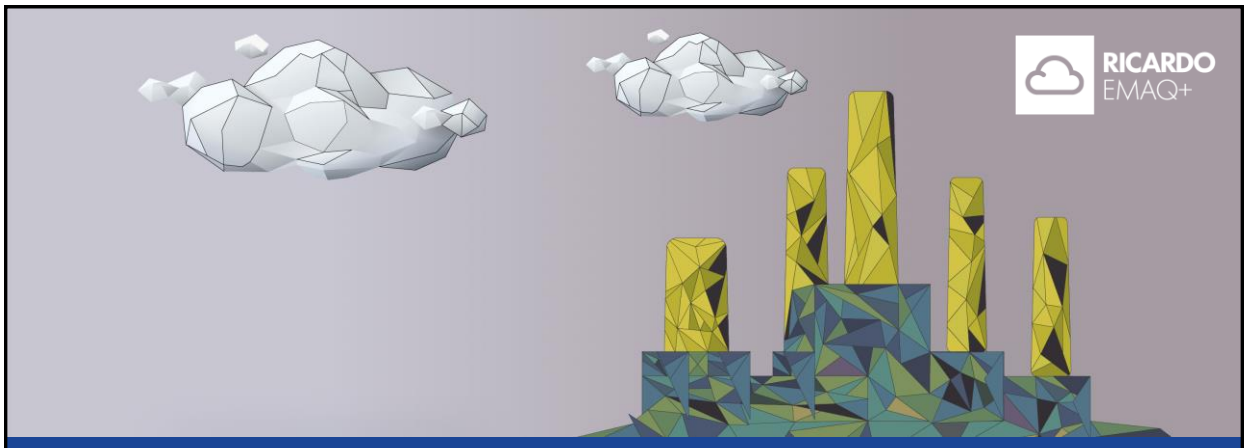

Toolbox Talk No. 13

Best Available Techniques (BAT) Option Appraisals

1

Tony Higgins

- Experienced EHO >30 years
- Former EH Manager Telford & Wrekin
- Environmental Consultant >15 years
- Expert Witness Court/Public enquiry
- Major applications
- ES
- Trainer with EMAQ since 2000

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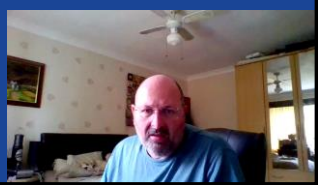

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3

Air Quality Monitoring

RICARDO EMAQ+

At Ricardo we have a dedicated team of AQ specialists and look forward to helping you with any of your air quality challenges:

- ISO 17025 UKAS accredited **QA/QC audits** – required by LAQM TG (22)
- **Data management**, data collection, checking, validation, ratification etc
- **Local site operations**, calibrations/call outs
- **Web reporting**
  http://www.airqualityengland.co.uk/
- **Routine data reporting** – weekly, monthly, quarterly, annual – for example
  http://www.airqualityengland.co.uk/assets/reports/291/KensingtonChelsea_month_2019_01.html
- **Short term monitoring surveys** (site installation/decommissioning through to reporting)
- Long term station hire
- Free advice on station installation and best practice
- Procurement of analysers and installation to LAQM TG (22) or AURN standards
- **Low cost sensor measurements**, network management
- **Real world vehicle emissions monitoring** aiding Action Planning
- **Mobile Monitoring** for point source and concentration contour mapping
- **Diffusion tube surveys**
- **Air quality forecasting** and public dissemination (via sms text, email, web, social media etc.)
- Air quality reporting
- LAQM TG (22) Annual Status Reporting (ASR), Detailed Assessment
- CAZ/LEZ consultancy
- Expert witness and Expert Advice
- Air Quality Modelling

