Dryers – Processes & Protection

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Introduction

- ***Purpose***
  - Understand basic dryer types for handling powders
  - Review loss history
  - Review process features related to operating safety
  - Review features controlling dust hazard & effects
  - Lessons learned – case studies

Dryer types

- ***Conventional (continuous tray/belt)***
  - Roasters, food, grains
- ***Flash dryers***
  - Wood, food, chemicals
- ***Ring dryers***
- ***Rotating drum dryers***
- ***Spray dryers***
- ***Fluid bed dryers***
- ***Direct or indirect heated***

Common hazards

- ***Fire or explosion***
- ***Fuel explosions***
- ***Release of flammable vapors/solvents***
- ***Deposits***
- ***Overheating***
- ***Spontaneous heating - autoignition***
- ***Sparks***
  - Electrostatic
  - Friction
  - Electrical
- ***Discharge hot product to downstream processes or storage***

Important material properties

- ***Solvent properties (where applicable)***
- ***Thermal stability***
  - DSC (Differential scanning calorimetry)
  - DTA (Differential thermal analysis)
  - Isothermal stability test
- ***Spontaneous ignition test***
- ***Layer ignition test***
- ***Minimum ignition energy (MIE)***
- ***Toxicity***
- ***K_{st}, P_{max}, MEC, Cloud ignition test, LOC***
- ***Resistivity, conductivity, chargeability***

Loss history – Dryers (explosions)

Dryer Type	Number of events	Percent of Loss $
Flash	2	36%
Rotary	7	37%
Spray	5	27%
Grand Total	14	

Cause		
Burner Flame	4	33%
Chemical Action	1	1%
Hot Surface	1	0%
Overheating	2	1%
Spark	2	37%
Static Electricity	1	9%
Unknown	3	19%
Grand Total	14	

Loss History F&X – Spray Dryers

Cause	Number of events	Percent of Loss $
Chemical Reaction	1	10%
Component Failure	1	0%
Hot Surface	1	1%
Overheating	8	15%
Spark	2	1%
Spontaneous Ignition	1	61%
Unknown	4	12%
Grand Total	18	

Industry	Number of events
Food	13
Chemical	4
Metal Product	1
Grand Total	18

Loss History – other

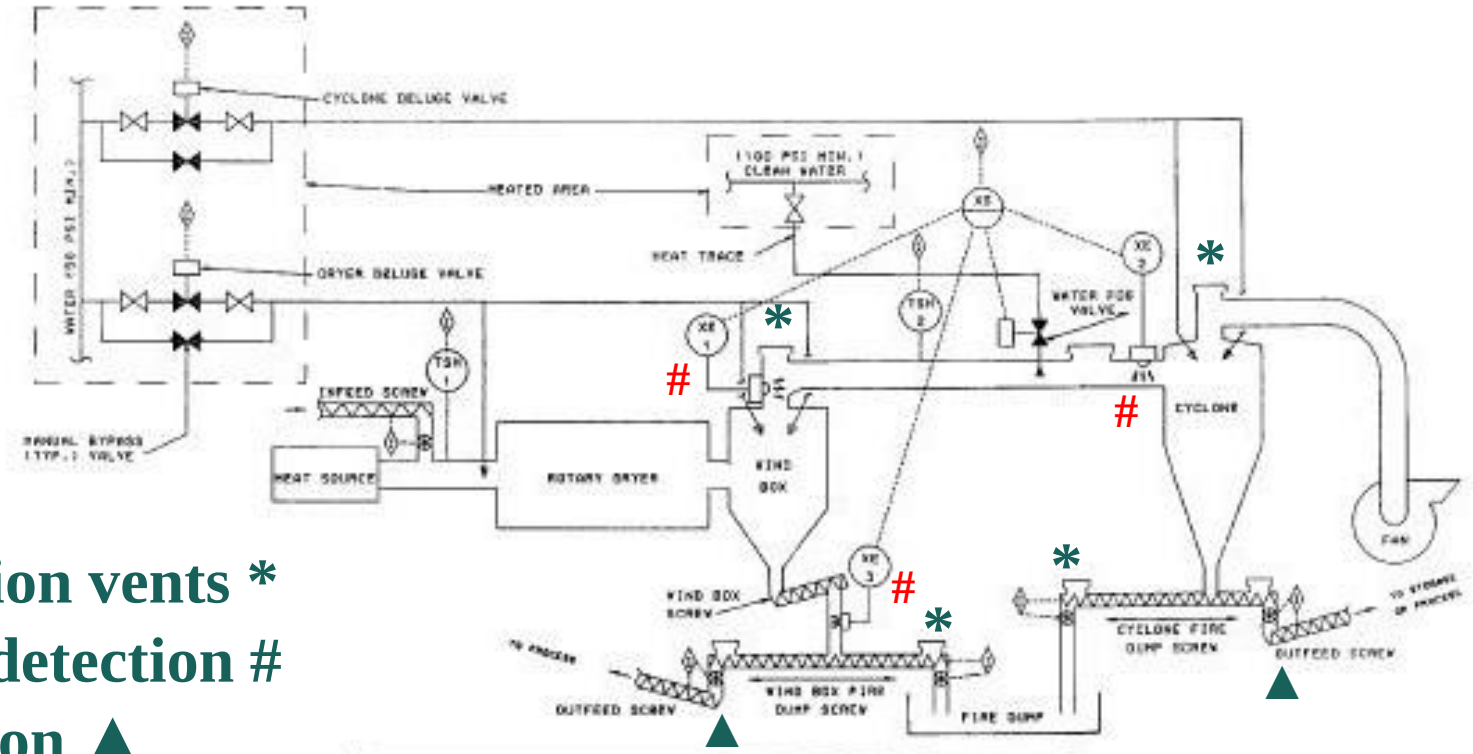
- ***CSB dust hazard study (1985 – 2005)***
  - 281 incidents – no spray dryers

