NESS
The Process Heat Company

REDUCING EMISSIONS FROM THERMAL OIL SYSTEMS

How to stay below the emission limits when separating low boilers

Whitepaper

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PREFACE

For over 50 years, we have been developing, designing, and manufacturing process heating systems for customers worldwide. In our engineering department alone, around 30 highly qualified and motivated engineers from various technical fields work on solutions for our customers across all continents.

We would like to share our accumulated expertise with you. To this end, we provide free whitepapers on various topics..

The costs of resources and plant operations are constantly rising, and sustainability has become more important than ever—not only to reduce costs but also to make the most efficient use of available resources. Therefore, systems, workflows, and processes must be analyzed and, if necessary, optimized. Ensuring a sustainable and future-proof plant operation presents us with new ecological and economic challenges. The latter, in particular, requires careful consideration of where investments are truly necessary.

We hope this whitepaper provides you with valuable insights and supports you in making well-informed decisions.

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SUMMARY

In thermal oil systems, light boilers (low-boiling compounds) form due to operation at high temperatures. Over time, these light boilers pose safety risks, which is why they should be removed regularly or continuously. However, some of these light boilers are non-condensable under ambient conditions and are released into the environment during removal. The limit value for benzene can be exceeded, particularly in the case of synthetic thermal oils with a high proportion of aromatic compounds.

By using an active light boiler removal system with built-in filter elements, emissions can be reduced to levels below the regulatory threshold. Retrofitting existing light boiler removal systems is also easily feasible, making it a more economical solution. In all probability, however, a NALD will remain below the de minimis limit of TA Luft even without the additional filter element. However, manual boiling does pose a problem, as high emissions are released into the environment over a longer period of time.

INTRODUCTION

We have already reported in detail on the formation of low-boilers in thermal oil systems, the resulting hazards and the measures to be taken and their effectiveness in the white paper 'Low-boilers in thermal oil systems - Why it is better to actively remove low-boilers instead of replacing oil'. However, a small part of the topic has not yet been sufficiently highlighted.

Some of the light ends produced consist of such small molecules that they do not condense during removal and therefore cannot be separated in liquid form. Instead, they inevitably escape into the environment. In Germany, the limit values for these emissions for industrial plants are specified in the Technical Instructions on Air Quality Control (TA Air).

Which limit values are particularly relevant for which type of plant, which emissions are to be expected and how it can be ensured that these are complied with are dealt with below.

EMISSION SOURCES AT THERMAL OIL SYSTEMS

Thermal oil systems in general are, as long as they correspond to the state of the art, permanently technically tight and have an opening to the environment at most at an expansion tank open to the atmosphere or a collecting tank. In modern systems, these tanks are also covered with nitrogen so that the thermal oil medium has no contact with the environment, i.e. the system is regarded as a strictly contained closed system. However, one source of emissions that is added by the continuous operation of such a system is at the point at which the low-boilers produced over time are to be removed from the system. This can be a simple boil-out line, in which the low boilers are regularly removed by a manual process, or a light-ends removal systems (NALD).

When the light ends are removed, the majority of these light ends are condensed and can be separated and disposed of in liquid form. However, the most volatile low-boilers, i.e. the molecules with the lowest boiling temperature, remain gaseous under normal ambient conditions and escape into the environment during the low-boiler removal process. This means that there is a source of emissions here.

COMPOSITION OF EMISSIONS

With regard to the possible substances that can be emitted into the environment during the removal of the low boilers, a distinction must be made according to the type of thermal oil.

In the case of 'classic' mineral thermal oils, which are obtained from a fraction of distilled crude oil, these emissions consist of short fragments of linear or branched hydrocarbon chains. The smallest possible fragment is methane with a boiling temperature of -162 °C (111 K). Up to n-pentane with a boiling temperature of 36 °C, it is very likely that these components will escape into the environment. Small amounts of higher-boiling components can also escape if they are not yet fully condensed.

