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# Troubleshooting of Draeger Neonatal Ventilator

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## Abstract

**Draeger Babylog8000 is a ventilator specially designed for premature infants, newborns and infants under 20 kg, which has been widely used in major hospitals in China. As a large comprehensive medical institution that excels particularly in the field of pediatrics, our hospital is equipped with more than ten such ventilators. This paper analyzes the basic structure of the ventilator and a maintenance case, which provides methods and basis for the daily management and maintenance of the ventilator in the future.**

## Keywords

**Draeger; Babylog8000; Ventilator; Maintenance cases.**

## 1. Introduction

In recent years, with the rapid development of cities, the safety of newborns has attracted great attention from all sides. Draeger Babylog8000 neonatal ventilator is a special ventilator [1]for newborns, which is suitable for children, infants, full-term newborns and premature infants of 400g-20Kg. The equipment adopts constant pressure mode and has the functions of high frequency ventilation. The basic breathing modes include IPPV, SIPPV, SIMV, CPAP, etc. As a medical device, with an increase in usage, Babylog8000 ventilator often fails in the process of use. This paper analyzes the basic structure of the equipment and a maintenance case, which provides methods and basis for the daily management and maintenance of the ventilator in the future.

## 2. Basic structure

The structure of the Babylog 8000 mainframe consists of two parts, the electrical circuit and the gas circuit. The structure of the electrical circuit part is shown in Figure 1. The front panel includes a control panel and a display panel, which are used to realize the human-computer interaction function, including the display of waveforms and parameters、the adjustment of parameters during breathing.

The main control system is the core of signal and data processing, and the monitoring system is used to monitor all monitoring data and status information. The main control system and the monitoring system work together to complete the verification of monitoring data and status information. They are two sets of micro-processing systems that operate relatively independently. Once a verification error occurs, an alarm will occur.

The flow sensor monitors the flow of inhaled or exhaled gas, converts it into an electrical signal and transmits it to the CPU to complete signal processing, so as to realize the real-time monitoring of the main working parameters of the ventilator, such as tidal volume, minute ventilation volume and gas flow rate [2] . Babylog8000 uses a proximal thermal flow sensor, which has the advantages of low respiratory resistance, fast response, and is very sensitive to low flow [3] . It is suitable for premature infants with low tidal volume, high respiratory rate,

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and low minute ventilation (≤250 mL/kg). Pressure sensors mainly include inspiratory and expiratory pressure sensors and air and oxygen pressure sensors.

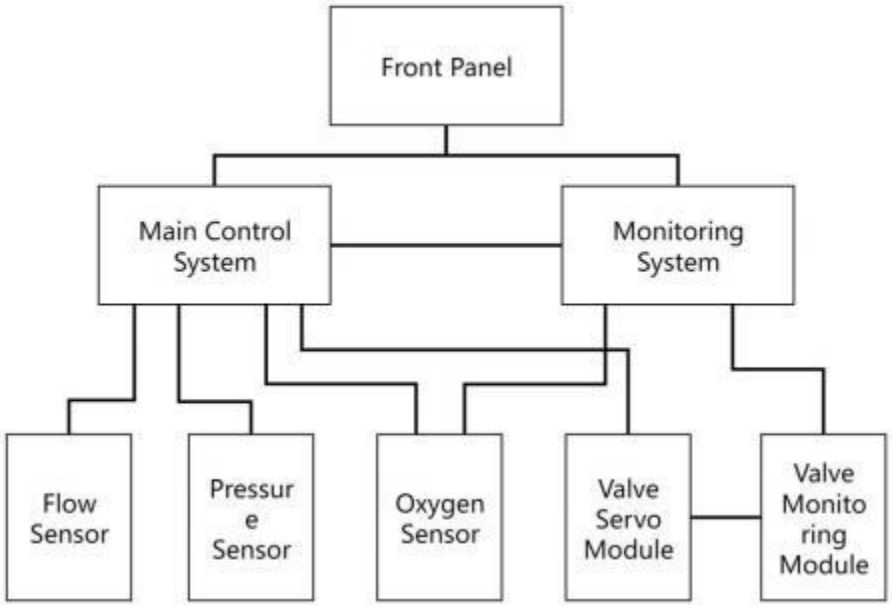


Figure 1: Babylog 8000 electrical circuit structure

The inspiratory and expiratory pressure sensors mainly monitor the inspiratory and expiratory airway pressures, while the air and oxygen pressure sensors mainly monitor the air and oxygen supply pressures, which are required to be 0.03~0.06 MPa. Finally, the Babylog8000 interior stabilizes the supply pressure at 0.17 MPa. In addition, Babylog8000 is a pneumatic and electrically controlled ventilator, and its driving source can be oxygen or air. Oxygen concentration monitoring sensor continuously measures the inspired oxygen concentration, and the system automatically performs a 2-point calibration (21%, 100%) every 24 hours. The calibration time for air (21%) and oxygen (100%) was approximately 2.5 min each.

