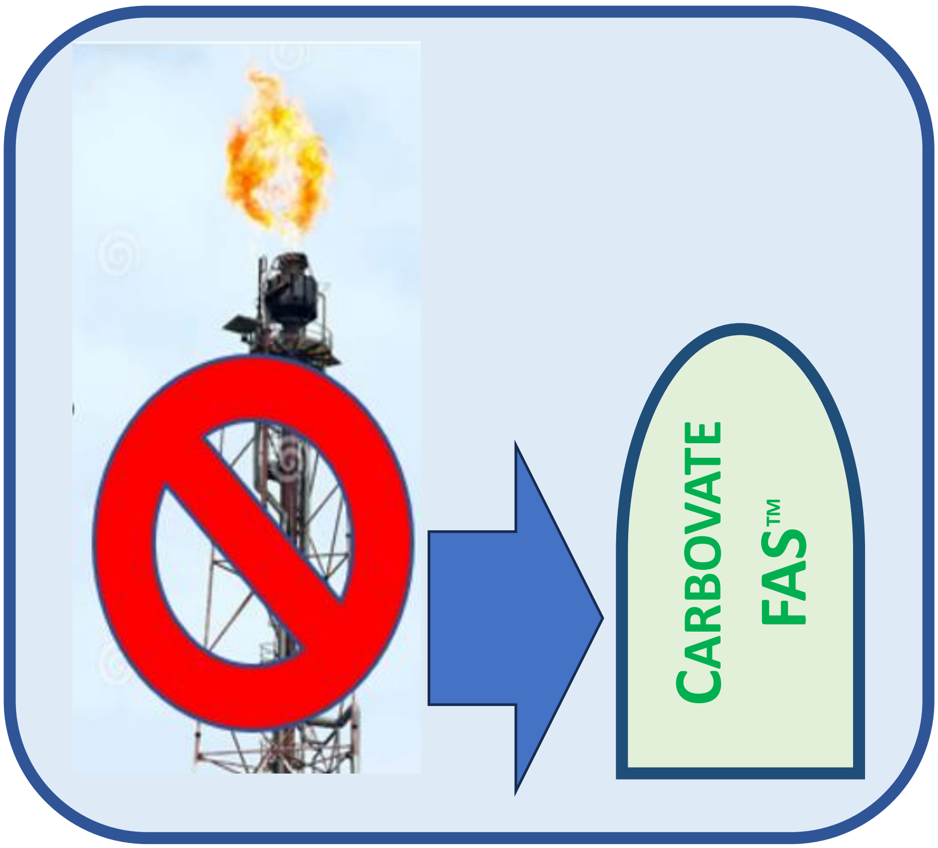
CARBOVATE DEVELOPMENT CORP.
Innovative Carbon Materials Solutions

CARBOVATE – Flare Alternative System (FAS)

Process Overview



Author, Ed Brost
Document Classification Level 4

CARBOVATE DEVELOPMENT CORP.
Innovative Carbon Materials Solutions

CARBOVATE FAS- Process Overview©[1]

Introduction

CARBOVATE DEVELOPMENT CORP. has developed and patented[2] a novel process to replace a flare system for certain industrial processes. See the Appendix for a short list of candidate processes. The alternative to a flare process uses the physical properties of fluids in the system to enable a self-regulating feature in terms of volume and pressure. These characteristics reduce the containment vessel physical size and therefore the system cost.

This alternative to a flare, referred to as the **CARBOVATE FAS**, when armed and in service is completely **passive**. That means it does not require any power, water, utilities of any kind and does not require operator intervention. Unlike a flare, the design captures and quarantines relieved materials allowing the captured materials to be processed into products rather than burned and dispersed into the atmosphere as is the case for a flare system.

1. CARBOVATE FAS Overview

Carbovate's flare alternative is based on the idea that fluids would be routed to a containment vessel following an emergency or planned event rather than to a conventional flare.

The CARBOVATE FAS concept is analogous to a storm water impoundment pond. During non-rain and normal operation, a storm pond is at low level. During abnormally heavy rain events, without a storm pond, sewer systems could overflow allowing untreated water to flow to a receiving water way. However, if the water management system includes a storm pond, the excess water is routed to the storm pond. The captured and quarantined excess water in the storm pond can be processed after the storm subsides and at a rate consistent with the treatment plant capacity. Nothing is released to the receiving waterway.

