Explosion Hazardous Area Classification on Refrigeration Systems

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Introduction

In the IEC Technical Committee report (TC31) a concern with the lack of guidance on hazardous area classification with industry`s increasing use of flammable refrigerant was raised. Historically the refrigeration standards in South Africa acknowledged the need for assessing such systems with regards to explosion prevention. With this short paper I will try to shed some light on how we approach refrigeration plants and explosion prevention in South Africa.

I. Overview of the current requirements for refrigeration systems (in South Africa)

SANS 10147 "Refrigerating systems including plants associated with air-conditioning systems" identifies "refrigerants that have flammability or explosion hazards as their dominant characteristic. They are of a low order of toxicity" as group 3 and group 2 refrigerants.

This standard then identifies the groups as:

Group	Number	Chemical name	Ignition temperature °C	Explosive range concentration in air % (by volume)	
				Lower limit	Upper limit
2	R-30	Methylene chloride			
	R-40	Methyl chloride			
	R-123	2,2-Dichloro-1,1,1-Trifluoroethane			
	R-160	Ethyl chloride			
	R-611	Methyl formate	456	4,5	20,0
	R-717	Ammonia	651	16,0	28,0
	R-764	Sulfur dioxide	519	3,7	12,0
	R-1130	Dichloroethylene	458	5,6	11,4
3	R-1701	Ethane	580	3,2	12,5
	R-290	Propane	525	2,4	8,5
	R-600	Butane	500	1,8	8,4
	R-600a	Isobutane	530	1,8	8,0
	R-1150	Ethylene	450	2,8	26,0
	R-1270	Propylene	497	2,0	11,1

and states that: "All electrical equipment shall comply with the requirements of SABS 0108 for hazardous areas."

II. Basic Zoning Philosophy

You can skip this section if you already understand the basics on how zoning is done.

The Classification of Hazardous areas as per SANS 10108 mean that one have to identify the sources of release and then determine how frequent they occur, to what extend it can form explosive atmospheres and how these explosive atmosphere can be limited (some literature talk about "flammable atmospheres" but I prefer calling it explosive since gasses will explode and won't necessarily burn).

The frequency of explosive atmospheres are captured by assigning a Zone to the area, a three Zone system is used with a Zone 0 meaning you have a constant explosive atmosphere Zone 1 a frequent one and Zone 2 only under abnormal conditions (typically for less than 10 hours per year is considered as Zone 2). It is important to remember that the zoning system should not be used to indicate where explosive atmospheres can form during a catastrophic events but it is for regular or controlled explosive atmospheres (even though spillages are considered, they are controlled and can be fairly regular on some processes).

III. Overview of the design of refrigeration systems (using flammable refrigerants)

The most common refrigerant used in South Africa that can be considered flammable are surely ammonia, but can form explosive atmospheres only in the unusually high concentration range of 15 % to 27 % (by volume). Ammonia at a concentration of 0,0025 % (by volume or 25ppm) or less is readily detected by smell and detectors are usually set to concentrations that are well below 10 000ppm to warn people of the presence of a toxic gas.

SANS 10147 therefore specify:

a) at least one refrigerant detector that

   1) operates at a level of concentration not exceeding 1 % (by volume) of ammonia,

   2) is fixed over non-static items of equipment from which leakage can occur,

   3) is so arranged as to give visual and audible alarms, and

   4) switches on equipment for increased ventilation (if installed); or

b) push stop buttons, if the area or enclosed space is continually manned and occupied. The push stop buttons shall be of the "break-glass" type, and shall be located outside exit doors.

By interlocking this detection system (that is primarily there to protect against people exposure) to isolate any unprotected (non-explosion protected) equipment in the plant room, the area can easily be rendered safe, should an explosive atmosphere form.

Note: please refer to the Standard if you are designing refrigeration systems as I might have missed some critical detail about human exposure safeguards.

IV. Examples

Next to do the hazardous area classification.

