



KAYDRILL TECHNICAL GUIDE

Portable Air Compressor Selection Guide

From physics and screw airends to selection and maintenance
For KayDrill dealers and equipment users

Inside

- Air & compression physics
- Screw airend & systems
- DTH drilling match-up
- Six-step selection
- Model tables & examples
- Operation & maintenance



Zhejiang Kaizuan Machinery Co., Ltd.

KayDrill • Air power solutions for demanding sites

2026

Dealer & Customer Edition

CONTENTS

Table of Contents

Before You Begin	4
How to Use This Guide	4
Conventions Used in This Guide	4
Edition Information	5
Introducing Portable Air Compressors and KayDrill	6
1.1 What Is a Portable Air Compressor?	6
1.2 Who Is KayDrill?	7
1.3 KayDrill Product Line Overview	8
1.4 Six Core Technologies	9
1.5 How to Read a Model Designation	10
Physics Fundamentals: Air, Pressure and Temperature	11
2.1 Pressure: Gauge and Absolute	11
2.2 Temperature and Absolute Temperature	12
2.3 The Ideal Gas Equation of State	12
2.4 Density and Mass Flow	12
2.5 Altitude: Why Machines "Shrink" at High Altitude	13
2.6 Humid Air and Condensate	14
2.7 Free Air Delivery (FAD)	15
Compression Thermodynamics and Formula Derivations	16
3.1 Where Compression Work Comes From	16
3.2 Deriving the Three Types of Compression Work	17
3.3 Discharge Temperature: Why Oil Injection Is Essential	18
3.4 Two-Stage Compression and the Optimum Intermediate Pressure	19
3.5 From Theory to Reality	20
The Screw Airend: How the Rotors Compress Air	21
4.1 Basic Construction	21
4.2 Working Cycle: Suction – Compression – Discharge	22
4.3 Rotor Profile and Lobe Count	23

4.4 Built-in Volume Ratio: The Most Overlooked Screw Parameter	23
4.5 Leakage and Volumetric Efficiency	25
4.6 Single-Stage vs. Two-Stage Airends	25
4.7 Airend Drive Arrangements	25
Complete Machine Systems Explained	27
5.1 Air Intake and Discharge System	27
5.2 Cooling and Lubrication System	29
5.3 Control System (Diesel Units)	30
5.4 Control System (Electric Units)	31
5.5 Power System	32
5.6 Fuel System	32
5.7 Chassis and Canopy	33
Matching the Compressor to DTH Drilling	34
6.1 How a DTH Hammer Works	34
6.2 Hammer Pressure and Air Consumption	35
6.3 Matching Hole Diameter, Hammer and Drill Pipe	35
6.4 Flushing: Annulus and Uphole Velocity	36
6.5 Water Column: The Pressure Killer in Deep Water Wells	38
6.6 Connecting to the Drill Rig	39
Selection Method: The KayDrill Six-Step Process	40
7.1 Step 0: Ask About the Job, Not the Specs	40
7.2 Step 1: Choose the Hammer from the Hole Diameter	42
7.3 Step 2: Calculate Pressure (Recommended and Minimum)	42
7.4 Step 3: Calculate Air Volume (Take the Larger of Two)	43
7.5 Step 4: Scale Up for Site Conditions	43
7.6 Step 5: Select the KayDrill Model	45
7.7 Step 6: Back-Check	45
7.8 Cases That Must Be Referred to a Technical Engineer	45
KayDrill Model Quick Reference and Selection Examples	47
8.1 Model Quick-Reference Tables	47
8.2 Quick-Reference Matrix	49
8.3 Example 1: Quarry Blast Holes in Yunnan	50
8.4 Example 2: Water Well with Grid Power	51

8.5 Penetration Rate Estimate	52
8.6 Getting Selection Support	52
Safety and Operation	53
9.1 Safety Rules	53
9.2 Site Positioning	53
9.3 Start-up and Shutdown: Diesel-Driven Units	54
9.4 Start-up and Shutdown: Electric-Driven Units	55
9.5 Operation in Special Environments	55
Maintenance	57
10.1 The Three Pillars of Maintenance	57
10.2 KayDrill Service Kit System: 500 h / 1500 h / 2500 h	57
10.3 Oil Selection	58
10.4 Daily Checks and Scheduled Maintenance	58
10.5 Use Genuine KayDrill Parts	59
10.6 Key Component Replacement	60
10.7 Diesel Fuel and Coolant	60
10.8 Long-term Storage	61
10.9 Maintenance Records	61
Alarms and Troubleshooting	62
11.1 Basic Troubleshooting Method	62
11.2 Diesel-Driven Unit Alarms	62
11.3 Electric-Driven Unit Alarms	63
11.4 Dedicated Procedure: High Discharge Temperature	64
11.5 Common Performance Faults	64
11.6 When to Contact KayDrill	65
Appendices	66
Appendix A Formula Summary	66
Appendix B Common Unit Conversions	67
Appendix C Glossary	67
Appendix E References	68

PREFACE

Before You Begin

Thank you for choosing KayDrill. This guide is written for KayDrill dealer partners and equipment users. It links everything about portable screw air compressors into one complete chain of knowledge, from the underlying physics, the airend and the complete machine system, through to sizing calculations, operation and maintenance. Our aim is to help you choose the air supply that is "just right" for every job site, and to keep it delivering its rated flow and pressure reliably throughout its service life.

KayDrill positions itself as a provider of compressed-air power solutions for demanding operating conditions. We do not simply recommend the nearest model from a product list. Instead, we work step by step from hole diameter, hole depth, rock type, water inflow, altitude, temperature and power availability to calculate the air flow and pressure you actually need. Every factor in this guide comes with its source and reasoning, so you can verify the calculations yourself or ask a KayDrill application engineer to review them at any time.

How to Use This Guide

If you want to...	Recommended reading
Select a machine quickly	Chapter 7 (Six-Step Selection Method) + Chapter 8 (Model Quick Reference and Worked Examples) + Appendix A (Formula Summary)
Understand the principles	Chapters 2 and 3 (Physics and Thermodynamics) → Chapters 4 and 5 (Airend and Complete Machine System) → Chapter 6 (DTH Drilling Applications)
Manage or operate equipment	Chapters 9–11 (Safe Operation, Maintenance, Alarms and Troubleshooting)

Conventions Used in This Guide

- **Pressure:** Unless otherwise stated, "bar" means gauge pressure; 1 MPa = 10 bar. The "kilo" often quoted on site (kgf/cm^2) is approximately equal to 1 bar. Thermodynamic calculations use absolute pressure, written as "bar(a)".
- **Air delivery:** Refers to Free Air Delivery (FAD), in m^3/min .
- **Model designations:** Follow the 2026 KayDrill product catalog. For example, CM360-27/23K = diesel-driven, 360 HP, 27 m^3/min @ 23 bar, Cummins engine.
- **DTH hammers:** Hammer data are based on the mainstream high-pressure DTH hammers used with KayDrill units. Altitude correction uses the internationally accepted mass-flow correction method.

- Estimates in this guide are intended for comparing options. The final configuration is subject to confirmation by a KayDrill application engineer and the documentation supplied with the machine.

The Whole Guide in One Sentence

Selection means translating site conditions into two numbers, **air flow Q** and **pressure P**, scaling them up for the site conditions and finding the best-fit model that meets them. Maintenance means keeping that machine delivering those two numbers throughout its service life.

Edition Information

October 2026 edition. KayDrill model specifications are subject to the latest product catalog; operation and maintenance are subject to the documentation supplied with each model and the diesel engine manufacturer's manual. For selection support, please call the KayDrill sales hotline: +86 570-8878277.

CHAPTER 01

Introducing Portable Air Compressors and KayDrill

A portable air compressor is the site's air power plant. With its own power source and its own chassis, it can be towed wherever it is needed and turn ambient air into high-pressure air on the spot, driving DTH hammers, rock drills, sandblasting guns and all kinds of pneumatic tools.

1.1 What Is a Portable Air Compressor?

An air compressor draws in atmospheric air, compresses it to a higher pressure and delivers it. Stationary compressors in factories are installed in a compressor room and supply the workshop through a pipe network. A portable compressor, by contrast, integrates the compression airend, the prime mover (diesel engine or electric motor), the cooling system, the control system and the chassis into a single unit inside a sound-attenuating canopy. It can be towed or lifted into place and works independently in the field, with no infrastructure required.

Almost all portable compressors use an **oil-injected screw** airend, for simple reasons. A screw compressor has few parts and no wear-prone valves or piston rings, so it runs reliably at continuous full load. The injected oil cools, seals and lubricates at the same time, allowing a very high single-stage pressure ratio. Its wide speed range also allows direct matching to a diesel engine. The reciprocating portable compressors of earlier years have now been almost entirely replaced by screw machines.

■ Main Applications

Sector	Typical use	Compressor requirements
Quarrying and open-pit mining	DTH drill rigs drilling blast holes (diameter 90–250 mm, depth mostly within 30 m)	Medium-high pressure (17–25 bar), high flow, continuous duty, reliability
Water wells and geothermal wells	Deep-hole DTH drilling, often with water inflow	High pressure (24–35 bar); pressure determines whether the hole can be completed
Piling and foundation works	Large-diameter DTH hammers, casing-advancement drilling	Very high flow, often requiring several machines in parallel

Geological exploration, geotechnical and slope works	Anchor holes, exploration holes	Mobility and flexibility, medium pressure and medium flow
Tunneling and underground works	Drilling jumbos, shotcreting, mucking, ventilation	Low pressure (7–8 bar), high flow, electric drive, low noise
Municipal works, pipelines and sandblasting	Breaking, pneumatic picks, sandblasting and rust removal	Low noise and low emissions; electric units are common in urban areas

1.2 Who Is KayDrill?

Zhejiang Kaizuan Machinery Co., Ltd. has thirty years of dedicated experience in compressors and mining equipment, integrating R&D, manufacturing, sales and application service. Its products cover the full range of portable and stationary screw air compressors. The company has fully implemented the ISO 9001 quality management system, and its R&D team carries out the joint matching and in-depth tuning of airends and drivetrains, guided by the principle of "real operating conditions define product performance".



A KayDrill portable screw air compressor on a job site

■ KayDrill in Four Key Words

- **Built for real-world conditions:** Every performance specification must be proven on site under extreme cold, heat, high altitude, dust and continuous heavy duty, not just in laboratory data.
- **System matching:** The four core systems (airend, power, filtration and cooling) are jointly matched by our own engineers. We never simply bolt components together.
- **Screw technology focus:** A full portable and stationary range on both diesel and electric platforms, built to unified engineering design standards, reduces customers' costs for multi-

machine selection and spare parts management.

- **Solution capability with the end goal in mind:** At the project's early stage, our application engineers go to the job site to calculate air demand, pressure losses, altitude and continuous duty cycles, and tailor the configuration from connection type to operating-condition matching.

1.3 KayDrill Product Line Overview

Table 1-1 KayDrill portable screw air compressor product line

Series	Sub-series	Coverage	Positioning
M Flagship Series	CM single-stage diesel	5–20 m ³ /min, 8–19 bar, Xichai 56 HP to Cummins 260 HP	General-purpose low- and medium-pressure work
	CM two-stage diesel	15–43 m ³ /min, 13–35 bar, Yuchai / Cummins / Xichai 190–755 HP	The workhorse for drilling, mining and water wells; performance first
	DM single-stage electric	13–17 m ³ /min, 10–17 bar, 90–132 kW	Low- and medium-pressure work where grid power is available
	DM two-stage electric	18–35 m ³ /min, 15–25 bar, 90–250 kW	Drilling where grid power is available; lowest operating cost
DMT Series	Tunnel VSD	36–66 m ³ /min, 7–8 bar, permanent-magnet VSD 160–315 kW	Tunneling and underground works with alternating air demands
LG Series	LGCY diesel	Same specifications as CM (single-stage / two-stage)	Economy series for budget-conscious customers
	LGDY electric	Same specifications as DM (single-stage / two-stage)	

Key selling points of the M Series: a **jointly developed screw airend**, with a controller offering manual mode selection between two preset operating points to cover both high-flow and high-pressure work; **power matching** based mainly on the Cummins and Yuchai platforms, with Xichai also available, covering 55–800 HP; **multi-stage air filtration**, with an optional pre-cleaner and desert air filter package; **high-capacity cooling** with generous heat-rejection margin to minimize high-temperature shutdowns; and an optional **cold-start system** for severe cold, high altitude and winter operation.

The DMT Series uses a high-efficiency four-pole permanent-magnet synchronous motor with variable-speed drive, providing stepless speed control across the full range. This eliminates the idle running of conventional fixed-speed units that unload frequently, delivering significant energy savings in tunnels where drilling, shotcreting and mucking alternate. The LG Series uses a large airend with an optimized rotor profile that delivers the target air flow at a lower speed, with direct drive or large-gear

transmission to reduce mechanical losses and noise. It also features a reinforced chassis and enhanced corrosion protection, making it well suited to frequent relocation and towing on unpaved roads.

1.4 Six Core Technologies



Six core technologies of KayDrill intelligent air compressors

Technology		What it means for the customer
Intelligent gateway	industrial	Operating data can be viewed remotely, so abnormalities are spotted early and downtime is reduced
High-performance screw air end		High volumetric efficiency and low specific power: more air for the same fuel
Integrated control system	electrical	Precise loading and unloading that follows the actual air demand curve, with instant protection against overpressure, overtemperature and phase-sequence faults
High-efficiency motor and transmission	motor	Low transmission losses and low operating cost for electric units
Precision lubrication and cooling system	lubrication	Oil temperature is held in the right range, neither overheating nor allowing condensate into the oil

Core oil separation system	Low oil carryover in the discharge air, low oil consumption and no oil contamination of downstream drilling tools
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1.5 How to Read a Model Designation

A KayDrill model designation is a specification sheet in miniature. Teaching customers to read it is the fastest way to build professional credibility.

Table 1-2 Decoding a model designation: CM430-34/26-36/18K

Segment	Meaning
CM	Series and drive: CM diesel, DM electric, DMT tunnel VSD electric (all M Flagship); LGCY diesel, LGDY electric (LG Economy Series)
430	Power rating: engine horsepower for diesel units (430 HP), motor power (kW) for electric units
34/26	Operating point 1: air delivery 34 m ³ /min, discharge pressure 26 bar
36/18	Operating point 2: 36 m ³ /min @ 18 bar. Switch with one touch on the controller, so one machine covers two types of work
K	Engine brand suffix: K = Cummins, X = Xichai, no suffix = Yuchai
B (e.g. CM220B, DM138B)	Economy version with the same power and specification class, a streamlined configuration and a lower price
* (asterisk in the catalog)	EU CE compliance documentation available; note for export customers

CHAPTER 02

Physics Fundamentals: Air, Pressure and Temperature

An air compressor does just one thing: it changes the state of air. To understand every factor used in selection, you first need to be clear about the three quantities that describe the state of air (pressure, temperature and volume) and how they relate to one another.

2.1 Pressure: Gauge and Absolute

Pressure is force per unit area. Its SI unit is the pascal (Pa), where $1 \text{ Pa} = 1 \text{ N/m}^2$. In engineering practice, bar and MPa are commonly used:

$$1 \text{ bar} = 100 \text{ kPa} = 0.1 \text{ MPa} \approx 1.02 \text{ kgf/cm}^2 \approx 14.5 \text{ psi} \quad (2-1)$$

The atmosphere above us exerts its own pressure. At sea level, standard atmospheric pressure is 101.325 kPa, or 1.013 bar. A pressure gauge measures how far pressure is "above atmospheric"; this is **gauge pressure**. Pressure measured from absolute vacuum is **absolute pressure**:

$$P_{\text{abs}} = P_{\text{gauge}} + P_{\text{atm}} \quad (2-2)$$

Example: a gauge reading of 25 bar at sea level corresponds to 26.0 bar(a); at 3000 m altitude (atmosphere approx. 0.70 bar), the same reading corresponds to 25.7 bar(a).

Why the Distinction Matters

Compressor model ratings, drill rig specifications and the "kilos" (kgf/cm^2) customers quote are all gauge pressures. But any calculation involving pressure ratio, work or gas volume conversion must use absolute pressure. Plugging gauge pressure directly into a formula is the most common calculation error.

Water Column and Pressure

Pressure within a liquid increases linearly with depth:

$$p = \rho g h \quad (2-3)$$

Water density $\rho = 1000 \text{ kg/m}^3$, $g = 9.81 \text{ m/s}^2$; each meter of water column is $9.81 \text{ kPa} \approx 0.01 \text{ MPa}$, so a 10 m water column $\approx 1 \text{ bar}$.

This rule is critical in water well selection: a DTH hammer working 60 m below the water level must overcome an additional back-pressure of about 6 bar from the water column. Chapters 6 and 7 use this repeatedly.