For further information please get in touch with David Madle

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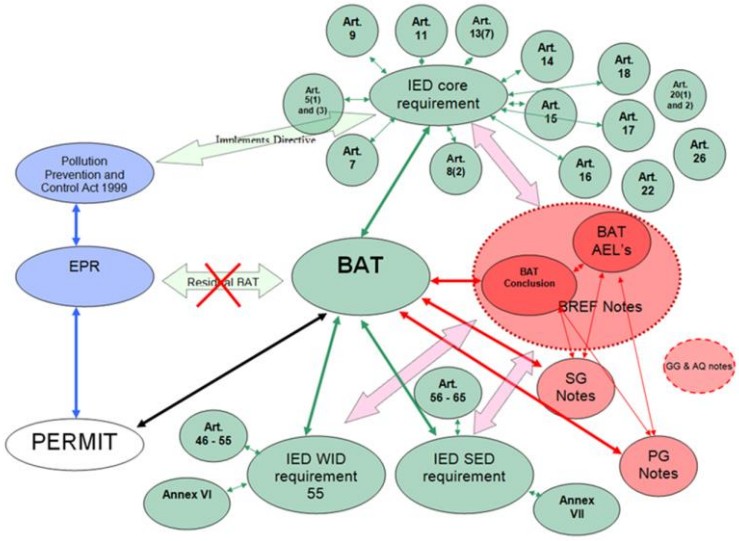
4

Aims and Objectives

- Introduction
- Summary of BAT Option Appraisal Guidance
- Practical Issues With BAT
- Practicalities
- BAT Option Appraisal Examples

5

BAT



Part B BAT is:

Schedule 8 Para 5

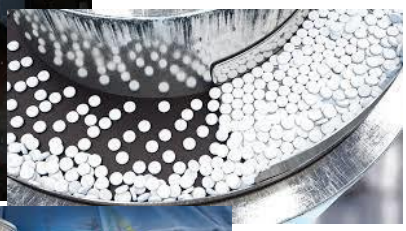
"appropriate preventive measures are taken against air pollution, in particular through the application of best available techniques."

"The regulator must ensure that emission limit values or equivalent parameters or technical measures are based on best available techniques without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the installation, including (except in the case of mobile plant) its geographical location and the local environmental conditions.

6

BAT Option Appraisals

- BAT is:
  - Activity specific;
  - Sector specific;
  - Site specific;
  - Company specific.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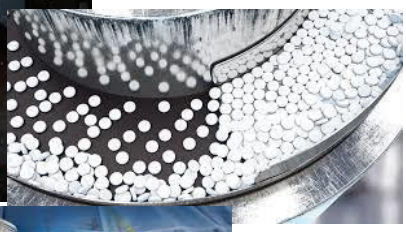
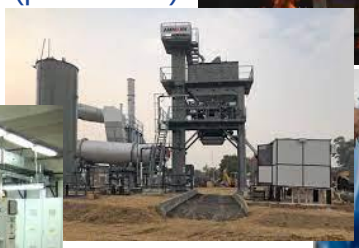
BAT Option Appraisals

- BAT is:
  - Activity type;
  - Sector specific pollutants;
  - Site specific issues (proximity);
  - Company specific (production).

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BAT Option Appraisals – Scheduled Activities

- BAT is defined by the activity carried out:
  - IED Annex I;
  - Environmental Permitting (England and Wales) Regulations schedule 1 Part 2;
    - A1, A2, Part B.
- BAT standards are sector specific:
  - A1 Guidance;
  - Sector Guidance (SG);
  - Process Guidance (PG);
  - Site specific;
  - Company specific.

IPPC → LAPPC

17.12.2010 EN Official Journal of the European Union L 334/51

ANNEX I

Categories of activities referred to in Article 10

The threshold values given below generally refer to production capacities or outputs. Where several activities falling under the same activity description containing a threshold are operated in the same installation, the capacities of such activities are added together. For waste management activities, this calculation shall apply at the level of activities 5.1, 5.3(a) and 5.3(b).

The Commission shall establish guidance on:

(a) the relationship between waste management activities described in this Annex and those described in Annexes I and II to Directive 2008/98/EC; and

(b) the interpretation of the term 'industrial scale' regarding the description of chemical industry activities described in this Annex.

1. Energy industries
1.1. Combustion of fuels in installations with a total rated thermal input of 50 MW or more
1.2. Refining of mineral oil and gas
1.3. Production of coke
1.4. Gasification or liquefaction of:
(a) coal;
(b) other fuels in installations with a total rated thermal input of 20 MW or more.
2. Production and processing of metals
2.1. Metal ore (including sulphide ore) roasting or sintering
2.2. Production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2.5 tonnes per hour
2.3. Processing of ferrous metals:
(a) operation of hot-rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;
(b) operation of smitheries with hammers the energy of which exceeds 50 kilojoule per hammer, where the calorific power used exceeds 20 MW;
(c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour.
2.4. Operation of ferrous metal foundries with a production capacity exceeding 20 tonnes per day
2.5. Processing of non-ferrous metals:
(a) production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes;
(b) melting, including the alloyage, of non-ferrous metals, including recovered products and operation of non-ferrous metal foundries, with a melting capacity exceeding 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals.
2.6. Surface treatment of metals or plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m³

