

TIP 0416-09

ISSUED – 2002

□2002 TAPPI

The information and data contained in this document were prepared by a technical committee of the Association. The committee and the Association assume no liability or responsibility in connection with the use of such information or data, including but not limited to any liability under patent, copyright, or trade secret laws. The user is responsible for determining that this document is the most recent edition published.

TIP Category Automatically Periodically Reviewed (Five-year review)
TAPPI

Collection and burning of concentrated noncondensable gases: regulations, design and operation

Scope

Typical design and operating information concerning the collection and burning of Concentrated Noncondensable gases (CNCG) are included in this TIP. Aspects of the Cluster Rule regarding CNCG systems are also discussed.

These systems are also referred to as Low Volume, High Concentration (LVHC) Noncondensable gases (NCG).

It should be noted that there are also High Volume, Low Concentration (HVLC) NCG. These are not covered in this TIP.

Definitions

NCG Noncondensable gases are the gases that remain after water vapor has been condensed out of a vapor-laden stream.

In pulp mills, NCG are emitted from digesters, evaporators, turpentine systems, strippers, brown stock washers and liquor storage tanks. They contain TRS, nitrogen, oxygen, and traces of methanol, Turpentine and other HAP's, and are normally saturated with water vapor.

TRS Totally reduced sulfur. The gases involved are hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3) and dimethyl disulfide (CH_3SSCH_3).

CNCG refers to NCG that are collected in concentrated form. These gases come from blow heat recovery systems, turpentine recovery systems, continuous digester flash steam systems, and evaporator vacuum systems and hotwells.

HVLC refers to NCG that come from sources such as brown stock washer hoods and are collected in dilute form.

Cluster Rules. A combined collection of air and water pollution control rules that are “clustered” together to ensure that an improvement in one, does not result in deterioration of the other. That is, air pollution control cannot result in an increase in water pollution, and vice-versa. The Cluster Rules are designed to bring pulp mills up to MACT standards for HAP's.

HAP Hazardous Air Pollutant

MACT Maximum Achievable Control Technology.

LEL The Lower Explosive Limit is the lowest concentration of gas, by percent volume, that, when mixed with air, will

burn. At lower concentration there is insufficient gas to sustain combustion.

TIP 0416-09

Collection and burning of concentrated noncondensable / 2

gases: regulations, design and operation

UEL Upper Explosive Limit is the highest concentration of gas, that, when mixed with air, will burn. At higher

concentrations there is insufficient oxygen to sustain combustion.

LDAR Leak detection and repair. This is required on CNGC systems by the Cluster Rule.

SSM Every CNGC system must have a Startup, Shutdown and Malfunction plan, which is designed to minimize

emissions during such occasions.

Safety precautions

CNGC are highly toxic and are responsible for deaths and injuries in the pulp and paper industry. The toxicity of

hydrogen sulfide is well known. At 20 ppm it causes irritation of the eyes and respiratory tract. Thirty minutes of

exposure at 500 ppm causes severe sickness. Exposure at 1000 ppm for 30 minutes is fatal. The other components of

CNGC are similarly toxic. TRS concentration in CNGC is 100,000 ppm or greater.

Because these gases are toxic, great care must be taken in the design and construction of systems to handle these gases.

Gas leaks, especially in enclosed areas, must be avoided. Adequate venting must also be provided, such that when there

is an upset condition causing the gases to vent, the gases are released in a safe area and in a safe manner.

Vent stacks

should be as high as possible and clear of any buildings, platforms and ladders where personnel may travel, and well clear

of any ventilation air intakes.

Consideration should be given to installing hydrogen sulfide detectors in areas, especially inside enclosed buildings,

where leaks from the CNGC system may occur.

TRS, methanol and turpentine are flammable in the presence of sufficient oxygen, and if contained in a pipeline or vessel,

can be explosive. Table I shows the combustion properties of the main components of CNGC.

CNGC are normally not explosive due to lack of sufficient oxygen to support combustion. Thus, these CNGC systems

must be designed and operated to prevent ingress of air. No open flames or welding should be allowed on or around the

vessels or process lines of a CNGC system. All parts of a CNGC system should be properly grounded to prevent build

up of static electricity, which could lead to sparking that could ignite the CNGC.

If maintenance work is required on all or part of the CNGC system, the affected part must be isolated, drained, purged

with air or steam, and checked for the presence of toxic and flammable gases before entry or welding. As TRS is known

to adsorb onto, and then desorb from metal walls, welding should be done immediately after purging and testing for

combustibles.