2.2 Temperature and Absolute Temperature

Temperature in the gas laws must be thermodynamic temperature (kelvin, K):

$$T(K) = t(^{\circ}\text{C}) + 273.15 \quad (2-4)$$

Temperature is a measure of the average kinetic energy of molecules. When air is compressed, work is done on the gas, the molecules move more vigorously and the temperature rises. This is the fundamental reason every air compressor needs a cooling system.

2.3 The Ideal Gas Equation of State

Within a compressor's operating range, air can be treated as an ideal gas with sufficient accuracy.

Pressure, volume and temperature satisfy:

$$p V = m R T \quad (2-5)$$

p : absolute pressure, Pa; V : volume, m^3 ; m : mass, kg; T : absolute temperature, K; R : gas constant of air, $287 \text{ J}/(\text{kg} \cdot \text{K})$.

For the same quantity of air (constant mass) changing from state 1 to state 2:

$$p_1 V_1 / T_1 = p_2 V_2 / T_2 \quad (2-6)$$

This yields three classic special cases: at constant temperature, $pV = \text{constant}$ (Boyle's law); at constant pressure, $V/T = \text{constant}$ (Gay-Lussac's law); at constant volume, $p/T = \text{constant}$ (Charles's law).

Worked Example: What Volume Remains When 1 m^3 of Free Air Is Compressed to 25 bar?

State 1: 1.013 bar(a), 20°C , 1 m^3 . State 2: 26.0 bar(a), 40°C after cooling.

$V_2 = 1 \times (1.013 / 26.0) \times (313 / 293) \approx 0.042 \text{ m}^3$, or about 42 liters. A $27 \text{ m}^3/\text{min}$ machine actually discharges only about 1.1 m^3 of high-pressure air per minute.

2.4 Density and Mass Flow

From Eq. (2-5), the density of air is:

$$\rho = p / (R T)$$

(2-7)

At sea level and 20 °C: $\rho = 101325 / (287 \times 293) \approx 1.20 \text{ kg/m}^3$.

What actually does the work is the mass of the air: each blow of a DTH hammer consumes a certain mass of air, and cuttings removal also relies on the mass and momentum of the airflow. **The same 1 m³ of air has less mass at high altitude.** This is the physical essence of altitude correction.

2.5 Altitude: Why Machines "Shrink" at High Altitude

Atmospheric pressure falls approximately exponentially with altitude. The International Standard Atmosphere gives the relationship:

$$p_h = 101.325 \times (1 - 2.256 \times 10^{-5} h)^{5.256} \text{ kPa}$$

(2-8)

h is altitude (m). At 2000 m it is about 79.5 kPa, 78% of sea level; at 4000 m about 61.6 kPa, 61%.

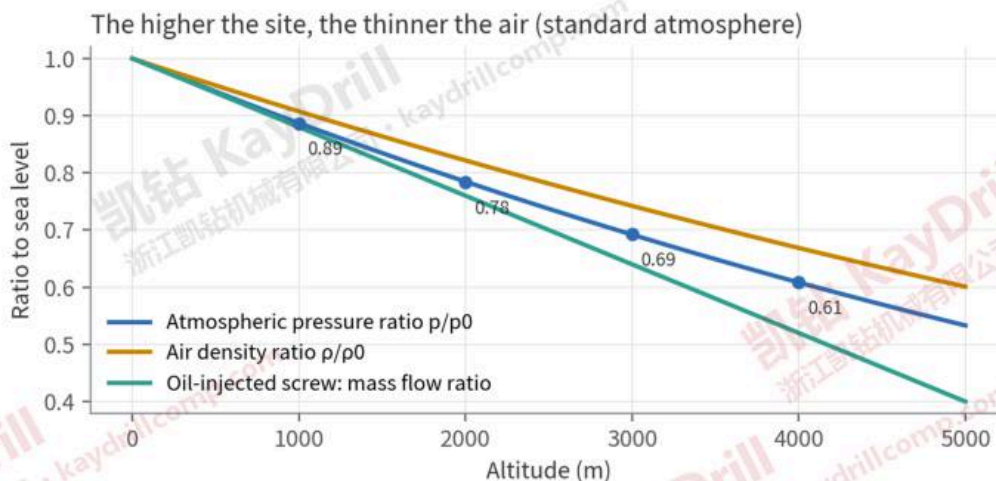


Figure 2-1 Altitude vs. atmospheric pressure, air density and screw compressor mass flow

A screw airend is a **positive-displacement** machine: each rotor revolution draws in a fixed volume of air. At high altitude, the volume drawn in stays the same, but each cubic meter contains less air mass. For drilling, impact and cuttings removal depend on mass, so a larger volume is needed to make up the difference. The air density ratio can be approximated as:

$$\eta_{alt} \approx p_h / p_0 = (p_h / p_0) \times (T_0 / T_h)$$

(2-9)

Extensive field measurements show that for every 1000 m rise in altitude, the **free air delivery (FAD) of an oil-injected screw compressor remains almost unchanged**, but the **mass flow of delivered air falls by about 12%**. In other words, the nameplate "cubic meters" stay essentially the same at

altitude; what is lost is the weight of the air. KayDrill selection corrects for mass flow using $\eta_{alt} = 1 - 0.12 \times h/1000$ (see Chapter 7).

High altitude also brings two knock-on effects. First, the diesel engine takes in less oxygen and loses power: turbocharged engines lose about 8% per 1000 m and naturally aspirated engines about 12%, with a further loss of about 5.4% for every 10 °C rise in air temperature. Second, for the same gauge pressure the absolute pressure ratio is higher (a machine with a pressure ratio of 8 at sea level reaches about 11 at 3000 m), so airtend power demand and discharge temperature both rise, while cooling becomes less effective in the thinner air. Above 3000 m, therefore, you need not only more air flow but also a dedicated high-altitude configuration.

2.6 Humid Air and Condensate

The atmosphere always contains water vapor. At a given temperature, the amount of water vapor air can hold has an upper limit; reaching that limit is called "saturation". The ratio of the actual content to that limit is the relative humidity. The higher the temperature, the more water the air can hold.

Table 2-1 Saturated water vapor pressure and moisture content (common values)

Temperature °C	20	30	40	60	80	100
Saturated vapor pressure kPa	2.34	4.25	7.38	19.9	47.4	101.3
Saturated moisture content g/m ³	17.3	30.4	51.1	130	293	—

When air is compressed, its volume shrinks dramatically but none of the water is removed. Once it is cooled, the moisture exceeds the saturation limit and the excess condenses.

Worked Example: How Much Water Does a 27 m³/min, 25 bar Machine Produce per Hour?

Summer conditions, 30 °C and 80% relative humidity: each cubic meter of free air contains $0.8 \times 30.4 \approx 24.3$ g of water. After compression to 26.0 bar(a) and cooling to 40 °C, the volume is only about 0.040 m³, which can hold at most $0.040 \times 51.1 \approx 2.1$ g. The remaining approx. 22.2 g condenses into water.

$27 \text{ m}^3/\text{min} \times 22.2 \text{ g} \approx 600 \text{ g}/\text{min}$, or **about 36 kg of water per hour**. If this water gets into the lubricating oil, the result is disastrous.

■ Pressure Dew Point: Why High-Pressure Machines Run Hotter Oil

In an oil-injected screw compressor, oil and compressed air are in intimate contact in the separator tank. Whenever the tank temperature is below the dew point of this high-pressure air, water condenses in the tank and mixes into the oil. The dew point is determined by the **partial pressure** of water vapor in the tank:

$$p_{v,tank} = p_{tank(abs)} \times (p_{v,atm} / p_{atm}) \quad (2-10)$$

The mole fraction of water vapor in the air is unchanged by compression, so its partial pressure is proportional to the total pressure.

In the example above, the atmospheric water vapor partial pressure is $0.8 \times 4.25 = 3.40$ kPa, or 3.35% of 1.013 bar. After compression to 26.0 bar(a), the water vapor partial pressure is $2600 \times 3.35\% \approx 87$ kPa, which corresponds to a saturation temperature of about **96 °C**. In other words, in hot and humid weather this high-pressure machine must keep its separator tank above about 96 °C, or it will continuously "make water". Under the same conditions, an 8 bar machine has a dew point of only about 69 °C.

Consequences of Water in the Oil

Lubricating oil contaminated with water emulsifies and turns milky, the lubricating film thins, and bearing corrosion and wear accelerate. Industry studies show that just 1% water in the oil can shorten bearing life by about 40%. This is why the thermostatic valve on high-pressure machines is set to open at a higher temperature, and why prolonged unloaded or low-load idling must be avoided on high-pressure machines.

2.7 Free Air Delivery (FAD)

The air delivery on a compressor nameplate (FAD, Free Air Delivery) is the volumetric flow of discharged compressed air **converted back to inlet conditions**, measured to standards such as ISO 1217. It is neither the actual volume of high-pressure air at the outlet nor the theoretical swept volume of the rotors:

$$Q_{FAD} = Q_{theo} \times \eta_v \quad (2-11)$$

η_v is the volumetric efficiency, which accounts for internal leakage, inlet heating and inlet pressure losses.

When comparing machines from different brands, always confirm that the air delivery is stated as FAD and measured at the same pressure. Some products quote theoretical displacement, which looks larger but actually delivers less air.

CHAPTER 03

Compression Thermodynamics and Formula Derivations

This chapter answers three questions: How much work does it take to compress air? Why are high-pressure machines built as two-stage units? Why do screw compressors inject oil into the compression chamber? There may seem to be many formulas, but the derivation follows a single thread: how gas heats up as it is compressed, and how that heating increases the work required.

3.1 Where Compression Work Comes From

Imagine a quantity of gas in a cylinder, compressed by a piston from volume V_1 to V_2 . The work done on the gas equals the integral of pressure over the change in volume. For a compressor that continuously draws in, compresses and discharges air, engineers use "technical work" to calculate the work required to compress each quantity of gas:

$$W = \int_{p_1}^{p_2} V dp \quad (3-1)$$

On a p-V diagram, this is the area to the left of the compression curve, between p_1 and p_2 .

The path the gas state follows during compression determines the size of this area. In engineering, it is described in general terms as a polytropic process:

$$p V^n = \text{constant} \quad (3-2)$$

$n = 1$: isothermal compression (heat is removed immediately, temperature stays constant); $n = \kappa = 1.4$: adiabatic compression (no heat exchange with the surroundings); $1 < n < 1.4$: polytropic compression (part of the heat is removed).

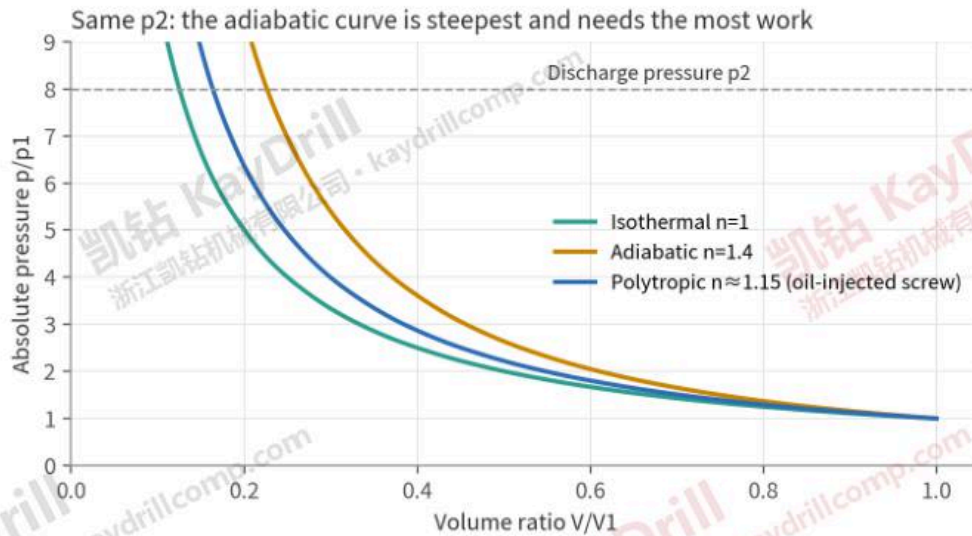


Figure 3-1 p-V curves for the three compression processes

3.2 Deriving the Three Types of Compression Work

■ Isothermal Compression (Theoretical Minimum)

From $pV = p_1V_1$, $V = p_1V_1/p$. Substituting into Eq. (3-1):

$$W_{\text{iso}} = p_1V_1 \int \frac{dp}{p} = p_1V_1 \ln(p_2/p_1) \quad (3-3)$$

Isothermal compression removes all the heat generated as it is produced and requires the least work. It is a theoretical limit no real compressor can reach, and is commonly used as the benchmark for efficiency.

■ Polytropic and Adiabatic Compression

From $pV^n = p_1V_1^n$, $V = V_1(p_1/p)^{1/n}$. Integrating:

$$W_{\text{poly}} = n/(n-1) \cdot p_1V_1 [(p_2/p_1)^{(n-1)/n} - 1] \quad (3-4)$$

Setting $n = \kappa = 1.4$ gives the adiabatic compression work; then $\kappa/(\kappa-1) = 3.5$ and the exponent $(\kappa-1)/\kappa = 0.286$.

The final compression temperature is determined by the same process:

$$T_2 = T_1 (p_2/p_1)^{(n-1)/n} \quad (3-5)$$

■ Converting to Engineering Units: Specific Power

In engineering, compressor energy performance is measured by **specific power**: the kilowatts required per 1 m³/min of free air delivered. Substituting $p_1 = 101.325 \text{ kPa}$ and $V_1 = 1 \text{ m}^3/\text{min} = 1/60 \text{ m}^3/\text{s}$ gives the constant $p_1 V_1 = 1.689 \text{ kW}$:

$$N_{\text{iso}} = 1.689 \ln r N_{\text{ad}} = 5.91 (r^{0.286} - 1) \text{ kW}/(\text{m}^3/\text{min}) \quad (3-6)$$

$r = p_2/p_1$ is the absolute pressure ratio.

Worked Example: What Is the Minimum Work to Compress to 25 bar?

$r = 26.0 / 1.013 = 25.7$. Isothermal: $1.689 \times \ln 25.7 = \mathbf{5.48 \text{ kW}/(\text{m}^3/\text{min})}$. Single-stage adiabatic: $5.91 \times (25.7^{0.286} - 1) = \mathbf{9.03 \text{ kW}/(\text{m}^3/\text{min})}$.

Single-stage adiabatic compression takes 65% more work than isothermal, and all of that extra work turns into heat.

3.3 Discharge Temperature: Why Oil Injection Is Essential

Using Eq. (3-5), the discharge temperature for single-stage adiabatic compression to 25 bar without oil injection is: $T_2 = 303 \times 25.7^{0.286} \approx 766 \text{ K}$, about **490 °C**. At this temperature any lubricant would coke and the rotors would seize from thermal expansion, which is why "dry" (oil-free) screw compressors are usually limited to a single-stage pressure ratio of about 4.

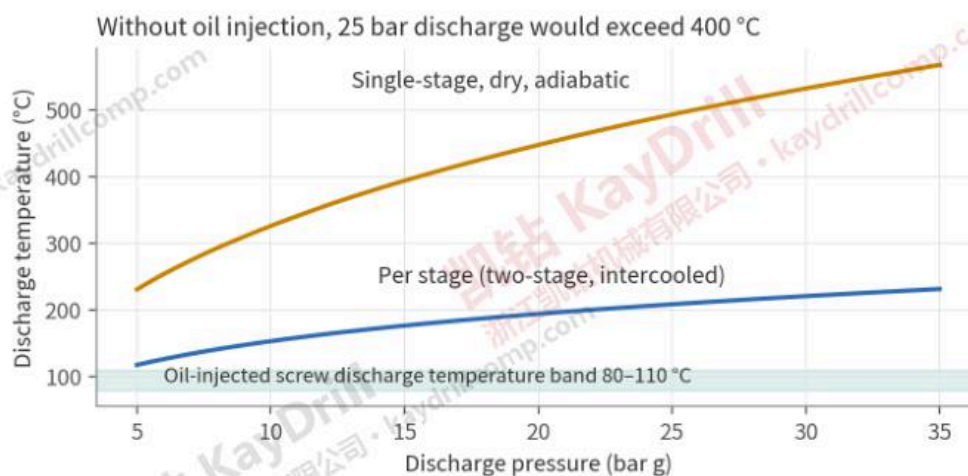


Figure 3-2 Discharge temperature vs. pressure (inlet 30 °C)

Oil-injected screw compressors solve this by injecting a large quantity of lubricating oil directly into the compression chamber during compression. Oil has a high specific heat (about 2.0 kJ/(kg · K)), and the injected oil mass is several times the air mass, so the heat of compression is absorbed by the oil

almost immediately. This brings the process close to polytropic compression with $n \approx 1.1-1.2$ and holds the discharge temperature at 80–110 °C. The oil then rejects the heat in the oil cooler before circulating back to the airend.

