2.8 Slightly open the vent valve to release the oil pressure, and check the switched valve for internal leakage.

稍开排气阀，将油压卸掉，同时确认切换阀有无内漏。

3.2.9 Drain the lube oil from the filter and replace the filter element.

将过滤器的润滑油排放干净，交出更换滤芯。

4 Daily maintenance 日常维护保养

4.1 For field operators 外操日常维护

4.1.1 Check and confirm that no alarm is actuated in the unit, otherwise, contact the involved disciplines for treatment in a timely manner.

检查机组有无报警信息，若有及时联系处理。

4.1.2 Check and confirm that the pressure difference across the inlet filter is not greater than 550 PaG.

检查机组入口过滤器差压应不大于 550PaG。

4.1.3 Check if condensate is drained completely from the intercooler.

检查级间冷却器凝缩水的排出情况。

4.1.4 Check and confirm that the cooling water supply pressure is not lower than 0.4 MPaG.

检查冷却水的供给压力应不低于 0.4MPaG。

4.1.5 Check and confirm that the cooling water supply temperature is not higher than 33℃.

检查冷却水的供给温度不大于 33℃。

4.1.6 Check and confirm that the operating temperature of each bearing is below 85℃.

检查各轴承运行温度应低于 85℃。

4.1.7 Check and confirm that the vibration at Stage 1/2/3 of the rotor is less than 25.4 μm.

检查转子一、二级、三级振动小于 25.4μm。

4.1.8 Check and confirm that the suction temperature at Stage 3 does not exceed 54℃.

检查压缩机三级进气温度应不高于 54℃。

4.1.9 Check if there is any leakage of water, oil and air.

检查水、油、空气的跑冒滴漏情况。

4.1.10 Check and confirm that the pressure difference across the oil filter is less than 0.1 MPaG.

检查滤油器的差压应小于 0.1MPaG。

4.1.11 Check and confirm that the lube oil supply pressure is between 0.16 -0.25 MPaG.

检查润滑油供油压力在 0.16-0.25MPaG 之间。

4.1.12 Check and confirm that there is no abnormal sound during operation.

检查机组运转无异常声音。

4.1.13 Check the compressor, motor and other facilities for cleanliness.

检查压缩机、电机等设施清洁状态。

4.1.14 Check if the auxiliary oil pump switch is at “Auto” position.

检查辅油泵开关是否在自启位置。

4.1.15 Check the lube oil tank level, drain the water at the low point once during the day shift, and check if the oil quality is normal.

检查润滑油箱液位，每天白班低点切水一次，检查油质是否正常。

4.1.16 Check if the foundation is firm and complete and if the anchor bolts and other connecting parts are loose.

检查基础是否坚固完整，地脚螺栓及其他连接部分是否有松动现象。

4.1.17 Check if the supports, hangers and pipe clamps of valves and pipelines are loose.

检查阀门、管线等设施支吊架、管卡等支撑有无松动。

4.1.18 Check if the measuring instruments of the compressor system are in good condition and if they are within the measurement range.

检查压缩机系统的测量仪表是否完好、是否超标。

4.2 For board operators 内操日常维护

4.2.1 Check and confirm that all alarm and interlock systems function properly.
检查所有报警联锁系统是否正常。

4.2.2 Check and confirm that the vibration at Stage 1/2/3 is less than 25.4 μm.
检查机组振动一级、二级、三级不大于 25.4μm。

4.2.3 Check if the temperature of each bearing is normal (it shall be <85℃).
检查机组各轴瓦温度是否正常（<85℃）。

4.2.4 Check and confirm that the oil supply temperature is between 32-60℃.
检查供油温度应在 32~60℃。

4.2.5 Check and confirm that the lube oil header pressure is between 0.16-0.25 MPaG (normal value: 0.23 MPaG), and the pressure difference across the filter is less than 0.1 MPaG.
检查润滑油总管压力 0.16-0.25MPaG，正常值 0.23MPaG 过滤器前后差压小于 0.1MPaG。

4.2.6 The board operators and field operators shall check and verify if the operation data of the unit are consistent.
检查核对内外操机组数据是否一致。