As with a storm pond, relieved fluids are captured and quarantined by the CARBOVATE FAS in a containment vessel for reprocessing after the event and at rates achievable by the facility.

The simplicity of this ***passive*** relief and containment system may lead to a lower risk approach to over-pressure protection than a conventional flare system that depends on numerous 'active' systems and sub-systems to ensure flare availability and performance.

Capture of relieved material during an over-pressure event avoids emissions associated with a flare because they are not burned to CO_2 and other air contaminants. Further, this eliminates fuel requirements and chronic emissions associated with a 24/7 pilot flame operation. Finally, since nothing is released to the atmosphere there is no reporting requirement due to releasing material to a flare system.

The CARBOVATE FAS process is suitable for processes handling volatile liquids including but not limited to alcohols, ethers, glycols, gasoline, gasoline components, and volatile chemicals such as benzene, toluene,

---

[2] Patents US20230265974A1 US20230264942A1 US11852299B2

xylene, ethylbenzene etc. The system can handle small amounts of gases[3] provided the Containment Vessel design reflects the anticipated gas content. The CARBOVATE FAS system is not suitable for processes dominated by gases. such as hydrogen, nitrogen, and light hydrocarbons.

The Carbovate FAS concept is predicated on a relief system using a Containment Vessel operated under vacuum. The underlying reason behind employing an evacuated vessel is to ensure the rapid and ***passive flow*** of relief materials (gas, vapour, and liquids) from the threatened equipment to the containment vessel. Critically important, the Containment Vessel and the fluid(s) selected by Carbovate enable the self-regulating characteristics of the process. [4] This results in an end state pressure following an event is the same or lower than if the equipment was connected to a convention flare header.

From a process unit perspective, it ***'looks'*** like a conventional flare header. By this, we mean the processes upstream of the PSVs would respond the same regardless of whether the relief is to a flare header or the Carbovate FAS vent line. Therefore, equipment design upstream of the relief systems would be the same as if they were to relieve to a flare. This also means that retrofitting existing equipment amenable to protection by the CARBOVATE FAS currently protected by a flare should be easy.

2. The CARBOVATE FAS– in the "Armed" State

The CARBOVATE FAS Containment Vessel in the ready, or "armed" state is under a modest vacuum. The pressure, head space volume and composition are governed by the physical properties of the fluid(s) used to 'arm' the system. The vacuum ensures passive fluid flow from the over-pressurized equipment to the Containment Vessel. Vessel pressure will decay and approach atmospheric pressure as the depressuring event subsides. The capacity of the system to contain relieved materials is governed by the physical properties of fluid(s) in the armed Containment Vessel as well as the physical size of the Containment Vessel.

The fluid(s) used in the armed Containment Vessel state facilitates capture of relieved vapours that significantly exceeds the physical volume of the vessel.

2.1 Creating the Containment Vessel Vacuum

The vacuum is developed using a very low vapour pressure fluid, typically an oil or a similar liquid. Creating the vacuum is achieved by liquid filling the vessel with oil to ensure no air, or gases remain in the Containment Vessel. The oil is then pumped from the vessel to create a deep vacuum in the Containment Vessel. This step causes a very small headspace (oil vapour) volume at the top of the vessel but under deep vacuum.

2.2 Creating the Containment Vessel Evacuated Head Space Volume

The very low vapour pressure properties of the oil results in a headspace, or vapour space, volume that is inadequate to accommodate the expected relieved volume from protected equipment. To create the required head space volume while maintaining vacuum conditions a small amount of a light liquid, is admitted to the Containment Vessel. This light liquid is used to achieve the target headspace volume in the Containment Vessel.

The light liquid is selected for its high vapour pressure relative to the oil. The light liquid will flash to a gas when admitted into the Containment Vessel since the headspace is under deep vacuum created by

[3] Non-condensable gas and vapours are fluids that are in the gas state at normal temperatures and pressures.
[4] This self-regulating feature significantly reduces the physical size of the Containment Vessel.

pumping oil from the Containment Vessel. As the light liquid is added, the pressure will rise, allowing more oil to be pumped from the vessel to maintain vacuum conditions inside the vessel. Adding light liquid and removing oil continues until ***both*** the target pressure (vacuum) ***AND*** headspace volume is achieved. This is the '**armed**' state.

The CARBOVATE FAS relief header, analogous to a flare header, connects the Containment Vessel to the protected equipment Pressure Safety Valves (PSV)s or rupture disks[5].

