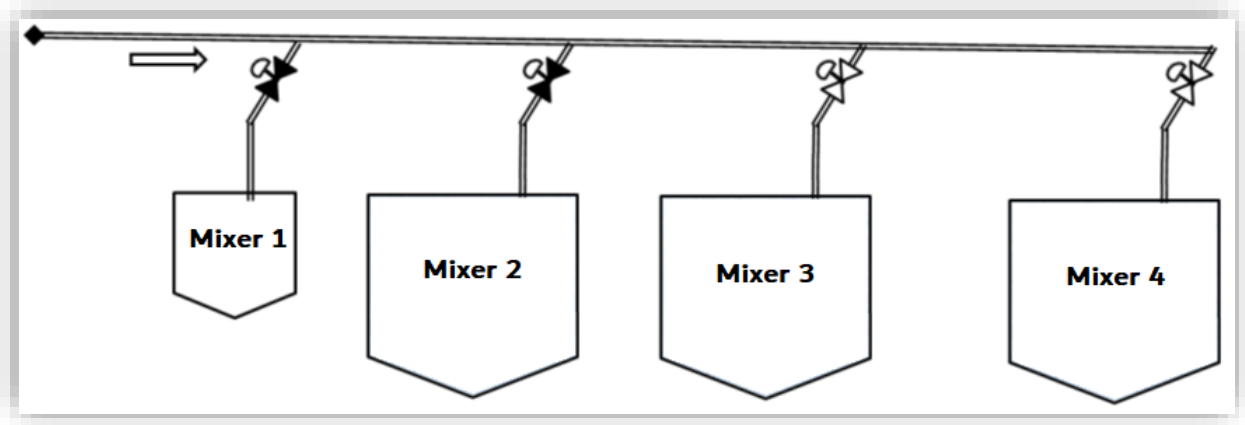
LESSONS LEARNED

Vessel Failure Due to Unintended Mixing of Incompatible Materials

WHAT HAPPENED?

- **Rozzano, Italy** (July 2013)
- Batch-Style Chemical Manufacturing Plant
- **Vessels Designed to Manufacture Multiple Products in each Vessel**
  - Inter-connected by mix of hoses, manifolds, and dedicated transfer lines
- **Limited instrumentation installed**
  - Mainly used for remote activation of transfer equipment
  - No Limit Switches



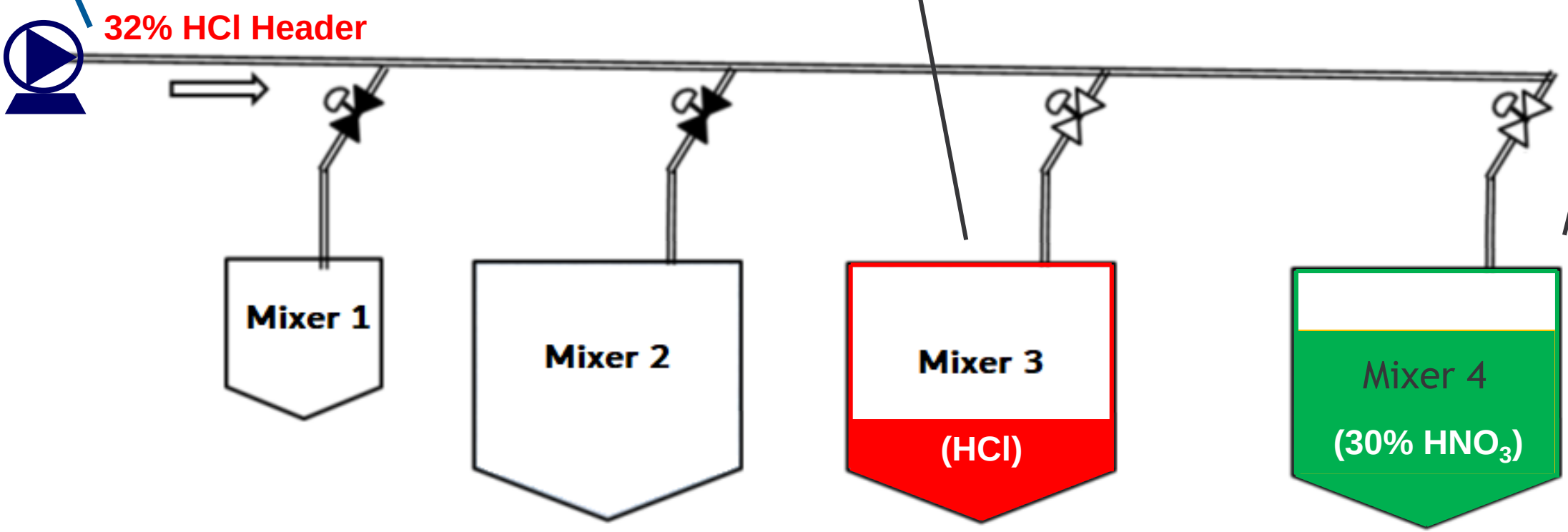
- **Mixers 1 to 4** can all make products with **Hydrochloric Acid** via dedicated header.
- **Mixer 4** can also make products with **Nitric Acid**.
- **Mostly Administrative Controls used** to manage material transfers.

