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Air quality in enclosed railway stations

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In 2012, the World Health Organisation International Agency for Research on Cancer (IARC) reclassified diesel engine exhaust and second-hand air pollution to be carcinogenic and associated with increased mortality from lung cancer. This classification has created considerable concern for both public and occupational health in enclosed railway stations where ventilation is often inadequate. Recent policies encouraging a shift to public transport, along with increasing passenger and train numbers, have led to a variety of challenges, including improved health and wellbeing from increased walking and cycling. This paper considers the unintended consequences of a reduction of air quality in enclosed railway stations and considers with a number of possible interventions to ensure that public health is not affected, especially for air pollution from stationary diesel trains. Pollution from electric trains can also lead to poor air quality due to the production of nitrogen dioxide particles from brake friction, friction between wheel and rail, and from overhead pantographs. Current occupational health standards are not suitable for enclosed railway stations and need to be reconsidered in the light of the IARC findings. More measurements of the levels of particulates and nitrogen dioxide in enclosed railway stations need to be undertaken and published.

Evaluation of air quality at the Birmingham New Street Railway Station

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Introduction

- Birmingham New Street (BNSS) is the busiest station outside London (entries & exits and interchanges). Up to 200,000 passenger movements per day. A £600m upgrade completed in 2015 including 98 ventilation fans.
- 12 platforms lie beneath the concourse in a tunnel like environment which traps the diesel air pollution.
- Approximately 45% of trains that serve BNSS are diesel. Up to 600 diesel train movements per day.
- University of Birmingham and Network Rail worked in collaboration with the HPRU and developed an extensive monitoring campaign to better understand the air quality in and around the station.



Introduction (Con)

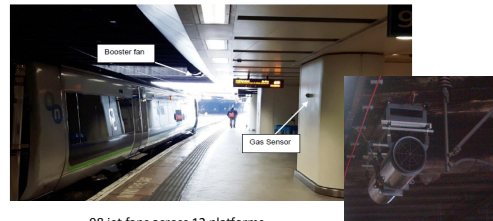
- Air Quality in Enclosed Railway Stations has been largely ignored up to now for both Occupational and Public Health.
- 2012: World Health Organisation (IARC) International Agency for Research on Cancer reclassified Diesel exhaust as carcinogenic and associated with increased mortality from lung cancer.
- 2014: EU (SCOEL) Scientific Committee on Occupational Exposure Limits introduced new Workplace Exposure Limits (WELs) for NO and NO₂ as key indicators of DEEEs (Diesel Engine Exhaust Emissions).
- 2018: New WELs for NO and NO₂ introduced to the UK by (HSE) Health and Safety Executive on August 25th.
- The (ORR) Office of Road and Rail are responsible for ensuring that these new WELs are enforced in railway stations together with the station operators and Train Operating Companies (TOCs).



Diesel Engine Exhaust Emissions (DEEEs)

- **Oxides of nitrogen:** Symptoms of bronchitis in asthmatic children increases in association with long-term exposure; reduced lung function growth is currently being observed in cities of Europe and North America
- **Particulate matter:** Fine particles can penetrate deep into lungs triggering inflammation and aggravation of heart and lung diseases
- **Carbon dioxide:** can cause headaches, dizziness, confusion and loss of consciousness when in high concentrations
- **Carbon monoxide:** Prevention of oxygen uptake by the blood leading to a reduction in oxygen supplied to the heart, particularly in those suffering from heart disease
- **Oxides of Sulphur:** Affects the respiratory system, function of the lungs and causes irritation of the eyes. When inhaled, pollutants can cause inflammation of the respiratory tract resulting in coughing, aggravation of asthma and chronic bronchitis
- **Polycyclic aromatic hydrocarbons (PAHs):** Short-term exposure can lead to impaired lung function in asthmatics, thrombotic effects in coronary heart disease sufferers, eye irritation, nausea, vomiting and diarrhoea. Long-term exposure can result in cancerous illness, kidney and liver damage and cell damage
- **Benzene, toluene, ethylbenzene and xylene (BTEX) volatile organic compounds:** Both carcinogenic and non-carcinogenic risks, including cancerous illnesses, respiratory irritation and central nervous system damage

Fume Extract System at New Street



- 98 jet fans across 12 platforms
- Fans are bi-directional depending upon wind direction
- Remove fumes towards end of platforms into open space
- Array of CO₂ sensors that control 4 speeds of each fan over 2 zones

8 June 2018


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COMEAP: NO₂ and Health

- NO₂ has been associated with adverse effects on hospital admissions for various diagnoses: decrements in measures of lung function and lung function growth, increases in respiratory symptoms, asthma prevalence and incidence, cancer incidence, adverse birth outcomes and mortality.
- The UK is currently subject to legal proceedings for failing to meet European Limit Values for NO₂. This is due in part to the failure of Euro standards to deliver the expected benefits in terms of reductions in emissions of oxides of nitrogen (NO_x) from diesel vehicles, and the increase in the proportion emitted as primary NO₂. The health effects associated with NO₂ are therefore very policy-relevant.

