TNO
HEAT TRANSFER & FLUID DYNAMICS

GARRELT ALBERTS
RESEARCH MANAGER

TNO innovation for life

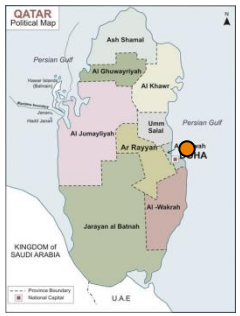
TNO TECHNICAL SCIENCES

- Acoustics and Sonar
- Business Information Services
- Distributed Sensor Systems
- Electronic Defence
- Energetic Materials
- Equipment for Additive Manufacturing
- Explosions, Ballistics and Protection
- **Heat Transfer and Fluid Dynamics**
- Holst Centre
- ICT Security
- Instrument Manufacturing
- Integrated Vehicle Safety
- Intelligent Imaging
- Materials for Integrated Products
- Media & Network Services
- Nano-instrumentation
- Network Technology
- Optics
- Optomechatronics
- Performance of Network and Systems
- Power Trains
- Process & Instrumentation Development
- Radar Technology
- Responsive Materials & Coatings
- Service Enabling & Management
- Space Systems Engineering
- Structural Dynamics
- Structural Reliability
- Thin Film Technology
- Weapon Systems

Heat Transfer & Fluid Dynamics

- **More than 60 experts on Heat Transfer and Fluid Dynamics.**
- **State-of-the art numerical simulation tools and experimental set-ups.**
- **Consultancy projects and contract R&D projects for the built environment, (petro-) chemical industry, semi-con and the pharmaceutical industry.**

Delft



Doha

Competencies:
- Fluid Dynamics
- Multiphase Flow
- Fluid Structure Interaction
- Process Optimization
- Mechanical Engineering
- Acoustics
- Building Physics

Modeling:
- Pipe Flow Pulsations
- Multiphase Pipe Flow
- Computational Fluid Dynamics
- Mechanical Response
- Noise Radiation
- Heat Transfer and Ventilation Flow

Experimental:
- Model validation
- Scale model tests

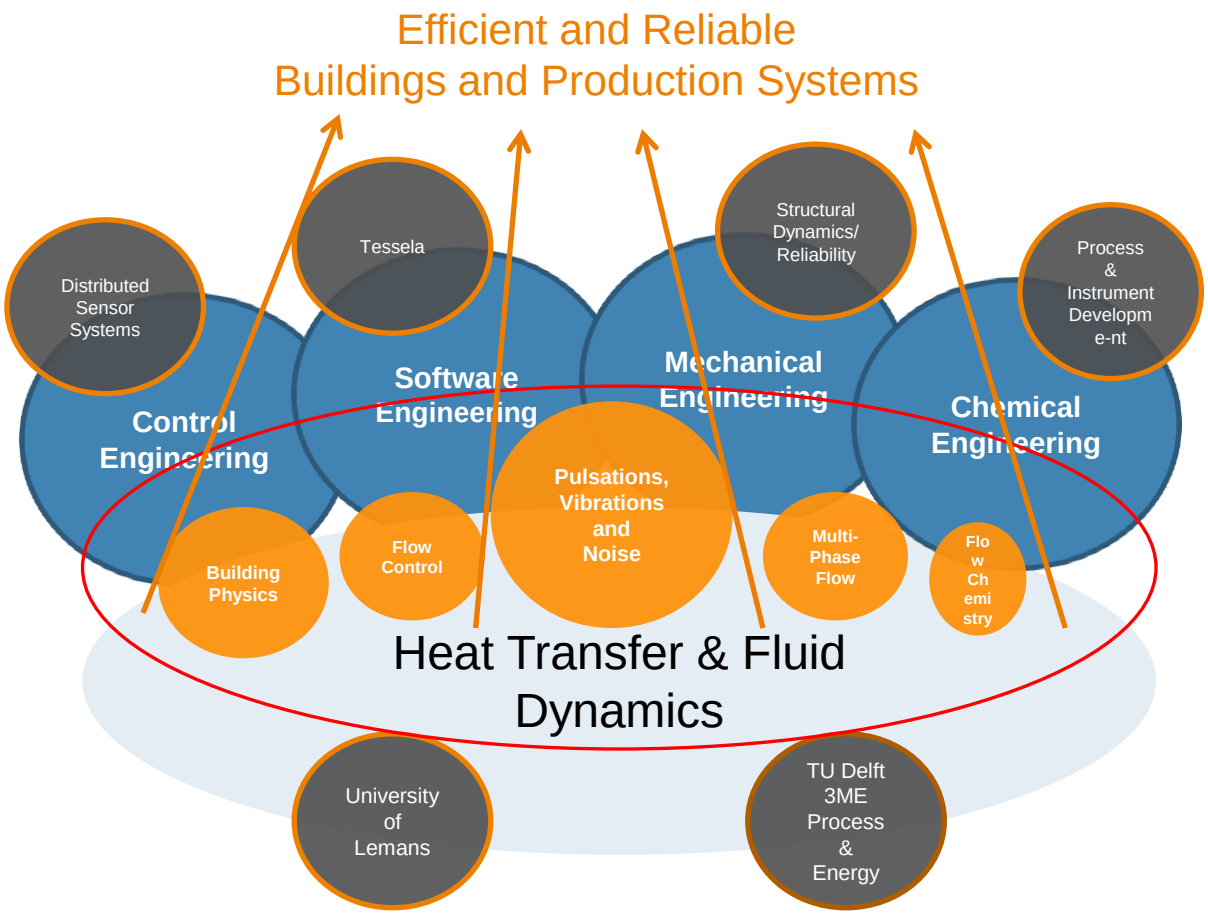
Products:

