Industrial Aspects of Deflagration & Detonation in Pipelines

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A Quotation to Start

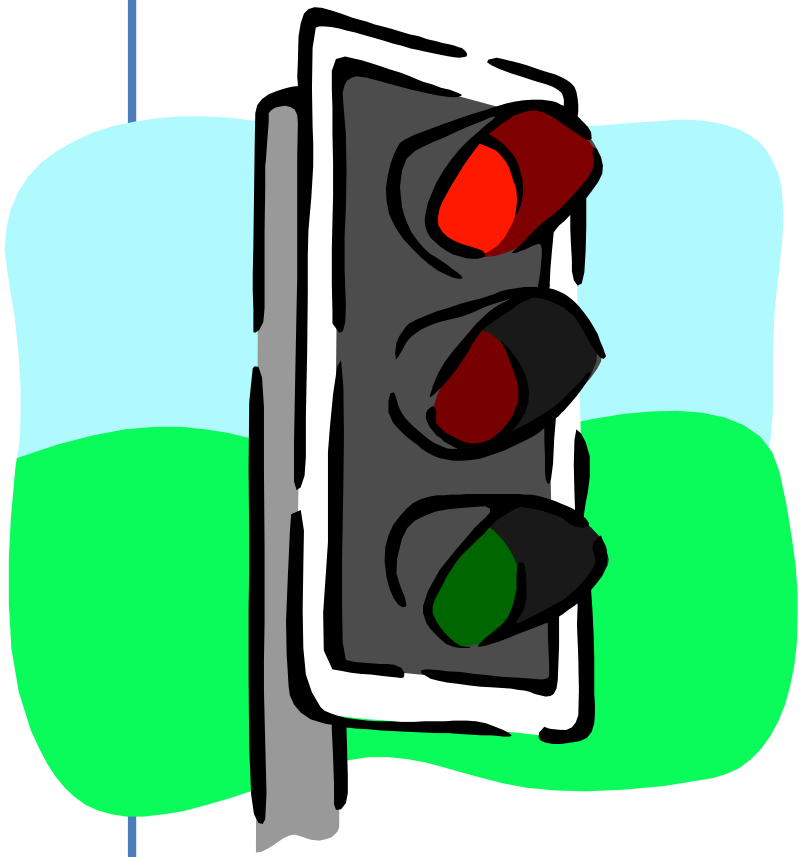
What has happened before will happen again

What has been done before will be done again

There is nothing new in the whole world

Ecclesiastes; 1, 9; Good News Bible

Green Intention – Red Result



- Best of environmental intentions
- Improve emissions
- Introduce hazards
- Operational issues

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The issues

- General lack of understanding of the issues of deflagration & detonation
- Lack of design guidance
  - Only one AIChemE book deals with the subject
- Limited academic interest
  - Non-industrial
  - Lack of relevance

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Design problem

- Multiple headers / flows
- Composition changes
- Near-limit mixtures
- Basis of safety?
  - Composition
  - Flame arresters
  - Ignition hazards

Industrial Example

- Merseyside VCDS
- Multiple other sites
- ICI Engineering Technology
- Experimental programmes
- Training courses

No design standards, issues poorly understood

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Key Factors

- Limited mixture flammability knowledge
- Mixing effects of flammable gases
- Effect of oxidants
- Understanding of flame behaviour in long pipes
- Plants up to 30 years old

- Flammability lab
- Extensive in-house knowledge of products
- Company fire & explosion experts
- Recognition of the issues
- Resource!