Current Legislation

- The Office of Rail and Road (ORR) is the national independent health and safety regulator for the UK rail network.
- Network Rail and the Train Operators have a legal duty to manage the risks to employees **and passengers** from exposure to hazardous substances.
- Workplace Exposure Limits (WELs) are used as part of COSHH (Control of Substances Hazardous to Health) regulations.
- Occupational Health versus Public Health Limits?

		RSD Internal Guidance		RIG-2014-04	
DIESEL ENGINE EXHAUST EMISSIONS (DEEE) IN THE RAILWAY SECTOR					
Date of issue/ last review		June 2018		Date of next review June 2021	
		RIG postholder/owner		Sharon Mawhood	
		RIG cleared by		Claire Dickinson Jen Abiltt	
		RIG type		Policy _____ <input type="checkbox"/> Information _____ <input type="checkbox"/> Procedure _____ <input type="checkbox"/>	
Target audience	RSD	<input type="checkbox"/>	Policy	_____	<input type="checkbox"/>
	RPP	<input type="checkbox"/>	Inspectors	_____	<input type="checkbox"/>
			Admin	_____	<input type="checkbox"/>
Keywords		DEEE EXHAUST EMISSIONS DIESEL ENGINE			
Summary This RIG summarises the current evidence base on health risks associated with exposure to diesel engine exhaust emissions (DEEE) and advises inspectors about action to take in securing compliance with the Control of Substances Hazardous to Health Regulations 2002 (COSHH) (as amended)					

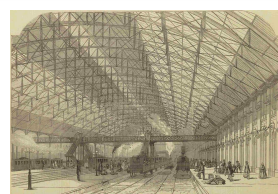
New Legislation (Con)

- Nitrogen Dioxide NO₂ WEL
- 8-hour TWA 0.5 ppm (955 ug/m³)
- 15-min STEL 1.0 ppm (1,910 ug/m³)
- Nitrogen Monoxide NO WEL
- 8-hour TWA 2.0 ppm (2,500 ug/m³)

Public Health Limits

Table 1: The revised Daily Air Quality Index.

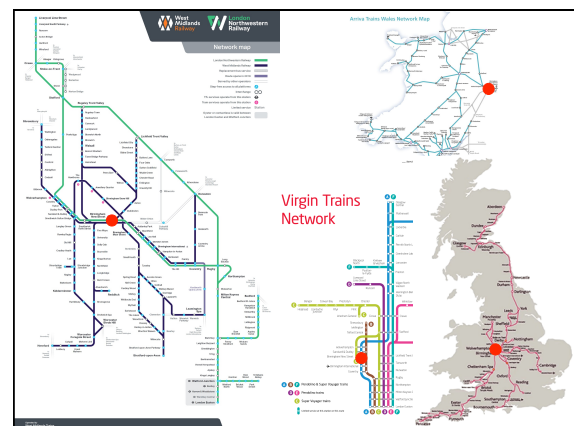
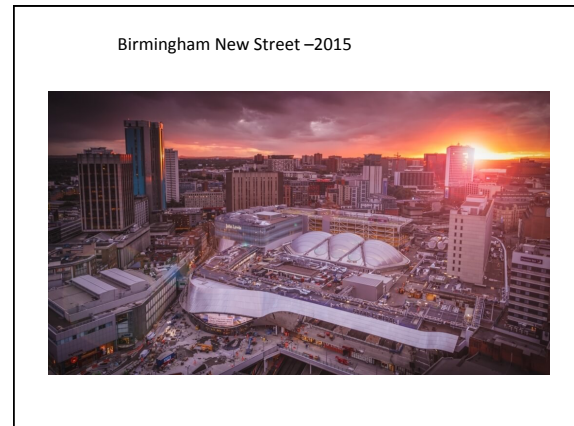
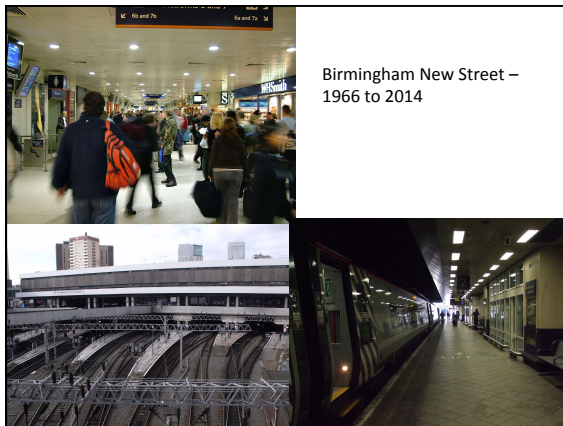
Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	PM _{2.5} Particles (EU Reference Equivalent)	PM ₁₀ Particles (EU Reference Equivalent)
		Running 8 hourly mean µg m ⁻³	hourly mean µg m ⁻³	15 minute mean µg m ⁻³	24 hour mean µg m ⁻³	24 hour mean µg m ⁻³
Low	1	0-33	0-67	0-88	0-11	0-16
	2	34-66	68-134	89-177	12-23	17-33
	3	67-100	135-200	178-266	24-35	34-50
Moderate	4	101-120	201-267	267-354	36-41	51-58
	5	121-140	268-334	355-443	42-47	59-66
	6	141-160	335-400	444-532	48-53	67-75
High	7	161-187	401-467	533-710	54-58	75-83
	8	188-213	468-534	711-887	59-64	84-91
	9	214-240	535-600	888-1064	65-70	92-100
Very High	10	241 or more	601 or more	1065 or more	71 or more	101 or more