9

BAT Option Appraisals - Installations

- BAT is determined for *an installation:*
  - All scheduled Part A and Part B activities (including waste;
  - (Technical connection) & Direct Association.
- BAT standards are sector specific:
  - A1 Guidance;
  - SG Guidance;
  - PG Guidance;
  - Company specific;
  - Site specific.

IPPC → LAPPC

Resource minimisation
Energy Efficiency
Water
Waste (incl. Sewer discharges)
Ground water
Land
Noise & Vibration

Air
Heat

10

Activities And Installations

- **What is an activity? (source General Guidance manual):**
  - 2.4. An activity is an industrial activity forming part of an 'installation'. Different types of activities are listed within Schedule 1 of the EP Regulations. They are broadly broken down into industrial sectors, grouping similar activities into chapters within this schedule. Other "associated" activities (not described in Schedule 1) may also form part of an installation, described in paragraph 2.6 below;
  - 2.5. Activities can be carried out in installations or by mobile plant;
  - In order for an activity to exist there must be one or more Stationary Technical Units;
  - Guidance RGN2 may help (NB withdrawn);
    - https://www.gov.uk/government/publications/rgn-2-understanding-the-meaning-of-regulated-facility.
- **What is an installation?**
  - 2.6. **Annex III** explains the term 'installation'. In summary, an installation comprises any relevant unit carrying out Part A2 or Part B activities listed in Schedule 1 to the EP Regulations. This includes any directly-associated activities which have a technical connection with the Schedule 1 activities and which could have an effect on pollution. Once the extent of an installation has been established, each activity (if listed in Schedule 1 or constituting a "directly associated activity" with a technical connection and which could have an effect on emissions and pollution) must be included in the permit . For the purposes of this Manual, any reference to "installation" should be taken to include "mobile plant" unless otherwise indicated.
- **Installation:**
  - Installations are by definition the sum total of all the activities that are technically connected and directly associated.

11

Activities and Installations

- **Technical Connection:**
  - Technical connections is difficult concept to grasp initially. But in practice if a part of a process, machine or chemical or management activity is absolutely **required** or the stationary technical unit will not function then it is technically connected;
  - **Example 1**; in order to cast iron, you need to melt it first, you also need prepare mould into which the iron will be cast. Melting and mould making are therefore technically connected to the casting activity;
  - **Example 2**; in order to respray a vehicle you absolutely require to mix the paint and to prepare the vehicles surface. These `elements` are technically connected to the spraying activity;
  - **Example 3;** in order to make roadstone, you require crushed stone and bitumen. Most roadstone is made within the quarry from where the stone arises. If connected to the stone crushers & bitumen coating plant with conveyors a technical connection would exist, however, if stone is transported by road vehicle it might not.

12

Activities And Installations

- Direct Association
  - An activity or stationary technical unit is directly associated with another where it satisfies that:
    - There is a technical connection;
    - There is an effect on emissions;
    - That it's on the same site and that it serves the activity or stationary technical unit.
  - In these circumstances direct association incorporates non scheduled parts of a process, that are on the same site and are potentially polluting.