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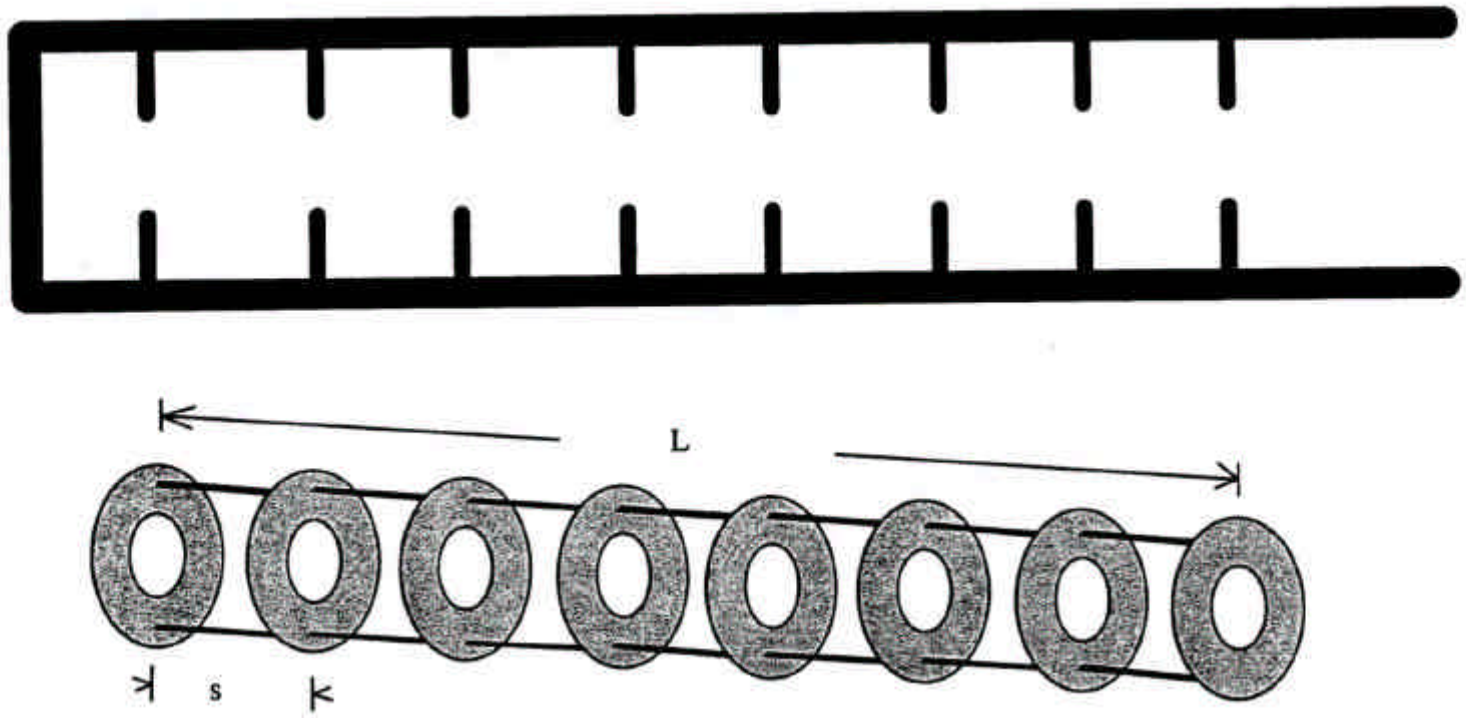
Information available

Academic & industrial experience

Academic Research

- Most work limited to very small scale systems, pure components, shock tube initiation, straight pipes, energetic mixtures
- Some work covering “industrial” systems of limited use
- Main conclusion of much academic work “**more research is required**”

Detonation tube



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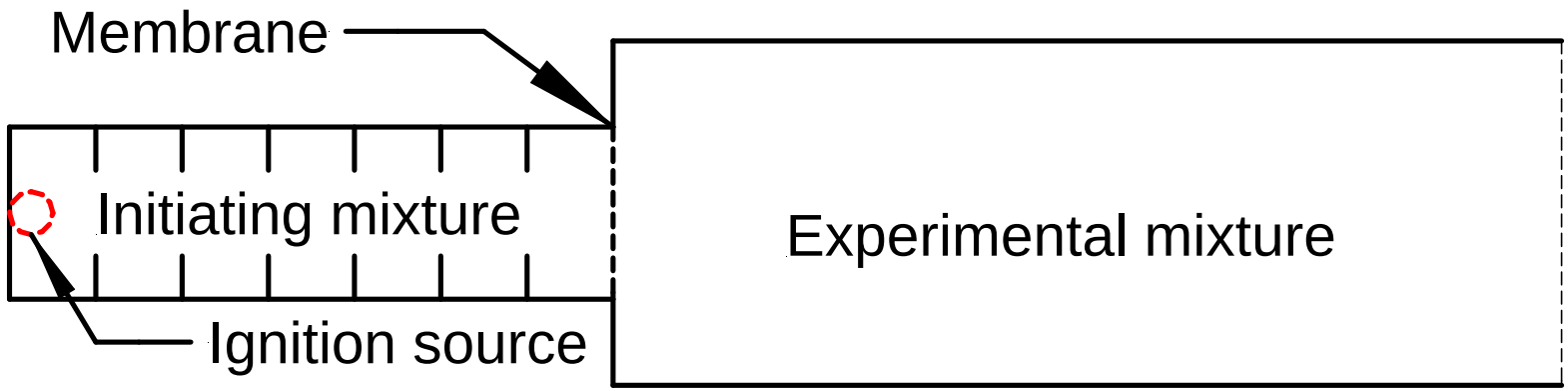
Limitations

- Stoichiometric mixtures
- Pure components
- Initiation by shock tube
- Small diameter
- Straight tube

Limited applicability to real-world problems



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Relating this to industry

- Scale difference – pipe diameters >150mm
- Impure components / mixtures
- Non-stoichiometric mixtures
- Non “standard” materials
- Bends and fittings
- Low-speed initiation run-up to detonation