- ***GEA – Niro (1963 – 2010)***
  - Estimated 4500 – 5000 spray dryers in service
  - 285 recorded incidents
    - 229 fires, 56 explosions (all with some venting)
    - 174 major
    - At least 28 starting in fluid bed
  - Contributing factors
    - Explosion vents welded shut or not ducted outside
    - Fire extinguishing inoperable

Rotary Drum Dryers

- ***Potential hot embers - direct fired or accumulations***
- ***Operate at rated capacity***
  - Higher capacity, increase operating temperature, overheating
- ***Monitor temperature***
- ***Systems for spark detection/extinguishing***
- ***Explosion risk usually downstream of dryer***
- ***Venting not practical***

Rotary Drum Dryers – protection

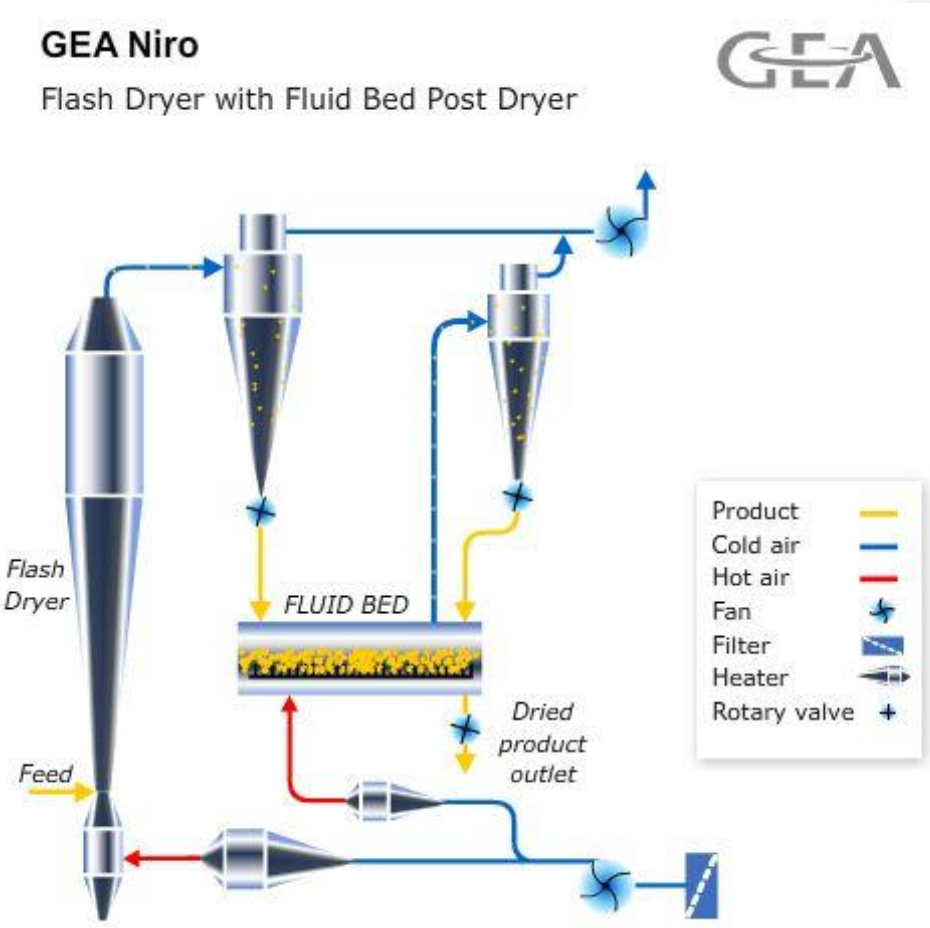


Explosion vents *
Spark detection #
Diversion ▲

SYMBOL	DESCRIPTION	LOCATION	SYMBOL	DESCRIPTION	LOCATION
XS			TSH 1		
			TSH 2		
XE 1					
XE 2					
XS 3					

Source – FM Global loss prevention data sheet 7-10

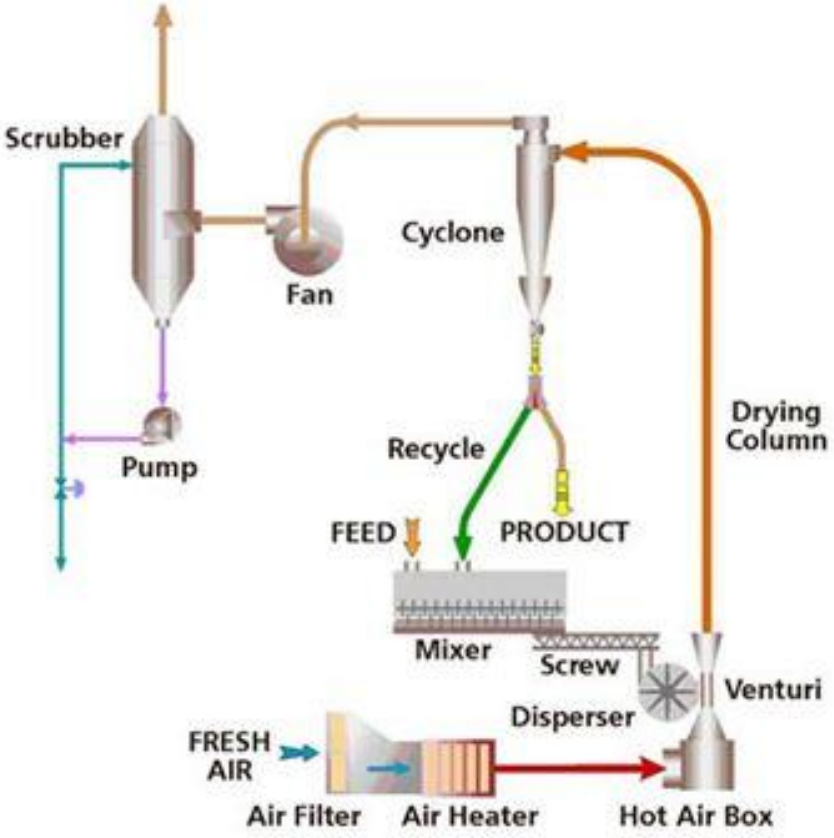
Flash Dryers



- ***Accumulation of wet material in ducts***
- ***Potential hot embers***
  - Direct vs. indirect fired
- ***Operate at rated capacity***
- ***Temperature monitoring***
- ***Systems for spark detection/extinguishing***
- ***Explosion venting***
- ***Fire protection for FBD***
- ***FM Global LPDS 7-10***

