The Anaesthetic Machine Explained

Pre Use Checks

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Components of an Anaesthesia Workstation.

Anaesthetic Machine

Breathing System Ventilator.

Gas Supplies

Hypoxic Guard.

Gas Supplies.

Airway Pressures.
Flows and Volumes.
Inspired & Expired gas composition.

Monitoring

SpO2.
ECG & EEG.

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The Anaesthetic Machine Explained

Pre Use Checks

- High Pressure System
- Intermediate Pressure System
- Low Pressure System
- Vaporiser
- Breathing Circuits
- Ventilator
- Circle Breathing Circuit

Session Checks
Per Case Checks
Why?
13,700 KPa  
400 KPa

High Pressure System

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High Pressure System
Intermediate Pressure System
Low Pressure System

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Vaporiser.
High Pressure System

Intermediate Pressure System

Low Pressure System

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High Pressure System
Intermediate Pressure System
Low Pressure System
A/M

Self inflating Bag

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Self inflating Bag
Self inflating Bag
Adjustable Pressure Limiting Valve.

A user adjustable valve that releases gases to the scavenge system once the pressure in the circuit reaches the pressure set on the control of the valve.

$P < P_s$
Adjustable Pressure Limiting Valve.
Controlled or Assisted Ventilation.

Mapleson D

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If we can minimise the dead space then we can eliminate the rebreathing.
Mechanical Ventilation in Anaesthesia

Bag in Bottle Type

Or

Bag Squeezer.
Inspiration.

A/M

Automatic Pneumatic Switch

Oxygen

Scavenge

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Inspiration.
Inspiration.
Inspiration.
Expiration.

A/M

Automatic Pneumatic Switch

Valve Opens

Oxygen
Expiration.
Expiration.
Expiration.

Automatic Pneumatic Switch

A/M

Oxygen
Expiration.

Automatic Pneumatic Switch

Oxygen

A/M

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Gap.
Gap.
Inspiration.

A/M

Automatic Pneumatic Switch

Oxygen

Valve Closes

Scavenge

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The Circle System

Low Flow Anaesthesia
Inspiration.
Inspiration.
Expiration.
Inspiration.
Inspiration.

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Inspiration.

A/M

CO$_2$ Absorber

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Expiration.

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Mapleson D

Controlled or Assisted Ventilation.

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Generic Anaesthetic Machine.

Mechanical Boyles Anaesthetic Machine

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Evolution of the Anaesthesia Workstation.

Gas Supplies

Anaesthetic Machine

Breathing System Ventilator.

Monitoring

Gas Supplies. Hypoxic Guard.


SpO2. ECG & EEG.

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Evolution of the Anaesthesia Workstation.
Electronic Anaesthetic Machine (Datex ADU).
Evolution of the Anaesthesia Workstation.

- Anaesthetic Machine
- Electronic Control
- Device & Breathing System Monitoring

Gas Supplies
- Gas Supplies
- Hypoxic Guard

Breathing System Ventilator

Airway Pressures
- Flows and Volumes
- Inspired & Expired gas composition

SpO2, NIBP ECG & EEG

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Evolution of the Anaesthesia Workstation.

- Gas Supplies
- Hypoxic Guard
- Airway Pressures, Flows and Volumes, Inspired & Expired gas composition
- SpO2, NIBP, ECG & EEG

Components:
- Anaesthetic Machine
- Electronic Control
- Breathing System Ventilator
- Device & Breathing System Monitoring

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Block Diagram of a Modern Targeted Controlled Anaesthesia Machine

Computer

Control of Gas Delivery to the patient

Mechanics and Electronics

Air
N2O
O2

Electronic Anaesthetic Machine

Electronic Ventilator

Safety Features
Block Diagram of a Modern Targeted Controlled Anaesthesia Machine

Mechanics and Electronics

Gas Monitor
- Fi O₂
- EtCO₂
- CO₂ Waveform
- Agent Concentration

Safety Features
- Air
- N₂O
- O₂

Electronic Ventilator

Electronic Anaesthetic Machine

Spirometry

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Block Diagram of a Modern Targeted Controlled Anaesthesia Machine

User Interface

End Tidal Agent
Minimum FiO2

Tidal Volume
Rate
I:E Ratio
PC or VC or PRVC
PEEP

Alarms
Airway Pressure High
Airway pressure Low
Minute Volume
FiO2
EtCO2

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Pre Use Checks

Session Checks

Per Case Checks

Why?