5 Accident handling 事故处理

Table 12 Accident handling

表 12 事故处理

Type of accident 事故类型	Phenomenon 现象	Measures 处理措施
Power failure 停电	1、Compressor and oil system tripped. 主机、油系统停运。	1、The compressor tripped. 压缩机已停机。
Instrument air supply failure 停仪表风	1、Compressor capacity control system malfunction. 压缩机气量调节系统失灵。	1、Maintain operation or stop the compressor unit following the normal shutdown procedures according to process requirements. 维持机组运转或按工艺要求正常停机处理。
Cooling water supply failure 停循环水	1、Temperature of lube oil from the lube oil cooler rises; 润滑油冷后温度上升； 2、Temperature of cylinder, motor, etc. rises. 气缸、电机等温度上升。	1、Follow the normal shutdown procedures. 按正常停机处理。

6 Cause analysis and treatment of abnormalities 异常现象的原因分析及处理方法

Table 13 Cause analysis and treatment of abnormalities

表 13 异常现象的原因分析及处理方法

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
1	Surge 喘振	1、IGV/BOV malfunction. IGV/BOV 故障。	1、Low I/A pressure; make sure the supply pressure is above 4.0 barG; remove the pilot valve for inspection. I/A 气压不足；确认供应 4.0barG 以上； 拆卸导向阀后检查情况。
		2、Blocked gas pipeline. 气体管路堵塞。	2、Check if there is any foreign matter in the inlet filter and if the pressure difference across the filter is normal; check the action of the check valve. 确认入口过滤器是否有异物，过滤器差压是否正常 ；确认止回阀的动作状态。
		3、Surge detection error. 喘振检测出错。	3、Check the sensor, remove the sensor and check the piping; check the external signal connected. 检查传感器，拆卸传感器后检查管线状态； 确认接入的外部信号。
		4、Improper adjustment. 调整不适合。	4、Adjust the operating speed of IGV and BOV. 调整 IGV 及 BOV 的运行速度 。
2	Low oil level 油位低	1、A small amount of oil. 油量少。 2、Oil pipeline leakage. 油管发生漏泄。 3、Level switch malfunction. 油位开关出错。	1、Replenish oil. 补充油。 2、Check and repair/ replace the pipeline. 检查管道后进行修理或更换。 3、Check and repair/replace the level switch. 检查后进行修理或更换。
3	Low oil level 油压低	1、MOP malfunction. MOP 故障。 2、Oil pipeline leakage. 油管漏油。 3、Insufficient oil flow. 供油量不足。	1、Start AOP. 启动 AOP 。 2、Check and repair/replace the pipeline. 检查后进行修理或更换。 3、Check/replace MOP and AOP; check/replace AOP check valve; check if the gas enters the pipeline; check the status of the valves on the oil pipeline. 检查/更换 MOP 及 AOP；检查/更换 AOP 止回阀； 检查是否气体进入管道；检查油路阀门状态。
		4、Blocked oil pipeline of the oil supply system.	4、Check, clean/replace lube oil strainer and filter; check PCV and TCV operation; check the

Table 13 Cause analysis and treatment of abnormalities (Continued)