Research & Design Info

- Understanding of deflagration & detonation, information available
  - Mainly small scale (<50mm diameter)
  - Straight pipes
  - Stoichiometric mixtures
  - Energetic materials
  - Detonation [shock] tubes
- **Limited applicability to real-world problems**

Defining the Problem

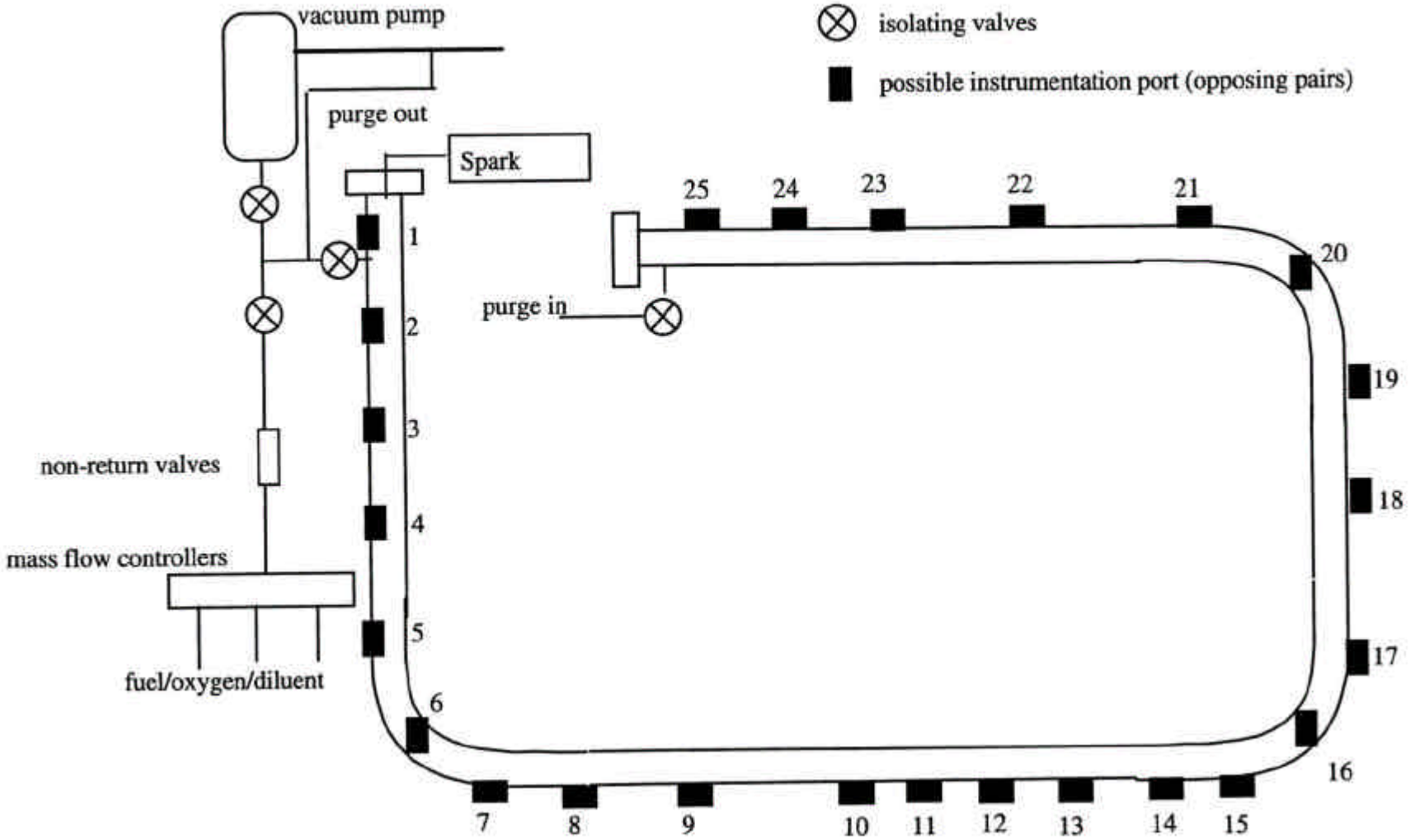
The problem

- How to design systems to be safe on an industrial scale
- Dealing with uncertainty
  - Composition
  - Flow
  - Ignition hazards
  - Pressures
  - Reaction forces

Experimental programmes

- PipEx Consortium
  - ICI / HSE / BNFL / BP / DSM
- Other ICI work
  - Specific mixtures
  - Different pipework materials
- Work carried out by UWA Shockwaves Group