Birmingham New Street
– 1854

Birmingham New Street
– 1885





Ind	Plan	Act	Origin	PI	ID	TOC	Destination	Plan	Act
WTT	0905	0916%	Lancaster	2	9431	VT	London Euston	0910	0919%
WTT	0918	0918	London Euston	1	1122	LM	London Euston	0914	0922%
VAR	0905	0921%	London Euston	6	9547	VT	Preston	0915	0925%
WTT	0918	0918	London Euston	3	1103	LM	Terminates here		
VAR	0905	0921%	Birmingham New Street	5	1056	XC	Nottingham	0919	0919%
WTT	0918	0918	London Euston	10	1056	XC	Nottingham	0919	0919%
VAR	0910	0908%	York	11	1146	XC	Plymouth	0917	0920
WTT	0918	0918	London Euston	7	1134	XC	Stansted Airport	0922	0921%
WTT	0918	0918	London Euston	1	9428	LM	Tyrolsey L.M.D.	0922	0926%
WTT	0921	0921%	Lichfield Trent Valley	12	2901	LM	Redditch	0923	0923
VAR	0921	0921%	Birmingham International	5	1012	AVL	Holyhead	0925	0925%
WTT	0922	0921%	Bromsgrove	8	2920	LM	Lichfield Trent Valley	0925	0925%
WTT	0926	0926%	London Euston	6	9507	VT	Terminates here		
WTT	0915	0927	Wolverhampton	2	2411	LM	Walsall	0927	0929
VAR	0924	0923	Nottingham	11	1105	XC	Cardiff Central	0930	0929%
WTT	0918	0919	Reading	4	1835	VT	London Euston	0930	0933%
WTT	0926	0925	Cardiff Central	7	1825	XC	Manchester Piccadilly	0931	0932%

One hour in the life of Birmingham New Street



Electric trains

- Class 390 Pendolino (2004) (Virgin)
- Class 350 Desiro (2004) (London Northwestern)
- Class 323 Commuter (1992) (West Midlands Trains)



Diesel trains

- Class 43 HST (1975) (Cross Country)
- Class 158 Sprinter (1989) (Transport for Wales)
- Class 170 Turbostar (1998) (West Midlands Trains, Cross Country)

