FIRE PROTECTION OF SILICON PRODUCTION

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Introduction

Since silicon is a widely used material in the electronic industry and in the solar batteries the issues of fire-and-explosion safety of its manufacturing have become very actual. At the modern level of know-how it is determined by the presence of hydrogen and trichlorosilane (hydridechlorosilanes) in the industrial process. Hydrogen safety is provided by a number of explosion safety measures specified by the appropriate normative documents: both Russian and foreign.

Results and discussion

The basic measures which should be envisaged at the design stage when the rooms and buildings are classified according to the fire hazard and fire-and-explosion hazard are:

- provision of tightness of process apparatus and pipelines with the help of cutoff devices for the delivery of hydrogen and trichlorosilane (TCS) or their mixture with the possibility of automated mechanisms failure of 10^{-6} per year and less;
- the use of explosion proof emergency ventilation;
- the reduction of possible spillage area of TCS and the device of emergency discharge of the spilled liquid into the emergency tank;
- the device of easily disposed constructions;
- the provision of the industrial process areas where TCS and chlorosilane mixtures are handled with the automatic fire-extinguishing and alarm systems.

The main target of the technological process of polycrystalline silicon manufacturing is the explosion prevention of hydrogen - air mixture in the reactor room. As far as TCS and its mixtures with chlorosilanes (having elevated density of 1,34 g/cm^3 at 20°C) are concerned the possibility of gas-vapor-air mixture formation at the lower limit of flammability in this case is substantially lower than for hydrogen even at elevated temperature. Consequently, the fire-and-explosion hazard of TCS and other hydridechlorosilanes (HCS) is connected with the necessity to extinguish fires of spilled or condensed TCS on the floor of the reactor room or other room.

The test results including the results of the full-scale tests on the extinguishment of TCS and other chlorosilanes fires show that the most effective and economically sound is the use of sprayed water. The use of air foam based on the fluorinated surface active substances is also possible. It is also proved that fire-extinguishing powders (FEP) and gas fire-extinguishing agents for HCS are not sufficiently effective. FEP can be used for extinguishing of small fire seats of TCS (HCS) with the area not exceeding 3,0 square meter. Simultaneously the consumption of the powders of general purpose (for extinguishing of Class A,B,C fires) is higher in comparison with hydrocarbon fires what is explained by the peculiar characteristics of TCS (auto ignition temperature of +175°C) and the lack of cooling ability of FEP.

A set of issues of fire protection of silicon production comprises also fire safety of TCS storages, that of TCS emptying and filling operations including operations performed on the railroad overpass if they are envisaged by the technological practices.

Taking into account the toxic hazard of the HCS especially if water is used for its extinguishment when substantial amount of hydrogen chloride is formed, a development of measures aimed at the liquidation of the aftereffects of fire-fighting takes on special significance: firstly, it is required to provide the discharge of HCS hydrolysis products to the special drain tank and, secondly, it is necessary to neutralize the gaseous hydrolysis products with the help of appropriate barriers, for example, the water curtains which should be created on the possible propagation paths of the hydrochloric acid vapors cloud.

Since the emergency spillage of TCS and that of HCS is accompanied by the release of HCl as a result of the reaction between TCS and the moisture in air, it is reasonable to use the gas analyzers for the detection of HCl vapors as an indicator of the emergency occurred and simultaneously as a detector of the possible ignition of TCS during the hydrolysis.

It should be emphasized that the reliable extinguishment of TCS fires by water is achieved at certain discharge intensity. The larger the amount of the spilled TCS the larger the volume of HCl released in case water or water-foam means are used for fire-fighting. That is why the problems of minimization of TCS emergency spillage (leakage) during silicon production and the prevention of emergency discharge of hydrogen in the room require solution.

Conclusions

The fire-and-explosion safety of silicon production based on modern technology is governed by the presence of hydrogen and HCS in the form of TCS in the mixture with other chlorosilanes. The experience gained in the field of silicon production, the analysis of the real cases of spillages and leakages, the analysis of the means and methods of their liquidation, a set of the measures developed to increase the level of the fire-and-explosion safety of the active industrial processes and those at the design stage allow at present to solve the problem of fire protection of silicon production.

Reference

1. Gabrielyan S.G. and others. Fire-and-explosion hazard of hydridechlorosilanes and means of their extinguishment. International Conference ICHMS – 2003, Sudak-Crimea-Ukraine, P. 1022–1023.