Flash Dryers

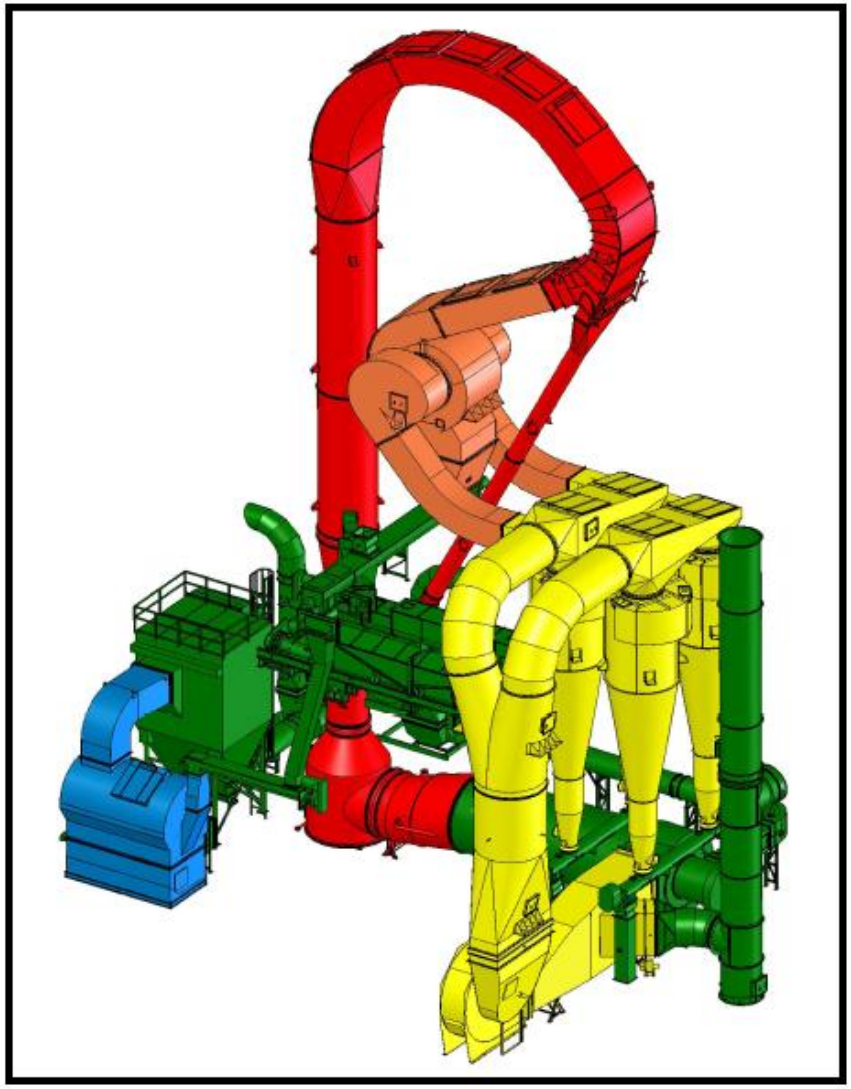
Ring dryers



GEA – Barr-Rosin

- ***Modified flash dryer***
- ***Ethanol industry***
  - 2 fires, 1 explosion, 1 implosion
  - Spontaneous heating
  - Sudden stop/start
  - Accumulations
- ***Operate within specs***
- ***Pre-plan response to process upsets***
- ***Fire protection***
- ***Explosion & implosion relief***

Ring dryers



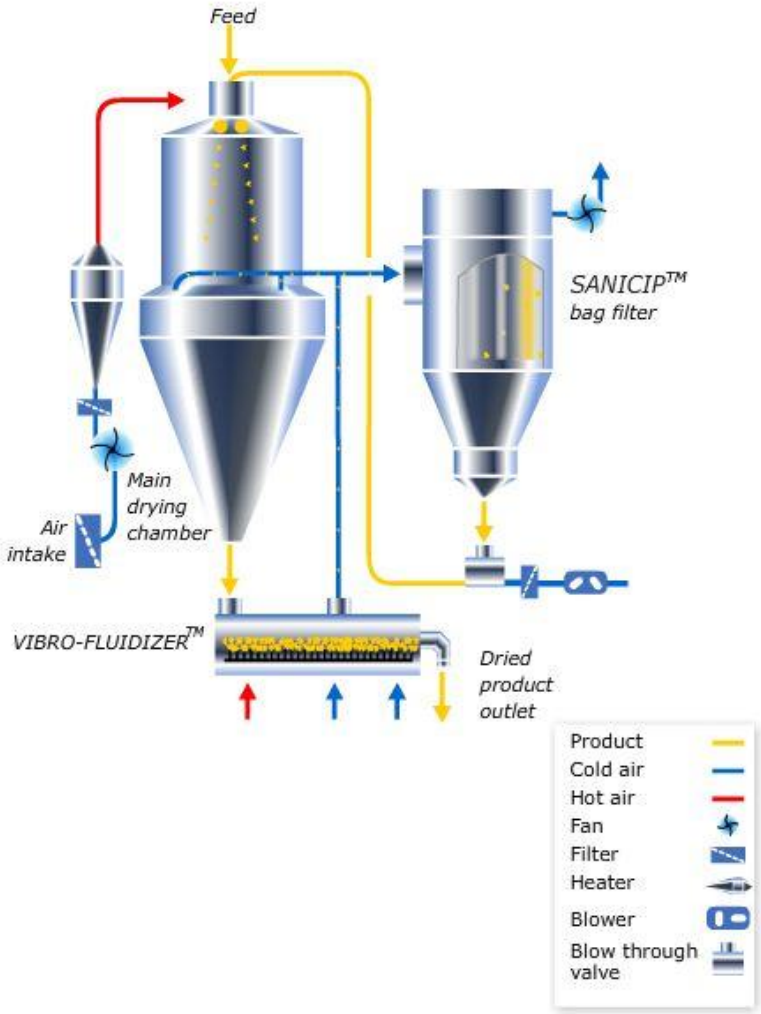
GEA – Barr-Rosin

- ***Explosion venting***
  - Break into zones
  - Cyclones, bag houses standard methods
  - Drying column has H/D issues; calculate in virtual sections