13

Defining An installation

A small installation (1 room). Multiple activities

14

Constructing A Permit

Waste Sand Recovery

Raw Materials Storage

15

Installation

Primary Metal Melt

Casting In Sand

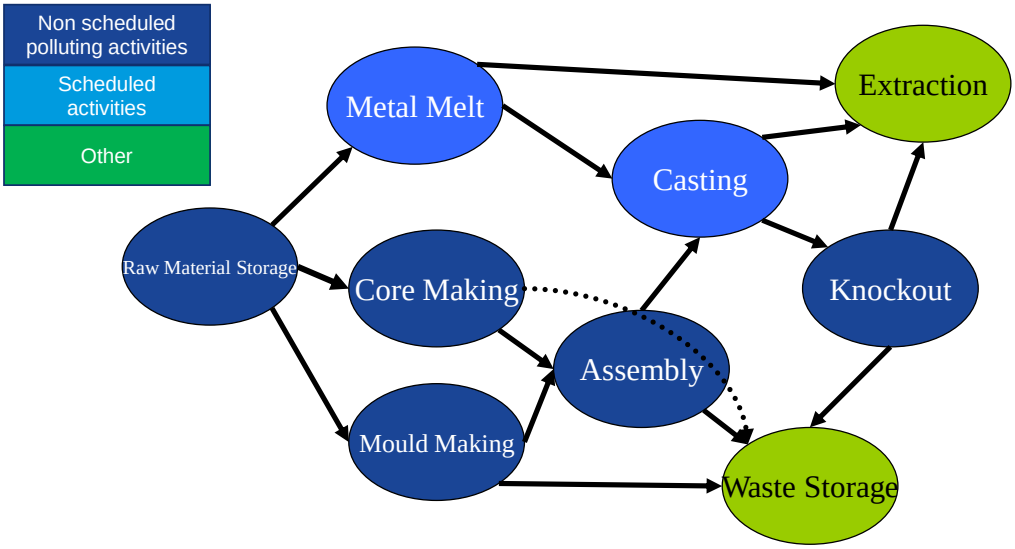
16

Constructing a Permit

Mould And Core Making

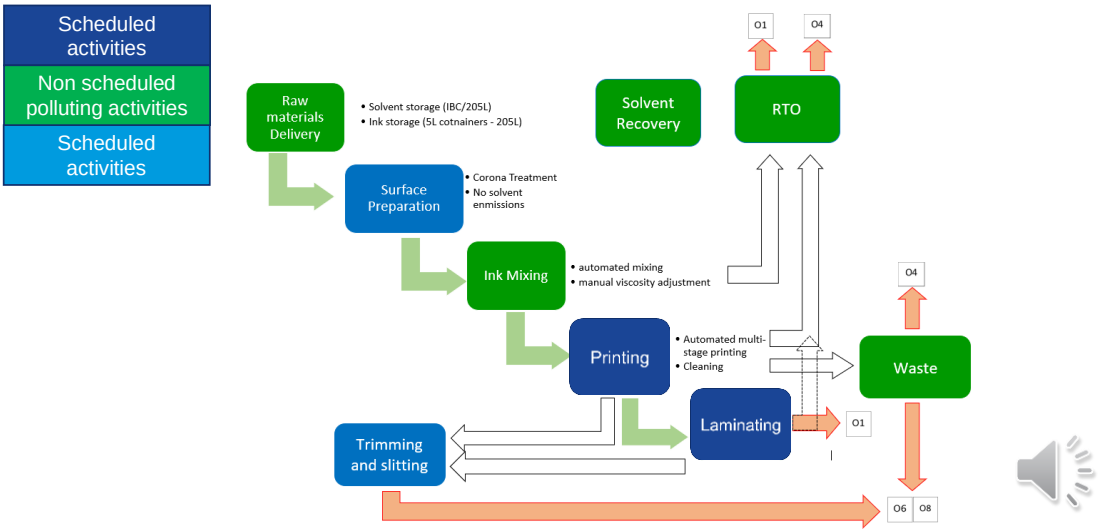
17

Installation



18

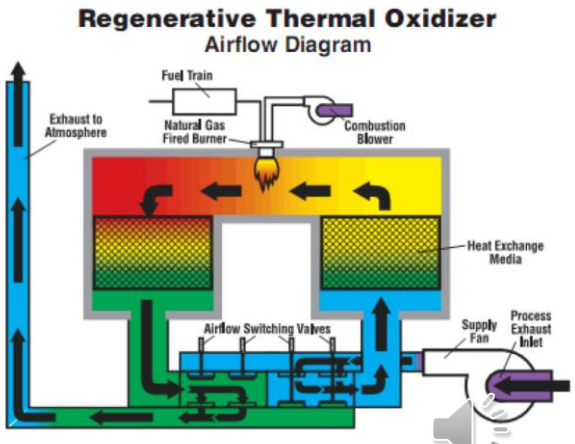
Installation



19

BAT Option Appraisal Example - RTO

- BAT for Regenerative Thermal Oxidation (printing/adhesive lamination.
- Steps:
  1. Size/Capacity requirements;
  2. Air flow requirements;
  3. BAT Associated Emission Level (AEL's);
  4. BAT Associated Environmental Performance Level (AEPL's);
  5. Other BAT considerations.



https://www.thecmmgroup.com/use-regenerative-thermal-oxidizer-voc-abatement/

20

Operational Requirements

- Pollutants & Concentrations.
- Air flow/movement.
- Process safety limits.
- Health and Safety controls.
- BAT for Printing/lamination (Flexographic). (See next slides)
- Cost.