The main control system and the monitoring system jointly control various types of valves, the main control system gives a servo signal, the servo module completes the driving of the valve, the monitoring system completes the power supply control, the valve monitoring module measures the working current of the valve and feeds back to the servo module and the monitoring system to form the whole valve control loop.

The gas path part is mainly divided into seven modules(see Figure 2). The gas supply module is mainly composed of a compressed gas filter, a check valve and a pressure regulator; the compressed gas flowing through this module will maintain a stable system pressure and will not flow back to the central gas supply system. The absolute pressure sensor measures and monitors the system pressure. The compressed gas is sent to the inspiratory module after gas mixing and flow blending, where the oxygen concentration of the mixed gas will be measured. In addition, the overpressure safety valve and emergency suction valve will ensure the breathing safety in case of pipeline overpressure and air supply failure. Airway pressure is measured by a relative pressure sensor.

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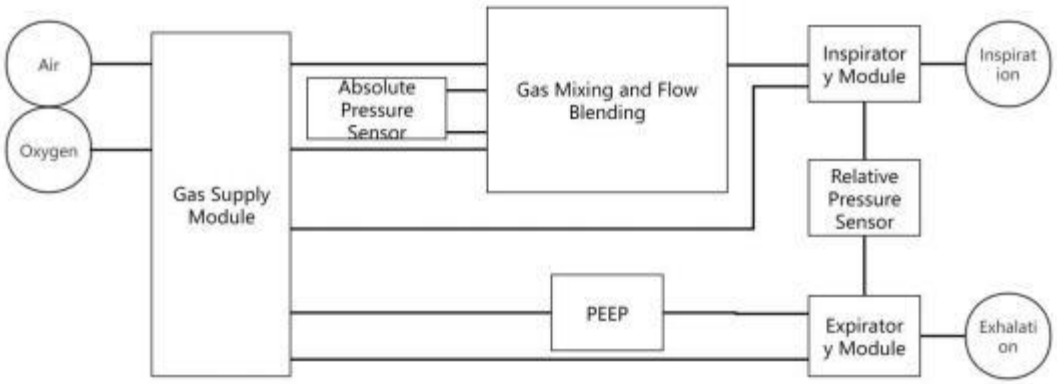


Figure 2: Babylog 8000 gas circuit structure

## 3. Repair case

### 3.1. Fault symptom:

The clinical users reported that the ventilator was unstable.

### 3.2. Fault analysis and maintenance:

After inquiring with the clinical department, it was found that the ventilator sometimes exhibits instability during patient ventilation, with irregular intervals between breaths.For the sake of safety, remove the ventilator. Connect the power supply and air source, turn on the machine, check the external pipeline, there is no abnormality. Connect the air circuit pipeline and the neonatal model lung, turn on the machine, set the breathing parameters according to the clinical requirements, observe the changes of the model lung, there is no abnormality, and the ventilator also didn't report any errors.

Considering the possible randomness of the failure, the observation time was prolonged, and it was seen that sometimes the model lung changed irregularly. Consider the problem of the flow sensor, replace it, re-observe it, and the failure occurs from time to time. Considering that the flow sensor is connected to the back of the machine through the connecting wire, the connecting wire is replaced and observed again, and the fault occurs from time to time.

Troubleshoot external attachments and pin the problem on the ventilator itself. Enter maintenance mode. The method to enter the maintenance mode is: in the shutdown state, press and hold the OK key and the mute key to start the machine until the maintenance interface appears and the key is released. In the maintenance mode [4] , observe the valve flow rate, as shown in Figure 3， record and summarize the values of the air valve and the oxygen valve as shown in Table 1.

Ask the engineer of the manufacturer and learn that the flow rates of oxygen valve and air valve should be consistent under normal conditions, and the flow rate values of each valve are basically arranged according to the geometric progression(common ratio is 2). Observing the data in Table 1, it can be found that the values of air valve No.10-8 is abnormal.

Disassemble the panels on both sides of the ventilator and remove the electrical circuit control part. The valve blocks [5] with 2 rows and 10 columns can be seen in the gas circuit section, see Figure 4. Find the 10-8 air valves, remove them, check and find that there are dirt on the surface, and wipe them with an alcohol swab. Reinstall, connect the power supply and air supply, start the machine and test, and find that faults occur from time to time.

