An Oven Explosion – Lessons Learned on PSM Concepts (or "PSM: It's not just for breakfast anymore")

Michael D. Cazabon, P.E.
FM Global
404 High Meadow Lane, Heath, TX 75032
Michael.Cazabon@fmglobal.com

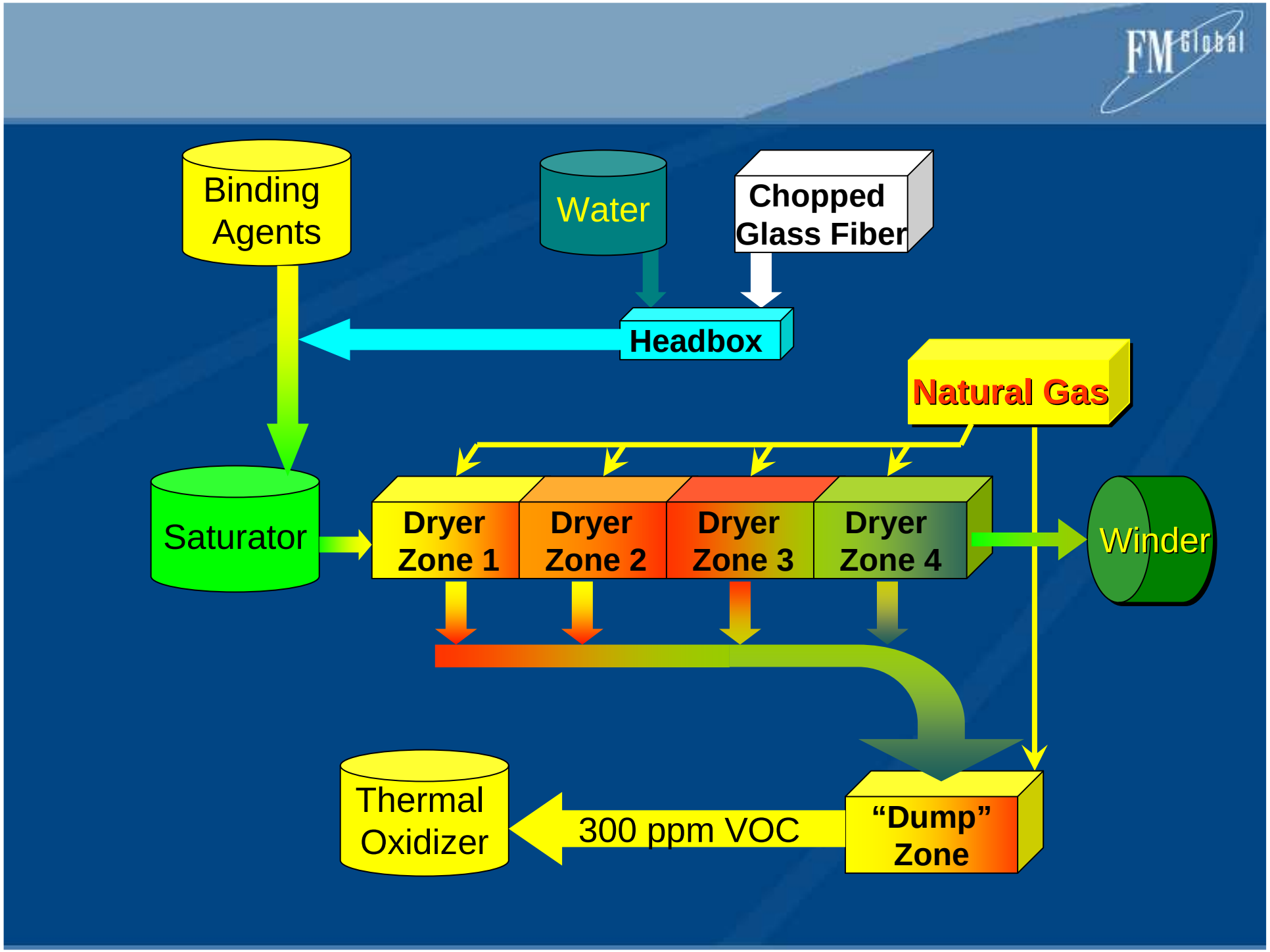
Kirby Erickson, P.E.
GAF-Elk
202 Cedar Road, Ennis, TX 75119
KirbyE@gaf.com

PSM Concepts & Applicability

- Should some concepts of PSM be applied in all industries?
- Are codes enough?
- Should we accept the notion that suppliers always know their process and equipment better than us?
- Should we view combustion as something more than a mundane, ubiquitous process?