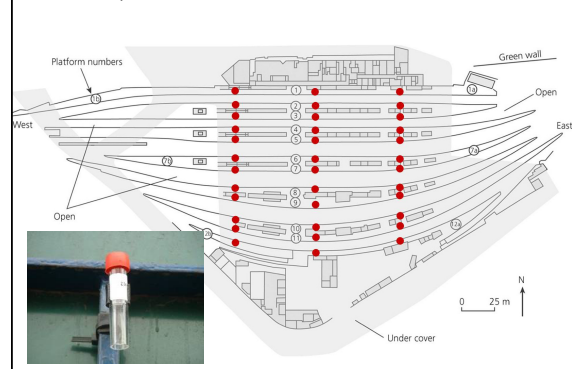


Diesel trains

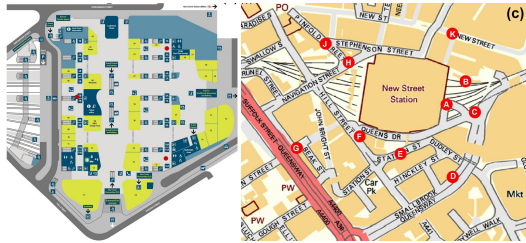
- Class 220/1 Voyager (2001) – Cross Country and Virgin

Ind	Plan	Act	Origin	PI	ID	TOC	Destination	Plan	Act
WTT	0905	0916%	Lancaster	2	9431	VT	London Euston	0910	0919%
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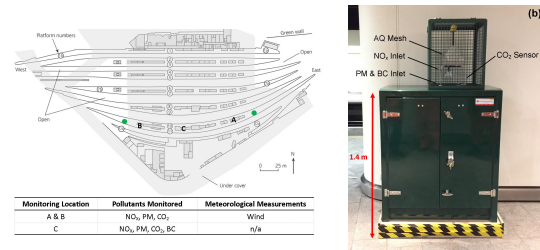
The experiments – Diffusion tubes



The experiments – Diffusion tubes



The experiments – main sites



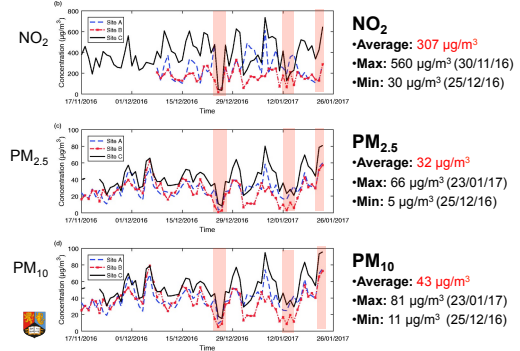
Diffusion Tube Results

Platform concentration					
West		Centre		East	
Sample one	Sample two	Sample one	Sample two	Sample one	Sample two
Platform 1	276	285	440	464	250 384
Platform 2	318	318	437	508	287 412
Platform 3	278	244	411	504	284 392
Platform 4	325	271	344	427	238 361
Platform 5	271	236	341	405	210 399
Platform 6	236	234	297	368	178 298
Platform 7	204	197	364	375	205 302
Platform 8	251	240	355	412	262 331
Platform 9	280	264	428	452	323 449
Platform 10	298	280	420	501	297 389
Platform 11	232	214	398	500	287 332
Platform 12	361	360	380	427	252 353

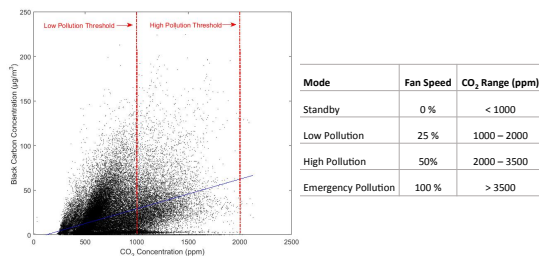
Sample one		Sample two	
Lounge concentrations			
Red lounge	152	145	
Blue lounge	295	354	
Yellow lounge	310	353	

Sample one		Sample two	
Area surrounding the station at locations A-K			
A	72	85	
B	70	80	
C	64	69	
D	60	64	
E	61	67	
F	55	60	
G	50	53	
H	62	74	
J	51	54	
K	45	47	