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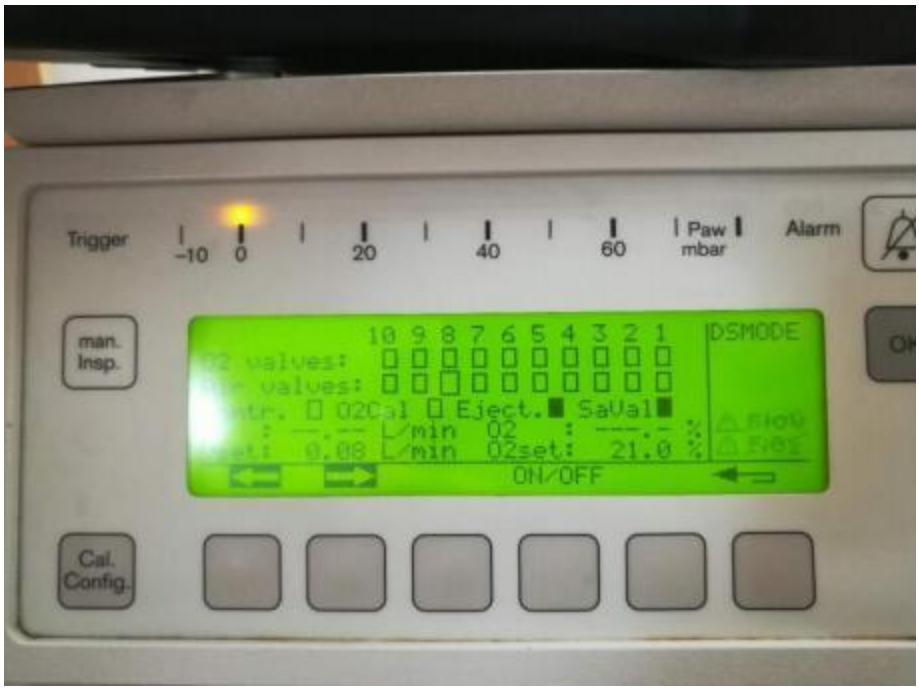


Figure 3: Viewing Manifold Flow in Maintenance Mode

Table 1: Flow rate of air valve and oxygen valve

| Oxygen valve number | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Flow rate（L/min） | 0.02 | 0.05 | 0.11 | 0.22 | 0.44 | 0.89 | 1.78 | 3.56 | 7.12 | 14.25 |
| Air valve number | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Flow rate（L/min） | 0 | 0.02 | 0.08 | 0.22 | 0.44 | 0.89 | 1.78 | 3.56 | 7.12 | 14.25 |

Consult the manufacturer's engineer. It is recommended to replace the 10-8 air valves. The 10-8 air valves were disassembled and replaced, but it was still invalid after replacement, and the flow rates of the three valves were the same as before, so excluding the possibility of air valves failure.

Since the valve blocks in 2 rows and 10 columns (20 in total) are fixed on an iron valve seat, refer to Figure 5. The inside of the valve seat is communicated, which is equivalent to pipeline connection. Considering that the pipeline is blocked or there is dirt, remove the valve seat, remove 20 valves, the actual disassembly diagram is shown in Figure 6, and clean valve seat with running water. After drying, the machine is installed and tested, and faults occur from time to time.

