Incident Title	**Batch Reactor Internal Overpressure**	
Incident Type	Runaway Reaction	
Date	28th April 2008	
Country	Ireland	
Location	Cork (Munster)	
Fatalities	**Injuries**	**Cost**
1	1	Unknown

Incident Description

Credit: IChemE Loss Prev. Bulletin 237

The active drug intermediate compound 2-cyano-3-methylpyridine (CMP) was being manufactured by batch reaction of picoline-N-oxide (PNO) with diethylcarbamoyl chloride (DECC) in acetone (C_3H_6O). The resultant intermediate, an acyloxypyridinium salt, is then further reacted with an aqueous solution of sodium cyanide (NaCN) in another reactor to produce the CMP product. On the day of the day of the incident, a glass-lined, mechanically agitated carbon steel reactor suffered significant deformation and a blowout of the manway gasket and solids addition (charge) chute top cover, resulting in the release of reactants at high temperature and pressure. Two operators were present at the time. Both were severely injured (one later died from his injuries). The reactor and associated hardware suffered significant damage. The blast wave from the vessel failure also caused extensive damage to the 4-storey building.

Incident Analysis

Basic cause was failure of the reactor manway gasket and loss of primary containment (LOPC) due to an exothermic runaway chemical reaction and consequent two-stage thermal decomposition (acyloxypyridinium salt and then picoline-N-oxide) when the exothermic onset temperature was reached.

Critical factors included: 1) PNO and acyloxypyridinium salts are thermally unstable and decompose violently, 2) The acetone solvent charge step prior to DECC addition was omitted (reason unknown), 3) Omission of acetone solvent results in a lower acyloxypyridinium salt decomposition onset temperature and a more violent decomposition reaction, 4) Omission of acetone solvent also increases the reaction mix batch viscosity, adversely affecting mixing and heat transfer efficiency, 5) The consequences of omitting acetone solvent addition were underestimated in the HAZOP review, 6) The solids charge chute provided (unintended) additional emergency relief capacity which may have prevented catastrophic failure of the reactor vessel.

Root causes included: 1) Inadequate process hazard analysis (HAZOP) and risk assessment, 2) Inadequate operating procedures (addition of acetone not highlighted as safety-critical step), 3) Inadequate design (pressure safety valve (PSV) and bursting disc (BD) set pressures and relief line sizing), 4) Inadequate emergency procedures (operators required to approach unstable reactor to close valves to isolate reactor overheads glassware).

Lessons Learned

1) Process hazard analysis (HAZOP) and risk assessment reviews should be carried out by experienced and competent staff with the full breadth of chemistry, process, engineering and operating knowledge.
2) Quantitative reaction hazard assessment data (thermal stability tests, calorimetry, etc) must be used to inform design of appropriate safeguards.
3) Operating procedures should clearly identify safety-critical steps.
4) Reliance solely on plant operators to routinely carry out safety-critical tasks or to approach a reactor operating out of control is not acceptable.

More Information

1) “Runaway Chemical Reaction at Corden Pharmachem, Cork”, S. J. Gakhar, S. M. Rowe, M. Boylan and P. Conneely, IChemE Symposium Series No 159, Hazards 24 - Paper 59.
2) HSG143: “Designing and Operating Safe Chemical Reaction Processes”, UK Health & Safety Executive (2000), ISBN 0-7176-1051-8.
3) BS EN ISO 4126-3: “Safety Devices for Protection Against Excessive Pressure (Safety Valves and Bursting Disc Safety Devices in Combination)”.

Industry Sector	Process Type	Incident Type
Pharmaceutical	Active Drug Ingredients	Runaway Reaction
Equipment Category	**Equipment Class**	**Equipment Type**
Mechanical	Vessel	Reactor

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