Thermal oils produced for operating temperatures higher than 320 °C usually consist of aromatic compounds, as these are chemically more stable. In contrast to the mineral thermal oils mentioned above, these thermal oils are often called synthetic thermal oils. They are produced in a reactor and cannot be obtained by pure distillation from crude oil. Although these thermal oils can be used at higher temperatures, they still decompose as these high temperatures are then also used. The decomposition products of these thermal oils are much more critical, as they are benzene and related substances that have very strict limit values.

In general, all of the emissions described here can be summarised under the generic term volatile organic compounds (VOCs). Ness Wärmetechnik GmbH has therefore developed a filter that removes about 80 % of the VOCs produced during light-ends removal and thus safely reduces the limit values to below the de minimis threshold of the emission limit values.

EMISSION VOLUMES

The amount of emissions depends in detail on the thermal oil used, the temperatures within the system, the age of the thermal oil and the method of light ends removal. However, for a fully automated automatic low-boiler removal system, such as our NALD, exemplary measurements could be carried out on a system with synthetic thermal oil. In this case, emissions only occur when a valve on the light ends removal opens to drain the condensed light ends into the collection tank. Nitrogen is added to re-pressurise the system. In the process, VOCs are released into the environment in approximately the same quantity as the nitrogen fed in. At each of these openings, around 20 litres of the gas mixture are released into the environment and this process usually takes place 5 times per hour. This means that 100 litres of gas are released into the environment every hour.

The measurements on a NALD without a built-in VOC remover showed loads in the order of 500 mg/m^3 for benzene. The buzzer of higher-boiling benzoalkyls was in the range between 800 and 1200 mg/m^3. The buzzer for all VOCs was in the range of 2500 mg/m^3. This results in an emission of 0.05 g/h for benzene. For emissions that are not discharged via a correspondingly high chimney, a de minimis limit value of 5.0 g/h applies here, above which the immission parameters of the plant must be determined in an authorisation procedure (TA Luft - Sections 4.6 and 5.5). It should be noted that the measured values vary significantly, i.e. emissions of over 5 g/h can also be possible for short periods. On average, however, the measured emissions were below the de minimis mass flow rates of TA-Luft even without filters.

In further tests, the loading with a built-in VOC remover was measured. The filter contains a highly adsorbent material that binds up to 95% of the emissions produced. The benzene emissions measured afterwards were in the range of 5 - 50 mg/m^3. Calculated over an hour, this means a maximum of 0.005 g/h. This means that the values are significantly reduced, even if they vary widely.

FILTERS AND LIFESPAN

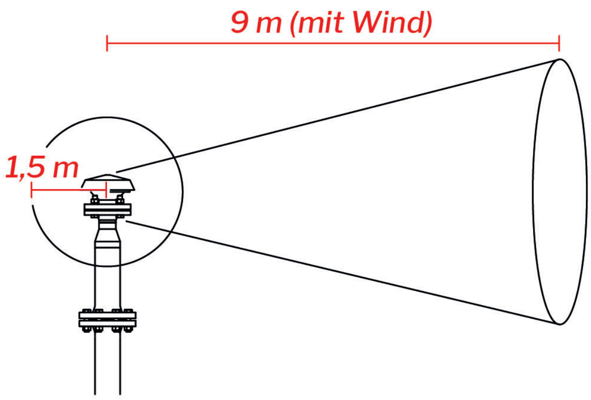
The filter consists of two parts, as well as an additional attachment kit for existing systems. One part is the filter housing with two flanges, which can be easily integrated into the outlet pipe of an existing NALD. The inside of the filter consists of a special cartridge that can be easily exchanged and returned for replacement. The 2500 mg/m^3 load of VOCs measured on average with the hourly blow-out quantity of 100 litres results in a mass flow of 0.25 g/h, of which an average of 0.2 g/h is separated. This already takes into account the decreasing filter performance over the service life of a cartridge. The filter cartridge can absorb around 440 g of VOC. It is therefore full after 3 months, cannot absorb any more VOCs and should be replaced.

