

ORANGE TASK - Students Instructions: Bowtie Analysis.

Within a group, using a large sheet of paper or a whiteboard; develop an Ammonia Refrigeration Bowtie of your plant. List all the barriers and "escalation factor controls" that you can think of are in place to protect the facility.

Below are some examples to include - think of what measures should be in place to prevent a safety-critical element from failure.

Cause	Safeguards			Loss of Anhydrous Ammonia containment	Safeguards			Consequence
Human Error								Death/ Injury
Overpressure	Hardwired Interlocks	Safety Instrumented Systems	Pressure Safety Relief valve		Fixed Gas Detection		Hazardous areas compliance	Ignition
Vehicle impact								Environmental Damage
Corrosion					Fixed Gas Detection	Emergency Shutdown	Portable fans/CO2	Product damage
Natural disaster	Structural design	Seismic sensor	Emergency Shutdown		Crisis Management Plan			Negative media

Fig.1.0 Bowtie Example

The Bowtie is a visual risk evaluation method that can be used to analyse plausible incidents and demonstrate what sometimes safety-critical element safeguards or barriers are in place to control and mitigate loss of containment. Once the control measures are identified, the Bowtie method also identifies factors or conditions in which control measures can fail which may require additional controls called "escalation factor controls."

An example is a fatigue management plan to prevent human error- what triggers are in place to ensure it is implemented?