



# Heating System design acc. EN 746-2 & ISO 13577-2






Martin Wicker  
2023-06-01

**DUNGS®**  
Combustion Controls

## Martin Wicker

- Application & Strategy Manager Process Heat
  - Dipl.-Ing. Process Engineering (RWTH Aachen University)
  - 20+ years of experience from different roles in thermoprocessing industry (R&D, Project Engineering, Product Management)
  - Active in ISO and CEN committees for Industrial Thermoprocessing Equipment and Industrial Furnaces leading working groups for EN 746-2 and ISO 13577-2
- 
- [m.wicker@dungs.com](mailto:m.wicker@dungs.com)
  - [www.dungs.com](http://www.dungs.com)



Heating		System Solutions		DUNGS® Global Services
 Heating Burners	 Heating Boilers	 Process Heat	 Gas Engines	 DUNGS® Global Services
Gebläsebrenner 100 kW – 50 MW	Brennwertkessel 70 – 4.000 kW	Thermoprozess- anlagen	Gasmotoren 1 KW <sub>e</sub> – 20 MW <sub>e</sub>	Field Service, Support Center, Academy

- Components and system solutions for heating and process heat as well as gas engines
- Family business, founded in 1945, today managed by the 3rd generation
- 142 Mio. EUR Turnover (2022)
- 5 Production plants, approx. 700 employees in the group (approx. 500 in Urbach)

## Heating System Design acc. EN 746-2 & ISO 13577-2

- Introduction
- Standards for heating system design
  - Info EN 746-2 / ISO 13577-2+4
  - Scope of EN 746-2 / ISO 13577-2+4
  - Safety Goals of EN 746-2 / ISO 13577-2
- System design
  - Single + multiple burner system acc. EN 746-2 / ISO 13577-2
  - Required safety devices for gaseous fuels
  - Combustion air supply
  - Burner & burner control
  - Control system

# Industrial thermoprocessing equipment - General & Examples -

- Thermoprocessing equipment defined in ISO 13574:  
“Equipment in which material or work piece is submitted to thermal energy” (definition 2.190)
- Standards applicable for the heating system:
  - EN 746 series “Industrial Thermoprocessing Equipment”
  - ISO 13577 series “Industrial Furnaces and associated processing equipment”
  - NFPA 86 “Standard for Ovens and Furnaces”
  - Other regional standards e.g. in Australia, South Africa, Brazil etc.



Forge furnace



Steel rolling



Aluminum furnace



Thermal afterburning



Shop roaster/coffee

## Risk assessment - by the manufacturer

- According to EU Machinery Directive
- For risk reduction before placing the machine on the market
- Iterative process, includes risk analysis, risk assessment and risk evaluation

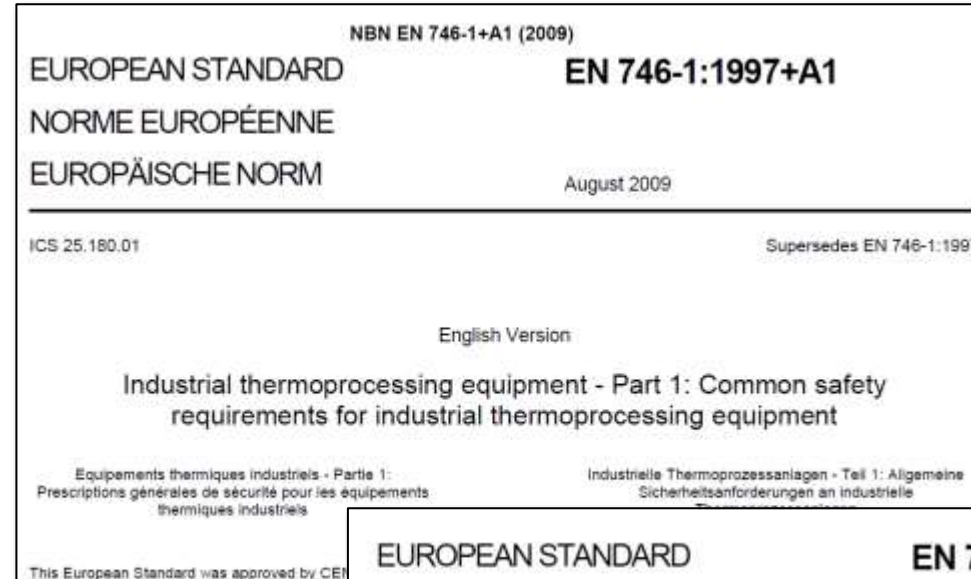
## Risk assessment - by the operator

- According to Occupational Health and Safety Act and Industrial Safety Regulation
- Consideration of all hazards that may occur in the working area of the machine
- Before commissioning the machine as well as regular inspection (BetrSichV-3(7))





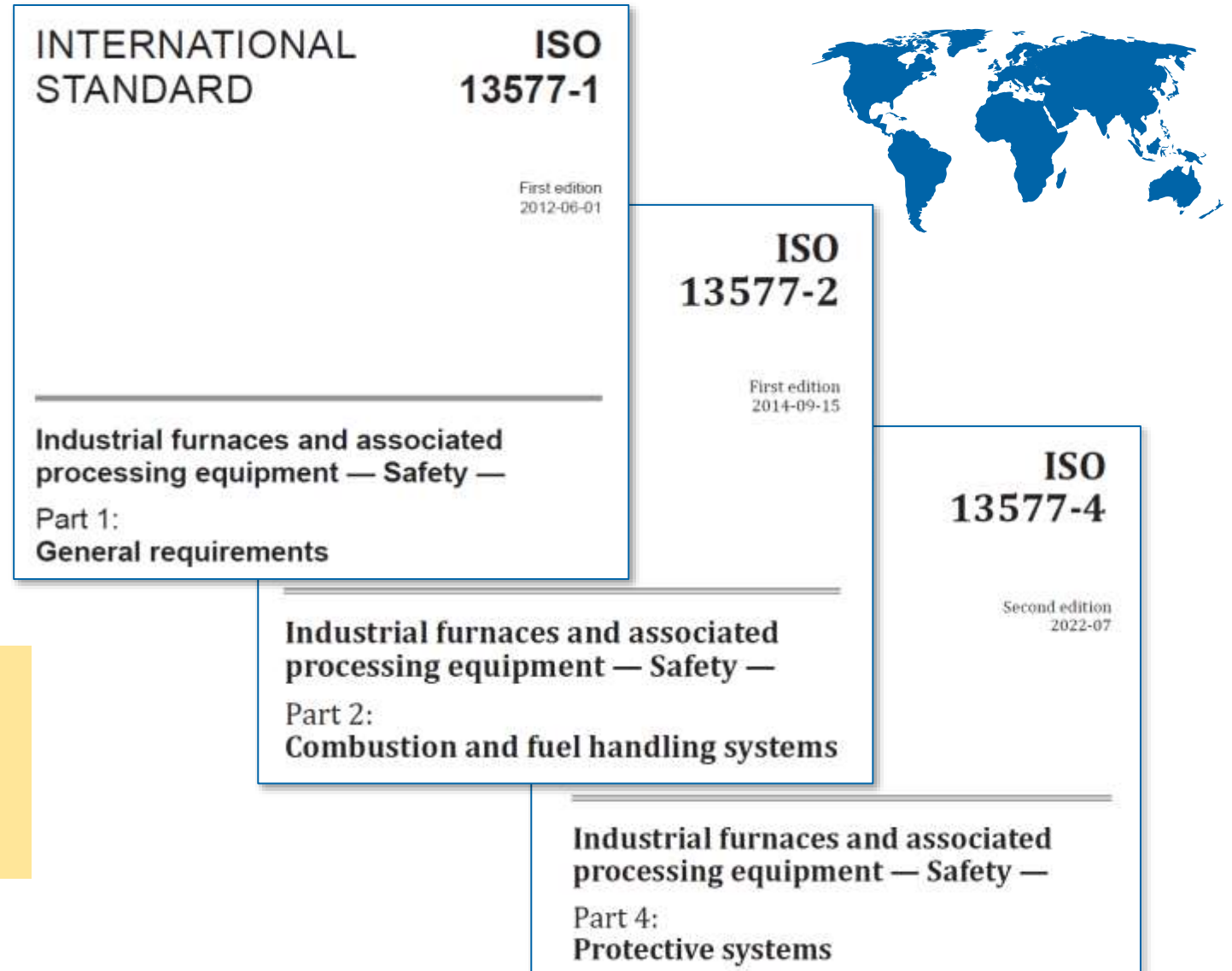
- Covers different aspects of industrial thermoprocessing equipment (IThE)
- IThE = equipment in which material or work pieces are submitted to thermal energy
- Part 2 contains
  - safety requirements for combustion and fuel handling
  - basic requirements for control system and protective system
- Latest version of EN 746-2 is dated 2010; new draft dd. 2020 was withdrawn!
- Intention is to replace EN 746-2 by ISO 13577-2 and ISO 13577-4; process for launching EN ISO 13577 was started...