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
3		供油系统油路发生堵塞。 5、Abnormal lube oil indication system. 润滑油指示系统异常。	status of the valves on the oil pipeline. 检查润滑油滤网、滤油器后清理/更换；检查 PCV 与 TCV 动作；检查油路阀门状态。 5、Check, clean/replace lube oil strainer and filter; oil level switch malfunction. 检查润滑油滤网后清洗或更换；油位开关发生故障。
4	Abnormal vibration 异常振动	1、Low oil temperature. 油温低 。 2、Inflow of condensate. 流入冷凝水。 3、Main motor out of balance. 主电动机不平衡 。 4、Damage caused by external substances. 由外部物质所造成的损伤。 5、Improper installation of compressor. 压缩机的安装不规范。 6、Damaged coupling. 联轴器损伤 。	1、Start the machine after the oil is fully preheated. 充分预热油温后启动机器。 2、Check if the drain device and the condensate drain valve function properly. 检查排水器，确认冷凝水排出阀是否正常。 3、Check the alignment of the shaft. 确认轴对中。 4、Clean/Replace lube oil and air filters. 清洗/更换润滑油及空气过滤器。 5、Check the contact between the base and the foundation; check if the base is damaged; check if the grouting & anchor bolts are loose. 检查机座与基础的接触；检查机座受损；确认灌浆&地脚螺栓是否松动；。 6、Check and repair/replace the coupling. 检查状态后进行修理或更换；。
5	High oil supply temperature 供油温度高	1、Insufficient supply of cooling water. 冷却水供给不足 。 2、High cooling water supply temperature. 冷却水供给温度高。 3、Abnormal indication system. 指示系统异常。 4、Temperature regulating valve malfunction. 调温阀故障。	1、Check and adjust the cooling water supply pressure. 确认冷却水供给压力后进行调节。 2、Check and adjust the cooling water supply temperature. 确认冷却水供给温度后并调整。 3、Check the sensor connection; check/replace the sensor. 检查传感器连接 ； 检查/更换传感器。 4、Check the temperature regulating valve settings; check and repair the temperature regulating valve. 检查调温阀设定，检查修理调温阀。

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
6	High temperature of compressed air 压缩气体温度高	1、Backflow of high temperature gas. 高温气体逆流。 2、RTD malfunction. 热电阻传感器故障。 3、Surge. 喘振。	1、Check/replace the discharge check valve. 检查/更换排气止回阀。 2、Check and repair/replace RTD wiring; check and repair/replace RTD. 检查 RTD 连线状态后进行修理或更换；检查热电阻传感器后进行修理或更换。 3、See S/N 1. 见第一条。
7	Motor overcurrent and overload 电机超电流过载	1、The motor starting current is limited. 限制电机启动电流。 2、The power cut-off device tripped. 电源切断装置的跳机。MMS/EOCR/CP/MCCP） 3、The power cut-off device is damaged. 电源切断装置的损坏 。	1、Check / resolve motor current. 确认/解决电动机电流。 2、Replace it according to the starting current and safety rate; change the set point to reflect the actual current; check the designed and actual consumption. 鉴于启动电流和安全率更换装置；变更设定值，反映实际启动电流值；确认设计和实际的消耗值。 3、Replace the faulty device. 发现装置故障须更换。
8	High temperature of motor (coil, bearing) 电机温度高(线圈、轴承)	1、Motor coil. 电机线圈。 2、High temperature of motor bearing. 电机轴承温度高。	1、Check the air outlet structure of the motor; check the ambient temperature of the compressor. 确认电机出风结构；确认压缩机的环境温度。 2、Check/replace the RTD wiring; check/replace the RTD; check whether the lube oil is sufficient; check the axial spacing of the shaft; check external noise, such as noise from welding around the compressor; check the motor bearing for self-injury. 检查/更换热电阻传感器的连线；检查/更换热电阻传感器；确认润滑油量是否充足；确认联轴器轴间间距；确认压缩机周边焊接等外部噪声的出现；确认电动机轴承的自损伤。
9	Large differential pressure of suction filter 进气过滤器差压大	1、Blocked filter element. 过滤器芯堵塞。 2 Foreign matter inside. 混入异物。	1、Check and replace the filter element. 检查后，更换过滤器芯。 2、Clean. 清理。

