Safe and sound

W. N. Tuttle and J. W. Young, Warner Nicholson Engineering Consultants, USA, discuss overlooked aspects of safety requirements for marine vapour control systems.

With the advent of clean air standards throughout the world, emphasis has been placed on the reduction of the formation of ground level photochemical pollutants. Ozone, a photochemical compound, was one of the first pollutants listed for reduction because it is a chief constituent of smog. To reduce the formation of ground level ozone, precursors that are required for its formation, such as volatile organic compounds (VOCs) were targeted for control. VOCs emitted during the loading of transportation vehicles with volatile products have been a major focus for environmental control regulations. First road tankers and then rail tankers were mandated for control. In the late 1980s, there was an effort to include marine loading in the vapour control arena. Authorities responsible for marine safety of personnel, marine vessels and facilities were reluctant at first to allow vapour control, believing it to be difficult to ensure adequate safety.

Marine vapour control safety regulations

In 1990, the first safety regulations required for marine vapour control systems (MVCS) were promulgated in the USA. Enforcement of these safety regulations was under the jurisdiction of the United States Coast Guard (USCG), at that time, a division of the US Department of Transportation. The regulations originally required MVCS safety requirements for facilities that loaded certain regulated volatile cargoes such as motor gasoline, crude oil or benzene. As the number of regulated VOCs increased, the USCG safety requirements have been expanded to encompass the additional cargo vapours.

The regulations are divided into 15 major categories with references to other USCG and International Maritime Organisation (IMO) regulations. Some of the crucial topics are vapour line connections, facility requirements for vessel liquid overfill protection, vessel pressure protection, and cargo vapour conditioning. Other categories include fire, explosion, and detonation protection, specific equipment requirements for flame and detonation arrestors, vapour compressors and blowers, and vapour recovery and vapour destruction units. There are also categories for personnel training and operational requirements.

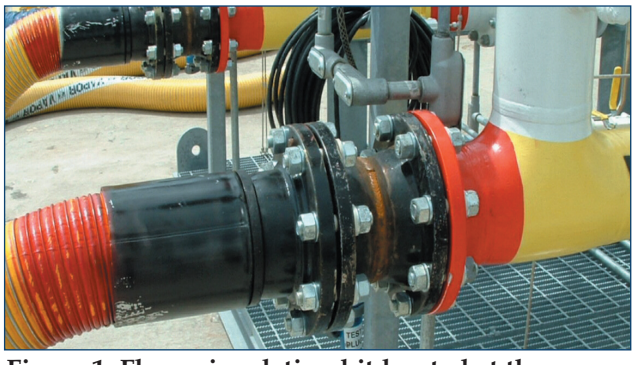

Figure 1. Flange insulating kit located at the interface of the facility vapour piping and the vapour hose.

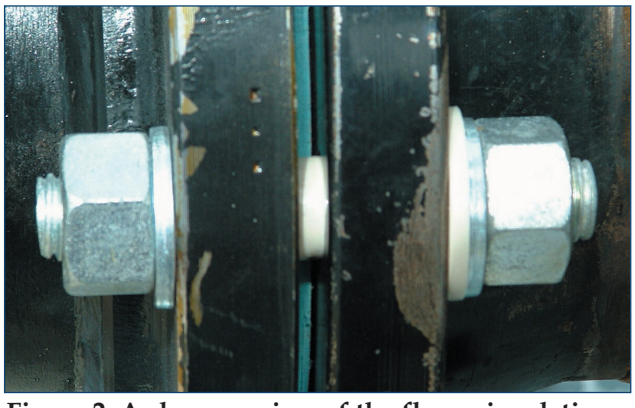

Figure 2. A close-up view of the flange insulating kit seen in Figure 1. Notice the white insulators around the flange bolt and between the flange and the metal washer.

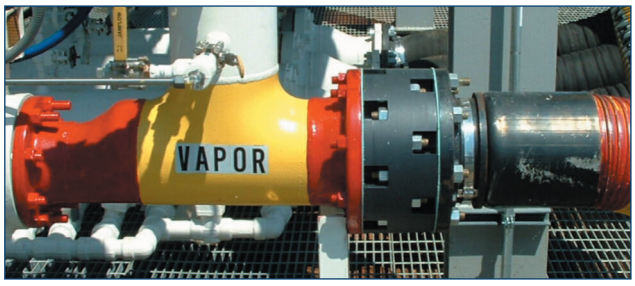

Figure 3. Insulating flange spool located at the interface of the facility vapour piping and the vapour hose. Notice the offset bolting arrangement.

Figure 4. Non-conductive cover installed on the vapour hose.