- ISO 13577 series was created based on EN 746:2010 involving specialists from Japan, US, Canada and Europe
- Wording is slightly different to EN 746, but scope and content is similar
- ISO 13577 standards can be regarded to be the most up-to-date standards for heating systems in thermoprocessing
- NOT harmonized under MD (Machinery Directive), but to be considered in risk assessments, especially part 4!!

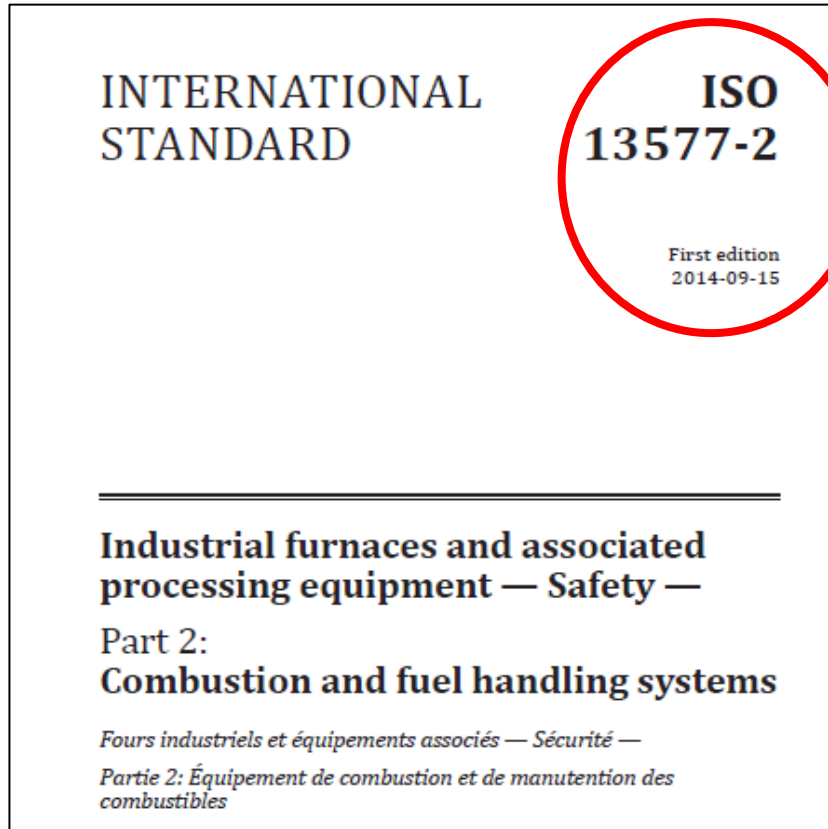
■ **Revision of ISO 13577-2 ongoing, under Vienna Agreement aiming to replace EN 746-2 by EN ISO 13577-2**

■ EN ISO 13577-4:2022 published already





# Industrial Thermoprocessing Equipment - Standards EN 746 and ISO 13577 -



INTERNATIONAL STANDARD

**ISO 13577-2**

First edition  
2014-09-15

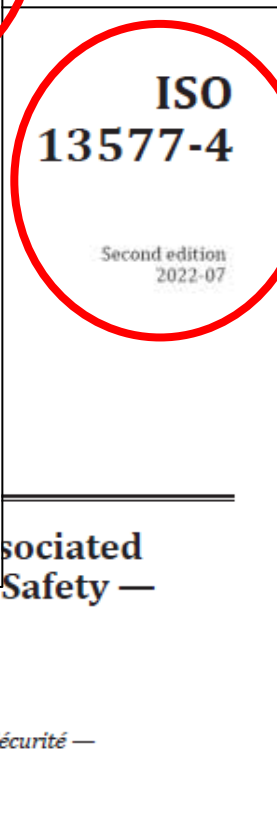
---

**Industrial furnaces and associated processing equipment — Safety —**

**Part 2:  
Combustion and fuel handling systems**

*Fours industriels et équipements associés — Sécurité —*  
*Partie 2: Équipement de combustion et de manutention des combustibles*

---



**ISO 13577-4**

Second edition  
2022-07


---

**Industrial furnaces and associated processing equipment — Safety —**

**Part 4:  
Protective systems**

*Fours industriels et équipements associés — Sécurité —*  
*Partie 4: Systèmes de protection*

- **ISO 13577** (based on EN 746:2010) must be regarded to be the most up to date standard for industrial thermoprocessing equipment
- ISO is NOT harmonized under MD (Machinery Directive). However, standard needs to be considered when doing the risk assessment, especially part 4!!
- Both standard series will be merged, ongoing process – coming soon!!



EUROPEAN STANDARD **EN 746-2**

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2010

ICS 25.180.01

Supersedes EN 746-2:1997

English Version

**Industrial thermoprocessing equipment - Safety requirements for combustion and fuel handling systems**

Équipements thermiques industriels - Partie 2: Prescriptions de sécurité concernant la combustion et la manutention des combustibles

Industrielle Thermoprocessinganlagen - Teil 2: Sicherheitsanforderungen an Feuerungen und Brennstoffführungssysteme

This European Standard was approved by CEN on 11 March 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.



When developing ISO 13577 series it was decided to create additional document with definitions and wordings common in thermoprocessing industry



**INTERNATIONAL  
STANDARD**

**ISO  
13574**

First edition  
2015-02-01

---

**Industrial furnaces and associated  
processing equipment — Vocabulary**

*Fours industriels et équipements thermiques associés — Vocabulaire*

## Introduction

The purpose of this vocabulary is:

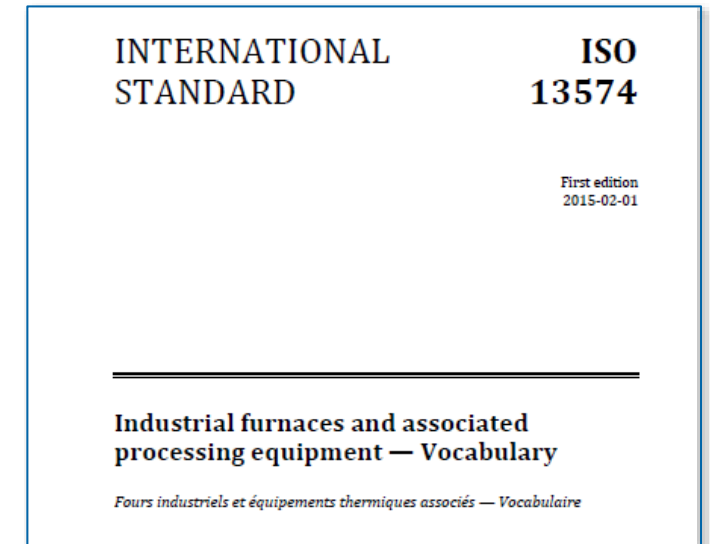
- to provide pertinent terms having a specific meaning in industrial furnaces and associated processing equipment technology (hereinafter "TPE"),
- to include common dictionary or engineering terms only when they are a generic root for a series of terms specific to TPE technology,
- to refer synonymous terms to the preferred term,
- to list deprecated terms, but to define and clearly mark these terms as such and to indicate the preferred term,
- to provide terms and definitions applied to International Standards developed by ISO/TC 244.



