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REFRIGERATION SYSTEMS – SAFETY & EMERGENCY PREPAREDNESS IN CASE OF HAZARDS – A MANAGEMENT AND DESIGN ISSUE

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Multilateral Fund for the Implementation of the Montreal Protocol | UNEP | UNIDO | UNDP | GEF

Annual meeting of the Regional Ozone Network for Europe & Central Asia
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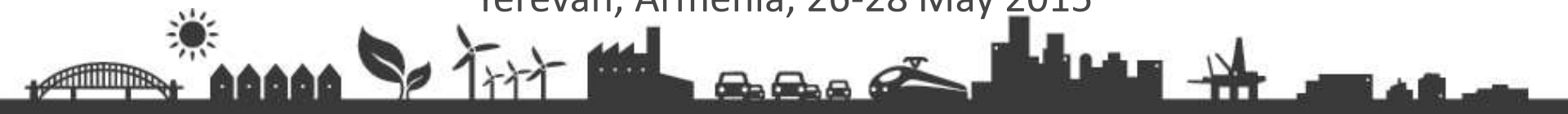


Outline

- Immediate safety and disaster handling. The sharp end.
- Where does safety start?
- Incident becoming accident. What happened?
- Preventing incidents becoming accidents.
- Accidents and disasters. Would stricter codes have prevented them?
- Tarzan syndrome.

Why train the operators in incident handling?

- Normal situation, the operators need to know where the emergency exits are, how to handle their personal safety equipment etc.
- Having adequate training and equipment might make it possible for the operators to bring a potential dangerous situation under control.
- In a disaster scenario the job will fall on the emergency services, but they will usually be unfamiliar with the facility.
- The local operator can be called upon to assist, to make the job for the emergency services quicker and safer.

Why train the operators in incident handling?

Why train the operators in incident handling?

Where does safety start?

- For most, safety is what the emergency services do.
- It is not.
- What they do is :Damage control, disaster control
- They go in when the situation is
  - Dangerous
  - Out of control
- Their job is to
  - Regain control
  - Restore safety

Where does safety start?

- When the emergency services are needed
- Safety is breached.

- SAFETY ENDS WHEN YOU NEED THE EMERGENCY SERVICES

- SAFETY STARTS IN YOUR HEAD

Where does safety start?

- SAFETY IS A MANAGEMENT DISCIPLINE
- Management has the duty to create a safety culture that permeates everything that is being done.
  - Design
  - Installation
  - Service and maintenance
  - Training of clients

Incident becoming accident. What happened?
Incident 1. Described by Dr. Andy Pearson in Ohrid, FYR Macedonia, 2013