Figure 5. Close-up of the permanently attached pin on the facility vapour connection. Notice the insulating kit, the white insulating washers are visible.

With the success of these safety regulations and the methods and procedures provided for, many authorities around the world, charged with marine safety, have been studying them. Some authorities have adopted many of the general provisions as found in the MVCS safety regulations for application within their jurisdictions.

The USCG regulations concerning the safety of MVCS are found under 33 CFR 154 subpart E.

Certifying entity

A provision of the USCG safety regulations is for third party inspection and certification of MVCS. A certifying entity (CE) is an individual or organisation accepted by the USCG commandant to 'review plans and calculations for vapour control systems.' Additionally, the CE cannot be involved in the design or installation of the specific facility. The CE must conduct all initial inspections and witness tests required to demonstrate that the facility:

- Conforms to certified plans and specifications.
- Meets the requirements of the applicable regulations.
- Operates properly.

Once the facility complies with these three items, the CE writes a certification letter stating that the facility complies with the applicable regulations. This letter is addressed to the USCG captain of the port (COTP) with jurisdiction over the geographical location of the facility and to the USCG marine safety office (MSO) in Washington DC. If acceptable, the COTP issues a letter of adequacy to the facility indicating that the MVCS is acceptable for collecting and processing the designated cargo vapours.

Common issues

The authors of this article are principals of a firm approved by the USCG as a CE and have worked on numerous certification projects over the past five years. They have noted that there are certain issues that reccur at facilities being certified. These issues fall into the general categories outlined below.

Improper vapour hose electrical isolation

33 CFR154.810 outlines the requirements for the vapour line connections. Subparagraph (g) states the dockside facility vapour connection must be electrically insulated from the vessel vapour connection. The safety concern addressed by this requirement is static electricity discharge between the vessel vapour connection and the vapour hose or arm during connection or separation. Since the vapour line may contain vapours in the flammable range, it is critical that there is no source of ignition during these operations. Paragraph (d)(4) also requires that a vapour hose be electrically continuous (≤ 10 000 ohms).

When a vapour hose is used, an insulating flange is typically installed between the vapour hose and the facility vapour connection to meet this requirement. There are two types of insulating flange configurations in use, an insulating flange kit, that incorporates insulating washers and bolt stud insulators, shown in Figure 1 with a close-up in Figure 2. The second is an insulating flange spool of non-conductive material shown in Figure 3.

The construction of the typical vapour hose includes heavy gauge external coiled reinforcing wire running the length of the hose that also provides electrical continuity. This wire can be seen in Figures 1 and 4. Once the hose is connected to the vessel, it is electrically continuous with the vessel and insulated from the dock equipment. However, many times the hose inadvertently contacts metal components on the dock, and bypasses the insulating flange. Care should be taken so that the vapour hose does not circumvent the insulating flange during cargo transfer. If the vapour hose is positioned on the dock, it must be placed so it does not contact any dock equipment. A non-conductive cover, as seen in Figure 4, may be installed to prevent electrical contact with items on the dock.

Another common problem has been with the pin permanently attached to the facility vapour connection flange as prescribed by 33 CFR 154.810 (c) and shown in Figure 5. This pin can be slightly bent and improperly aligned with the hole in the vapour hose flange, defeating the isolation of the vapour hose through the contact of the pin and the vapour hose flange. Usually this can be corrected by simply straightening the pin so that it is centered.

Other problems include:

- When a vapour hose is suspended by a dock-mounted crane using conductive cables, a non-conductive strap or sling should be used to contact the vapour hose.
- Elevated facility vapour connections should be positioned so that the draped hose does not contact the metal dock structures, including platforms, handrails and stairs during any portion of the transfer.
- Shifting of the vapour hose because the marine vessel, as it fills, changes elevation relative to the dock. Care should be exercised that this movement does not cause

the vapour hose to come into contact with metal items on the dock.

Qualitative failure analysis (QFA)

Part of the regulatory requirements, per 33 CFR 154.804 (d), is that each MVCS design must include a QFA that demonstrates:

- The design can operate continuously and safely over the expected cargo transfer rates.
- The MVCS is provided with proper alarm and controls to prevent unsafe operation.
- The MVCS is equipped with sufficient automatic or passive devices to minimise damage in the event of an accident.
- If a quantitative failure analysis is also performed, the level of safety attained must be at least one magnitude greater than calculated for operating without a MVCS.

When a QFA is performed, a team using 'what if scenarios' determines if any changes or modifications must be made to the final design. Most often, the recommendations are followed and the changes/modifications implemented. However, there are times when the recommendations are considered unnecessary and simply ignored. Documentation should be included in the QFA that specifically addresses recommendations that were not implemented and the reason for non-implementation.