ICI / UWA Final Rig



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The Rig

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The Result

Courtesy of Gwyn Oakley

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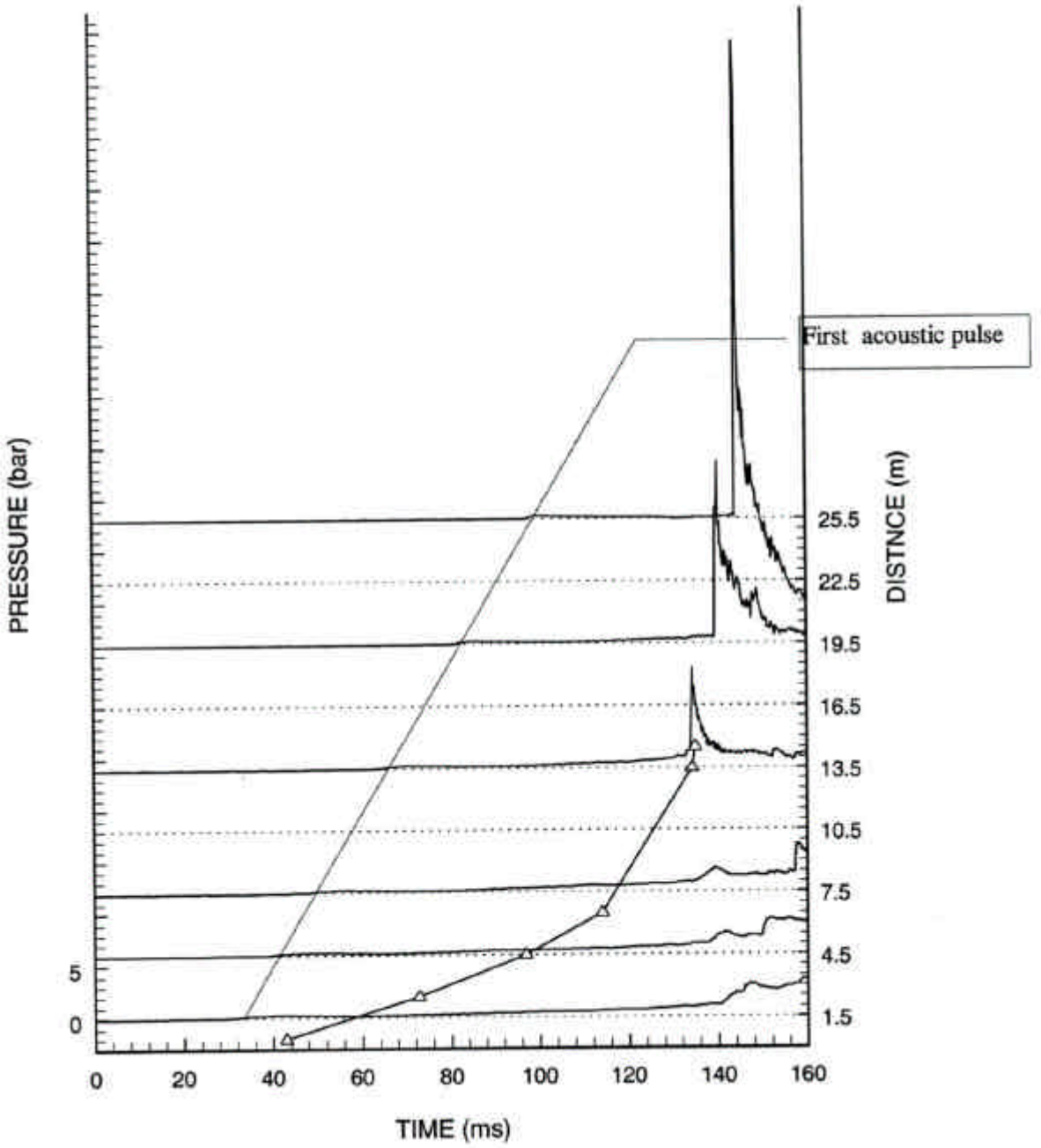
Typical readout from DDT test, 300mm pipe

