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Study of fire impact on detritiation of atmosphere in tritium handling facility: catalytic oxidation of fume gas produced by cable burning

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Fire is one of main scenario for accidental tritium release in tritium handling facilities. Preventing this tritium escape to the environment requires maintaining sub-atmospheric pressure in the affected rooms and detritiation of the gas prior to its discharge. In all gas detritiation systems designed to process a large gas flow (in JET, ITER) first operation stage is catalytic conversion of tritium in hydrogen-containing gases to form of tritiated water. Then the tritiated water is either removed from the gas steam by its drying or detritiated by phase isotopic exchange with liquid water. For handling accidental tritium leak to atmosphere of the room affected by fire the challenge is to ensure operability and efficiency of catalytic recombiner. Gaseous hydrocarbons unavoidably produced during fire present a source of fuel for catalytic recombiner. Their oxidation in exothermic reactions will result in rise of the catalyst's temperature. Because power supply and I&C cables are most common fire load this study focused on catalyst behavior in oxidation of fume gas produced in cable's burning in air atmosphere. Cables for power supply and I&C of low-halogen ALSECURE type from NEXANS S.A., France were used in experimental tests. Their burning was performed in electrical furnace under purge with constant flow of ambient air.
An analysis of the flue gas's composition showed that the combustion of polymeric materials in cable's electrical insulation occurs under oxygen starvation conditions. The flue gas contains a large number of different organic products of insulation's thermal cracking in addition to carbon monoxide. Aerosols were removed from the gas stream by its filtration through HEPA filter. Prior to injection to the catalytic recombiner the gas stream was mixed with an additional flow of atmospheric air and heated to operation temperature of the recombiner (473K). Mixing of gas stream from the furnace with an additional air stream was at several ratio, 1:3.5, 1:8, 1:27 and 1:80. Temperature of of gas stream at recombiner's inlet and catalyst's temperature at various points of the recombiner were measured continuously. The recombiner was filled with catalyst which contains 0.5weight % of platinum on alumina.
It was observed that increase of catalyst temperature depends on mixing ration of the gas from furnace with stream of additional air. For example, at ratio 1:3.5 catalyst temperature rised from 473K to reacged 1570K and the gas's temperature from 473K to 1270K. At ration 1:8 highest catalyst's temperature exceeds upper limit for the thermocouples. Recombiner investigation after this test reveals that internal components made of stainless steel were melted down. With further increase of the mixing ratio to 1:27 rise of catalyst's temperature felled down to 970K. At mixing ratio of 1:80 no temperature rise was detected.
The experimental data were compared with mathematical modeling of the process. Heat transfer parameters of the recombiner needed for the model were evaluated by measuring temperatures rise in tests with air containing constant concentration of hydrogen in air. Comparison of the experimentally measured and calculated temperatures indicates a satisfactory adequacy of the model for the process interpretation.

Eligible for student paper award?

Yes

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