Urea Supply Systems for Multi-engine SCR Systems

Introduction

The size of on-site power systems is continually increasing. It is not unusual to see a hospital with over 5 MW's of emergency standby power. Water pumping stations can have over 10 MW of emergency standby power and large data centers often have over 20 MW of standby power. With the low price of natural gas we are seeing large scale natural gas engines being used in Combined Heat and Power (CHP) installations. CHP plants can often be over 5 MW in size. Large on-site power installations have multi-engine installations to deal, not only with the high levels of required electrical power, but also with the need for increased reliability. Increasingly these large sites have Selective Catalytic Reduction (SCR) systems to deal with the high potential levels of NOx that are emitted when the engines are tested. The requirement for SCR's is especially relevant when the local air board looks at the worst case 1 hour average as required by the National Ambient Air Quality Standards (NAAQS). SCR systems work by injecting urea into the exhaust system to convert NOx into harmless Nitrogen and water vapor. Multi-engine SCR systems require Urea Supply Systems that must take into account unique urea liquid issues, the reliable delivery of the liquid and finally ease of use for the operators of the facility. The specialized nature of Urea Supply Systems can make it desirable for the SCR system vendor to include the Urea Supply System in his scope. As an SCR system vendor, Safety Power has done the design of many different Urea Supply Systems for multi-engine SCR installations. This article describes some of the considerations required for an effective design.

Urea Liquid Considerations

In North America urea is usually specified as Diesel Exhaust Fluid (DEF). In Europe, urea is typically specified as Adblue. Both Adblue and DEF have urea salt dissolved in demineralized water. For DEF and Adblue the urea concentration is 32.5% by weight. The freezing point is 12 degrees Fahrenheit or -11 degrees Celsius. While freezing does not make the urea unusable, care should be taken to avoid freezing because of damage that it can cause to piping and downstream SCR injection equipment. Other concentrations of urea are commercially available. If a concentration other than 32.5% is to be used, be sure your SCR vendor's system can be setup to use it. Avoid the use of agricultural grade urea because it typically does not use demineralized water. Agricultural grade urea will plug urea injectors over time. DEF is available in bulk, 1100 litre totes, 205 litre drums and 22 litre pails. If the urea is to be supplied by a bulk tanker a remote fill station as described in more detail later in this article may be required.

Unlike CHP systems, onsite power systems that are used for emergency standby usually do not operate frequently. As a result it is not unusual to see urea stored onsite for several years before requiring a refill. In one installation Safety Power has seen the urea quality change from 32.5% to over 41% as a result of evaporative losses. It is extremely important that correctly specified breather valves be installed on the urea storage tanks. The breather valves must allow air inflow when tanks are being emptied but must ensure there are minimal evaporative losses due to the liquid's vapor pressure. Nonetheless, even with the correct breather valves, for standby emergency power applications it is inevitable that there will be urea quality changes over time due to evaporative losses. Be sure your SCR

vendor has an online urea quality sensor and takes into account urea quality changes in his closed loop injection control system. It is also important that the SCR vendor provides an alarm notification when the urea quality drifts too far from specification. When such an alarm occurs it is usually due to high urea concentration. The operational fix is then to simply add demineralized water to the storage tank.

Storage Tank Considerations

Multi-engine SCR systems can have numerous different urea tank configurations depending on the available space and local operational requirements. Specifying engineers are typically requesting urea storage capacity that matches fuel capacity (in the case of liquid fuel), which is usually between 48 and 120 hours of operational capacity at full load. Regardless of tank configuration it is important for urea liquid temperature to be taken into account under cold weather conditions. If a tank is located outdoors in a cold climate it will likely require heat tracing and insulation as will any associated outdoor piping and valves. In addition the selection of tank material is important. If the tanks will not be subject to high static head pressure, High Density Polyethylene (HDPE) would be an acceptable construction material. While urea is a relatively benign substance, PVC or other materials containing chlorides should be avoided due to the harmful interaction with urea. Brass fittings or any material containing copper must be avoided. Urea quickly dissolves copper and any of its alloys. Safety Power have seen installations where the mechanical designer carefully avoided copper piping, but the instrumentation designer specified level sensors with brass components – they didn't last long.

If the tanks are subject to high static head (ie the tanks are located in a basement and the fill point is at street level) there may be a pressure concern in the event they are overfilled. For these applications stainless steel, rated for the head pressure, should be used as the tank material. Consideration must also be given to the venting strategy. Safety Power typically prefers to have the vent come out through the fill station as a failsafe in the event the level alarm is ignored by the bulk tank truck driver. It is important to check with local regulatory authorities to see if the tanks must be classified as pressure vessels and as a result may require specific ASME certification.

Large tanks or tanks installed in equipment rooms should have a means of leak detection and/or leak containment. Where there is a requirement for double walled tanks the leak detection should be located in the interstitial cavity. The vast majority of installations will have urea level monitoring specified. The urea level indication is often fed into the client's Building Automation System (BAS) so that the building operator can be notified when urea level is low. Where there is a separate Urea Fill Station it is important that a high level alarm is provided at the Fill Station so that the bulk tank truck driver is notified to stop the fill.

