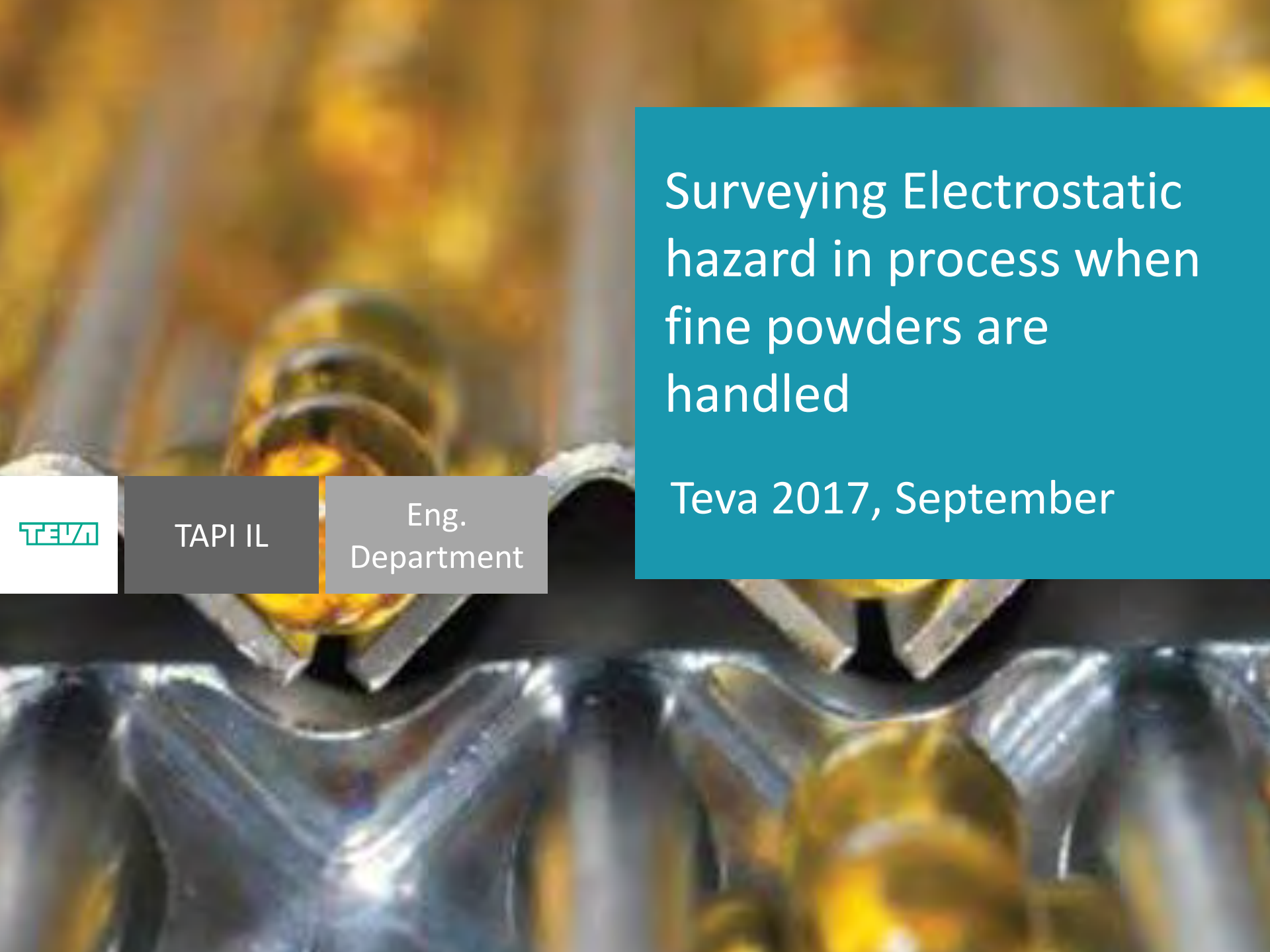


Surveying Electrostatic hazard in process when fine powders are handled

Teva 2017, September

TAPI IL

Eng. Department

Dust risk survey

- Know the risk
  - Why dust in focus?
  - Sensitivity characteristics
  - Severity characteristics
- Safety measures
  - Prevention
  - Mitigation
- Managing safety

Avoid similar situations

Know the risk - what can happen

- Fire: when flammable substance set in fire and ignites the surrounding.
  - Fire can be confined to restricted areas or can spread to neighbor areas.
  - Smoke, usually toxic and highly harmful emits.
  - Escape routs can be cut out – risk to trapped peoples
  - Severe damage to structures and systems.
- Explosion:
  - In confined volumes pressure front is built rapidly.
  - If acceleration length exists the shock wave will be formed
  - In open space fire ball is formed and spreads ignition all over.
  - Secondary explosion can be formed

Pics

Know the risk - focus on ESD

- Sourse of ESD: trace friction in movement.
  - When non conductive particulate solid flows over a non conductive surface
  - When non conductive solid mixes – shear between layers.
  - When high shear velocities acts on Solid – Gas mixture (two phase flow).
- Accumulation of charges:
  - When solids are flowing through conductive media – not grounded (inductivity).
  - When non conductive solids are piled inside containers, surfaces, bins (metal or insulative materials)
  - Special cases – big bags type A.