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Pre Use Checks

Start of every operating session
1

Learn your Equipment
How to operate it and how it functions

Do not use this equipment unless you have been trained
Gas Supplies

approx 60 %
reported faults
are user error

Responsibility of Anaesthetist.

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Check a self inflating bag is available

An alternative source of oxygen should be readily available
Perform the manufacturers automatic self check
4

Power Supply

Connected to the mains and turned on.
  No extension leads
  Battery back-ups checked
  System clock is correct
Check Gas Supplies
Check Gas Supplies

Pipeline supply of Oxygen - Gauges read > 400 kPa.
Tug test on wall connections

Adequate reserve Oxygen spare cylinder available

Pipeline supply of other gases intended for use.

All cylinders should be securely seated and turned off.
Medical Gas Cylinders.

1. Colour Coded
2. Free from Water Vapour
3. E Size is used on Anaesthetic Machines

Oxygen
Black Body & White Shoulder 13700 kPa

Air
Grey Body & White/Black Shoulder 13700 kPa
Medical Gas Cylinders.

Nitrous Oxide

Vapour

Gas Phase on top @ 4,400 kPa (room temperature)

Liquid Phase
5

Check **Gas Supplies**

Flowmeters

Anti Hypoxia Devices

Oxygen Monitor reads 100% when only Oxygen is flowing

Oxygen Flush

Suction Unit
5

Check **Gas Supplies**

Oxygen Failure Alarm

Session - Turn Off the machine

Weekly - Disconnect the wall supply while flowmeter is on
6
Check Vaporizer
Vaporiser.
Pre-Use Checks

5. Check the Vaporizers.

Fitted correctly & Controls Work
Then turn them off.

Check they are sufficiently filled
with agent.

Leak Test.
A. Vaporizer Off – 5 L/min Oxygen
Occlude the common gas outlet
Check for leaks around fittings

B. Vaporizer On – 5 L/min Oxygen
Occlude the common gas outlet
Check for leaks around filling port
Check Breathing Circuit

Visual Inspection

No leaks

Pressure test by occluding the tube and squeezing the bag

All breathing systems tested using a two bag test.
8

Check the Ventilator

Ventilator tubing is secure

Operate the ventilator and ensure positive pressure during the inspiratory phase

Check alrms

Check over pressure relief valve functions

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Two Bag Test

Attach a test lung

Set flow to 5 litres a minute

Check circuit patent

Check one way valves

Check APL valve by squeezing both bags
Two Bag Test

Attach a test lung

Set flow to 5 litres a minute

Check circuit patent

Check one way valves

Check APL valve by squeezing both bags

Switch to ventilator and ventilate the test lung

Turn off fresh gas flow and open the vaporisers - no loss of volume

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Check the **Absorber & Alternative Breathing System**
10
Check the Airway Equipment
Check the Patient Monitoring

- NIBP
- Gas Analysis Lines
- Oxygen Analyser
- Pulse Oximeter
- Capnography

Alarm Limits are appropriate

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11

Scavenging

Check scavenging is switched on

Check tubing is correct
Use Checklists & Protocols
"As I learn more about anesthesia I realize how important protocols and procedures are to increase patient safety. As a lawyer I also see that these procedures can protect the anesthetist.

Should the anesthetist be required to defend himself or herself, it may be difficult to remember the exact details of an anesthetic given years before. Sometimes, it is helpful to be able to testify that certain matters are always done by following careful procedures, even if you cannot remember what happened in a particular case.

If you begin your day or each operation checking out your anesthesia machine according to FDA guidelines, then even if you cannot remember what you did on February 1, 1995, you will know you checked the anesthesia machine because that is what you always do."

"Apparatus of reliable appearance engenders a strong feeling of security which is often not supported by facts. A critical attitude often forestalls unpleasant surprises."

Lucien Morris,
in Aldrete Lowe & Virtue
Low Flow & Closed System Anesthesia
## Checklist for Anaesthetic Equipment 2012
### AAGBI Safety Guideline

Checks at the start of every operating session  
Do not use this equipment unless you have been trained

### Check self-inflating bag available

### Perform manufacturer’s (automatic) machine check

#### Power supply
- Plugged in
- Switched on
- Back-up battery charged

#### Gas supplies and suction
- Gas and vacuum pipelines – "bag test"
- Cylinders filled and turned off
- Flowmeters working (if applicable)
- Hypoxic guard working
- Oxygen flush working
- Suction clean and working

#### Breathing system
- Whole system patent and leak free using 'two bag' test
- Vaporisers – fitted correctly, filled, leak free, plugged in (if necessary)
- Soda lime - colour checked
- Alternative systems (Bain, T-piece) – checked
- Correct gas outlet selected