- **Pulsim/Dampersim**
  Software tools for the analysis of pulsations and vibrations (API 618, API 674, API 619)
- **Operation Support Systems**
  Real-time monitoring and control systems, based on our computer models, that provide an operator with advice regarding optimal production.

Services:

- **Debottlenecking & Integrity Analysis**
  Prediction, analysis and mitigation of (multiphase-) flow, compressor or pump induced instabilities, pulsations and vibrations in systems and/or components.
- **Design & Optimization**
  Design, monitor and control of systems and/or components with respect to performance and integrity.
- **Field Surveys**
  On site pulsation & vibration measurements, indoor climate measurements, energy monitoring and monitoring energy use in (nearly zero energy) dwellings.

HTFD MISSION

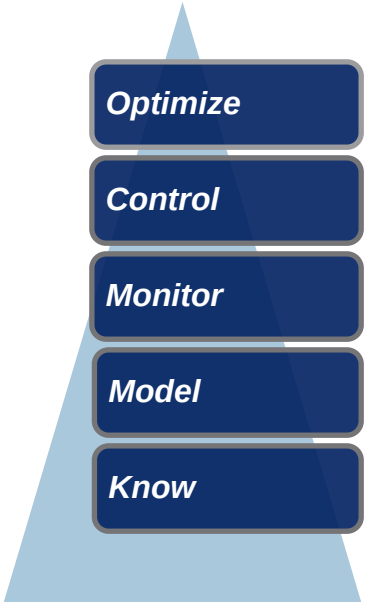


Products & Services

Enabling

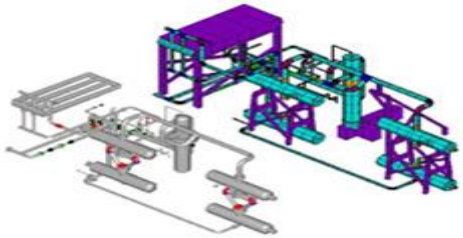
Core

Base

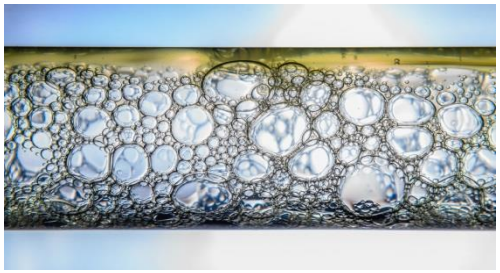


OUR EXPERTISE

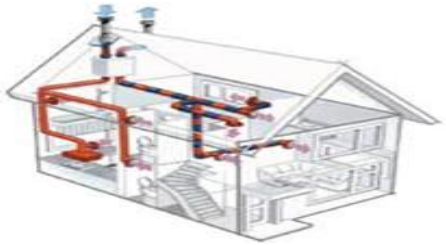
PULSATIONS, NOISE & VIBRATIONS



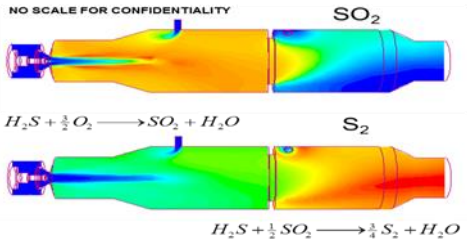
MULTIPHASE FLOW



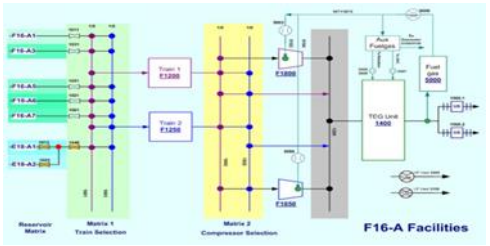
BUILDING PHYSICS



FLOW CHEMISTRY



FLOW CONTROL