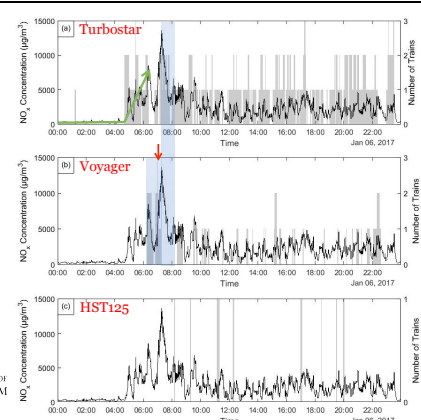
Monitoring Results



CO₂ and the impulse fan system



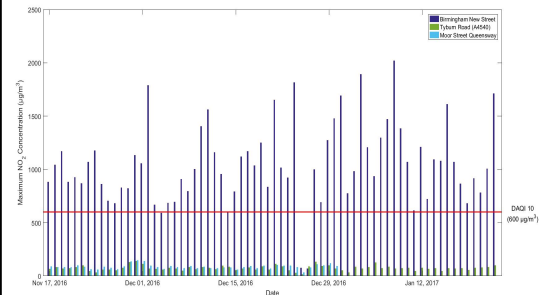
Train Analysis



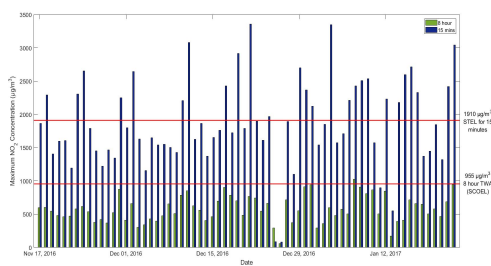
Ratio of concentration when platforms occupied to not occupied

	t	NO ₂
EMU	1395	0.80
InterCity 125	45	1.21
Turbostar	37545	1.93
Voyager	3405	3.21
InterCity 125 & Express Sprinter/Turbostar	2820	1.79
Express Sprinter/Turbostar & Voyager	11115	2.16
EMU & Express Sprinter/Turbostar	2385	1.56
EMU, Express Sprinter/Turbostar & Voyager	120	1.94

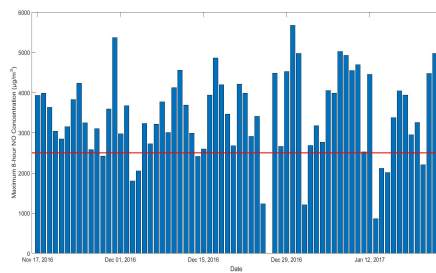
DAQI: BNS vs A4540 & Moor Street



Workplace Exposure Limits (WEL) NO₂ 15 min STEL Exceeded on 40% of days



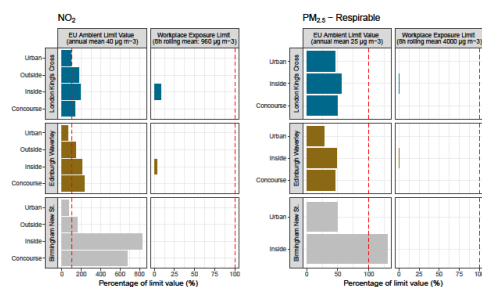
Nitric Oxide WEL 8hr 2,500 µg/m³ 8-hour TWA Exceeded 86% of days



NR Action Plan: Interventions

- **Reduce Train idling**
 - ✓ Platform supervisors monitoring
 - ✓ Discipline monitoring reports for station non compliance
- **Auto-Shutdown (Software upgrade)** to shutdown after 8-12 mins idling
 - ✓ Virgin implemented upgrade onto 16 out of 20 trains
 - ✓ Cross Country implemented on 3 trains
- **Train Coupling / de-coupling**
 - ✓ Working group set up
 - ✓ Check hot spots around the station
- **Occupational Health Check**
 - ✓ Network Rail health screening for all train dispatch staff
- **Engagement with DfT / ORR / RSSB/ NR**
 - ✓ Share best practices
 - ✓ Steering Group for T1122 research at Kings Cross / Edinburgh Stations
 - ✓ Feedback into DfT to influence change via Train operator franchise
 - ✓ Impulse Fan Enhancements £1m upgrade
 - ✓ Introduce Electric/Battery/Hydrogen Trains

Comparison RSSB Study: Kings X, Edinburgh & Birmingham NSS



The future – new trains for Birmingham New Street?

West Midlands Trains (2018 - 2026)

- New diesel trains - Class 196 Civity (2020)
- New electric trains – Class 730 Aventura (2020/21)

Transport for Wales (2018 -)

- New diesel trains – Class 196 Civity (2021-2023)

Virgin Trains (1997 - 2020) – to be replaced by West Coast Partnership

Cross Country (2006 - ??)



Civity - CAF



Aventura - Bombardier

CONCLUSIONS

- The air quality in Birmingham New Street Station is/was probably as poor as anywhere in the UK?
- Improved ventilation at BNSS by Network Rail is only a short term solution.
- Diesel Trains must be phased out of enclosed railway stations as soon as possible.
- Lessons learned at BNSS are being applied to other enclosed railway stations by ORR.
- Monitoring air pollution in enclosed railway stations should be mandatory.