

Chemistry on the Edge

- Testing the Limits of Safety

Hu, Y.K. (Michael)



Agenda



1. Introduction: TNO in general
2. Cluster: Process Safety & Solutions
3. Case studies

1932 TNO established by Dutch Law

(Netherlands Organisation for Applied Scientific Research)

**“Connecting people and knowledge
to create innovations that boost the competitive strength of
industry, government and the well-being of society in a
sustainable way”**

Organisation

- RTO
- Not for Profit

Assessment

- Independent
- Objective
- Scientific

Number of employees

4,524 Total workforce (2024)

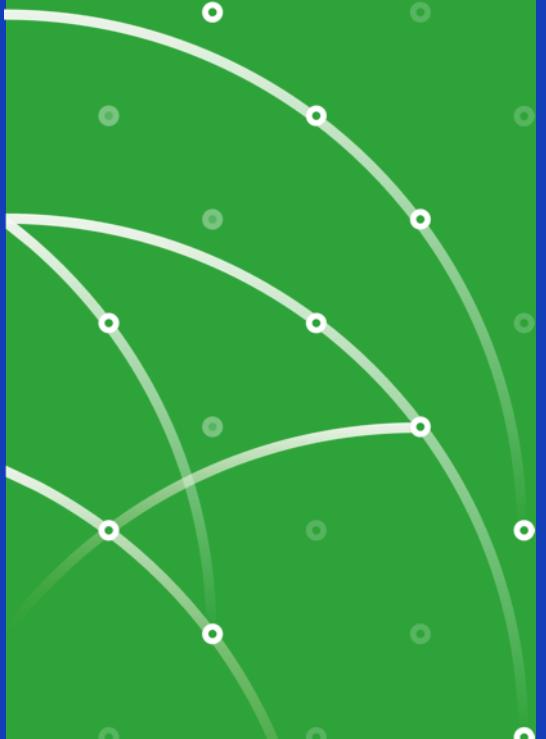
Number of locations

22 Locations



Developments in specific focus area

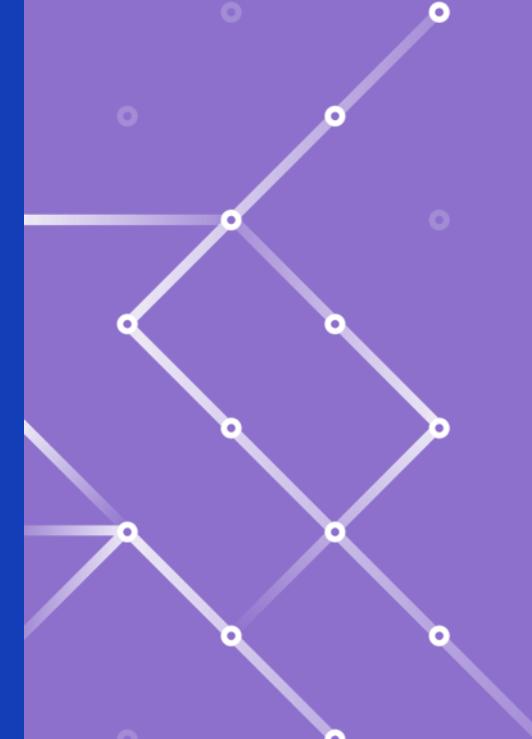
Sustainable society



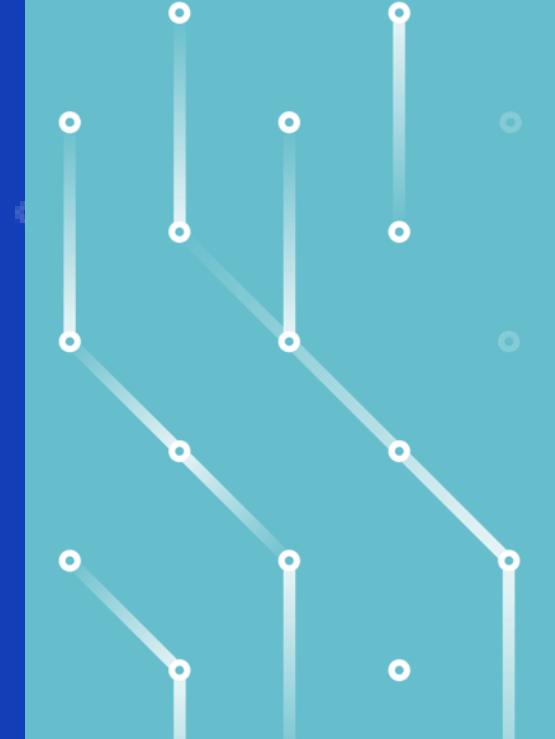
Healthy living



Safe and secure society



Digital society



Units



Defence, Safety
& Security

Human & Organisational Effectiveness (HOE)



