Application to PVC powder of European Directive 1999/92/EC "on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres" ("ATEX Directive")

The risk of PVC dust explosion is extremely low. This is demonstrated by the absence of any explosion reported in the relevant sections of the PVC production plants of ECVM member companies: drying, storage, packaging, loading, transport and by the fact that no PVC dust explosion has been reported by current insurers and insurance brokers of ECVM member companies.

However, like all organic materials, PVC is flammable and hence an explosion risk assessment should be carried out in all cases when handling PVC powder may cause the formation of a cloud of dispersed PVC, be it inside or outside equipment items.

In all cases where it is impossible to be certain that application of the appropriate design rules will prevent formation of such a cloud of dispersed PVC, it is necessary to apply the measures imposed by Directive 1999/92/EC [1, 2]. PVC properties, equipment characteristics and type of on-going operation have to be taken into account. Examples of equipment and operations to be considered in a risk assessment include silos, pneumatic transport, mixers, milling and grinding equipment, air filters, buildings in which the equipment is present, filling operations, start up or shut down, cleaning and maintenance.

In view of the large amount of energy required to cause the explosion of PVC dust dispersion in air, simple prevention measures are sufficient to effectively avoid any risk of explosion. This includes but is not limited to :

- ✓ Design of the installation :
  - ➢ Absence of non conducting equipment (consult good practice guidelines for ensuring conduction continuity and grounding when using flexible fitting made out of insulating material)
  - ➢ Correct grounding of all equipment. Prevention of electrostatic charges
  - ➢ Absence of exposed ignition points in the neighbourhood of PVC resin/dust, such as e.g. hot surfaces and open flames
  - ➢ Protection against lightning.
- ✓ Procedures :
  - ➢ Handling and mixing procedures should be such as to minimise dust cloud formation.
  - ➢ Good housekeeping to avoid dust accumulation. In particular, dust should not be allowed to accumulate inside or on top of electrical switchgear.
  - ➢ Moving parts should be inspected regularly to ensure free operation without overheating
  - ➢ Work permits.

When these prevention measures are implemented, it is possible to justify the use of non ATEX compliant equipment and the absence of protective systems in classified zones. According to Directive 1999/92, Annex II, this decision has to be documented by a risk analysis and included in the explosion protection document. This decision has been implemented by some ECVM member companies. It remains however under the responsibility of the company operating the equipment.

These considerations are also underpinned by the publication referred [3], classifying powdered solids into 5 categories, depending on the minimum energy required to cause an explosion. PVC is below the lowest risk category, which is defined by a minimum ignition energy between 100 and 1000 mJ and by a minimum ignition temperature above 500 °C. Applying the prevention measures recommended for this lowest risk category therefore provides an additional safety margin.

The above mentioned recommendations only apply to dispersions of pure PVC in air. The mixing of PVC powder with additives will frequently create a powder blend with explosion properties different from those described above. In particular polymeric powder additives will have their own propensity to dust explosion while other volatile additives will modify the ignitability of the gas phase. The safety of such operations is under the sole responsibility of the compounder or converter carrying out the operations. If other flammable materials (e.g. additives or gases other than air) are involved in the handling process, the person responsible for the activity must seek advice from the manufacturers and must carry out an additional risk analysis in order to determine which other substances may contribute to the explosive atmosphere, to assess the explosion characteristics of this mixture and to take the appropriate measures imposed by Directive 1999/92/EC.

References

1. Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).
2. Non-binding Guide of Good Practice for implementing of the European Parliament and Council Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.
3. "*Is your dust collection system an explosion hazard*", by Vahid Ebadat. Chemical Engineering Progress CEP, October 2003.

Appendix 1

SOME VALUES MEASURED FOR THE MAIN RELEVANT CHARACTERISTICS OF PVC DUST

The results listed below were obtained during laboratory tests. They give an indication of values that may be expected, but do not purport to cover all possible cases

Explosion characteristics according to VDI 2263	**E-PVC**	**E-PVC**	**S-PVC**
Average particle size	50 µm	15 µm	120 µm
Max. rate of pressure rise (dP/dt)	93 bar/s	44 bar/s	No ignition
Auto-ignition temperature	> 220°C	> 220°C	
Maximum explosion pressure – P max.	6,9 bar	8,4 bar	
Minimum ignition energy – E min.	> 2500 mJ	> 2500 mJ	
Volume dependency of max. rate of pressure rise – Kst	72 bar m/s	168 bar m/s	
Dust explosion class – St	1	1	Non explosive
Ignition temperature	> 500°C	> 500°C	No ignition
Lowest explosion limit	125 g/m³	45 g/m³	

