AIGA 2008 MEETING

Product Vehicle Safety & Accident Prevention

AIGA

Asia Industrial
Gases Association

FMM MIGMA

Co-organiser:

FMM Malaysian Industrial Gases Manufacturers Group

Safety by Design: Cryogenic Trailers

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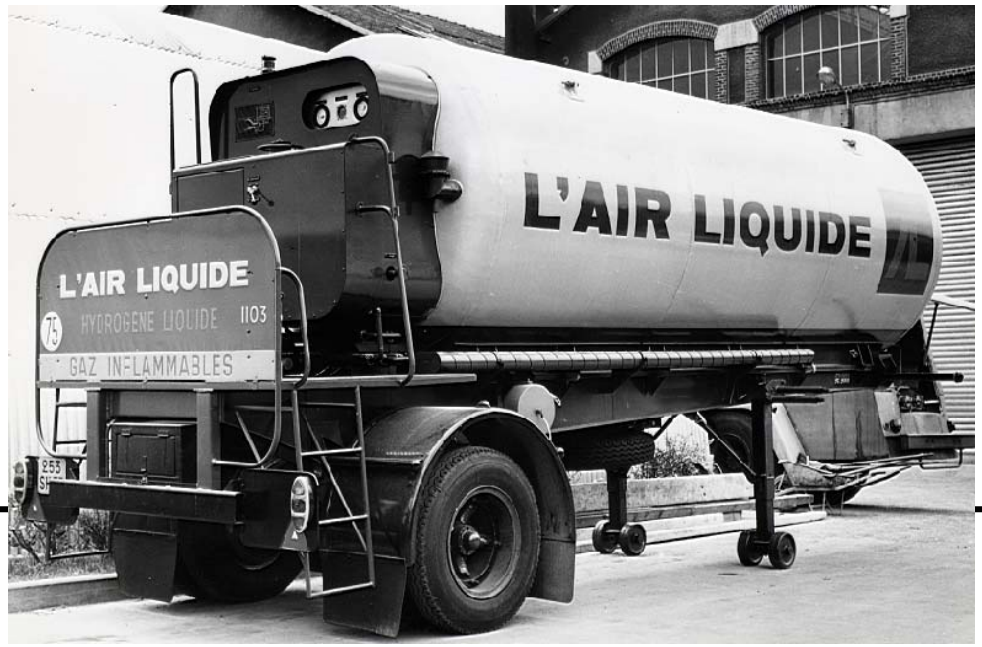
Basis of Design Safety Study

Design Experience Feedback

- 50+ years design & manufacturing experience
- 15 years self supporting trailer design experience
- Exclusive use of super insulation 40+ years for trailers
- 750+ trailer units operating world-wide
- Most recent trailer design based on 400 + units since ‘00

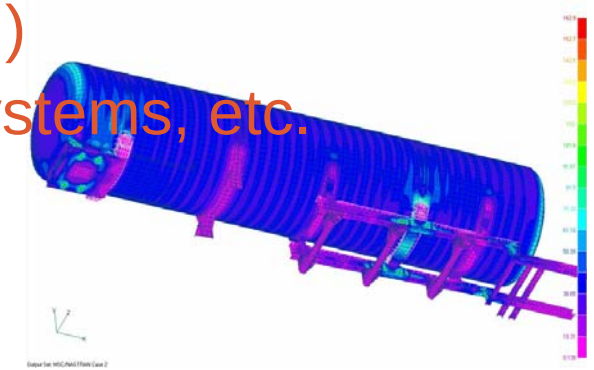


Summary: Safety Through Experience

- Road Handling & Stability
  - Braking & stability
  - Center of gravity
- Prevention & Protection
  - Rear Door Warning System
  - Remote Closing of Main Shut-off (Actuated) Valves
  - Isolation of PBU line (in case of overturn)
  - Rear Impact
  - Accessibility & Liquid Leakage
  - Adapted to Asian Conditions
  - Separation of Trailer & Prime mover
  - « Passive » protection
- Overfill Prevention
  - Customer Tank & Road Tanker