Spray Dryers

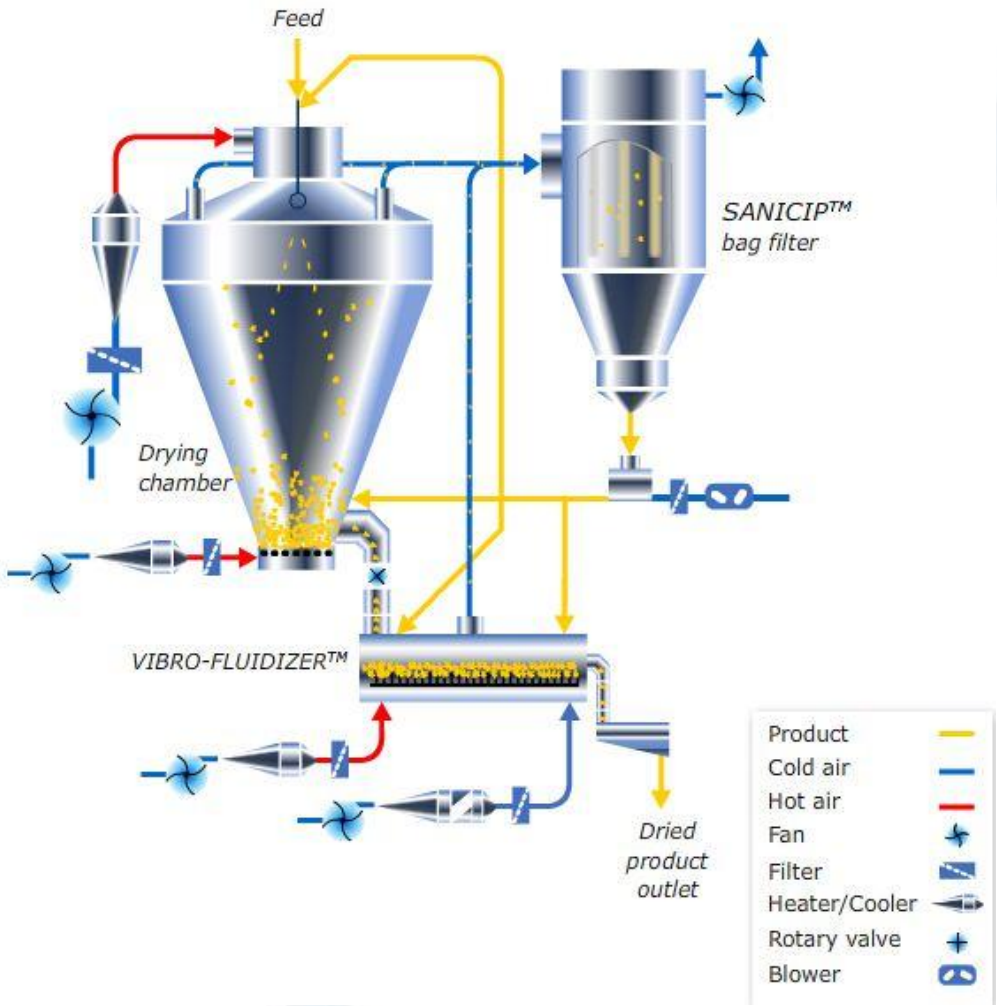
GEA Niro

TALL FORM DRYER™



GEA Niro

MSD™ (Multi Stage Dryer) / FSD™



Spray Dryers

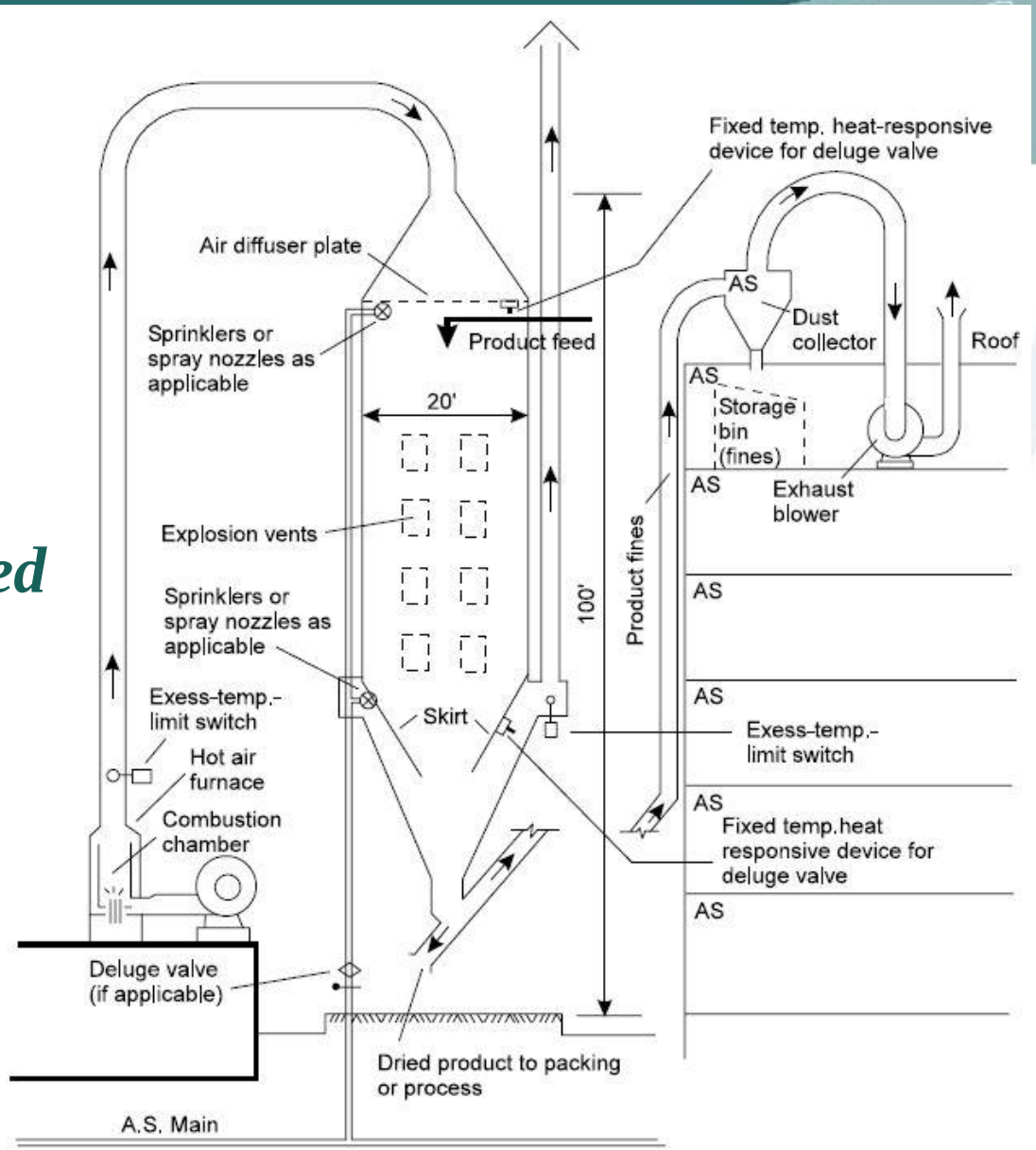
- ***Process hazards***
  - Solvent wet material; hybrid mixtures
  - Accumulations near atomizer, elsewhere
  - Potential spontaneous heating
  - Peripheral equipment hazards
    - Hot bearings/surfaces
    - Fans/blowers – mechanical sparks
  - Heating system hazards
    - Direct – sparks, glowing particles, fuel explosions
    - Indirect – external fires, fuel explosions
  - Dust explosion
  - Unit isolation