Acoustic pulse – sound speed in gas = 350 m/s approx



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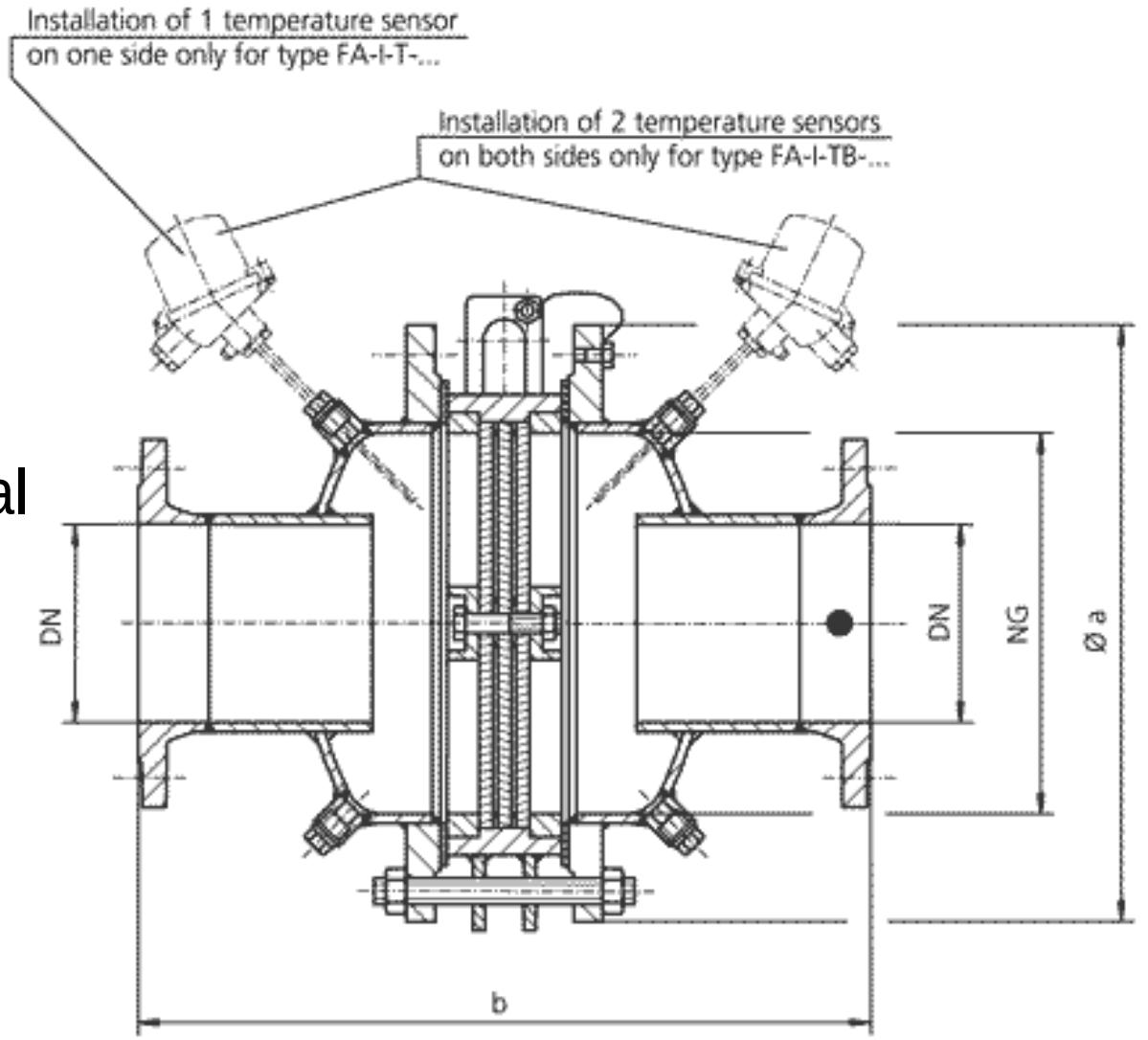
Flame arresters

Protection measures

Role of flame arresters

- Type
  - Knitmesh
  - Crimped metal
  - Liquid seal
- Specification
- Location
- Reliability
- Durability



● Connection to the protected side (only for type PROTEGO FA-I-T-...)
Number of flame arrester discs depends on explosion pressure and max. allowable operating pressure