WHAT HAPPENED?

HCl Pump & Header
Dedicated Hydrochloric Acid piping to Mixers 1-4

Mixer 3
Contents: *Partial transfer of Hydrochloric Acid (28%) from previously paused batch.*

Mixer 4
Contents: *Previously Completed batch (30% Nitric Acid), Waiting to be transferred to storage*

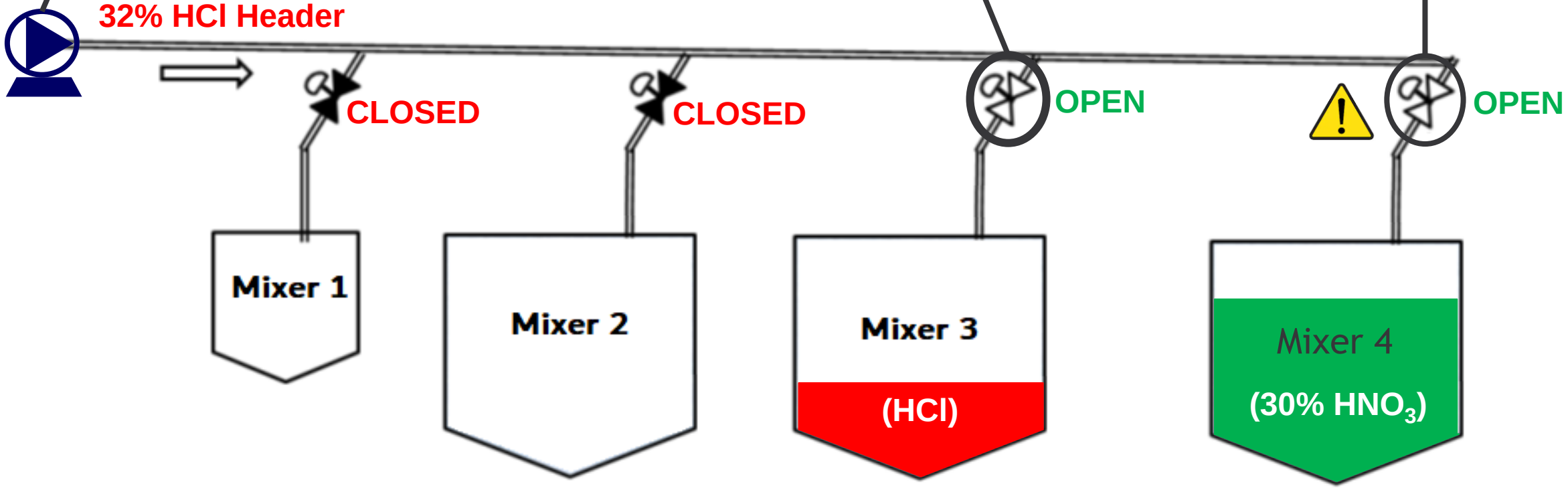


WHAT HAPPENED?

