Environment Agency guidance on deriving start-up and shut-down definitions for waste incinerators and co-incinerators

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Contents

1. Introduction

Purpose and use of this guidance

This guidance provides advice to Environment Agency compliance officers on how to assess start-up and shut-down definitions for waste incineration and co-incineration plants. It can also be freely shared with operators of such plants so that they can clearly understand our expectations.

Start-up and shut-down definitions should be written by operators in the format set out in Section 5 of the UK Regulators' Waste Incinerator and Co-incinerator OTNOC Management Plan Template.

When do emission limits apply?

The emissions limit values (ELVs) specified in environmental permits apply during normal operating conditions (NOC) but not during start-up and shut-down (SU & SD). This includes limits from Chapter IV of the Industrial Emissions Directive (formally the Waste Incineration Directive), as well as those from the 2019 Waste Incineration BAT Conclusions (whereby the BAT-AELs do not apply during other than normal operating conditions (OTNOC), which includes SU and SD periods).

Why do we not apply limits during start-up and shut-down?

There are two main reasons why we don't apply limits during SU and SD:

1. Combustion during these periods can be unstable, meaning it can be difficult to control emissions to precise levels.
2. Because of the way in which we correct (standardise) the raw monitoring results to a reference oxygen concentration (normally 11% for incinerators and 6% for co-incinerators), high oxygen levels during SU and SD can lead to unrealistically high corrected emissions readings, which are not representative of actual emissions.

This is also the reason that BAT-AELs do not apply during SU and SD i.e. these are transient states which do not represent NOC.

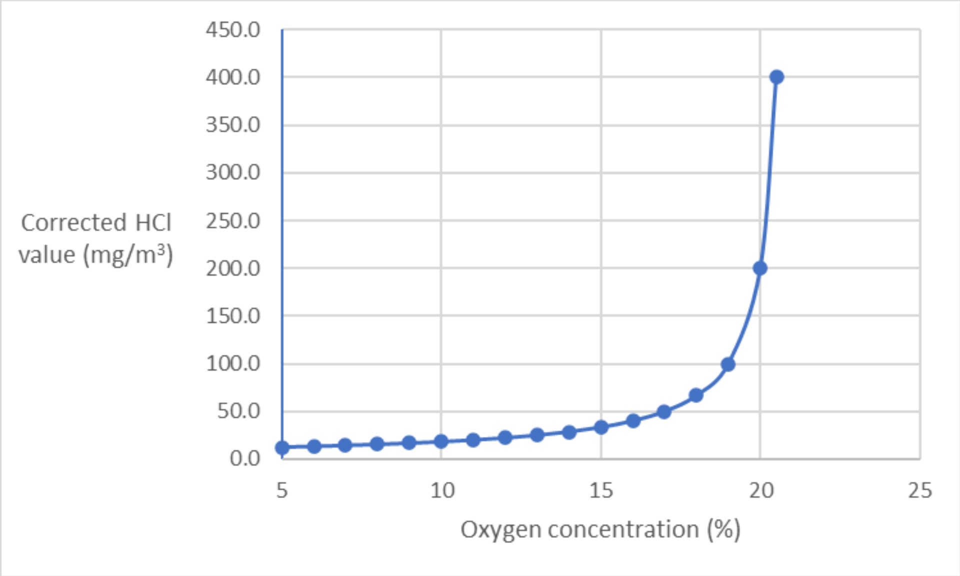
It's also important to remember that most plants (particularly large municipal waste incinerators) start up and shut down very infrequently, and will only shut down when necessary in the event of a major fault for example, or for a planned maintenance outage. It is not otherwise in the operator's interests to shut down and then subsequently restart the plant, which will involve burning costly support fuel, as well as reducing the amount of waste they can treat and their electrical generation.

Further explanation about the effects of oxygen correction

When a plant first starts up, the oxygen concentration will be similar to that of ambient air, but then will gradually reduce as the waste starts to burn and use the oxygen, and vice-versa when the plant shuts down. Because of the way the calculation for oxygen correction works, at an oxygen concentration of 20%, the correction factor is 10x the measured concentration, tending to infinity as the concentration gets closer to 21%!

This effect is illustrated by the following example where HCl is emitted at a constant mass emission (i.e. the same amount of HCl is being emitted from the stack throughout) at dry oxygen concentrations between 5 and 20.5%. When the plant is operating at the reference oxygen level (11%), the corrected value of HCl is 20 mg/m^3. But when it is operating at an oxygen level of 20%, the corrected HCl value is 200mg/m^3, even though the mass emission and volumetric flow rate is the exactly the same.

Figure 1 – effect of oxygen concentration on corrected value of HCl emitted at a constant mass



High oxygen levels during SU and SD therefore often lead to an artificially high corrected result which is way above the ELV in concentration terms, whereas the actual mass emission of the pollutant will often be much lower than during NOC due to less waste being burned at that point in the cycle.

Why do plants need to have start-up and shut-down definitions?

Operators must still continuously monitor and record their emissions during SU and SD periods, but the results can be excluded from the calculation of half hourly and daily average emissions values and do not need to be reported to us.

It is therefore important that the operator has clear SU and SD definitions to allow the monitoring software to correctly exclude or include monitoring data as necessary, and that we scrutinise those definitions to ensure that they are appropriate and justified.

An effective set of definitions will ensure that the boundaries of SU and SD are drawn sufficiently tightly so as to count as much operational time as possible under NOC (and therefore maximise the amount of time that ELVs apply), whilst excluding periods when combustion is unstable and/or when oxygen levels are high (and therefore when it would be unrealistic for us to expect operators to comply).

Can't we just have a standard start-up and shut-down definition which applies to all plants?

