INDUSTRIAL PUMP AND EQUIPMENT

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SUNDYNE

COMPRESSOR TROUBLSHOOTING GUIDE

GEARBOX AND COMPRESSOR

Many factors affect the performance of your compressor. Among them are suction pressure, temperature, molecular weight, driver speed, flow rate, and discharge control. You need to check all of these when there is a problem with the compressor and when you are analyzing the performance of the system. For details on the performance of the compressor including the performance curve. See final data package.

The following table provides information for analyzing gearbox and compressor problems.

TROUBLESHOOTING FOR GEARBOX AND COMPRESSOR

Trouble	Possible Cause	Investigative/Corrective Action
The compressor produces no flow and no pressure at start-up	A component of the drive, such as the coupling or the impeller spline, has failed, or an item is missing from the assembly	Disassemble and inspect the component.
	The drive shaft rotates in the wrong direction	Make sure that the drive shaft is rotating in the direction shown by the arrow on the compressor gearbox.
	The suction valve or the discharge valve is closed.	Check the valving *(see section 3. Startup instructions)*.
The head rise is insufficient.	The flow is too high.	Check the head rise and the flow rate against the performance curve.
	The driver shaft is rotating in the wrong direction.	Make sure that the drive shaft is rotating in the direction shown by the arrow on the compressor gearbox.
	The suction pressure is low.	Check the Sundyne specification sheets
	Recirculation from the discharge to the inlet is excessive.	Check the flow through the external piping, such as the bypass
	The molecular weight is not that for which the compressor was designed.	Check the molecular weight against the value given on the specification sheet. Low molecular weight will cause low discharge pressure.
	The driver speed is too low.	Check the speed against the value listed on the Sundyne specification sheets.
	The pressure gauges or the flow meters are in error	Calibrate the instrumentation.
The oil pressure in the gearbox is low.	The pressure gauge is faulty.	Check the accuracy of the gauge.
	The main lubricating pump has failed.	Remove the pump and coupling, and check them for damage.
Driver overloaded.	Molecular weight higher than values listed on specification sheet	Check actual molecular weight against value listed on specification sheet.
	Electrical failure in electric power unit.	Check circuit breaker heater size and setting.
		Check voltage.
		Current for each phase should be balanced within three percent.

TROUBLESHOOTING FOR GEARBOX AND COMPRESSOR - CONT.

Trouble	Possible Cause	Investigative/Corrective Action
Driver overloaded. (continued)	Mechanical failure in driver, gearbox, or compressor.	Disconnect spacer coupling and check for freedom of rotation of compressor, driver, and gearbox shafts.
		Drain oil and remove gearbox oil level sight glass and inspect bottom of sump for wear particles. Bearings are probably not damaged if no wear particles are present.
		Disassemble compressor end and search for any mechanical failure.
	Corrosion pitting on surface of diffuser adjacent to impeller blades. Head rise is reduced by this condition.	Disassemble and inspect. Check diffuser bowl area, cover plate and diffuser throat for material buildup. Clean these areas of all obstructions and restore surfaces to a smooth polished finish (use emery cloth) free of all corrosion pitting. Edge of diffuser throat must be sharp. If damage is more severe (i.e. impeller is deformed or has come in contact with diffuser) replace the damaged parts.
	High suction pressure.	Check specification sheet. Increase suction pressure and corresponding mass flow rate will result in high horsepower consumption.
Excessive discharge pressure pulsation.	Flow rate too low (surge).	Increase flow rate through compressor. Add controlled bypass to suction, if necessary.
	Defective flow control valve.	Check control valve.
Change of gearbox automatic transmission fluid color from normal color to milky pink or yellow.	Gearbox oil contaminated with water or process fluid.	Inspect gearbox heat exchanger for leakage.
		Check for excessive compressor seal leakage.
		Inspect shaft sleeve “O” rings.
Shaft sleeve rubs on inside diameter of seal.	Gearbox journal bearing failure.	Install replacement exchange gearbox or repair gearbox as outlined under “MAINTENANCE.”
Excessive gearbox automatic transmission fluid consumption.	Low speed shaft seal (115) leakage.	Check drain port for leakage. Replace shaft seal if required
	High speed shaft mechanical seal (60C) leakage.	Check for fluid leakage from port 1.
	Leakage through heat exchanger into cooling fluid.	Pressure test heat exchanger and replace if required.
Excessive oil foaming.	High oil level.	Shut down the unit and check oil level.
	Low gearbox temperature.	Adjust coolant to heat exchanger, keeping oil temperature above 140°F. (60°C).

