CRT: 1,200 Berlin buses retrofitted since 2000

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Overview of Berliner Verkehrsbetriebe (BVG)

BVG

12,224 total staff
8,712 blue-collar workers
3,512 white-collar workers
(incl. 405 trainees / apprentices)

1,035.2 million passenger trips / year

Underground
- 144.9/120.3 km total route length (day/night)
- 9 day-time lines
- 7 night lines
- 3/2 workshops / main workshops
  - 1 workshop for underground vehicles
- 170/145 stations (day/night)
- 1,372 underground vehicles
- 2,791 staff
- 456.8 million passenger trips / year

Tram
- 285.5/59.7 km total route length (day/night)
- 21 day-time lines
- 5 night lines
- 6 depots
- 374/115 stops (day/night)
- 602 vehicles
- 1,634 staff
- 171.3 million passenger trips / year

Bus
- 1,626/751 km total route length (day/night)
- 150 day-time lines
- 54 night lines
- 6 depots
- 2,601/1,504 stops (day/night)
- 1,388 buses
- 3,931 staff
- 407.1 million passenger trips / year

12,224 total staff
8,712 blue-collar workers
3,512 white-collar workers
(incl. 405 trainees / apprentices)
### Environmental measures so far tested in BVG’s buses

<table>
<thead>
<tr>
<th>Technology</th>
<th>Vehicle</th>
<th>Additional costs compared to diesel</th>
</tr>
</thead>
</table>
| Methanol (1985 - 1988) | 7 MAN SL 200  
7 Mercedes Benz O305 | approx. 28% |
| CNG (1996 - 1999) | 4 MAN NG 232  
2 Mercedes Benz O405 GN  
4 Mercedes Benz O405 N | approx. 20% |
| Aquazole* (1999) | 15 buses | approx. 8% / 100km additional consumption |
| CRT (1999 - 2001) | 800 buses retrofitted and all new buses | approx. 5500 EUR/unit |
| Euro 5 / EEV (2003 – to date) | 25 VOLVO buses | Funded by the German Ministry of Environment |
| Euro 5 / EEV | new buses to be commissioned in 2006 | series |
| Hydrogen (2006 – to date) | 4 MAN suction engine (in operation)  
1 ICE / FC hybrid (in operation)  
10 MAN ICE turbo charged (planned) | |

* Diesel water blend helping to reduce NOx emissions
Temperature and exhaust-gas back-pressure ahead of CRT
(Berlin double-decker, February 2000)
Cumulative probability of bus exhaust-gas temperatures

(CRT filter regenerates above curve, but accumulates particles below curve)

- MAN bus
- MAN bus
- Volvo bus
- Volvo bus

CRT Regeneration
CRT Soot particle storage

Sums Time frequency (%)
Exhaust gas temperature (°C)

Average value entirely
BVG bus fleet composition (number of buses) in 1998

Double-decker | Single-decker | Articulated buses

- **Double-decker**: Euro 0
- **Single-decker**: Euro 0, Euro 1
- **Articulated buses**: Euro 0, Euro 1, Euro 2
By the end of 1999, BVG had retrofitted (Fig. 4) 126 city buses. By the end of 2002, 1,000 of its total 1,350 buses were retrofitted with this system. All new vehicles purchased after 1999 came with the CRT ex-factory.
Back-pressure instrument and location

- Exhaust-gas back-pressure measurement
- Vehicle warmed up (75°C)
- Connect instrument
- Run engine at limiting RPM for 1 minute
- Read exhaust-gas back-pressure
- If the back-pressure exceeds prescribed level, then filter cleaning is necessary
Exhaust-gas back-pressure alarm display in new buses
Quality assurance software
(Screen shot of bus data, e.g. type, filter, date, odometer, test history, etc.)
HJS new regeneration method for CRT systems

Step 1: Heat filter

Step 2: Cool filter

Step 3: Blow out oil ash
SMF
Low-ash oils and lower lube consumption prolong cleaning intervals

Source: MAN

Approach: Ash deficient motor oils + reduced oil consumption

<table>
<thead>
<tr>
<th>Lines are:</th>
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<tbody>
<tr>
<td>1.3% ash content at oil consumption 1.0 and 0.5 liters per 1,000 km</td>
</tr>
<tr>
<td>0.9% ash content at oil consumption 0.5 and 0.3 liters per 1,000 km</td>
</tr>
<tr>
<td>Vertical axis is calculated ash burden [g]</td>
</tr>
<tr>
<td>Cleaning or replacement recommended at 400g ash burden</td>
</tr>
</tbody>
</table>
Defective CRT filter
## CRT costs

<table>
<thead>
<tr>
<th></th>
<th>Material cost</th>
<th>Wage cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRT retrofitting</td>
<td>5,500 to 7,000 EUR</td>
<td>150 EUR</td>
</tr>
<tr>
<td>CRT regeneration</td>
<td></td>
<td>200 EUR</td>
</tr>
<tr>
<td>CRT failure</td>
<td></td>
<td>0.5% p.a.</td>
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