Appendix 2

Additional SolVin Information

RANGE OF VALUES FOR THE MAIN RELEVANT CHARACTERISTICS IN SOLVIN PVC RESINS

Property	Unit	Method/ reference	Typical values for emulsion	Typical values for suspension
Medium particle size	µm	ISO 1624	5	100
Minimum ignition energy	mJ	VDI 2263	> 2500	> 2500
Lowest concentration limit in air above which an explosion risk may exist	g/m^3		125	125
Minimum cloud ignition temperature	°C		660	670
Maximal rate of pressure rise (dP/dt)	Bar/s	VDI 2263	<65	<35
Minimum product layer ignition temperature	°C		> 450	> 450
Exothermal reaction temperature	°C		< 415	< 415
Maximum explosion pressure	Bar	VDI 2263	8	6
Volume dependency of maximum rate of pressure rise (Kst)	Bar.m/s	VDI 2263	<65	<35

Remark : Tests of SolVin homo and copolymer resins were performed on fine fraction passed 63 µm in a $1m^3$ sphere by the BVS (Westfälische Berggewerkschaftskasse Bergbau-Versuchstrecke), Beylingstrasse, 65, D - 4600 Dortmund

English	Français	Deutsch
Material name	Nom du produit	Materialbezeichnung
Apparent bulk density	Masse Volumique Apparente	Schüttgewicht
Median particle size	Diametre median	Korngröße
Maximum explosion pressure	Pression maximale d'explosion	Max. Explosionsüberdruck
Maximum pressure increase rate	Vitesse maximale de montée en pression	Max. Druckanstiegsgeschwindigkeit
Dust explosion class	Classe d'exposibilité des poussières	Staubexplosionsklasse
Minimum ignition energy	Energie minimum d'ignition	Mindestzündenergie (mit Induktivität)
Minimum cloud ignition temperature	Température minimum d'inflammation en nuage	Zündtemperatur
Exothermal reaction temperature	Température d'exothermie (en couche)	Selbstentzündungstemperatur
Minimum product layer ignition temperature	Température minimum d'inflammation en couche	Glimmtemperatur
Lower Explosion Limit	Limite inférieure d'inflammabilité	Untere Explosionsgrenze

Appendix 3

BACKGROUND INFORMATION ON DUST EXPLOSION

Unless advised differently, PVC powders should be regarded as having a st1 rating in the VDI 2263, test. The rating indicates that dust clouds formed from PVC resin can be ignited under the specified conditions of the test. In this test, the rate of pressure rise after ignition is measured and expressed as a constant Kst calculated by the 'cube root law'. The calculated Kst value is then converted to the st rating according to the following table:

Kst (bar m s^{-1}) (1 m^3 vessel and 10kJ) ignition energy

Dust class rating

Characteristics

0	St0	No explosion
<200	St1	Weak/moderate Explosion
200-300	St2	Strong explosion
>300	St3	Very strong Explosion

As supplied, some PVC powders would rate st0, ie: would not explode in the test. This is probably because there are insufficient small particles to form an ignitable dust cloud. However, processes such as air conveying are capable of separating and concentrating the fine particles, for example, in dust filters and therefore it is prudent to regard all resins as having a st1 rating when designing safety features and procedures. In recognition of the fact that it is essentially the fine particles that contribute to dust cloud formation, tests are often made on a fine particle fraction, expressing the result as characteristic of the whole powder.

Any given PVC powder will form an ignitable dust cloud in the test only if the concentration of dust is between certain limits. These limits are known as the upper and lower explosive limits and are measured in g/m^3. The upper value is not normally measured because such dust clouds constantly settle out.

The minimum ignition temperature (°C) is a standard measurement that is important because it has been adopted by the IEC, DIN (VDE0165) and the (BS 6467) to specify the maximum allowable surface temperatures for electrical equipment in the presence of dust clouds. It is determined in a Godbert Greenwald furnace and it is the minimum temperature at which a dust cloud will self-ignite and propagate flame. Unless advised differently, the value for PVC powders should be taken as >500°C. Information on the design and use of electrical equipment in the presence of combustible dusts can also be found in these standards.