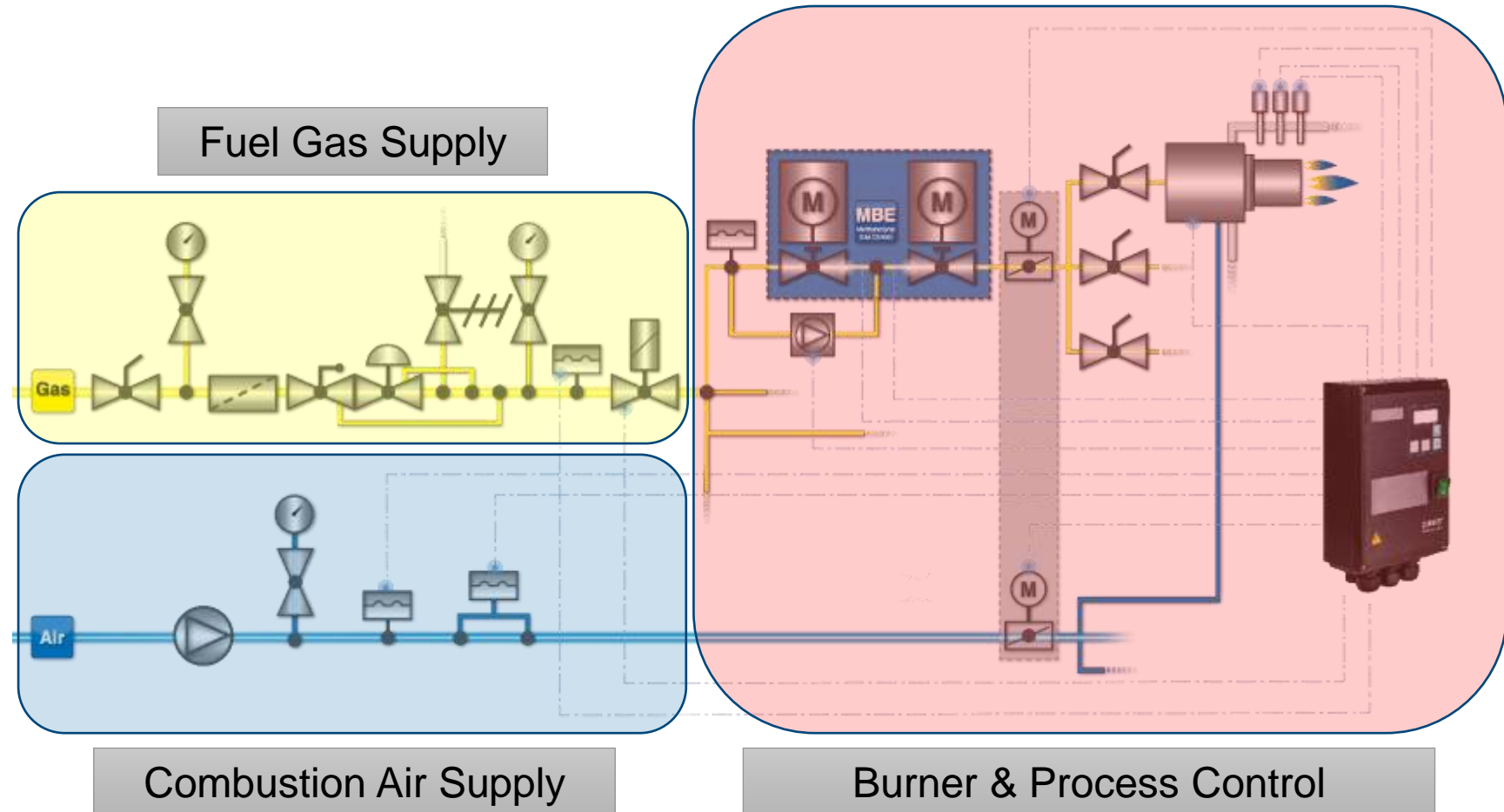
When developing ISO 13577 series it was decided to create additional document with definitions and wordings common in thermoprocessing industry



<b>2.190</b>	
<b>thermoprocessing equipment</b>	
equipment in which material or workpiece is submitted to thermal energy	
fr	<b>équipement thermique</b> équipement dans lequel des matériaux ou des pièces sont soumis à l'action de la chaleur
de	<b>Thermoprozessanlage, f</b> Anlage, in der Materialien oder Werkstücke thermischer Energie ausgesetzt werden
es	
ja	<b>熱処理設備</b> 材料及び加工対象物が熱エネルギー下に置かれる設備
ko	<b>열처리 설비</b> 재료 및 가공 대상물이 열에너지에 의하여 처리되는 설비
pl	<b>wyposażenie do procesów cieplnych</b> wyposażenie, w którym materiał lub przedmiot obrabiany jest poddawany działaniu energii cieplnej
zh	<b>热处理设备</b>
NOTE	This item is intended to be applied to ISO 13577-2.