Know the risk - rare but violent

- Dry and flammable powder tends to produce dust cloud
  - High volume of air – available oxygen
  - Easily ignitable – formation of severe detonation is possible
- Mixture of powder dust and flammable gas or vapors increases the ignitability of the mixture – hybrid mixture.
- If explosion occurs in confined area, the over pressure is accelerated and can demolish the construction.
- If explosion occurs in open area, shock wave (fire ball / flash) can be formed and secondary explosion is possible.
- Dust explosion is characterized in relatively high speeds, long distance and short times,

Injury and death of people in the close area
Damage for the facilities from systems to buildings and facilities.

Know the risk – characterization

- Screening tests:
  - Spatula test
  - Carius (tube) test
- Sensitivity parameters:
  - MIE – Ignition energy for igniting dust cloud
  - MIT – Temperature for self igniting of dust cloud
  - LIT – Temperature for igniting a layer of powder

Determine the electrostatic risk of the powder
Determine the T class of the used equipments

Know the risk – magnitudes of ESD

Type of Discharge	Maximum Energy[1] (mJ)	Examples
Corona	0.1	Wires, Type D Bulk Bags
Brush	1 - 3	Flexible boots and socks
Bulking Brush	1 - 10	Piles of powders with resistivities > 10^9 Ω-m in hopper or silo
Propagating Brush	1000 - 3000	Boots, plastic pipe or duct
Spark	> 10,000	Ungrounded conductor, e.g. baghouse cage, or person, e.g. packager

1. Maximum energies are from Figure 5.3.1 of NFPA 77-2006.

Know the risk – Consequence scale

- When explosion can occur, risk should be mitigating by engineering design.
  - Smoldering tendency (Spatula test)
- Sensitivity parameters:
  - Pmax – Max pressure that can form in enclosure.
  - Kst – rate of pressure elevation in enclosed volume

Determine the strength of a confined structure
Determine the venting approach

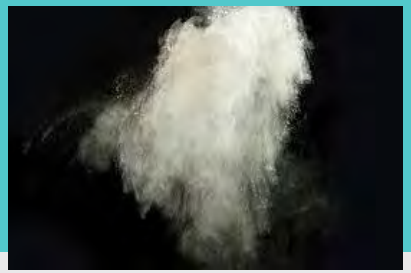
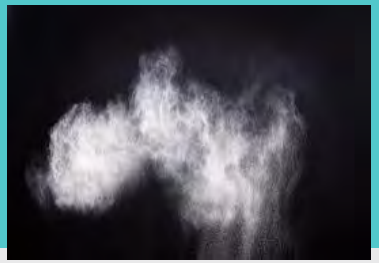
Know the risk – further parameters

- Various parameters that should be assessed when design required (case by case):
  - Volumetric resistivity – for dry powders and special cases wet powders
  - Chargeability (triboelectric tendency) – when powder should flow over surfaces (pneumatic conveying etc.)
  - MEC – minimum oxygen concentration to form an explosion in cloud (when inerting is concerned)

When risk exists ?

When processing bulk materials characterize the risky substance:

- Powders and granules of organic substances on dry basis.
- Powders and granules of reactive substances (strong oxidizers etc.).
- Powders of light metals or mixtures with light metals.
- Pyrophoric solids or mixes (products with exothermal release of oxygen)
- Phibrous substances, especially polymers and naturals (wood dust, cotton etc) – smoldering effects

When risk exists ?

When surrounding conditions tend to increase hazard:

- Dry atmospheres.
- Lightning source and sparks
- High shear speeds like winds, dusty air high flow, gas/solids flow.
- Construction with non visible areas (acoustic ceilings, onto horizontal ducts, wide beams etc) enable dust to pile up.

Strategy for dust explosion risk reduction

When dust explosion risk exists, there are two routs to reduce the risk (separately or combination of both):

- Fire / Explosion prevention:
  - Avoiding dust formation / accumulation
  - Avoiding ignition source
  - Avoiding oxygen (inerting)
- Mitigation of explosion:
  - Venting enclosures
  - Containing the explosion
  - Suppression of the explosion.

Safety management

- Adopt a standard and be familiar with it's details.
- Screen test your raw, intermediate and final powders and granular solids.
- Based on knowledge of the processes, equipment, SOP workers etc.

  define and draw hazardous zone classification maps.
  - You may segregate the maps for several routs depending on various actions (standard operation, cleaning, maintenance, setup)
  - It is a good practice to consult experts, but the classification should rely on actual (internal) practice and experience.
- Check for compatibility of the facility and systems to the zone classifications, create a gap analysis and sorted actions to be made according to the danger presented.