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
10	Unstable IGV opening and closing IGV 开合不稳定	1、Foreign matter inside the control ring. 控制环内有异物。 2、Foreign matter at the connection. 连接部有异物。 3、Drive mechanism/control dome bolts are not tightened. 驱动机构装置/控制拱顶螺栓松。	1、Remove the foreign matter after shutdown. 停机后去除异物。 2、Remove the foreign matter. 去除异物。 3、Check the connection and re-tighten the bolts. 检查连接状态，并重新拧紧。
11	High temperature of bearing and rotor 轴承及转子温度高	1、High oil supply temperature. 供油温度高。 2、Insufficient oil supply. 供油量不足。	1、See S/N 5. 见第五条。 2、Gas enters the pipeline; check and replace MOP and AOP; check/replace AOP check valve; check and clean the filter; check the status of oil line valves (switches). 气体进入管道；检查 MOP 及 AOP 后更换；检查/更换 AOP 止回阀；检查清理过滤器；检查油路阀门状态（开关）。
12	Abnormal vibration of main motor 主电机异常振动	1、The motor housing vibrates. 电动机壳体发生振动。	1 Check and retighten the core part. 确认核心部分的拧紧状态，重新拧紧。 2 Check if the motor housing is broken. 确认电动机壳体有无破裂。 3 Check the oil tank installation strength / installation side reinforcement. 检查油箱安装强度/安装侧面补强。 4 Check each motor foot for gasket thickness. 检查各电机脚位置确认垫片厚度。 5 Recheck/correct the soft support. 重新检查/修正软支承。 6 Recheck/correct the motor alignment. 重新检查/修正电机对中。
13	Abnormal noise from main motor 主电机异常噪声	1、Unbalanced air gap. 气隙不均衡。 2、Friction between the rotor and the stator. 转子和定子有摩擦。 3、Broken part of the motor. 转子有破裂部位。	1、Repair the motor. 修理电机。 2、Check and repair. 检查及修理 。 3、Repair the motor. 修理电机 。

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
13		4 、 Damaged motor bearing is damaged. 电机轴承破损。 5 、Single phase (open phase). 单相（打开相）。 6、Defective soft support. 软支撑不良 。 7、Motor support (oil tank, etc.) and resonance. 电机支撑（油槽等）和共振。 8、Insufficient rigidity of the motor. 电机自身刚性不足。 9 、 Defective internal part(s). 电机内部部件有缺陷。 10 、 Contact between motor and other parts. 电机与其他零件之间发生接触 11、Motor box vibration. 电机箱振动	4、Analyze the cause and repair the motor. 分析破损原因及修理电动机 。 5、Check and repair the power supply system. 检查电源系统及修理。 6、Check the soft support and alignment. 确认软支撑及对中。 7、Check the vibration frequency of the support structure; reinforce the structure. 确认支撑结构物的振动频率 ；加固结构。 8、Reinforce the structure or replace the motor. 加固结构或更换电机。 9、Check and repair the motor. 检查及修理电机。 10、Isolate the interfering part. 隔开干涉部位。 11、Check if the motor box structure is broken; check the supporting strength of the oil tank; check if the gasket and bolt of each motor foot are loose. 确认电机箱结构物破裂；确认电机支撑油箱强度；检查各电机底脚的垫片及螺栓是否松动。
14	Motor start failure 电机启动故障	1、The motor starter cabinet failure has not been eliminated. 电机启动柜故障未排除。 2、The running signal cannot be transmitted to the motor starter cabinet. 无法向电机启动柜传递运行信号。 3、The motor start mode is set to local. 电机启动方式设为就地模式 。 4、otor starter cabinet failure.	1、Press the reset button. 按复位键。 2、Check relay operation and preparation conditions. 确认继电器的动作及准备条件。 3、Switch to remote mode. 切换为远程模式。 4、Check if the magnetic contact is damaged. 确认磁力接触是否烧毁。

Table 13 Cause analysis and treatment of abnormalities (Continued)