OUR CORE BUSINESS

GAS TRANSPORT & STORAGE

OFFSHORE PRODUCTION SYSTEM

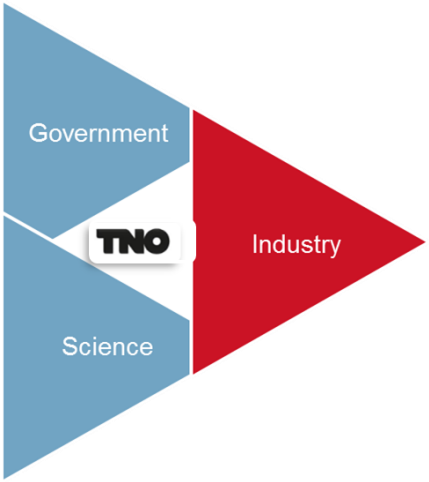
WELL & FLOWLINE MANAGEMENT

ENERGY PERFORMANCE

COMFORTABLE & HEALTHY INDOOR CLIMATE

Contract Research & Development:

- **<u>Research</u> on heat transfer and fluid dynamics using our test facilities and models. Research & Development activities performed under:**
  - Early Research Programme (ERP)
  - Joint Industry Programme (JIP)
  - Topconsortia voor Kennis en Innovatie (TKI)
  - Samenwerkingsmiddelen Onderzoek (SMO)

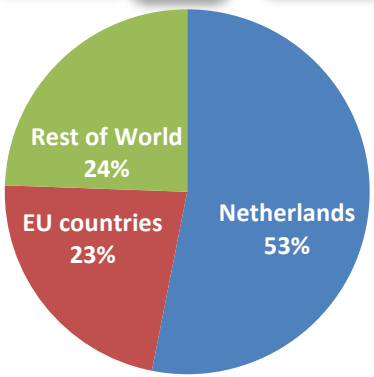


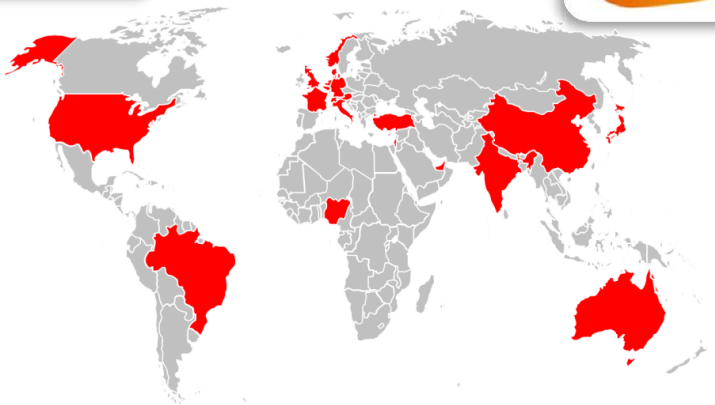
- **<u>Development</u> of innovative mitigation strategies and dedicated models and instrumentation**

Consultancy:

- **<u>Analysis</u> of performance of production and HVAC systems and components**
- **<u>Assessment</u> of mitigation strategy efficiencies**
- **<u>Design</u> of production and HVAC systems and/or mitigation strategy**
- **<u>Optimization</u> by means of real-time monitoring and control**

TECHNOLOGY DEVELOPMENT TOGETHER WITH PARTNERS





OUR FACILITIES

Software tools:

- PULSIM
- OLGA
- LedaFlow
- TRNSYS
- WIS
- Unisim
- PULSDS
- Fluent/CFX
- ANSYS
- COMSOL
- Dedicated tools

Test rigs:

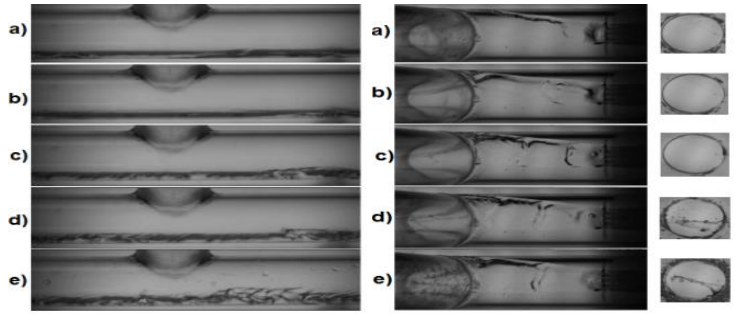
- Single and Multiphase flow rigs
- Climate Controlled Rooms
- Dedicated setups

Field Surveys:

- Indoor climate surveys
- Building energy use
- Flow & pulsations
- Vibrations & stresses

RESEARCH

INTERACTION BETWEEN FIP & MF IN GAS LIQUID SYSTEMS



PRESSURE DROP LNG HOSES (VIDEO)

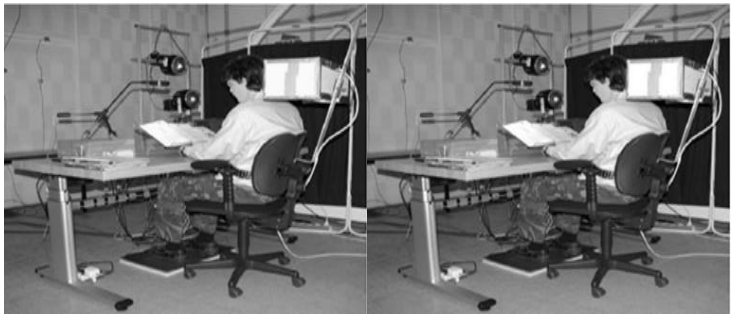
MULTIPHASE FORCE ON BENDS

FOAM DELIQUIFICATION

RESEARCH

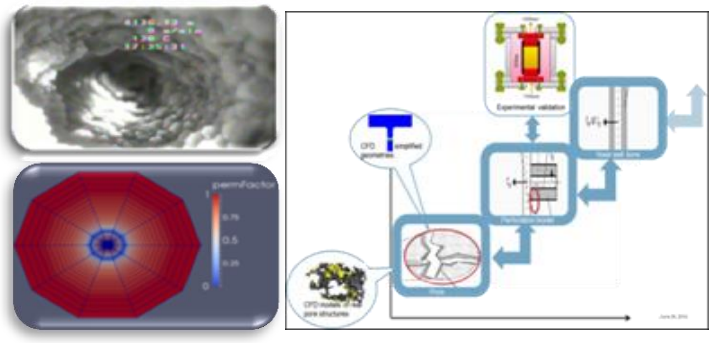
HEATING, VENTILLATION & AIR CONDITIONING (HVAC)