Worked Example: How Much Oil Must Circulate?

Airend shaft power is about 220 kW, almost all of which is converted to heat. If the oil temperature rises by 25 K in the airend, oil mass flow = $220 \div (2.0 \times 25) \approx 4.4$ kg/s, or about **310 L/min**. This is why an oil-injected screw compressor has a substantial oil circuit, and why the condition of the oil cooler and oil filter directly determines airend life.

Oil injection brings two further benefits: the oil film fills the clearances between the rotors and between the rotors and housing, **reducing internal leakage**; and the male and female rotors mesh and drive each other directly through the oil film, **eliminating timing gears** for a simpler, lower-cost design.

3.4 Two-Stage Compression and the Optimum Intermediate Pressure

The higher the pressure ratio, the further adiabatic compression departs from isothermal and the more extra work is required. If the air is cooled back to inlet temperature between two stages (intercooling), the second stage starts compressing "cool" air and the total work drops significantly. The question is: what intermediate pressure minimizes the work?

Let the first stage compress from p_1 to p_m , and after cooling the second stage compress from p_m to p_2 , with the same inlet temperature for both stages. Let $m = (n-1)/n$ and $C = n/(n-1) \cdot p_1 V_1$. The total work is:

$$W = C [(p_m/p_1)^m + (p_2/p_m)^m - 2] \quad (3-7)$$

Differentiating with respect to p_m and setting the result to zero:

$$m p_m^{m-1} / p_1^m - m p_2^m / p_m^{m+1} = 0 \Rightarrow p_m^{2m} = (p_1 p_2)^m \quad (3-8)$$

$$p_m = \sqrt{p_1 p_2}, \text{ i.e. equal pressure ratios per stage: } r_1 = r_2 = \sqrt{r} \quad (3-9)$$

Worked Example: How Much Does Two-Stage Compression Save at 25 bar?

Pressure ratio per stage $\sqrt{25.7} = 5.07$. Two-stage adiabatic work: $2 \times 5.91 \times (5.07^{0.286} - 1) = \mathbf{6.97}$ kW/(m³/min), a saving of about **23%** compared with 9.03 for single-stage. The discharge temperature per stage also falls from about 490 °C to about 210 °C (without oil injection).

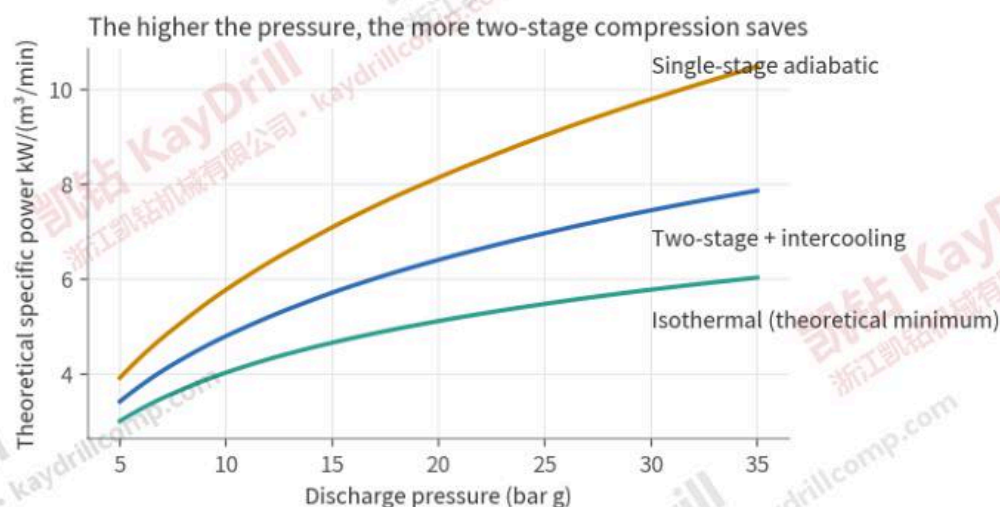


Figure 3-3 Theoretical specific power for single-stage, two-stage and isothermal compression

In an oil-injected screw compressor, the oil-air mixture discharged from the first stage of a two-stage airend is already cooled by oil injection before entering the second stage, so a separate intercooler is not necessarily required. The principle, however, is the same: sharing the pressure ratio reduces the temperature rise and leakage in each stage. This is why every KayDrill model rated above 20 bar uses two-stage compression: at the same pressure, a two-stage machine uses less fuel, runs at lower discharge temperatures and delivers longer airend life.

3.5 From Theory to Reality

Beyond the theoretical work, a real machine also has volumetric losses (leakage, inlet heating), mechanical losses (bearings, transmission) and auxiliary power consumption (cooling fan). KayDrill minimizes these losses through its jointly developed high-efficiency screw airends, large-rotor low-speed design, two-stage compression and precise oil temperature control. The result: the same air delivery and pressure with less fuel or electricity, a cooler-running airend and longer service life.

Chapter Key Points

- The heat produced by compression is wasted work; the closer to isothermal, the less work is required.
- Oil injection allows a screw compressor to reach a high pressure ratio in a single stage, while cooling, sealing and lubricating at the same time.
- The optimum intermediate pressure for two-stage compression is $\sqrt{p_1 p_2}$; at 25 bar, two-stage compression theoretically requires about 23% less work than single-stage.
- Specific power in kW/(m³/min) is the common yardstick for comparing compressor energy performance; the lower the value, the less fuel or electricity consumed.

CHAPTER 04

The Screw Airend: How the Rotors Compress Air

The airend (often called the "compressor element") is the heart of the compressor, and a large share of the machine's value and performance depends on it. Understand the rotors and you understand the efficiency, service life and pressure range of a screw compressor.

4.1 Basic Construction

A screw airend consists of a pair of intermeshing helical rotors enclosed in a housing. The rotor with convex lobes is the **male rotor**, usually driven directly by the prime mover; the rotor with concave flutes is the **female rotor**, which in an oil-injected machine is driven by the male rotor through the oil film. Each rotor is supported by bearings at both ends: radial bearings carry gas forces and weight, while thrust bearings carry the axial force generated by compression. The housing has an inlet port at one end and a discharge port at the other, and its precision-machined bore maintains a very small clearance to the rotor tips.

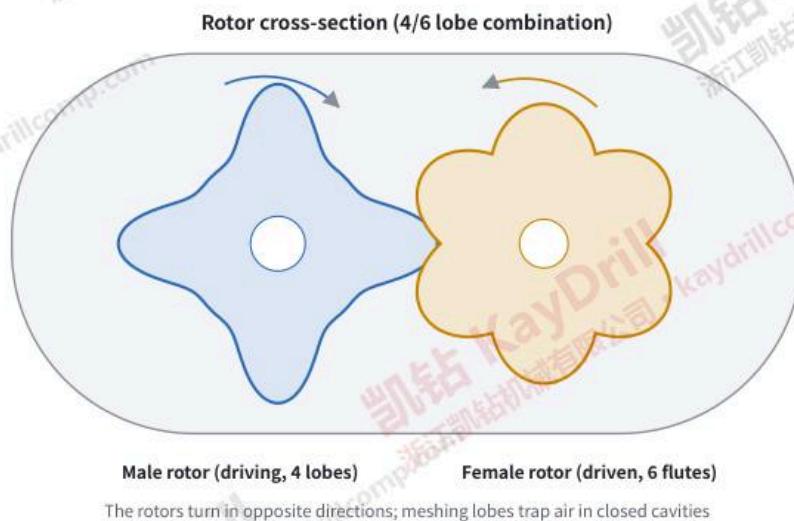


Figure 4-1 Male and female rotor end-face profile

Table 4-1 Main airend components

Component	Function	Maintenance focus
Male rotor / female rotor	Mesh to form closed volumes and perform compression	Not field-repairable; protected by oil quality and filtration

Housing (incl. inlet and discharge end covers)	Forms the working chamber; contains inlet, discharge and oil-injection ports	Discharge-end temperature is a key health indicator
Radial bearings (mostly cylindrical roller)	Carry radial loads	Service life most affected by water and contaminants in the oil
Thrust bearings (angular-contact ball / tapered roller)	Carry axial loads; set the discharge-end clearance	Abnormal noise and vibration are early warning signs
Shaft seal	Prevents oil leakage at the input shaft	Wear part; replace promptly if seeping
Oil-injection ports / nozzles	Inject oil into the compression chamber for cooling and sealing	A blocked oil circuit causes a rapid rise in discharge temperature

4.2 Working Cycle: Suction – Compression – Discharge

As the rotors turn, the space enclosed by two adjacent lobes and the housing is called the "interlobe volume". It travels helically along the axis and passes through three stages in sequence:

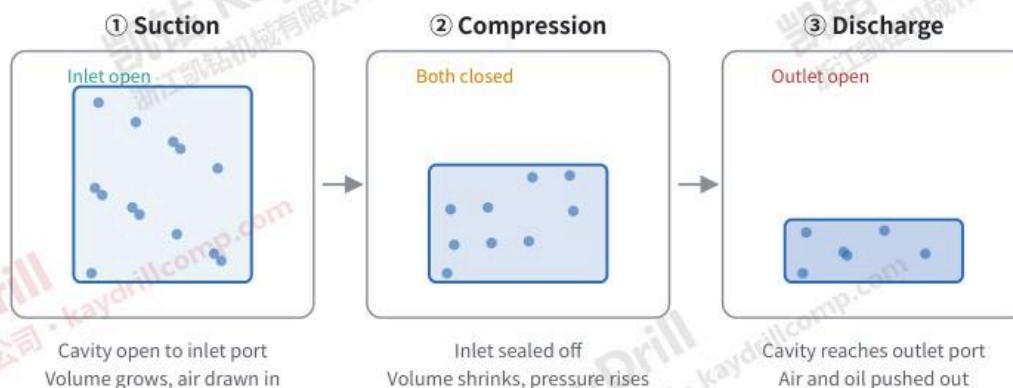


Figure 4-2 The three stages of screw compression (schematic)

- 1. Suction:** The interlobe volume is open to the inlet port. As the lobes unmesh, the volume grows from zero and draws in air until it reaches its maximum and is sealed off from the inlet.
- 2. Compression:** The interlobe volume is closed. The meshing line between the male and female rotors advances axially toward the discharge end, the volume steadily shrinks, and pressure and temperature rise; oil is injected into the chamber during this stage.
- 3. Discharge:** The interlobe volume rotates into communication with the discharge port, and the compressed air is pushed out together with the oil until the volume reaches zero.

Every interlobe volume completes one cycle per rotor revolution, and several volumes are at different stages at the same time. As a result, a screw compressor delivers air **continuously and smoothly**, without the pulsation of a piston compressor and without suction or discharge valves.

4.3 Rotor Profile and Lobe Count

■ Lobe combinations

Common male/female lobe combinations are 4/5, 4/6, 5/6 and 5/7. Fewer male lobes mean a larger interlobe volume and higher displacement for a given size; more lobes give stiffer rotors, a smaller pressure difference per lobe and less leakage, making them better suited to high pressure ratios. Portable high-pressure machines commonly use 4/6 or 5/6 combinations to balance displacement against sealing.

■ Profiles: symmetric vs. asymmetric

The lobe curve on the rotor end face is called the "profile", and it is the core technology of any screw compressor. Early designs used **symmetric profiles** made of circular arcs. They were easy to machine but left a triangular "blowhole" at the tip of the meshing line through which high-pressure gas could leak back to the low-pressure side. Since the 1970s, **asymmetric profiles** have become standard: the two flanks of each lobe follow different curves, greatly reducing the blowhole while making the contact line shorter and more continuous, with clear gains in volumetric efficiency and specific power.

What the profile determines

The profile determines three things: how much air is drawn in per revolution (displacement), how much high-pressure gas leaks back (volumetric efficiency), and the relative sliding and loading between lobe surfaces (service life). KayDrill M-series airends are co-developed with a specialist airend manufacturer, and the LG series uses large-frame airends with optimized lobe geometry—both built on careful work on rotor profile and rotor size.

■ Large rotors, low speed

Airend displacement is proportional to rotor size and speed. Running larger rotors at lower speed keeps tip speed low, reducing friction and oil-churning losses, lowering noise and extending bearing life; the trade-off is a heavier, more costly airend. In oil-injected screw compressors the male-rotor tip speed is typically 20–50 m/s: too low and leakage time increases and efficiency drops; too high and oil-churning and flow losses rise. The LG series principle of "delivering the target air flow at a lower airend speed" is a direct application of this.

4.4 Built-in Volume Ratio: The Most Overlooked Screw Parameter

A screw compressor has no discharge valve; the moment discharge begins is fixed by the position of the discharge port. The ratio of the maximum interlobe volume at the end of suction to the volume at the start of discharge is the **built-in volume ratio V_i** , a geometric parameter fixed when the housing is machined. From the polytropic compression relationship, the corresponding **built-in pressure ratio** is:

$$p_i / p_s = V_1^n \quad (4-1)$$

p_i is the internal pressure at the instant the interlobe volume opens to the discharge port, p_s is the suction pressure (absolute), and n is the polytropic exponent (approx. 1.1–1.2 for oil-injected machines).

Discharge is smoothest when the internal pressure equals the discharge line pressure; any mismatch creates additional losses:

Shaded area = extra work caused by a mismatched built-in volume ratio

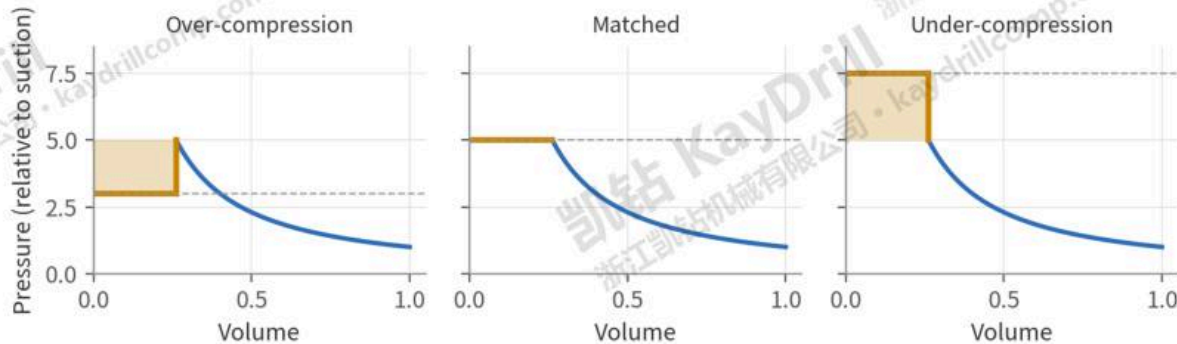


Figure 4-3 Extra work from over-compression and under-compression

- **Over-compression** (internal pressure > discharge pressure): The air is compressed further than necessary and "blows off" as soon as the port opens, so the extra compression work is wasted. Common when a high-pressure machine is run at low pressure for long periods.
- **Under-compression** (internal pressure < discharge pressure): When the port opens, high-pressure air flows back into the interlobe volume and the airend must do extra work to push it out. Common when a low-pressure machine is adjusted for high-pressure use.

Worked example: V_i vs. pressure

To compress in a single stage to 13 bar(a) (about 12 bar gauge), with $n = 1.15$ the required $V_i = 13^{1/1.15} \approx 9.3$. To reach 26 bar(a) in a single stage would need $V_i \approx 17$ —extremely long rotors with severe leakage, which is practically unworkable. Split into two stages, each stage needs a pressure ratio of only about 5.1 and $V_i \approx 4.1$, which is entirely reasonable. In practice, rotor length and stiffness limit single-stage airends to a V_i of about 5–6, so they run with some under-compression at high pressure. This is one reason single-stage high-pressure machines have higher specific power, and another physical reason why "above 20 bar, two-stage is a must".

4.5 Leakage and Volumetric Efficiency

A screw compressor seals by clearances, so some leakage is unavoidable. The main leakage paths are: the clearance between rotor tips and housing, the contact line between male and female rotors, the blowhole, and the clearance between the discharge end face and end cover. Leakage depends on clearance size, pressure difference and leakage duration:

- **Higher pressure difference, more leakage:** This is why volumetric efficiency falls at high pressure ratios and why two-stage designs have the advantage;
- **Lower speed, more leakage:** Each interlobe volume spends longer at high pressure;
- **Better oil film, less leakage:** Insufficient oil or excessive oil temperature (viscosity too low) both reduce volumetric efficiency, showing up as "pressure won't build, not enough air".