Courtesy of Protego UK

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Misapprehensions

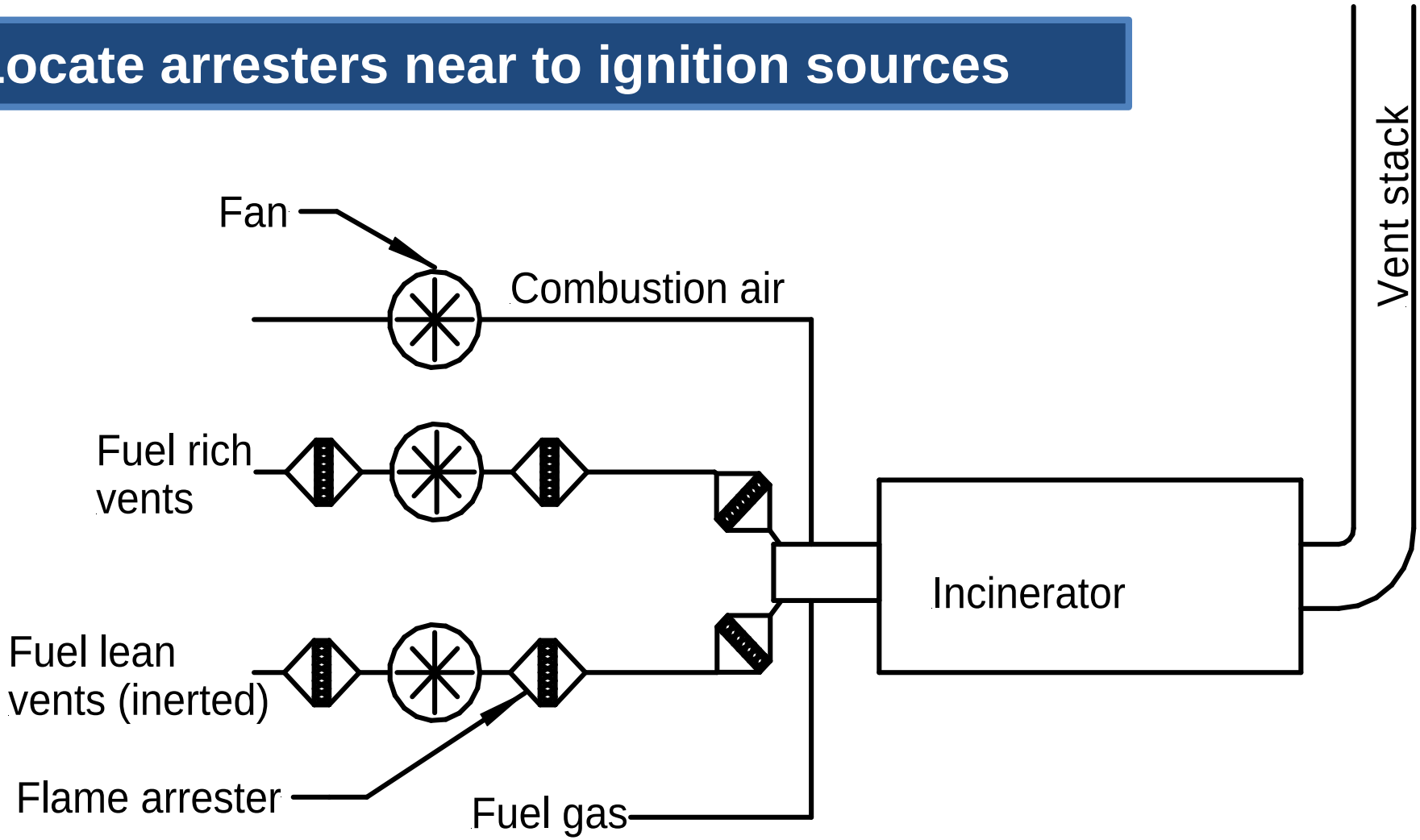
- ☒ They are 100% reliable
- ☒ Flame arresters will stop all types of pipeline explosions
- ☒ Maintenance free
- ☒ Can be installed anywhere in a line

Flame arrester use

- Location in the line
- Suitability (detonation / deflagration)
- Orientation
- Process material issues
  - Polymerisation
  - Corrosion
- Information available only from vendors

Typical VCDS

Locate arresters near to ignition sources



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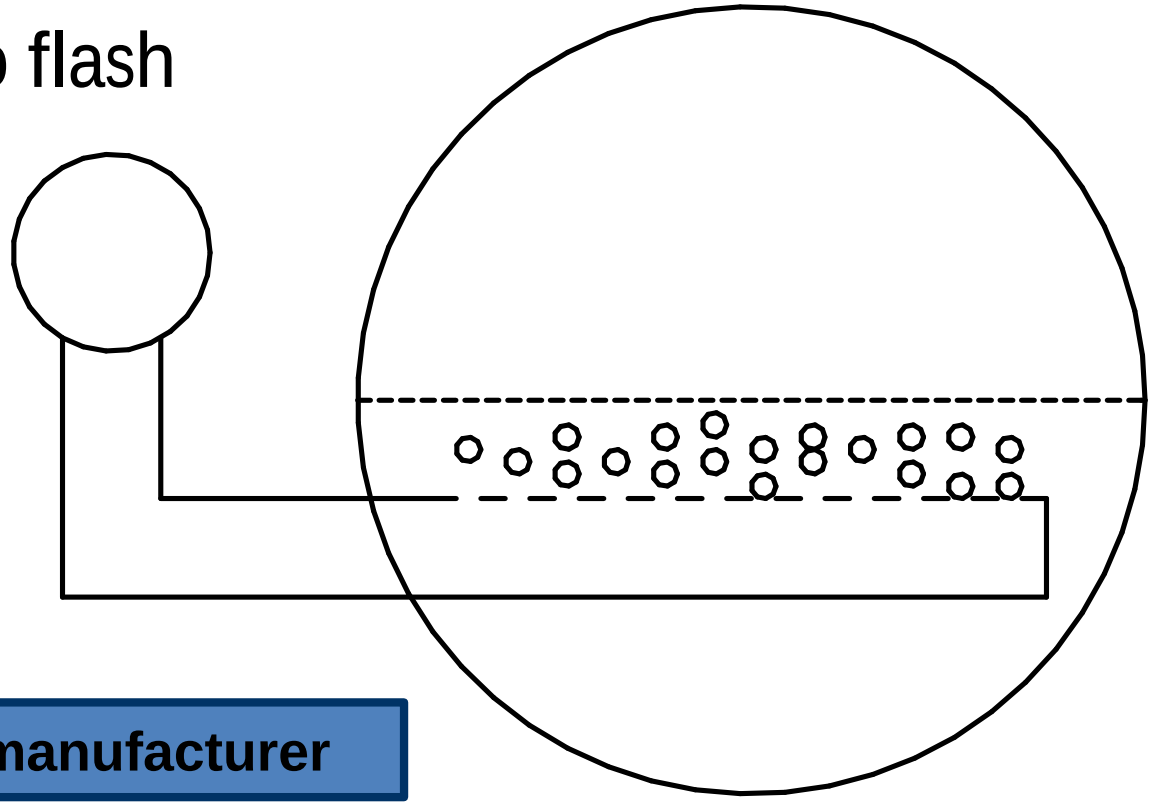
Liquid seal arresters