HUMAN FACTOR INDOOR CLIMATE



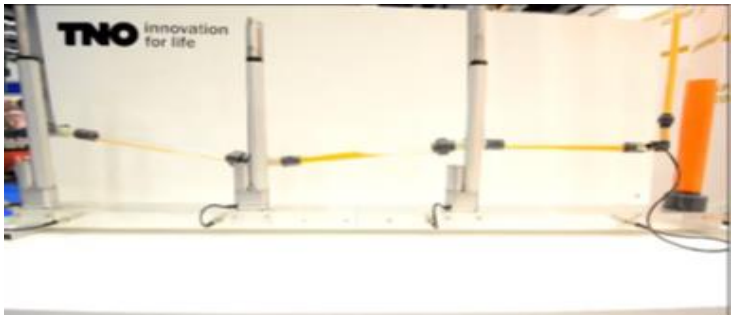
DENSE GASES

SALT DEPOSITION

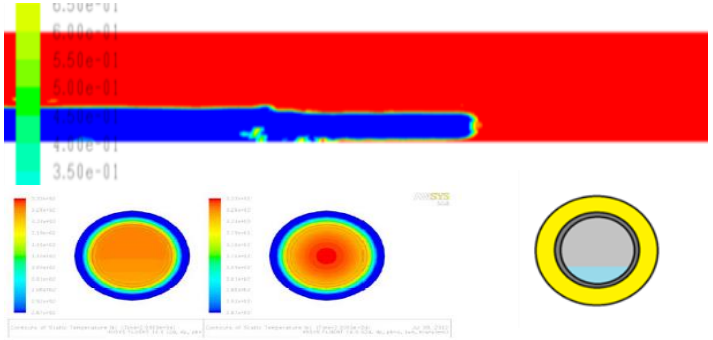


RESEARCH

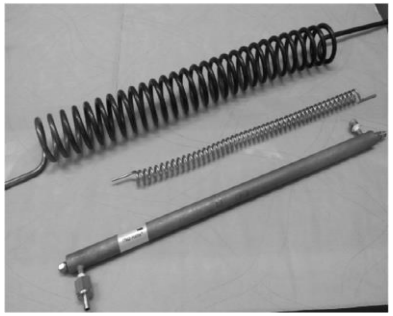
SLUGGING PHENOMENON

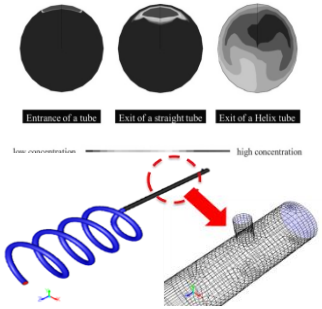


HEAVY OIL FLOW



TNO HELIX REACTOR



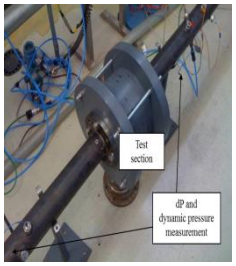


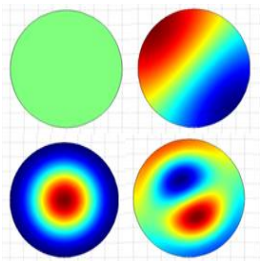
VIDEO: PRESSURE DROP LNG HOSES

DEVELOPMENT: INNOVATIVE MITIGATION STRATEGIES DEDICATED DESIGN TOOLS AND INSTRUMENTATION

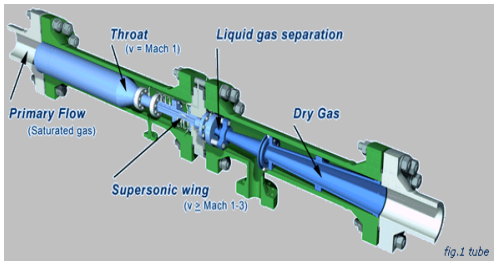
COATED TUBES

SILENCER FOR TURBO-COMPRESSOR





SEPARATOR DESIGN TOOL



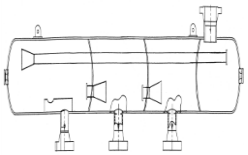
VENTILATION CEILING

GAS ASSEST MONITORING SYSTEM

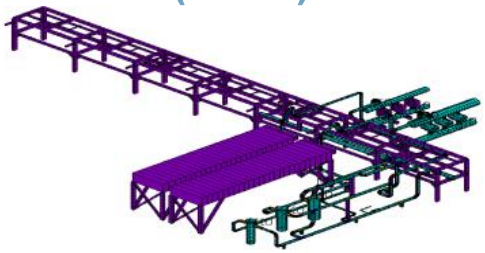
EXTRACTOR WELDING TORCH

CONSULTANCY: ANALYSE, ASSESS, DESIGN AND OPTIMIZE RELIABILITY AND EFFICIENCY OF SYSTEMS AND EQUIPMENT

PULSATION ANALYSIS DAMPERS & PIPE SYSTEM (API 618/674)



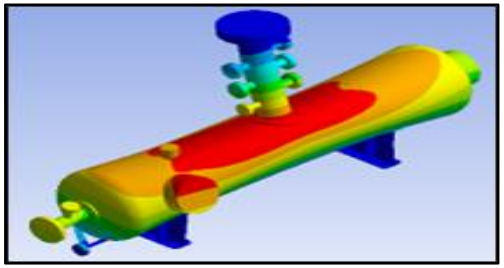
MECHANICAL VIBRATION ANALYSIS PIPING & COMPRESSOR (API 618)