Spray Dryers

- ***Process interlocks/alarms/monitoring***
  - Vibration (fans in dust stream)
  - Temperature
    - Dryer inlet & outlet (spray & fluid bed)
    - Product outlet
    - Heating system
    - Key fan/blower bearings – supply, exhaust
  - Video for buildup in equipment & process ducts
  - Carbon monoxide/CO (spontaneous heating)

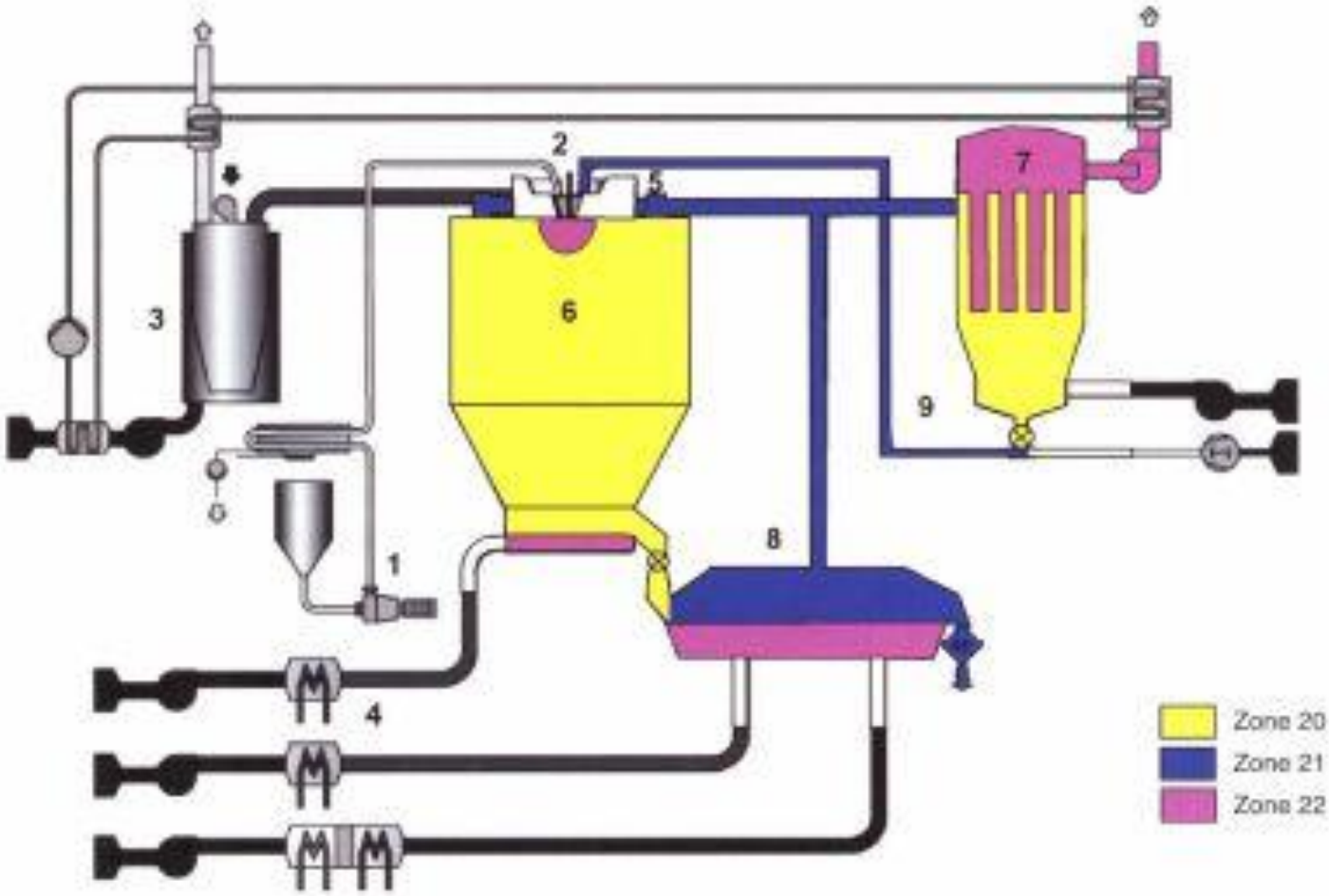
Spray Dryers

- *Fire protection*
  - *Detection fixed temp*
  - *Deluge sprinklers*
  - *Spray & fluid bed*
  - *Dust collectors (closed heads)*
- *Explosion venting*
  - *Spray & fluid bed*
  - *Dust collectors*
  - *Cyclones*



Source – FM Global loss prevention data sheet 6-9

Spray Dryers – Ignition Sources



VDI 2263 Part 7

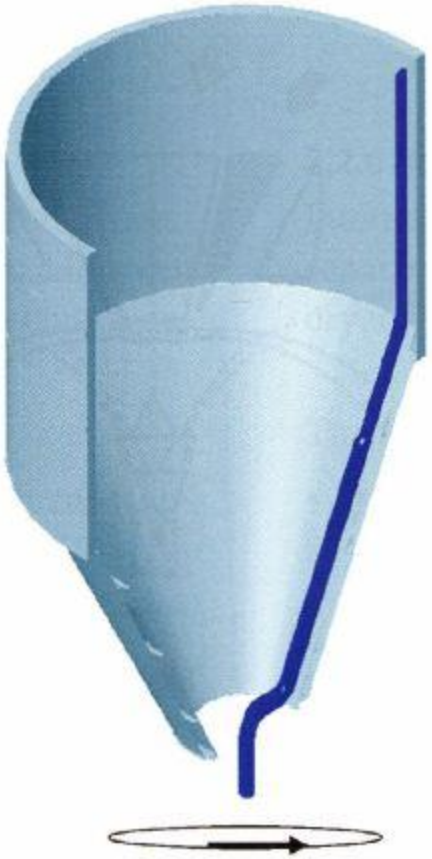
20 – continuous, long term (Div 1)

21 – occasionally normal operation (Div 1)

22 – seldom, short term (Div 2)

Spray Dryers – Ignition Sources

- ***Flame or hot work***
  - Indirect heating preferred
  - Hot work permit and controls
- ***Overheated materials***
  - Accumulations especially near atomizer where hot air usually enters
  - Proper operating limits for atomizer
  - Temperature limits – hot air & dryer
  - Monitor (video)
  - Maintenance (lubrication, alignment, clean)
  - Clean – air broom or wash down



Spray Dryers – Ignition Sources

- ***Static ignition***
  - MIE less than 10 – 25 mJ
  - Grounding, bonding, inerting, other controls
- ***Mechanical spark***
  - Fans in dust stream
  - Type A or B construction per AMCA 99-0401-86, Classifications for Spark Resistant Construction
  - Monitor (detection or physical check)
  - Maintenance (lubrication, alignment, clean)
- ***Friction sources***
  - Monitor & maintenance

Spray Dryers – Explosion Mitigation

- ***Eliminate fuel***
- ***Eliminate oxygen***
  - Operate inert sometimes possible with direct heated systems
- ***Explosion suppression***
  - Large scale up factor from testing
  - Proprietary design
  - Detection usually pressure
  - Will suppressant reach the flame core?
  - History of success
- ***Containment***
  - Explosion ‘pressure’ or ‘pressure shock’ resistant