Essentially no, as there are many different plant types, feedstocks, and incineration technologies, which would make the setting of a standard definition very challenging, and certainly much less effective in achieving the aims of minimising SU and SD periods and maximising NOC. Bespoke definitions are therefore needed, but whereby these definitions are based on a set of common principles outlined by this guidance.

2. What happens during a typical start-up and shut-down?

All plants will have standard operating procedures which describe the process for starting up and shutting down the plant. Below are the key features of those processes which will normally form part of the SU and SD definitions.

What happens during a typical start-up?

The following sequence of events typically occurs as part of the SU of a waste incineration plant:

1. The support burners are switched on (fuelled by either oil or natural gas) and the furnace starts to warm up.
2. Once the temperature in the secondary combustion chamber has reached a minimum of 850 °C (or other temperature specified in the permit) (the T 2s temperature), waste feed onto the grate begins.
3. Once steady-state conditions have been achieved and the minimum T 2s temperature can be sustained by the combustion of waste alone, the support burners are switched off. It is during this stage that the plant will transition from OTNOC (SU) to NOC for the purposes of ELV compliance.

Further points to note about start-up

- Start-up is characterised by falling oxygen levels, whereby oxygen is initially at a level similar to that of ambient air, but then starts to fall once the burners are lit and then as waste feed begins, settling to a level consistent with NOC.
- Control of oxygen levels and combustion stability between steps 2 and 3 above is affected by a number of factors including:
  - The composition of the waste, including the moisture content
  - The ambient temperature including the effect on combustion air temperatures and warm up curve
  - The combustion air flow and distribution
  - The combustion control system, including bed depth

What happens during a typical shut-down?

The following sequence of events typically occurs as part of the SD of a waste incineration plant:

1. Waste feed ceases.
2. As the temperature starts to approach the minimum T 2s temperature, the support burners are switched on, and then the plant will transition from NOC to OTNOC (SD) for the purposes of ELV compliance.
3. The support burners remain in service until combustion of the waste has ceased (normally confirmed by a visual check of the grate or equivalent) and the plant is considered to be off. Note, however, that the status of support burners are not normally required to be included in shut-down definitions.

Further points to note about shut-down

- Shut-down is characterised by rising oxygen levels, whereby oxygen is initially at a level consistent with NOC, and then starts to rise after waste feed has ceased, tending to ambient levels once the burners have been switched off.

- Control of oxygen levels and combustion stability between steps 2 and 3 above is affected by a number of factors including:
    - The reduction in feed rate and bed depth
    - The composition of the waste
    - Combustion air flow and distribution

See Section 3 of this guidance for example profiles of a SU and SD.

Are there any variations on the typical start-up and shut-downs described above?

The descriptions above are that of a typical "cold" SU. A cold SU will occur following periods of extended downtime on a facility, for example following a period of planned shutdown for planned maintenance. Ambient temperatures will be present within the combustion chamber with support burner use to achieve the required temperatures before waste is introduced. The warmup rate/ramp may be lengthy (e.g. 36-48 hours) following planned outage if refractory work has been undertaken (due to the need to raise the temperature at a slower rate), but a start up from cold to the point at which waste can be introduced (the pre-start up period) is typically more than 8 hours for a municipal EfW plant.

A "warm" start up on the other hand may occur following a short period where the plant has ceased feeding waste, for example to clear blockages. Temperatures can be maintained within the combustion chamber through use of the support burners. Once the issue requiring the plant to come off waste has been rectified, waste feeding can recommence immediately.

For the above example, in some instances the plant may actually still be under NOC when waste feed recommences, especially in the case of a moving grate plant which has only had to cease feeding waste for a very short period of time, and where the operator has continued to optimise combustion of the waste inside the combustion chamber (a key requirement) whilst the blockage is cleared.

Plants may sometimes need to undergo an unplanned (emergency) SD due to a plant fault or power cut, leading to an instant loss of combustion air. This may lead to a breach in ELVs under the operator's definition for a "standard" SD.

It is not possible to write a plant-specific definition for an emergency SD, since these will be inherently variable and difficult to anticipate. However, the Environment Agency has developed further guidance for compliance officers to help them decide whether any apparent ELV exceedances which occur during these events should be scored as a permit breach (see Section 6 of this document) whereby the general definition of an emergency SD is an event involving loss of combustion air. Operators can of course also use AO provisions in such situations where these can be applied.

What is there to stop an operator declaring a shut-down solely to avoid the need to comply with ELVs?

When an operator initiates a SD of their plant, emissions data should continue to be recorded for the purposes of permit compliance for as long as possible after waste feed has ceased (i.e. before combustion becomes unstable and/or the oxygen correction factor becomes too great).

It is generally unacceptable for an operator to have a SD definition where SD starts as soon as waste feed ceases because:

- It removes the incentive for the operator to continue to optimise combustion (and therefore minimise emissions) after waste feed has ceased; and

- In the event of rising emissions during NOC, an operator could cease feeding waste and declare the plant to be in SD, then simply resume waste feed once emissions have fallen, thereby avoiding an ELV breach. This would clearly be unacceptable as it would remove the incentive to properly control emissions and would lead to non-reporting of emissions that would otherwise constitute an ELV breach.

Any operator who wants to have a definition whereby SD begins as soon as waste feed ceases will therefore need to provide very robust justification for us to be able to consider it.

There is, of course, nothing wrong in principle with temporarily ceasing waste feed in order to reduce emissions and ensure compliance with ELVs, provided the plant remains under NOC. Nor is there any reason why an operator shouldn't initiate a SD in order to fix a problem which would otherwise lead to an ELV breach (and which cannot be corrected within the 4 hours allowed under abnormal operation for example).