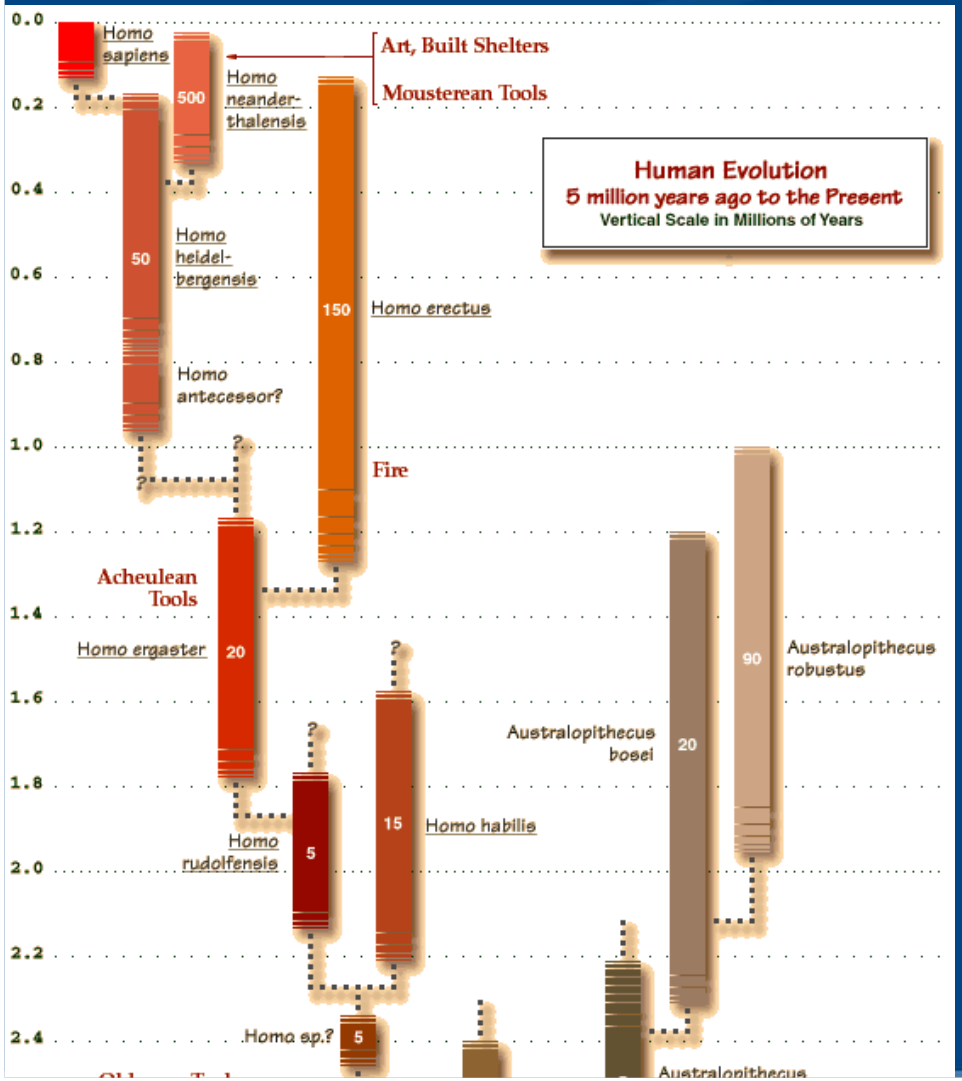
The Event

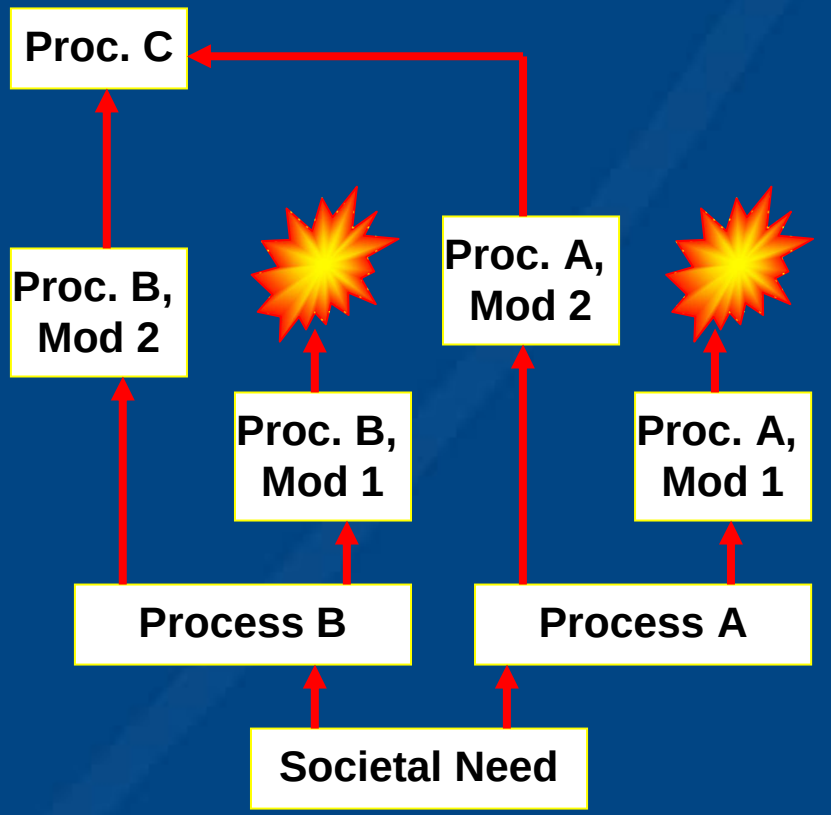
- *September 15, 1998: Difficulties starting up new line.*
- *Once started, operations ramps up to full speed. Ovens ramp up to high fire settings.*
- *Within 12 minutes of ramp initiation, an explosion, heard for 6 miles, takes place.*


Binding Agents
Water
Chopped Glass Fiber
Headbox
Natural Gas
Saturator
Dryer Zone 1
Dryer Zone 2
Dryer Zone 3
Dryer Zone 4
Winder
Thermal Oxidizer
300 ppm VOC
"Dump" Zone

Evolution or Managed Change?

Evolution or Managed Change?