Spray Dryers – Explosion Mitigation

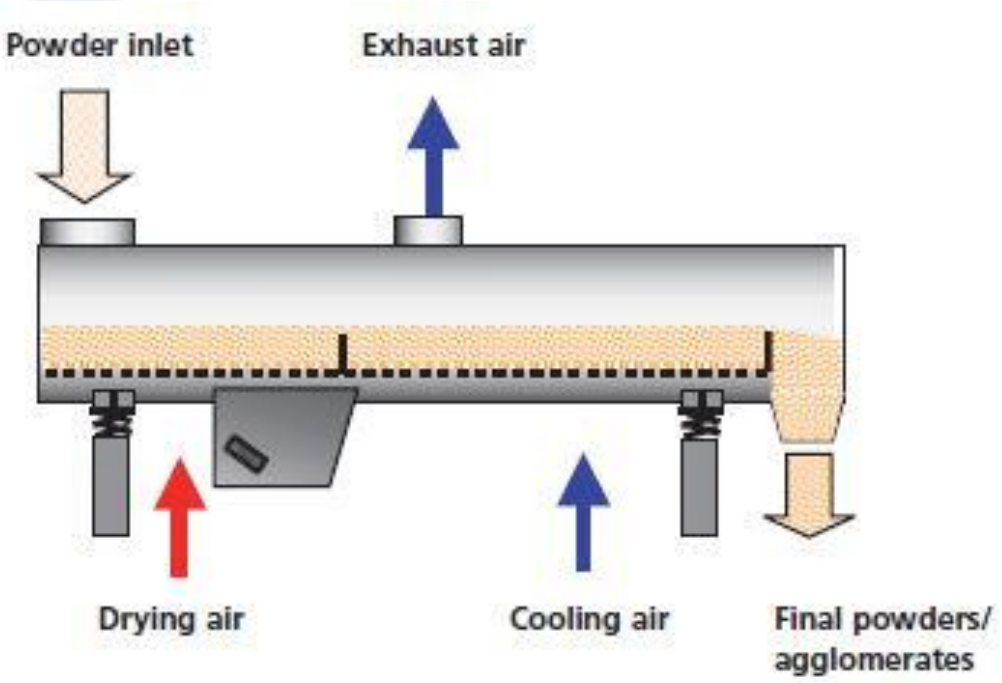
- ***Isolation***
  - Between major pieces of equipment
  - Flexible connections rated for P_{red}
  - Rotary valves designed to prevent flame passage
  - Monitoring for hot particles and diversion to a safe location
  - Fast acting valves
  - Chemical blocking
  - Design criteria in NFPA 69

Spray Dryers – Explosion Mitigation (vents)

Design criteria

- ***FM Global DS 7-76 & NFPA 68 (2007)***
  - Partial volume & full K_{st}
- ***VDI 3673 (2002) or EN 14491 (2006)***
  - Full volume & K_{st} but adjustment permitted 'based on published or experimental data from representative venting trials'
- ***GEA – Niro***
  - Radandt adjustment to VDI/EN equations based on testing at moderate scale
  - Filling factor to adjust for cloud dispersion method
  - Reduced K & P_{max} values by test at 250 g/m^3 (typical)

Fluid Bed Dryers



GEA – Niro

Fluid Bed Dryers

- ***Process hazards***
  - Solvent wet material; hybrid mixtures
  - Potential spontaneous heating
  - Maintain fluidizing medium (air) flow
  - Product thermal stability / temperature control
  - Hot bearings/surfaces
  - Mechanical sparks
  - Grounding & bonding
  - Dust explosion
  - Component isolation
  - Flexible connections

Fluid Bed Dryers

- ***Process interlocks/alarms/monitoring***
  - Maintain fluidizing medium (air) flow
  - Loss of fluidizing medium, shut down heating
  - Temperature
    - Fluidizing medium inlet & outlet
    - Product outlet
    - Heating system
    - Key bearings – mechanical components, blowers
  - LEL monitoring for hybrid mixtures
  - Carbon monoxide/CO (spontaneous heating)

Fluid Bed Dryers – Explosion Mitigation

- ***Eliminate fuel***
- ***Eliminate oxygen***
- ***Explosion suppression***
- ***Containment***
- ***Isolation***
- ***Venting***
  - FM Global DS 7-76 & NFPA 68 (2007)
  - VDI 3673 (2002) or EN 14491 (2006)
    - Standard design criteria

Other References

- ***Guidelines for Safe Handling of Powders & Bulk Solids, AIChE CCPS, 2005 Chap 5.3.3 Drying Equipment***
- ***VDI 2263 Part 5 Dust fires and dust explosions, Hazards – assessment – protective measures, Explosion protection in fluidized bed dryers (2005)***
- ***VDI 2263 Part 7 Dust fires and dust explosions, Hazards – assessment – protective measures, Dust fires and explosion protection in spraying and drying integrated equipment (2010)***
- ***Approved Code of Practice for the Prevention, Detection and Control of Fire and Explosion in New Zealand Dairy Industry Spray Drying Plant, Department of Labour, June 1993***
- ***HSE 103, Safe Handling of Combustible Dusts (2003)***