SAFETY ON AMMONIA BARGES

The refrigeration system maintains the cargo at 0 lb./sq.in. gauge; U.S. Coast Guard regulations are followed

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In this discussion of the safety aspects of the refrigeration on ammonia barges a few ground rules will be followed:

1. We will be describing the most common barge arrangement employing diesel drives for refrigeration and cargo.
2. The refrigeration system will be of the direct type.
3. All design pressures and test pressures are typical onlyy.

The normal ammonia barge consists of a box barge in which there are two cylindrical tanks about 17-19 ft. in dia. x 200-250 ft. long made of special low temperature steel which is ½-⅝in. thick. These tanks are designed for 20-25 lb. pressure and are usually tested at 50 lb./sq.in. gauge. The tanks are supported by poured in place high density polyurethane saddles. The tanks are insulated with boardform polyurethane or polystyrene although Foamglass and Aluma-seal insulations have been employed.

Fast loading rates

The ammonia is loaded into the barges at a rate of around 300 tons/hr. through cargo piping which is arranged to both load and unload cargo. This piping takes on a myriad of arrangements but fundamentally it is installed so that cargo can be loaded, unloaded, or recirculated in the cargo tanks, Figure 1. Dummy headers are often installed for parallel unloading or loading of barges.

Cargo pumps are installed on each tank. They are usually vertical multistage 4 to 6 stage pumps driven through an angle drive by a 100 hp diesel engine. The capacity is typically in the neighborhood of 400 tons/hr.

The refrigeration system is designed to maintain the cargo at 0 lb./sq.in. gauge (28 F.). The United States Coast Guard rules require that the high side be designed for 300 lb./sq.in. gauge and the low side for 150 lb./sq.in. gauge, Figure 2. The intercooler which qualified for 150 lb. is better designed at 200 lb./sq.in. gauge, or even 300 lb./sq.in. gauge as these systems are exposed to direct sunlight, sometimes actuating the relief valves when idle. The system consists of a diesel engine (108HP) driving directly a 2-stage standard internally compounded compressor and a self priming water pump plus an air compressor if controls are pneumatic. The compressor takes suction at 0 to 5 lb./sq.in. gauge from the main suction scrubber which is a knockout or separation device employing a shell within a shell. The discharge from the low stage goes through an oil trap (oil is automatically returned to the compressor through a float) and to the flash type intercooler.

The gas is discharged beneath the surface of the liquid in the intercooler and after being desuperheated, it and the flash gas from receiver are taken into the high stage suction of the compressor at about 40 lb./sq.in. gauge, compressed to 225 lb./sq.in. gauge and discharged into an oil trap (oil is automatically returned to the crankcase through a float) and then condensed at 225 lb./sq.in. gauge (108 F.) in the condenser. Water from the keel cooler (a series of 4 in. x 18 in. channels welded to the bottom of the barge) is pumped through the condenser tubes to condense the NH . The small storage receiver is used to provide some NH for startup. The ammonia is drained from the receiver by a high pressure float drainer and flashed to the intermediate pressure. Another float drains the 40 lb. cooled liquid back into the cargo tanks. The liquid is sprayed into the vapor dome of the cargo tank to help desuperheat the gases returning to the compressor. A bubble tray here would be more effective.

This refrigeration system will transmit a certain amount of oil to the cargo. The amount depending upon quite a few factors. Oil free systems with non-lubricated compressors are also in use....employing the same direct refrigeration cycle.

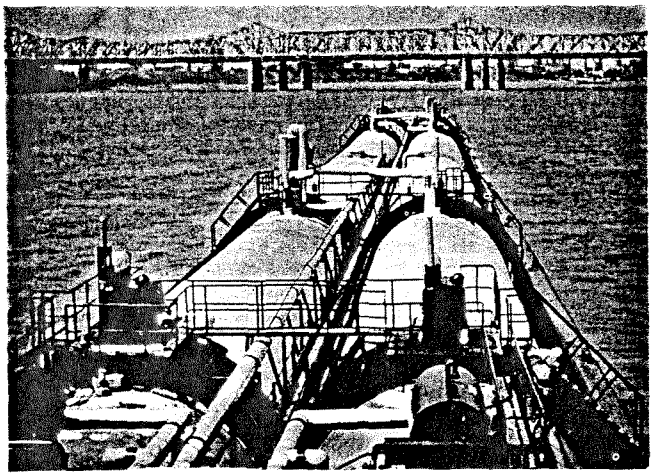

Figure 1. The tanks are designed for 20-50 lb. pressure.

