

SEMICON TAIWAN

CIISC

- PV Tool and Facility Safety Considerations
- Presenter: Chris Illerhaus
- CI Industrial Safety Consulting, LLC
- www.IPVES.com
- EMail: cillerhaus@ipves.com

CI Industrial Safety Consulting,
LLC

Your complex facility

CIISC

	Source	Distribution	Tool / Use	Distribution	Abatement
H ₂	yes	yes	yes	yes	yes
SiH ₄	yes	yes	yes	yes	yes
Solvents	yes	yes	yes	yes	Rather collection / treatment
Electricity	yes	yes	yes	no	no
ETC					

Standards / Codes / Guidelines

- SEMI S2
- SEMI S14
- EN50014
- EN60204
- **NFPA318**
- NFPA497
- FM6050
- **FM7-7 / FM7701**
- ATEX Directive
- NEC
- UBC
- **But: no “to-the-point” facility code**

Code competition

CIISC

- There is some unhelpful code competition out there: which of the following overlapping ones should we use: IBC, NFPA, IFC, DIN, BGV, FM etc

What is covered by codes

- Tools, silane cylinder cabinets etc well covered by codes but
- Facility issues: interfaces, preventive maintenance, thin film cell chemistry supply distribution, facility spill clean up, complex relations between facility parts not covered

Stuff Happens

CIISC

- Plasma CVD Machine
- 1 death during Preventive Maintenance
- Explosion of accumulated byproduct $\text{SiO}_x\text{N}_y\text{H}_z$ after opening of exhaust line
- Cause: $\text{SiO}_x\text{N}_y\text{H}_z$ to roof scrubber → scrubber not yet in bypass → $\text{SiO}_x\text{N}_y\text{H}_z$ exposed to / reacted with water → generated H_2 → H_2 ignited @ scrubber heater → generated blast → dispersed fine powder dust-exploded

Stuff happens

CIISC

- Plasma CVD Machine with Abatement
- 1 death during accident mitigation effort
- Explosion of unreacted SiH_4 after it was exposed to air in the facility duct downstream of the point-of-use abatement system
- Cause: single fault in gas delivery control system
→ too much SiH_4 → unreacted SiH_4 downstream of tool → insufficient dilution → SiH_4 hits air in duct → explosion / fire

Stuff happens

CIISC

- Plasma CVD Machine
- 2 deaths
- Violent reaction of SiH_4 and N_2O with subsequent fire
- Cause: SiH_4 and N_2O shared purge line, N_2O check valve leaked \rightarrow N_2O through purge line into SiH_4 cylinder, ignition source: possibly temperature rise due to compression from valve operation

Stuff happens

CIISC

- Solvent (DMSO) recovery drum
- 1 death
- Incompatible chemicals in drum reacted, caused leakage at breather valve, temperature increase, explosion, pipe damage, more solvent leaks, fire
- Cause: single fault at block valve in liquid chemistry distribution → leakage of incompatible chemistry into recovery drum → reaction

Stuff happens

CIISC

- Disilane facility distribution
- 4 injuries
- After attempted line purging a blind flange was removed → disilane ignited and flames blew out
- Cause: hurricane causes facility power failure → air entered piping during hour-long power failure and reacts with disilane to cause a small pipe rupture → upon restart rupture is noticed and piping is purged → upon opening a blind flange during repair disilane from a dead space is exposed to air and reacts violently

Stuff happens

CIISC

- Water scrubber
- 2 injuries
- Explosion during scrubber cleaning
- Cause: Scrubber was isolated from process tool → purged → liquid was drained → hydrogen acid was introduced → material on internal scrubber surface was Si covered with silicon oxide → after silicon oxide was consumed, silicon and hydrogen fluoride produced hydrogen → when hydrogen fluoride level was lowered, air entered → ignition source: some compound reacted with water