However, operators must not otherwise routinely use SD as a way of managing performance against ELVs, and we will closely scrutinise the performance of any plants which appear to be having frequent or inappropriate SDs to ensure that this is not being used as a method of ELV compliance, and that operators are making proper use of abnormal operation allowances where relevant

3. How should start-up and shut-down definitions be derived?

New plants

For a new plant, we would expect the technology provider to have sufficient knowledge and experience to be able to help the operator derive a suitable SU & SD definition which can be used for its initial operation. We then expect the operator to review this definition after every start-up and planned shut-down in the first 2 years of operation to make sure it remains fit for purpose and is drawn sufficiently tightly.

Existing plants

For existing plants, we expect them to review their current definitions and justify them against their historic emissions profiles as part of their new OTNOC management plans. Wherever possible, profiles from the last 3 planned start-ups and shut-downs should be provided, and definitions should not be based on profiles which show one-off/atypical events (e.g. a one-off emission spike due to an ID fan trip during SU). Explanation should be provided as to why emissions are unstable at certain points, and what measures are being employed to maximise stability and manage oxygen levels.

The key emissions profiles of interest will be CO and TOC, although operators should check the definitions derived from these pollutants to ensure that they are compatible with the profiles for other pollutants. It is also very important that these are the corrected values for these pollutants (including confidence interval subtraction), NOT the raw data values.

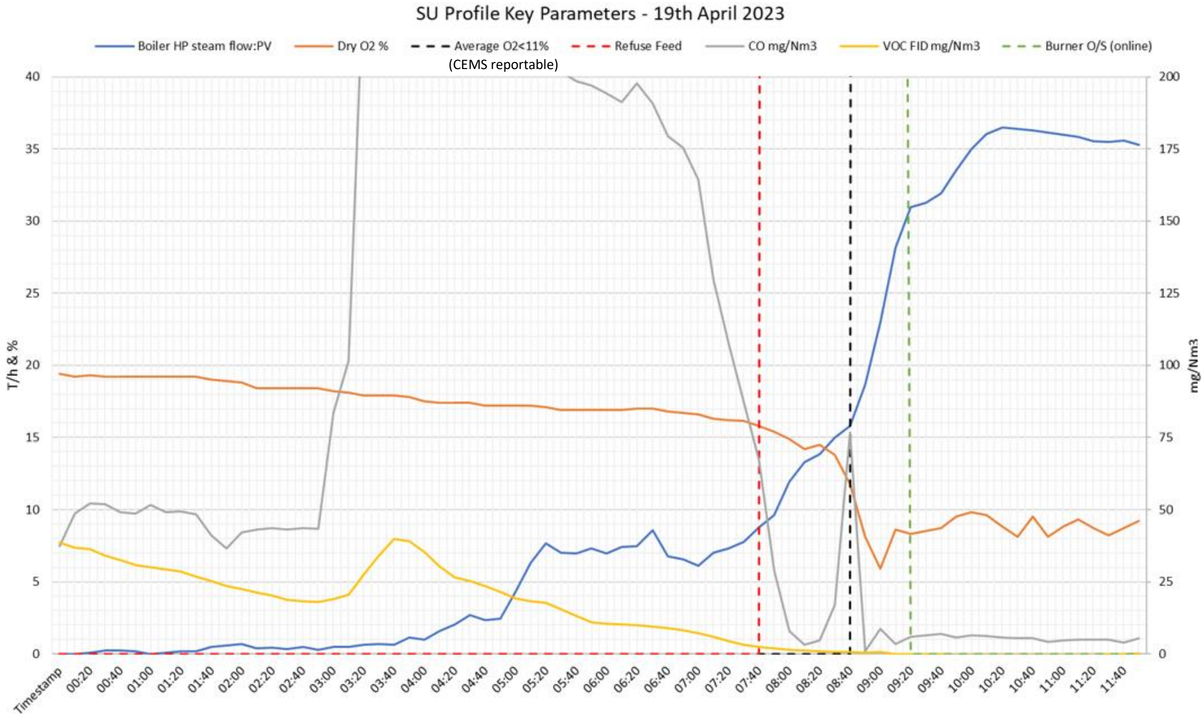
The profiles themselves should show the following on charts with time along the X axis and the values of the various parameters on the Y axis, with one chart for SU and another for SD.

The charts should include:

- Values of CO and TOC (corrected for moisture, temperature, pressure and oxygen, and with the confidence intervals subtracted)
- Wet or dry oxygen levels (state which – the preference is for definitions to be based on dry levels as this is more logical and aids consistency – see Section 5 below for more information on flue gas moisture content)
- Live steam mass flow
- Normalised flue gas flow rate
- Point at which burners are switched on (or support fuel flow rate)
- Point at which burners are switched off (or support fuel flow rate)
- Point at which waste feed begins (SU chart)
- Point at which waste feed ceases (SD chart)
- Point at which SU ends and NOC commence (SU chart) i.e. “CEMS reportable”
- Point at which NOC cease and SD begins (SD chart) i.e. “CEMS not reportable”
- Point at which waste combustion ceases and the plant is considered to be “off” (SD chart)
- Any other relevant events which the operator proposes to include as part of their start-up or shut-down definition