Road Handling & Stability
(Vehicle Design to Reduce Rollover)

- Braking & stability
  - Use of most advanced technologies available from the axle manufacturers (SAF, Mercedes, BPW, etc.)
    - braking systems (EBS, RSS, etc.)
    - wheel base width, suspension systems, etc.
    - lightweight solutions



- Center of Gravity
  - Self-supporting cradle design significantly lowers the center of gravity & reduces risk of vehicle overturn.
  - Design extensively verified through finite element analysis, tilt table tests & actual conditions (350+ currently in operation)

Rollover Stability Regulation (ECE 111)

- Tilt table inclination of a full 23,000-litre LOX trailer
  - According to ECE 111, the maximum allowable rollover threshold angle at the platform is **23°**
  - The actual rollover threshold angle obtained with a full LOX trailer, measured at ;
    - Platform **24.6°**
    - Bumper **28.4°**

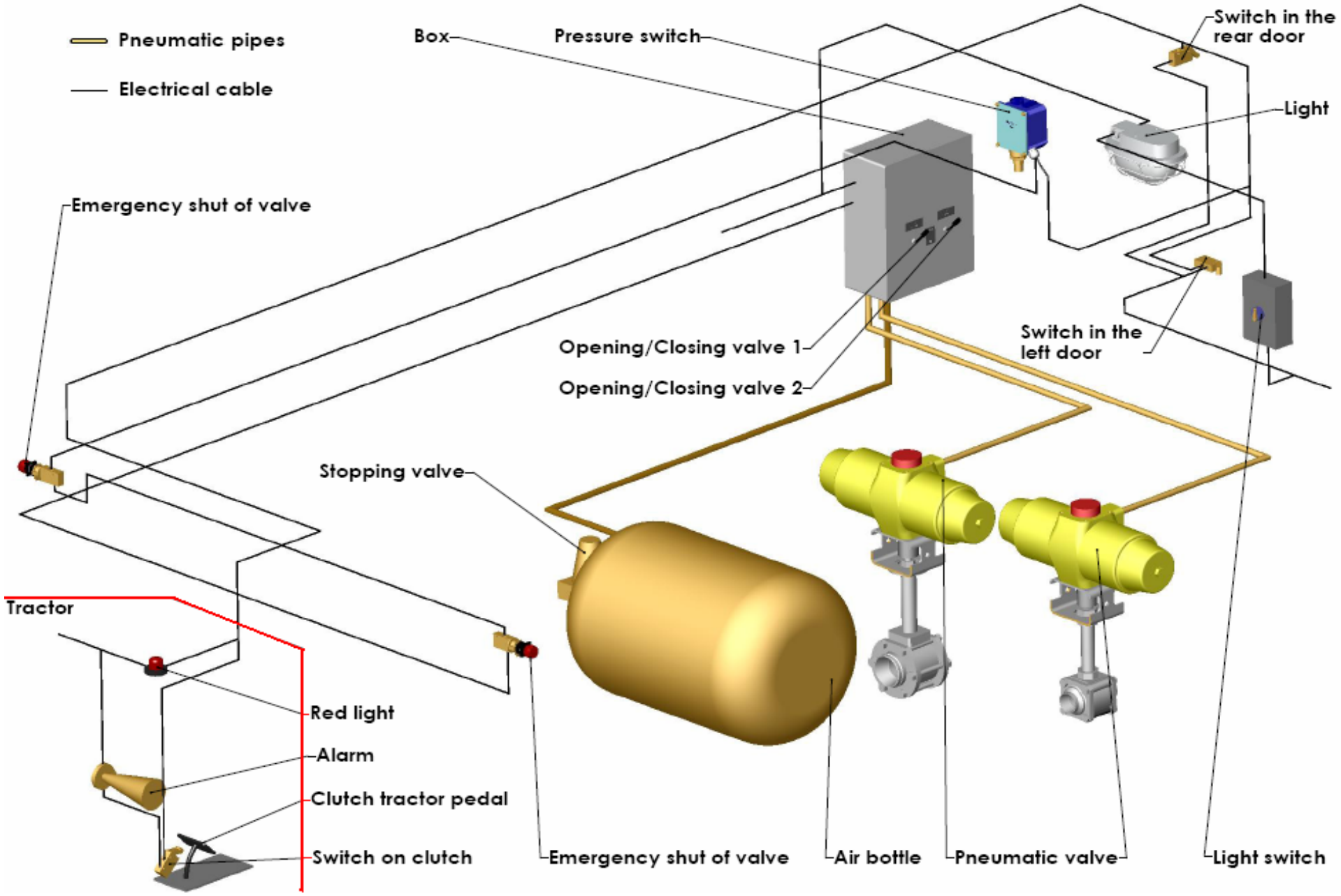
Prevention & Protection

Rear Door Warning System & Actuated Shut-Off Valve

- Other systems rely on mechanical solutions
- Burdened with incidents (brakes activated on road)
- Latest solutions overcome dependence on mechanical systems & rely more on driver responsibility
- Concept:
  - Make driver more aware of overall process
  - System is activated by opening rear door
  - Unexpected opening of door triggers a dashboard warning signal & siren in the truck cab

    (& brakes in certain cases)

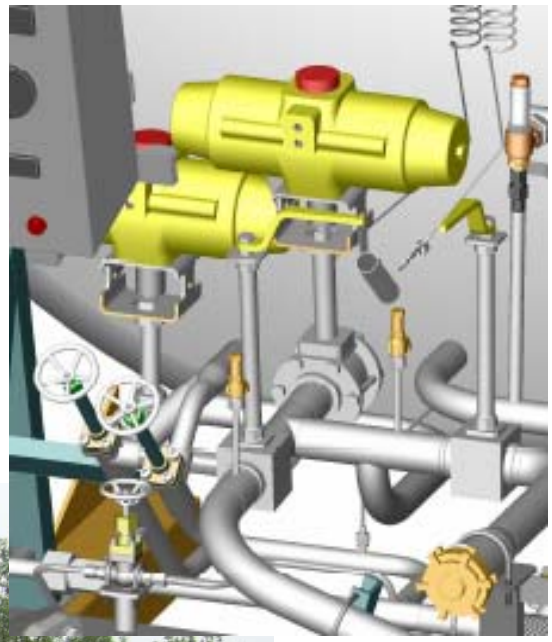
Safety System (Rear Door Warning, Emergency Shut-off Switches, Siren)