#### Ventilator
- Working and configured correctly

#### Scavenging
- Working and configured correctly

#### Monitors
- Working and configured correctly
- Alarms limits and volumes set

#### Airway equipment
- Full range required, working, with spares

### RECORD THIS CHECK IN THE PATIENT RECORD

### Don’t Forget!
- Self-inflating bag
- Common gas outlet
- Difficult airway equipment
- Resuscitation equipment
- TIVA and/or other infusion equipment

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This guideline is not a standard of medical care. The ultimate judgement with regard to a particular clinical procedure or treatment plan must be made by the clinician in the light of the clinical data presented and the diagnostic and treatment options available.

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**Wednesday 11 July 2012**
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Check</th>
</tr>
</thead>
</table>
| Breathing system   | Whole system patent and leak free using ‘two-bag’ test  
Vaporisers – fitted correctly, filled, leak free, plugged in (if necessary)  
Alternative systems (Bain, T-piece) – checked  
Correct gas outlet selected |
| Ventilator         | Working and configured correctly |
| Airway equipment   | Full range required, working, with spares |
| Suction            | Clean and working      |
ALL medical devices can fail but an increasing number of incidents that result in significant morbidity or mortality arise out of user error or because of poor practices. This edition highlights common issues in anaesthetic and respiratory device use in an attempt to make users more aware of what can go wrong – it is all too easy to take equipment for granted.

Keep your back covered?
The MHRA is aware of vaporizer leaks due to misplacement on the backbar of the anaesthetic machine.

Ensure that vaporizers are correctly seated on the backbar. Before the induction of anaesthesia the machine must be tested for leaks in accordance with the manufacturer’s instructions and the Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines.

Bag for life!
The MHRA is aware of reports of re-usable manual resuscitators being misassembled after cleaning.

These devices must only be cleaned and reassembled by appropriately trained staff following the manufacturer’s instructions. After cleaning, the resuscitators must be fully checked for correct operation before patient use.

sHaME!
The MHRA is aware of ineffective patient ventilation if breathing system filters, heat and moisture exchangers (HMEs) or heat and moisture exchanging filters (HMEFs) become occluded.

Ensure that filters, HMEs and HMEFs are correctly positioned in the breathing system following the manufacturer’s instructions for use. Staff should be aware that occlusion of the filter, HME or HMEF increases the resistance to airflow, resulting in increased airway pressures. Airway pressures should be monitored during use and the filter, HME or HMEF changed as necessary.

Silence of the Alarms
We have received reports of misunderstanding of the alarm operation in older models of ventilators. Older models may not issue an audible alarm if a second high priority alarm condition occurs when the alarm has already been set.

Users must ensure that alarms are set appropriately and that they are fully aware of the ventilator’s alarm system configuration.

Under pressure

The MHRA received a report of the power cable being damaged when caught between the anaesthetic machine and its monitor arm, resulting in power loss to the anaesthetic machine.

Ensure that the manufacturer’s instructions for use are followed, whenever respiratory therapy devices are connected to endotracheal or tracheostomy tubes.

Staff must ensure there is free passage of expired gases.

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Under pressure
The MHRA is aware of reports of incorrectly assembled respiratory therapy devices, where an expiratory pathway was not provided, resulting in the build-up of excessive pressures causing lung injury.

Ensure that the manufacturer's instructions for use are followed, whenever respiratory therapy devices are connected to endotracheal or tracheostomy tubes. Staff must ensure there is free passage of expired gases.

ShockERR
The MHRA received a report of the power cable being damaged when caught between the anaesthetic machine and its monitor arm, resulting in power loss to the anaesthetic machine.

Users must ensure the power cables are free from any danger of entrapment; special care is required when the machine is plugged into an overhead beam.

Silence of the Alarms
We have received reports of misunderstanding of the alarm operation in older models of ventilators. Older models may not issue an audible alarm if a second high priority alarm condition occurs when the alarm has already been silenced for two minutes. New models made to modern standards will alarm if a second high priority condition occurs.

Users must ensure that alarms are set appropriately and that they are fully aware of the ventilator's alarm system configuration.

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The One Liners editions are published by the MHRA, an executive agency of the Department of Health. Adverse incidents should be reported at the earliest opportunity. We prefer to receive reports via the online reporting system on our website www.mhra.gov.uk You may also use this online system to send an email copy of your report to your medical device liaison officer. We also have an adverse incident hotline: 020 3080 7080. You can find detailed reporting guidance on our website.
fhegarty@mac.com