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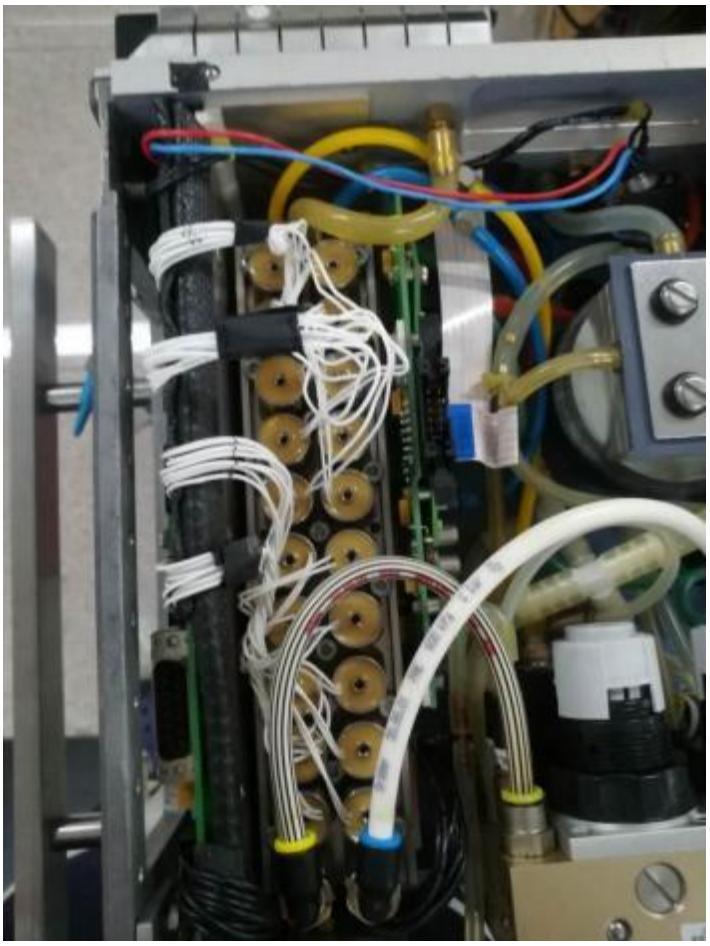
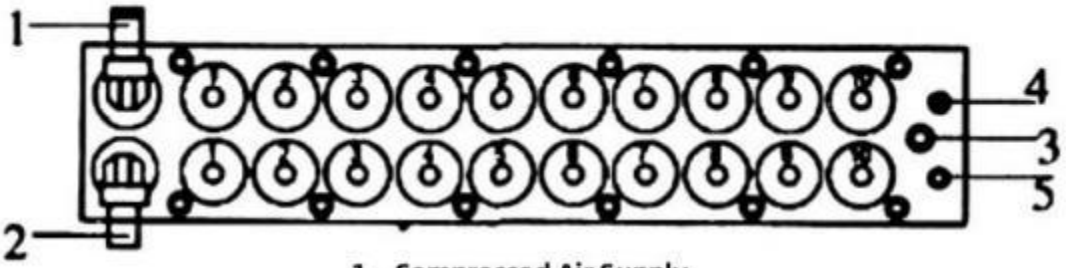


Figure 4: Disassembly diagram




1、Compressed Air Supply
2、Compressed Oxygen Supply
3、Merged Gas Output
4、Air Pressure Sensor
5、Oxygen Pressure Sensor

Figure 5: Valve Block Diagram

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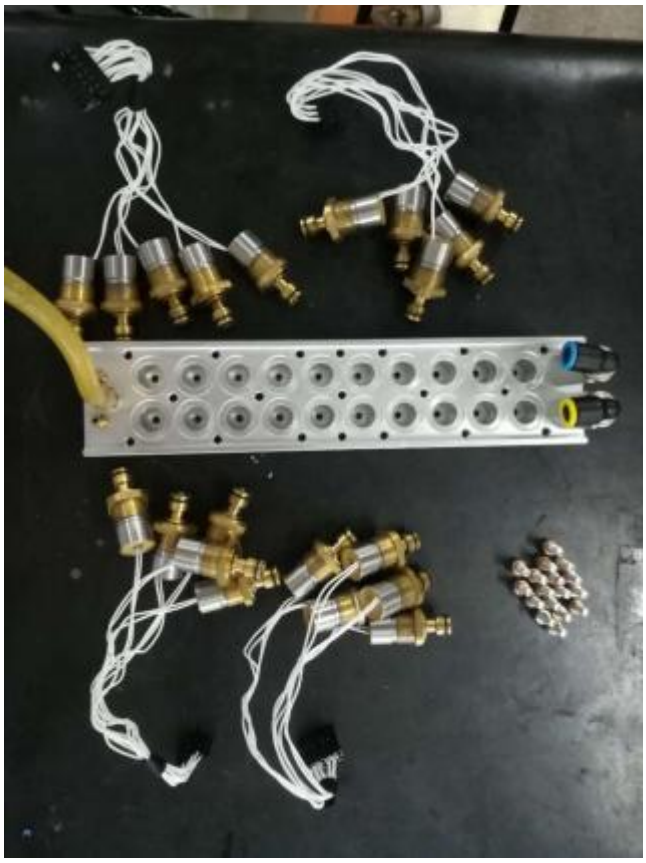