Skid-mounted assemblies

All of the components shown in the schematic are normally assembled on a structural skid each of which is about 8 ft. wide x 8½ ft. high x 18 ft. long weighing about 24,000 lb. The relative location of the components may be seen in Figure 3.

Two such packages aare employed on each barge. Note the supports and bracing plus the special treatment for the relief valves. In designing barge refrigeration units every pipe and component must be rigidly braced. The United States Coast Guard is the regulatory body which has the jurisdiction over construction of the barges. Their regulations CG-115, as amended generally covers this type construction. Four to five years ago there was no criteria specifically for such barges.

The United States Coast Guard has had to formulate policies almost on a daily basis; many times on a one time look-see basis. All pressure vessels must have the U.S.C.G. Stamp, the requirements of which incidentally are somewhat different from ASME AND TEMA. Ammonia compressors must also be pressure tested at 450 lb. sq.in. The cargo tanks require low temperature steels, X-ray inspection and charpy impact tests all of which are specifically outlined by the United States Coast Guard in CG-115. Each refrigeration package (one is a spare) must be designed with a capacity sufficient to maintain 0 lb./sq.in gauge tank pressure during the maximum heat leakage through the tank insulation. This is normally under 20 tons of refrigeration. The systems are usually in the range of 30 to 35 tons of refrigeration each as they are sized for the additional vapor condensing load imposed by the 300 tons/hr. loading rate. Some systems are also sized for cargo pull-down during transit....however, this can only be a limited amount due to the space limitations on the barges.

Built-in safety features

The cargo tanks must be protected with relief valves for both pressure and vacuum. The valves are normally set at 10 lb./sq.in. pressure, and 1 lb./sq.in. vacuum. The cargo piping also has relief valves installed where liquid ammonia may be isolated by stop valves. Also there is a United States Coast Guard requirement for a quick closing (hydraulic or air actuated) valve on the loading-unloading header so that the header may be "cut-off" from a remote location in an emergency.

Each cargo pump has a high discharge pressure switch arranged to stop the diesel driver if high pump discharge pressure occurs. All diesels have a water cooled manifold and spark arresting muffler plus high temperature, water and oil pressure shut-downs (all U.S.C.G. requirements).

There are three sets of dual relief valves on the refrigeration packages, Figure 4. One set each on the condenser, 300 lb.; receiver, 300 lb.; and intercooler, 200 lb. These valves are arranged with a 3-way stop valve so that when one valve is shut off for replacement the other valve is always "active".

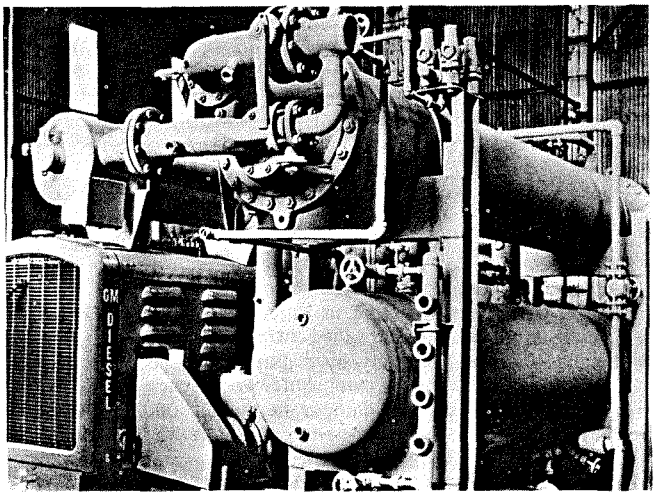

Figure 3. Components are assembled on structural skids.