1

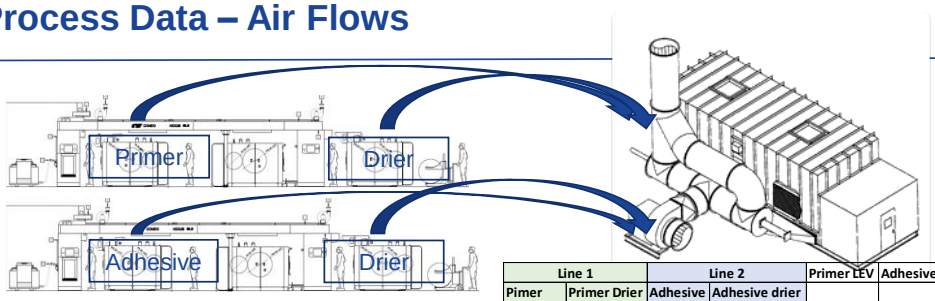
The 2 key solvents used in the process are Toluene and Hexane. Relevant properties of the solvents are provided in the table below:

Parameter	Value for Toluene	Value for Hexane
Chemical Formula	C_7H_8	C_6H_{14}
Molecular Weight	92	86
Vapour density @ 20°C	3.72 kg/m^3	3.56 kg/m^3
Liquid density @20°C	862 kg/m^3	660 kg/m^3
LEL	1.2%v/v (~44.9 g/m^3)	1.2%v/v (~42.0 g/m^3)
UEL	7.1% v/v	7.4% v/v
% Carbon w/w	91.3%	83.7%
Calorific Value @25°C	40,589 kJ/kg	44,752 kJ/kg
Heat capacity @ constant P	1.127 kJ/kgK	1.658 kJ/kgK

According to BS EN: 12753:2005+ A1 2010, the maximum operating load should be 20% LEL for solvents mixtures with greater than 50% aromatic content. If we take Hexane as the worst case then this is a level of 8.54 g/m^3 in the combined stream to the oxidiser (if Toluene is greater than 50% of the solvent load and 10.68 g/m^3 if the toluene is less than 50% of the solvent load).

21

Process Data – Air Flows



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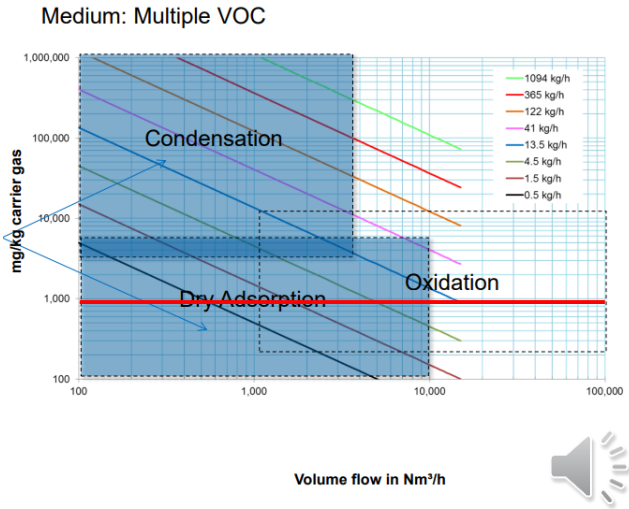
Line 1		Line 2		Primer LEV	Adhesive LEV	Flow (m3)	kg/hour	g/Nm3
Pimer	Primer Drier	Adhesive	Adhesive drier					
		Min		Min		4250	64.5	15.18
		Max		Max		4250	64.5	15.18
Min		Min		Min		20250	117.4	5.8
Max		Max		Max		20250	347.4	17.15
		Min	Min	Min	Min	58250	250.4	4.3
		Max	Max	Max	Max	58250	657.2	11.28
Min		Min	Min	Min	Min	74250	303.26	4.08
Max		Max	Max	Max	Max	74250	940	12.66
	Min	Min	Min	Min	Min	78250	202	6.43
	Max	Max	Max	Max	Max	78250	676	8.64
Min	Min	Min	Min	Min	Min	94250	556	5.9
Max	Max	Max	Max	Max	Max	94250	959	10.17
			Min		Min	54000	185.9	3.44
			Max		Max	54000	597.2	10.58
	Min		Min		Min	54450	249.9	4.59
	Max		Max		Max	54450	656.7	12.06