Prevention & Protection

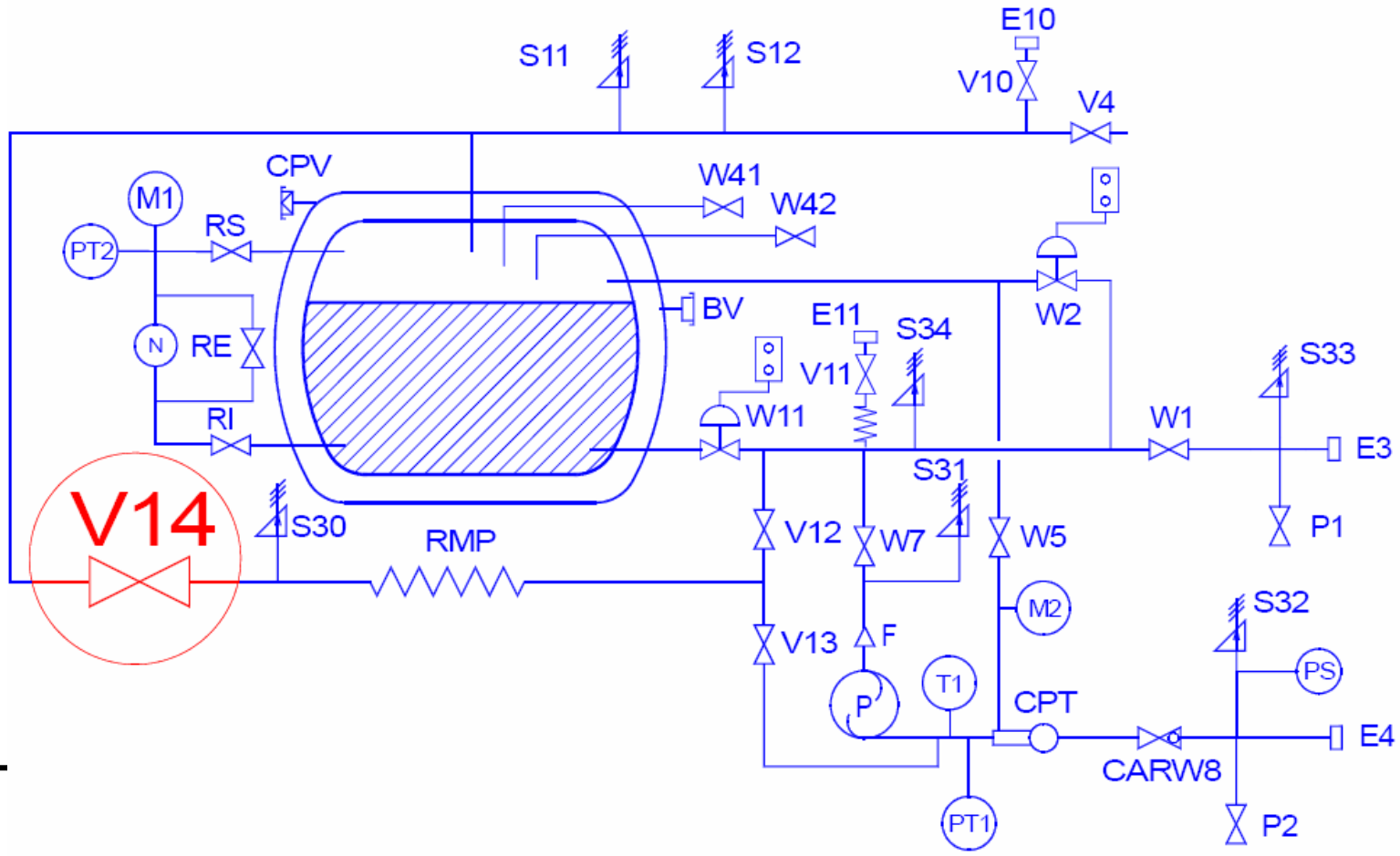
Remote Closing of Actuated Valves

- Normally closed during transport
- May be closed by emergency shut-off trigger on both sides of trailer
- Ensures product is safely kept inside



Prevention & Protection

- Pressure Build Isolation (in case of overturn)
  - V14 isolates PBU line to avoid pressure increase & venting of product



