Air Liquide

SHTE Swedish Suppliers of Heat Treatment Equipment

Heat treatment of fitting elements, troubleshooting analysis and compliance with EN 746-3+A1

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Bålsta, Sweden • Mai 2022 • ALTEC HT
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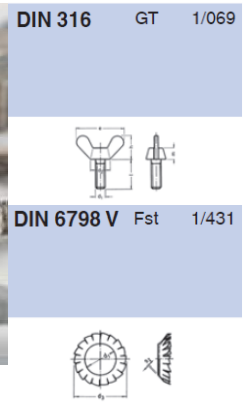
INDUSTRIAL MERCHANT

Fitting and fastening elements - Diversity

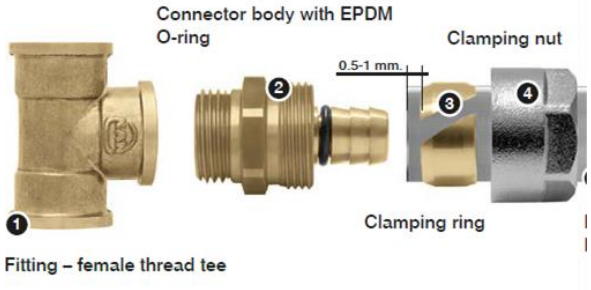


Steel fastening

Source: https://www.schrauben-gross.com/

Source: https://www.swagelok.com/

Source:http://en.kan-therm.com/



Source:https://www.hilti.fr/

Fitting and fastening elements

Fitting and fastening elements = mass production, often automatic

Elements, diversity of:

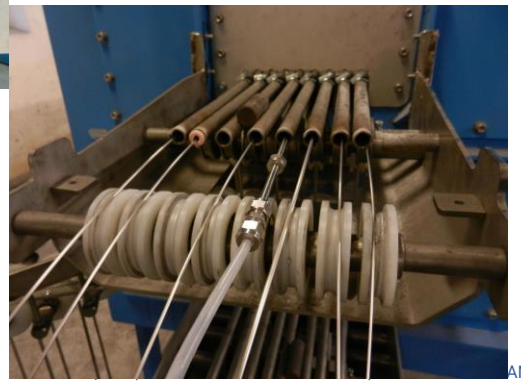
- Shapes
- Materials
- Multi-material assembling
- **Specifications**
  - Process
  - Surface aspect
  - **Assembling**
  - Compatibility
- **Mechanical properties**
- Multi reference facilities
- Mature & Innovative domain

Diversity of Heat treatments:
Hardening
Neutral annealing
Cryogenic
...

Diversity of technologies:
Atmospheric pressure
Low pressure
Quenching (gas, oil, polymer salt bath…)
...