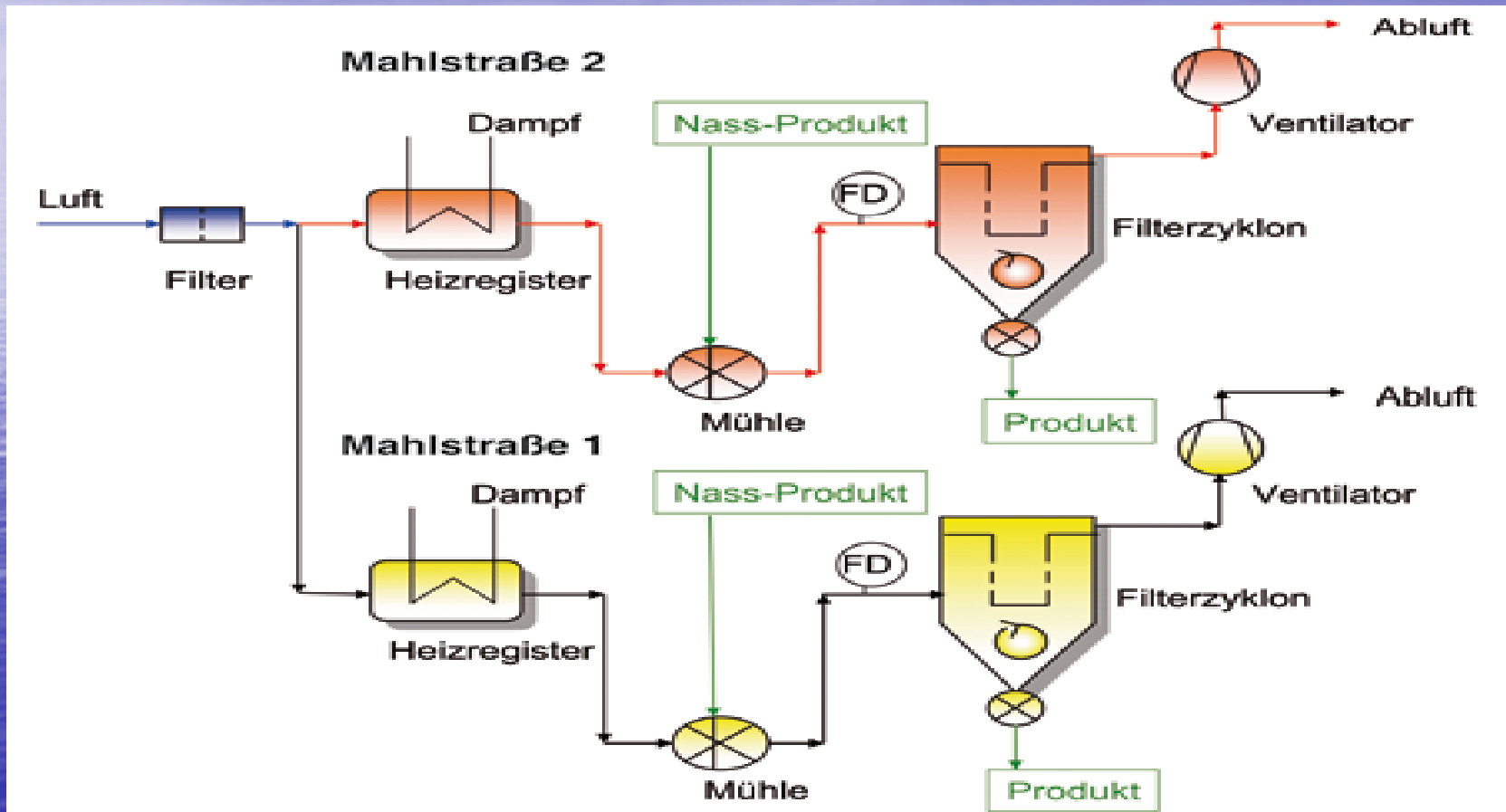
Stuff happens

CIISC

- Waste liquid treatment tank
- 1 injury
- Explosion during neutralization treatment
- Cause: 350 l of sodium hydroxide was used to neutralize acid waste water, reused sodium hydroxide was used containing dibutyl ether → some of the dibutyl ether evaporated after being fed into the acid waste water tank → combustible gas-air mixture → upon starting the tank agitation pump, pump liquid / piping acquired electrostatic charge due to flow friction → ignition: electrostatic discharge occurred when recirculation loop valve was opened

Stuff happens

CIISC



Stuff happens

CIISC

- Plant with parallel heaters and cyclones
- 1 death
- Dust-air explosion
- Cause: one air-intake, remainder of process parallel → if only one plant processing → reverse flow in other plant → process material deposition in unused plant → deposition of flammable materials in heater → upon restart heater fire → fire pushes burning particles into cyclone → upon opening of the shut-down cyclone deposits + incoming air + ignition from particles