22

Process Air flows

- Air flow:
  - 94,250 Nm^3/hr (102,876 Am^3/hr @25°C) of extract containing 959 kg/hr of solvent;
  - This equates to 10.17 g/Nm^3 or 9.32 g/Am^3 @ 25°C;
  - This would require dilution prior to feeding to an RTO to comply with BS EN: 12753:2005+;
  - A1 2010.;
  - The resulting dilution would be to a minimum flow of **107,489 Am^3/hr** (40°C).



23

BAT Option Screening

BAT options summary:

Wet Chemical Scrubbing: The solvents have limited solubility and high volatility. Low reactivity with any aqueous reagents. Ruled out fails ELV's;

Non-Aqueous Scrubbing: Scrubbed using lower volatility, high boiler solvents that have low vapour pressures at the operational temperatures. No availability of data to suggest that a suitable tertiary solvent exists. Detailed pilot trials would be required. Recovery plant would be required;

Biological Filtration/Scrubbing: The loadings for this application are well beyond the reported limits for biological technology. High air flows would be prohibitive resulting large footprint of biofilter required (at least 500 m^2). Significant water consumption and waste which would add to other emissions (estimated 10 m^3/day). Not practical and biofiltration unreliable;

Carbon Adsorption: The loadings within any of the flow permutations would mean that the carbon consumption rate would be extremely high (Calculated 71 tonne bed would last just 13 hours at full flow). The secondary waste carbon would also add to other emissions and hence replaces an emission to air with an emission to solid waste. Not practicable or viable unless linked with recovery…;

Recuperative/Catalytic Oxidation: Even at high solvent loadings a 65% thermally efficient heat exchanger is required to theoretically achieve autothermal operation. Very high airflow would mean that mechanical heat exchanger size or catalytic chamber size would be impractical. As mechanical heat exchangers are prone to thermal stress and associated maintenance issues the size of such a system would make the systems vulnerable and costly to replace;

Regenerative Thermal Oxidation: selected option.

24

BAT Options Selected

Regenerative Thermal Oxidation: selected option

- Proven existing technology already used at site;
- Existing RTO which has served well for the last 8 years or so. The existing operates autothermally and is optimised manner to avoid pre-ignition;
- Capacity of existing system can be improved to 190,000m^3/hour. Installation of larger motor required. Chamber sizes and flows sufficient;
- Heat recovery options:
  - Use the heat from a hot side bypass directly to raise steam or heat thermal oil – this is high grade heat that can generate high pressure, superheated steam;
  - Mix the hot side bypass with the RTO exhaust to create a higher outlet temperature and use this to generate hot water - mechanical heat exchanger can be used to take heat from all or part of the mixed exhaust.
- Option maintains familiarity and hence reliability of operation.

25

BAT AEL's

BAT C	BAT Conclusions (BATC) requirement (abatement plant)	Comments
16	Internal concentration of solvents in the off-gases • Off-gases are recirculated within the process (internally) in the curing ovens/dryers and/or in spray booths, so the VOC concentration in the off-gases increases and the abatement efficiency of the off- gas treatment system increases.	BAT technologies need to be confirmed where abatement is necessary… This is considered to represent a BAT technology
16	In order to reduce the energy consumption of the VOC abatement system, BAT is to use one or a combination of the techniques given below. (f) Regenerative thermal oxidation with multiple beds or a valveless rotating air distributor. (i) Thermal oxidation of VOCs by heating off-gases … to above their auto-ignition…	The design and engineering of the facility needs to be reviewed. Options for optimising the flow and handling of effluent gases need to be considered and justified with cost accounting to provide an site specific BAT option.
17	In order to reduce NOX emissions in waste gases while limiting CO emissions from the thermal treatment of solvents in off-gases, BAT is to use technique (a) or both of the techniques given below. (a) Optimisation of thermal treatment (b) Use of low-NOx burners	The design and engineering of the regulated facility needs to be reviewed. Options for optimising the flow and handling of effluent gases are considered and justified with cost accounting to provide a site specific BAT *Revised BAT AEL for NOx of 130 mg/Nm^3

26

BAT AEL's

Table 29

BAT-associated emission level (BAT-AEL) for fugitive emissions of VOCs from flexography and non-publication rotogravure printing

Parameter	Unit	BAT-AEL (Yearly average)
Fugitive VOC emissions as calculated by the solvent mass balance	Percentage (%) of the solvent input	< 1–12

The associated monitoring is given in BAT 10.