Resilience & Security



Strategic defence & security analysis



Human behaviour & collaboration



Human performance



Learning & workforce development



Electromagnetics & Military Operations (EMO)



Electronic warfare



Electromagnetic signatures & propagation



Radar technology



Compact radar systems



Surface & aerospace warfare



Modelling of tactical ops



Acoustics & Underwater Warfare (AUW)



Acoustic signatures & noise control



Underwater operations & seabed security



Acoustic sensor & sonar systems



Instrument manufacturing Waalsdorp



Autonomous Systems & Decision Support (ASDS)



Autonomous systems & robotics



Intelligent imaging



Human machine teaming



Mission simulation & training



Intelligence & decision support



Protection, Munitions & Weapons (PMW)



Energetic materials



Platform protection & advanced materials



Personal protection & explosives safety

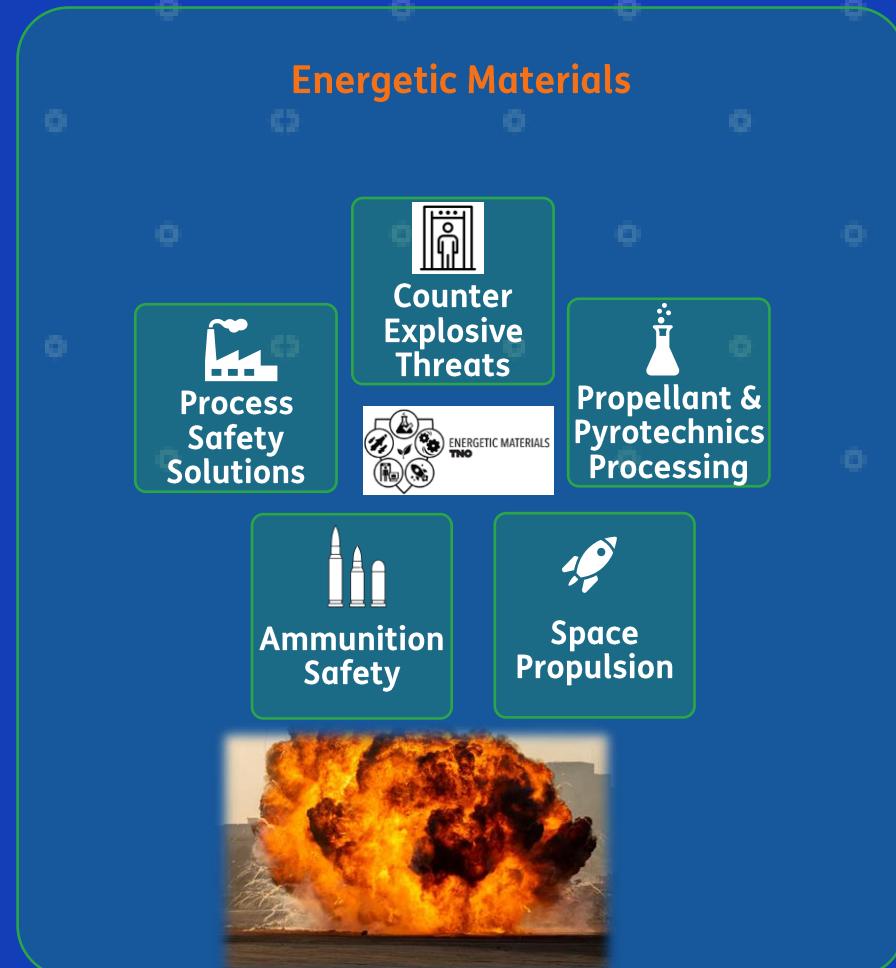


CBRN protection



Instrument manufacturing Ypenburg







Agenda



1. Introduction: TNO in general
2. Cluster: Process Safety & Solutions
3. Case studies

What is the added value of PSS?

Facilities

Bunkers up to 25 kg TNT eq.

Customized testing

Set-ups build for customer needs

Legislation

Broad permits

Knowledge

Vast amount of knowledge & experience

Equipment

Large variety of equipment



Hazardous Materials Testing

Sensitivity assessments

- Spark, Friction, Impact

Product characterization and compatibility testing

Thermal Stability assessments

- Response to heat
- Burning behaviour
- Processing and storage

Fertilizers

- AN detonation test
- Notified Body

Non-standard testing at Extreme Conditions

Explosion Characterization

- dP/dT
- P_{max}
- Propagation, sensitivity

Compatibility testing

- Hazardous Chemicals
- Extreme conditions

Permeability testing

- High Pressure
- High or Low temperature
- Hazardous Chemicals

Runaway testing

- Venting trials
- Calorimetric evaluation

Classification

Fireworks

- Classification tests
- Risk Assessment
- Product & Process Development

Classification of Dangerous Goods

- UN and CLP tests – Class 1, 3, 4, 5, 9
- Safety & Handling Consultancy

Hydrogen safety

- Tensile testing
- Embrittlement analysis
 - Permeation
 - Hydrogenation
 - Liquid hydrogen



Agenda



1. Introduction: TNO in general
2. Cluster: Process Safety & Solutions
3. Case studies

When does it explode?