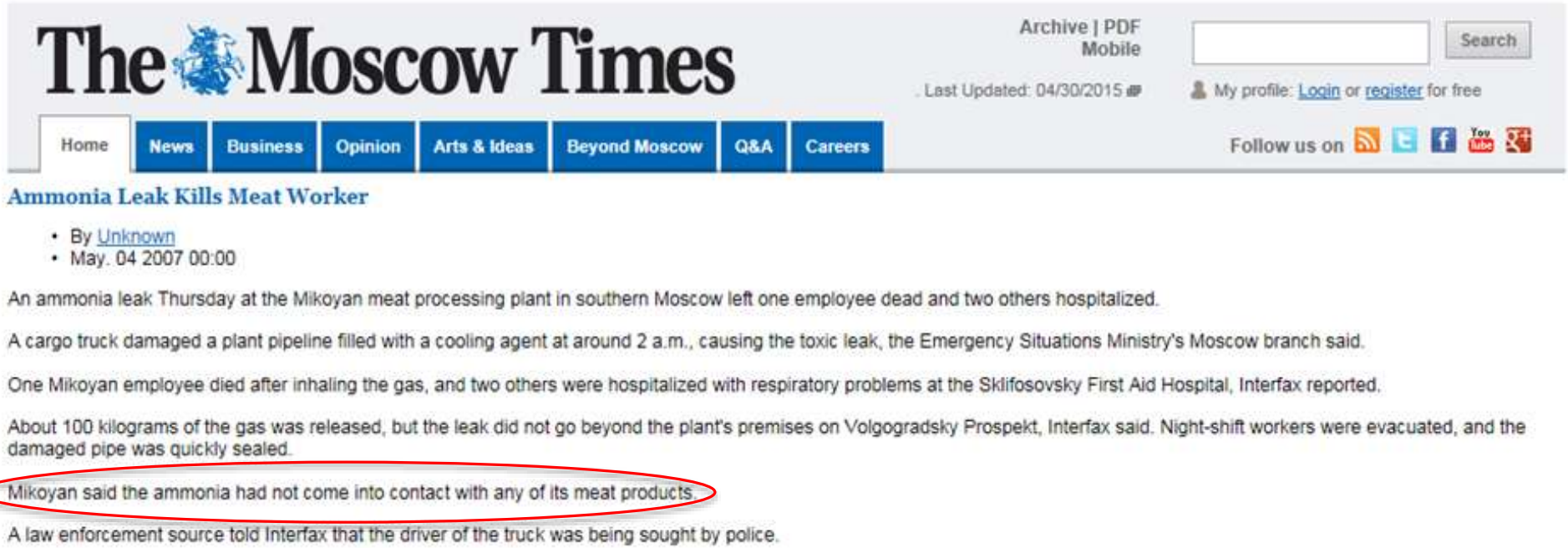
- An operator covers for a colleague at a facility he is not 100% familiar with.
- Oil cooling is a siphon system supplied from a high pressure receiver.
- The design of the high pressure receiver allows oil to be mixed in with the ammonia for the oil cooler. => oil build-up on the ammonia side of the oil cooler.
- One compressor tripping on high oil temperature .
  Diagnose: Oil build-up. Cure: drain the oil
- Before draining : Isolate the oil-cooler.
- Isolating valve on the gas return line is located 7 m up, directly above the compressor. No gantry. Ladder needed. None found! =>
- Isolation of the oil cooler ammonia side is not possible!
- Oil drain valve is NOT spring-closed valve. Oil drain valve has neither wheel nor handle. Operated by spanner!

Incident becoming accident. What happened?
Incident 1. Described by Dr. Andy Pearson in Ohrid, FYR Macedonia, 2013

- The operator closed the liquid inlet valve, attached a hose to the oil drain valve and ran it into a barrel of water, opened the oil drain valve, and left while doing other jobs on the facility.
- On return, the hose had come out of the barrel, ammonia was being sprayed on the floor.
- When trying to close the drain valve, the operator collapsed from the fumes and died.
- WHO WOULD YOU POINT THE FINGER AT?!
- The operator?
- The designer?

- No doubt that the operator made some mistakes, probably being a too conscientious worker, wanting to solve the problem, but his own safety was not thought of.
- Major problem here, as I see it, were poor or flawed design.

Incident becoming accident. What happened? Incident 2.



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Ammonia Leak Kills Meat Worker

- By Unknown
- May. 04 2007 00:00

An ammonia leak Thursday at the Mikoyan meat processing plant in southern Moscow left one employee dead and two others hospitalized.

A cargo truck damaged a plant pipeline filled with a cooling agent at around 2 a.m., causing the toxic leak, the Emergency Situations Ministry's Moscow branch said.

One Mikoyan employee died after inhaling the gas, and two others were hospitalized with respiratory problems at the Sklifosovsky First Aid Hospital, Interfax reported.

About 100 kilograms of the gas was released, but the leak did not go beyond the plant's premises on Volgogradsky Prospekt, Interfax said. Night-shift workers were evacuated, and the damaged pipe was quickly sealed.

Mikoyan said the ammonia had not come into contact with any of its meat products.

A law enforcement source told Interfax that the driver of the truck was being sought by police.

- A truck driver hits an ammonia liquid line.
- One employee dies, two others goes to hospital.

- WHO WOULD YOU POINT THE FINGER AT?
- The truck driver or the idiot who left an ammonia line where it can be hit by a truck?

Incident becoming accident. What happened? Incident 3.

https://www.youtube.com/watch?v=_icf-5uoZbc

http://www.csb.gov/assets/1/19/final_CSB_CaseStudy_Millard_0114_0543PM.pdf

An important point not made by the CSB report was the possibility of leak containment. As the wet suction line was located out doors, any leak containment was impossible.

Or is it?

Incident becoming accident. What happened? Incident 3.

- At the ammonia safety course at Falck-Nutec in Esbjerg, Denmark, the training includes how to manage and contain a liquid/gass leak from a ruptured pipe by very simple means.
- Requires a “chemical diver” suit.