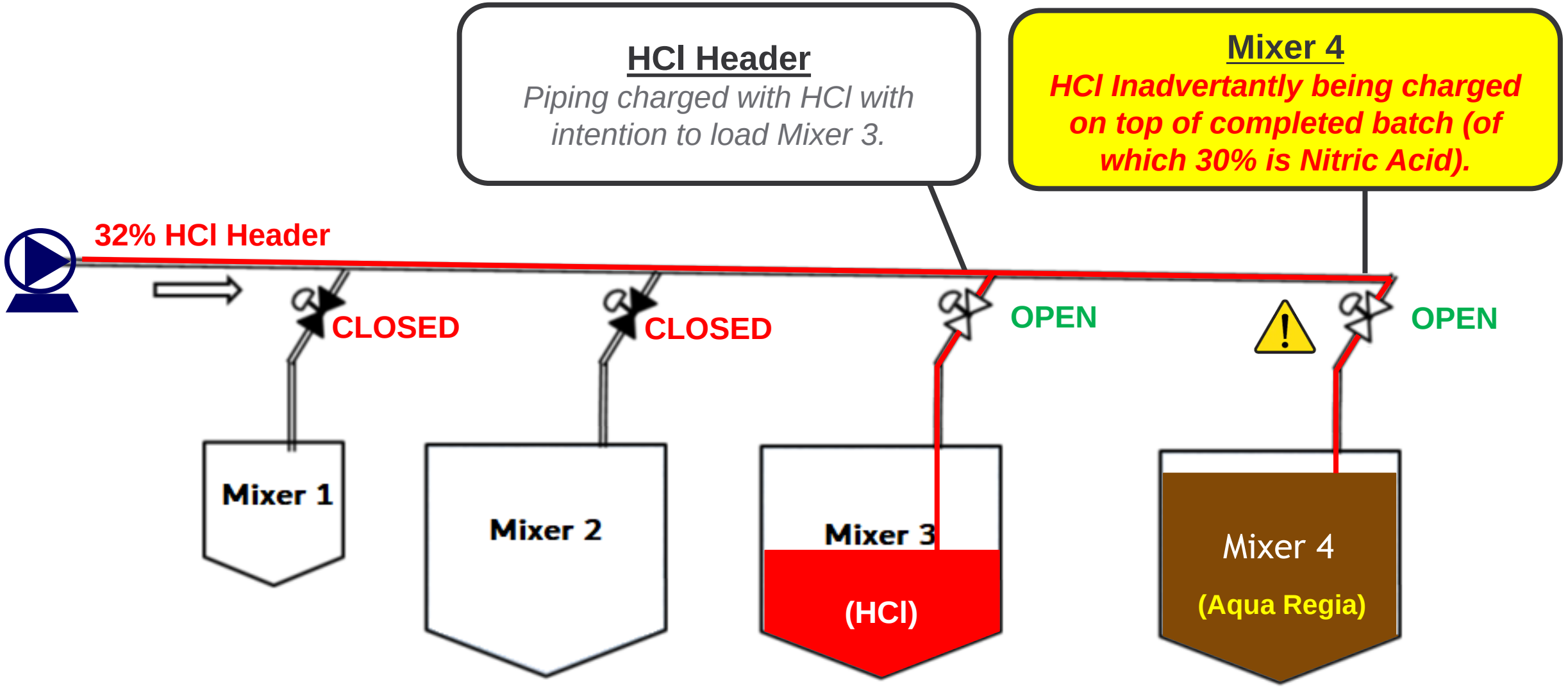
HCl Pump
Activated by Operator (via PLC) to load HCl, per the formula.

Mixer 3 HCl Inlet Valve
Opened remotely (per Batch Instructions) to charge HCl

Mixer 4 HCl Inlet Valve
***Stuck open** due to valve failure. No limit switch, so **error wasn't detected remotely**.*