Table 30

BAT-associated emission level (BAT-AEL) for VOC emissions in waste gases from flexography and non-publication rotogravure printing

Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
TVOC	mg C/Nm³	1–20 (¹) (²)

(¹) The upper end of the BAT-AEL range is 50 mg C/Nm3 if techniques are used which allow the reuse/recycling of the recovered solvent.
(²) For plants using BAT 16 (c) in combination with an off-gas treatment technique, an additional BAT-AEL of less than 50 mg C/Nm3 applies to the waste gas of the concentrator.

3

New Emission Limit 20mg/m³

+

Fugitive emission <12% of solvent input

New NOx limit

Existing Emission Limit 50mg/m³

+

Fugitive emission <20% of solvent input

27

BAT AEPL's

4

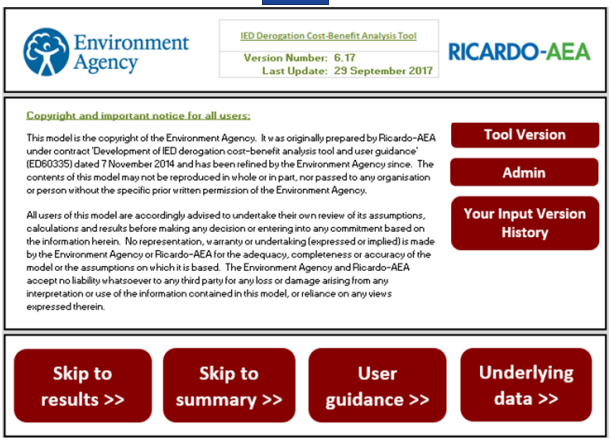
BAT C	BATC Requirement (Abatement Plant)	Comments
19	BAT 19. In order to use energy efficiently, BAT is to use techniques (a) and (b) and an appropriate combination of the techniques (c) to (h) given below: a) Energy efficiency plan; b) Energy balance record; e) Heat recovery from hot gas streams.	Energy recovery from hot gas streams (e.g. from dryers or cooling zones), e.g. by their recirculation as process air, through the use of heat exchangers, in processes, or externally. Applicability may be restricted by the plant layout, the characteristics of the hot gas streams (e.g. flow rate, temperature) or the lack of a suitable heat demand.
	BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption.	50 – 350 Wh/m² of printed area.

28

BAT Option Appraisals – Other

5

- Finance:
  - EA guidance document;
  - Used for derogations but generally helpful for cost accounting; Or
  - Simple Financial comparison.



https://www.gov.uk/government/publications/industrial-emissions-directive-derogation-cost-benefit-analysis-tool

29

BAT Option Appraisals – Other

- Simple financial comparison:

Option	Capital estimate (£m)	Electrical Cost / annum (£m)	Gas cost /annum (£m)	Other costs (£m)	Total operational cost (£m)
RTO	1.3 – 1.5	0.28	0.35		0.63
Activated Carbon	4	0.25	-	1.6*	1.85
Activated Carbon/Solvent recovery	5	0.98	-		(1.5 – 3)**

*waste treatment.

**assumed benefit of recovery based on sale of solvent £800/tonne hexane, £1200/tonne toluene.

Tabulated costs based on a 2019 dataset.

30

Conclusion

- BAT Option appraisal is a fundamental part of determining BAT.
- The fully option appraisal should be considered for all parts of the installation where significant pollution occurs or is likely to occur.
- The detail of the option appraisal is determined by the operator, BUT, the regulator needs sufficient justification to sign off.
- If the operator uses the appraisal as part of a Derogation application a full option appraisal with more detail is required, and the EA spreadsheet approach is recommended.
- The conclusion of the appraisal should support the selected option!

31