Safety management (2)

- When major risk exists (fatalities, serious damage to structure etc.) base the action items on inherent prevention and mitigation overlapping one another (triple to Quadra redundancy).
- When lower risk present redundancy can be reduced, whenever fatality is a reasonable cause use interlocking and inherent solutions.
- When medium damage and injury is considered, you may consider operational solutions, in this case trained personnel only should be allowed to work in the area.
- Operational orders in writing should be used for any risky operation, train the workers on what is actually written.

Safety management (3)

- Whenever non regular action is to be done (non production, non standard) enforce signed permits before action is started.
- Keep attention to the cleaning of the area and restrict tools as appropriate (hot work, special tools, personal protection, inspection and supervision).
- Whenever possible rely on standard procedures.

Recommendations for prevention

MIE (mJ)	Actions
> 1000mj	Low risk – keep out of open fire
500mj	Ground all metal parts and electrical apparatus
100mj	Ground all metal parts and electrical apparatus Use antistatic clothing and shoes for workers
30mj	Ground all metal parts Antistatic flooring, Antistatic clothing and shoes
10mj	ESD is a risk factor – avoid non conductive parts Packaging – use of C and D type big bags Avoid dust formation Consider proper mittigation
3mj	Avoid any spealage or dust piles at any time Add inerting when possible, control humidity or use ionization Actively Mittigate risks, Avoid any dust formation

Fire and explosion concequences

Fire:
Cause by
electric
short circuit

Explosion:
Sugar plant
Explosion initiated in milling unit
Secondary explosions caused
Wide area demolitions

Back

Sensitivity to ignition - MIE

- **Minimum ignition energy**

  For igniting a DUST CLOUD

  When in normal conditions: ambient pressure, temperature, oxygen concentration.

  Rule of thumb levels

  0.08 to 1.6 mJ for hybrid mixtures

  1 to 3 mJ for very sensitively explosible dusts

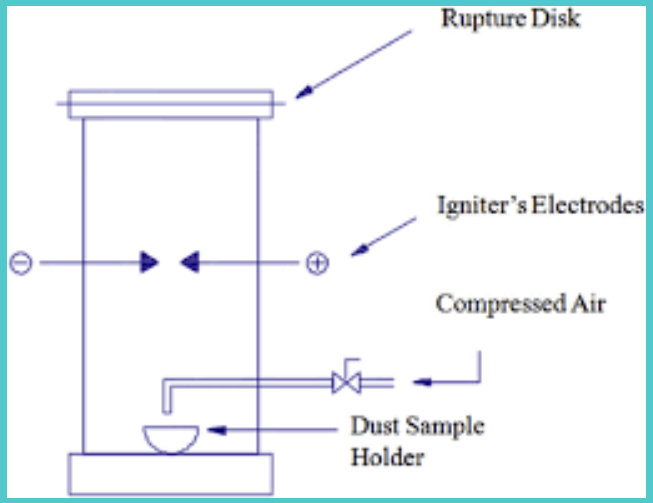
  3-10 mJ for sensitively explosible dusts

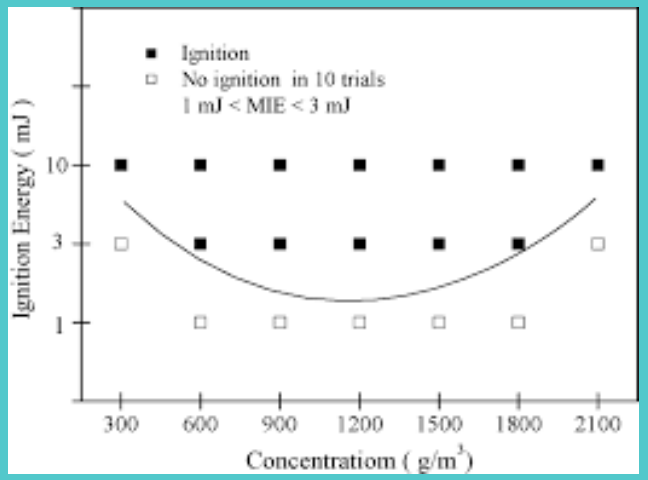
  10 to 30 mJ – risk for dust explosion to be considered

  >500 mJ – minor risk for dust explosion

  >1000 mJ – no risk of dust explosion.