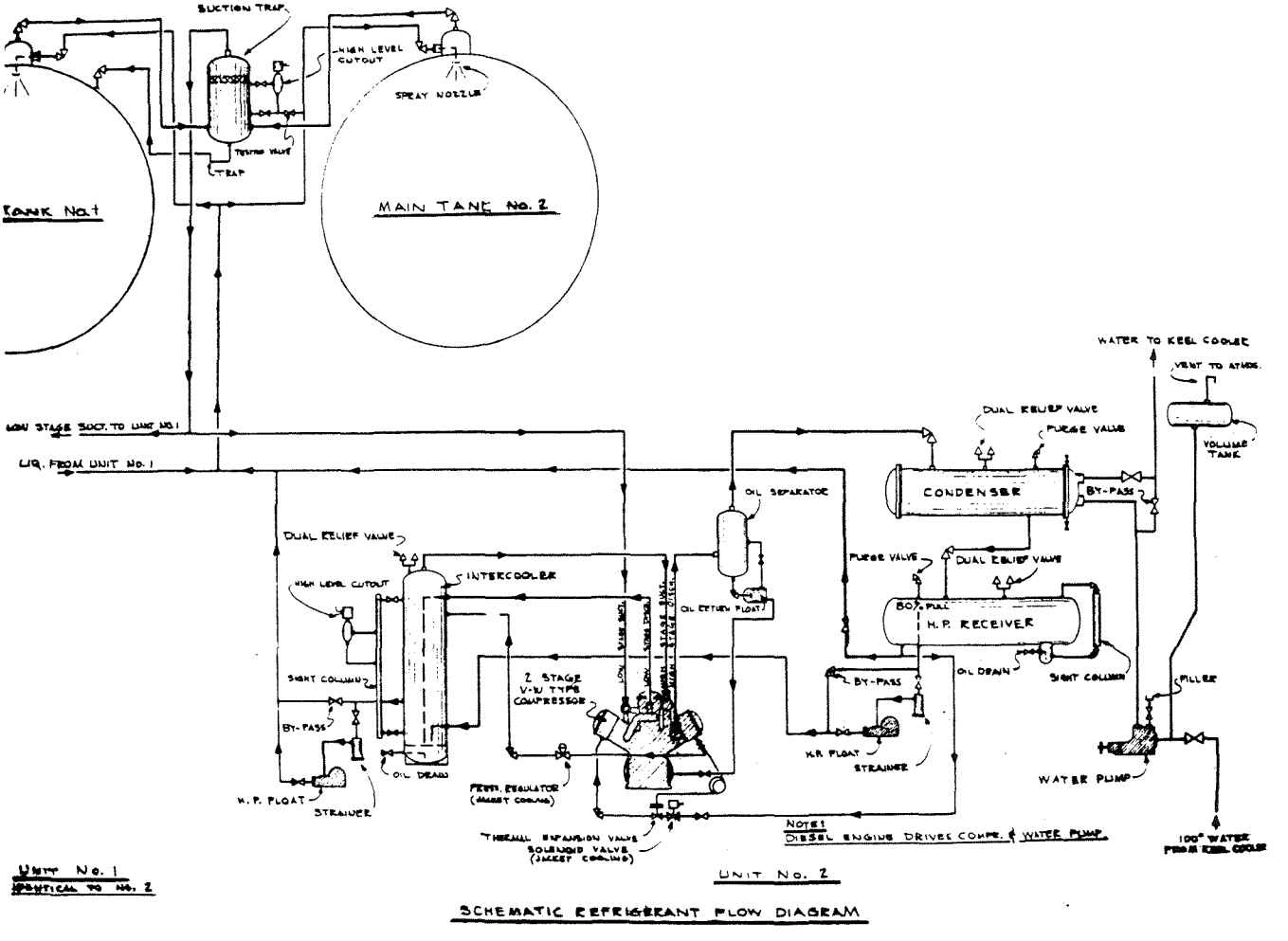

Figure 2. The high side is designed for 300 lb.; the low for 150.

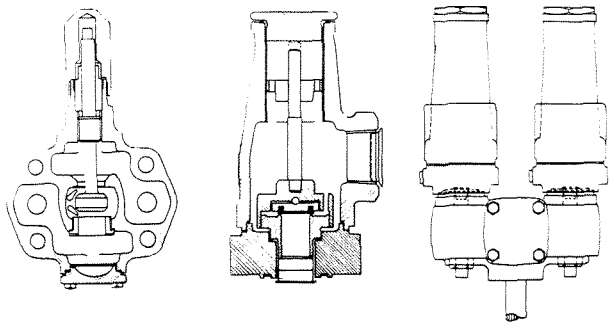

Figure 4. There are three sets of dual relief valves.