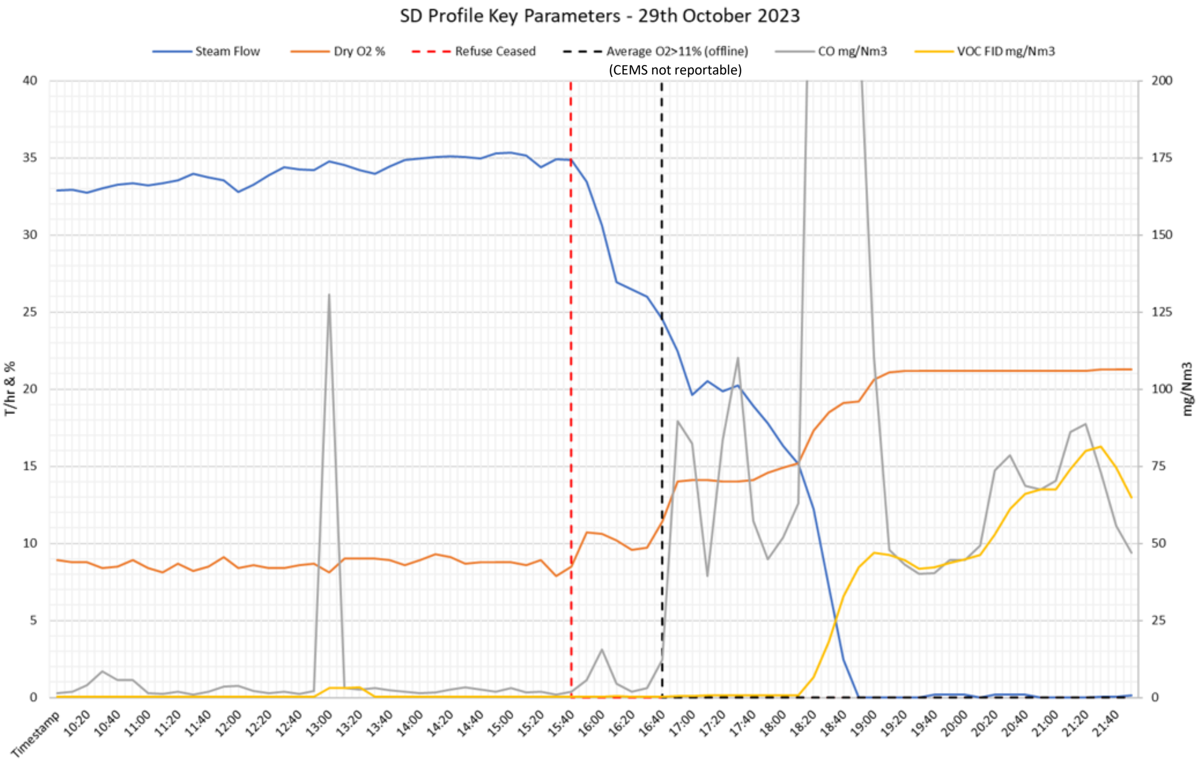
Example start-up chart

Figure 2 – start-up chart for a municipal energy from waste plant



Example shut-down chart

Figure 3 – shut-down chart for a municipal energy from waste plant



Reviewing start-up and shut-down definitions

For plants that have been operating for more than 4 years, we expect SU and SD definitions to be reviewed at least every 4 years, and we will carry out audits to ensure that this is happening and that definitions are fit for purpose. Definitions should also be reviewed following a change in primary waste type or significant changes to the furnace or its operation.

4. Principles for deriving start-up and shut-down definitions

The following sections contain a number of terms such as pre-start-up, end of SU, end of SD etc. These descriptors are important to the SU and SD definitions themselves, but do not necessarily need to be reflected in operators' standard operating procedures for starting up and shutting down the plant.

Pre-start-up

Before SU can begin, the EA expects operators to ensure that CEMS are operational and ready to start recording emissions as soon as the support burners are lit. The burners are then lit and the combustion chamber is warmed to the required temperature for waste feed to begin, with this period often being referred to as pre-start up.

The EA also expects operators to maximise the readiness of the abatement plant by:

- Avoiding the need for a bag-filter bypass where technically feasible by pre-heating the bag filters.
- Ensuring the bag filters are coated with lime/sodium bicarbonate and activated carbon as soon as possible after burners are lit. In some cases the bag filters may remain coated following a SD, otherwise procedures should ensure that they are recoated as soon as possible and fully coated before waste feed begins, normally once the bag house has reached a defined temperature. This is to maximise abatement of any pollutants which may arise when the plant restarts due to residual material being present in the flue gas path, and to ensure that abatement is fully active once waste feed begins

The EA does not expect any municipal EfW plant to use bag filters bypasses during SU or SD. For other types of plant, where bypasses are currently used during either SU or SD, operators are expected to make improvements to remove the need for them wherever technically feasible. Any such planned improvements should be captured in Section 6 of the OTNOC Management Plan Template.

What are the key factors which will normally feature in an operator's start-up definition?

Primary factors that we expect to feature in plant start-up definitions:

SU ends/NOC begin when all the following are true:

- Waste is being fed onto the bed/grate/hearth/kiln
- Support burners are removed and T 2s temperature is maintained above 850 °C (or other temperature specified in the permit) through waste combustion alone. (Note, however, that some plants may be able to comfortably comply with ELVs at a point before the burners have been switched off i.e. burner status has no bearing on when start-up ends, in which case burner status does not need to be included in the SU definition).
- The 1-minute average oxygen value (normally measured at the stack) is generally stable and consistently below a site-specific value (as justified by the operator and supported by emissions profiles). To satisfy this requirement, we have proposed a default definition which requires the oxygen level to be consistently below the site-specific threshold for 30 minutes, but alternative durations can be justified where appropriate.

Secondary factors that should only be included if necessary:

The following parameters may be generally indicative that a plant is operating under NOC, but our preference is for them only to be concluded in SU if absolutely necessary. This is because the primary factors above should be sufficient in most cases, and secondary factors have the potential to unnecessarily delay the end of SU.