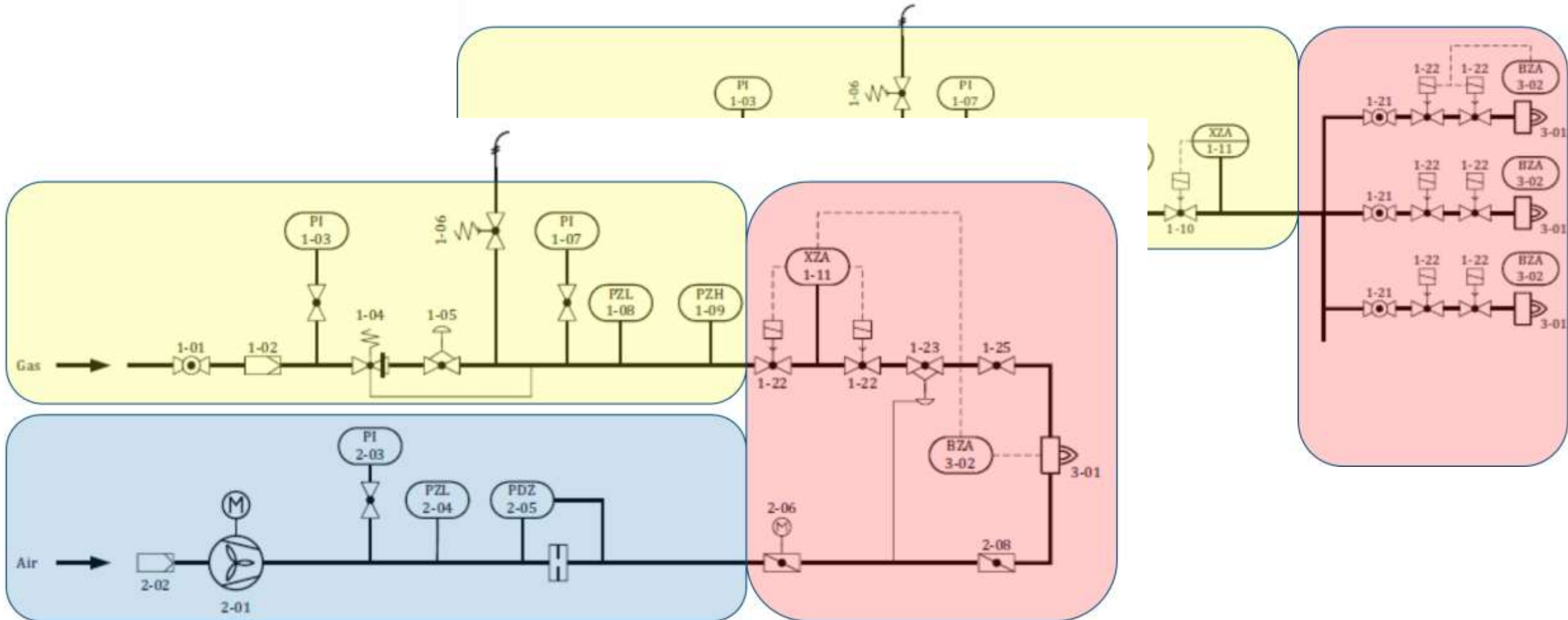
- Safety goals are defined by the standards
- Implementation by the designer according to the results of the risk assessment
- Standards are not "building instructions"!



Standards do not contain any specific statements on H2 - greater importance is attached to risk assessment

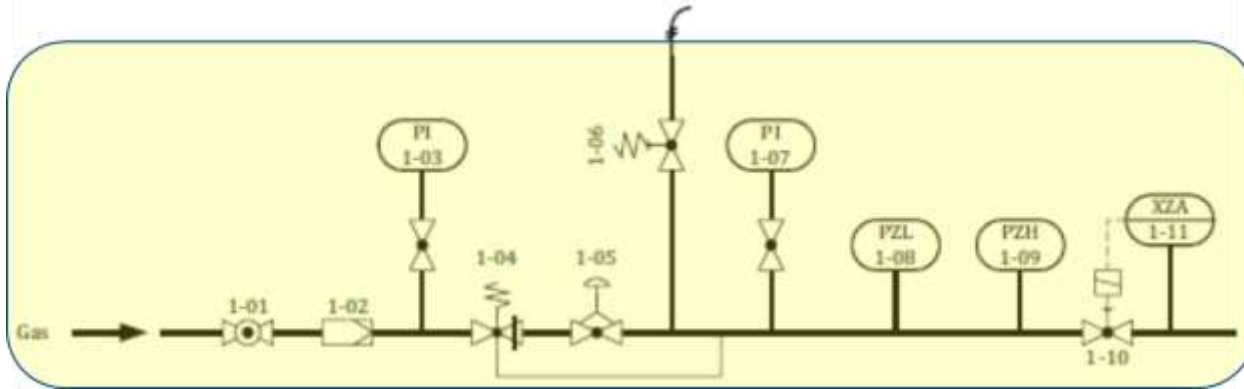
# Industrial thermoprocessing equipment

## - Single + multiple burner system acc. EN 746-2 / ISO 13577-2



Quelle: ISO 13577-2, informative Annex "Typical examples of piping and components"

# Industrial thermoprocessing equipment - Main gastrain GDR acc. EN 746-2 / ISO 13577-2



## Equipment as specified in EN 746-2 / ISO 13577-2

- Manual isolating valve
- Gas filter
- Gas pressure regulator (with SSV/RV for overpressure protection)
- ★ Gas pressure monitoring min/max
- ★ Automatic shut-off valve(s)
- ★ Tightness control (depending on rating)

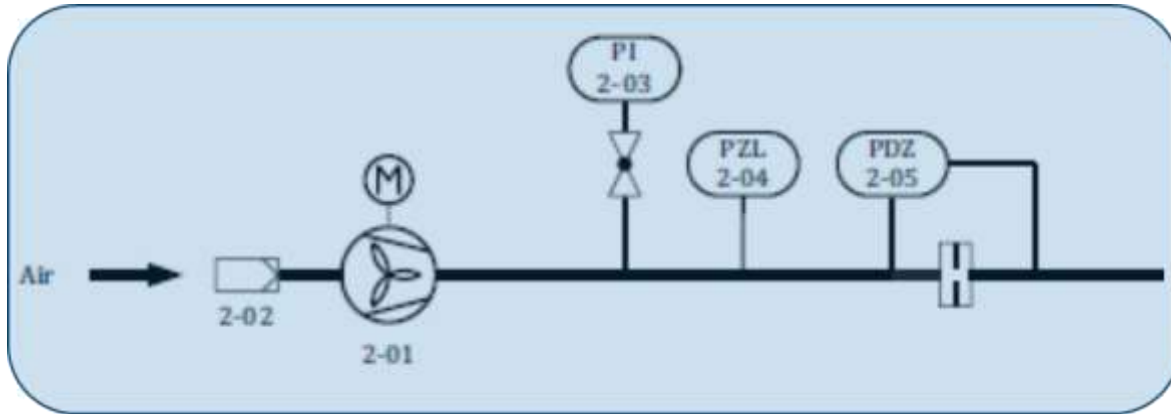
No special functional requirements by H<sub>2</sub>,  
but suitability of equipment used must be ensured