Preventing an incident becoming an accident

- Designing for safety. (1)
- How?
- Identifying the risks.
- Example : Hot gas defrost has an inherent risk of liquid hammer or hydraulic shock, as seen on the video.
- Choice of refrigerant

Preventing an incident becoming an accident

- Designing for safety. (2)
- Different refrigerants => slightly different solutions.
- What are the different main risks
- Standard unnatural refrigerants
  - Main concern => Suffocation
  - Secondary concern => Formation of poisonous gasses when burnt
  - Odourless. No natural warning.
- Low GWP unnatural refrigerants. I.E HFC 1234s
  - As standard unnatural refrigerants +
  - Slightly flammable (2L)

Preventing an incident becoming an accident

- Designing for safety. (3)
- Natural refrigerants
- CO_2
  - A part of the human metabolism. High CO_2 concentration might impede respiration, even when O_2 levels are sufficient.
  - Odourless. Can be tasted at levels above 5 000 ppm.
- Hydrocarbons (HCs)
  - Highly flammable (3)
  - Odourless.
- Ammonia
  - Toxic
  - Slightly flammable (2L)
  - Pungent odour. Natural warning at very low concentrations

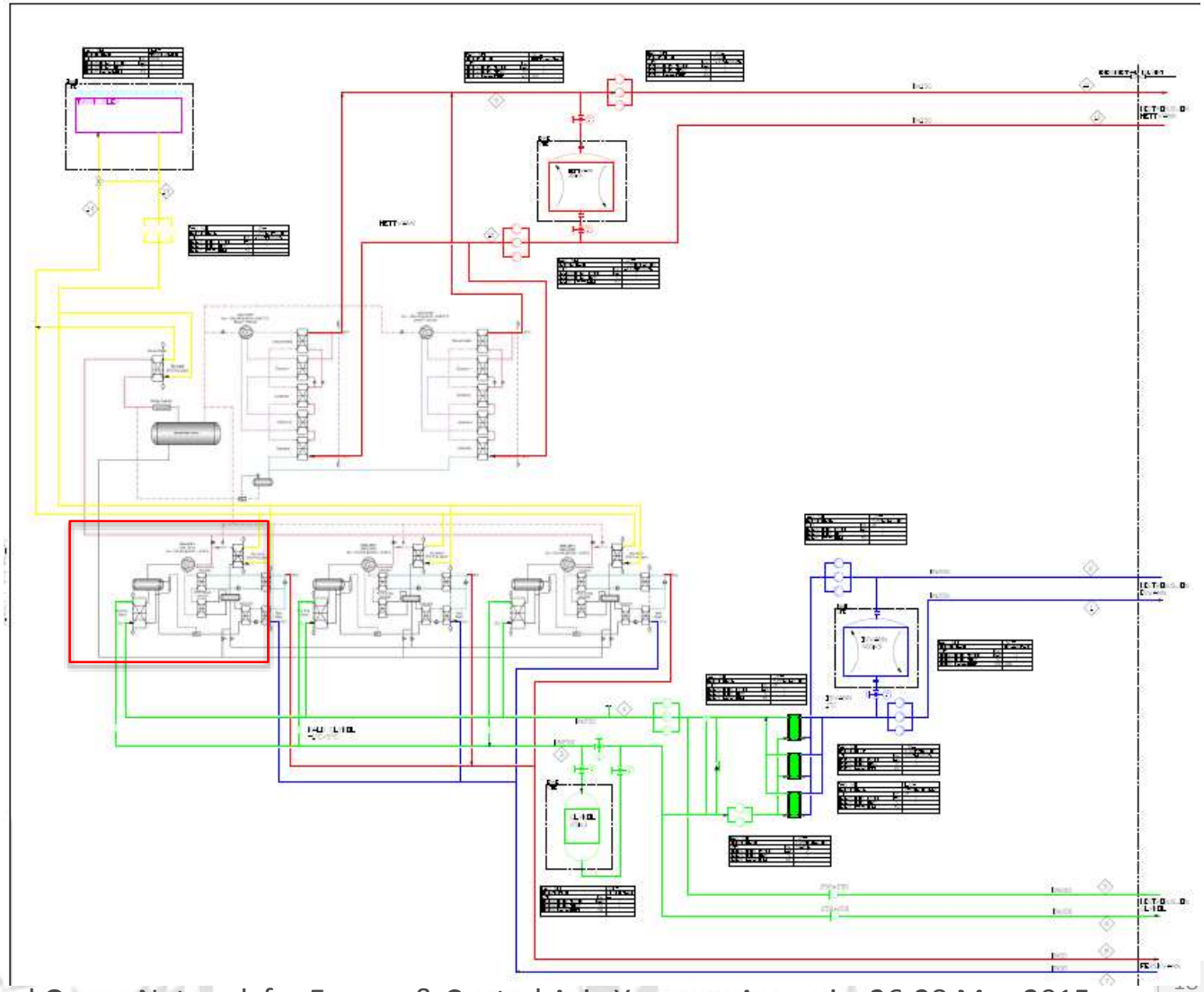
Preventing an incident becoming an accident