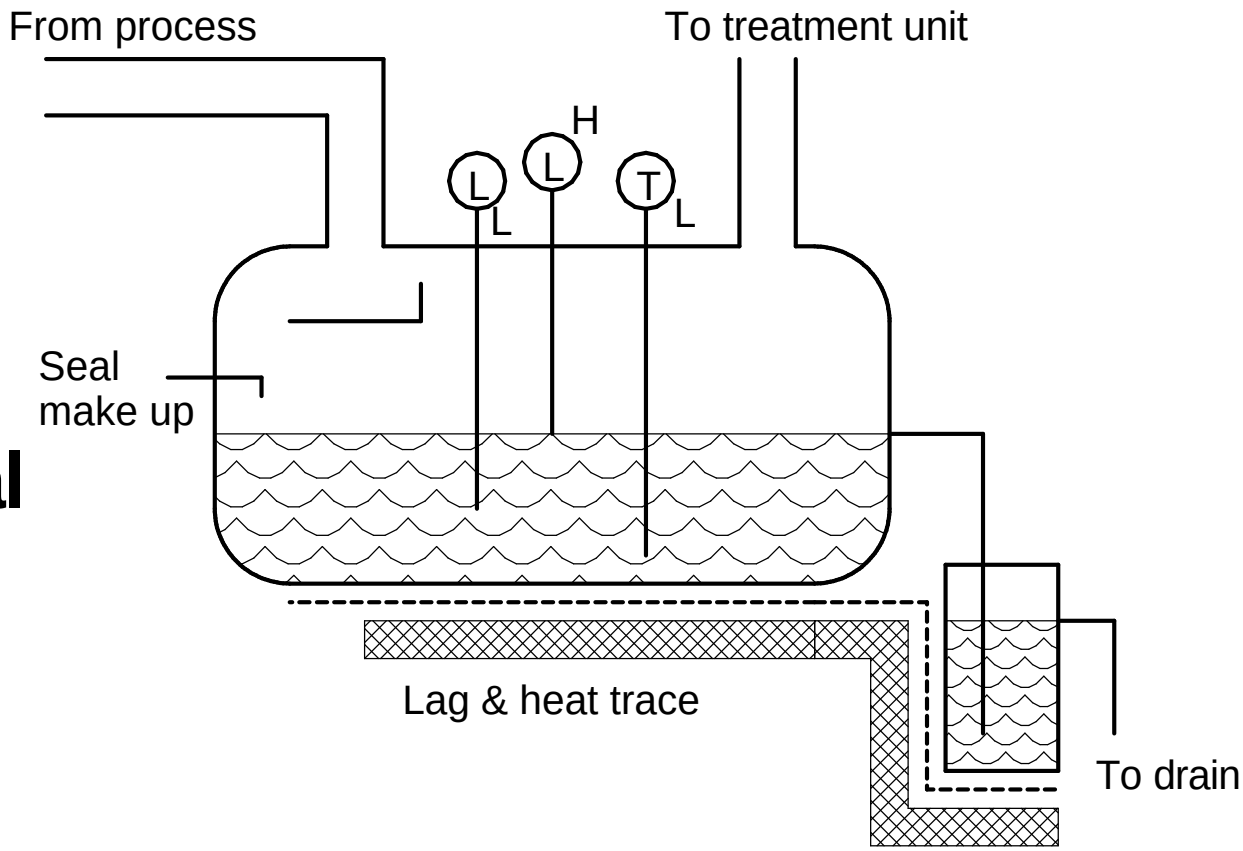
- Useful for particulates
- Very little design data
- Need to ensure no flash back path
- Flow limitations
- Pressure drop limitations



Only one known EU manufacturer

– Liquid Removal

- **Freezing**
- **Effluent disposal**
- **VOC flash**
- **Level**
- **Solids deposition**