MIE – Measuring apparatus





Back

Sensitivity to ignition - MIT

- **Minimum ignition temperature**:

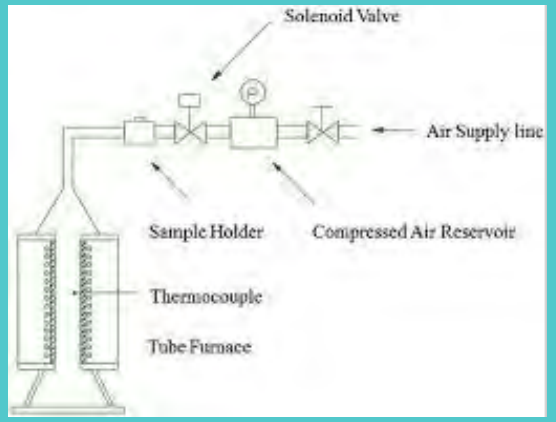
  Requires to self ignition of **dust cloud**

  Analogous for “auto ignition temp.” in gases / fumes.

  Interlocking temperature of production devices are calculated from this parameter by taking 2/3 of it’s value.

  Rule of thumb levels:

  >350°c, >400°c, >500°c



Back

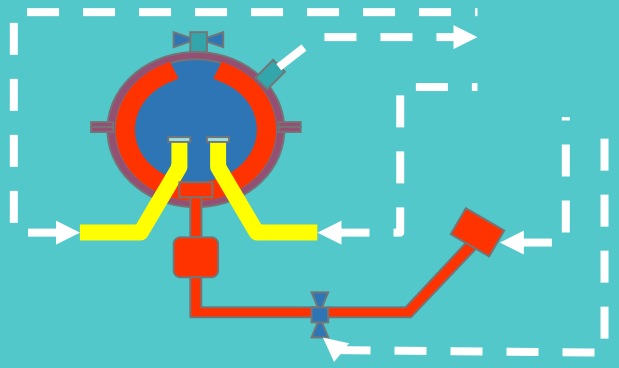
Sensitivity to ignition - LIT

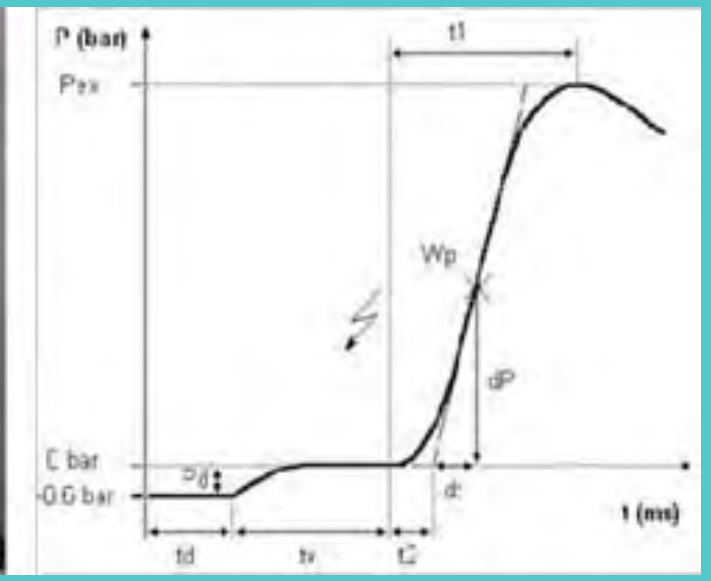
- **Layer ignition temperature**:
  - Minimal temperature to ignite a static layer (5 mm) of powder.
  - The parameter represents “thermal insulation” of the layer to the device that is cooled by natural convection.
  - Most of the cases the ignition is represented by smoldering of the powder.
  - Interlocking is done with safety margin of 75°c
  - Rule of thumb levels:
  - >350°c, >400°c, >500°c

Back

Measuring of Pmax and Kst

$$K_{ST} = \frac{dP}{dt} (V_{test})^{1/3}$$





Back

Kst and ST class

Explosion characteristics	St class	Kst (bar m s-1)
Weak	St1	0-200
Strong	St2	200-300
Strong and loud	St3	300<
Detonation	St4	500>

Table 1: Explosion Characteristics of Some Dusts in the Food Industry *(Ref. various sources)*

Product	Explosible?	P_{max} (bar)	K_{st} (bar.m/s)	MIE (mJ)	MIT- Cloud (°C)	MEC (g/m³)
Corn	Yes	6.5	112	45 – 100	390 – 400	73
Wheat	Yes	7.4	87	50 – 100	370 – 380	67
Oats	Yes	7.2	43	>500	420 – 430	30
Barley	Yes	6.3	100	50 – 100	360 – 370	73
Soybeans	Yes	9.2	110	50 – 100	600 – 620	80
Starch (rice)	Yes	10.0	220	>30	460 – 470	60
Starch (wheat)	Yes	9.1	156	10 – 30	470 – 480	30
Sugar	Yes	9.0	138	<10	470 – 480	30