CEN EN 746-3:2000+A1:2009

Single standard relevant to various furnace technologies



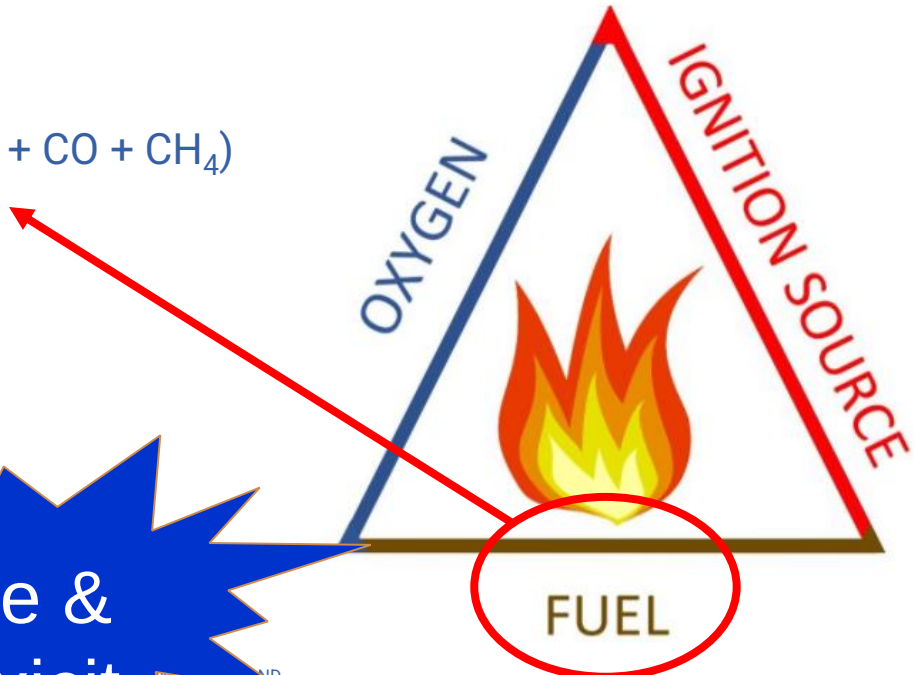
Flammable atmosphere gas - Combustible

EN 746-3:2000+A1:2009 Industrial thermoprocessing equipment - Part 3: Safety requirements for the generation and use of atmosphere gases technologies

Combustible and subproducts

Flammable mix of gas:

- + 5 % (V/V) flammable components (H_2 + CO + CH_4) with CH_4 < 1 % (V/V)
- > 1 % (V/V) of C_nH_m
- > 2,5 % (V/V) of NH_3
- > 1 % (V/V) d'oxygène



$C_nH_m + O_2 \longrightarrow nCO + mH_2$

$2NH_3 + O_2 \longrightarrow 2NO + 3H_2$

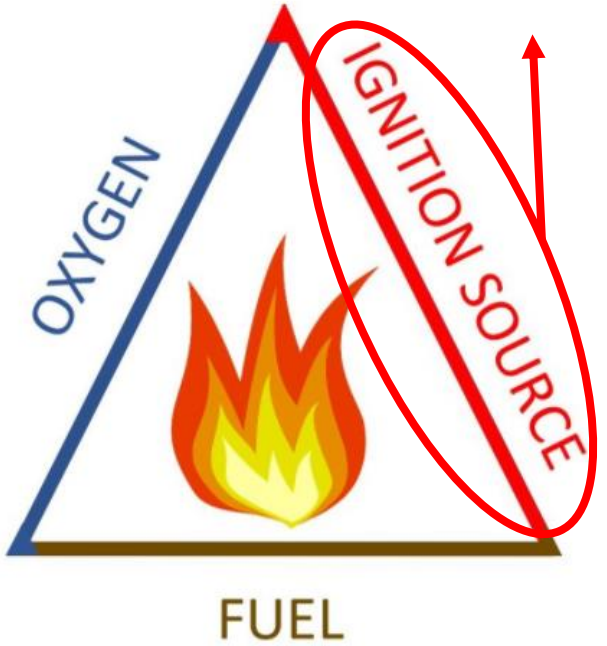
Fire & Toxicit

Source : http://umich.edu/~safeche/firetriangle.html

Flammable atmosphere gas - Ignition source

Gas	Lower Explosive Limit (LEL) (%)	Upper Explosive Limit (UEL) (%)	Autoignition Temperature (°C)
Hydrogen	4	75	500
Acetylene	2.5	81	300
Carbon Monoxide	12.5	74	605
Methane	5	15	535
Propane	2.2	10	450

