BP Process Safety Series

Hazards of Trapped Pressure and Vacuum

A collection of booklets describing hazards and how to manage them
Contents

1 Introduction ......................................................... 1
  1.1 Theory of pressure and vacuum .............................. 2
  1.2 Definitions .................................................... 4
  1.3 Different units of pressure ................................... 4
  1.4 Absolute pressure vs. gauge pressure ..................... 5
  1.5 The behaviour of gas ......................................... 6
  1.6 Pressure-force relationship .................................. 10
  1.7 Compressed air ................................................ 11
  1.8 Hydraulic and pneumatic systems ......................... 12
  1.9 Identification of trapped pressure and unexpected vacuum hazards ........................................... 13
  1.10 Sources of trapped pressure and vacuum ................ 14

2 Hazards of trapped pressure ................................. 15
  2.1 Breaking containment under pressure ..................... 15
  2.2 Storage tanks are fragile vessels ......................... 19
  2.3 Blocked/choked/isolated safety valves, vents and drains ..... 25
  2.4 Hydraulic legs .................................................. 35
  2.5 Trapped pressure in pigging operations .................. 38
  2.6 Thermal expansion ............................................ 46
  2.7 Ice or hydrate formation .................................... 51
  2.8 Leak and pressure testing ................................... 54
  2.9 Hydrostatic testing ............................................ 61
  2.10 Work permits and isolation certificates .................. 62
  2.11 Trapped pressure underneath catalyst crust ............... 63
  2.12 Trapped pressure in a fire .................................. 65
  2.13 Utility/process connections and flexible hoses ........... 66
  2.14 General advice and safe practices ......................... 71

3 Hazards of vacuum ................................................. 75
  3.1 Ignorance of hazards of ambient pressure ................. 75
  3.2 Blocked/choked/isolated vents and drains .................. 77
  3.3 Steam condensation ............................................ 82
  3.4 Ammonia dissolved in water .................................. 84
  3.5 Management of change ........................................ 84
  3.6 Can your vessels deal with vacuum? ......................... 85

4 Points to remember ................................................ 86

Short bibliography for regulations and norms .................. 91
Test yourself! ....................................................... 92
Acronyms and abbreviations ..................................... 95