Unit Operation	Explosion Screening[1]	MIE (mJ)	MIT – Cloud[2] (°C)	MIT – Layer[2] (°C)	Explosion Severity – Kst (bar.m/s)	LOC[3] (%)	MEC (g/m³)	Volume Resistivity[4] (Ω.m)	Chargeability[5] (C/Kg)	Self-Heating Onset Temp. (°C)
Manual Handling / Pouring	X	X						X	X	
Sieving / Screening	X	X						X	X	
Tumble / Double Cone Blending	X	X			X	X		X	X	
Ribbon Blending	X	X	X	X	X	X		X	X	
Milling	X	X	X	X	X	X		X	X	X
Jet Milling	X	X			X	X		X	X	
Drying (Fluidized Bed, Spray, Tumble)	X	X			X	X		X	X	X
Tray Drying	X	X								X
Pneumatic Conveying	X	X			X		X	X	X	
Screw Conveying	X	X	X					X	X	
Transfer to Hopper / Bin / Tote / Container	X	X			X			X	X	
Dust Collector and Exhaust Ventilation	X	X			X		X	X	X	

הגדרת אזורי נפיצות

- ההגדרות הנ"ל הנן לפי תקן IEC 60079-10:

Gas / Vapors		Dust	
Zone 0	1G	Zone 20	1D
Zone 1	2G	Zone 21	2D
Zone 2	3G	Zone 22	3D

הגדרות לפי תקנים אמריקאיים אינם שונים מהותית, שיטת הסימון שונה.

הגדרה ותיחום אזורים מבוצעים על ידי מי שמוסמך לתקן ובשיתוף עם נציגי המפעל המכירים היטב את שגרת העבודה.

התאמת מוגנות הציוד להגדרת האזור מבוצעת על ידי מוסמך לתקן

Example for secondary explosion caused by non effective houskeeping (PE dust)

Figure 34. Dust accumulation on roof trusses.

HAYES LEMMERZ INTERNATIONAL–HUNTINGTON, INC.

One dead worker, 6 severely wounded

Back

Potential Sources of ignition

electromagnetic waves ($3 \cdot 10^{11}$ - $3 \cdot 10^{15}$ Hz)