Temperature > 750 °C
Standard lower limit

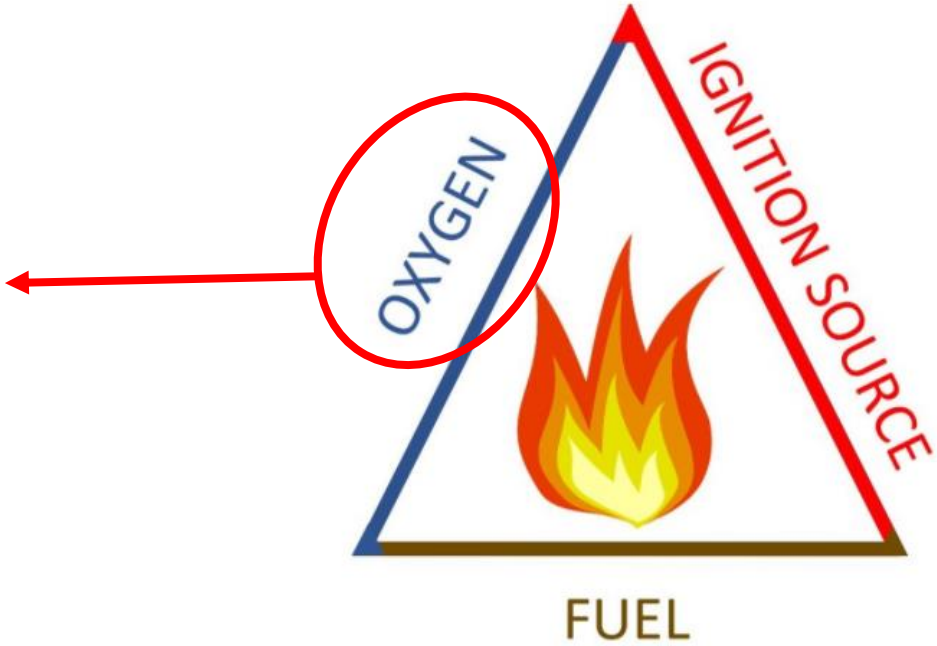


Flammable atmosphere gas - oxygen

Avoid the presence of oxygen (in the chamber)

Various means:

- Tightness
- Permanent gas flow
- Chamber over pressure
- Purge (Nitrogen, Argon, Helium…)
- Vacuum
- Adsorption /!\



Practical Solutions - Avoid Fire & Explosion Risk

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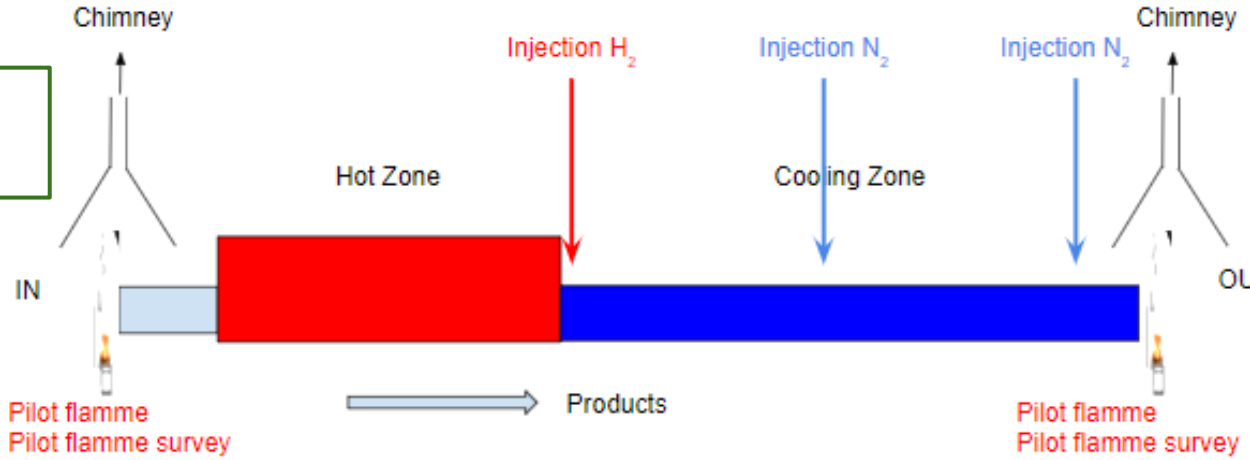
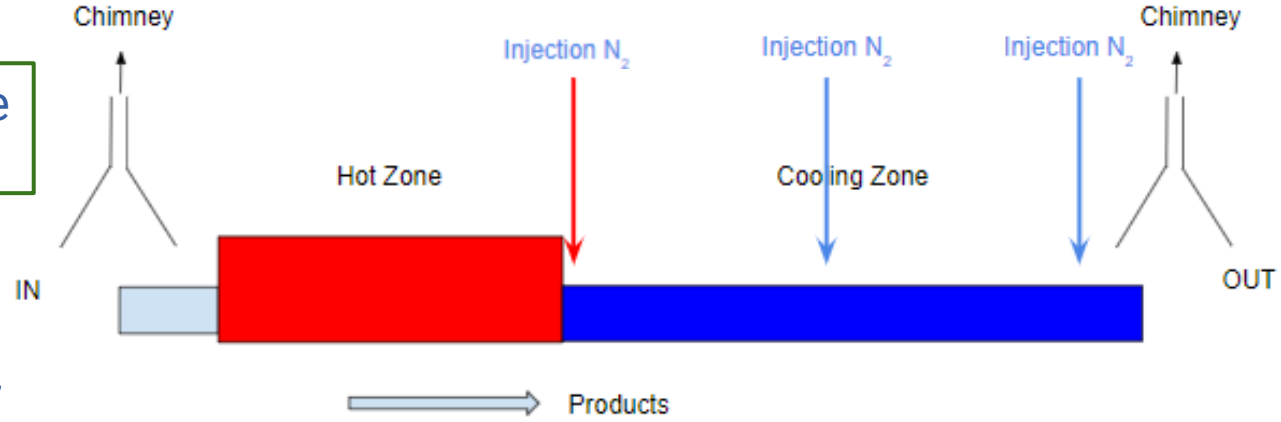
Flammable Atmosphere