4.6 Single-Stage vs. Two-Stage Airends

Table 4-2 Single-stage vs. two-stage airend comparison

Item	Single-stage airend	Two-stage airend
Construction	One pair of rotors	Two rotor pairs in series; the low-pressure stage discharges directly into the high-pressure stage, usually sharing one gearbox or an integrated housing
Pressure range (KayDrill)	8–19 bar	13–35 bar; above 20 bar, two-stage only
Energy use	Economical at low to medium pressure	Lower specific power at the same pressure; noticeably lower fuel use at high pressure
Discharge temperature and service life	Discharge temperature and bearing loads run higher at high pressure ratios	Smaller pressure ratio per stage, lower discharge temperature, lighter bearing loads
Price and weight	Lower	Higher
Typical applications	Rock drills, breakers, shallow-hole drilling, sandblasting	DTH drill rigs, water well drilling, geothermal drilling, deep holes

In the overlapping 14–19 bar range, either single-stage or two-stage can be chosen: for short projects with few operating hours per year, a single-stage machine has the lower purchase price; for long-term continuous drilling, the fuel saved by a two-stage machine recovers the price difference within a few years. The longer and more continuous the duty, the greater the two-stage energy advantage.

4.7 Airend Drive Arrangements

- **Direct drive:** The airend is connected to the diesel engine or electric motor through a flexible coupling and runs at the same speed—simple construction with minimal transmission loss.
- **Step-up gearing:** A pair of step-up gears between the prime mover and airend lets the airend run at its optimum speed and allows one airend to be matched to different air flows. The LG series can

use direct drive or a large gear transmission.

- **Variable speed:** The electric motor is driven by a variable-frequency drive (VFD) so speed tracks air demand continuously. The DMT series uses a permanent-magnet synchronous motor with VFD, delivering significant energy savings at part load.

Chapter Key Points

- A screw compressor compresses by shrinking the interlobe volume; delivery is continuous and there are no valves.
- Asymmetric profiles reduce leakage; large rotors at low speed improve service life and efficiency.
- The built-in volume ratio fixes the airtend's "design pressure"; operating far from it causes over- or under-compression losses.
- High pressure difference, low speed and a poor oil film all increase leakage; two-stage is the better choice for high pressure.

CHAPTER 05

Complete Machine Systems Explained

A portable screw air compressor can be broken down into six systems: air intake and discharge, cooling and lubrication, control, power, fuel and electrical, and chassis and canopy. Knowing what each system does—and what symptoms appear when a component fails—is the foundation for correct selection, operation and maintenance.

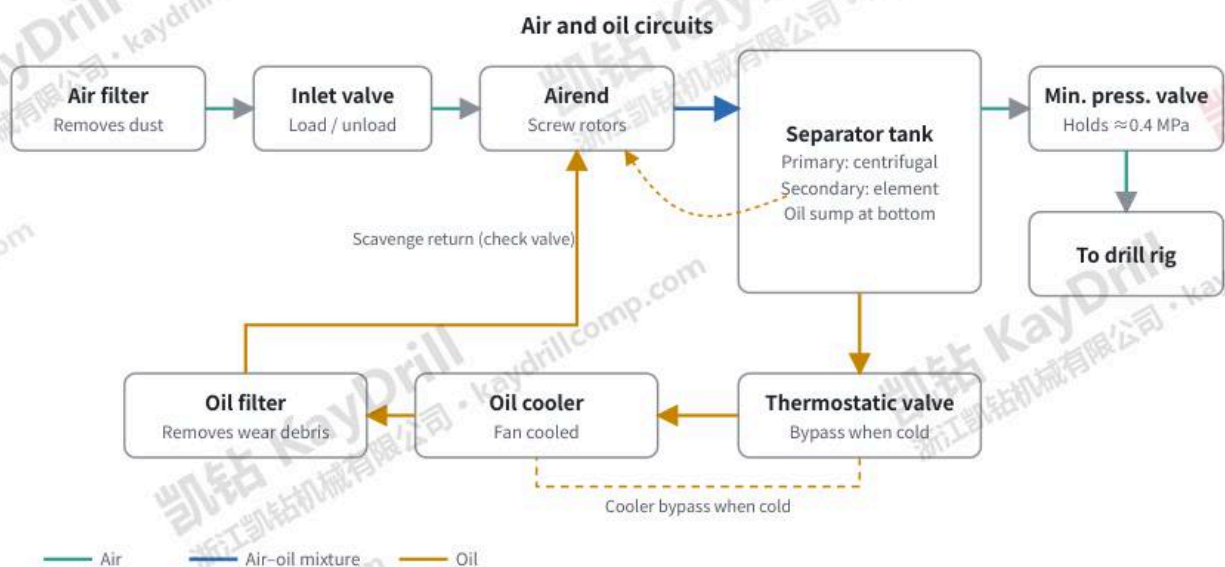


Figure 5-1 Air and oil circuits of the complete machine

Figure 5-1 shows the core flow of an oil-injected screw compressor: air enters the airend through the air filter and is compressed together with injected oil; the oil-air mixture enters the separator tank; clean compressed air passes through the minimum pressure valve to the user; and the separated oil returns to the airend via the thermostatic valve, oil cooler and oil filter, in a continuous loop.

5.1 Air Intake and Discharge System

■ Air filter

Every particle of dust drawn into the airend ends up in the oil, wearing the rotors and bearings. Job sites are extremely dusty, so the air filter is the first line of defense for the airend. KayDrill machines have separate air filters for the diesel engine and the compressor, mostly of two-stage design: an external cyclonic pre-cleaner removes large particles, the main element captures fine dust, and some models add a safety element. For extreme dust conditions such as deserts, gravel plains and open-pit mines, heavy-duty pre-cleaners and desert air filter kits are available as options.

- The air filter has a **restriction indicator**; when it turns red or the "filter alarm" lights up on the control panel, the filter must be cleaned or replaced;
- Check the dust cup / dust valve daily and keep the dust outlet clear;
- Hoses and clamps between the air filter and airend must be leak-free; otherwise unfiltered air will be drawn straight in.

■ Inlet valve

The inlet valve, mounted on the airend inlet, is the "throttle" that regulates air delivery. It consists of a valve plate (or butterfly) and a servo cylinder: as control air pressure rises the plate closes, reducing intake; when control air is removed the plate opens fully and the airend runs at full load. At start-up the inlet valve stays closed so the airend starts easily under light load; at shutdown it closes quickly and, together with its non-return design, prevents oil and air from blowing back out of the inlet.

■ Airend

See Chapter 4. The temperature sensor at the airend discharge is one of the most important protection signals on the machine; excessive discharge temperature triggers an alarm and shutdown.

■ Separator tank and oil separator

The airend discharges a hot oil-air mixture, and the separator tank must remove the oil from the air. Separation takes place in two steps:

1. **Primary separation:** The mixture enters the tank tangentially at high velocity; centrifugal force and gravity throw most of the oil onto the tank wall, from where it drains to the bottom, which also serves as the oil sump;
2. **Secondary separation:** The remaining fine oil mist passes through the **separator element** (multi-layer precision glass-fiber media), where it coalesces into droplets that collect at the bottom of the element and are drawn back to the low-pressure side of the airend by differential pressure through the **scavenge line** and **scavenge check valve**.

A well-performing unit can reduce oil carry-over in the discharge air to a few ppm. When the separator element clogs, its differential pressure rises, resulting in higher oil consumption, oil in the discharge air, and higher motor current or engine load; a ruptured element causes heavy oil carry-over and must be replaced immediately. The separator tank also has an oil fill port, oil level sight glass, safety valve and oil drain valve.

■ Minimum pressure valve

The minimum pressure valve, fitted at the separator tank outlet, is a spring-loaded check valve that opens to supply air only when tank pressure reaches its set point (typically about 0.4–0.5 MPa; refer to the machine documentation). It has three functions:

- **Building oil pressure:** An oil-injected screw compressor uses tank pressure, not a pump, to push oil back to the airend, so pressure must build up first at start-up;
- **Protecting the separator element:** It limits air velocity through the element, preventing large amounts of oil from being carried over at low pressure and high flow;
- **Non-return:** After shutdown it prevents compressed air in the lines from flowing back into the separator tank.

■ Safety valve

The separator tank safety valve is the last line of defense, set slightly above the rated discharge pressure. If a control failure causes overpressure, it vents automatically. Never raise its setting or block it; have it tested at the specified intervals.

5.2 Cooling and Lubrication System

■ Screw compressor oil

Screw compressor oil performs four tasks at once: cooling, sealing, lubrication and rust protection. Only dedicated screw compressor oil may be used—never substitute diesel engine oil or hydraulic oil. By base stock, oils fall roughly into three types: mineral (short change interval), semi-synthetic, and fully synthetic (high-temperature resistant, long life, recommended for high-pressure machines). **Never mix** oils of different brands or types; when changing oil type, flush the oil circuit thoroughly. See Chapter 10 for specific grades and change intervals.

■ Thermostatic valve

The thermostatic valve sits between the separator tank oil outlet and the oil cooler and contains a temperature-sensitive element that expands and contracts with temperature. When cold, the valve routes oil through a bypass around the cooler so the oil warms up quickly; once oil reaches the set temperature, the valve progressively opens the path to the cooler, holding oil temperature in the proper range. As calculated in Chapter 2, a high-pressure machine in hot, humid weather needs a separator tank temperature above about 96 °C to avoid condensate. The thermostatic valve setting must therefore not be lowered arbitrarily, and the valve must never be removed to "improve cooling".

■ Oil cooler and fan

Portable machines mostly use aluminum plate-fin coolers combined with the engine radiator and charge-air cooler and cooled by a single fan. KayDrill machines feature a generously sized cooling design with optimized piping routes and enlarged heat-transfer area, reducing the likelihood of protective shutdowns in high-temperature and high-altitude conditions. Oil sludge and dust caked on the cooler surface is the most common cause of high discharge temperature; blow the cooler clean with compressed air regularly.

■ Oil filter

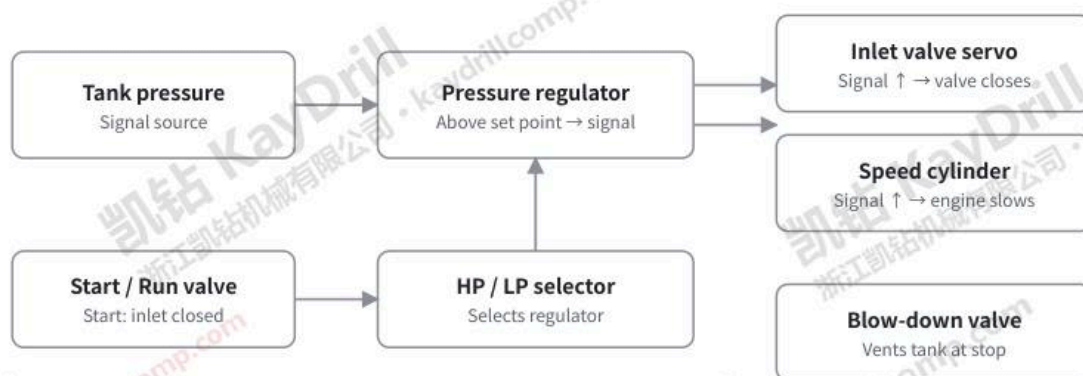
The oil filter removes wear debris, dust and sludge from the oil to protect the rotors and bearings. The filter has a bypass valve: if the element clogs and differential pressure becomes too high, the bypass opens to keep oil flowing to the airend—but that oil is now unfiltered. The oil filter must therefore be replaced on schedule, not when the alarm comes on.

■ Scavenge check valve

Fitted in the separator element scavenge line, it allows oil to flow only from the separator tank to the airend. After shutdown it prevents oil in the airend from flowing back into the separator element, which would otherwise cause heavy oil carry-over at the next start. A blocked orifice in the scavenge line lets oil accumulate at the bottom of the separator element, likewise causing oil carry-over.

5.3 Control System (Diesel Units)

Air delivery on diesel-driven portable machines is regulated by **varying intake and engine speed simultaneously**, using a pneumatic control circuit:



Less demand → tank pressure rises → inlet closes + engine slows → output matches demand

Figure 5-2 Pneumatic control principle of a diesel unit

Table 5-1 Control components and functions

Component	Function
Start / run valve (load/unload valve)	Handle on the panel. In "start" the inlet valve stays closed so the engine starts and warms up under light load; switching to "run" places the inlet valve under control of the pressure regulator and the machine begins to load
Pressure regulator / proportional valve	Senses separator tank pressure. As pressure approaches the set point it begins sending control air, increasing output as pressure rises, for "proportional regulation"
Inlet valve servo cylinder	The more control air, the smaller the inlet valve opening and the lower the air delivery
Speed cylinder control	Linked to the throttle lever; as control air increases it pulls the engine from rated speed toward idle, further reducing delivery and saving fuel

High/low pressure selector valve	Switches between two regulators with different set pressures, corresponding to the two operating points in the model designation (e.g. 34/26 and 36/18), so one machine can drill deep holes and also work efficiently on shallow holes
Blowdown valve	Opens at shutdown or unloading to vent separator tank pressure to a safe level, enabling a light-load start next time
Adjustable breather cap / pressure-stabilizing valve	Adjusts the response speed of the control circuit to prevent hunting of the inlet valve and engine speed

How it works: drill air demand falls → separator tank pressure rises → regulator sends control air → inlet valve closes down and engine slows → air delivery falls until it matches demand; when demand increases, the process reverses. Regulation is continuous and proportional, unlike an electric unit with only two states, "load / unload".

■ Control panel

A diesel unit control panel typically includes: digital readouts for speed, discharge temperature, engine oil pressure and coolant temperature; indicator lights for preheat, filter alarm, air pressure alarm, oil pressure alarm, air/coolant temperature alarm and charging; a cold-start aid button; a key switch (off / on / start); discharge pressure gauge and fuel gauge; and the high/low pressure selector and start/run handles. The latest KayDrill models feature an intelligent controller and industrial gateway supporting fault code display, service hour tracking and remote monitoring, so site personnel can troubleshoot quickly without specialized experience.

5.4 Control System (Electric Units)

Electric units are managed by an electrical cabinet and microprocessor controller. Fixed-speed models use **load / unload** control: when pressure reaches the unload pressure, the inlet valve closes and the blowdown valve vents, and the motor runs unloaded; when pressure drops to the load pressure, the machine reloads; after an extended period unloaded it stops automatically and stands by. The controller also monitors phase sequence, voltage, current, discharge temperature and discharge pressure, alarming or shutting down on any fault (see Chapter 11).

DMT variable-speed models use a VFD to adjust motor speed continuously, holding discharge pressure constant at the set point and eliminating the power consumed by unloaded running. In tunneling work, where drilling, shotcreting and mucking alternate and air demand fluctuates widely, the energy savings of variable speed are greatest.

Two basic checks for electric units

- **Phase sequence:** If the controller reports "phase sequence error" after power-up, disconnect power and swap any two of the three incoming phases.
- **Rotation:** After any electrical repair, confirm correct rotation of the airend and fan before starting; reverse rotation will damage the rotors and bearings.

5.5 Power System

■ Diesel engine

KayDrill diesel units are built mainly on the Cummins and Yuchai platforms, with Xichai also available, covering 55–800 HP. The emission stage can be selected to suit local regulations, and each engine is matched to the airend across both its power output curve and the compression load curve. When selecting, note:

- At high altitude, prefer **turbocharged, charge-air-cooled** engines; naturally aspirated engines lose significant power at altitude;
- In emission-sensitive locations such as urban areas and tunnel portals, check the emission stage and exhaust aftertreatment requirements;
- Engine service intervals and filter specifications **follow the engine manufacturer's manual**, and service can be handled through the engine manufacturer's service network.

■ Electric motor

Electric units use industrial motors from leading brands; the DMT uses a high-efficiency four-pole permanent-magnet synchronous motor. Electric units place high demands on the power supply: voltage fluctuation, phase loss and undersized cables all cause overcurrent and overload alarms. Site power capacity and cable specifications must be confirmed at the planning stage.

5.6 Fuel System

The fuel system comprises the fuel tank, primary filter (water separator), lift pump, fine filter, injection pump and injectors. The most common faults are all related to fuel quality:

- **Water in the fuel:** If water is not drained from the water separator regularly, it causes hard starting, power loss and injector damage;
- **Wrong fuel grade:** Using summer-grade (0#) diesel in winter causes wax to precipitate and block the fuel lines, showing up as "engine starts then stalls, won't rev up";
- **Air ingress:** Loose fuel line fittings or running the tank dry; bleed air per the engine manual before starting.

Select diesel grade according to ambient temperature; see Table 10-4 in Chapter 10.