Each type of tank configuration has its associated set of advantages and trade-offs. Some of the types of configurations Safety Power has designed include:

(1) One tank per SCR. Where space and handling permits, a 1100 litre urea tote can be used in place of the permanent tank to further reduce costs. This type of installation also works well when there is not enough room for a larger common storage tank. A common approach for using one tank per SCR would be a multi-engine installation where each engine is in a pre-built

outdoor enclosure. A dedicated tank can then be located close to the individual enclosure. A disadvantage with this approach is that an operator must fill multiple tanks. Also depending on the local requirements, relatively expensive leak detection systems may be required at each small tank. Instrumentation for urea level monitoring must also be replicated in each tank, unless the operator is prepared to do a regular visual scan. An outdoor heated and insulated tank that supplies urea for a 1.7MW enclosure mounted SCR is shown in Figure 1. An indoor urea tank that supplies urea for a 1.8MW engine is shown in Figure 2.

Figure 1
Outdoor Urea Tank Heated and Insulated

Figure 2
Indoor Urea Tank

(2) A shared tank or shared tanks. Sometimes a single shared tank is used and sometimes 2 or more shared tanks are used. The use of multiple shared tanks allows one tank to be taken out of service without affecting the entire urea supply system. The use of multiple shared tanks may also be advantageous if there is insufficient space for a single large tank.

(3) Day tank. If used, a day tank is typically located close to the SCR Control Panel(s). The Day Tank provides a minimum run time for urea supply in the event that a urea transfer pump fails. If a Day Tank is not used a urea supply loop provides the urea to the SCR Control Panel(s). The Day Tank will need level measuring instrumentation so that it can control a transfer pump to ensure an adequate level of urea is maintained in it. Safety Power has used Day Tanks made of HDPE or Stainless Steel – depending on the static pressure.

Urea Fill Station

Large multi-engine onsite power installations often have large urea storage requirements. Typically a large urea tank is fed through a Urea Fill Station at ground level by a bulk tanker truck. In North America the most common connection for the urea bulk truck would be through a 2” camlock fitting in the Fill Station. As mentioned before, it is important that there be a high level alarm indication in the Fill Station. Safety Power will typically vent the tank through to the Fill Station as a failsafe. If in an outdoor

location the Urea Fill Station will need to be heat traced. Be sure to pick a vendor who has experience in designing a Urea Fill Station. Safety Power has a standard product that has a high level alarm, is lockable and has clear signage for the fill operator. An example of a Fill Station installed at an existing site is shown in Figure 3.

Figure 3
Urea Fill Station

Urea Transfer Pump Configurations

Inside each SCR Control Panel (shown in Figure 2 beside the urea tank) is an injection pump which will meter the correct amount of urea into the engine exhaust. This injection pump will typically have a limited suction head. As a result, if the urea supply tank is located relatively far away or at a lower elevation than the SCR Control Panel, it may be necessary to have a transfer pump that delivers urea from the storage tank to the SCR Control Panel. If a Day Tank is used, typically there is a gravity feed from the Day Tank to the SCR Control Panel, but nonetheless, a urea transfer pump will likely be required between the main Urea Storage Tank and the Day Tank.

Safety Power has designed many types of urea transfer systems. The following urea transfer pump configurations are the most common in our experience:

(1) No transfer pump. Where the SCR Control Panels can be gravity fed or if the suction head is relatively small, a urea transfer pump is not required. This would typically be the case for enclosure mounted gensets. The SCR Control Panel would usually be in the enclosure and the urea tank would be at ground level. Under these circumstances the SCR Injection pump can deal with the relatively small suction head requirements.

(2) Simplex transfer pump. For a multi-engine SCR installation using simplex pumps there would be one transfer pump per SCR. The transfer pump would be located close to the urea storage tank. The transfer pump is sized so that it delivers the required discharge head and the necessary urea flow volume. It is important that the transfer pump be equipped with strainers that are suitable for urea service. Ensure the pump is supplied with electricity from a secure supply so that the system is functional when the facility is operating on standby power. The pump should be setup so that it only runs when the engine runs to save electricity. It is highly desirable to have a panel

mounted booster pump system to save valuable floor space – for example the transfer pump controller shown in Figure 4 has the pump built into the panel making the unit compact and easy to install. It is best to pick a vendor who has experience with urea transfer systems. Often vendors who do fuel transfer systems are selected – they may not have experience with the unique attributes of urea that affect pump selection.

Figure 4
Simplex Transfer Pump
(Pump is in the Panel)

(3) Duplex transfer pump. Instead of having one transfer pump per engine another approach is to have a duplex transfer pump system. In the event of failure of one of the pumps a backup pump takes over. Any installation that has more than 3 SCR systems is likely best served by a duplex transfer pump system instead of separate simplex systems. Ensure the system has pressure gauges installed on it so that maintenance staff can verify how each pump is operating.

In Summary

Large multiple engine installations with SCR's require an effective urea supply system. There are many possible configurations related to tankage, fill stations and transfer pumps. It is important to select a

vendor with experience in urea supply systems. If the SCR system vendor has experience in urea supply systems there can be a benefit to having that vendor also handle the urea supply system – this makes one vendor responsible for the functioning of the overall system.

About the Author

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