COMPRESSOR MECHANICAL SEALS

Table 3 provides information on problems with single units, as well as double and tandem seal units.

TROUBLESHOOTING FOR GEARBOX AND COMPRESSOR

Trouble	Possible Cause	Investigative/Corrective Action
Leakage around the seal suddenly increases	The system is operating at a low flow rate or a low inlet pressure, causing vibration of the high-speed shaft, bouncing on the face of the seal, and chipping on the nose of the carbon seal.	Make sure that the compressor always operates above the specified minimum flow rate and/or inlet pressure.
	The action of the stationary face spring on the seal is rough and sticky	If contamination in the process gas (from entrained solids) causes a sticky seal, there may be need for a seal flush, double seals, or tandem seals.
	The seal is worn or damaged.	Disassemble the seal and rebuild or replace it by the instructions in Section 5.
	The wear pattern on the rotating faces of the seal is not uniform.	Lightly lap the surfaces on the shaft sleeve and the impeller hub that contact the rotating face of the seal, to remove high spots. Install new seal faces. Do not remove more than 0.005 in. (0.12mm) from any surface.
	The rotating face of the seal is cracked or broken. This may have been caused by damage at the assembly or by heating due to lack of leakage (cooling) past the seal.	Make sure that the system operates above the specified minimum flow rate at all times.
		Check the seal environment to make sure that there is a leakage path of process or buffer fluid across the compressor seal(s) and that there is a differential across the seal(s) to force this leakage. Replace the damaged seal.
	The seal faces, seal parts, or o-rings have become chemically attached.	Investigate the properties of the process gas, and replace the components with chemically resistant materials.
	The seal on a low-temperature compressor is icing, or there is heavy condensation on the atmospheric side of the seal.	Purge the atmospheric side of the seal with dry nitrogen gas.

OPERATION

Some form of control is required for the majority of SUNDYNE compressor applications. The purpose of control is twofold:

1) to achieve the desired performance as required by process conditions, and
2) to protect the compressor from mechanical damage due to surge or overload conditions.

This section is a general guideline on controls. A control system should be selected only after completion of a detailed analysis of the specific installation.

Surge Control

It is recommended that a surge control system be installed whenever there is any chance that the process flow could decrease appreciably from design flow. In most surge control systems, a flow sensor is placed in the suction line to the compressor. The signal from this sensor is input to a controller which controls a valve in the bypass loop. When the minimum safe flow is reached, this valve opens and the flow through the compressor is kept above the surge point. Again, the recycled gas must be cooled to prevent heat build-up. Both pneumatic and electrical surge control systems are available.

Suction Throttling

Suction throttling is generally the most economical control method with a constant speed drive. Throttling the control valve on the suction side causes a reduction of inlet pressure to the compressor. Although the compressor creates the same compression ratio as if it were unthrottled, the discharge pressure is reduced. The net result is to lower the total head output to the system. The reduction of inlet pressure correspondingly decreases inlet gas density, and thus, power consumption. Suction throttling also has the advantage of slightly lowering the compressor surge point.

Discharge Throttling

Discharge throttling is controlled by means of a valve placed at the compressor discharge. A constant speed compressor will always operate on its design head-flow curve. For a given system operating point, the compressor will operate at the system flow rate, thus producing more head than the system requires. This excess head is throttled by the discharge valve. Since the throttling occurs downstream of the compressor, there are no power savings by this method. Discharge throttling offers no real advantages over suction throttling, but is nonetheless an acceptable control method.

OPERATION - CONT.

Speed Control

Speed control is the most efficient means of compressor control. To operate at points below the design head-flow curve, the driver speed may be reduced accordingly. This creates an infinite "family" of head-flow curves on which the compressor may operate. Since consumed horsepower, assuming constant inlet conditions, varies as the cube of the speed, substantial power savings can be realized. Also, the compressor surge point is lowered proportional to the speed decrease. This method is used mainly on turbine driven units although variable speed motors or mechanical drives are available. Since the main lube oil pump in the SUNDYNE compressor is driven by the gearbox input shaft, provision must be made so the speed is not reduced to a point where adequate lube oil pressure is no longer present.