electrical installation

adiabatic compression, shock waves

flames, hot gases

ultra-sonic

electric stray currents, cathodic corrosion protection

hot surfaces

electro -statics

ionising radiation

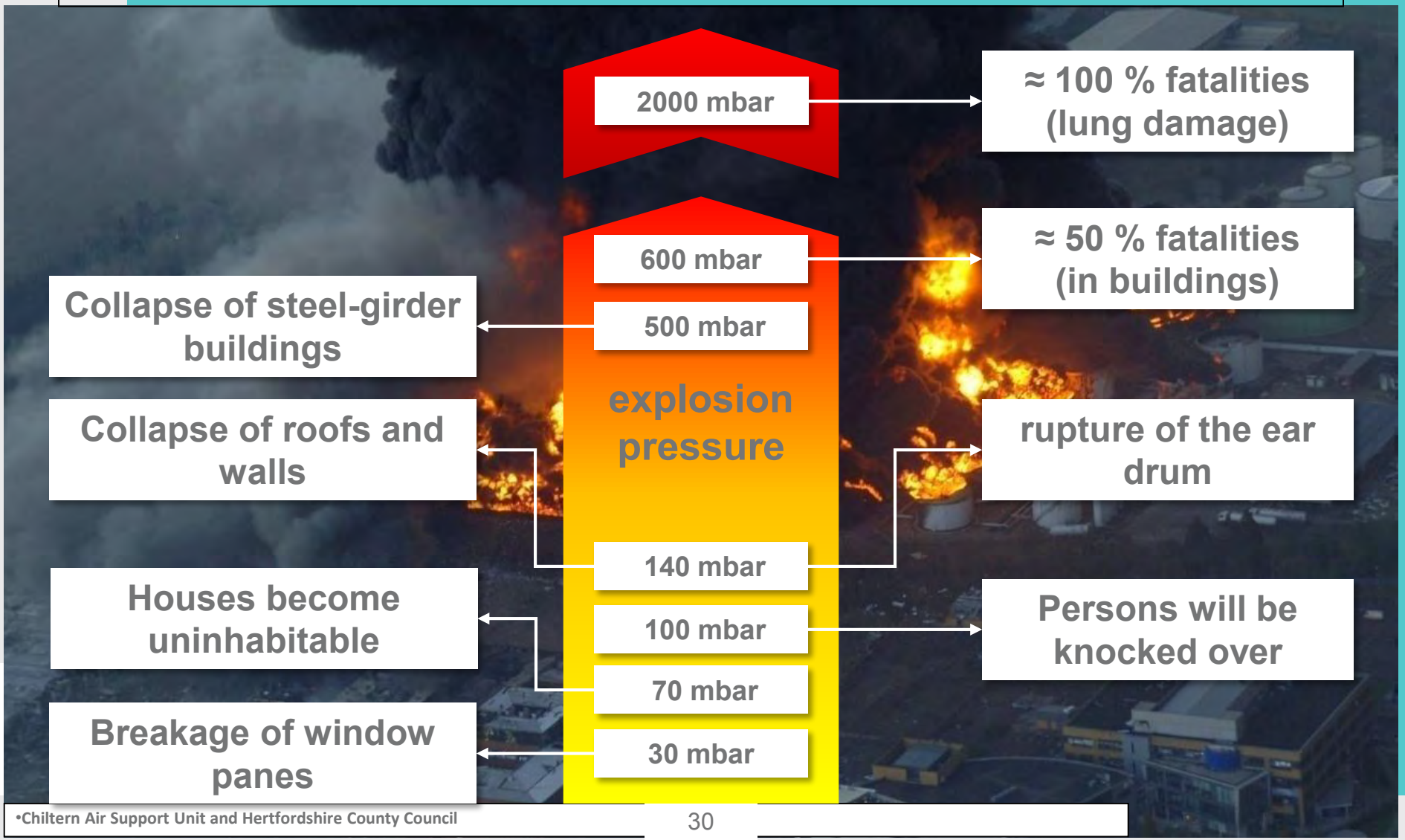
lightning strikes

exothermal reactions

mechanical sparks

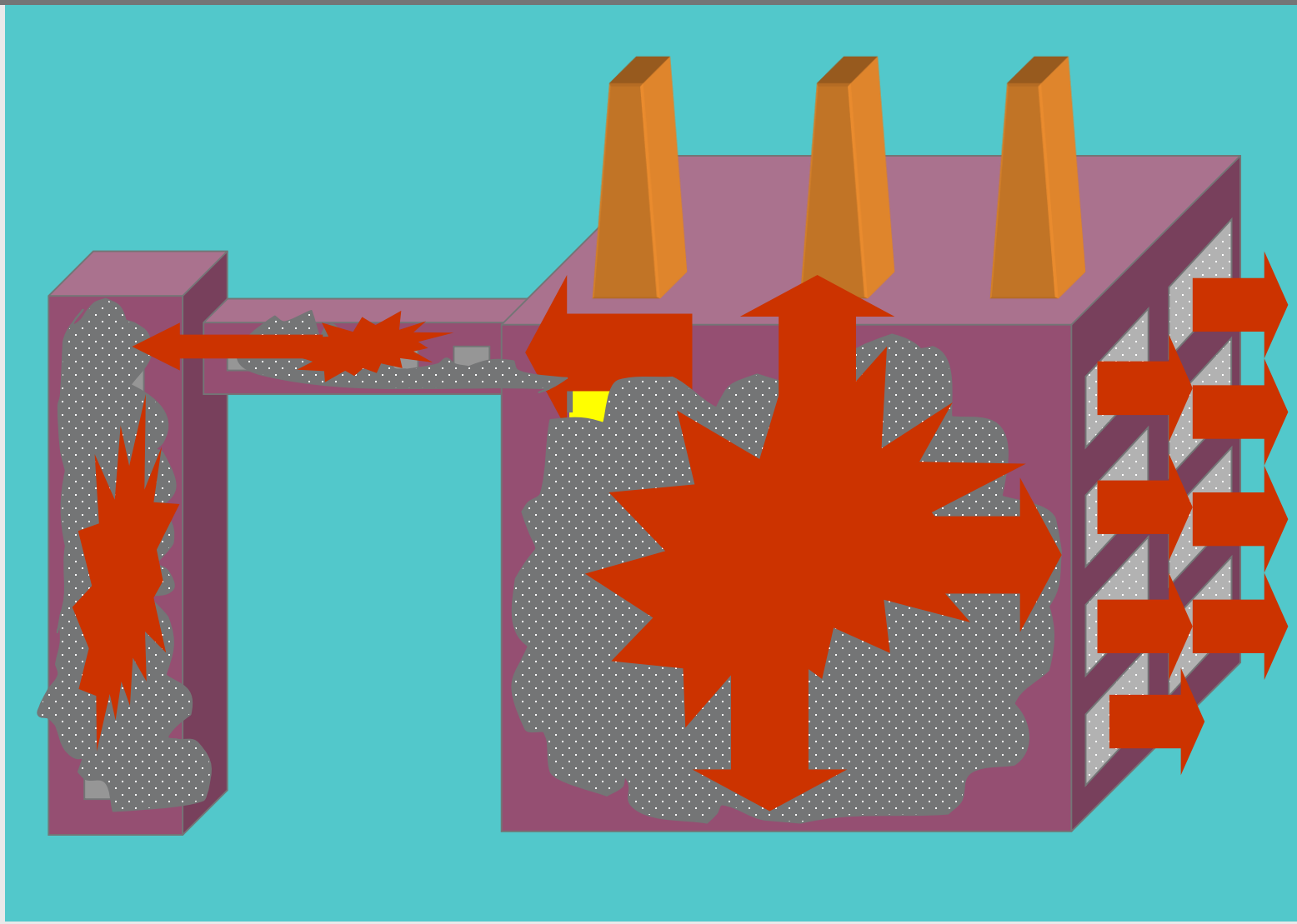
electromagnetic waves (10^4 - $3 \cdot 10^{12}$ Hz)