5.7 Chassis and Canopy

Portable machine chassis come in two-wheel, four-wheel and fixed (skid) versions, and some large models are offered in both "four-wheel / fixed" configurations. The KayDrill LG series uses a high-strength steel chassis with outdoor-grade anti-corrosion coating, a heavy-duty towbar and high-wear-resistance tires, suited to frequent relocation and unpaved roads. Side-opening and lift-up doors place wear parts such as air filters, oil filters and the oil separator within easy reach, shortening service time. The canopy uses multi-layer sound insulation and anti-vibration mounts to reduce overall noise, meeting noise-control requirements for industrial sites, municipal works and tunneling.

Towing and lifting

Before towing, confirm that the drawbar is locked and check tire pressure, lights and the parking brake; never tow while the unit is running. Lift only from the designated lifting point on top of the canopy; never overload or lift at an angle.

CHAPTER 06

Matching the Compressor to DTH Drilling

The largest users of portable high-pressure compressors are DTH drill rigs and water well rigs. The compressor does not work in isolation: together with the hammer, drill pipe, borehole and formation, it forms one system. This chapter covers only the matching relationships, not rig construction.

6.1 How a DTH Hammer Works

The down-the-hole hammer (DTH hammer) is mounted at the bottom of the drill string and works directly at the hole bottom. Compressed air travels down the center of the drill pipe to the hammer, driving an internal piston back and forth at high frequency; on each stroke the piston strikes the bit shank, transferring impact energy directly into the rock. Meanwhile the rig's rotation unit turns the drill pipe and bit slowly so each blow lands on fresh rock. Exhaust air exits through the bit's flushing holes, lifting cuttings off the hole bottom and carrying them up the annular space between the hole wall and drill pipe (the annulus) to the collar.

Compressed air therefore does three jobs at once in DTH drilling: **driving the piston**, **cooling the bit** and **flushing cuttings out of the hole**. Pressure determines the force of each blow; air flow determines blow frequency and flushing capacity.

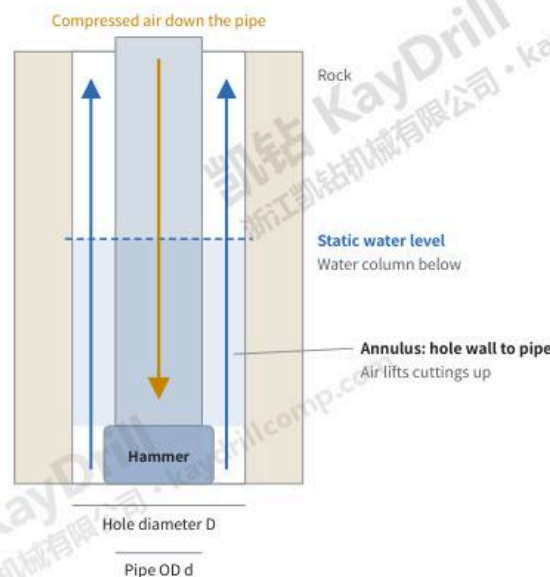


Figure 6-1 Air flow path and annulus in DTH drilling

6.2 Hammer Pressure and Air Consumption

Table 6-1 Hammer types and operating pressures

Type	Rated operating pressure	Characteristics
Low/medium-pressure hammers	0.7–1.7 MPa	Older or small-diameter equipment; lower penetration rate
Standard high-pressure hammers	1.7–1.8 MPa (lower limit of usable range 1.0 MPa)	Current mainstream; default for selection
Ultra-high-pressure hammers	2.0–2.4 MPa	Marked speed gains in hard rock; demanding on compressor pressure
Deep-hole / geothermal hammers	2.5–3.5 MPa	Deep wells and geothermal; requires a project-specific solution

For a given hammer, higher supply pressure means more impact energy, higher frequency and faster penetration—but air consumption rises as well. As a rule of thumb, hammer air consumption is roughly proportional to supply **absolute pressure**:

$$Q_2 \approx Q_1 \times (p_2 + 1) / (p_1 + 1)$$

(6-1)

p is gauge pressure (bar). Example: a 5" hammer consuming 17 m³/min at 18 bar uses about $17 \times 25/19 \approx 22$ m³/min at 24 bar. This is an empirical relationship; refer to the hammer manufacturer's performance curves for exact values.

Never exceed the hammer's rated pressure

If compressor pressure exceeds the hammer's rated upper limit, the hammer internals and drill pipe threads are overloaded and their service life drops sharply. When recommending a higher-pressure model, confirm that the customer's hammer, drill pipe, high-pressure hoses and rig air circuit are all rated for the same pressure class.

6.3 Matching Hole Diameter, Hammer and Drill Pipe

Table 6-2 Hole diameter, hammer and drill pipe matching

Hammer size	Hole diameter (mm)	Selection air consumption @1.8 MPa (m ³ /min)	Common drill pipe OD (mm)	Default pipe (mm)
3.5" high-pressure hammer	90–110	10	φ60–φ76	76
4" high-pressure hammer	110–127	13	φ60–φ76	76

5" high-pressure hammer	127–165	17	φ76–φ89	89
6" high-pressure hammer	152–203	22	φ76–φ89	89
8" high-pressure hammer	203–254	35	φ76–φ102	102
10" and above high-pressure hammer	254–305	45	φ89–φ102	102

Values are for the mainstream high-pressure DTH hammers used with KayDrill units (valveless design, good sealing, resistant to cuttings fall-back in water, well suited to casing-advance and water well drilling). High-pressure hammers typically have a minimum operating pressure of 1.0 MPa, which is why Chapter 7 uses 10 bar as the minimum hammer pressure. Air consumption values are selection values at 1.8 MPa; refer to the catalogue of the hammer actually used. The default pipe is the upper end of the common range; if the customer uses a smaller pipe, calculate with the actual value—flushing air will increase accordingly. Holes larger than 12" require multiple compressors in parallel, with a solution prepared by a KayDrill technical engineer.

6.4 Flushing: Annulus and Uphole Velocity

Whether cuttings can be lifted out depends on the air velocity in the annulus. Annulus area:

$$A = \pi/4 \times [(D/1000)^2 - (d/1000)^2] \text{ m}^2 \quad (6-2)$$

D is the hole diameter in mm; d is the drill pipe OD in mm.

The accepted industry rule: without foam or additives, uphole velocity should not fall below about 914 m/min (3000 ft/min); otherwise cuttings are not lifted and are reground at the hole bottom, slowing penetration or even causing the string to stick. The upper limit is generally about 2133 m/min (7000 ft/min); higher velocities accelerate erosion of the drill pipe and hole wall.

■ Key point: calculate velocity at the hole bottom

The compressor's rated air delivery is a volume at atmospheric conditions. At the hole bottom, the air is compressed by the resistance of cuttings and flow in the annulus (annular back-pressure), so its volume—and velocity—are lower. For the same air, velocity at the collar can be three times that at the bottom. Since cuttings are lifted from the bottom, it is velocity **at the hole bottom** that must meet the requirement:

$$v_{\text{bottom}} = (Q / A) \times 1.013 / (1.013 + \Delta p_{\text{ann}}) \quad (6-3)$$

Q is the actual site air delivery in m³/min; Δp_{ann} is the annular back-pressure at the hole bottom in bar. Derived from the isothermal ideal-gas relationship p₁V₁ = p₂V₂.

Worked example: collar vs. bottom velocity

A 6" hole (152 mm) with 89 mm drill pipe gives $A = 0.0119 \text{ m}^2$. With a $36 \text{ m}^3/\text{min}$ compressor, collar velocity is $36 \div 0.0119 \approx 3020 \text{ m/min}$. At 150 m depth, annular back-pressure is about 2 bar, so bottom velocity is $3020 \times 1.013 \div 3.013 \approx 1016 \text{ m/min}$ —just meeting the requirement. Collar velocity is three times the bottom velocity; judging by the collar alone badly overestimates flushing capacity.

■ Drill pipe size: theory vs. practice

In theory, the larger the drill pipe, the smaller the annulus and the higher the uphole velocity for the same air flow, so flushing needs less air. In practice, however, drill pipe on site is generally **no larger than $\phi 102$** , for three reasons:

- **Weight:** pipe weight per metre rises roughly with the square of the diameter. Above $\phi 102$ each rod becomes too heavy, and the rig's pullback, rotation head and rod handler all have to be upsized;
- **Transport and handling:** fewer rods fit on a truck, and on remote sites rods are often carried and made up by hand—heavy rods are slow and unsafe to handle;
- **Flushing clearance:** with oversized pipe, the radial gap between pipe and hole wall becomes too small. Large chips and wet, sticky cuttings jam in the gap, flushing suffers and the string can get stuck.

So take the drill pipe OD from the common range in Table 6-2, and do not push oversized pipe just to save air. If flushing needs more air, increase compressor delivery first; if the requirement exceeds a single unit, a KayDrill technical engineer will evaluate foam drilling or parallel units.

■ Stepped holes: size air on the largest diameter, check clearance on the smallest

Water wells are often drilled "large at the top, small at the bottom": for example $\phi 300$ from 0 to 80 m, where casing is set to seal loose overburden, then a smaller hammer drills $\phi 254$ or $\phi 203$ in bedrock down to final depth. The same drill string runs through every section, so:

1. **Size air flow on the largest-diameter section:** the large section has the biggest annulus and the lowest uphole velocity, so cuttings settle there first. Calculate Q_{flush} with that section's diameter, pipe and depth;
2. **Check clearance on the smallest-diameter section:** the pipe OD must fall within the common pipe range of the hammer used at the bottom, so there is enough gap for cuttings;
3. **Size pressure on the deepest point:** recommended pressure is still based on maximum depth and water level.

Stepped-hole example: the same hole with different pipe sizes

Section	Hole	With $\phi 102$ pipe	With $\phi 140$ pipe
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Upper large section (0–80 m)	φ300	Annulus 0.0625 m ²	Annulus 0.0553 m ² (about 12% less air)
Lower bottom section	φ203	Radial gap about 50 mm, cuttings clear freely	Radial gap about 31 mm, large chips jam easily

The oversized pipe saves only about 12% air in the upper section, yet cuts the flushing gap at the bottom by almost 40%. That is the difference between theoretical data and real-world use, and the reason drill pipe on site rarely exceeds φ102.

6.5 Water Column: The Pressure Killer in Deep Water Wells

Once drilling passes below the water table, water in the hole forms a column that bears on the hammer exhaust. To exhaust, the hammer must first push back this column. Per Eq. (2-3), every 10 m of water column equals about 1 bar:

$$P_{\text{hammer, bottom}} = P_{\text{comp}} - \Delta p_{\text{line}} - \Delta p_{\text{ann}} - (H_{\text{depth}} - H_{\text{SWL}}) / 10 \quad (6-4)$$

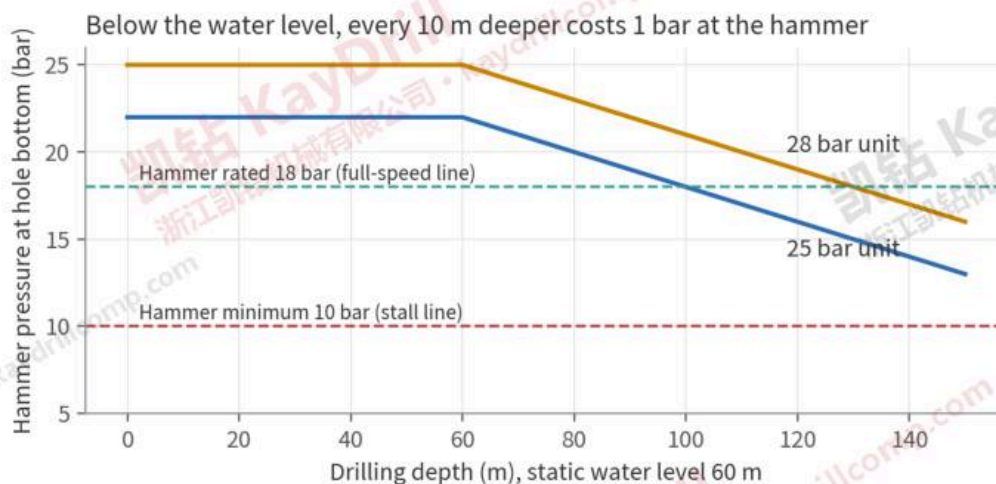


Figure 6-2 Bottom-hole hammer pressure falls with depth below the water table (annular back-pressure 2 bar, line loss 1 bar)

In Figure 6-2, for the same 150 m well with water at 60 m: a 25 bar machine holds bottom-hole hammer pressure above 18 bar (full speed) down to about 100 m, with penetration gradually slowing below that; a 28 bar machine extends the full-speed section to about 130 m. Both machines can complete the hole—the difference is penetration rate in the deep section.

Table 6-3 Bottom-hole hammer pressure vs. penetration rate (typical drilling trend; 6" hole, 150 m, same 25 bar / 30 m³/min machine)

Water column height	Bottom-hole hammer pressure	Average penetration rate	Relative to full speed
0 (dry hole)	21 bar	18 m/h	100%

60 m	16 bar	16 m/h	approx. 89%
120 m	12 bar	11 m/h	approx. 61%
120 m (switched to 20 bar / 20 m ³ /min machine)	10 bar	7 m/h	approx. 39%

Calculating water column height correctly

Water column = maximum hole depth – static water level depth, i.e. the length of string below the water surface. If a customer says "water at 30 m, drilling to 150 m", the water column is 120 m and the back-pressure is 12 bar—not 3 bar. When a water well project is short of pressure, this item has almost always been left out of the calculation.

6.6 Connecting to the Drill Rig

- **Outlets and hoses:** KayDrill machines typically have a combination of 1-2" and 1-1" discharge outlets (refer to the manual). Undersized high-pressure hoses cause significant pressure drop; for long supply runs, increase hose diameter and shorten length where possible. Joints between hose sections must be locked tight and fitted with whip restraints.
- **Rig air circuit:** The rig's lubricator and pneumatic valves also have pressure ratings; confirm these before recommending a high-pressure machine above the customer's existing rating.
- **Parallel operation:** When a single machine cannot supply enough air for large-diameter or very deep holes, two machines can run in parallel, isolated by check valves and set to the same pressure, with a solution prepared by a KayDrill technical engineer.
- **Foam drilling:** With foam or additives, the required uphole velocity can be greatly reduced, but the compressor must have a foam injection pump connection; this is a project-specific solution.

CHAPTER 07

Selection Method: The KayDrill Six-Step Process

The first six chapters explained the "why"; this chapter covers the "how". KayDrill selection follows six steps: define the application, choose the DTH hammer, calculate pressure and air volume separately, scale up for site conditions, select the model, and finally back-check how that compressor will actually perform on site.

Translate site conditions into two numbers, Q and P, then pick the model

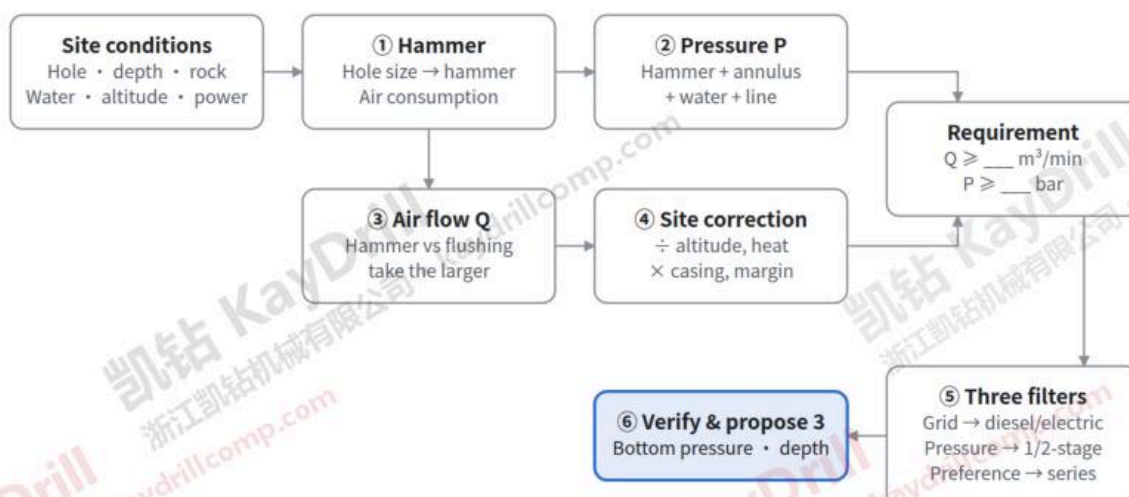


Figure 7-1 KayDrill forward selection process

7.1 Step 0: Ask About the Job, Not the Specs

Customers rarely say "I need 27 m³/min at 23 bar". They say "blast holes in a quarry in Yunnan, 140 mm hole, 25 m deep, granite, no grid power". The first task is to get clear answers to the following eight questions:

Table 7-1 Essential question checklist

#	Topic	How to ask	If the customer is unsure
1	Industry / application	What type of work do you mainly do? Quarrying, mining, water wells or foundation piling?	Must be confirmed; it sets the remaining defaults
2	Hole diameter	What hole size? What is the bit diameter in mm?	Work back from the hammer size (inches) in use

3	Hole depth	How deep do you usually drill? What is the maximum depth?	Size for the maximum depth
4	Rock type	What rock do you mainly drill?	Use the industry default; if uncertain, assume the hardest rock
5	Water	Do you hit water while drilling? At what depth?	Water wells are assumed wet; static water level must be asked
6	Altitude	Where is the site located? What is the altitude?	The location is enough to look it up
7	Temperature	What is the highest summer temperature? And the lowest in winter?	Use typical regional values
8	Power grid	Is stable grid power available on site? Do you relocate often?	If in doubt, choose diesel drive

After the technical questions, ask about preferences: hammer model, drill pipe size, engine brand, performance versus value, and budget. Preferences do not change the calculation; they only determine which unit is chosen at the end.

