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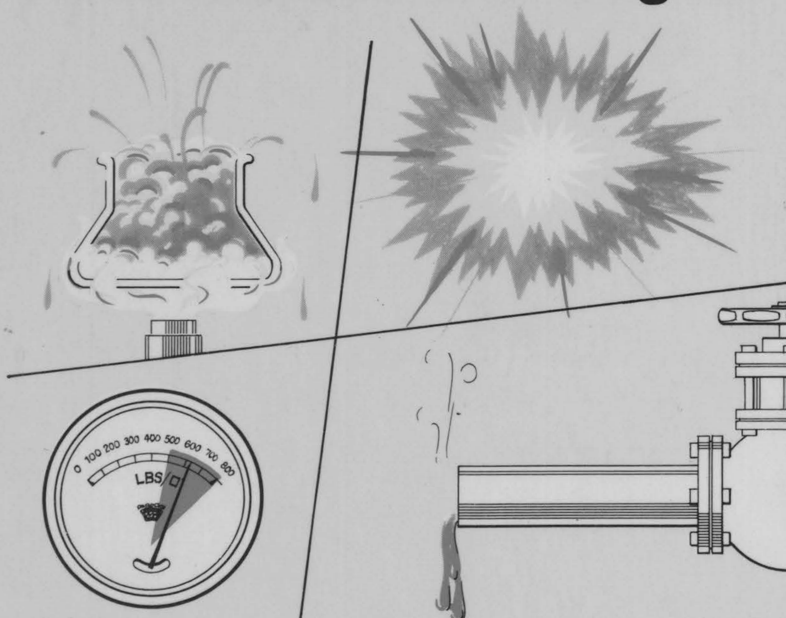
Hazards from Pressure: Exothermic Reactions, Unstable Substances, Pressure Relief and Accidental Discharge.



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Hazards from Pressure:

Exothermic Reactions, Unstable Substances, Pressure Relief and Accidental Discharge

A three-day symposium organised by The Institution of Chemical Engineers (North Western Branch) and the IChemE's Safety and Loss Prevention Group and held at the University of Manchester Institute for Science and Technology (UMIST), 16–18 June 1987.

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PREFACE

Exothermic reactions, unstable substances, pressurised systems and accidental disharges can lead to hazardous situations in the process industries if they are not under control. Safe manufacturing practice requires constant vigilance and the adoption of systematic procedures to assess sources of potential risk, to define safety operating procedures and to implement and maintain such measures.

Symposia were organised by the North Western Branch of the Institution of Chemical Engineers in 1981 and 1984 on Runaway Reactions, Unstable Products and Combustible Powders and on the Protection of Exothermic Reactors and Pressurised Storage Vessels.

Since these symposia, considerable advances have been made in our knowledge of these topics. This symposium will assemble the most up to date information, with expert reviews of current art being supplemented by reports of recent advances.

The papers contribute to all the essential stages of understanding hazard technology, identifying hazards in particular processes, analysing and assessing risk, and defining and maintaining safe operating procedures.

The discussion sessions and informal contacts will provide an invaluable opportunity for participants from universities, industry and the regulatory authorities to exchange information on process safety.

NORBERT GIBSON

ERRATA

Page 75, last paragraph, 5th line from bottom – 1.5 should read 1.05.

Page 117, Table 2, last column – 144.1 should read 1441.

Page 202, first paragraph, line 5 should read "offensive substances and of rendering them harmless or"

Page 218, Equation (2) should read:

$$\dot{m} = \frac{C_D A_r P_s}{\sqrt{Z R T_s}} \sqrt{\gamma \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

where the units of R are J/kg/°K

Pages 230 and 231, Tables 1 and 3 should be replaced by the following:

TABLE 1:– Test conditions, all tank sizes	1/4 tonne	1 tonne			5 tonne			
Percentage fill (nominal)	40%	80%	40%	20%	80%	60%	40%	20%
Tank total surface area (m^2)	3.8	10.4	10.4	10.4	27.7	27.7	27.7	27.7
Wetted surface area (m^2)	1.68	6.28	4.32	3.02	18.1	15.2	11.3	8.7
Initial vol. of propane (l)	185	1635	789	308	7640	5900	3676	2250
Initial depth of liquid (m)	0.22	0.68	0.35	0.18	1.17	.934	.66	.474
Ambient temperature (°C)	5	14.0	–3	–3	9.5	12	1.5	11
Initial tank pressure (bar)	5.5	6.1	4.1	4.1	4.8	4.6	4.2	5.5
Initial propane mass (kg)	100	870	420	160	3860	3109	1930	1170
Average wind speed (m/s)	–	–	–	–	4.7	4.8	4.6	1.3

TABLE 3:– Average measured heat fluxes	1/4 tonne	1 tonne			5 tonne			
Percentage fill	40%	80%	40%	20%	80%	60%	40%	20%
Av. heat flux into propane before PRV opens (kW/m^2)	73	84	59	33	61	76	68	56
Av. Heat flux into tank wall before venting (kW/m^2)	14	5	4	12	9	6	7	9
Av. heat flux into propane during venting (kW/m^2)	85	50	54	76	–	53	66	43
Av. heat flux from the fire to water calorimeter (kW/m^2)	–	–	–	–	77	–	80	79
Av. boil-off rates (kg/s)	–	–	–	–	1.4	1.9	2.2	1.0

Page 262. Figure 3 should appear as follows:–

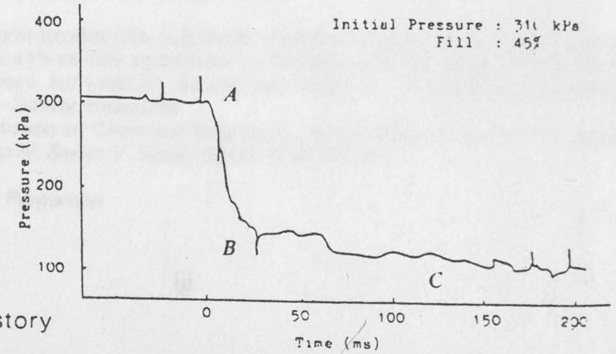

FIGURE 3 – Internal Pressure History

CONTENTS

Unstable Substances

Reaction Stability

* These papers are printed out of page sequence.

† This paper was received in summary form only. The full paper is to be published in Chemical Engineering Science.

Pressure rise during homogeneous decomposition and deflagration

Th. Grewer and O. Klais, Hoechst AG, Frankfurt/M.

Only a small part of the non-explosive substances are deflagrable. But a number of incidents have been caused by their deflagration. We have measured the temperature-time curves of the deflagration of some of these substances in a closed vessel. The rate of pressure increase was to a first approximation proportional to the pressure, except for one substance where it was proportional to a higher power of pressure. The pressure-time-curves of homogeneous decomposition were also measured but were more complicated than the results of the deflagration measurements.

Keywords:- pressure rise, homogeneous decomposition, deflagration.

The progressive exothermic decomposition of substances, commonly known as "deflagration", has frequently led to unpleasant incidents in the chemical industry. While it is true that only a small proportion of the substances produced are capable of deflagration, for the few that are the probability of its occurrence is especially large.

Deflagration is a familiar process in rocket fuels and explosives. In these cases the process is usually rapid and can easily become a detonation. Here we wish to consider slow deflagration which can appear in certain chemical compounds as an undesirable occurrence. These substances are usually not capable of detonation.

The following table lists some of these substances that are capable of deflagration and shows their deflagration rates [cf. 1].

Table 1: Deflagrable substances

Substances	Deflagration rate (cm/min)
4-Nitrosophenol	8
1-Nitrosonaphthol-(2)	0.74
Hydroxylammonium sulfate	5.6
Ammonium dichromate	2.2
Sodium-3-nitrobenzene sulfonate	4.5
Diphenyltriazene	2.0
Pigment orange CI 12075	1.8