- ★ must satisfy the requirement of a protective system

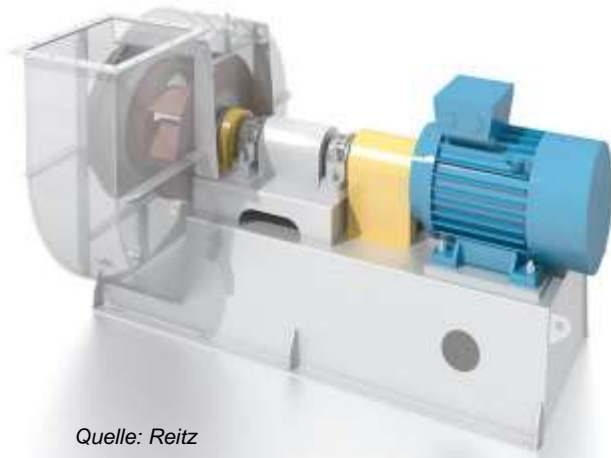


# Industrial thermoprocessing equipment - Combustion air supply acc. EN 746-2 / ISO 13577-2



## Equipment as specified in EN 746-2 / ISO 13577-2

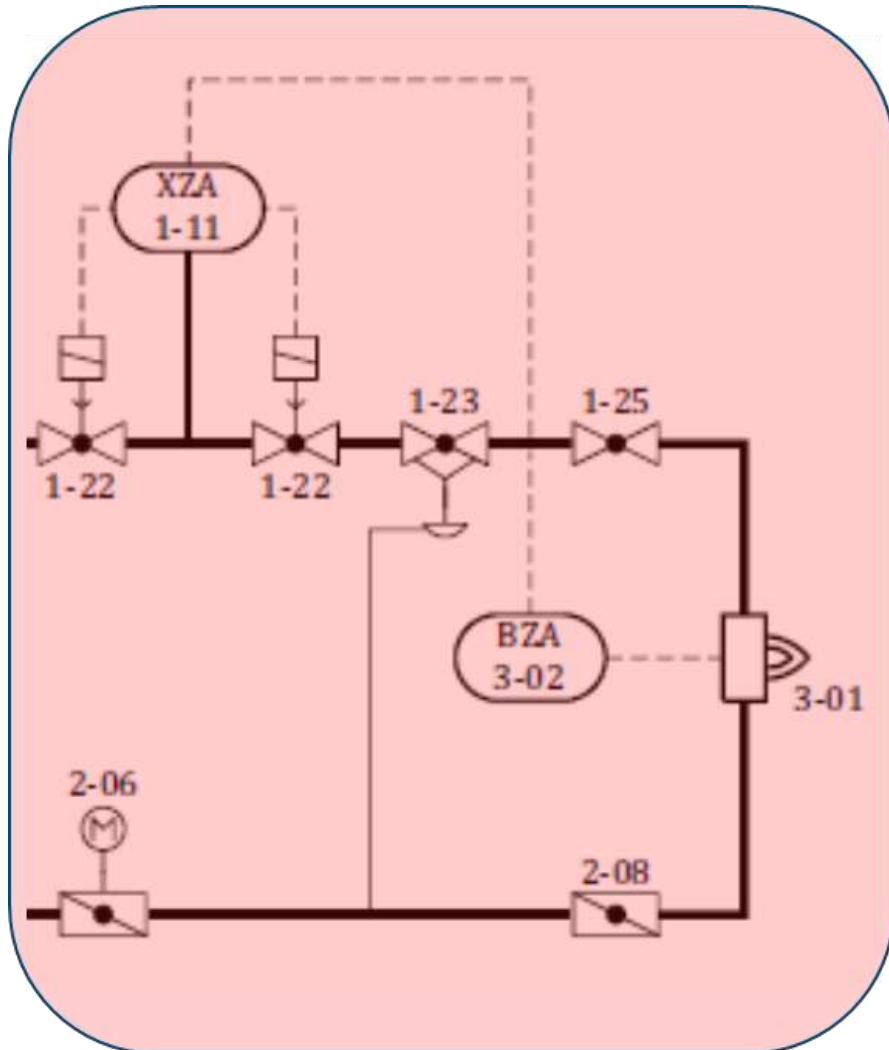
- Combustion air fan with optional filter
- ★ Air pressure monitoring (Air MIN pressure switch)
- Additional filter monitoring (optional)
- ★ Pre-purge flow monitoring



Quelle: Reitz

No special functional requirements by H2

- ★ must satisfy the requirement of a protective system



### Equipment/topics covered in EN 746-2 / ISO 13577-2

- Burner with ignition device
- Automatic burner control for flame supervision (safeguarding)
- Safety time and start fuel flow rate
- Burner capacity control
- Air/gas ratio control



### Burner and ignition device

- Burners must be suitable for the application and be able to be operated stably and safely in the required control range
- Ignition device must ignite burner reliably
- Burner is interface to the process  
=> Selection according to process requirements  
(power, flame shape etc.)
- **No CE marking** required for burners

- No special requirements due to H<sub>2</sub>, but suitability of burners must be ensured
- Suitable flame sensor required



Source: flox.com




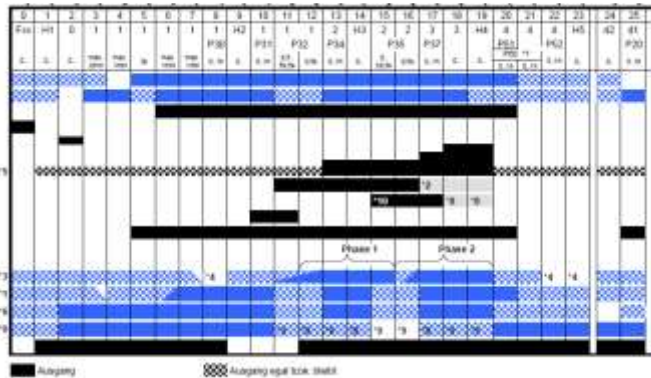
Source: Fivesgroup.com



Source: Scharrtec.de

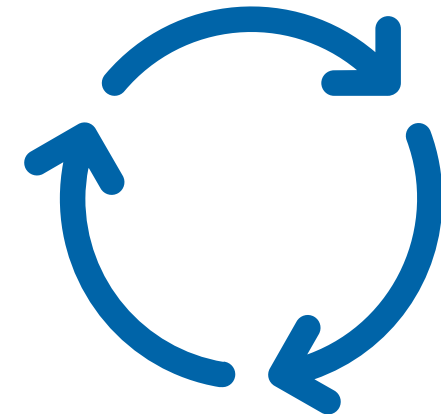
### Automatic burner control/flame monitoring

- The main flame and the flame of the pilot burner must be monitored by an automatic burner control.
- Automatic burner control system controls the sequence of burner start-up, switches the valves and the ignition transformer.
- Separate flame sensors for continuously burning pilot burners; exception from EN 746-2 no longer included in ISO 13577-2! 
- In case the pilot flame is extinguished during main burner operation, a single flame scanner is sufficient
- For wall temperature > 750°C, flame scanner can be omitted and temperature monitored instead; high-temperature operation must meet the requirements of a protection system.



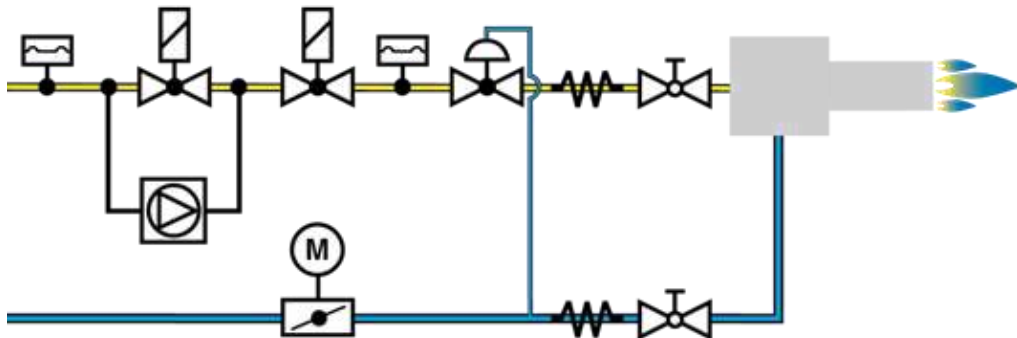
### Start-up attempts and restart

- In case of flame failure... a fault shutdown must occur at the burner. However, restart is permissible provided that the safety of the system is not impaired (e.g. if the atmosphere in the combustion chamber does not exceed 25 % of the LFL).
- The control of the restart(s) must meet the requirements of a protection system. If no flame signal is present after the restarts, fault shutdown must occur.
- Flame failure during start-up (burner start without flame signal)
  - The number of restarts must not exceed two => max. 3 start attempts
- Flame failure in operating condition
  - not more than one restart attempt in ISO 13574:
- Definition for recycling (restart) in ISO 13574:
  - Process in which a **complete** startup program is repeated automatically after a safety shutdown.