Table 7-2 Industry default values

Industry	Typical hole dia. mm	Typical depth	Common rock	Key points
Quarry blasting	90–165	≤ 30 m	Granite / limestone	Meters per shift and running cost; adequate pressure class + economy
Open-pit mining	140–250	≤ 30 m	Granite / iron ore / basalt	High downtime cost; Cummins + ample margin
Water wells	150–305	100–300 m	Sandstone / granite / limestone	Always ask static water level; pressure is decisive
Geothermal	150–250	300–2000 m	Granite / metamorphic rock	Refer to a technical engineer
Piling foundations /	300–450	≤ 60 m	Overburden + bedrock	Often parallel units; always ask about casing drilling
Exploration geotechnical /	90–150	50–200 m	Complex variable and	If rock is uncertain, assume the hardest and keep margin
Municipal / slope works	76–140	≤ 20 m	Weathered / soft rock	In urban areas with power, prefer electric drive

7.2 Step 1: Choose the Hammer from the Hole Diameter

Use Table 6-2 to find, from the hole diameter, the hammer size, its rated air consumption Q_{hammer} (take the upper end of the range) and the default drill pipe (pipe is generally no larger than $\phi 102$). If the customer already has a hammer and pipe, use theirs. For stepped holes, follow Section 6.4: size air on the largest diameter and check clearance on the smallest. Where two sizes overlap (e.g. 152–165 mm), choose the larger size for hard rock and deep holes, and the smaller size for soft rock and shallow holes.

7.3 Step 2: Calculate Pressure (Recommended and Minimum)

Rearranging Eq. (6-4): to achieve a given hammer pressure at the hole bottom, what pressure is needed at the compressor outlet?

$$P_{\text{rec}} = P_{\text{hammer}} + \Delta P_{\text{ann}} + \Delta P_{\text{water}} + \Delta P_{\text{line}} \quad (7-1)$$

The hammer receives its rated pressure at the hole bottom and drills at full speed throughout.

$$P_{\text{min}} = P_{\text{hammer,min}} + \Delta P_{\text{ann}} + \Delta P_{\text{water}} + \Delta P_{\text{line}} \quad (7-2)$$

The lowest value at which the hammer still drills. Below it, the hammer essentially stops cycling.

Table 7-3 Pressure terms

Term	Value	Notes
P_{hammer}	Standard high-pressure hammer 18 bar; ultra-high-pressure hammer 22 bar	Determined by the customer's hammer
$P_{\text{hammer,min}}$	10 bar	Mainstream high-pressure hammers: minimum working pressure 1.0 MPa
ΔP_{ann}	≤ 20 m: 0.5; 20–50 m: 1.0; 50–100 m: 1.5; 100–200 m: 2.0; 200–500 m: 3.0 bar; add 0.5 for heavy rock such as iron ore	Calibrated to 1–3 bar at 150 m under typical drilling conditions
ΔP_{water}	$(\text{max. hole depth} - \text{static water level}) \div 10$ bar	Fixed physical value; 0 for dry holes
ΔP_{line}	1 bar (1.5 for long, narrow air lines)	Hoses, drill pipe bore, fittings

By default, select on the recommended pressure. If the customer's budget is tight or they want an electric unit, a compressor between the recommended and minimum pressure may be chosen, but it must be back-checked in Step 6 and the reduced drilling speed explained clearly. **Never go below the minimum.**

Table 7-4 Branching by recommended pressure

Recommended pressure	Which table to use	Reason
7–8 bar and air volume $\geq 36 \text{ m}^3/\text{min}$	DMT tunnel VSD	Low pressure, high volume, alternating duty
$\leq 13 \text{ bar}$	Single-stage	Fully adequate performance, lower purchase price
14–19 bar	Offer both single- and two-stage	Single-stage costs less; two-stage saves fuel
$\geq 20 \text{ bar}$	Two-stage only	Single-stage units go up to 19 bar
26–30 bar with grid power	Back-check a 25 bar electric unit first, then decide diesel / electric	Electric units go up to 25 bar, but can drill if the minimum is met
$> 35 \text{ bar}$	Refer to an engineer	Beyond single-unit range

7.4 Step 3: Calculate Air Volume (Take the Larger of Two)

Source ① Hammer air consumption Q_{hammer} . **Source ②** Air volume required for bottom-hole flushing, obtained by rearranging Eq. (6-3): to reach the target bottom-hole air velocity v_{bottom} , the free air required is

$$Q_{\text{flush}} = A \times v_{\text{bottom}} \times (1.013 + \Delta P_{\text{ann}}) / 1.013 \quad (7-3)$$

$$Q_{\text{base}} = \max(Q_{\text{hammer}}, Q_{\text{flush}}) \quad (7-4)$$

Table 7-5 Target bottom-hole air velocity

Cuttings condition	v_{bottom} (m/min)
Normal (granite, limestone, sandstone)	1000 (about 10% above the 914 lower limit)
Heavy cuttings (iron ore and other high-density ores)	1100 (empirical)
Wet, sticky cuttings, mudstone	1200 (empirical)

7.5 Step 4: Scale Up for Site Conditions

$$Q_{\text{buy}} = Q_{\text{base}} \times K_{\text{casing}} \times K_{\text{margin}} \div (\eta_{\text{alt}} \times \eta_{\text{temp}}) \quad (7-5)$$

Altitude correction uses the **internationally accepted mass-flow correction method**: the free air delivery (FAD) of an oil-injected screw compressor barely changes with altitude (only about 0.5% lower per 1000 m), but the **air mass flow drops by about 12% for every 1000 m of elevation**. DTH drilling depends on air mass, so the correction is based on mass flow:

$$\eta_{\text{alt}} = 1 - 0.12 \times h / 1000$$

(7-6)

h is altitude (m); calculated continuously rather than in stepped bands.

Table 7-6 Altitude correction factor η_{alt} and diesel engine power reserve

Altitude	η_{alt}	Extra air volume needed	Turbocharged diesel available power	Note
500 m	0.94	+6%	96%	—
1000 m	0.88	+14%	92%	Allow ample margin
1500 m	0.82	+22%	88%	Choose a turbocharged diesel
2000 m	0.76	+32%	84%	Turbocharged + enhanced cooling
2500 m	0.70	+43%	80%	High-altitude configuration
3000 m	0.64	+56%	76%	Dedicated high-altitude configuration; add a further 2–4 bar pressure margin
4000 m	0.52	+92%	68%	Refer to a technical engineer

Diesel engine power also decreases: a turbocharged diesel loses about 8% per 1000 m of elevation and about a further 5.4% for every 10 °C rise in air temperature (naturally aspirated engines lose about 12% per 1000 m). KayDrill checks the engine power reserve at the same time; where the reserve is insufficient, a high-altitude turbo package, enhanced cooling or the next model size up is specified. Electric motors of standard design run at full rating up to 1000 m and 40 °C; beyond that, derating applies.

Table 7-7 Other factors

Factor	Value
η_{temp}	$\leq 35\text{ °C}$: 1.00; $35\text{--}45\text{ °C}$: 0.95; $> 45\text{ °C}$: 0.90 (also select the enhanced cooling configuration)
K_{casing}	No casing: 1.00; casing / overburden drilling: 1.10–1.15 (engineer review recommended)
K_{margin}	1.10 across the board, covering output loss from wear and operational variation

Two common mistakes

- ① The temperature correction factor must be a **divisor**, just like altitude; multiplying it in the numerator underestimates air volume for hot conditions.
- ② Rock type and hole depth are already reflected in v_{bottom} and the annular back-pressure; do not apply additional rock or depth factors, or the requirement will be double-counted.

7.6 Step 5: Select the KayDrill Model

With the purchase target " $Q \geq \dots, P \geq \dots$ ", apply three filters:

1. **Drive:** stable grid power → DM / LGDY / DMT; no power or frequent relocation → CM / LGCY.
2. **Stages:** determined automatically by the recommended pressure (Table 7-4).
3. **Series and brand:** performance / harsh conditions → M flagship series; budget-sensitive → LG equivalent models; engine brand is indicated by the suffix K / X / none.

In the model quick-reference tables in Chapter 8, find the row whose pressure is $\geq$ the recommended pressure, then pick from that row and all rows below it the models with delivery $\geq$ the purchase air volume. The one with the closest delivery is the "smallest qualifying model". For dual-mode units, use the delivery at the high-pressure setting.

7.7 Step 6: Back-Check

Put the candidate model's pressure and delivery back into the site conditions to answer the customer's key question: "How deep can this compressor drill, and how fast?"

Table 7-8 Four back-check values

Check	Formula (bar; every 10 m of water column = 1 bar)	Assessment
Bottom-hole hammer pressure	$P_{\text{comp}} - \text{line} - \text{annular back-pressure} - \text{water column}$	$\geq$ rated: full speed; minimum to rated: slower in the deep section; < minimum: cannot drill
Max. full-speed depth	$\text{SWL} + (P_{\text{comp}} - \text{line} - \text{annulus} - P_{\text{hammer}}) \times 10$	No loss of penetration rate within this depth
Max. drillable depth	$\text{SWL} + (P_{\text{comp}} - \text{line} - \text{annulus} - P_{\text{hammer,min}}) \times 10$	Actual hole depth must be less than this
Actual on-site delivery	$\text{Rated delivery} \times \eta_{\text{alt}} \times \eta_{\text{temp}}$	$\geq Q_{\text{base}}$, and bottom-hole air velocity $\geq 914 \text{ m/min}$

Finally, offer the customer three options: the **primary recommendation**, the smallest qualifying model (stating the air volume and pressure margins); **alternative 1**, one size up or the LG equivalent (more headroom or lower cost); and **alternative 2**, a dual-mode unit or electric solution. If the budget is below the threshold, never downgrade to a non-qualifying model; instead offer the LG series, installment payment, rental, or suggest a smaller hole diameter.

7.8 Cases That Must Be Referred to a Technical Engineer

- Deep geothermal holes, or any hole depth > 500 m; altitude > 4000 m;
- Casing / overburden drilling; weathered zones, fractured zones, hole collapse or air loss;
- Required pressure > 35 bar, or delivery > 43 m³/min (multiple units in parallel);

- Large-diameter holes above 10 inches, high-volume piling projects; foam drilling and other special methods.

CHAPTER 08

KayDrill Model Quick Reference and Selection Examples

This chapter is the selection toolbox: model tables arranged by pressure class, a quick-reference matrix, two complete worked examples and a penetration-rate estimate. For a complete solution, contact a KayDrill technical engineer at any time.

8.1 Model Quick-Reference Tables

How to use: find the row whose pressure is $\geq$ the recommended pressure, then choose from that row and all rows below it a model with delivery $\geq$ the purchase air volume. Figures in parentheses are the delivery at the high-pressure setting (m^3/min). The LG economy series offers equivalent models (LGCY / LGDY) for most units.

Table 8-1 Two-stage diesel CM series (sorted by high-pressure setting)

High-pressure setting	Available models (delivery, engine)
18 bar	CM190-15/18-17/13 (15, Yuchai) • CM220B-19/18-21/15 (19, Yuchai) • CM220-20/18-22/15 / ... K (20, Yuchai / Cummins) • CM260-24/18K (24)
19 bar	CM240-21/19-23/15 (21, Yuchai) • CM260-22/19 / ...K (22) • CM260-22/19-24/15K (22) • CM260-24/15-22/19 (22, Yuchai)
20 bar	CM310-23/20-25/15 (23, Yuchai)
21 bar	CM240-19/21-21/15 (19, Yuchai) • CM260-21/21 / ...K (21) • CM260-21/21-23/15 (21, Yuchai) • CM260-21/21-23/16K (21)
22 bar	CM260-19/22 (19, Yuchai) • CM310-24/22-26/16 (24, Yuchai) • CM325-24/22K (24) • CM325-24/22-26/18K (24) • CM360-29/22K (29)
23 bar	CM260-19/23-21/16 (19, Yuchai) • CM360-27/23K (27)
24 bar	CM360-29/24K (29)
25 bar	CM360-31/25K (31) • CM360-31/25-33/18K (31) • CM400-31/25 (31, Yuchai) • CM400-31/25-33/18 (31, Yuchai)
26 bar	CM420-33/26 (33, Yuchai) • CM430-34/26-36/18K (34)
28 bar	CM480-34/28X (34, Xichai)
30 bar	CM550-36/30-38/20K (36) • CM755-40/30-43/20K (40)

34 bar	CM550-35/34-38/25K (35)
35 bar	CM755-38/35-40/30K (38)

Table 8-2 Two-stage electric DM series (LGDY equivalent)

Pressure	Available models (delivery, motor kW)
15 bar	DM90-18/15 (18, 90)
18 bar	DM110-18/18 (18, 110) • DM135-22/18 (22, 132) • DM185-28/18 (28, 185) • DM250-35/18 (35, 250)
19 bar	DM138-23/19 / DM138B-23/19 (23, 132)
20 bar	DM139-23/20 (23, 132) • DM250-34/20 (34, 250)
21 bar	DM185-26/21 (26, 185) • DM250-33/21 (33, 250)
24 bar	DM185-23/24 (23, 185)
25 bar	DM250-31/25 (31, 250)

Table 8-3 Single-stage diesel CM series (5–20 m³/min, 8–19 bar; LGCY equivalent)

Pressure	Available models (delivery)
8 bar	CM56-5/8X (5) • CM72-7/8X (7) • CM125-12/8K / CM130-12/8K (12) • CM150-13/8 / ...K (13)
10 bar	CM125-10/10K / CM130-10/10K (10) • CM150-12/10 / ...K (12)
12 bar	CM125-9/12K / CM130-9/12K (9) • CM150-10/12 / ...K (10) • CM180-18/12 / CM190-18/12 (18, Yuchai)
13–14 bar	CM180-16/13K (16) • CM180-15/14K (15)
15–16 bar	CM180-15/15K (15) • CM180-16/15 / CM190-16/15 (16, Yuchai) • CM180-15/16 / CM190-15/16 (15, Yuchai)
18 bar	CM205-18/18K / CM220-18/18K (18) • CM220-18/18-20/15 (18, Yuchai) • CM260-19/18 (19, Yuchai) • CM260-20/18K (20)
19 bar	CM260-19/19K / CM260-19/19-20/15K (19)

Table 8-4 Electric single-stage and DMT tunnel VSD

Series	Models (delivery @ pressure)
DM / LGDY single-stage	DM90-16/10 (16 @ 10) • DM90-13/14.5 (13 @ 14.5) • DM132-17/13 (17 @ 13) • DM132-15/17 (15 @ 17, DM only)
DMT tunnel VSD	DMT160-36/7 • DMT200-42/7 • DMT220-45/7 • DMT250-56/8 • DMT315-72/8

8.2 Quick-Reference Matrix

When only the hole diameter and depth are known, use the table below to find the approximate class, then correct for water and altitude. The table gives the recommended pressure / purchase air volume calculated with the six-step method for sea level, dry holes, normal rock and $\leq 35^{\circ}\text{C}$, together with the smallest qualifying diesel model.