Start by identifying and evaluating the sources of release:

Ammonia refrigeration plants typically have the following release sources:

1. Emergency vents to atmosphere,

   In accordance to the area classification standards emergency vents can release small amounts of gasses and for LPG a Zone 2 of 3m is normally assigned. For ammonia this can probably safely be reduced depending on the pressure, ventilation around the vent opening, the relative density of the gas and the frequency that a release is expected.

2. Top-up or road tanker connection point

   Again for LPG this will constitute a Zone 1 within 1.5m of the filling connection point, this will however be a very conservative Zone and again it can be reduced will be less frequent leading to a Zone 2 for a smaller radius.

3. Oil Drain Points
   These draining points are installed on all the low points of the ammonia handling pipe work (for systems with a lubricated/oil seal on the compressors) and is used to drain oil that collect in the system. The drain point is opened manually and is done up to once per week. For this basic procedure the operator open a manual valve fitted with a pipe and container and drain the oil until liquid ammonia is observed and the valve is then quickly closed.
   This release is therefore <<1minute and therefore adds up to <<52minutes per year.

   A minimal Zone 2 of 1m can be applied around these release points and by locating the drain pipe opening to be away from any possible ignition sources (and your gas detection system) this operation should not cause disruption of the plant or cause any explosion hazard.

4. Releases on flanges, instrumentation connections, compressor seals, screwed joints on pipes ect.

   In the past these release points were regarded as safe and suitable gas detection close to the sources of release was installed. This however does not necessarily mean an explosive atmosphere cannot form but all the equipment that is not explosion protected can safely be isolated. We might have to consider Zoning it a Zone 2 area and then implement the correct safety measures to render the non explosion protected device safe, such as by safely isolating them. (The new IEC60079-42 “Explosive atmospheres - Part 42: Electrical safety devices for equipment” standard might just be very useful in this regard!)

Refrigeration plants is therefore designed to all the requirements of SANS 10147 taking into account human safety with regards to toxicity and human exposure limits and additionally the following features are usually added to protect against explosions as defined in SANAS 10108:

1. The gas detection systems that primarily function to protect people from exposure are interlocked with the electrical equipment on the plant to isolate all the “non-explosion protected” equipment. These sensors are also normally not isolated during alarm conditions and are therefore selected as explosion protected equipment (normally with a rating of Ex ic or better).

2. Artificial ventilation is installed by means of an extraction ventilation fan (or fans) and these fans are placed close to the roof/ceiling with fresh air opening(s) close to ground level to allow good cross ventilation over the plant. The fan motors are normally not isolated during a gas alarm and are selected as Explosion protected devices with an EPL of Gc (Equipment Protection Level, normally Ex nA or Ex ec).

3. The emergency vent openings and gas filling points are positioned outside the plant in an open well naturally ventilated area where released gas can quickly be diluted and where a Zone around these points won`t influence electrical equipment.

At present the guidance provided in IP Part 15 can be used to derive a Zoning for these facilities but in future I suspect that more guidance on the classification of these facilities will be included in SANS60079-10-1 and we will keep an eye open for any such changes.

V. Conclusion:

SANS 10147 gives a great summary:

"Standard electrical equipment may be installed in the plant, provided that a suitable number of gas detectors are properly located ... to isolate the electricity supply to the plant. However, all auxiliary equipment, such as ventilation fans and emergency lighting, shall be to a classification as if there were no gas detectors."

I assume "classification" in the second sentence refer to the selection of equipment in SANS10108.

Nuisance trips are not common (on well maintained gas sensors) and the good level of ventilation quickly dilutes any released gas in the plant this makes it possible to have different "levels" of alarm conditions and the plant can be isolated at the "higher alarm level" only. Spillages that cause hazardous conditions are readily detected and can almost be regarded as catastrophic events.

VI. Other Useful Information:

SANS 10108:2014 "The Classification of hazardous locations and the selection of equipment for use in such locations".

IP Part 15, "Area Classification code for installations handling flammable fluids, 3rd Edition ".

IEC/SANS 60079-10-1 "Explosive Atmospheres Part 10-1: Classification of areas – Explosive gas atmospheres".

SANS 10147:2014 "Refrigerating systems including plants associated with air-conditioning systems".

I sincerely hope this was useful, let me know what you think, Regards, Jaco.