WORKSPACE LIMIT VALUES

Although most ventilation ducts probably do not end near permanent workplaces, for the sake of completeness it is worth taking a look at the limit values that are permissible for workplaces. In the Technical Rules for Hazardous Substances: Risk-related concept of measures for activities involving carcinogenic substances (TRGS 910), two limit values are defined for carcinogenic substances such as benzene. The first limit value is called the acceptance concentration and represents a long-term limit below which a workplace is considered sufficiently safe. This concentration for benzene is 0.2 mg/m^3.

The second is the tolerance concentration, which can be tolerated for a short time. However, suitable countermeasures should be taken promptly to bring it back to the acceptable concentration. This is 1.6 mg/m^3 for benzene. The short-term emissions at the outlet of an automatic light-ends removal system can reach up to 5000 mg/m^3 in exceptional cases. In the case of spherical dispersion (i.e. when there is no wind) and good mixing with the surrounding air, the distance is then 3.25 metres until the concentration falls below the acceptance concentration. With wind from a corresponding direction and conical dispersion, the distance can increase to 20 metres. If, on the other hand, the VOC remover is used, the maximum distance in windy conditions is 9 metres, and if there is spherical dispersion around the deflagration flame arrester, the concentration falls below the acceptable level from a distance of 1.50 metres.

With integration of the VOC remover



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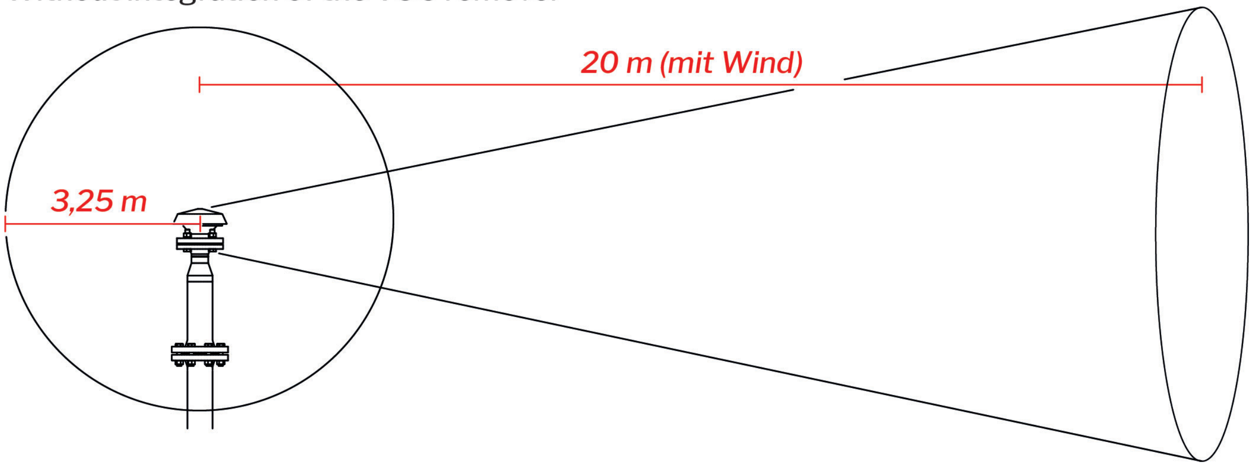

The situation becomes even more critical if the tolerance concentration is exceeded, as this risk is considered unacceptable. Without a filter, this can still be the case at a distance of 1.65 metres from the outlet opening in the case of spherical dispersion, while the concentration with the VOC remover is below the limit from 0.75 metres. This simple measure therefore reduces the distance from which the limit values are reached by more than half.

CONCLUSION

The discontinuous emissions at an automatic light-ends removal plant (NALD) can be converted to a continuous mass flow. In normal operation without a filter, this is generally below the de minimis mass flow of TA-Luft and therefore no immission measurements need to be carried out in the surrounding area. To be on the safe side and to use the best available technology in practice, we nevertheless recommend using the filter specially optimised for VOCs on a NALD. This reduces emissions to a minimum at a reasonable cost and employees are not exposed to any unnecessary risk.

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