Pressure Effects



•Chiltern Air Support Unit and Hertfordshire County Council

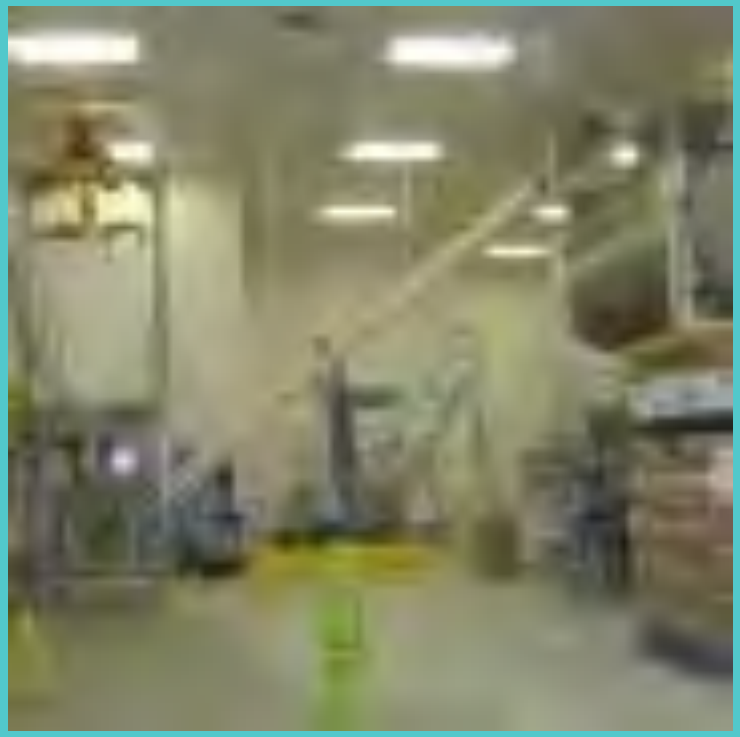
Primary and secondary explosion



First step:

Keep area clean - Housekeeping !!!!!