- A specified time from waste feed commencing (a time delay – see further notes below)
- Specified steam generation levels being achieved (t/hr)
- Specified flue gas flow being achieved
- Specific plant or equipment is in use such as clinker roller, ash discharger

What are the key factors which will normally feature in an operator's shut-down definition?

The requirements for the plant to be considered to be in SD will in many cases simply mirror those required for a SU.

Primary factors expected to feature in plant shut-down definitions:

NOC ceases / shut down begins when both of the following are true:

- Waste feed has ceased (waste crane inhibited or equivalent)
- The first 1-minute average oxygen value (normally measured at the stack) has reached a site-specific threshold value. Note that, unlike for SU, we are not by default recommending that the 1-minute average oxygen value be above the threshold for a certain period of time, but rather that SU is triggered as soon as the threshold is reached, as stability is likely to then decrease from that point onwards. However, a longer duration can still be used if necessary (e.g. the 1-minute average oxygen value has been consistently above the site-specific threshold for 10-minutes) if this means that the plant will be under NOC for longer (e.g. if a brief oxygen spike is normally observed once waste feed has ceased).

Note that most incinerators and co-incinerators will also use support burners during shut-down to maintain the minimum required temperature while the waste is burning out, but shut-down definitions do not normally need to include having support burners in service as a specific criterion.

Following the cessation of waste feed, operators need to take all reasonable steps to maintain stable combustion and manage oxygen levels, including continuing to operate the combustion optimisation systems used during NOC, and to be able to demonstrate that they are doing so via site procedures.

By so doing, emissions will continue to be minimised for as long as possible, with control of oxygen levels within NOC parameters (by gradual reduction of air supply as the waste burns out) helping to maximise the amount of time before the threshold oxygen value is reached, and therefore the amount of time during which ELVs continue to apply.

SD will then begin at the point when waste has burned out to such an extent that it is no longer possible to control emissions to a stable level and/or the oxygen correction factor is too high.

Note that in a small number of cases such as certain waste wood or clinical waste incinerators, it may be possible for operators to keep complying with ELVs right up until the point that waste combustion has ceased. It is perfectly acceptable for definitions to be written on this basis, though operators must take care to ensure that this will be appropriate under all likely NOC scenarios.

Secondary factors that should only be included if necessary:

The following parameters may be generally indicative that a plant has entered SD, but as with SU, they should only be included if absolutely necessary (for the same reasons as for SU stated above).

- Support burners are put into service (excluding test firing or temperature support during NOC)
- After a time delay e.g. waste feed ceases + 30 mins
- Specific equipment is removed from service (see list above for SU)
- Steam flow or flue gas flow goes below a certain threshold (e.g. a % of MCR equivalent- to be determined by plant)

The end of shut-down

SD ends when combustion of waste on the grate has ceased (normally confirmed by a visual check of the grate surface) and support burners are taken out of service, at which point the plant is considered to be “off”. This excludes situations where any residual waste must be removed from the grate manually following an emergency shut-down (see Section 6).

Reagent dosing during start-up and shut-down periods

Even though ELVs do not apply during SU and SD, operators must still take all appropriate measures to minimise emissions during these times, including continuing to dose lime (or bicarbonate) and activated carbon to the required levels. Practices will vary according to site-specific designs, and in some cases it may not be possible to dose at very low flue gas flow rates due to the inability of reagents to be entrained, but in all cases operators must be able to justify their operating procedures in this respect.

5. Further considerations for deriving start-up and shut-down definitions

Considerations around the threshold value for oxygen

The oxygen value chosen for both SU and SD definitions will ultimately need to be justified on the basis of emissions profiles showing the corrected values of various pollutants. We would normally expect this value to be somewhere around 15% dry.

Considerations around time delays

In some circumstances, for example where waste composition is consistent with very stable energy content, the time required for SU and SD may also be consistent. In these circumstances it may be appropriate to use a time delay as an indication of the end of SU or the beginning of SD. For example, waste chute damper closed + 30 minutes.

However, as a time delay is not directly related to the circumstances of a specific shutdown, when conditions change and/or waste feedstocks are variable, there is a strong possibility that the time required to achieve steady-state or to unstable conditions will vary. Therefore, a time delay is not suitable for many plants, and so is included as a secondary parameter above for use in SU and SD definitions only if necessary.

Considerations around flue gas moisture content

Flue gas moisture content wouldn't normally be considered as a defining factor for SU or SD, but as the emissions are corrected to a standardised moisture content, this can affect the emissions profiles. Permits require that emissions are reported as dry following correction for moisture.

Functioning in a similar way to the oxygen correction, the moisture correction increases emissions concentrations as the moisture concentration approaches 100%, at which point it increases exponentially. This means that wet (uncorrected) oxygen levels may be stable, but the corresponding dry (corrected) oxygen levels could be unstable due to fluctuating moisture levels, which in turn means that definitions based on dry oxygen thresholds are likely to be most suitable, and are also preferred for the purposes of consistency.

Although high moisture content is not common, it can occur as the result of boiler tube leaks, during which time large volumes of feed water are dumped into the boiler generating large volumes of steam and requiring the plant to be shut down. Such a situation would normally be considered as an unplanned SD (see Section 6 of this guidance).

Considerations around cessation of waste feed

Cessation of waste feed would normally mean that the crane has been inhibited, or alternative loading system in the case of a clinical waste incinerator for example. SD definitions should therefore state what cessation of waste feed means in practice.