- O2 probe
- Temperature lower limit
- Purging
- Tightness…

Non Flammable Atmosphere



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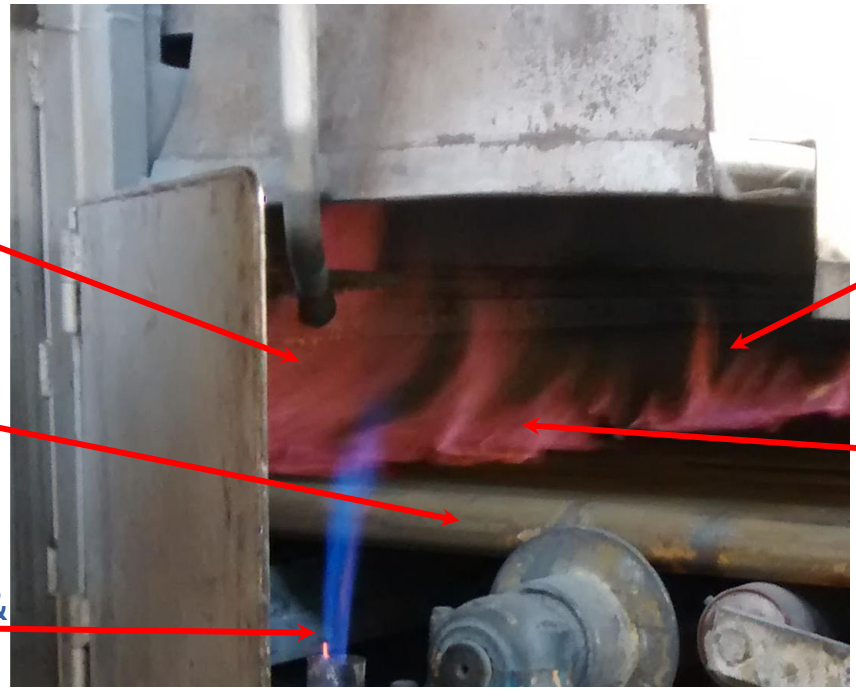
Practical Solutions - Avoid Fire & Explosion