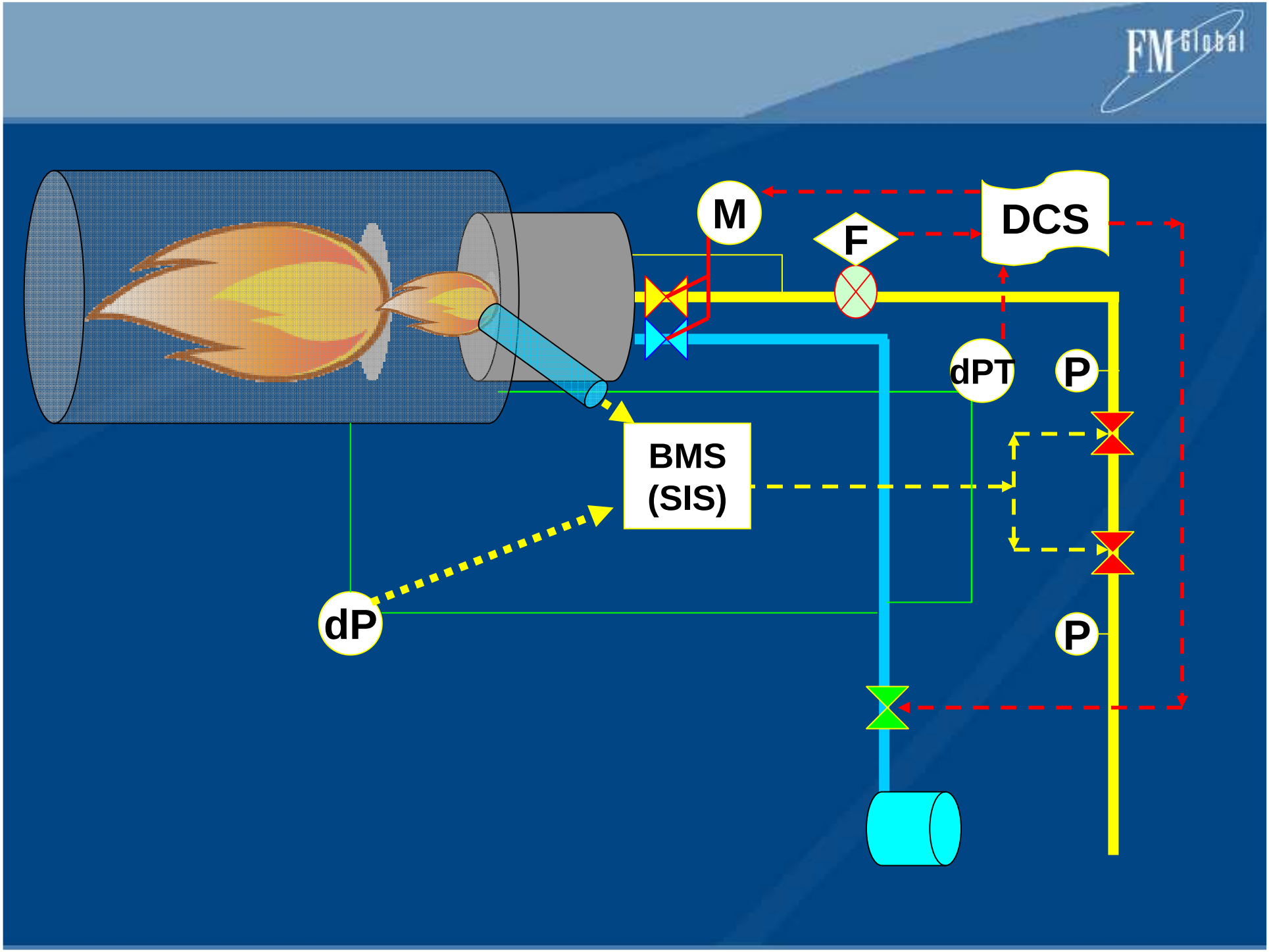


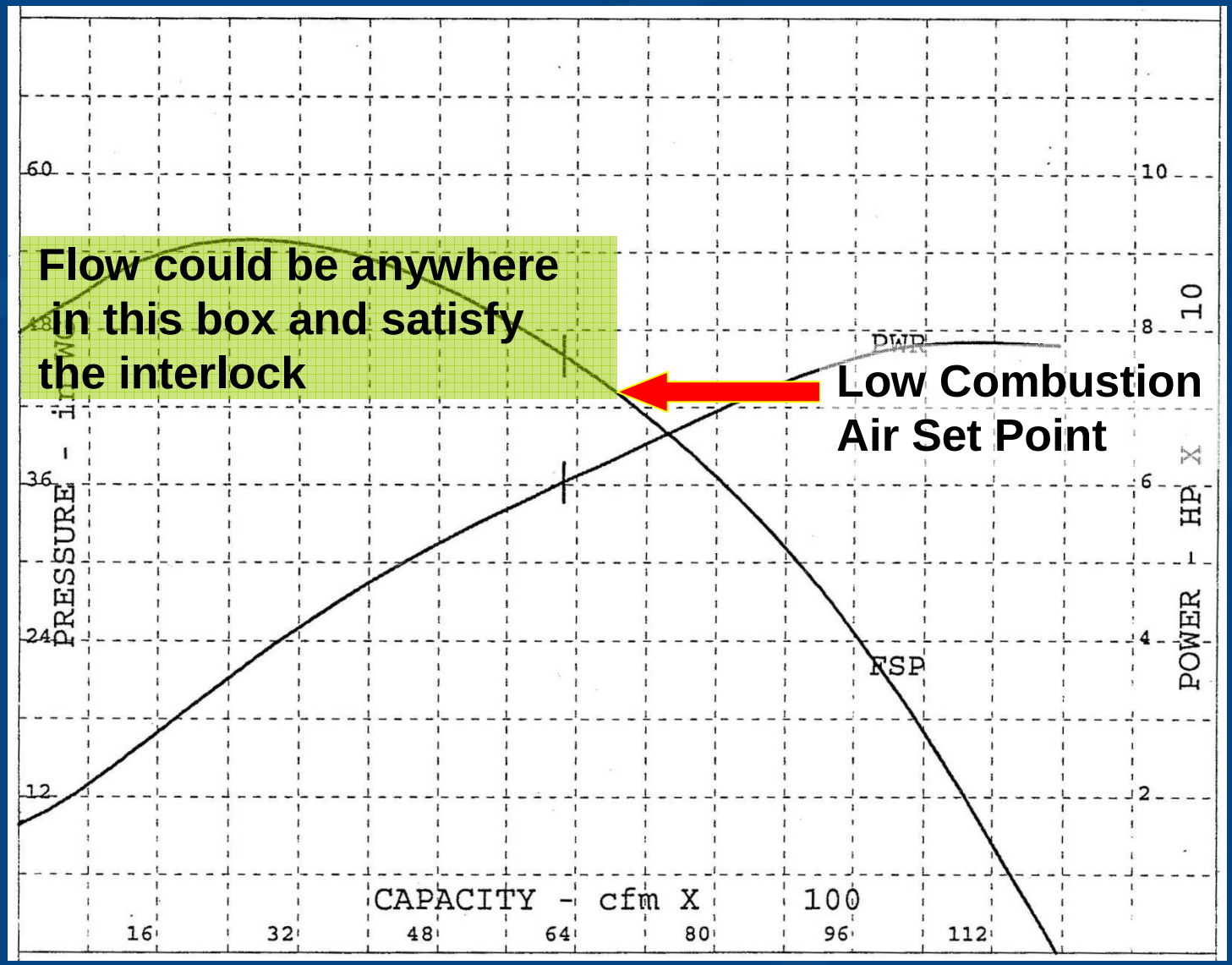
Sequence of Changes

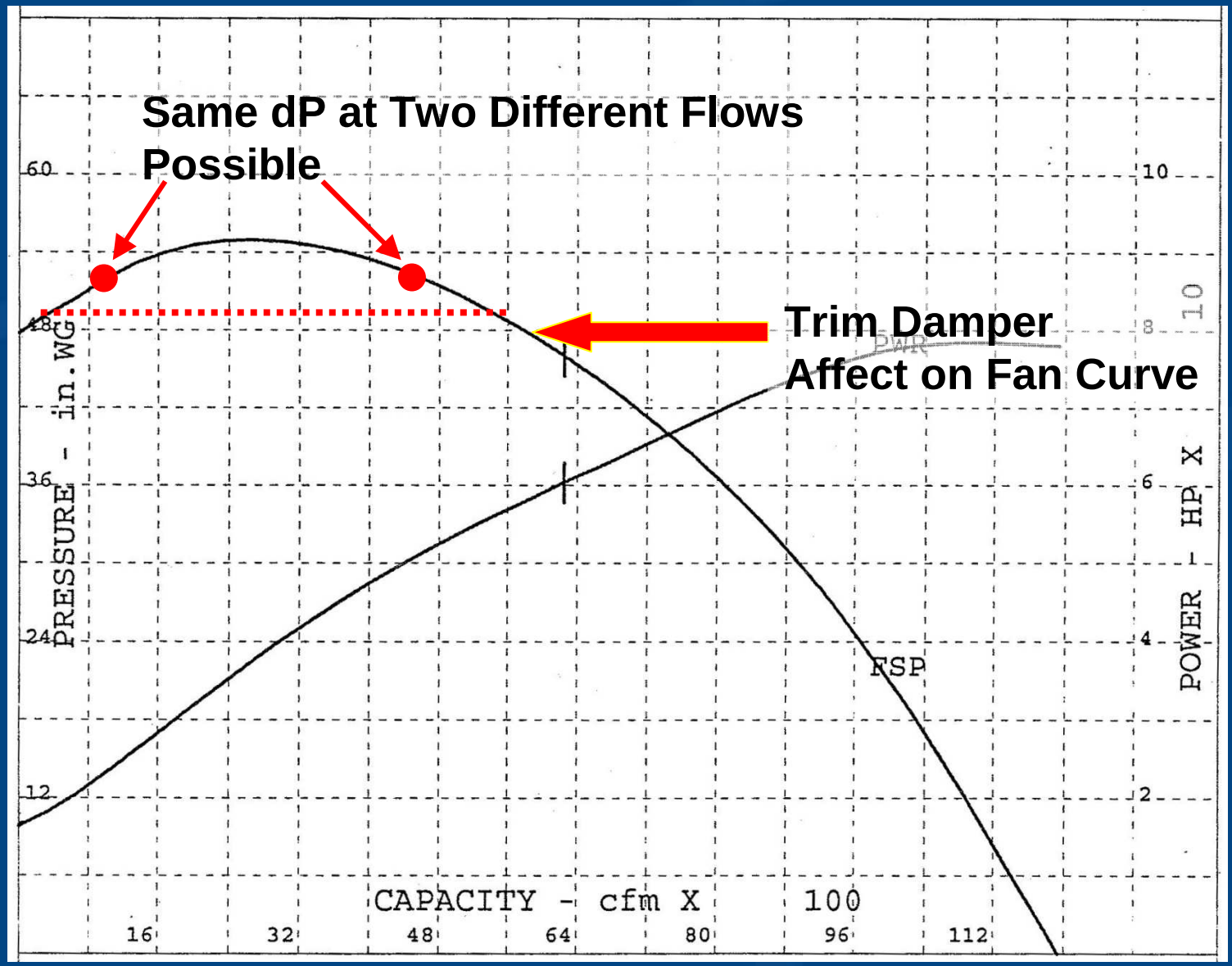
- *Orders a machine capable of X feet/minute*
- *Changes order to 1.5 X feet/minute*
- *Machine manufacturer changes burner requirements*
- *Burner manufacturer uses same burner, but increases gas flow to get higher rating*
- *No one changes combustion air fan capability*

Sequence of Changes

- *Start up problem: Unstable low fire flame*
- *First Solution: Weighted Pressure Relief Valve on Combustion Air – Too Noisy!*
- *Second Solution: Combustion Air Trim Damper*


FM Global
M
F
DCS
dPT
P
BMS
(SIS)
dP
P


Flow could be anywhere in this box and satisfy the interlock
Low Combustion Air Set Point
PWR
FSP
PRESSURE - in WG
POWER - HP X 10
CAPACITY - cfm X 100
60
36
24
12
10
8
6
4
2
16
32
48
64
80
96
112


Same dP at Two Different Flows Possible
Trim Damper Affect on Fan Curve
PRESSURE - in.WG
60
48
36
24
12
PWR
FSP
POWER - HP X 10
10
8
6
4
2
CAPACITY - cfm X 100
16
32
48
64
80
96
112

The Burner

The Incident

21:15 Line shut down due to quality; burner at low fire

21:34 Line re-started, 12 minute ramp up to maximum speed. Burner demand set to high-fire

21:39 Leakage alarm – calculated number indicating pressure is high within oven. Operators should smell binder fumes. No smell reported. Thermal oxidizer temperature begins rising