Table 8-5 Quick reference matrix (recommended pressure bar / required FAD m³/min → smallest diesel model)

Hammer (typical hole / pipe)	≤ 20 m	20–50 m	50–100 m	100–200 m
3.5" ($\phi 102 / \phi 76$)	20 / 11.0 CM240-19/21-21/15	20 / 11.0 CM240-19/21-21/15	21 / 11.0 CM240-19/21-21/15	21 / 11.9 CM240-19/21-21/15
4" ($\phi 115 / \phi 76$)	20 / 14.3 CM240-19/21-21/15	20 / 14.3 CM240-19/21-21/15	21 / 16.0 CM240-19/21-21/15	21 / 19.1 CM260-21/21
5" ($\phi 140 / \phi 89$)	20 / 18.7 CM240-19/21-21/15	20 / 20.1 CM260-21/21	21 / 25.0 CM360-27/23K	21 / 30.0 CM360-31/25-33/18K
6" ($\phi 165 / \phi 89$)	20 / 24.9 CM360-27/23K	20 / 33.1 CM430-34/26-36/18K	21 / 41.4 Parallel units required	21 / 49.6 Parallel units required
8" ($\phi 203 / \phi 102$)	20 / 39.7 CM755-38/35-40/30K	20 / 52.9 Parallel units required	21 / 66.0 Parallel units required	21 / 79.2 Parallel units required

Hole diameters are typical values for each class, and drill pipe follows the defaults in Table 6-2 (upper end of the common range, no larger than $\phi 102$). Large and deep holes need a lot of flushing air; where this exceeds a single unit, a KayDrill technical engineer will evaluate foam drilling or parallel units. For a formal proposal, complete the full six-step process or contact a KayDrill technical engineer.

Three corrections to apply immediately

- **Water:** add "hole length below water level $\div 10$ " bar to the pressure; 50 m below water adds 5 bar;
- **Altitude:** air volume $\div (1 - 0.12 \times \text{altitude in km})$; 1000 m $\div 0.88$, 2000 m $\div 0.76$, 3000 m $\div 0.64$;
- **High temperature:** if summer regularly exceeds 35°C , divide the air volume by a further 0.95.

8.3 Example 1: Quarry Blast Holes in Yunnan

Conditions: blast holes in granite, 140 mm diameter, 25 m deep, dry, altitude 2200 m, summer maximum about 35 °C, no grid power, reliability is the priority.

Step	Working	Result
① Hammer	140 mm falls within 127–165 → 5-inch high-pressure hammer	$Q_{\text{hammer}} = 17$, default $\phi 89$ drill pipe
② Pressure	Recommended $18 + 1.0$ (annulus, 25 m) $+ 0 + 1$; minimum $10 + 1.0 + 0 + 1$	Recommended 20 bar , minimum 12 bar → two-stage
③ Air volume	$A = \pi/4 \times (0.140^2 - 0.089^2) = 0.00917 \text{ m}^2$; $Q_{\text{flush}} = 0.00917 \times 1000 \times 2.013 \div 1.013 = 18.2 > 17$	$Q_{\text{base}} = 18.2$
④ Scale-up	$\eta_{\text{alt}} = 1 - 0.12 \times 2.2 = 0.736$; $18.2 \times 1.10 \div 0.736 \div 1.00$ (35 °C)	$Q = 27.2 \text{ m}^3/\text{min}$
⑤ Model	No power → diesel; 20 bar → Table 8-1; reliability first → M series + Cummins	CM360-29/22K
⑥ Back-check	Bottom-hole hammer pressure $22 - 1 - 1 - 0 = 20 \geq 18$; engine power reserve $1 - 0.08 \times 2.2 - 0.054 \times 1.0 \approx 77\%$	Full speed throughout ; power reserve is on the low side, so specify the high-altitude configuration

Recommendation Purchase target: $Q \geq 27.2 \text{ m}^3/\text{min}$, $P \geq 20 \text{ bar}$

Option	Model	Reason
Primary	CM360-29/22K	Cummins 360 HP, 7% air volume margin and 10% pressure margin; the smallest qualifying model; with high-altitude turbo package and enhanced cooling
Alternative 1 (lower cost)	LGCY360-29/22K	Equivalent economy-series model
Alternative 2 (more pressure)	CM360-29/24K	22 bar bottom-hole hammer pressure; also suitable for an ultra-high-pressure hammer
Alternative 3 (dual-purpose)	CM360-31/25-33/18K	Also handles shallow, high-volume work

After altitude correction, the air requirement at 2200 m is about 36% higher than at sea level. Judging only by the nameplate delivery, a $27 \text{ m}^3/\text{min}$ model might seem sufficient, but once converted to mass flow it has no margin. That is why the $29 \text{ m}^3/\text{min}$ model is the primary recommendation, ensuring full-speed drilling throughout.

8.4 Example 2: Water Well with Grid Power

Conditions: water well, 140 mm diameter, maximum depth 100 m, water struck at 60 m, granite, altitude 800 m, summer 32 °C, stable grid power on site, currently using $\phi 89$ drill pipe, budget-sensitive.

Step	Working	Result
① Hammer	140 mm falls within 127–165 → 5-inch high-pressure hammer; $\phi 89$ pipe is within the 5-inch common range $\phi 76$ – $\phi 89$	$Q_{\text{hammer}} = 17$, pipe $\phi 89$
② Pressure	Recommended $18 + 1.5$ (annulus, 100 m) + 4 (40 m water column) + 1; minimum $10 + 1.5 + 4 + 1$	Recommended 25 bar, minimum 17 bar
③ Air volume	$A = \pi/4 \times (0.140^2 - 0.089^2) = 0.00917 \text{ m}^2$; $Q_{\text{flush}} = 0.00917 \times 1000 \times 2.513 \div 1.013 = 22.8 > 17$	$Q_{\text{base}} = 22.8$
④ Scale-up	$\eta_{\text{alt}} = 1 - 0.12 \times 0.8 = 0.904$; $22.8 \times 1.10 \div 0.904 \div 1.00$	$Q = 27.7 \text{ m}^3/\text{min}$
⑤ Model	Stable grid → electric first; 25 bar is within the electric range; diesel option given for comparison	DM250-31/25, CM360-31/25K
⑥ Back-check	DM250-31/25: bottom hole $25 - 1 - 1.5 - 4 = 18.5 \text{ bar} \geq 18$; air margin $31 \div 27.7 - 1 \approx 12\%$	Full speed throughout

Recommendation $Q \geq 27.7 \text{ m}^3/\text{min}$; recommended 25 bar, minimum 17 bar

Option	Model	Reason
Primary (electric, lowest running cost)	DM250-31/25 (LGDY250-31/25 for a tighter budget)	12% air margin, full speed over the entire 100 m
Alternative 1 (no grid or frequent moves)	CM360-31/25K	Cummins 360 HP, also full speed throughout
Alternative 2 (deeper holes in future)	CM550-36/30-38/20K	23.5 bar bottom-hole hammer pressure, full speed to about 150 m

Note: if the customer wants to switch to $\phi 114$ pipe to save air, the radial gap in a 140 mm hole drops to only 13 mm—cuttings will jam easily, and the pipe is outside the common range for a 5-inch hammer. Not recommended.

Electric or Diesel?

On sites with stable grid power, electric units burn no fuel, have no diesel engine maintenance, and offer lower noise and zero on-site emissions. At typical industrial electricity and diesel prices, the hourly energy cost of an electric unit is usually less than half that of a diesel unit with the same delivery, adding up to substantial running-cost savings over a year of continuous operation.

8.5 Penetration Rate Estimate

On a diesel-driven portable compressor, the airend speed is set by the engine, so delivery is essentially constant; penetration rate depends mainly on the pressure actually reaching the hammer at the hole bottom. The closer the bottom-hole hammer pressure is to the hammer's rated pressure, the closer the penetration rate is to full speed:

Table 8-6 Bottom-hole hammer pressure vs. relative penetration rate (typical trend)

Bottom-hole pressure / hammer rating	≥ 100%	89%	67%	56% (10 bar)	< 56%
Penetration rate relative to full speed	100%	approx. 90%	approx. 60%	approx. 40%	Practically no progress

This is why KayDrill insists on selecting by the "recommended pressure": with the right pressure, the hammer runs at full speed throughout, minimizing both time and energy per meter drilled.

8.6 Getting Selection Support

KayDrill technical engineers can prepare a free selection proposal based on your site data (hole diameter, depth, rock type, water, altitude, temperature, power supply), including the recommended model, bottom-hole hammer pressure, full-speed depth and configuration advice. Please contact the KayDrill sales hotline at +86 570 8878277 or your local dealer.

CHAPTER 09

Safety and Operation

A portable air compressor combines a pressure vessel, high-temperature components and rotating machinery. The vast majority of accidents and early failures are caused by improper operation. This chapter sets out general operating procedures; for each specific model, the Operator's Manual supplied with the unit and the engine manufacturer's manual take precedence.

9.1 Safety Rules

The following are strictly prohibited

- Opening the oil filler cap or oil drain valve, or removing any pressurized line or filter element, while the unit is running or while the separator tank is still under pressure;
- Raising the safety valve setting without authorization, bypassing temperature or pressure protection switches, or removing the thermostatic valve;
- Blowing compressed air at people, or using a discharge hose as a blow-off tool pointed at people;
- Supplying air before high-pressure hose connections are locked and whip restraints are fitted;
- Operating a diesel-driven unit in a confined space or deep inside a tunnel without adequate ventilation;
- Towing or lifting the unit while it is running, or reaching near the fan and belts with the canopy open.

Safety warning labels on the unit (hot surface, high pressure, rotating parts, electric shock, noise, read the manual, etc.) must not be covered or removed. Operators must wear hearing protection and safety glasses.

9.2 Site Positioning

- Place the unit on firm, level ground, with an inclination no greater than the value specified in the unit documentation, to avoid false oil level readings and oil starvation at the suction pickup;
- Keep the air intake side away from dust sources, blasting points and engine exhaust, and leave enough clearance around the unit for servicing and cooling;

- Prevent hot exhaust air from recirculating into the air intake; when several units are placed side by side, stagger them;
- Apply the parking brake and chock the wheels front and rear.

9.3 Start-up and Shutdown: Diesel-Driven Units

A. Pre-start Checks

☐	Item	Requirement
☐	Compressor oil level	With the unit stopped and depressurized, check the sight glass; level between the specified marks
☐	Engine oil, coolant	Per the engine manual; coolant grade suited to the local minimum ambient temperature
☐	Fuel	Sufficient fuel of the correct seasonal grade; drain water from the fuel/water separator
☐	Air filters	Restriction indicator not red; dust ejector valve clear
☐	Cooler exterior	Free of oil sludge and dust build-up
☐	Belts, hoses, clamps	No cracks, looseness or leaks
☐	Battery and wiring	Connections secure, battery fully charged
☐	Service valve and downstream	Hose connections locked; service valve closed or slightly open at start-up

B. Starting

1. Set the Start / Run lever to "Start" (inlet valve closed for light-load starting);
2. Turn the key to "On" and let the panel complete its self-test; in cold weather, hold the cold-start aid / preheat button;
3. Turn to "Start" and release once the engine fires; do not crank longer than the time specified in the unit documentation per attempt, and wait between attempts if it fails to start;
4. Warm up at idle for 3–5 minutes, watching oil pressure, coolant temperature and discharge temperature rise to normal.

C. Running

1. Move the lever to "Run"; the unit loads and pressure rises to the set point;
2. Select the operating mode with the high/low pressure selector as required, then open the service valve slowly;
3. Inspect at regular intervals during operation: discharge pressure, discharge temperature, engine oil pressure and coolant temperature, speed stability, and any abnormal noise, oil leaks or air leaks.

■ D. Shutdown

1. Close the service valve and return the lever to "Start"; let the unit run unloaded for 3–5 minutes to cool down;
2. Turn the key to "Stop"; the blowdown valve automatically vents the separator tank pressure;
3. Confirm the pressure gauge reads zero before carrying out any service work; in winter, drain condensate and take freeze-protection measures as needed after shutdown.

Do not idle high-pressure units unloaded for long periods

During prolonged unloaded running the oil temperature stays low, and moisture in the air condenses in the separator tank and enters the oil. If the drill rig will be idle for an extended period, shut the compressor down rather than leaving a high-pressure unit idling.

9.4 Start-up and Shutdown: Electric-Driven Units

■ A. Pre-start Preparation

- Verify that supply voltage and frequency match the nameplate and that supply capacity is sufficient; size the cable cross-section for motor power and line length, going up one size for long supply runs;
- Ensure reliable grounding, close the control cabinet door and reset the emergency stop button;
- Check oil level, cooler, air filter and piping as in Section 9.3.

■ B. Power-on Checks

- If the controller reports "Phase Sequence Error" after power-on, switch off the power and swap any two of the three incoming phases;
- On the first start after maintenance, jog the motor to confirm the correct rotation of the airend and fan;
- In cold weather when the oil is thick, jog for about 2 seconds first to establish oil flow, then start normally.

■ C. Starting and Stopping

Press "Start"; the unit loads automatically after star-delta or soft starting. During operation, monitor discharge pressure, temperature, current and operating status on the controller. To stop, press "Stop"; the unit unloads and stops after a delay. Do not cut the main power directly; use the emergency stop button only in an emergency.

9.5 Operation in Special Environments

Environment	Key points
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Extreme cold (< -10 °C)	Use winter-grade diesel, low-temperature engine oil and coolant (antifreeze) of the appropriate grade; fit the optional cold-start system; preheat before starting; drain all condensate after shutdown
High temperature (> 35 °C)	Clean the coolers daily; keep the air intake out of direct sunlight; monitor discharge temperature closely under heavy afternoon loads and reduce load if necessary
High altitude (> 2000 m)	Select a high-altitude configuration; discharge temperature and engine coolant temperature run higher than at low altitude, so shorten service intervals accordingly
Heavy dust	Use a pre-cleaner / desert air filter kit; check air filters every shift; double the cooler blow-out frequency
High humidity, coastal	Never run unloaded for long periods; shorten oil change intervals and watch for oil emulsification; pay attention to corrosion protection

CHAPTER 10

Maintenance

The service life of a portable air compressor is earned through care, not just use. Almost every failure of high-value components such as the airend, bearings and separator element can be traced back to poor management of oil, filters and cooling. This chapter sets out a general maintenance system; for specific intervals, the documentation supplied with each model and the engine manufacturer's manual take precedence.

10.1 The Three Pillars of Maintenance

1. **Manage the oil:** correct oil, correct level, changed on time, kept free of water and dust;
2. **Manage the filters:** air filters, oil filter, separator element and fuel filters — replace them when clogged, do not wait for failure;
3. **Manage the heat:** keep coolers clean, the thermostatic valve working and fan belts in good condition, so discharge temperature stays consistently within the normal range.

10.2 KayDrill Service Kit System: 500 h / 1500 h / 2500 h

KayDrill supplies standard service kits for every model, in three levels by accumulated running hours: **500 h, 1500 h and 2500 h** (a few earlier models use 500 / 2000 / 4000 h; follow the service kit for the specific model). All service kits are assembled from the same set of part groups:

Table 10-1 Service Kit Composition

Group	Parts included	Electric units	Diesel units
A Compressor airend	Separator element, compressor oil filter, airend air filter element (with safety element), compressor oil	Every level	Every level
B Engine	Engine air filter element (with safety element), fuel filter, engine oil filter, fuel/water separator, coolant (antifreeze), engine oil	N/A	Every level
C Controls and valves	Air/water separator, temperature sensor, pressure sensor, high-pressure regulator valve, solenoid valve, controller	2500 h major service	2500 h major service

In short: **Electric service kit = A (plus C at 2500 h); Diesel service kit = A + B (plus C at 2500 h)**. Parts of the same specification in groups A and C are common across a large number of models, making stocking easy for dealers.

10.3 Oil Selection

Table 10-2 KayDrill Lubricants

Oil	Specification	Application	Typical fill quantity
Compressor oil ZH	KayDrill dedicated compressor oil, red drum, 16 L/drum	Low and medium pressure models (mainly single-stage, 19 bar and below)	Diesel units: 4–6 drums; electric units: 60–120 L
Compressor oil ZD	KayDrill dedicated high-pressure compressor oil, grey drum, 16 L/drum	High-pressure two-stage models (mainly above 20 bar)	
Compressor oil ZB	Dedicated to small electric units	Small-capacity electric units	Approx. 20 L
Engine oil	CH-4 15W-40	All diesel units	Per engine model
Coolant (antifreeze)	–25 °C	All diesel units; use a lower freezing point in extremely cold regions	Per engine model

Individual models may differ; always follow the specification marked on the service kit for that model.

- Use only the dedicated compressor oil specified by KayDrill; **never mix ZH with ZD, or oils of different brands**. When changing oil type, drain all old oil, flush the oil circuit, and replace the oil filter and separator element at the same time;
- Add oil only with the unit stopped and depressurized; read the oil level from the sight glass after shutdown;
- Oil that turns white (emulsified), dark and thick, or smells burnt indicates water ingress, overheating or oxidation; replace it immediately and identify the cause.