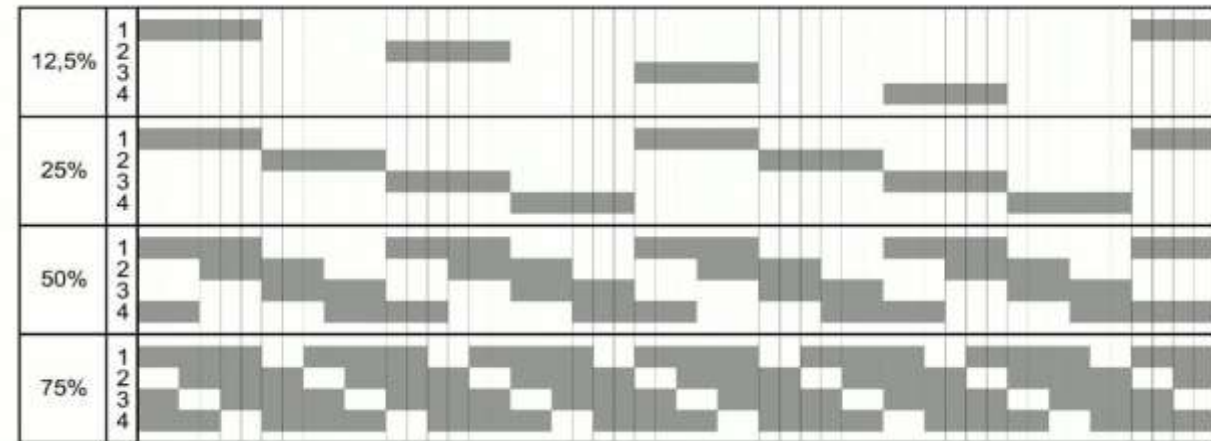


### Burner capacity control

- **Modulating** = stepless adjustment of fuel and air volume
  - Stable burner operation must be ensured, limited control range or increased excess air at low loads
  - Low convection in the furnace chamber at partial load

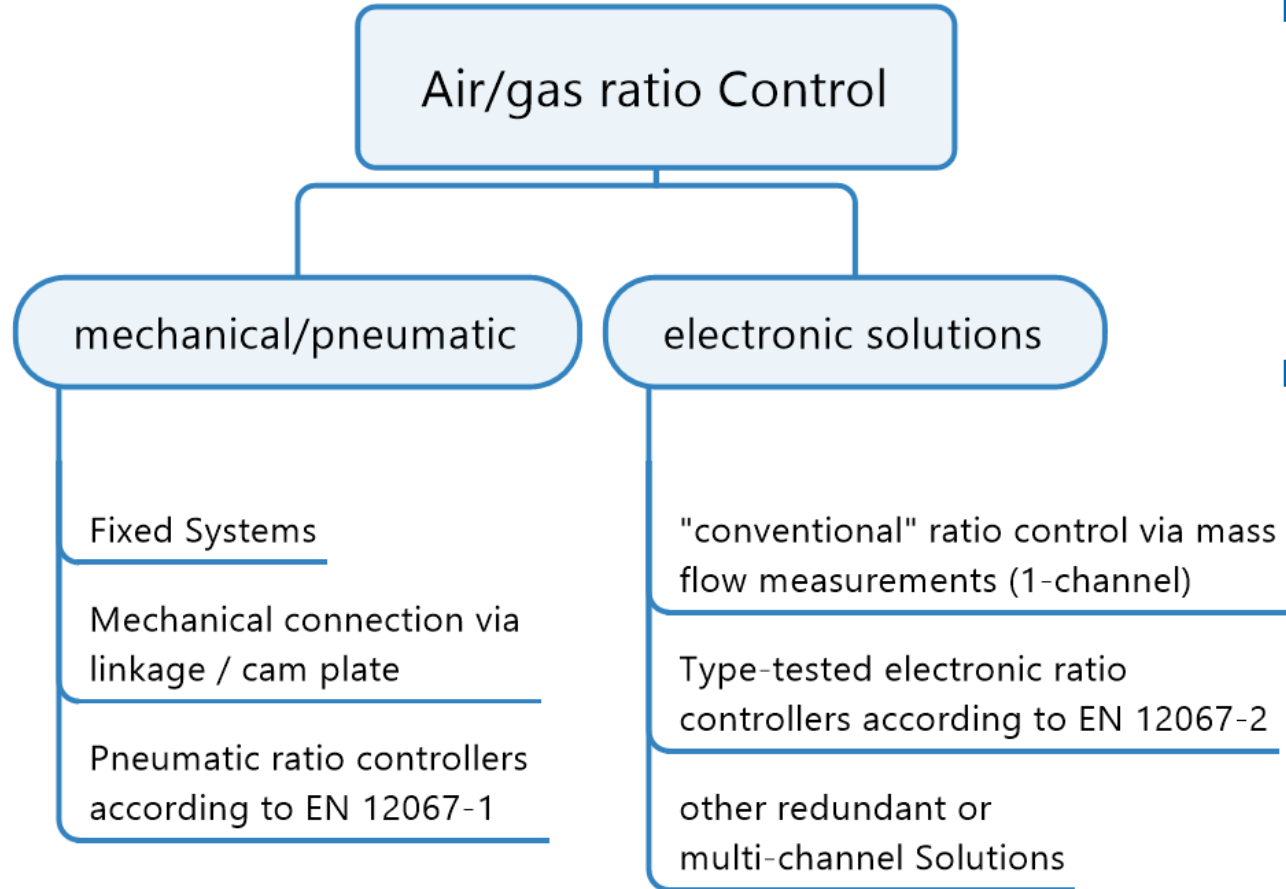


- **Impulse control** = stepped burner operation with variable ratio of operating time and pause time
  - Burner operation ON/OFF or HIGH/LOW
  - High convection in the furnace chamber and no limitation in the control range



Source: Prozesswärme-Tagung Brennertechnik an Thermoprosessanlagen





### Air/gas ratio control

- The air mass flow shall always be in a ratio with the fuel mass flow in order
  - to ensure safe ignition and
  - that throughout the operating range, a stable and safe combustion is maintained at each individual burner.
- The ratio does not need to be the same value at all operational conditions.

- No special functional requirements by H2
- Suitability of the equipment used must be ensured
- Compensation is required for variable mixture, hot air compensation

### ISO/FDIS 13577-2:2023 Statement on air/gas ratio

- The design of the air/fuel ratio control has to consider process conditions as well as fuel and combustion air properties. Defect or malfunction should affect that the system will tend towards higher excess air or proceed to lock-out if the air/fuel ratio results in an unsafe condition.
- Pneumatic fuel/air ratio controls for gaseous fuel shall comply with ISO 23551-2:2018 or regional product standard(s)
- Electronic fuel/air ratio controls shall comply with ISO 23552-1:2007+A1: 2010 or regional product standard(s)
- In case other methods/technologies are used for the ratio control and depending on the combustion air and fuel properties, additional protective measures shall be applied according to the results of the risk assessment (e.g. air/fuel ratio monitoring by protective system according to ISO 13577-4:2022).



