

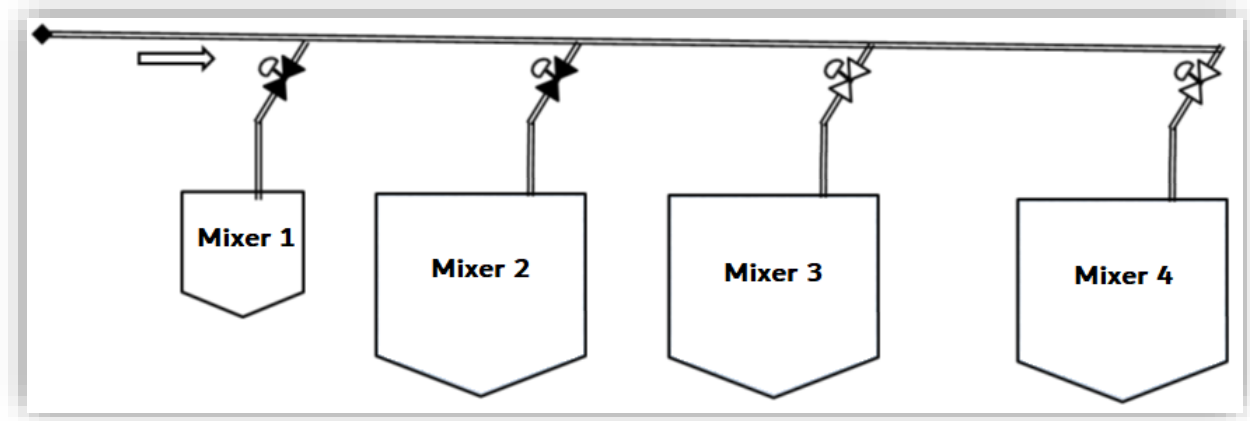
LESSONS LEARNED

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.

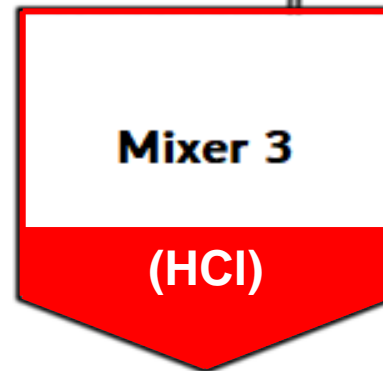
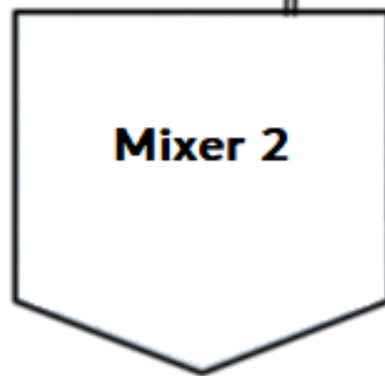
WHAT HAPPENED?