- Designing for safety. (4)
- Charge reduction. Use secondary coolant when possible.
- Limit the amount of refrigerant that might escape => divide the system into manageable parts. Containment.
- Example of an incident that became unmanageable due to lack of possibility to section the system was the Millard case turning an incident into an accident.
- Valves and other components used by operators shall be placed with easy access. Makes maintenance faster, better and safer.
- Use prefabricated equipment as much as possible.
- Standardized solutions, so that one facility resembles another

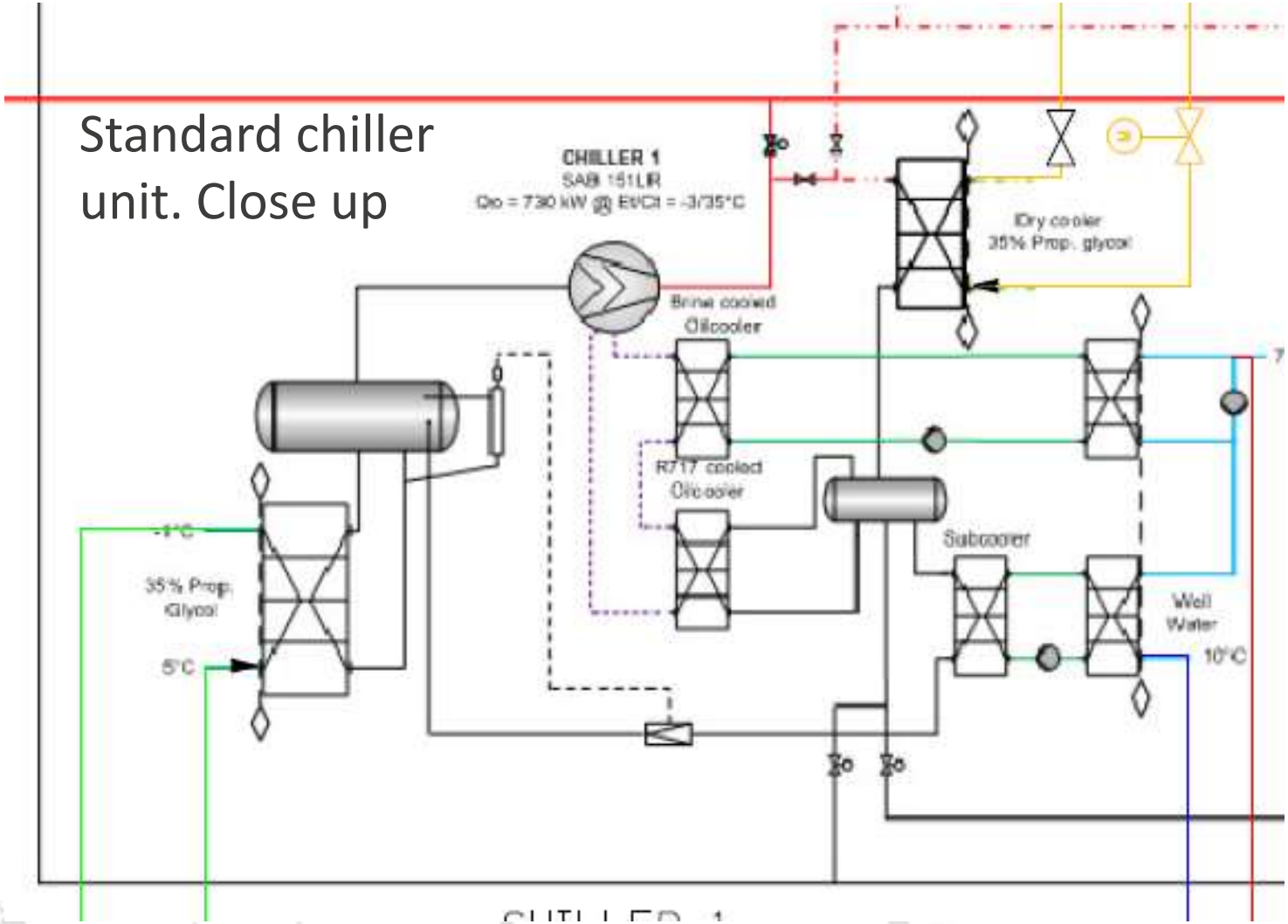
Preventing an incident becoming an accident