10.4 Daily Checks and Scheduled Maintenance

Table 10-3 Inspection and Maintenance Intervals

Item	Daily / per shift	Weekly (approx. 50 h)	500 h	1500 h	2500 h	Remarks
Compressor oil level	Check					Check sight glass after stopping and depressurizing
Airend group (separator, oil filter, air filter, compressor oil)			Replace	Replace	Replace	Earlier in severe conditions

B Engine group (three filters, fuel/water separator, engine oil, coolant)			Replace	Replace	Replace	Diesel units only; also follow the engine manufacturer's manual
C Controls and valves					Replace	Major service
Air filter restriction indicator, dust ejector valve	Check	Clean				Check every shift in heavy dust
Cooler exterior	Visual	Blow out				More often in hot, dusty areas
Fuel/water separator drain	Drain					Diesel units
Hoses, clamps, belts	Visual		Check and tighten	Check	Replace as needed	Aged high-pressure hoses must be replaced
Safety valve				Manual test lift	Calibrate	Per local pressure vessel regulations
Scavenge line orifice, check valve; minimum pressure valve, thermostatic valve				Check and clean	Check	Check at any time if related faults occur
Electrical grounding wiring,			Check and tighten			Electric units

10.5 Use Genuine KayDrill Parts

Separator elements, oil filters and air filter elements directly determine airend life and air quality. KayDrill genuine service parts are selected together with the airend and compressor oil for each model, and are supplied as complete 500 h / 1500 h / 2500 h service kits, so dealers can stock by model.

- When ordering, always quote the full model designation and serial number: parts for the same model from different production batches may not be interchangeable;
- Consumables are generally not covered by the warranty; warranty scope and duration are governed by KayDrill's current warranty terms.

10.6 Key Component Replacement

Oil Filter

1. Stop the unit, depressurize to zero and allow the oil to cool;
2. Remove the old filter counterclockwise with a filter wrench, catching any residual oil;
3. Clean the filter head sealing surface and apply a thin film of clean compressor oil to the new filter's gasket;
4. Screw on by hand until the gasket makes contact, then tighten a further 3/4 turn; do not overtighten with a wrench;
5. Check for leaks after start-up, then stop, depressurize and recheck the oil level.

Separator Element

1. Stop and depressurize the unit; disconnect the lines and remove the bolts on the separator tank cover, then lift off the cover;
2. Remove the old separator element and inspect the tank for sludge and debris;
3. Replace the gaskets; when fitting the new element, do not remove the static-grounding clip (staple / conductive strip), which prevents static build-up;
4. Refit the scavenge line, setting the gap between its lower end and the bottom of the element as specified in the unit documentation — too high and oil will not be returned, too low and the filter media will be damaged;
5. Tighten the cover bolts evenly in a cross pattern, and check the seal after start-up.

Air Filter

- The primary element may be cleaned by blowing low-pressure dry air from the inside out; never tap, wash or blow it with high-pressure air. Replace it if the paper is damaged or restriction remains high after cleaning;
- The safety element is generally not cleaned; replace it once for every 2–3 primary element replacements;
- When replacing, make sure the seal is properly seated so that unfiltered air cannot bypass into the aircend.

10.7 Diesel Fuel and Coolant

Table 10-4 Diesel Grade Selection (by local minimum ambient temperature)

Diesel grade (GB 19147)	No. 0	No. -10	No. -20	No. -35	No. -50
Minimum ambient temperature	≥ 4 °C	≥ -5 °C	≥ -14 °C	≥ -29 °C	≥ -44 °C

The freezing point of the coolant (antifreeze) should be 5–10 °C below the lowest recorded local temperature. KayDrill diesel service kits include –25 °C coolant as standard; in extremely cold regions, use –35 °C or –45 °C grade instead. Do not mix different types of coolant.

10.8 Long-term Storage

- Stored for more than one month: drain condensate, fill the fuel tank to prevent rust, and disconnect the battery negative terminal;
- More than three months: change to fresh compressor oil and run for 30 minutes to coat internal surfaces with an oil film; seal the intake and discharge openings to keep out moisture and foreign matter;
- Before returning to service: check oil level and condition, belts, hoses and battery; turn the airend by hand to confirm it is not seized; run unloaded for 10–15 minutes before loading.

10.9 Maintenance Records

Every unit should have a maintenance record including at least: date, accumulated running hours, work performed, oil and filter part numbers used, technician, and any problems found. Complete records are the basis for diagnosing faults and resolving warranty claims. On models equipped with an industrial gateway, service reminders can be set in the controller.

CHAPTER 11

Alarms and Troubleshooting

Controller alarms have two levels: a **Warning** indicates an abnormal condition but allows continued operation; a **Shutdown Fault** stops the unit immediately, and the cause must be cleared and the fault reset before restarting. The principle of troubleshooting is to review the alarm information and data first, then work from the simplest and most common causes.

11.1 Basic Troubleshooting Method

1. **Record:** alarm name, time of occurrence, pressure, temperature, speed / current at the time, ambient temperature, and running time;
2. **Outside in:** first check external factors such as oil level, filter indicators, coolers, power supply and fuel, then valves and sensors, and only then consider the airend;
3. **Verify the reading:** when a reading looks abnormal, compare it with a mechanical gauge or another sensor to rule out a sensor or wiring fault;
4. **Reset only after clearing:** do not repeatedly reset and force a restart before the cause has been found.

11.2 Diesel-Driven Unit Alarms

Table 11-1 Common Alarms on Diesel-Driven Screw Compressors

Alarm	Common causes	Action
Engine speed alarm (overspeed / underspeed)	Speed regulator cylinder sticking or leaking; throttle linkage disconnected or misadjusted; insufficient fuel supply; speed sensor fault	Check the speed regulator cylinder and throttle linkage; inspect the fuel system; verify the sensor
Compressor pressure alarm (overpressure)	Pressure regulator set too high or faulty; inlet valve fails to throttle; control air line leaking or blocked; high/low pressure selector in wrong position	Check the regulator, inlet valve servo cylinder and control lines; confirm selector position
Engine oil pressure alarm (low oil pressure)	Low or diluted engine oil; clogged oil filter; oil pump fault; oil pressure sensor fault	Stop and check engine oil level and condition; follow the engine manual and contact an engine service center if necessary

Compressor high temperature alarm (high discharge temperature)	Low compressor oil; dirty or clogged cooler; thermostatic valve failure; clogged oil filter; fan or belt fault; excessive ambient temperature; wrong or degraded oil	See the dedicated procedure in Section 11.4
Engine coolant temperature alarm	Low coolant; dirty radiator exterior; thermostat or water pump fault; fan belt slipping; prolonged overload	Top up coolant once the engine has cooled, clean the radiator, check the belt and thermostat
Filter alarm	Air filter clogged	Clean or replace the air filter element
Charging indicator	Alternator not charging, loose belt, wiring fault	Check the alternator, belt and wiring

11.3 Electric-Driven Unit Alarms

Table 11-2 Common Alarms on Electric-Driven Screw Compressors

Alarm	Common causes	Action
Phase sequence error	Incoming phase sequence does not match the setting	Switch off the power and swap any two incoming phases
Phase loss	Blown fuse, burnt contactor contacts, broken cable or loose connection	Measure three-phase voltage stage by stage, replace damaged components, tighten connections
Voltage out of range	Grid voltage too high or too low; voltage drop from an overlong or undersized cable	Measure no-load and on-load voltage; use a heavier cable or adjust the supply
Current imbalance	Unbalanced three-phase voltage; poor contact on one contactor pole; motor winding fault	Measure three-phase voltage and current; check the contactor and motor
Airend overload	Discharge pressure set too high; clogged separator element; oil too cold and thick; low voltage; airend bearing damage	Verify pressure settings, check separator differential pressure and oil, measure voltage; if overload persists, inspect the airend
Airend locked rotor	Airend seized (bearing damage, foreign object); high starting resistance from thick oil in winter; starting under load	Switch off and turn by hand to diagnose; jog to warm up in winter; confirm the inlet valve is closed at start-up
High discharge temperature	Same causes as for diesel units; insufficient cooling water on water-cooled models	See Section 11.4
Discharge overpressure	Incorrect pressure setting; inlet valve fails to close; blowdown valve not operating; pressure sensor fault	Check set point, inlet valve, blowdown valve and sensor

Low water (water-cooled models)	Insufficient cooling water pressure or flow; blocked water circuit	Check the water source, valves and strainer; treat water quality per the unit documentation
Sensor fault	Sensor missing, damaged or disconnected	Check connectors and wiring; replace the sensor

11.4 Dedicated Procedure: High Discharge Temperature

High discharge temperature is the most common fault on screw compressors and the one that demands the most attention, because it directly threatens the airend. Troubleshoot in the following order:

1. **Oil level:** check the level after stopping and depressurizing; if below the minimum, top up first and find the cause of the leak or oil carry-over;
2. **Cooler:** check whether the exterior is caked with oil sludge and dust, and whether the fan and belt are working properly;
3. **Environment:** check for high ambient temperature, direct sunlight, hot air recirculation, or open canopy doors disrupting the airflow path;
4. **Thermostatic valve:** if, with the unit running, the temperature difference across the cooler is very small and the cooler does not feel hot, the thermostatic valve has not opened;
5. **Oil filter:** when clogged it goes into bypass and oil flow drops;
6. **Oil:** check for wrong oil, mixed oils, or aged oil with carbon deposits;
7. **Operating conditions:** check for prolonged operation above rated pressure, or high-altitude operation without the high-altitude configuration;
8. **Sensor:** compare the reading with an infrared thermometer.

11.5 Common Performance Faults

Table 11-3 Common Performance Faults and Remedies

Symptom	Possible causes	Action
Insufficient air delivery, pressure will not build	Clogged air filter; inlet valve not opening fully; engine not reaching rated speed; leaking minimum pressure valve or piping; worn airend or insufficient oil; no altitude correction	Check air filter, inlet valve, speed and piping in turn; recheck model sizing against altitude
Oil in discharge air, high oil consumption	Oil level too high; damaged or clogged separator element; blocked scavenge line orifice or failed scavenge check valve; minimum pressure valve not holding pressure; running at too low a discharge pressure	Drain to normal oil level; check scavenge line and check valve; replace separator element; avoid prolonged low-pressure, high-flow operation

Oil emulsified (white)	Prolonged low-load / unloaded operation with oil temperature below the pressure dew point; overcooling; hot and humid environment	Change the oil; check the thermostatic valve; adjust operation to avoid prolonged unloaded running
Oil spray from the air intake after shutdown	Inlet valve non-return function failed; unit not unloaded before stopping	Repair the inlet valve; follow the shutdown procedure
Safety valve blows	Overpressure; clogged separator element causing high tank pressure; faulty safety valve	Check the pressure control circuit and separator differential pressure; calibrate the safety valve
Pressure and speed hunting	Control air line leaking or breather cap misadjusted; regulator fault; sharp fluctuations in air demand	Check control air lines; adjust the pressure stabilizer valve / breather cap
Abnormal airend noise, heavy vibration	Worn bearings; damaged coupling or elastomer; loose mounting bolts; severe oil shortage	Stop immediately; check coupling and oil level; bearing issues must be handled by qualified personnel
Engine hard to start	Discharged battery; water in fuel or wrong fuel grade; air in fuel system; no preheating in cold weather	Charge or replace the battery; drain water and replace fuel, bleed air; use the cold-start aid

11.6 When to Contact KayDrill

- Abnormal airend noise or sticking, or discharge temperature that remains high after external factors have been confirmed normal;
- The same alarm recurring after common causes have been eliminated;
- Any need to adjust factory settings such as the safety valve, pressure regulator or high/low pressure set points;
- Any major component failure during the warranty period — do not disassemble it yourself, as this may affect warranty coverage.

When contacting after-sales service, please have ready: model and serial number, accumulated running hours, alarm information and photos, pressure and temperature readings at the time, and the most recent maintenance record.

APPENDIX

Appendices

Appendix A Formula Summary

Name	Formula	Source
Absolute pressure	$p_{abs} = p_{gauge} + p_{atm}$	(2-2)
Water column pressure	$p = \rho gh$, 10 m water $\approx$ 1 bar	(2-3)
Ideal gas law	$p_1 V_1 / T_1 = p_2 V_2 / T_2$	(2-6)
Atmospheric pressure vs. altitude	$p_h = 101.325 \times (1 - 2.256 \times 10^{-5} h)^{5.256}$ kPa	(2-8)
Air density ratio	$\rho_h / \rho_0 = (p_h / p_0) (T_0 / T_h)$	(2-9)
Partial vapor pressure at pressure dew point	$p_{v,sep} = p_{sep} \times p_{v,atm} / p_{atm}$	(2-10)
Isothermal specific power	$N = 1.689 \ln r$ kW/(m ³ /min)	(3-6)
Adiabatic specific power	$N = 5.91 (r^{0.286} - 1)$ kW/(m ³ /min)	(3-6)
Final compression temperature	$T_2 = T_1 r^{(n-1)/n}$	(3-5)
Optimum two-stage intermediate pressure	$p_m = \sqrt{(p_1 p_2)}$	(3-9)
Internal pressure ratio	$p_i / p_s = V_i^n$	(4-1)
Hammer consumption air vs. pressure	$Q_2 \approx Q_1 (p_2 + 1) / (p_1 + 1)$	(6-1)
Annular area	$A = \pi / 4 \times [(D/1000)^2 - (d/1000)^2]$	(6-2)
Bottom-hole air velocity	$v_{bottom} = (Q/A) \times 1.013 / (1.013 + \Delta P_{ann})$	(6-3)
Bottom-hole hammer pressure	$P_{comp} - \Delta P_{line} - \Delta P_{ann} - (H - H_{SWL}) / 10$	(6-4)
Recommended / minimum pressure	$P_{hammer} / \min + \Delta P_{ann} + \Delta P_{water} + \Delta P_{line}$	(7-1)(7-2)
Flushing air volume	$Q_{flush} = A \times v_{bottom} \times (1.013 + \Delta P_{ann}) / 1.013$	(7-3)
Altitude factor (mass flow correction)	$\eta_{alt} = 1 - 0.12 \times h / 1000$	(7-6)

Engine power reserve	$1 - 0.08 \times h/1000 - 0.054 \times (t - 25)/10$ (turbocharged)	Section 7.5
Purchase air volume	$Q_{\text{buy}} = \max(Q_{\text{hammer}}, Q_{\text{flush}}) \times K_{\text{casing}} \times K_{\text{margin}} \div (\eta_{\text{alt}} \times \eta_{\text{temp}})$	(7-5)

Appendix B Common Unit Conversions

Quantity	Conversion
Pressure	1 MPa = 10 bar = 1000 kPa; 1 bar = 14.5 psi = 1.02 kgf/cm ²
Flow	1 m ³ /min = 35.31 cfm = 16.67 L/s; 1 cfm = 0.0283 m ³ /min
Power	1 kW = 1.341 HP; 1 HP = 0.746 kW
Length	1 in = 25.4 mm; 1 ft = 0.3048 m
Velocity	1000 ft/min = 304.8 m/min; 3000 ft/min = 914 m/min
Temperature	°F = °C × 1.8 + 32; K = °C + 273.15

Appendix C Glossary

Term	Definition
FAD (free air delivery)	Discharge volume flow converted to inlet conditions; the standard basis for nameplate air delivery
Gauge / absolute pressure	Pressure referenced to atmosphere / to vacuum
Specific power	Power consumed per m ³ /min of air delivery; a measure of energy efficiency
Built-in volume ratio V _i	Ratio of the airend volume at the end of suction to the volume at the start of discharge; determines the design pressure
Interlobe volume	The working space enclosed by adjacent rotor lobes and the casing
Separator element	Secondary oil/air separation element inside the separator tank
Minimum pressure valve	Outlet valve that maintains a minimum separator tank pressure, also acting as a check valve
Thermostatic valve	Valve that routes oil through or around the cooler according to oil temperature
Annulus	The annular space between the borehole wall and the drill pipe, through which cuttings are returned
Uphole velocity	Upward air velocity in the annulus; determines cuttings removal capability
Annular back pressure	Pressure at the hole bottom created by cuttings and air flow resistance in the annulus
Static water level	Depth from the surface to the groundwater level in the borehole
Purchase coordinates	The two threshold values from selection: "Q ≥ ..., P ≥ ..."

Recommended minimum pressure	/ Compressor outlet pressure required for the hammer to run at full speed / to operate at all at the hole bottom
Dual mode	A single unit that can switch between two delivery-pressure combinations

Appendix E References

- KayDrill 2026 Product Catalog (M / DMT / LG Series); KayDrill model service kits (500 / 1500 / 2500 h);
- GB 19147 Automobile Diesel Fuels — grades and applicable temperatures; ISO 1217 Displacement compressors — Acceptance tests.



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This guide is provided for technical reference. Product data are subject to the latest KayDrill catalogue; operation and maintenance follow the documents supplied with each unit and the engine manufacturer's manual. Zhejiang Kaizuan Machinery Co., Ltd. reserves the right of final interpretation.