HCl Pump & Header

Dedicated *Hydrochloric Acid* piping to Mixers 1-4



32% HCl Header



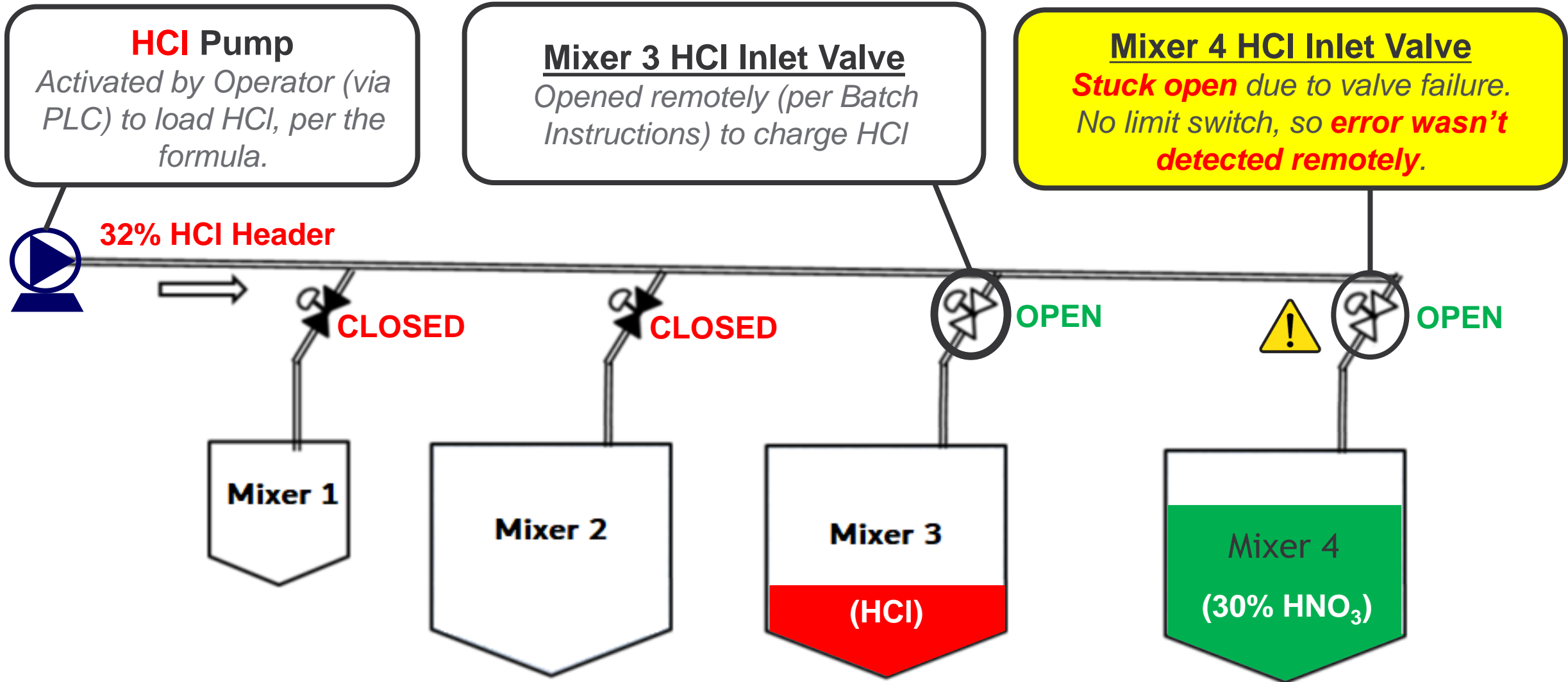
Mixer 3

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

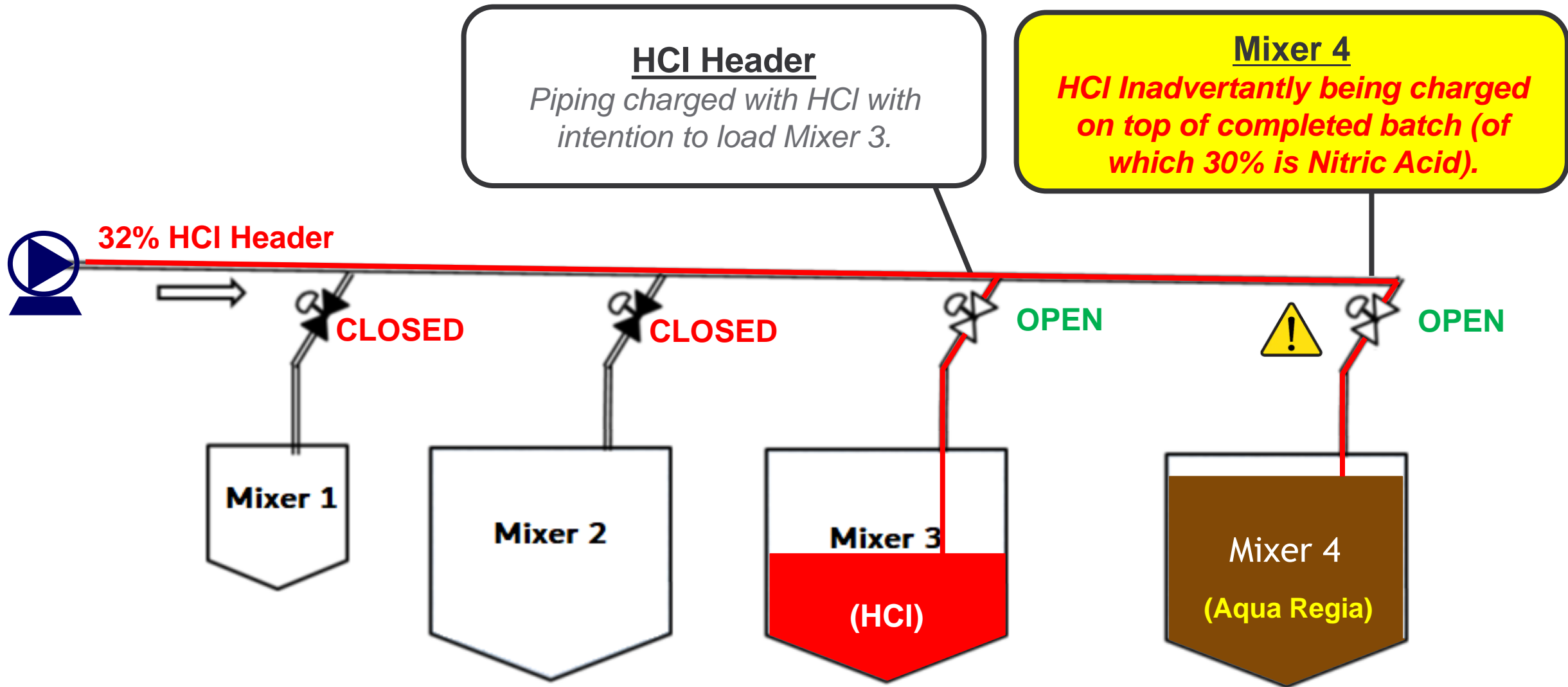
Mixer 4

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

WHAT HAPPENED?