Figure 6: Valve Blocks Disassembly Diagram

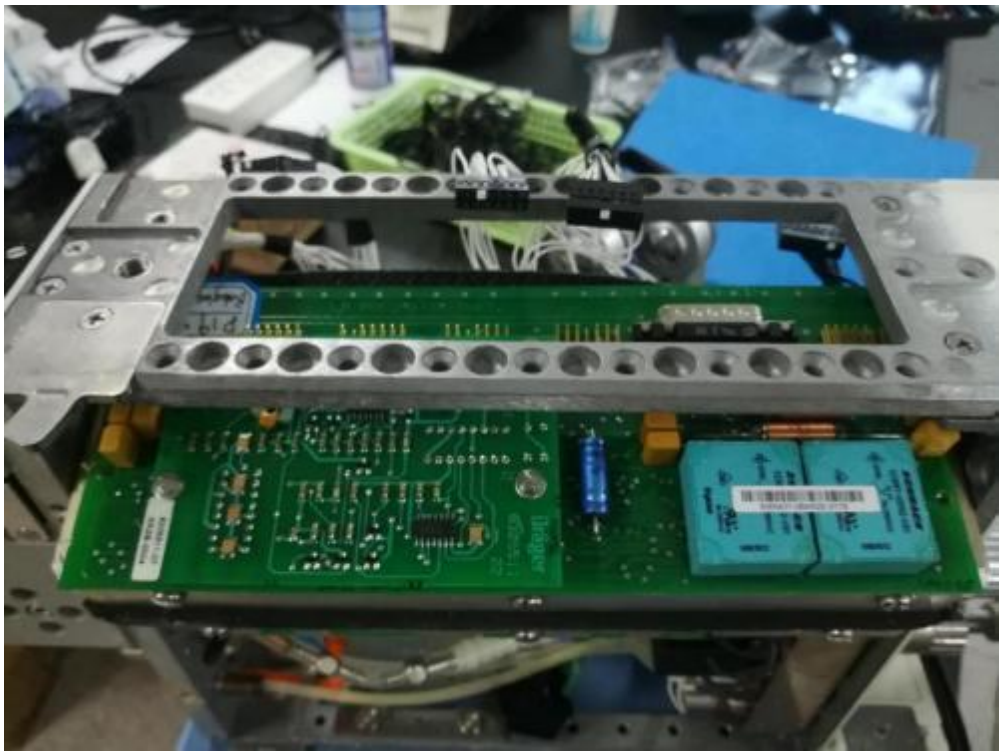

Figure 7: Valve Control Board

In view of the poor cleaning effect of running water, each valve socket of the valve seat was cleaned several times with an air gun, and the entire flow valve seat was placed in an ultrasonic cleaning machine for vibration cleaning. Reinstallation and testing, failures occur from time to time.

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This eliminates the problem with the valves and the valve seat, so the valve block should be normal. When the machine was disassembled, it was found that the valve seat was connected to other components by a pipeline. Check that the pipeline was normal and there was no leakage at the pipeline interface.

Considering that all valves are electrically controlled by the valve control board on the side, and the connecting wire of the valve is connected with the control board through the pin socket, as shown in Figure 7, the row of metal pins on the upper side of the control board is the connection. Considering the possibility of poor contact, wipe the contact part of the control line pin, reinstall the machine, test, and the fault occurs from time to time.

It is suspected that the valve control board is faulty. Replace a scrapped and removed valve control board, reinstall it and test it. Faults occur from time to time.

Through comprehensive analysis of each link of flow monitoring, the following parts are related to the fault: valve control board — valve — valve seat (equivalent to pipeline) — internal pipeline — external breathing circuit — flow sensor — flow sensor connecting line — monitoring main board.

According to the analysis of the above links, it is finally suspected that the monitoring main board is faulty. Remove the top cover plate of the ventilator, pull out the monitoring main board in the middle, and observe that there is a lot of dust on the main board, and some dust has adhered to the main board. It is suspected that due to the high humidity of the environment, the dust is accompanied by water vapor, resulting in the failure of the electrical circuit part of the monitoring main board. Remove the dust, brush the adhesive part with a brush, reinstall it, start the machine and test it for several times, and no fault occurs.

## 4. Sum up

Ventilator is one of the most important instruments in clinical rescue equipment. Ventilation mode, ventilation parameters and safety alarm function of ventilator are three important indexes [6] affecting the ventilation quality and safety of patients. In order to meet the needs of clinical rescue of critically ill patients, as a clinical engineer, we should be familiar with the working principle, gas circuit and electrical circuit structure, main characteristics of the ventilator, and master the use of maintenance mode in order to quickly judge and troubleshoot [7] . In case of equipment failure, start with the functions involved in the failure phenomenon [8] , gradually analyze and troubleshoot [9] , determine the location and cause of the failure [10] , and finally deal with the failure and summarize. In addition, regular maintenance and other work [11] is also necessary.

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