The development of new chemical routes and/or new industrial installations requires the evaluation of explosion limits (e.g. composition or ignition energy) and the assessment of the explosion effects (e.g. dP/dt or P_{max}).

The Approach

- Tailor-made solution and fully remote operation
- Complex design

The Result

Custom made set-ups allow safe testing and determination of the operating limits and the explosion effects.



Aftermath

Soot formation after an explosion



Halogenated hydrocarbons

- Acute toxic gasesous reaction products (H330).
- PPE capabilities to work with H330 gasses.



Does mud acid undermine the operational range?

Mud Acid, a mixture of HCl and HF, is used in the off-shore industry to dissolve sand and other contaminations. A new drilling technology uses an innovative coil hose. This hose must be suited to withstand the dangerous acid solution while keeping the ability to withstand high working pressure.

The Approach

- Expose coil hose segments to mud acid ($> 60^{\circ}\text{C}$) for 72 hrs
- Pressurized to > 3000 bar for leak testing

The Result

Custom made set-up allowed safe testing and proved the performance of the hoses.



What vent size is required for a runaway reaction?

An organic compound and a peroxide is known to produce a runaway reaction after an induction time. Increasing the concentration of their peroxide requires extensive safety studies. Therefore, the customer wanted to verify what vent size is required in case of a runaway in the plant.

The Approach

The organic compound and peroxide were safely mixed in a vessel and slowly heated.

The Result

The vent size was verified, and the customer can safely run their process at increased efficiency.



Which novel catalysts can be used for acetylene hydrogenation?

The screening of novel acetylene hydrogenation catalysts is a dangerous process due to the explosive decomposition that can take place.

The Approach

- Continuous operation and screening of products
- Tailor-made solution and fully remote operation
- Automated control of the setup

The Result

Safe screening of novel catalyst for the hydrogenation of acetylene.



How to safely assess the permeability coefficient at high P and T?

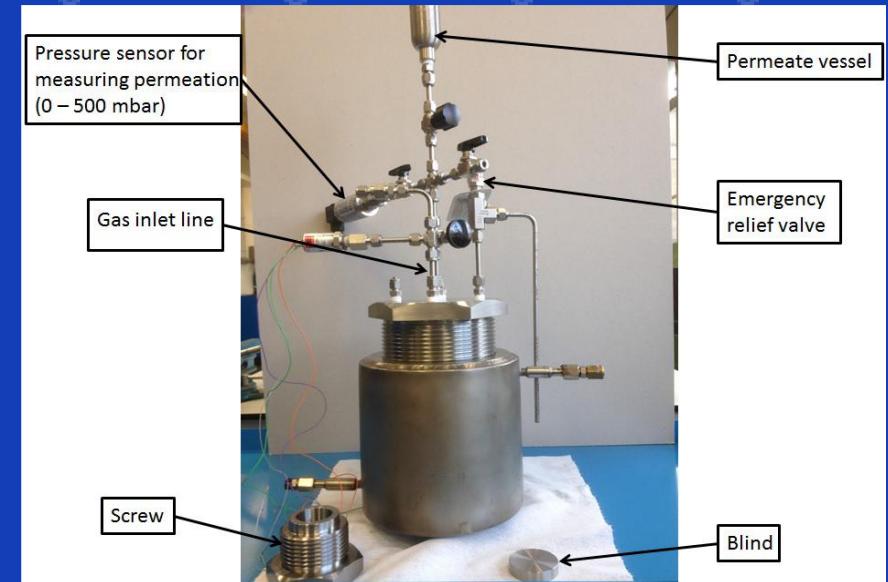
Development of a new polymer material whose application requires the material to be impermeable at demanding conditions.

The Approach

- Customized setup
- ASTM D1434 practice → manometric method
- High pressure and temperatures
- Specially engineered test cell → overcome mechanical breakdown features and material swelling

The Result

Safe determination of the permeability coefficient.



How to safely assess the embrittlement effect of hydrogen on novel materials?

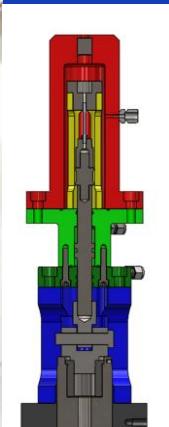
Development of a new material whose application requires the material to tolerate hydrogen at demanding conditions.