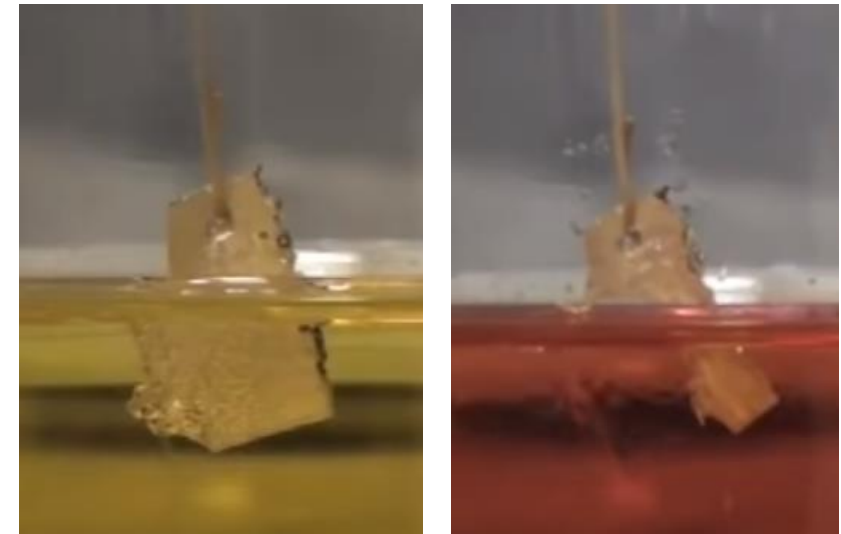


WHAT HAPPENED?



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**

A screenshot of a software interface titled "Evaluate Raw Material Process Safety Issues in my Plant". The interface shows a list of actions and their status. The top right corner displays "Release: 1.48" and a note: "If you find errors with this program, please click the link and send an email with a description of the error (a screen shot of the error would be very helpful)". The main table lists various tasks such as "User Login: KICROSS", "Plant Location file: PlantSelect.XML", "Selected Region: North America", "Selected Plant: NA-Burlington", "RM Data Input - Manual: File: Burlington Inventory List for RL 9 2015.xlsx Tab: 2014 Raws us", "RED List Previous file: NA-Burlington_RedList_20151008_BENS.xml", "RM Substance file: PrCSafety02_RM_Substance.nSAP.xml", "Process Safety data file: PrCSafety03_SubstanceClassification.xml", "Generating Plant RED List: Calculating Process Safety Setting by Substance", "Substances list as NOT CLASSIFIED: 33", "NOT CLASSIFIED Substance file: SubNotClass_NA-Burlington_20151023_1008", "Generating RED List: Calculating Process Safety Classifications", "Moving Column from previous RED List: ProcessSafetyHarardClass", "Moving Column from previous RED List: StorageLocation", "Raw Materials with Process Safety listed as RED: 15", "Raw Materials with Process Safety listed as EMERGER: 17", "Raw Materials with Process Safety listed as LESS HAZARDOUS: 85", "Raw Materials with Process Safety listed as NOT CALCULATED: 34", "Process Safety Reaction Interaction file: PrCSafety04_Rxn_Interactions.xml", and "For RED List see tab: RedList_20151023". The status for each action is either "Downloaded", "Imported", "Done", or "Uploaded". On the right side, there are four steps: (1) Start, (2) Select Reaction Outcomes Raw Materials, (3) Create Reactivity Outcomes, and (4) Save data to SharePoint. Each step has a corresponding icon and a "Reset" button.

“RED” LIST & REACTIVITY TOOL

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

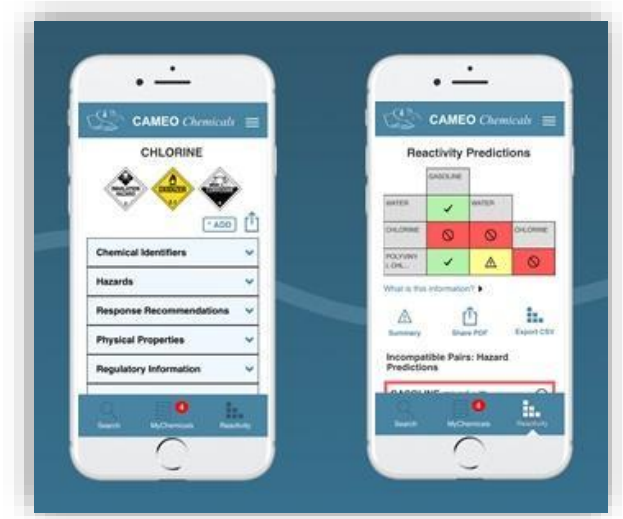
➤ **Tool created to cross-reference Site Inventory** with “Red” List Materials

“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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