Stuff happens

CIISC



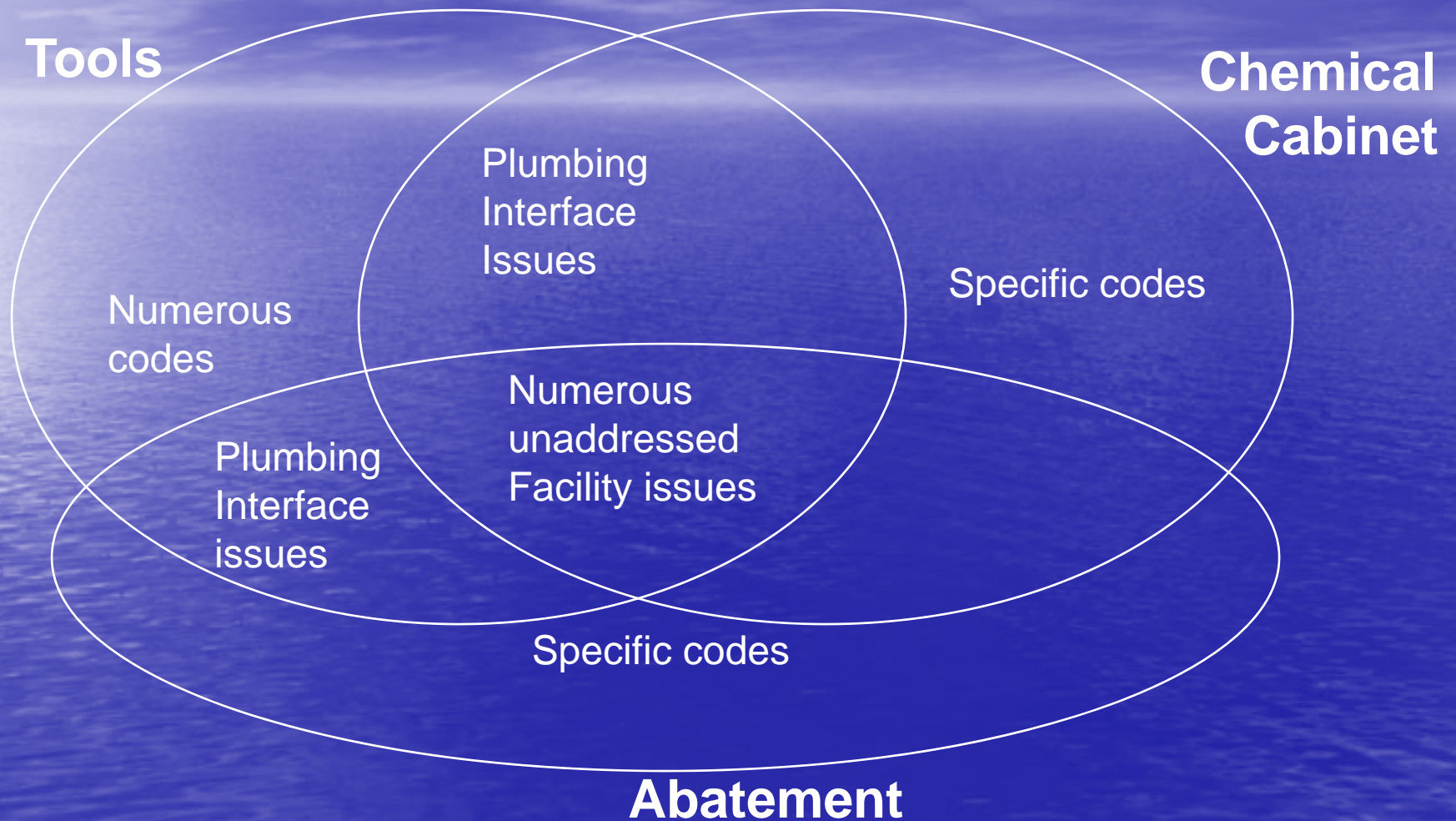
CI Industrial Safety Consulting,
LLC

Stuff happens

CIISC

- Local plant using Silane
- 1 death
- Significant release indoor
- Cause: catastrophic failure → rapid Silane **accumulation** → bulk-autoignition / explosion

Standards, Codes, Guidelines, Directives



System Evaluation and Component Considerations

- Plant HazOp
- Machine SEMI S2
- Power Distribution Panel EN60204
- Power supply EN60950
- Thin Film Capacitor IEC60384-17
- Dielectric Sheet, metallic DIN44116

How do we address facility issues

- You need HAZOP

- = Hazard and Operability Study
- = methodology for identifying and dealing with potential problems in industrial processes
- = tickling out non-obvious stuff

When to do "HAZOP" CIISC

- (1) during design of facility to get the fundamentals right
- (2) during commissioning of facility to catch "little" things
- (3) after facility modifications / upon introduction of new process / tool line

Focus of HAZOP

CIISC

- Walkdowns during construction / tool installation
- Tool installation safety checklist crucial
- See “Stuff happens”: good preventive maintenance procedures
- HAZOP is a “living document / process”, occasional updating important

Gratefully acknowledged **CIISC**

- www.IPVES.com
- www.AppliedMaterials.com
- www.Q-Cells.com
- www.Rushbrook.com
- www.HandHSafety.com
- www.Xyratex.com
- www.centrotherm.com
- www.shippai.jst.go.jp