In some cases, existing SD definitions may require the feed chute damper/flap to be closed. In the case of a blockage in the waste feed, however, it may be necessary to shut down the line but not physically possible to close the feed chute flap. Definitions should therefore be written accordingly to avoid the possibility of a plant technically not being able to enter SD because it's feed chute damper cannot be closed due to a blockage, e.g. specifying ""Waste feed has ceased" rather than "Waste feed chute doors closed".

DCS and DAHS logic diagrams

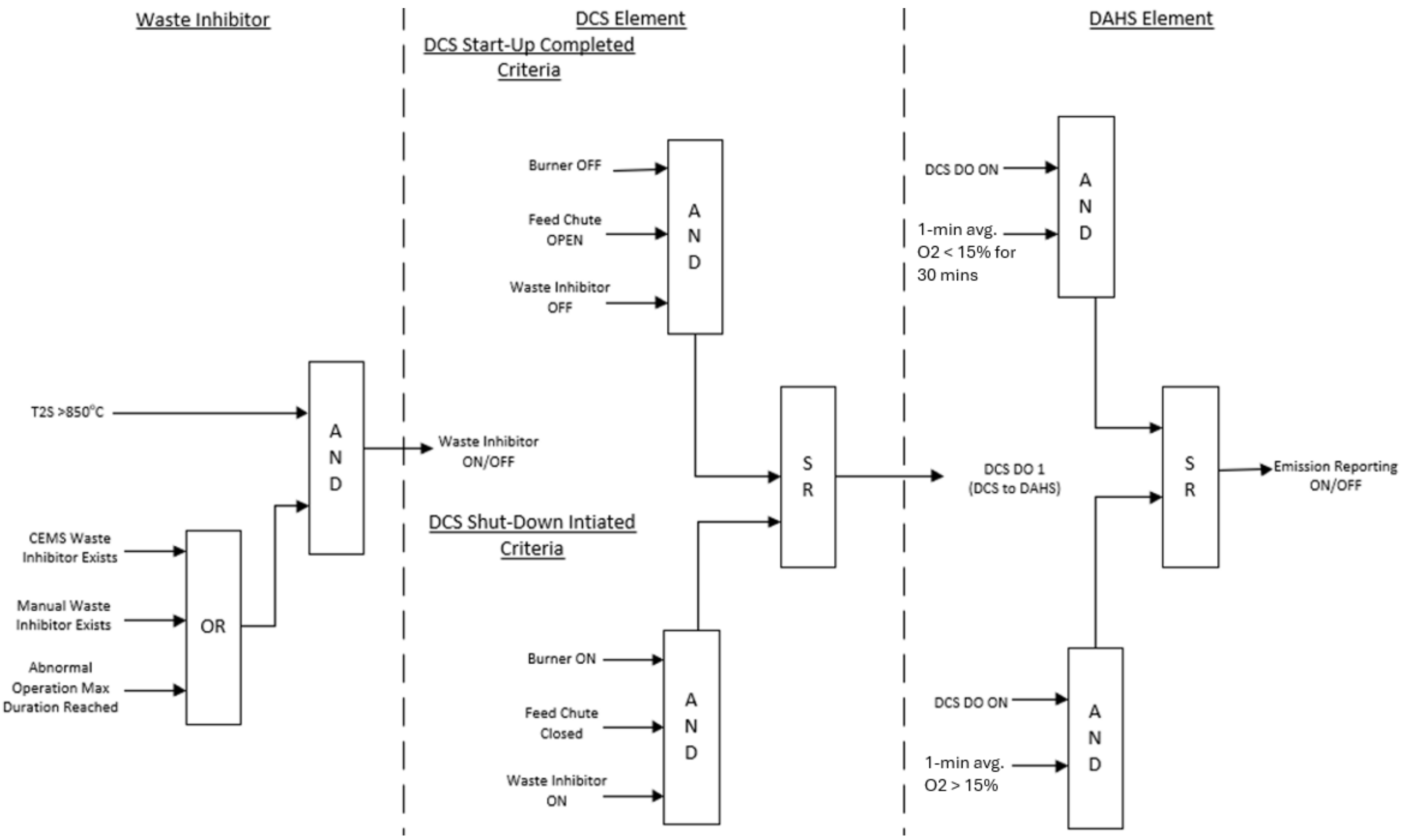
In addition to written SU & SD definitions entered into the relevant section of the OTNOC Management Plan template, operators should also provide logic diagrams for the distributed control system (DCS) and (if separately needed) data acquisition and handling systems (DAHS) which reflects those definitions.

There is a preference for the process which eventually leads to the "CEMS not reportable" signal to be fully automated within the plant DCS. However, in some cases this may not be possible to achieve, either due to the nature/age of the DCS, or because definitions need to be changed but the DCS logic cannot be updated until the next planned outage. It is therefore acceptable for an operator to have a "manual" process which the plant operatives follow in the interim, and to then automate at the next outage wherever possible.

If the process is not (yet) fully automated within the DCS, logic diagrams should still be provided which show how the start-up and shut-down definitions work.

An example is provided as follows:

Figure 4 – example logic diagram



6. Guidance on ELV compliance during emergency shutdowns

1) **What is an emergency shut-down?**

Incinerator operators will have standard procedures on how to carry out a planned plant shut-down, for example ahead of a major outage. They will also have a definition of start-up and shut-down for the purposes of defining when emissions limit values (ELVs) apply for the purpose of compliance (which will form part of their Other Than Normal Operating Conditions (OTNOC) Management Plan).