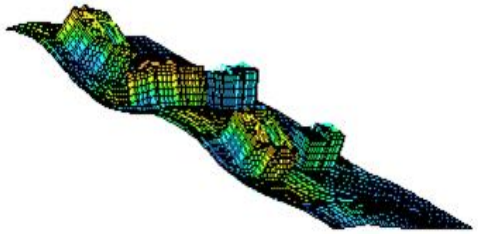
COMPRESSOR VALVE DYNAMIC ANALYSIS (API 618,ISO 13707)

STRUCTURE AIR BORNE/ SOUND ANALYSIS

VESSEL STATIC & DYNAMIC ANALYSIS (API 618,ISO 13707)

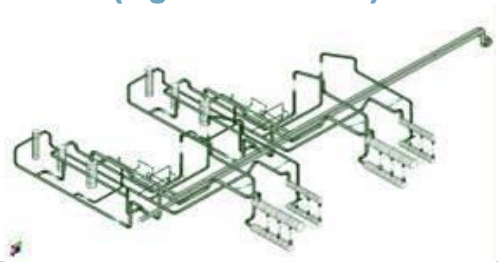


FOUNDATION DYNAMIC ANALYSIS

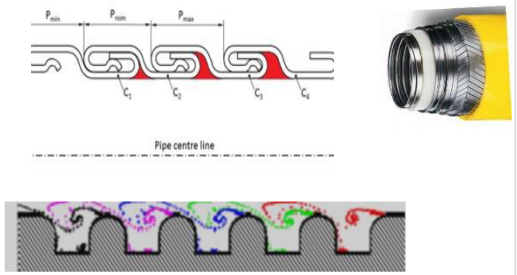


CONSULTANCY

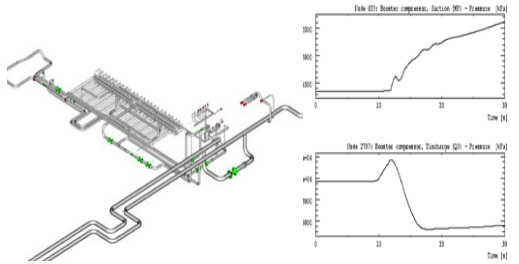
PIPING FLEXIBILITY (THERMAL) STRESS ANALYSIS (e.g. ASME B31.3)