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
14		电机启动柜故障。 5、The motor cannot be started. 电机无法启动。 6、Soft start control error. 软启动控制错误。 7、Soft start overheating. 软启动过热 。 8、Incorrect soft start setting. 软启动设定值不正确	5、Check the motor rotation axis. 检查电机旋转轴。 6、Check that the input and output control values are greater than 10K ohms. 确认输入输出控制值大于 10K 欧姆。 7、Check/replace the cooling fan. 检查/更换冷却扇 。 8、Change mode; voltage control --> current control. 变更方式；电压控制--> 电流控制。
15	Unload - Load switchover failure 不能切换 (卸载–加载，Unload – Load)	1、Low air supply pressure of IGV. IGV 供气压力低。 2、IGV operating range adjustment. IGV 运转范围调节。 3、IGV in poor working condition. IGV 动作状态不良。 4、IGV initial position setting error. IGV 初始位置设定出错。 5、Low air supply pressure of BOV. BOV 供气压力低。 6、BOV operating range adjustment. BOV 运转范围调节。 7、BOV operation failure. BOV 运行故障 。	1、Adjust the minimum pressure to 4.0 BarG or higher. 调整最低压力至 4.0 BarG 或更高。 2、Adjust. 调整。 3、See S/N 10. 见第十条。 4、Press the reset button. 按复位（Reset）键 5、Adjust the minimum pressure to 4.0 BarG or higher. 调整最低压力至 4.0 BarG 或更高。 6、Adjust. 调整;。 7、See S/N 25. 见第二十五条。
16	Large power consumption 用电量多	1、Low power supply voltage. 电机供给电压低。 2、Overload. 过载运转。 3、Low motor efficiency. 电机效率低 。	1、Check the supply voltage. 确认供电电压状态。 2、Adjust the operating load. 调整运转负荷。 3、Consult the motor manufacturer. 咨询电机制造商。

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
17	Heater failure 加热器故障	1、The oil heater cannot be powered on. 油加热器无法供电。 2、The oil heater is damaged. 油加热器受损 。	1、Check the power supply. 确认供电。 2、Replace the oil heater. 更换油加热器。
18	Lube oil color change 润滑油变色	1、Lube oil state change. 润滑油状态发生变化。 2、Use of non-standard oil. 使用非标准油。 3、Foreign matter in the lube oil. 润滑油中混入异物 。 4、Entrance of moisture. 水分流入。	1 、Replace the lube oil. 换油。 2、Replace with standard oil. 更换标准油。 3、Analyze the composition and replace the lube oil. 分析成分后更换油。 4、Replace the lube oil. 更换润滑油。
19	High oil supply pressure 供油压力高	1、Pressure setting error. 压力设定错误 。 2、Increase in lube oil viscosity. 润滑油的粘度增加。 3、Oil pressure gauge damage. 油压表损坏 。	1、Check and reset the oil pressure. 确认油压后重新设定。 2、Check the oil supply temperature; check the oil heater disconnection and running status; check TCV status. 确认供油温度；检查油加热器断线及运行状态；检查 TCV 状态。 3、Check and repair/replace the oil pressure gauge. 检查后进行修理或更换。
20	Oil in gas 气体含油	1、Oil mist filter element malfunction. 油雾过滤器芯故障。 2、Damaged seal. 密封损坏 。	1、Check the vacuum system / oil mist filter. 确认真空系统/油雾过滤器。 2、Check/replace the seal. 确认/更换密封。
21	Abnormal system pressure control 系统压力控制异常	1、Pressure transmitter malfunction. 压力传送器故障。 2、Small motor setting point. 电动机设定点的值小 。 3、Failure to open and close IGV. 无法开闭 IGV。 4、Pressure set point error. 压力设定点错误 。	1、Replace the pressure transmitter. 压力传送器更换； 2、Make sure the set point has a sufficient margin. 确保设定点的设定值具有充分裕度； 3、Press the reset button. 按复位键 ； 4、Press the reset button. 按复位键。