There may, however, be occasions when an operator experiences a plant fault which results in a shut-down which cannot be carried out in the standard way. This normally falls into one of the following 2 categories, although these do not provide an exhaustive list, and other scenarios are possible:

1. The plant has "tripped" (meaning that power is automatically cut to the primary and/or secondary air fans (or total air fans in some cases) and/or induced draft (ID) fan, which will lead to a loss of combustion air. This is as a result of the operation of automated safety systems to ensure compliance with Pressure Systems Safety Regulations (PSSR), which are designed to prevent serious harm to personnel or plant. Plant trips can be caused by events such as boiler tube leaks (leading to low water levels in the steam drum), sensor failures, furnace over-pressure events (e.g. due to nitrous oxide cylinder explosion) compressor failures and motor drive failures (non-exhaustive list).
2. There has been a complete failure of the power supply to the plant, which will likely result in a similar outcome to a plant trip, with certain systems still operating automatically to meet the PSSR, and some plant functions still possible via use of the emergency generator.

In both cases, the event will be characterised by **a loss of combustion air**, which effectively defines an emergency shut-down.

2) **Start and finish of an emergency shut-down**

The emergency shutdown will start at the point when combustion air is lost, and will finish either when:

1. Combustion air supply is restored and normal operating conditions (NOC) can be resumed; or
2. Combustion air supply is restored and the normal start-up or shut-down definitions can be met.

These scenarios are illustrated in the following examples:

Example 1 (Scenario 1) – short-duration trip with quick rectification of fault

In this example, a gas cylinder explosion has caused momentary furnace-over pressurisation, resulting in the combustion air fans tripping but quickly being restored.

Plant operating normally	Short plant trip – oxygen remains below the SD threshold and temperature above the threshold; air supply quickly resumed	Plant operating normally
NOC	**Emergency shut-down**	**NOC**

Example 2 (Scenario 2) – plant trip with longer time taken to rectify fault

In this example, a faulty drum-level sensor has failed, resulting in all the fans tripping. The sensor is replaced but in the meantime the oxygen level is above the threshold specified in the start-up definitions and the temperature is below that required by the permit. The plant therefore needs to switch on the burners before waste feed can recommence, and so is effectively back in the start-up phase once air supply is restored.

Plant operating normally	Longer plant trip – oxygen rises above the SD threshold and temperature below the minimum; air supply resumed	Plant under start-up conditions	Plant operating normally
NOC	**Emergency shut-down**	**Start-up**	**NOC**

Example 3 (Scenario 2) – longer plant trip with air supply restored but need to shut-down to fully rectify fault

In this example, a fault has caused the plant to trip. The fans and burners can be manually restarted but it is not possible to rectify the fault without firstly shutting the plant down, and the oxygen has risen above the threshold specified in the shut-down definition. The plant is therefore under shut-down conditions as soon as the air supply is restored. See also section 6 below on minimum temperature requirements.

Plant operating normally	Longer plant trip – oxygen rises above the SD threshold and temperature below the minimum; air supply resumed	Plant under shut-down conditions
NOC	**Emergency shut-down**	**Shut-down**

Example 4 (Scenario 2) – more significant fault meaning that waste must be removed before combustion air can be restored

In this example, a significant boiler tube leak in the second pass has meant that it is not possible to restart the combustion air fans without replacing the boiler tube. This means that it will not be possible to meet the normal shut-down definition for the plant. The waste is removed via the ash discharger system (or manually) and the boiler tube replaced once the plant has sufficiently cooled. The plant is then started-up in the usual way.

Plant operating normally	Significant fault – air supply cannot be restored and normal shut-down definitions cannot be met; waste removed; combustion air then restored	Plant under start-up conditions	Plant operating normally
NOC	**Emergency shut-down**	**Start-up**	**NOC**

3) Why is ELV compliance a challenge during an emergency shut-down?

ELVs apply at all times during normal operating conditions (NOC). During shut-down, ELVs can be disapplied, but only if the operator is able to meet their normal shut-down definition. During an emergency shut-down, it will rarely be possible for an operator to meet their normal shut-down definitions due to loss of combustion air. This means that the operator is unable to claim that the plant is in "normal" shut-down, but they will also be unable to claim abnormal operation (AO) for any apparent exceedances of CO, TOC, and could even experience an exceedance of the particulate ELV for AO (see below).

4) Why may an operator not be able to comply with CO, TOC or particulates ELVs during an emergency shut-down?

When combustion fans trip, this can initially give rise to higher concentrations than normal of CO or TOC due to unstable or incomplete combustion. Oxygen levels may also then rise as waste combustion is significantly reduced (but air continues to be drawn through the plant by the natural draft created by the stack), leading to unrealistic oxygen correction factors.

If a plant experiences a boiler tube leak, this can cause significant amounts of water to enter the flue gas, potentially leading to unrealistically high reported emissions due to moisture correction, or in some cases high apparent particulate readings due to water droplets.

5) What is the EA's position on ELV compliance during emergency shut-downs?

Our position is broadly the same as for regular shut-downs (and start-ups) in that emergency shut-downs form a category of OTNOC, during which it may be unreasonable to expect the operator to be able to comply with their ELVs due to unstable combustion or unrealistic correction factors. In this way, they can be treated the same as regular shut-downs, provided that certain criteria are met as per the assessment process in Annex 1 below.

6) What is the EA's position on compliance with the minimum temperature requirements during emergency shut-downs?

Permits will normally contain the following standard condition:

The operator shall have at least one auxiliary burner in each line which shall be operated at start up, shut down and as required during operation to ensure that the operating temperature specified in condition [2.3.12] is maintained as long as incompletely burned waste is present in the combustion chamber.

In practice therefore, this condition could be breached under an emergency shut-down scenario if it is not possible to operate the burners due to safety requirements and the temperature falls below the minimum specified temperature with waste still present on the grate (or equivalent).