Closing all accesses to the vessel, other than the relief header, will maintain vacuum without any other inputs, i.e., a passive system when 'armed.' Other than ambient temperature variations, a chronic vacuum decay would indicate a leak, potentially a leaking PSV.

3. System Response to an Over Pressure Event

Should a PSV open (or rupture disk burst), flow from the protected equipment to the Containment Vessel will immediately begin due to the low pressure (vacuum) on the downstream side of the PSV. If necessary, relieved material may be cooled by using an optional passive finned air-cooled heat exchanger.

As the cooled relieved fluids enter the containment vessel, the armed state vacuum will decay, i.e., the pressure will increase.

As the pressure increases, the light material, which is in a gas/vapour state, occupying the headspace would begin to condense. Condensation of the light material to form a light liquid result in the tendency of the systems headspace volume[6] and pressure to be maintained. This tendency partially offsets the space required by the relieving fluids entering the vessel. This self-regulating tendency affects both headspace volume and vessel vacuum. While this self-regulating volume and pressure offset occurs, the relieved fluid flow rate would also decay because of dropping pressure in the over-pressured equipment.

As the Containment Vessel vacuum decays (increasing pressure) the heavier vaporized relief material components will also condense and tend to preserve headspace volume and pressure. The condensed liquids would fall into the sponge oil heel and dissolve in the sponge oil.

4. System Recovery following an Over Pressure Event

Following a relief event, i.e., recovery mode, fresh oil would be pumped into the Containment Vessel. This will raise the vessel's pressure causing residual condensables to condense and dissolve in the oil. After reaching the target pressure, the oil, with its load of dissolved relief material, can be pumped to storage for reprocessing and sale.

Following displacement and purging the Containment Vessel of relieved materials the system is ready for rearming following the procedure described in section **2 - The Carbovate FAS– in the "Armed" State** .

---

[5] A rupture disk is a pressure limiting device. Rupture disks are typically a metal disk inserted into the body of a vessel with the inside of the vessel on one side of the disk and the other side connected to a safe relief header. Should an overpressure event occur the disk ruptures allowing the overpressure fluids to flow to a safe location such as the Carbovate FAS, flare, or to atmosphere if the fluids are non-hazardous.

[6] A light hydrocarbon vapour occupies about 300 times as much volume as the same mass of material occupies in the liquid state at a given temperature and pressure. As relieved material flows into the Containment Vessel causing a pressure rise and condensation of the light material, headspace pressure and volume tend to be maintained.

5. Maintenance Support Mode

The CARBOVATE FAS concept is amenable to supporting limited maintenance operations. Limited operation in the sense that the CARBOVATE FAS unit is not available[7] for any other service while in maintenance support mode. In other words, the unit can be used in Maintenance Mode when the plant is shut down, making the CARBOVATE FAS system available to support activities such as steaming out equipment, including preparation for equipment opening and entry.

Following removal of the water, the Containment Vessel and associated equipment may be re-armed for return to service per section **2 - The Carbovate FAS– in the "Armed" State** .

6. Managing non-Condensables

The CARBOVATE FAS system is not a practical control system for processes containing a high content of non-condensable materials, such as CO, CO_2, C4 or lighter hydrocarbons, H_2S, hydrogen, nitrogen etc. However, the concept can be 'tuned' to accommodate higher non-condensable content applications.

Appendix - Potential Applications for a CARBOVATOR FAS

Petroleum Refinery and Chemical Plant Units

- BTX/EB Distillation
- Alkylation
- Distillation Units processing C5 and heavier
    - Atmospheric and Vacuum
    - De-isohexnizer
    - Naphtha splitter
    - Reformate splitter
- Jet treater/Merox
- Conversion Unit Fractionators with upstream pre-flash or light ends removal
- Alcohol distillation
- Glycol distillation

Maintenace Support

- Prepare equipment for maintenance and entry without flaring.
- Process unit preparation for maintenance without flaring.
- Mobile CARBOVATE FAS to support planned maintenance and unit shutdown activities.

Plant Protection

- Protecting suitable process units with a CARBOVATE FAS unit would free up flare capacity.
    - Allow for expansion of existing units.
    - Addition of new process units at sites with flare capacity limitations.
- Reduce load on an existing flare system.
- Single process Unit protection.

[7] This constraint could be eliminated by including a spare Recovery Vessel.