For example, one installation involved an MVCS that utilised a vapour destruction device. The device was properly located away from the dock in a safe area. The QFA recommended that a UV fire detection system be installed to monitor the vapour destruction device. A vapour destruction device is a modified flare with a flame that may occasionally become visible. Additionally, a smoking shed for the operators and barge crews was located in the same area. A fire sensing system of the type recommended would probably have caused many nuisance alarms and did not make good operational sense when considering the overall installation. However, this recommendation was not removed from the QFA and was not implemented, it became part of the final design documentation. During the certification inspection, the installation did not comply with the final design documentation.

Maximum cargo transfer rate control

33 CFR154.850 (g) states that the maximum cargo transfer rate cannot exceed the lesser of the maximum vapour processing rate of the shore side vapour control equipment per §154.3 and the relieving capacity of the cargo tank pressure/vacuum relief valves, 46 CFR 39.30-1(d). In either case, the cargo transfer rate must be known so that this maximum transfer rate is not exceeded during loading. Additionally, the regulations require a pre-load conference where the respective maximum loading rates are disclosed and an agreed upon transfer rate is established. Transfer rates higher than the maximum rate could result in over-pressurisation and rupture of the cargo tank.

Prior to the implementation MVCS at marine facilities, the maximum cargo transfer rate was limited only by the physical restrictions of the shore side liquid transfer equipment, the marine vessel pressure limits and the piping system. As a result, many terminals that previously did not monitor the cargo transfer rate must now implement procedures or install new equipment to monitor cargo transfer rates. This is necessary so that the capacities of the vapour control system and the pressure relief valves on the marine cargo tank are not exceeded. Facilities installing new MVCS should review their procedures for determination of the cargo transfer rates and ensure that these rates can be monitored and responded to quickly once the MVCS is installed.

Pressure drop calculations

The CE has the responsibility to review all plans and calculations per 33 CFR 154.802 and 33 CFR 154.804(e). Among the crucial calculations are the pressure drop calculations for the facility vapour collection system. The designer is required by 33 CFR 154.814(a), to ensure that the facility vapour collection system has the capacity to collect cargo vapours at a rate no less than 1.25 times the facility's maximum liquid transfer rate, plus any conditioning gas injection. Provisions are made for liquid cargoes with low vapour growth factors during turbulent loading.

Many times the designers utilise isometric drawings for the vapour collection piping that do not coincide with what is actually installed. Actual distances, pipe size changes and the number and type of pipe fittings do not correlate. Therefore, the equivalent pipe length used in the calculations may be incorrect and the resulting pressure drop calculations would be invalid.

Location of initial safety devices

33 CFR 154.820 and §154.824 require that a detonation arrestor (DA) and the conditioning gas injection point (if required) be no more than 6 m (19.7 ft) and 10 m (32.8 ft) respectively from the facility vapour connection. These distances are actual piping lengths and not a direct measurement. The aim is to minimise the length of unprotected vapour piping.

Many marine loading facilities find it impossible or impractical to place these items within the distances required and still be able to access dock equipment. In other instances, placement of these items within the distances specified could cause additional hazards by blocking or otherwise limiting personnel access routes. The USCG has granted exemptions to this aspect of the regulations, based on the merits of each case. An exemption to the required maximum distances may be obtained with the submittal of proper documentation and an explanation of the rationale for an alternate location.

Most often problems arise not from receiving an exemption, but from underestimating the revised distance. It has been found that the source of the error is twofold. Sometimes the designer overlooks a component on the dock that the actual vapour piping will need to be routed around, extending the piping distance beyond the length requested and granted. In other installations, the designer fails to communicate the planned vapour pipe route to the equipment installers. In either case, the certification of the vapour control system is delayed until a second exemption is granted or changes to the actual piping are made in the field.

Conclusion

Another critical issue that has been witnessed numerous times is the reluctance of the owner/operator to ask questions of the regulatory agency or certifying entity. The overriding concern of the regulations is safety, and the owner/operator has the right and should feel free to ask as many questions as necessary to clarify any points within the applicable regulations.

Choose a CE early in the project and have them clarify the various issues and questions about the regulations as they arise. Keep in mind that the CE cannot be involved in the design or installation of the MVCS. If the CE proves to be uncooperative or unwilling to answer your questions, you will have time to choose another CE before the project is completed.

Addressing the issues discussed in this article, prior to the onsite inspection, will facilitate the certification process and aid in reducing extra expenditures of time and money.