Given that this scenario will sometimes be a feature of an emergency shut-down, we will apply the same assessment process as Annex 1 in determining whether or not to score such events as a permit breach.

7) Reporting of emergency shut-downs

Operators must notify the EA following an emergency shut-down using a Schedule 5 notification form (within 24 hours for the Part A) including:

- The nature of the event which led to the emergency shut-down (Part A of the notification)
- The values of any apparent ELV exceedances (Part A of the notification)
- A justification against the criteria in Annex I as to why the event constituted an emergency shut-down and therefore that ELVs do not apply, along with measures to prevent recurrence. (Part B of the notification)

The EA also expects operators to record such incidents and ensure that they are taken into account as part of periodic reviews of their OTNOC Management Plans.

8) Further points to note

- Whilst reported concentrations of CO and TOC may sometimes be higher than the ELVs during an emergency shut-down, the flue gas volumetric flow rate which will be much lower than normal, meaning that mass emissions may not be significantly elevated compared to normal operation.
- If there is an impact on amenity as a result of an emergency shut-down, this may be scored for separately to any ELV exceedances.
- In the event of a power cut, emergency generators are unlikely to be able to power in the full plant load, in particular the air fans. Thus, even with emergency generators running, it is likely that a plant will still technically be in an emergency shut-down scenario, but certain plant operations beyond operation of the fans should still be possible.
- This guidance does not apply to activation of emergency release valves fitted to plants such as clinical and hazardous waste incinerators.
- This guidance does not apply to plants that are still in commissioning and operating to the agreed trigger level ELVs in their commissioning plans.

Annex 1 - Assessment process for emergency shut-downs

Summary:

ELVs can normally be disapplied if an emergency shut-down meets the criteria of either Category A or B below. If not, ELVs will continue to apply, and we will score the operator for any exceedances.

Category A

All of the following criteria were met:

1. The emergency shut-down was less than 4 hours in duration (see "Start and finish of an emergency shut-down" above)
   AND
2. There was no likely impact on air quality
   AND
3. There was no impact on amenity
   AND
4. The event is not due to a known existing or recurring fault

Category B

The emergency shut-down was more than 4 hours in duration (see "Start and finish of an emergency shut-down" above) and:

1. There was no likely impact on air quality

   AND

2. There was no impact on amenity

   AND

3a. The failure which led to the emergency shut-down was technically unavoidable i.e:

- Item(s) of plant adequately maintained
- Not reasonably foreseeable
- Not due to a known existing or recurring fault

OR

3b. The event was due to the actions of a third party beyond the operator's control (not withstanding the expected proper operation of e.g. power supply back-ups – see point 3a.)

OR

3c. The shut-down event was due to damage or plant upset characteristic of a compressed gas cylinder explosion (provided that the operator can demonstrate that appropriate measures are in place to minimise occurrence of such cylinders entering the furnace)

Definitions (for the purposes of this guidance only):

No likely impact on air quality:

A short-term duration event (<24 hours) is unlikely to have an impact on air quality where only concentrations of TOC and/or CO are above the ELVs. ELV exceedances for any other pollutants are unlikely and may be covered by abnormal operation provisions. Seek further advice from the Sector

Lead if the bag filters were compromised or smoke (i.e. a visible plume not due to water vapour) observed, as an air quality impact assessment may be needed in this situation. Recurring faults or amenity impacts (see below) may also require the operator to perform an air quality impact assessment.

No impact on amenity:

This means that there were no odour, noise or dust complaints as a result of the incident.

Item(s) of plant adequately maintained

Operators should be able to provide evidence of adequate preventative maintenance plans and maintenance records for the equipment associated with the failure if requested by the EA – seek further advice from the Sector Lead if necessary.

Appropriate measures to minimise occurrence of compressed gas cylinders in the waste

Operators cannot check every load of waste they receive for the presence of gas cylinders. However, there are appropriate measures which they can use to minimise the occurrence of gas cylinders entering EfW facilities. These include waste specifications to commercial contractors which outline prohibited waste (i.e. cylinders), onsite and offsite load inspections, and processes to feedback to customers when those waste types are received.

It should also be noted that operators have a strong incentive to do everything they can to ensure compressed gas cylinders are removed from the waste stream, beyond just permit compliance. Cylinders can explode when enter the furnace of EfW facilities, putting personnel at risk and requiring the plant to be shut down to repair the damage. Repairs are often costly, with further cost impacts due to loss of revenue from gate fees and electricity generation while the plant is down

Appendix 1 – glossary of acronyms used in this guidance

Acronym	Meaning
AO	Abnormal operation (an allowance which allows certain ELVs to be exceeded for up to 4 hours duration at any one time)
CEMS	Continuous emissions monitoring systems
CO	Carbon Monoxide
DAHS	Data acquisition and handling systems
DCS	Distributed control system
ELVs	Emission limit values
HCL	Hydrogen Chloride
MCR	Maximum continuous rating
NOC	Normal operating conditions
OTNOC	Other than normal operating conditions
SD	Shut-down
SU	Start-up
T 2s temperature	The minimum temperature which must be maintained whilever waste is being burned (as specified by the permit – normally 850 °C)
TOC	Total organic carbon

Appendix 2 – example start-up and shut-down definitions

The Environment Agency will agree a small number of start-up and shut-down definitions with operators of a variety of different incinerator and co-incinerator types and share them as illustrative examples for the benefit of other operators with similar plants.

As these become available, they will be uploaded to the folder at the following link:

https://brandfolder.com/s/9cvx64j2ghts7qzrhpmrhgc

Note that this folder has kindly been set up by the Environment Services Association due to limitations in the Environment Agency's ability to host the content themselves.