The Approach

- Slow Strain Rate Testing (SSRT)
- In-situ hydrogen testing
- Temperature -50 to 320°C and up to 700 bar

The Result

The SSRT allows testing of hydrogen embrittlement effects at elevated conditions.



Can you use liquid hydrogen as a fuel for aviation?

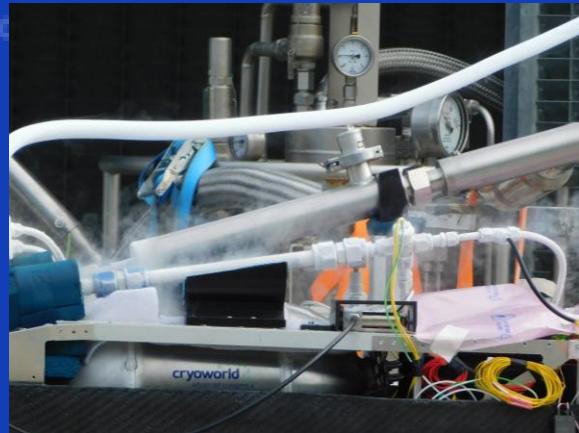
- AeroDelft tested their small-scale hydrogen powered electric propulsion system for aircrafts with the use of our liquid hydrogen facility.

The Approach

The hydrogen fuel cell was powered with vaporized liquid hydrogen.

The Result

New development into sustainable aviation.



How to safely process Fireworks?

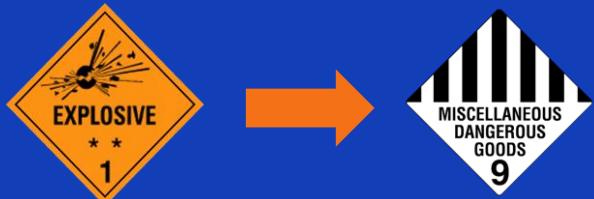
Tons of illegal fireworks are confiscated each year. These items are dangerous and their transport plus dismantling is a costly and elaborate procedure.

The Approach

Phlegmatization (desensitizing) technology developed for this type of material.

The Result

Based on TNO knowledge of the past we were able to proof the working principle and assist the Dutch government to roll-out the method safely.



THANK YOU FOR YOUR ATTENTION

- Point of Contact:

Alexandre Olive, PhD

Business Developer

TNO Energetic Materials - Extreme Chemistry & Dangerous Goods

alexandre.olive@tno.nl / +31 6 21 32 36 00



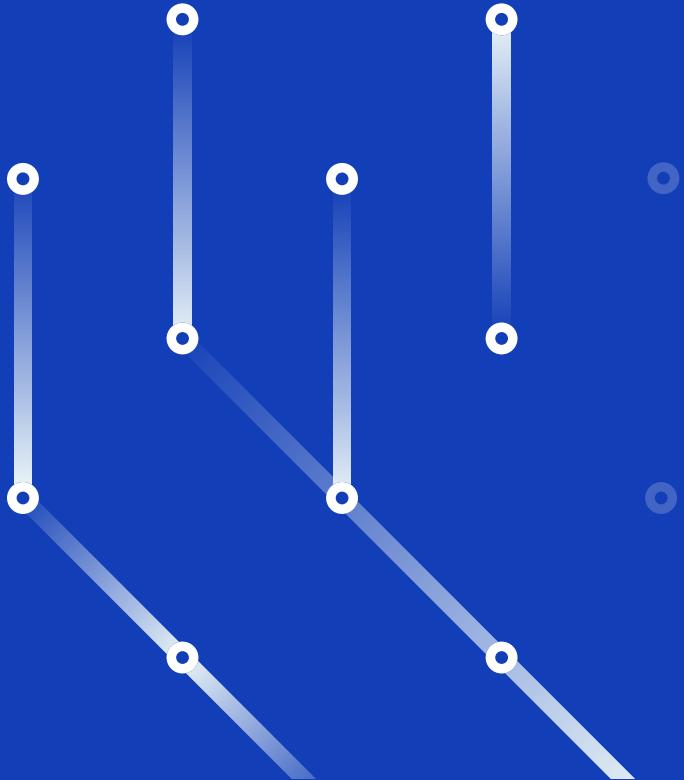
Webinar by TNO: Hazards of liquid H₂

Online

Discover the fundamentals of liquid hydrogen in this TNO webinar, including its characteristics, safety risks, and key guidelines for safe use.

[Read more >](#)

[About Webinar by TNO: Hazards of liquid H₂ - EPSC - European Process Safety Centre](#)



Any questions?

TNO innovation
for life

Feel free to visit our booth for more information