- Prefabricated and standardized units. An example from a dairy in Norway.
- Total cooling incl. heat pump 5 MW. Charge 1500 kg
- 300 g/kW.
- Ammonia restricted to machinery room.

- Existing system total cooling 3.5 MW. Charge 22000 kg.
- 6.3 kg/kW.
- Ammonia distributed in multiple locations



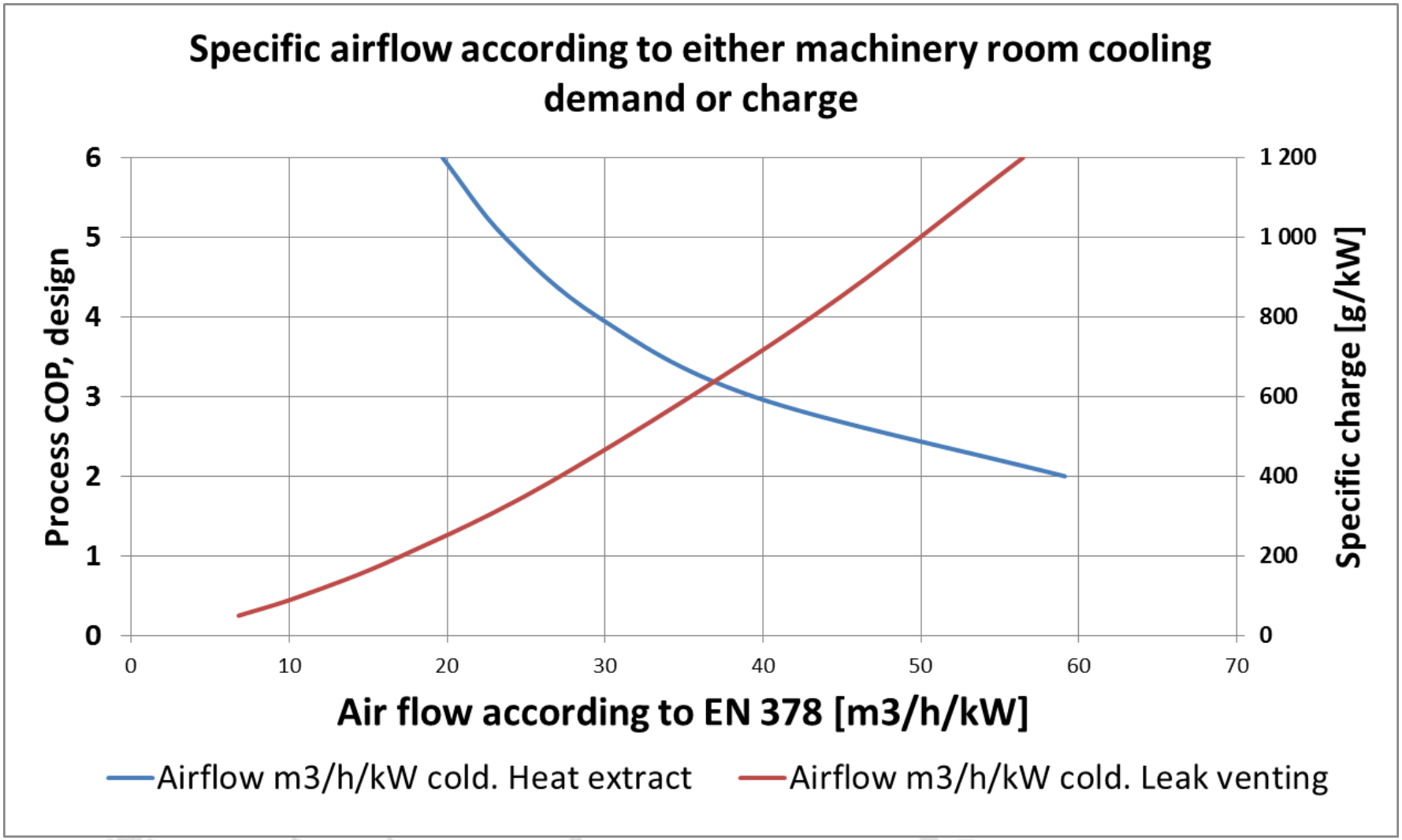
Preventing an incident becoming an accident