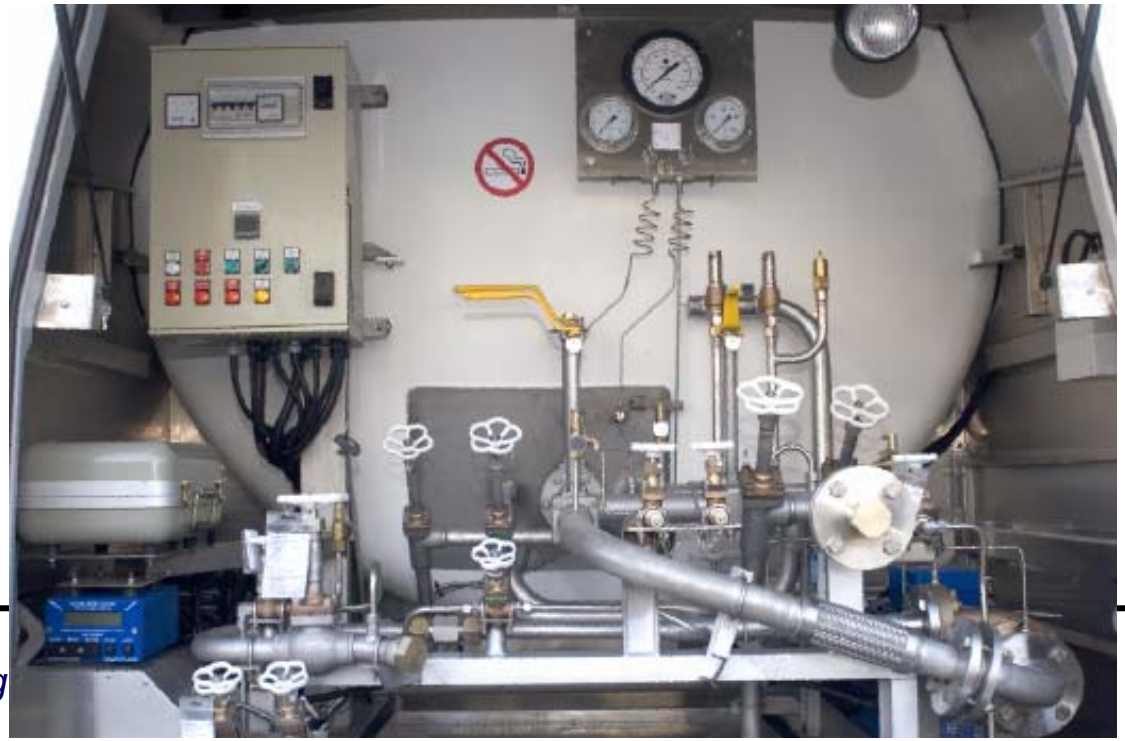
Prevention & Protection

Rear Impact Safety

- Thinner (1.3 mm) “sacrificial” pipe absorbs shock
- Thick pipe (3.6 mm) & valve remain intact

Prevention & Protection

- Accessibility of Control Devices
  - Improved accessibility & ergonomy encourages safe operating & maintenance conditions
- Liquid Leakage
  - Stainless steel rear dished end, globe valves, welded connections & control piping prevent leakage



Prevention & Protection

Adapted to Asian Conditions

- Trailers used in difficult road conditions are “precision reinforced”
- Landing Leg are reinforced to give additional support
- Robust design yet allows the most optimal payload in the market

- Without Reinforcement

With Reinforcement

Prevention & Protection

Adapted to Asian Conditions

- Chassis Reinforcement to give additional support to inner and outer vessels

Without Reinforcement

With Reinforcement

Prevention & Protection

Separation of Truck & Prime Mover

- Demountable king pin (5th wheel) plate
- Eliminates potential for corrosion
- Avoid accidents related to separation of truck & trailer

