A brief introduction to London Underground

- 270 stations
- 249 route miles
- 68.8m (221ft) below ground level at the lowest (Holly Bush Hill, Hampstead – Northern Line)
- 1,065 Million passenger journeys last year

What defines a tunnel?

What services & facilities are required?

Environmental Considerations:
- Air, Light, Water

Safety Factors:
- Fire & temperature, flooding, fumes,
- Electrocuton

Operational & working considerations:
- Communications, power

What services must we consider?
- Ventilation
- Drainage
- Lighting
- Fire / emergency access and egress
- Power
- Communications
- Pneumatic (compressed air) systems
- Flood prevention

Tunnel (& public area) ventilation (1)
(Railway Safety Principles)

Air quality & quantity:
An acceptable environment in normal operation (tunnels), and maintain a supply of fresh air (stations)

Temperature:
Stations: Ideal limit 25°C, but no more than 5°C above outside ambient when this exceeds 20°C (research indicates that 29°C permissible).
**Tunnel (& public area) ventilation (2)**

**Requirements of Railway Safety Principles**

**Air velocity:**
Low noise, must not cause hazard

**Pressure pulse:**
For underground stations, system should include a means to accommodate the aerodynamic effects generated by trains passing through restricted spaces

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**Air quality and quantity**

- There should be sufficient air movement to prevent the formation of pockets of stale, stagnant air
- Fresh air supply and foul air removal to limit levels of air pollution/build up of hazardous vapours (air changes)
- Air temperature should be limited by removal of heat which means:
  
  **Air change rate**  4-6 changes/hr
  
  **Personal fresh air supply**  3.5 litres/s per person

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**Piston Effect (1)**

**Blockage ratio:**

- **Heavy Rail** - 20-30% of double track
  - 50-60% of single track
- **Metro** - 70-90% of deep level tube tunnel

Idealised design would be adequate to maintain sufficient air flow under normal operations without need for mechanical ventilation.

**BUT -**

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**Piston Effect (2)**

Under abnormal and degraded conditions (high ambient or stalled service), additional mechanical ventilation becomes necessary

i) To maintain comfort and limit panic;

ii) To prevent thermal stress (heat stroke)

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**Ventilation & Fire (1)**

**Tunnels:**

For new build, there must be the ability to control movement of smoke in an emergency

(and clear smoke after a fire)

**Stations:**

Must be constructed to maintain a safe environment and escape routes for a sufficient period of time to enable evacuation, and must have a means of purging smoke once evacuation completed

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**Tube tunnel cross-section**
**Arrangement of tunnel vent shafts**

**Fire Design Considerations**

**Fire load:**
Assume heat produced by single vehicle fire (tunnel) or suitcase (station)

**Tunnel Signage:**
Giving direction and distance to nearest access point

**Hydrant main:**
Dry or wet mains, outlet pressure: 4.5 ± 0.5 bar; leak monitoring; drainage capability

**Tunnel fire**

Schematic of unventilated tunnel fire
- Uncontrolled smoke flow
- Symmetrical airflow pattern

Schematic of insufficiently ventilated tunnel fire
- Uncontrolled smoke flow
- Back layering occurs

**Ventilated tunnel fire**

Controlled smoke flow
- Critical velocity established

**Fire – operational considerations**

**Access**
Provided at distances determined by ability of fire brigade to penetrate effectively into the fire zone. Could be portals, stations or intermediate shafts

**Intermediate shafts**
Should be designed to BS 5588 (pt 5), with a fire fighting lift if tunnel deeper than 9m. Must have adequate hard standing at surface for emergency vehicles.

**Side walkway**
Preferred configuration

**Tunnel side walkway and access space**
**Communications**

*Radio:*
  - Driver to control
  - Control to train PA (Discrete)
  - Control to all (Open)
  - Emergency services

*Telephones:*
  - Direct line to control

*Traction supply:*
  - Means of emergency discharge

**Other Considerations**

*Drainage:*
  - Seepage rate
  - Access limitation (maintenance)

*Traction Power:*
  - Emergency switch-off facility

*Power supply:*
  - Site work purposes
  - Safety low voltage

**Escalators**

- Public Service Type
- Compact (Shop) Type

**A bit of history**

- Early Lighting was open-flame gas
- Electric arc lamps came soon after – before gas mantles
- Filament lamps introduced progressively from around 1900
- For deep-level tube platforms, light tiling was important
- Fluorescent arrives during WW2
- GLS dominated until late 1970s
How standards have changed

- Before about 1910, present metrics were not available
- By 1920s, lighting was being “designed”, but with far lower illuminance than we use today – typically 10-25lux
- The 1935-40 New Works Plan (extensions of Northern & Central Lines) produced the first “New Works Standards” typically 15-30lux
- With the arrival of fluorescent lighting, standards revised upwards again – now 30-50lux
- Victoria Line Standards push up to 100lux
“Standardization”

- After Victoria Line construction, the “New Works Standards” were extended and adopted for all works
- Some discussion with main-line rail, but no convergence of standards at that stage
- Very different values for open and sub-surface areas (20lux vs. 100lux)
- 1980s: Standards applied for all relighting schemes through Electrical Design Notices (EDNs) – Churchouse conversion
- By mid-1980s, non-engineers were having significant input to lighting requirements

Lighting Good Practice (1)

- Lighting the task:
  - This is the main aim, so evaluate what the tasks are (or might be);
  - There are varied tasks in the LU environment, so we have to compromise;
  - It is usually more practical to design area illuminance;
  - Contrast can help – integration with surface finishes is important

Lighting Good Practice (2)

- Light Vertical surfaces:
  - Although it’s easier to design for horizontal illuminance, some light in the vertical plane is needed to help us see, and to aid facial recognition;
  - Using reflected light helps;
  - Using luminaires with wide distributions (such as Churchouse!) helps too;
  - The small sacrifice in energy consumption will be more than compensated for by the effectiveness of the scheme

Lighting Good Practice (3)

- Uniformity:
  - In the extreme, this is used as a way of defining the minimum illuminance relative to the average;
  - It is really about much more than that;
  - Uniform lighting may be easier to create, but it can also be bland;
  - Some non-uniformity is desirable to assist orientation

Lighting Good Practice (4)

- Glare
  - Public areas are active environments, people are not fixed in one position as in offices;
  - Light sources (luminaires) are generally positioned well outside normal visual zones;
  - Established glare criteria are only applicable to regular arrays of luminaires;
  - Luminance limits are far less significant for the visually impaired than gradual changes in brightness;
  - In some areas such as control rooms and workshops, we must consider glare

Lighting Good Practice (5)

- Colour:
  - There are many tasks where colour is important (for example, reading the Underground map);
  - Colour rendering is what defines how well light sources enable to see colour;
  - Good colour lamps no longer carry a serious energy penalty;
  - Colour temperature (or appearance) determines the warmth or coolness of the appearance of an area, but does not itself affect how colours can be identified
Controls (1)
• These are mandatory – Part L
• Even if they weren’t, using controls is good practice
• The most simple control is a switch
• No new installation should rely on MCB control alone
• Contactor wiring needs careful design
• Automate – give people a choice and they will leave the lights on

Controls (2)
• Use daylight-linking and occupancy detection wherever possible
• Put manual controls where the operators can access them
• Put over-rides where the operator has to make an effort to access them
• “Exotic” systems such as DALI need careful consideration, and our traditional contractors don’t like working with them (so charge a premium)
• Emergency Lighting