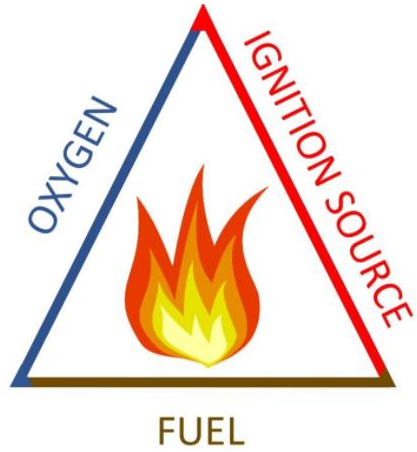
Examples of protection devices in continuous & batch furnaces



Practical solutions - Fire explosion risk - Control loop

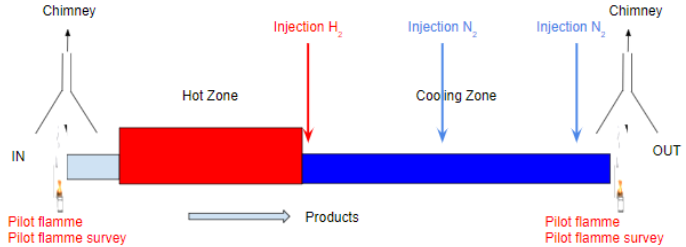
Condition control loop for flammable atmospheres:

1. Presence of pilot flame ⇒YES
2. **Furnace temperature** ⇒YES
3. **Room oxygen at 21%** ⇒YES
4. Room free of explosive species ⇒YES
5. Purge cycle ⇒YES
6. Previous (equilibrium, maintenance, leaks…) ⇒ OK