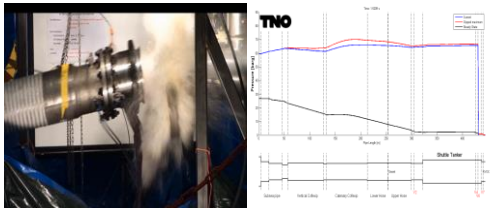
ACOUSTIC RISER ASSESSMENTS



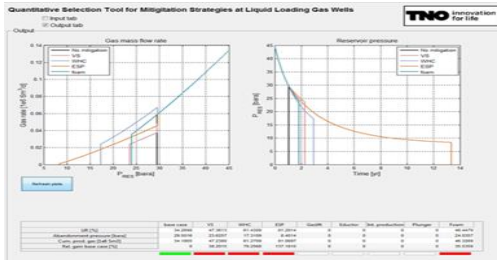
SYSTEM DYNAMIC STUDIES



WATER HAMMER ANALYSIS



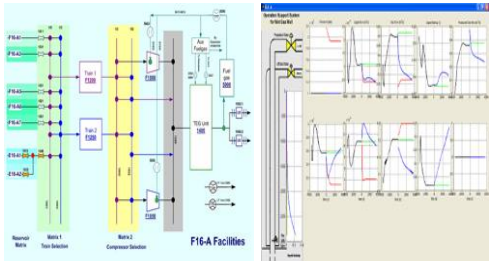
WELL PERFORMANCE ANALYSIS



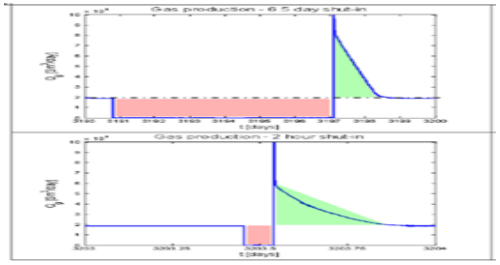
FIELD SURVEYS & MEASUREMENTS

CONSULTANCY

OPTIMAL DESIGN OF PRODUCTION STRATEGY



ASSESSMENT OF PRODUCTION STRATEGIES



REAL-TIME OPTIMIZATION OF PRODUCTION SYSTEMS

STANDARDISATION OF ENERGY LABELLING BUILDINGS

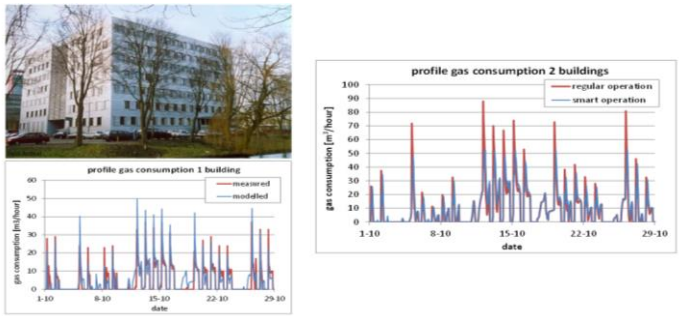
OPTIMAL DESIGN OF VENTILATION & AIR FILTERING SYSTEM

OPTIMIZATION OF ENERGY PERFORMANCE BUILDINGS

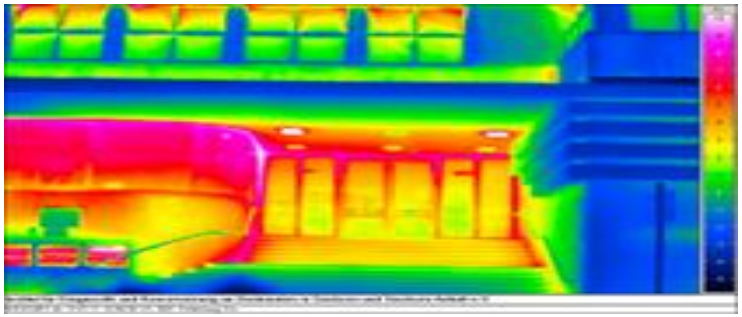
CONSULTANCY

MONITORING NEARLY ZERO ENERGY DWELLINGS

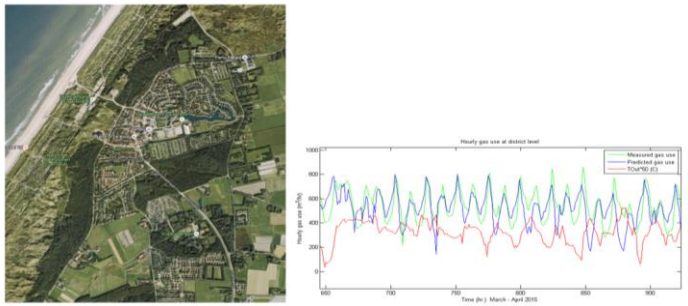
SMART BUILDINGS HEATING DEMAND MANAGEMENT



ENERGY PERFORMANCE ANALYSES BUILDINGS



DISTRICT ENERGY PERFORMANCE PREDICTION



OTHER BUSINESSES

- Projects on aerospace engineering in the HTFD department:
  - Ariane Vulcain engine – combustion modelling of igniters
  - VEGA launcher - external aerodynamics, thermal processing, measurements on thrusters (heat flux/pressure)
  - Design of an ejector-facility for rocket propulsion testing
  - Particle contamination in rarefied flow
- Expertise on aerospace engineering in the HTFD department:
  - Micro thrusters
  - Aerothermodynamics
  - Supersonic and hypersonic flows
  - Rarefied flow

COURSES

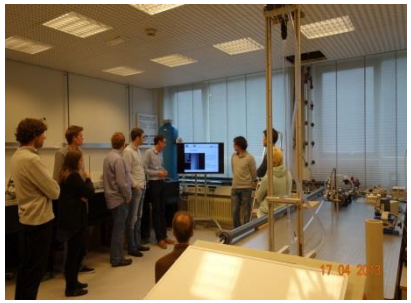
- "Pulsation and Vibration Control in Process Installations workshop" is organized yearly.
- “Flow Assurance for Flow lines and Wells" is organized yearly.

For more information please visit our website; www.tno.nl/htfd

Workshops & Conferences:

- “EFRC training workshop on Basic Design and Operation of Reciprocating Compressors”. For more information, please visit; http://recip.org/2nd-efrc-workshop/
- “International Conference on Flow Induced Vibration”. For more information please visit; http://fiv2016.com/






TNO Heat Transfer & Fluid Dynamics

For reliable and efficient
production systems and buildings

MORE INFORMATION:

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