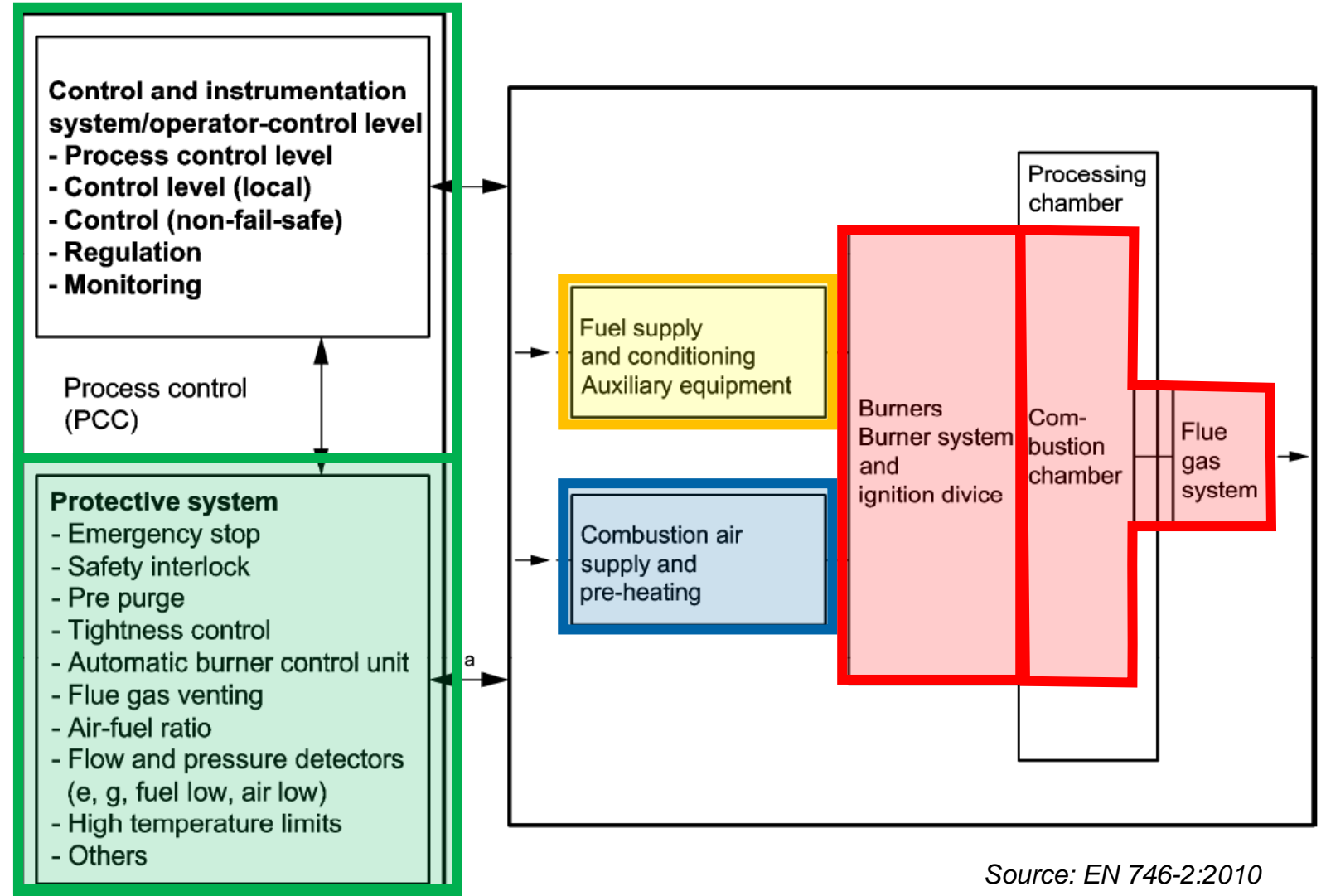
"Fail-safe" solution which meets the requirements of a protection system.

# Industrial thermoprocessing equipment

## - Control and protective system acc. EN 746-2 / ISO 13577-2+4

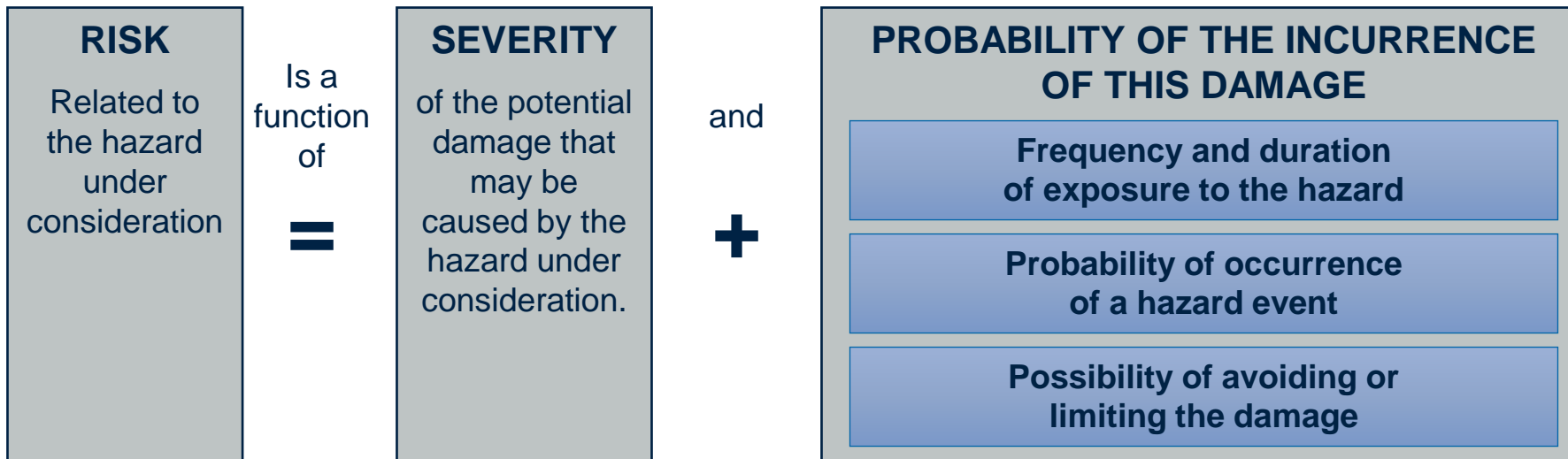
- **Process control**  
non-fail-safe part of the process control system

- **Protective system**  
fail-safe part of the process control system





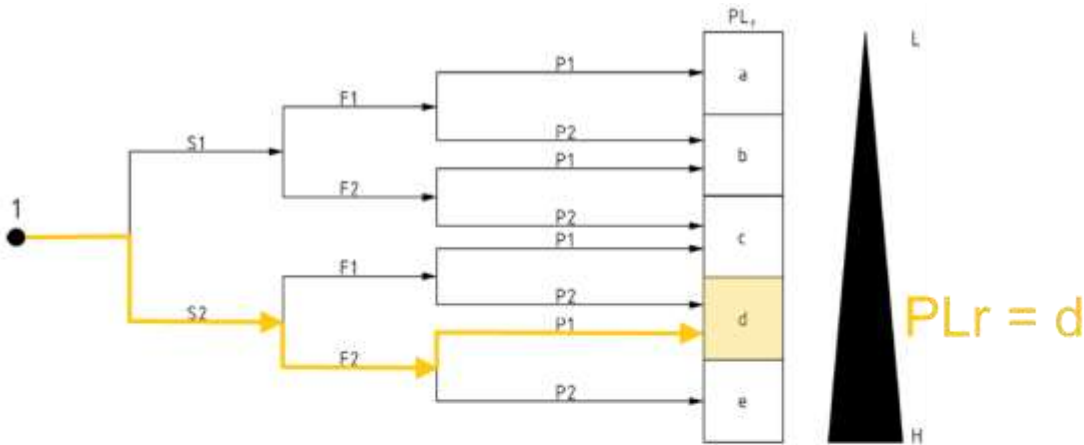
- The protective system includes all functions that serve to protect persons, the plant and the environment.
- Risk assessment must be carried out for each hazard (ISO 12100)



ISO 13577-2 and ISO 13577-4 include **examples**

## **i** Determination of the PL acc. to EN 13849-1

## **i** Determination of the SIL level acc. to IEC 62061



- Legende**
- 1 Startpunkt zur Bewertung des Beitrags der Risikominderung
  - L niedriger Beitrag zur Risikoreduzierung
  - H hoher Beitrag zur Risikominderung
  - PL<sub>r</sub> erforderlicher Performance Level