Preventing an incident becoming an accident

- Installing for safety. (1)
- Check the overall layout of facility.
- Make sure that the layout of the machinery room is orderly and stringent.
- Make sure that the emergency exits are sufficient and easy to find.
- Perform and document risk assessments.
- Make sure that the machinery room is “Restricted area”.
- If at all possible: Keep the charge in the machinery room.
- When designing the ventilation. Make sure that the flow is enough to handle the heat losses from the equipment.

Preventing an incident becoming an accident



Preventing an incident becoming an accident

- Safe Maintenance and Service . (1)
- Always have personal protective equipment (PPE) close at hand.
- **Failing to use PPE is ground for immediate dismissal.**
- Make sure that all tools and spare parts are present before starting work.
- Before work starts, make sure that emergency exits are clear, and that the area around is open and clear of obstacles.
- An example
- Service personnel found a machinery room looking like this.
- They took this picture and left. The plant owner was billed for the time used.
- The restricted area was clearly not respected.
- You don’t compromise on your own safety!

Preventing an incident becoming an accident

- Customer / End user training (1)
- If the end user has their own skilled operators, they should be an integrated part of the build, so that they understand all aspects of the plant.
- If the end user does not employ skilled operators they should be restricted from the machinery room.
- They should be thoroughly instructed in the emergency handling, such as exits, cooperation with emergency services and location of protective equipment.

Accidents and disasters. Would stricter codes have prevented them?

- Incident 1
- The oil drain valve in question was not up to code. Built before 2000.
- The operator either didn't carry or didn't bother to use PPE.

- Would stricter codes have save this mans life?

- Not necessarily, as the system wasn't up to code, and the operator didn't act according to code.

Accidents and disasters. Would stricter codes have prevented them?