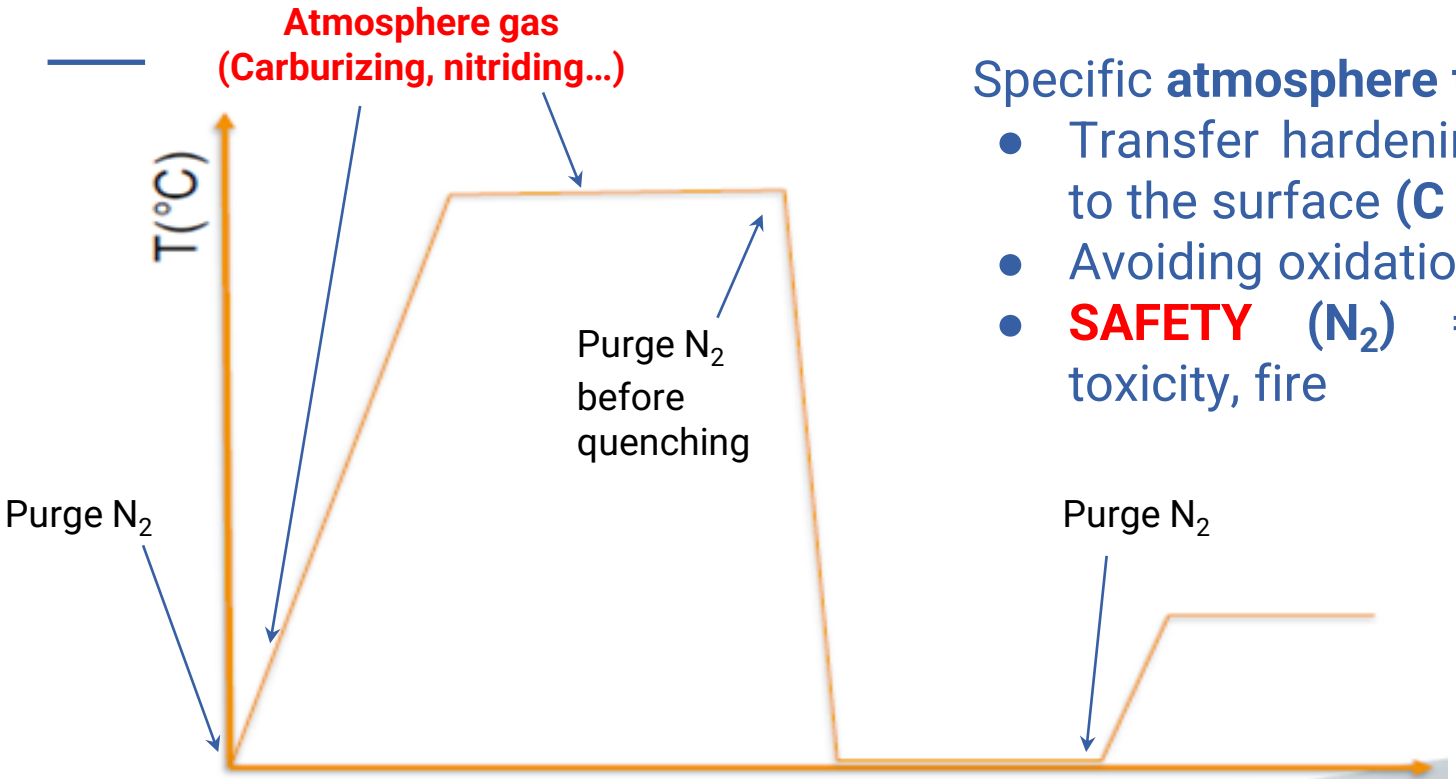


Flammable atmosphere injection

If default of one condition ⇒ purge & production stops



Gas injection stages for Heat Treatment process

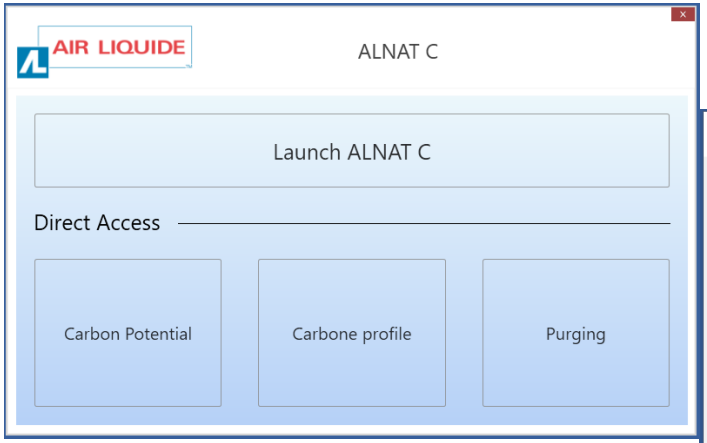


Specific **atmosphere that**:

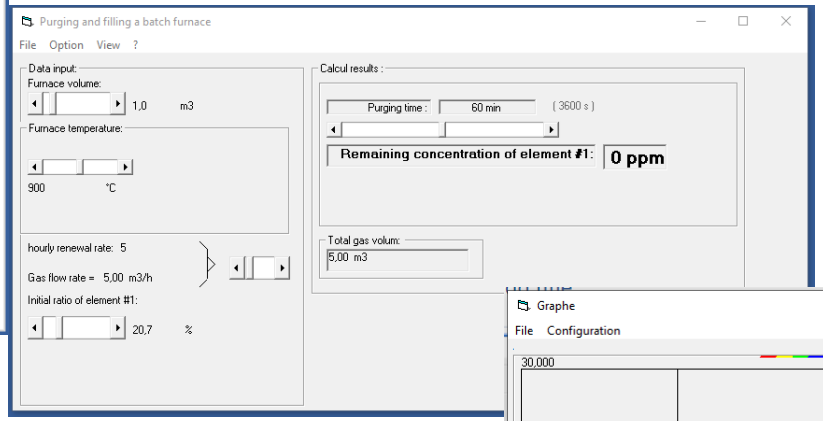
- Transfer hardening molecules to the surface **(C or N)**
- Avoiding oxidation **(N_2, Ar…)**
- **SAFETY** **(N_2)** = Explosion, toxicity, fire