Flow Bypass

Flow bypass requires a recycle line from the compressor discharge to suction. The compressor is operated at the desired flow or discharge pressure and the excess flow not required by the process is recycled through the bypass. A cooler is required in the loop to cool the recycled gas to normal suction temperature. This method is generally less efficient than other methods discussed, but may be warranted in some special situations.

Flow Bypass

Flow bypass requires a recycle line from the compressor discharge to suction. The compressor is operated at the desired flow or discharge pressure and the excess flow not required by the process is recycled through the bypass. A cooler is required in the loop to cool the recycled gas to normal suction temperature. This method is generally less efficient than other methods discussed, but may be warranted in some special situations.

OTHER ASPECTS WHICH SHOULD BE CONSIDERED IN COMPRESSOR OPERATION ARE:

Series Compressor Control - Inlet throttling on the first stage is the most practical method of controlling compressor in series. It is necessary to throttle only the first stage, which in turn acts as a throttle for the second stage. Inlet throttling between stages offers no advantages and should be avoided. Efficiency gains by variable speed control of series units will seldom justify its cost and complexity.

Surge control on series units consists of a flow sensor and controller in the suction line of the first stage. This sends a signal to the control valve in a bypass loop around both compressors. It must be determined which compressor surges at the lowest inlet flow to the first unit so the flow controller can be set such that neither compressor will surge. A more complex system which offers maximum machine protection consists of separate bypass loops for each unit which are operated by separate flow controllers.

Parallel Compressor Control - The control of two or more compressors operating in parallel would appear to be relatively simple. More than likely, though no two compressors ever operate identically across their flow range. To produce identical discharge pressures, one compressor could be operating at a different flow than the unit in parallel with it. As a result, the control system would have to include a separate flow controller for each unit. Either suction or discharge throttling may be used, but again, suction throttling is the preferred method. If variable speed drivers are used, extreme care must be taken to insure that the speeds can be precisely controlled. In any case, check valves must be installed in the discharge line of each compressor to prevent possible back flow due to any slight imbalance in the characteristics of the compressors. Separate surge control systems for each compressor should be considered for maximum unit protection.

Surge Control

It is recommended that a surge control system be installed whenever there is any chance that the process flow could decrease appreciably from design flow. In most surge control systems, a flow sensor is placed in the suction line to the compressor. The signal from this sensor is input to a controller which controls a valve in the bypass loop. When the minimum safe flow is reached, this valve opens and the flow through the compressor is kept above the surge point. Again, the recycled gas must be cooled to prevent heat build-up. Both pneumatic and electrical surge control systems are available.

SPARE PARTS

General

Assemblies, subassemblies and components of the Sundyne compressor are illustrated on the exploded and cross sectional views in Reference D. Refer to your Sundyne Compressor Specification Sheet for those options applicable to your compressor. The corresponding parts lists, keyed to each part by item number, identify detail parts by part name, quantity and location. A complete bill of materials list for the compressor and gearbox end is included in the final data package. Refer to the unit outline drawing for a list of the major kit bills of material.

Recommended Spare Parts

Refer to your final data package for recommended spare parts identified for your particular unit. These are provided as guidelines only.

Repair Kits

Seal and O-ring repair kits are not illustrated herein, but may be purchased directly from Sundyne Corporation. Seal repair kits contain all normal wearing parts (springs, washers, o-rings, carbon faces, etc.) of the compressor or gearbox mechanical seals.

O-ring repair kits contain all o-rings necessary for maintenance or overhaul of the compressor. The use of these kits reduces maintenance time, prevents assembly mistakes, simplifies stocking and inventory, and reduces delivery time.

PUMP TROUBLSHOOTING GUIDE

GEARBOX & PUMP DIAGNOSTICS

Several system factors may affect the performance of the pump. These factors are:

- Temperature
- Specific gravity
- Suction pressure
- Driver speed
- Flow rate
- Control characteristics

These factors as well as internal problems must be considered when analyzing pump system performance. The following table gives diagnostic information that can be useful when analyzing gearbox and pump performance problems.Table 2 provides information for analyzing gearbox and compressor problems.