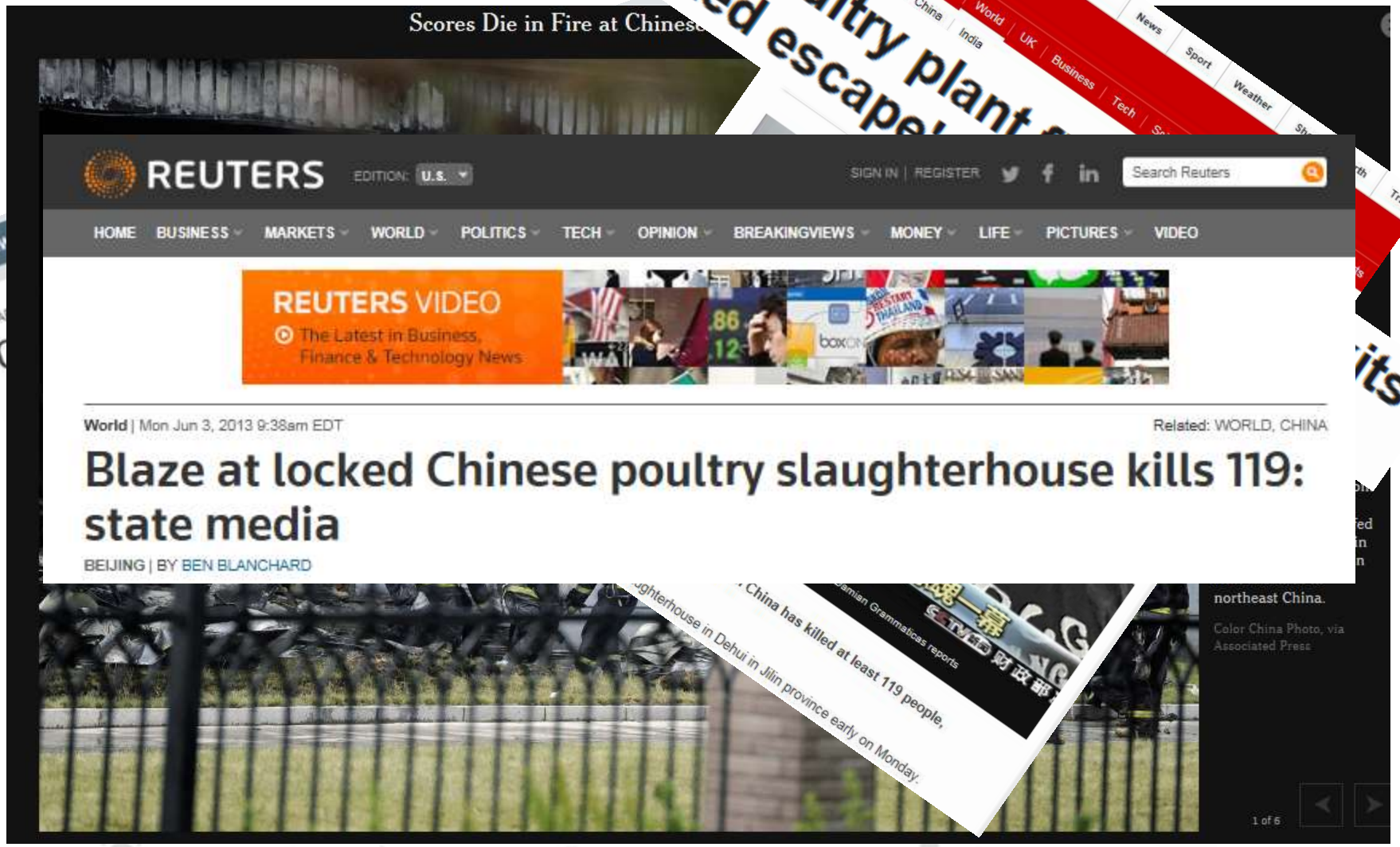
- Incident 2
- Not familiar with the Russian codes at the time of this incident.
- However, placing a liquid line in harms way, can not be in accordance with any codes anywhere!

- Again, stricter codes would have no influence of the outcome.

Accidents and disasters. Would stricter codes have prevented them?

- Incident 3
- This incident is harder to assess, but previous risk assessments during design should have shown the dangers of the design.
- The operator clearing alarms and resetting the system did not have the necessary understanding of the process.
- The plant engineer gave priority to continued operation, rather than safety.
- It is not clear whether or not the plant had access to chemical diver suits, but the leakage could have been stopped by very simple means, had the personnel had the proper training.
- I believe that the design and especially the running was not in compliance with code.

A preventable disaste



A preventable disaster.

- Locked emergency exits. Probably to reduce the risk of theft.
- Is a chicken worth more than a human life?

- If it is possible for the ammonia concentration to reach flammable levels the power supply should have cut out at app. 25% of LFL.

- This was definitely not to code!

Accidents and disasters. Would stricter codes have prevented them?

- In general the codes a strict enough.
- However, designing according to code does not mean that you can disengage your brain.
- Assessment of scenarios and systems do demand good system understanding.

- What is **NOT** strict enough is the enforcement and the understanding of the codes.
- Especially the end users and their representatives, usually the consultants have a deplorable lack of competence.
- This means that corner-cutters wins the contracts because price is the only parameter understood by the end user. Safety costs money.
- This leads to everyone cutting corners to stay in business.

Accidents and disasters. Would stricter codes have prevented them?

- As said : In general the codes a strict enough.
- However training, education and enforcing is far from good enough.
- Especially the enforcing have to be sufficiently harsh to ensure an even field of competition.
- This applies globally.

The “TARZAN” syndrome

- Another risk we haven’t addressed yet is the
- TARZAN syndrome.

- Or an “I know just too well, so I can’t be bothered” attitudes of many operators and service engineers.

- Typically they will not use the PPE because
  - “it’s sissy”
  - “it’s in the way”
  - “the ones saying that we should use this don’t know what they are talking about”!
- Plenty of excuses, but no reasons.

- Are human beings the only species who will make their life unnecessarily dangerous?

Conclusion

- The codes in general a good enough.
- The education, training and enforcing is not.
- The general safety culture is virtually non-existent.
- The TARZAN syndrome must be met with harsh reactions.

- Thank you for your attention.