The Incident

21:41	Thermal oxidizer shuts down on high temperature. Machine shutdown initiated, atmospheric bypass opened.
21:41:58	Last of product leaves oven, triggers “sheet break” alarm.
21:45:33	Operator clears alarm
21:46:04	Explosion occurs (pressure disturbance in Zone 1)

Explosion Venting

- ***Recommended by FM & NFPA***
  - Only for ovens regardless if flammable vapors are generated or not
  - Does this mean we do not trust combustion safeguards?
- ***Venting not provided***

Investigation

- *Identified, secured and tested the low combustion air pressure switch*
- *Confirmed valve positions and determined failure mode – Combustion air trim damper was "fail last"*
- *Found water in instrumentation lines*
- *Preserved lines and tested for effect of water on dPT*

Affect of Water in the Instrumentation Line

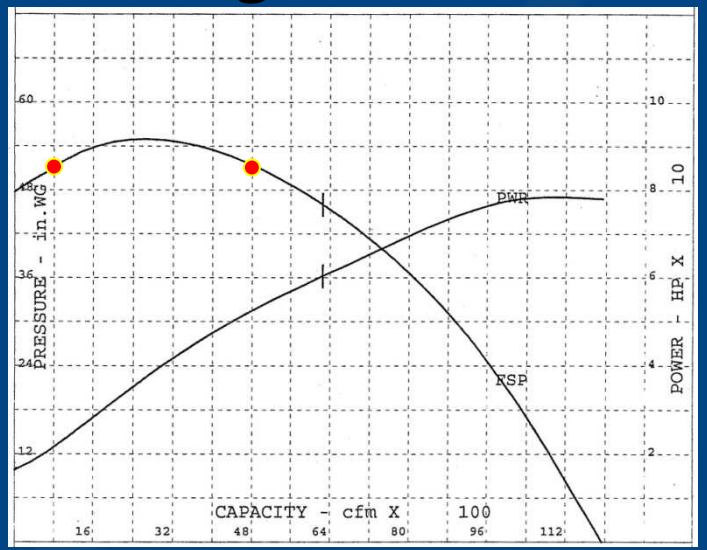
Test No.	Amount of Water	dP Applied (in. WC.)	dP from DPT (in. WC.)	Error (in. WC)
1	0 ml.	4.1	4.1	0
2	5 ml.	4.8	6.0	1.2
3	10 ml.	4.1	5.9	0.8
4	15 ml.	4.12	6.17	2.05
5	20 ml.	4.3	5.1	0.8

Conclusions

- ***Failure to manage change:***
  - ***Upsized burner from 30 MM to 40 MM BTU***
  - ***Never increased fan rating***
  - ***Original specification of 14:1 air/fuel ratio***
  - ***Actual ability at high fire was 10:1***

Conclusions

- ***Failure to manage change:***
  - ***Due to flame instability at low fire, dP was reduced first by relief valve, then by trim damper***
  - ***Fan curve truncated resulting in multi-point dP***
  - ***Allowed trim damper to seek low flow position***



Conclusions

- ***Failure to properly install:***
  - ***Instrument locations changed to become accessible without building ladders/platforms***
  - ***Tap points were higher than instruments***
  - ***Condensate filled lines***
  - ***Induced error***
  - ***Corroded switch contact closed***

Conclusions

- ***Questionable design of burner***
  - Seemed to meet code, but high fire flame was not monitored
  - Low fire flame monitored and stayed lit
  - Became ignition source of explosion

Conclusions

- *We are not measuring meaningful parameter*
  - *Combustion air pressure limits do not mean we have sufficient air for combustion!*
- *We assume linkage will not slip or bind*
  - *Linkage slip has happened!*

Conclusions

- *Should we measure air and fuel flow instead?*
  - *Ratio control and interlock systems?*
- *How about measuring combustibles in the exhaust?*
- *Can we make them reliable enough to preclude the need for venting?*
  - *ASME Code Case 2211?*
  - *SIL 1 or 2 needed?*