GEARBOX AND PUMP DIAGNOSTICS

Trouble	Possible Cause	Investigative/Corrective Action
No flow, no pressure at start-up.	Pump not completely filled with liquid.	Bleed all vapor or air from port 6. Allow more cool-down time if pumping low temperature fluid. Check suction line for air leak if suction pressure is lower than atmospheric.
	NPSH actually lower than NPSH requirement listed on specification sheet.	Suction line blocked – check suction screen and valve. Excessive pressure drop through suction piping. Flow restricted by vapor pockets in high points of suction line. Suction tank level or pressure too low. Entrained air or vapor in pumped fluid. NPSH reduced by presence of more volatile fluid in process fluid.
	Failure of drive component, such as interconnecting shaft or impeller key, or item missing from assembly.	Disassemble and inspect.
	Reverse direction of rotation.	Direction of driver shaft rotation must be as shown by arrow on pump casing. Note: Impeller and driver rotate in the same direction.

GEARBOX AND PUMP DIAGNOSTICS - CONT.

Trouble	Possible Cause	Investigative/Corrective Action
Insufficient total head.	Flow too high.	Check total head and flow rate against performance curve
	Wrong direction of driver shaft rotation. (It is possible for the pump to develop greater than 50 percent design total head in this condition).	Direction of driver shaft rotation must be as shown by arrow on pump casing. Note: Impeller and driver rotate in the same direction.
	NPSH actually lower than NPSH requirement listed on specification sheet.	Refer to solutions listed under "No flow, no pressure at start-up".
	Flow too low, causing overheating of fluid resulting in internal boiling and unstable pump operation.	Increase through-flow rate. Bypass part of pump discharge to supply tank.
	Diffuser discharge throat partially plugged or impeller damaged by passage of a solid particle.	Clean these areas of all obstructions and restore surfaces to a smooth polished finish free of all corrosion pitting. Edge of diffuser throat must be sharp.
	Corrosion and/or erosion of diffuser throat (may also be accompanied by corrosion/ erosion of diffuser and cover surface adjacent to impeller).	If edge of throat is no longer sharp and smooth or has opened in size, head-rise may be reduced. Opening of the inlet area of the throat will result in higher flow rate and horsepower consumption. Corrosion/erosion of diffuser and cover surfaces will result in a significant horsepower increase.
	Excessive recirculation from discharge to inlet.	Check flow through external plumbing. Pump o-ring (936C) damaged or missing. Integral centrifugal separator orifice worn.
	Process fluid specific gravity or viscosity different from values shown on specification sheet.	Check actual viscosity and specific gravity at operating temperature. Viscosity higher than five centipoise will cause reduced head and flow and increased power consumption.
	Driver speed too low.	Check speed against value listed on specification sheet.
	Pressure gauges or flow meters in error	Calibrate instrumentation.

GEARBOX AND PUMP DIAGNOSTICS - CONT.

Trouble	Possible Cause	Investigative/Corrective Action
Driver overloaded.	Fluid specific gravity or viscosity higher than values listed on specification sheet.	Check actual viscosity and specific gravity against value listed on specification sheet.
	Electrical failure in electric driver.	Check circuit breaker heater size and setting. Check voltage and voltage balance between phases. Current for each phase should be balanced within three percent.
	Mechanical failure in driver, gearbox or pump.	Remove driver and check for freedom of rotation, correct spacing of pump and gearbox shaft assemblies. Remove fluid end and search for any mechanical failure. Remove gearbox oil level sight glass and inspect bottom of sump for wear particles. Bearings are probably not damaged if no wear particles are present.
	Corrosion pitting on surface of diffuser cover or diffuser, adjacent to impeller blades. Head rise is also reduced by this condition.	Disassemble pump and inspect. Rough or pitted surfaces can cause friction losses which will significantly increase horsepower consumption. Clean these areas of all obstruction and restore surfaces to a smooth polished finish. Check diffuser throat area at the inlet; erosion or corrosion resulting in roughness or increased area will increase horsepower consumption. Note: A larger throat size than design will allow a higher flow and horsepower for a given head rise.
Excessive discharge pressure pulsations.	Flow rate too low.	Increase flow rate through pump. Add bypass to suction tank if necessary.
	Insufficient NPSH available	Refer to solution for insufficient NPSH under “No flow, no pressure at startup,” above.
	Defective flow control valve.	Check control valve.
Change of gearbox oil from normal color to milky pink or yellow	Gearbox oil contaminated with water or process fluid.	Inspect gearbox heat exchanger for leakage. Check for excessive pump seal leakage. Inspect shaft sleeve o-rings. Inspect that seal housing port 1 and other seal drains are open for unrestricted seal leakage flow.
Shaft sleeve rubs on inside diameter of seal.	Gearbox journal bearing failure.	Install replacement exchange gearbox or repair gearbox as outlined under “Maintenance”.
Excessive gearbox oil consumption.	Low speed shaft seal (115) leakage.	Check upper gearbox housing lip seal drain port for leakage. Replace shaft seal if required.
	High speed shaft mechanical seal (60C) leakage.	Check drain port 1 for leakage. Replace shaft seal if required.
	Leakage through heat exchanger into cooling fluid.	Pressure test heat exchanger and replace if required.