שינוע חלזוני סגור

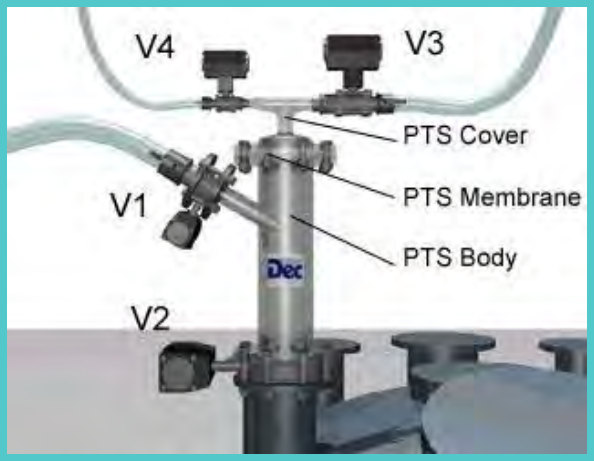


חילזון גמיש ללא ציר – שינוע משופע ופריקת שקי ענק למערבל
)אוטאוס בע"מ - Hapman(

מערכות שינוע בוואקום - Sequencing

P-10 by K-tron Premier

PCS by Hecht



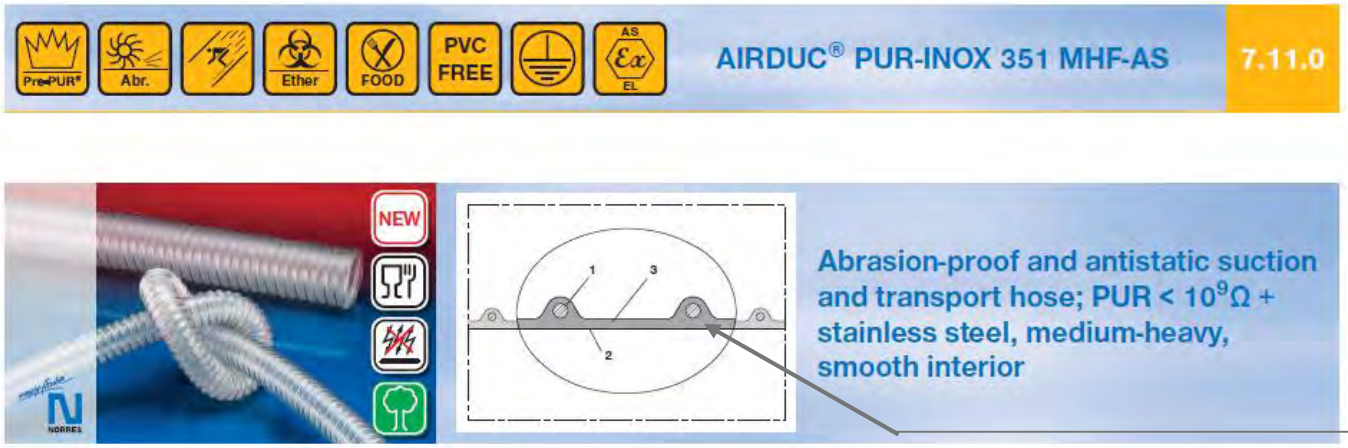
PTS by DEC

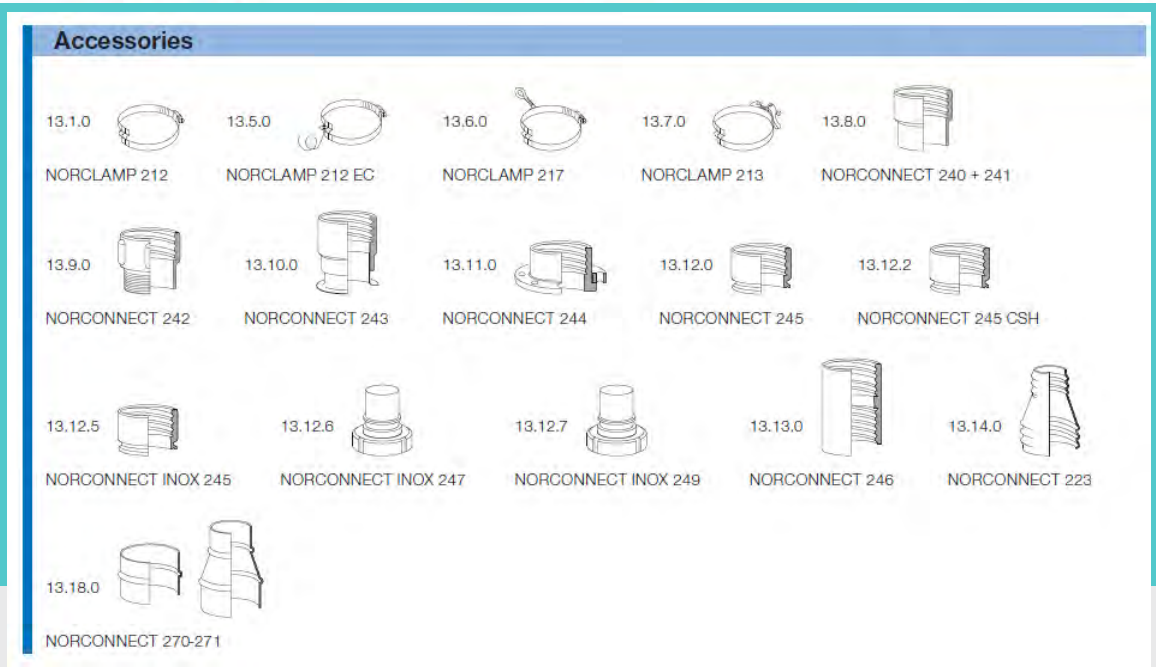
Powders and granules transfer in close manner

HSM discharging to FB dryer
FB dryer discharge with vacuum conveying

Bin filling by sequence conveying
Discharging to single pot in continuous conveying

Low vacuum conveying hoses Antistatic





Smooth hose for wet conveying and explosion pressure resistance

inescoflex

ChemLine

IF51

תיאור: צינור פוליאתילן דחוס (UPE) חלק וגמיש, מחוזק סיבים וספירלות ובעל כיסוי גומי שחור אנטי-סטטי.
חומרי מבנה: צינור פנימי: פוליאתילן דחוס (UPE- Ultra High Molecular Weight Polyethylene) שחור וחלק.
חיזוק: סיבים סינטטיים, ספירלת מתכת, וחוטי נחושת המוטבעים בקיר הצינור.
כיסוי: גומי EPDM שחור, אנטי-סטטי $R<10^6\Omega$, חלק, עמיד בשחיקה, באוזון ובפגעי מזג-האויר.
עמידות בואקום: עד 0.9- בר
טמפ' עבודה: מ- 35- ℃ עד 100 ℃ (עמיד בקיטור עד לטמפרטורה של 130 ℃ למשך עד 30 דקות)
שימושים: צינור חזק וגמיש המשמש להובלת מגוון רחב של כימיקלים. מתאים לעבודה בלחץ וביניקה.

משקל	לחץ פיצוץ ב- 20 ℃	לחץ עבודה מקסימלי ב- 20 ℃	רדיוס כיפוף מינימלי	קוטר חיצוני (OD)	קוטר פנימי (ID)	קוד צינור	הקוטר	
Kg/m	bar	bar	mm	mm	mm			
0.63	30	10	100	31	19	510020	DN20	3/4"
0.77	30	10	125	37	25	510025	DN25	1"
0.94	30	10	180	44	32	510032	DN32	1-1/4"

צנרת מומלצת לשינוע
אבקות רטובות בממס דליק

MIE < 1mJ

Thank you!