- Risikoparameter:**
- S Schwere der Verletzung
  - S1 leichte (üblicherweise reversible Verletzung)
  - S2 **ernste (üblicherweise irreversible Verletzung einschließlich Tod)**
  - F Häufigkeit und/oder Dauer der Gefährdungsexposition
  - F1 selten bis weniger häufig und/oder die Zeit der Gefährdungsexposition ist kurz
  - F2 **häufig bis dauernd und/oder die Zeit der Gefährdungsexposition ist lang**
  - P Möglichkeit zur Vermeidung der Gefährdung oder Begrenzung des Schadens
  - P1 **möglich unter bestimmten Bedingungen**
  - P2 kaum möglich

Risikobeurteilung und Sicherheitsmaßnahmen							Dokument Nr.:					
Produkt:						Teil von:						
Hersteller:						vorläufige Risikobeurteilung						
Datum:						zwischenzeitliche Risikobeurteilung						
schwarzer Bereich = Sicherheitsmaßnahmen erforderlich grauer Bereich = Sicherheitsmaßnahmen empfohlen							nachfolgende Risikobeurteilung					
Auswirkungen	Schwere S	Klasse K					Häufigkeit und Dauer, F	Wahrscheinlichkeit gef. Ereigniss, W	Vermeidung P			
		3-4	5-7	8-10	11-13	14-16						
Tod, Verlust eines Auges oder Arms	4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3	≤ 1 Stunde	5	häufig	5		
Permanent, Verlust von Fingern	3		AM	SIL 1	SIL 2	SIL 3	> 1 h – ≤ 1 Tag	5	wahrscheinlich	4		
Reversibel, medizinische Behandlung	2			AM	SIL 1	SIL 2	> 1 Tag – ≤ 2 Wo.	4	möglich	3	unmöglich	5
Reversibel, Erste Hilfe	1				AM	SIL 1	> 2 Wo. – ≤ 1 Jahr	3	selten	2	möglich	3
							> 1 Jahr	2	vernachlässigbar	1	wahrscheinlich	1
Lfd. Nr.	Gef. Nr.	Gefährdung	S	F	W	P	K	Sicherheitsmaßnahme	sicher			

EXAMPLE: Hazard with S=3, for which F=4, W=5 and P=5 were determined results in K = F + W + P = 14 **SIL 3**

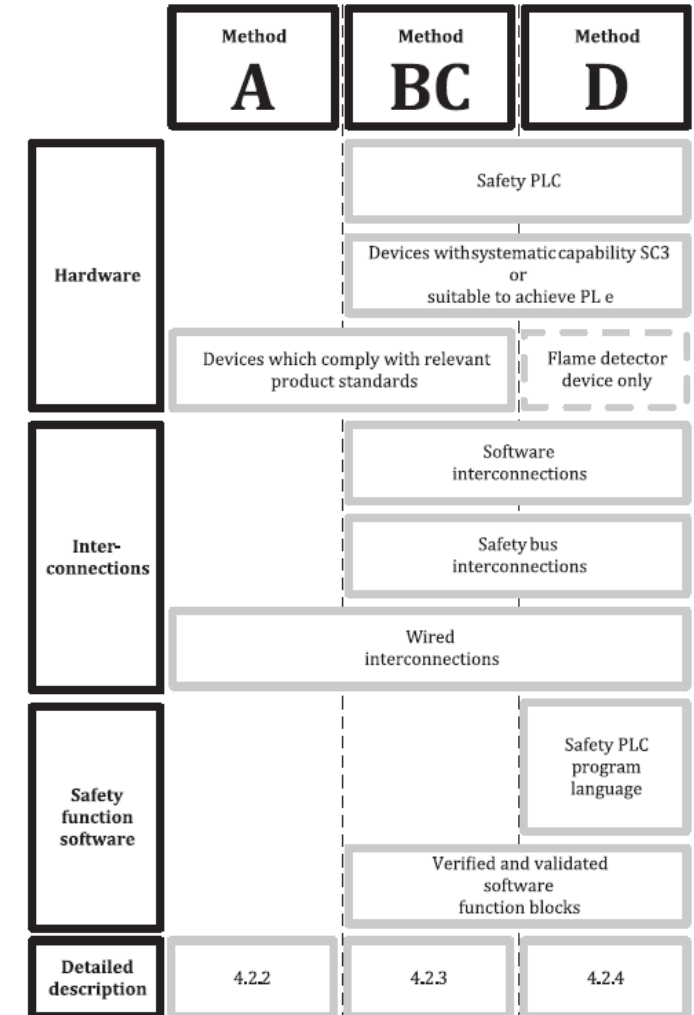
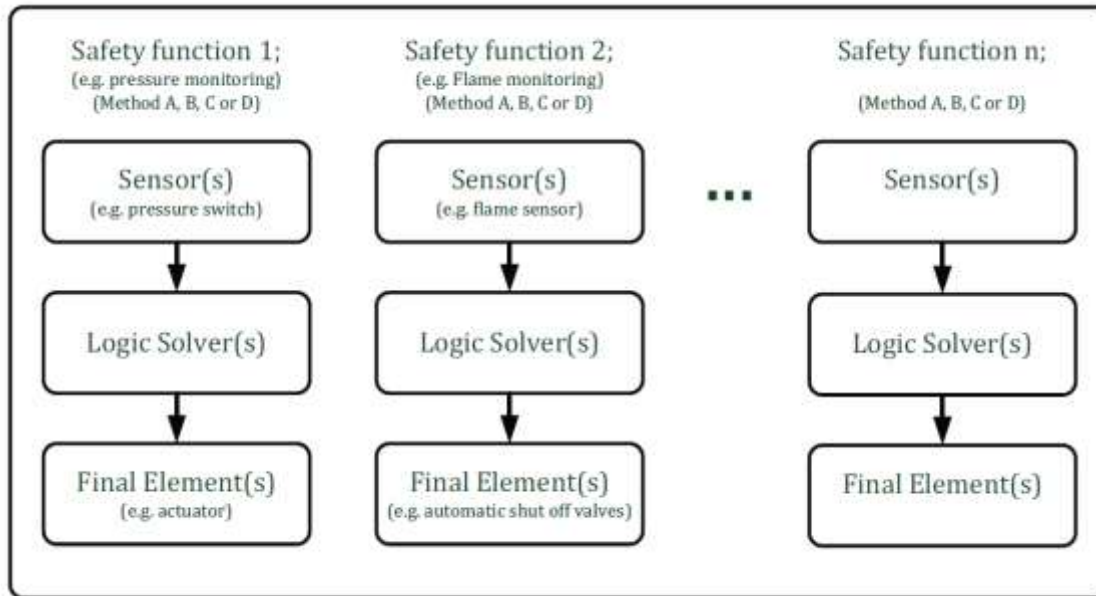
**✓** ISO 13577-2 and ISO 13577-4 include **examples**

# Industrial thermoprocessing equipment - Control and protective system acc. EN 746-2 / ISO 13577-2+4

Several options for implementing safety functions:



- A Hardwired, all components according to product standards
- BC Combination of devices according to product standards + SIL components
- D FS - PLC based, all components SIL certified



ISO FDIS 13577-4:2022 includes **examples**



Do you have any questions?  
**Thank you very much!**





**Karl Dungs GmbH & Co. KG**



Karl-Dungs-Platz 1



D-73660 Urbach, Germany



Telefon +49 7181 804-0



Telefax +49 7181 804-166

[info@dungs.com](mailto:info@dungs.com)

[www.dungs.com](http://www.dungs.com)



**DUNGS®**  
Combustion Controls