clean essential energy

YELLOW PLUME MITIGATION FOR DIESEL AND NATURAL GAS GENERATORS

WHAT IS THE YELLOW PLUME?

Yellow plumes can sometimes be observed at the exhaust of diesel and natural gas generators during certain operating conditions (see Figure 1). This is a visible representation of nitrogen dioxide (NO_2) present in the exhaust gasses from an engine. Utilizing Selective Catalytic Reduction (SCR) technology such as the ecoCUBE®, NO_2 is reduced to colourless and harmless nitrogen gas and steam, and then released into the atmosphere. When an SCR system is operational, there should be no visible yellow plume as a large majority (> 90% typically) of the NOx present in the exhaust stream is destroyed.

Figure 1: Yellow plume from on-site power generation

However, for a brief period of time after engine start-up, the SCR system is not operational as the catalyst needs to heat up to operating temperature. The highest risk of a visible yellow plume exists during this stage. This risk is more prevalent in diesel engine systems that have a Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF) as part of the emission control system. This is because the DOC and DPF system encourage the conversion of nitric oxide (NO) to NO_2 for DPF regeneration. The amount NO that is converted to NO_2 depends on the catalyst formulation. This NO_2 shift increases the visibility of the yellow smoke prior to SCR catalyst activation; once the SCR catalyst is active, the majority of NO_2 is reduced and the plume disappears.

clean essential energy

YELLOW PLUME MITIGATION STRATEGIES

The visibility of the yellow plume prior to SCR catalyst activation can be reduced in multiple ways (or a combination of the suggested methods):

1. **Selection of stack diameter**
   The visibility threshold levels for NO_2-related yellow plume varies based on the outlet stack diameter[1]. A rule of thumb suggested by the United States Environmental Protection Agency (EPA) is

$$NO_2 \text{ Minimum Threshold [ppm]} = \frac{6100 \text{ [ppm . cm]}}{\text{Stack Diameter [cm]}} = \frac{2400 \text{ [ppm . in]}}{\text{Stack Diameter [in]}}$$

This relationship is tabulated below for common stack diameters:

Stack Diameter [in]	10	16	18	20	22	24	26	28	32
NO_2 Minimum Visibility Threshold [ppm]	240	150	133	120	109	100	92	86	75

Thus, for a given amount of NO_2 concentration in the exhaust system, one can size the stack to eliminate the yellow plume, keeping in mind the additional backpressure added by smaller exhaust piping.

Example:
Total expected NO_2 in stack, prior to SCR activation: 120 ppm
Based on the formula/table, choosing a stack that is 20" in diameter should render the yellow plume invisible to the naked eye.

2. **Dilution**
   The simple concept of dilution can be highly effective in reducing the visible yellow plume. It can be easily achieved by piping the outlet of the emission control system into the engine cooling air flow, downstream of the radiator. The radiator air flow is generally much greater than the exhaust flow, allowing for excellent dilution.

[1] U.S. Dept. of Health, Education, and Welfare; "Control Techniques for Nitrogen Oxide Emissions from Stationary Sources"; March 1970