GEARBOX AND PUMP DIAGNOSTICS - CONT.

Trouble	Possible Cause	Investigative/Corrective Action
Excessive oil foaming.	High oil level.	Shut down the unit and check oil level.
	Low gearbox temperature. Incorrect lubricant.	Adjust coolant to heat exchanger, keeping oil temperature above 140°F, 60°C.
High gearbox temperature.	Heat exchanger fouled or coolant shut off. Oil level too high.	Check coolant flow and/ or clean heat exchanger. Check oil level and adjust.

PUMP MECHANICAL SEAL DIAGNOSTICS

The following table contains diagnostic information that is applicable to single seal, double seal, and tandem seal equipped units.

Repair procedures for mechanical seals are listed in this manual under Maintenance.

Trouble	Possible Cause	Investigative/Corrective Action
Sudden increase in seal leakage.	Severe cavitation or loss of suction causing vibration and bouncing of seal face.	Correct pump suction condition causing cavitation. Bleed vapor from seal cavity and restart. Install double seal if loss of suction cannot be prevented.
	Seal icing on low temperature pumps or icing when handling fluids which vaporize at a temperature of less than +32°F (0°C) at atmospheric pressure	Quench with compatible fluid which will not freeze at pump temperature through seal drain port 2 or 7 to prevent ice formation on atmospheric side of seal during start-up and in running condition. Use purge of dry nitrogen gas through ports 2 or 7. Install double or tandem seal if ice is caused by water in process fluid or supply external seal flush of compatible fluid which does not contain water.
	Solid particles in seal cavity or seal spring area (seal faces usually have rough scratched appearance).	Inspect for clogged integral centrifugal separator orifices. Clean orifices if necessary (plan 31 if so equipped.) Supply external clean seal flush or double seal if particles cannot be removed by separator.
	Seal stationary face spring action is rough and sticky.	If parts are corroded, replace with parts made from compatible materials. If formation of solids causes sticky seal analyze fluid properties. Use external seal flush or double seal arrangement.

PUMP MECHANICAL SEAL DIAGNOSTICS - CONT.

Trouble	Possible Cause	Investigative/Corrective Action
Sudden increase in seal leakage. - cont.	Worn or damaged seal.	Disassemble seal and rebuild or replace per instructions in maintenance section.
	Wear pattern on seal rotating faces not uniform.	Lightly lap surfaces of shaft sleeve and impeller hub which contact rotating seal face to remove high spots. Install new seal faces.
	Wear pattern on stationary face smooth but not uniform.	Lap flat or replace seal.
	Edges of stationary face chipped and seal face worn. (Vapor flashing in seal cavity will cause excessive wear and/or cracking of rotating face.)	Install seal cavity bypass to suction tank. Prevent loss of pump suction. Supply cool seal flush. Install double seal.
	Seal rotating face cracked or broken. May be caused by damage at assembly or thermal shock caused by seal running dry.	Prevent loss of pump suction or supply continuous external seal flush. Install double seal.
	Chemical attack of seal faces, seal parts or o-rings.	Investigate fluid properties and determine suitable materials for replacement.
	Excessive radial high speed shaft movement. Bent high speed shaft or severe out-of-balance.	Check high speed shaft journal bearings and replace if necessary. Check if damage exists on impeller and/or inducer which will indicate that a large particle went through the pump. Deposits on the impeller/inducer causing unbalance.
	Damage to mechanical seal secondary seal (Teflon® wedge or U-cup or elastomer o-ring).	Check for erosion and/or corrosion attack. Install seal flush or double seal arrangement.
	Loose stack-up of high-speed shaft attaching components.	Check for correct impeller bolt/inducer torque. Check for cold flow of Teflon® o-rings.