Prevention & Protection

Passive Protection

- Based on improving visibility
  - Reflecting Strips
  - Double Rear Lights

Overfill Prevention

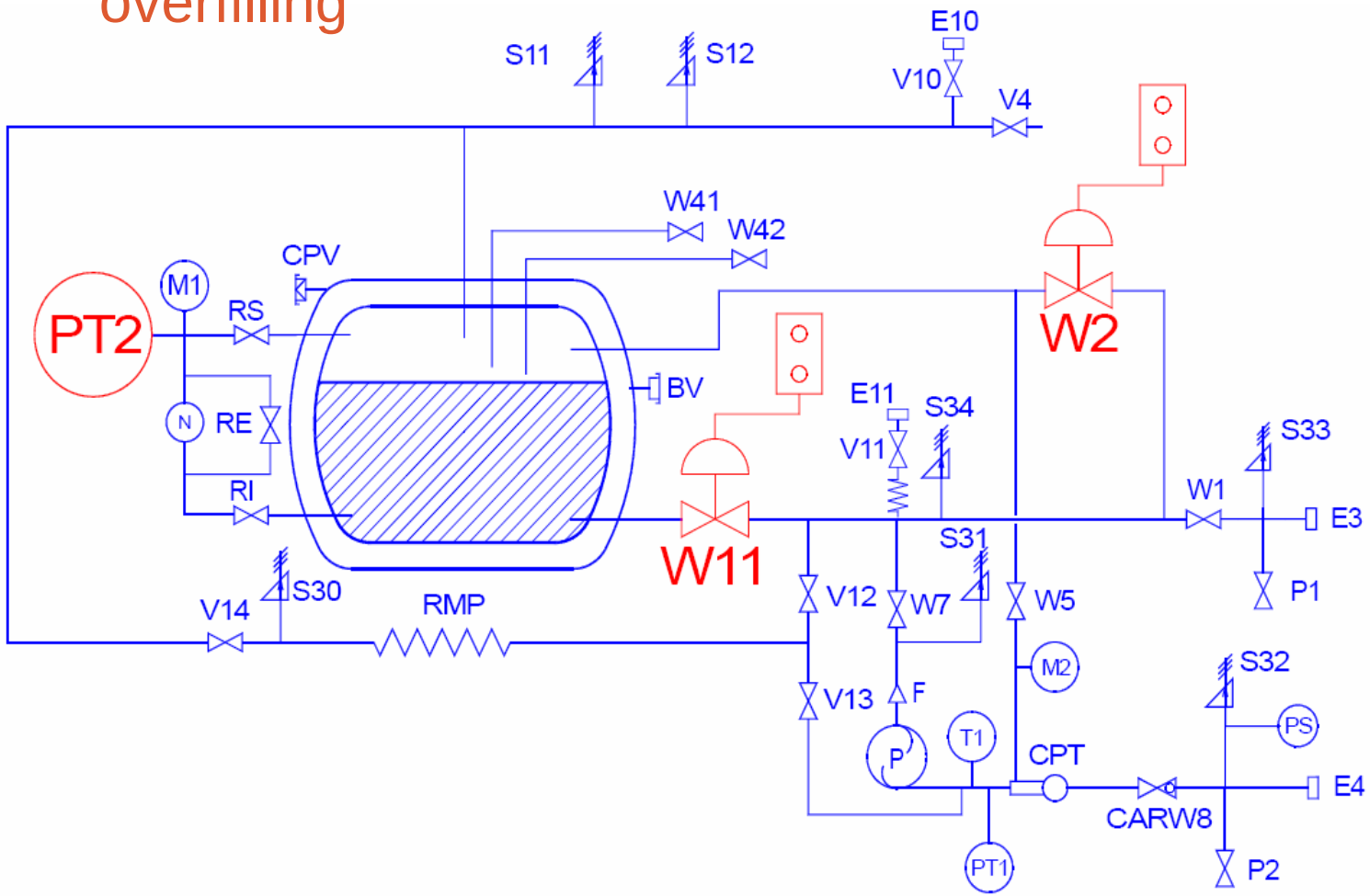
Customer Tank : Time Cycle Control

- Pump operation is interrupted if button is not activated at regular intervals of 3 minutes.

Overfill Prevention

Road Tanker : Pressure Switch Control

- Pressure switch PT2 automatically closes main valves W11 & W2 when pressure increases to avoid overfilling



Conclusion

Future Safety / Design Evolutions

- Independent wheels to improve stability, reduce weight, increase payload
- Continued efforts to improve payload while ensuring reliability
- Continued efforts on driver training, based on the feedback from all major industrial customers.

Safety has a Cost

- World Class companies, leading in Safety & Environment.
- 7 out of 9 causes are “driver/behavior related”
- 2 of the 9 were design / maintenance related:
  - “Higher center of gravity” is a “primary cause of accidents “
  - “Equipment selection is a cause of transportation risk”
- Invest in the equipment that allows World Class companies to deliver on Safety & Environmental goals
  - With the lowest center of gravity & widest wheelbase
  - With optimised payloads to reduce the carbon footprint
- Investment decisions are also safety & environmental decisions!

Thank you for your attention

Questions ?