Example of purging calculation

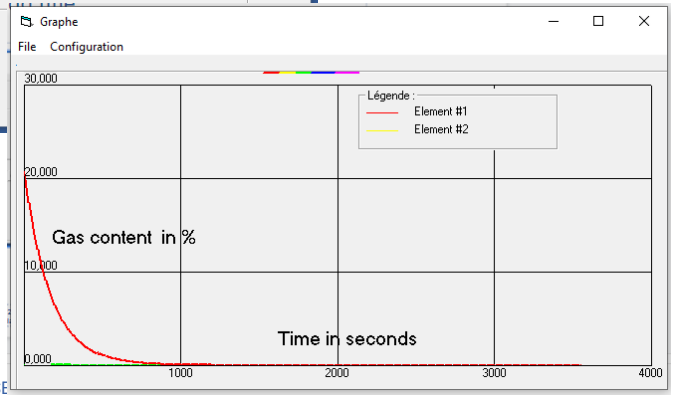
Calculation tool



Purging input data



Oxygen content profile



Toxicity

Gas	For 8 hours of exposition: Permissible Exposure Limit (PEL) (ppm)	For 8 hours of exposition: Permissible Exposure Limit (PEL) (mg/m3)	For 15 minutes of exposition: Short Term Exposure Limit (STEL) (ppm)	For 15 minutes of exposition: Short Term Exposure Limit (STEL) (mg/m3)
Cyanhydric acid	2	2	10	10
Ammonia	25	18	50	36
Methanol	200	260	1000	1000
Carbon monoxide	50	55	-	-
Hydrogen sulfide	5	7	10	14

Remember: 1 % = 10 000 ppm, so 20% CO = 200 000 ppm CO

Physics and chemistry of heat treatments

(Metal) + H_2O → (Metal)O + H_2

(Metal) + CO_2 → (Metal)O + CO

(Metal) + ½ O_2 → (Metal)O

Systematic Analysis Methodology

Application to:

- Heat treatment process design
- Troubleshooting

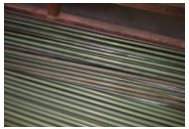
Steps:

1. Verification of **existing** installation
2. **Physics and chemistry** of heat treatments
3. **Productivity** analysis
4. **Modification** and commissioning
5. **Performance** verification