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Basis of Safety

Understanding how it is safe

BoS issues

- What is a “Basis of Safety”
  - No formal definition
- Not written down
- Not understood by operations team
- Does not match plant operation
- Operation too close to limits

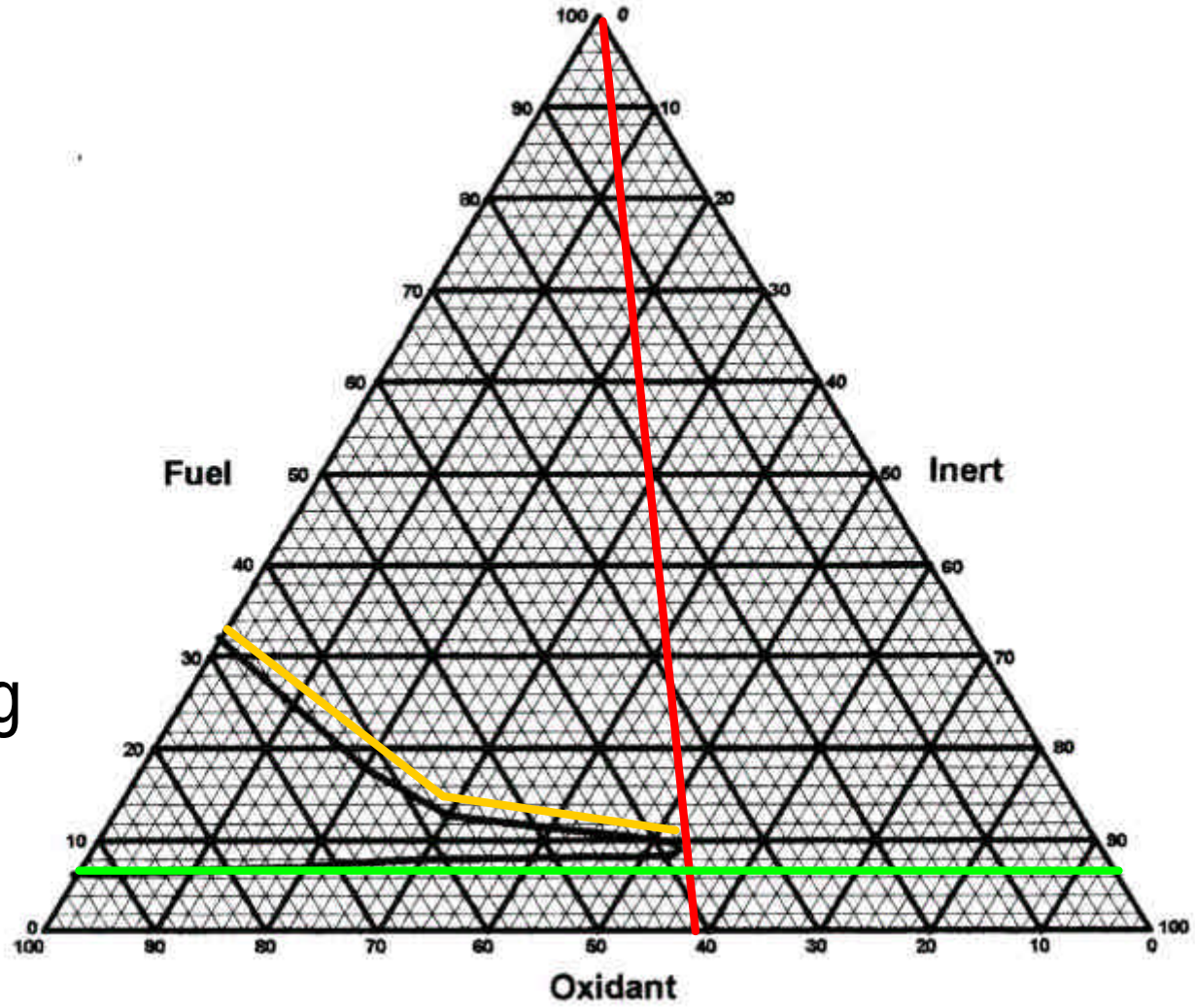
Basis of Safety

Operation below MOC

Below LFL

Above UFL

Assess variability of flows and compositions during all operating scenarios



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What is needed?

- Research on full scale systems
- Work on DDT
  - 150mm+ pipe diameters
  - Pipe with bends & fittings
  - Effect of oxidants
  - Pressure piling
- Design guidance
- Use of protective systems e.g. flame arresters

Industrial Perspective

- Problem often not recognised
- Lack of design guidance
  - HSE / IChemE
- Academic work not focused towards industrial problems
- Lack of cohesion / organisation in research

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A final thought ...

Perfect
Planning
Prevents
Pathetic
Performance

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