The safety controls which are normally employed for the refrigeration packages are listed in Figure 5. They are identical for electric or pneumatic. All of the controls are arranged to shut down the diesel engine instantly by draining the hydraulic governor. There is also a remote manual shutdown for each diesel operated by a lahyard. This is a damper in the air intake. The control systems are generally arranged for automatic shut-down with manual start-up. Besides the controls listed, a liquid level sensor is installed on the intercooler and suction scrubber to shut down the refrigeration units in case of high ammonia levels.

HIGH COMPRESSOR DISCHARGE PRESSURE

LOW COMPRESSOR SUCTION PRESSURE

COMPRESSOR OIL PRESSURE FAILURE

HIGH COMPRESSOR DISCHARGE TEMPERATURE

HIGH WATER TEMPERATURE (CONDENSER)

HIGH WATER TEMPERATURE DIESEL

OIL PRESSURE (DIESEL)

HIGH CARGO PRESSURE (ALARM ONLY)

LOW CARGO PRESSURE (DUAL)

Figure 5. All of these controls are arranged to shut down the engine.

Signal lights off on failure

The electrical control panels in the waterproof enclosure are made up with standard U.L. approved relays and pressure switches, another U.S.C.G. requirement. The low tank pressure switch is set 0 lb./sq.in. gauge with a differential of 3 to 5 ounces. Two of these units in series, with a valved test arrangement, have been used as a substitute for a cargo tank vacuum relief on several barges. The signal lights are arranged to be on when the system is operating and to be off on failure.

When pneumatic control is used, it is a dead-end system, as compared to the normal bleed type air control. This is done to reduce air usage. With this type system, a small air compressor is installed on both refrigeration system diesel engines to furnish air for controls and starting.

The initial purging and pulldown of the cargo tanks is a critical operation. The tanks must be pulled down slowly to prevent excessive stresses and possible rupture. The ammonia air concentration must be watched carefully. At a ratio of 1:4 the ammonia/air cencentration is explosive. The area should be treated as hazardous. Gas masks, no smoking, no electrical hazards are in order. The ammonia (usually about 10 to 12 tons/tank) is introduced into one end of the tanks and the air ammonia mixture is vented through a nozzle on the opposite end of the tank. This vented vapor should be vented into the water. As the purging progresses. . . .the total job should take 8 to 12 hours. . . .the concentration of NH is analyzed. When the cargo tank pressure reduces to approximately zero psig, the purging is basically complete, however all of the air is usually not removed until the first cargo is loaded.

Discussion

Q. At a dock, the keel cooler will not always function properly in hot weather. has any consideration been given to providing an alternate cooling mechanism?

Briley: Yes. This has been discussed and studied. Some of the keel coolers are getting quite big and will hold quite a few tons of ammonia No matter how big a keel cooler, if there is no movement of water in a slip problems can develop. Sometimes water can be pumped out of a slip to let cooler water enter.

Q. Can you use air as a coolant for condensing?

Briley: Theoretically, yes, but the size would be prohibitive for a barge.

Q. You indicated that some of the loading temperatures are in excess of -28. What have you encountered?

Briley: About -18 to -20 F., and not just at one or two terminals. Some of the barges are arranged so that they do not run the refrigeration machinery during loading. They have 20 lb. relief valve settings, and allow the barge pressure to rise while loading, and then pull down the pressure while underway. This requires considerable more refrigeration than the normal design.

Q. If you are unloading the barge to large storage tanks, what loading temperature is normally required?

Briley: The ammonia has to be at -28 F., and this is measured rather precisely.

Q. What size are the flexible connections for unloading?
Briley: They are normaly 6 in.

Q. Rubber hose?
Briley: No, the ones I've seen were stainless steel flexible hose.

Q. How much does one of these barges cost per ton of ammonia carried, and could one regard the barge for use as storage?

Briley: As a rough guess the cost would be $350-400 ton. I doubt very seriously that a barge would be economical for storage except under temporary special conditions.

Q. The compressors which you mentioned that are started and shut down automatically, is there a reason they aren't started automatically?

Briley: The basic problem we run into when we start any diesel drive automatically is engaging the clutch and finding a clutch that will take the punishment. The clutch slams whether you go to air type or standard type and this is the only limitation.