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
22	Low discharge pressure 排气压力低	1、Pipeline leakage. 管道发生漏泄。 2、Pressure gauge damage. 压力计受损 。 3、Clogging of suction filter. 进气过滤器发生堵塞 。	1、Check and repair/replace the pipeline. 检查管道后进行修理或更换 。 2、Check and repair/replace the pressure gauge. 检查后进行修理或更换 。 3、Check and repair/replace the suction filter. 检查后进行修理或更换。
23	High temperature of oil cooler 油冷却器温度高	1、Clogging of cooling water pipeline. 冷却水管道发生堵塞 。 2、Low cooling water pressure. 冷却水压力不足 。 3、Clogging of the oil pipeline. 油管发生堵塞 。 4、Low oil pressure. 油压不足 。 5、Defective auxiliaries of the lube oil system. 润滑油系统附件不良。 6、Defective RTD. 热电阻传感器不良 7、Defective cooler. 冷却器不良。	1、Clean the filter and remove foreign matters / replace the pipeline. 清理过滤器、去除异物/更换管道。 2、Check the valve opening and pipe network pressure. 检查阀门开度，管网压力。 3、Clean the filter and remove foreign matters / replace the pipeline. 清理过滤器、去除异物/更换管道。 4、Check/Replace MOP and AOP filters and check the pressure regulator. 检查/更换 MOP, AOP 过滤器，检查调压阀门。 5、Check/Replace TCV/PCV/oil filter/oil strainer. 6、Check/Replace RTD; check the connection of the PLC RTD module. 检查/更换温度传感器;确认 PLC 热电阻模块连接。 7、Check and repair/replace the cooler. 检查修理或更换。
24	Abnormal noise from MOP MOP 发生异常噪声	1、Check the rotation direction of MOP. 检查 MOP 旋转方向。 2、Entrance of foreign matter into MOP. MOP 内混入异物。 3、Entrance of gas into MOP. MOP 内混入气体。 4、Deformed or damaged MOP shaft. MOP 轴发生变形或受损。	1、Check if the rotation direction of MOP is correct. 确认 MOP 旋转方向是否正确。 2、Check and clean/replace MOP; replace MOP if necessary. 检查后清洗或更换；更换 MOP(必要时)。 3、Check and repair the part from which the gas enters; replace MOP if necessary. 检查及修理气体流入的部位；更换 MOP(必要时)。 4、Replace MOP. 更换 MOP。

Table 13 Cause analysis and treatment of abnormalities (Continued)

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
25	Unstable BOV movement BOV 移动不稳定	1、No I/A supply. 未供给 I/A 。 2、Defective positioner. 定位器不良。 3、Pneumatic actuator malfunction. 空压式传动装置动作异常。	1、Check if the I/A supply valve is shut off; check the I/A supply pressure. 确认 I/A 供给阀的切断与否；确认 I/A 供应压力。 2、Check if there is any foreign matter in the instrument air source; correct it according to the change of the operating range. 确认仪表气源内是否混入异物；根据运用范围变化进行校正。 3、Check if the I/A contains any foreign matter (the air flow path is blocked); check/replace the spring of the drive mechanism. 确认 I/A 混入异物（气路堵塞）；检查/更换驱动机构的弹簧。
26	Abnormal control panel 控制板异常	1、Touch panel operation error. 触摸屏操作错误。 2、Dark screen of the touch panel. 触摸屏画面较暗。 3、Operation switch error. 操作开关错误。 4、Abnormal air conditioner fan (noise, shutdown). 冷气风扇异常（噪音、停止）。 5、Relay error. 继电器错误。	1、Check and modify the HMI program. 检查触摸 HMI 程序后修改。 2、Adjust the brightness of the touch panel and replace the touch panel when it is defective. 调节触摸屏亮度，不良时更换。 3、Check the contact connection and replace defective switches. 确认接点连接，开关类不良时更换。 4、Replace the fan. 更换风扇 。 5、Check cable connection and replace defective cable. 确认线连接，不良时更换。
27	PLC component malfunction PLC 零部件故障	1、Abnormal card (relay failure, defective card). 卡异常（继电器故障、卡不良）。 2、Card insertion error. 卡插入错误。 3、The entire PLC is not started.	1、Replace the card. 更换卡。 2、Check the card specification and replace the card. 确认卡规格后更换。 3、Check the program and power supply. 确认程序及电源

Table 13 Cause analysis and treatment of abnormalities（Continued）

表 13 异常现象的原因分析及处理方法（续）

S/N 序号	Abnormality 异常现象	Cause analysis 原因分析	Treatment 处理方法
27		整个 PLC 未启动。 4、Abnormal communication. 通信异常 。 5、Abnormal time display. 时间显示异常 。 6、The program is deleted. 程序被删除。	 4、Check the communication protocol and wiring. 确认通信协议及线的连接。 5、Replace the mercury battery. 更换汞电池。 6、Replace the backup battery. 更换备份电池 。