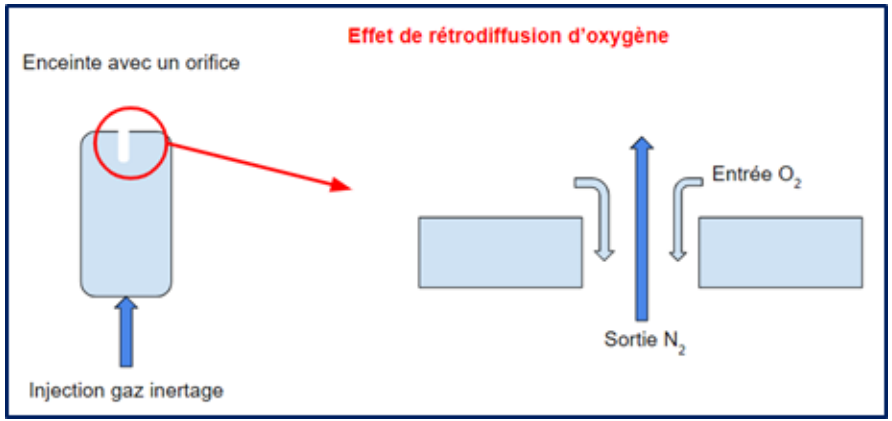
Turnkey solution

Troubleshooting… using chemistry

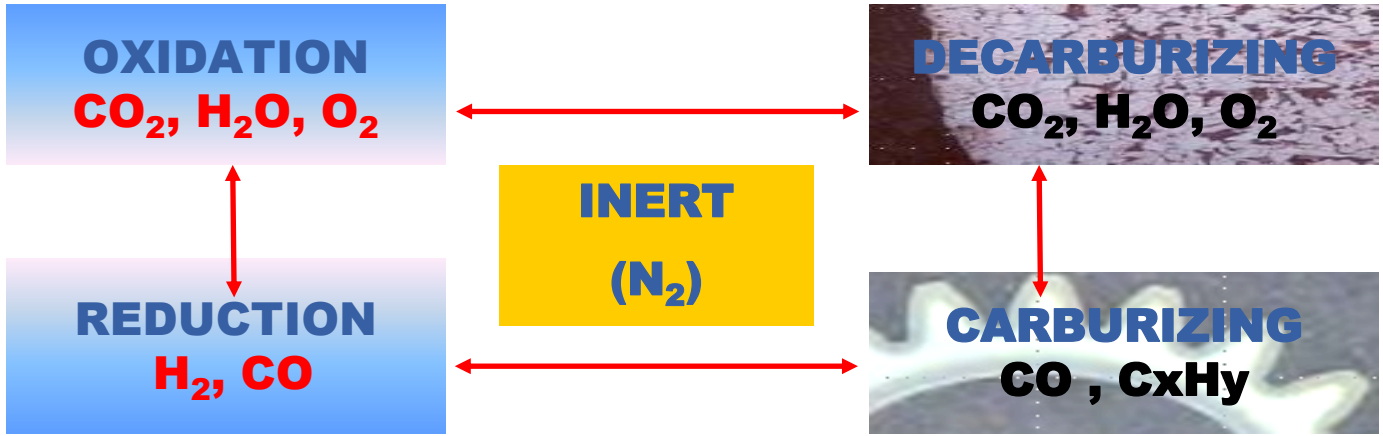
Oxidation evidence

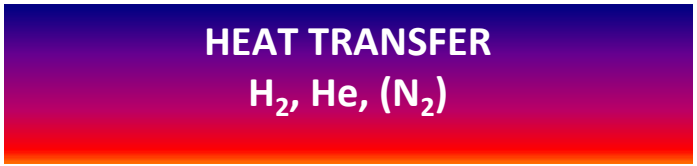


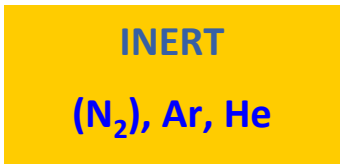
Air inlet and hydrogen leak in the cooling zone

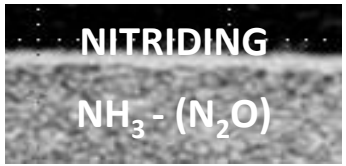


The function of gases in heat treatment - Summary









nexelia offer for Heat Treatment

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A combination of all 3 elements to answer the customer's needs

- Production increase / cycle time reduction
- Quality improvement / troubleshooting
- Safer, compliant operation
- Gas usage optimization
- Heat-Treatment process support

Value Added Solution with ALTEC support = Reliability & production cost reduction for the customer

Heat Treatment - Safety & Productivity

- **Fitting and fastening industries**
  - Diversity of **products**
  - Diversity of **manufacturers** = in-house or subcontractors using TTh
  - Dedicated shops offering heat-treatment as service company = **Heat treaters**
  - Mechanics for high added value products = tools, **medical**, niche
  - **Additive manufacturing**…

- **Safety and productivity combined**
  - Is a **challenge** to combine the **safety** requirements of CEN EN 746-3:2000+A1:2009 with **productivity** requirements
  - Specific **design** of the installation is critical in particular for **safety loop**
  - The knowledge of **physics** and **chemistry** of species in the **atmosphere** allows to optimise and solve problems found in mass production of fittings and fasteners industries

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Thank you