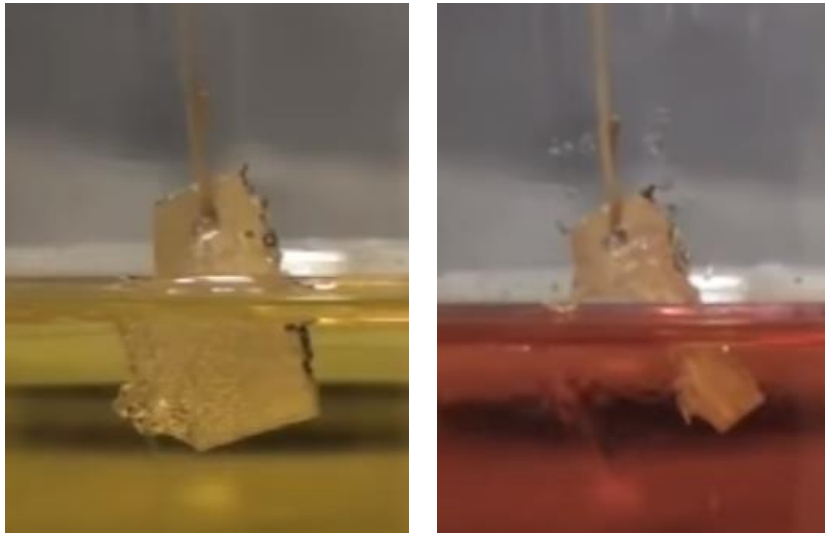


WHAT HAPPENED?



WHAT IS AQUA REGIA?

- Nitric Acid + Hydrochloric Acid
- Latin for **Royal Water**
- Named for **ability to dissolve noble metals**
- Yellow / Orange Fuming Liquid
  - **EXTREMELY CORROSIVE**
  - Oxidizer, Toxic, Etc.
- Commercially used to **remove metals from microelectronics** & produce **gold / platinum precipitate** in refining process.



Gold dissolving in Aqua Regia

CONSEQUENCE

- *Aqua Regia* **quickly ate away at bottom of vessel** resulting in spill and release of Nitrogen Dioxide.
- **Local businesses evacuated**, residents in the area advised to stay inside.
- Thankfully, no one injured, but it was obvious that **consequences could've been far worse**

CORRECTIVE ACTIONS

Rozzano:

- **Complete overhaul of Material Transfer System**
  - Limit Switches, Fail to Safe State, Reduced Potential for Human Error by Installing automated valve matrix

Company wide:

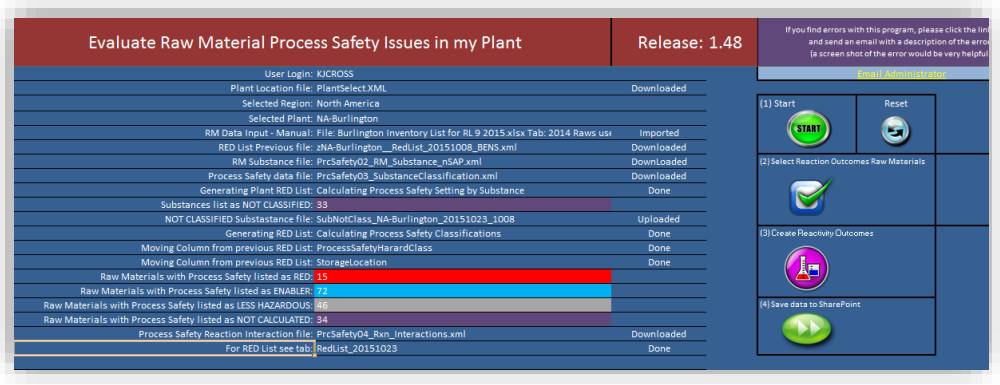
- Issued Safety Alert & Worked w/ All Facilities to address similar scenarios for Incompatible Mixing
- **Created Regional Process Safety Networks** to:
  - Directly Support Site Personnel to Reduce Risks
  - **Develop Tools, Guidance, Standards/Policies** to continuously maintain and improve performance

MAJOR OPPORTUNITY FOR IMPROVEMENT

- **Awareness of Incompatible Mixing** was in need of improvement
- Low Frequency, High Consequence Event
- **Process Safety & R&DE SMEs worked together** to develop a method to better recognize where incompatibility risks exist

Result:

- **"Red" List & Reactivity Tool**



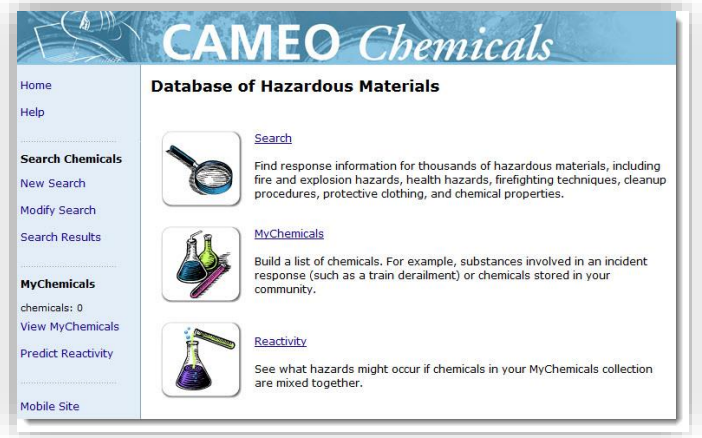
“RED” LIST & REACTIVITY TOOL

Raw Material Process Safety Hazard Class Calculation	Raw Material ERP Description	MinOrderQty	PlantUsage Yr	PlantInventory	UOM	StorageLocation
7732-18-5 (water) [70%] >> **Water** 1336-21-6 (ammonium hydroxide) [22%] >> **Ammonium Hydroxide**	AQUA AMMONIA 21 BE	1520	16347	1330	LB	zNotDefined
7732-18-5 (water) [38.4%] >> **Water** 1336-21-6 (ammonium hydroxide) [61.6%] >> **Ammonium Hydroxide**	AQUA AMMONIA 26 BE'	370		0	LB	zNotDefined
7681-57-4 (sodium metabisulphite) [98%] >> **Bisulfites, metabisulfites, hydrosulfites** 7757-83-7 (Sodium sulphite) [1.5%]	SODIUM METABISULFITE PHOTO GRD	2200	0	0	LB	zNotDefined
7681-57-4 (sodium metabisulphite) [100%] >> **Bisulfites, metabisulfites, hydrosulfites**	SODIUM METABISULFITE	50		0	LB	zNotDefined

- Relatively few materials meet threshold of applicable country regulations
  - *Example: OSHA PSM ➔ Nitric Acid (94.5%)*
- **“Red” List:** Ecolab’s developed list of materials that **contain hazardous properties that deserve careful attention**; Includes potential for Incompatible Mixing
- **Tool created to cross-reference Site Inventory** with “Red” List Materials

“RED” LIST & REACTIVITY TOOL

- Able to generate a Site or Location Specific “Reactivity Outcomes Table”
- Uses Reactivity information from **Cameo Chemical Reactivity Tool** (Publicly available)
- **Incorporated into Risk Assessments** to identify and prevent scenarios of incompatible mixing



RMCode	Raw Material ERP Description	240077	240081	122010	830090	124015	116005	171318	121012	830789	171405	171405	250324	176115
240077	SODIUM HYPOCHLORITE 12.5%	240077	N	HL1	N	HL1	HL1		HL1	N	HL9		HL1	HL9
240081	HYDROGEN PEROXIDE 50%	N	240081	N	N	N	N	HL2	N	N	N	HL2	N	N
122010	SULFURIC ACID 93% TECH (66 BE)	HL1	N	122010	HL9	N	N		C	HL9	N		N	N
830090	SODIUM HYDROXIDE 50% LIQUID	N	N	HL9	830090	N	N	?	HL9	X	N	?	N	N
124015	GLACIAL ACETIC ACID(PERACID)	HL1	N	N	N	124015	C	C	HL9	N	N	C	Y	N
116005	BARLOX 12	HL1	N	N	N	C	116005		N	N	Y		N	Y
171318	SODIUM C14-16 OLEFIN SULFONATE		HL2		?	C		171318	?	?	?	x	N	?
121012	PHOSPHORIC ACID 75%	HL1	N	C	HL9	HL9	N	?	121012	HL9	HL4	?	N	HL4
830789	KOH LIQ, 50%	N	N	HL9	X	N	N	?	HL9	830789	N	?	N	N

QUESTIONS?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