Composition and volume of CNGC

Table II shows a typical analysis for CNGC on a dry basis. These gases come from blow heat recovery systems,

turpentine recovery systems, continuous digester flash steam condensers, evaporator vacuum systems, and hotwells. The

actual composition will vary widely from system to system, and from time to time within the same system. It should be noted that in CNCG, the TRS gases make up only about 50% of the volume. The largest component of

CNCG is air that has been depleted of 50% or more of its oxygen. Although some air enters the system by dissolving in

white and black liquors and is then stripped back out of them, most air enters through leaks in the system. The oxygen is

depleted by reacting with reducing agents, such as Na_2S , in the liquors that it contacts. The data shown is for a “tight”

system.

The volumes of gases to be collected vary greatly from mill to mill, and from time to time within each mill. Table III

shows the expected ranges of CNCG flow from various sources. It is always best to design on actual test data. If this is

not available, then conservative values should be used. Line sizes should be chosen to give a low pressure drop (0.4 to

1.0 inches w.c. per 100 ft. of pipe) (10-25 mm. w.c. per 30 m. of pipe) at peak flow conditions. If in doubt as to line size,

go larger.

3 / Collection and burning of concentrated noncondensable TIP 0416-09 gases: regulations, design and operation

Collected CNCG are typically at 140°F (60°C) or cooler. If the gases are hotter than this, the volume of the water of

saturation greatly increases the total volume of gas to be handled. This increases the line and equipment sizes required

for transport. Consideration should be given to cooling CNCG if the temperature is above 140°F (60°C).

Materials of construction

CNCG, are highly corrosive to carbon steel. These gases are normally saturated with water vapor, such that condensation

occurs in the collection system. Some of the TRS gases, especially H_2S and CH_3SH are acidic, and will absorb in the

condensate formed. The combination of this acidic condensate, along with the oxygen present in the CNCG, can be very

corrosive to carbon steel. Therefore, carbon steel should be avoided in CNCG collection systems.

Other components of CNCG, especially turpentine and methanol, are very strong solvents and can dissolve or soften

plastics or resin in Fiberglass Reinforced Plastic (FRP) piping. Therefore, plastics or FRP should also be avoided in

CNCG collection systems. Further, FRP should be avoided because of potential failure during a fire started by CNCG

ignition.

Stainless steel, especially of the 300 series, typically 304 or 316, has proven to be corrosion resistant to CNCG and is the

preferred material of construction for CNCG systems.

Explosive nature of CNCG

Unfortunately, the terms LEL and UEL only explain the situation in theoretical terms. In reality, CNCG gases, as

emitted, are mixed with air that has most of its oxygen depleted, such that the gases are not explosive.

Figure I illustrates

this situation. It is based on some test data and the assumption that mixed TRS gases, which also contain other

combustibles such as MeOH and turpentine, are flammable over the range of 2% to 50% for all combustibles

Point A on Figure I is the pure air case with 21% oxygen, 0% combustible. Point B is the pure combustible case with 100% combustible and 0% oxygen. The two points, C and D, on Line AB represent the LEL and UEL respectively.

The shaded area under CD represents the range of mixtures that are explosive. . The exact shape of this shaded area has

not been determined, and will vary depending on the TRS components present.

Point E represents a typical concentrated CNCG mixture, which is well outside the explosive range.

However, as air is

added, the mixture moves along Line AE towards Point A. At some point, if enough air is added, the gases will enter the explosive range.

Another characteristic of flammable gases is flame propagation speed. This is a measure of how fast the flame will travel

through the pipeline or vessel once a fire is started. See Table I. The flame propagation speed for sulfur gases is

relatively slow. However, the flame propagation speed for turpentine compounds is extremely fast. The value reported in

Table I for alpha-pinene, which is the primary compound in turpentine, is currently being disputed by some experts in the

field, who claim the speed is much slower. Regardless, explosions caused by TRS are usually minor, with minimum

damage, while explosions caused by turpentine can be catastrophic.

It should be noted that the flame propagation speeds listed in Table I are based on pure compounds in pure air.

It should also be noted that while CNCG systems are designed to handle the flame propagation speed of TRS, it is not

practical to design against the flame propagation speed of turpentine. For this reason, it is very important to minimize the

amount of turpentine entering the CNCG system.

System design

See Figure II.

The system must be designed to prevent ingress of air into the system. This is done by sealing all parts of the system to

make them airtight. However, a sealed system can be exposed to high pressure or vacuum under upset conditions. Most