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Section C – Mechanics

Part 5: Thermoprocessing equipment

The following delivery specifications of Wieland-Werke AG form part of the contract.
Any deviating specifications are to be agreed upon between the supplier/contractor and Wieland, and documented.

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Table of contents

1. Definitions 2
2. Media 2
3. Pipes / pipe connections / seals / fittings 2
4. Device selection and makes 3
5. Implementation specifications 4
   5.1 Construction 4
   5.2 Components 4
   5.3 Control system 5
   5.4 Measuring devices 5
   5.5 Design of gas lines 6
   5.6 Device arrangement in the fuel gas inlet line 6
   5.7 Burner installation 6
   5.8 Exhaust gas paths 7
6. Safety equipment 7
7. Commissioning and acceptance 9

The following have to be taken into account:

Directives and ordinances:
- EC Machinery Directive
- German Ordinance on Industrial Safety and Health (*Betriebssicherheitsverordnung,* BetrSichV)
- ATEX Directive – equipment in potentially explosive atmospheres
- Pressure Equipment Directive

Standards:
- EN 746 – Industrial thermoprocessing equipment
- DIN EN ISO 12100 – Safety of machinery
- DIN EN 626 – Reduction of risk to health from hazardous substances emitted by machinery
- DIN EN ISO 13849 – Safety of machinery – Safety-related parts of control systems
- Accepted codes of good engineering practice *("Technische Regeln"),* DVGW regulations, VDE, VDI, noise and air pollution regulations (UVV-Lärm, TA-Lärm, TA-Luft), German Federal Immission Control Act (BImSchG)

1. Definitions

Definitions and explanations can be found in DIN 24201 – Industrial furnaces; heating and heat-treating furnaces; concepts.
The units for physical quantities are to be defined in accordance with DIN 1301.
Graphical symbols shall be used in accordance with DIN 1219.

2. Media

At the time of a request for quotation, the following have to be defined:
- Supply pressures of all media
- Maximum volume flow
- Maximum and minimum pressure

The connection values of the required media must be specified in the quotation.

If cooling water is required, the following must be stated in the quotation, with binding effect:
- Cooling power to be dissipated (kW)
- Flow and return temperature
- Water quality (hardness, conductivity, etc.)

Detailed information is to be obtained from the respective plants.

3. Pipes / pipe connections / seals / fittings

Flammable gases	**Pipes**	**Seals**	**Pipe connections**
Natural gas / air <100 mbar Natural gas Forming gas >5%H2 Hydrogen	Steel tube DIN EN 10220 black	Pure graphite seal with perforated steel insert and inner eyelet made of 1.4571 with DVGW approval	**Pressure >= 500 mbar** Flange welded **Pressure < 500 mbar and nominal diameter < DN 50** Flange welded Thread seals to be executed in accordance with applicable gas regulations (hemp only in conjunction with sealant)

Non-flammable gases	Pipes	Seals	**Pipe connections**
Protective gas <100 mbar Nitrogen Forming gas <=5%H2	Steel tube DIN EN 10220 black	Hard fibre gasket, anti-stick coating, permissible continuous use range: -50 to +250°C, but to be used only up to 100 °C!	**Pressure >= 500 mbar** Flange welded **Pressure < 500 mbar and nominal diameter < DN 50** Flange welded Thread seals to be executed in accordance with applicable gas regulations (hemp only in conjunction with sealant)

4. Device selection and makes

Original type and make designations and labels must be easily accessible and visible. They must not be removed or tampered with.
Their use for the media specified by the manufacturer must be taken into account.

a) Gas applications
(Listed suppliers are to be preferred. Alternative suppliers after consultation.)

Gas safety shutoff valves	Medenus, Fiorentini, Honeywell Gas Technologies
Gas solenoid valves	Honeywell Kromschröder, Uni-Geräte, Bürkert
Gas pressure regulators <500 mbar	Honeywell Kromschröder
Gas pressure regulators >500 mbar	Medenus, Fiorentini, Honeywell Gas Technologies
Oxygen partial pressure measurement	Metrotec
Leak testing device	Honeywell Kromschröder
Electrical temperature, mixture, furnace chamber pressure regulators and transducers	Siemens, ABB
Gas filters	Medenus, Honeywell Kromschröder, Honeywell Gas Technologies
Gas and air pressure switches	Honeywell Kromschröder, DUNGS
Pilot burners and ignition transformers	Honeywell Kromschröder
Ignition and monitoring equipment	Honeywell Kromschröder (Type subject to consultation)
Actuators for control/proportional valves and flaps	Siemens, Honeywell Kromschröder, Aris, A&R, EL-O-Matic
Mechanical balanced pressure regulators	Honeywell Kromschröder, Siemens
Gas analysis	ABB, Vaisalla
Vacuum pumps and vacuum devices	Leybold, Busch, Edwards
Absolute pressure switch	Leybold
Rotary piston meters	Itron, RMG
Thermocouples – only class 1, testable type	B&B, Reckmann, Heraeus, Günther, Löbach
Main burners	Honeywell Kromschröder, WS, Bloom, Wiedemann
Rotameter flowmeters	Kirchner & Tochter, Krohne
Gas monitoring / gas warning device	Subject to consultation

Gas mixers	L+T Gasetechnik, Witt, Thermco
Fans	Meierling
Shutoff flaps	Jasta, Crane Series VIA, Ebro Armaturen
Ball valves	Böhmer

5. Implementation specifications

5.1 Construction

The following devices shall be provided:

- For direct-fired furnaces: furnace chamber pressure control to prevent false air intake
- For protective gas atmosphere furnaces: annealing chamber pressure control, oxygen partial pressure monitoring, dew point measurement and H2 measurement
- Sample ports for checking the protective gas atmosphere
- Suitable aid for carrying out the system tightness test (e.g. mechanical slide valves in the intake airlock)
- For the protective gas atmosphere furnaces, pressure gauge for furnace chamber pressure with large display
- Safety temperature limiter for protection against overheating
- Thermocouple feed-throughs or sample ports for carrying out temperature measurements (test runs with monitored and logged temperatures)
- Use measurement openings / sample ports to check the exhaust gases (for radiant tubes every single tube)
- For furnace systems with long time annealing processes, use correspondingly thick insulation layer
- Protection against accidental contact for hot surfaces
- Automation of maintenance functions (e.g. extension function of tinning furnace)
- A power socket 230 V AC on the switch cabinet (outside). For large systems (e.g. continuous furnaces), power sockets must be provided in the furnace entry, furnace centre and furnace exit on both sides.

If large amounts of lost heat have to be dissipated, it must be checked whether increasing the cooling water outlet temperature would make a use of waste heat worthwhile.
Thermal bridges should be avoided by design as far as possible.

The protective gas atmosphere furnaces shall be designed in such a way that the weld seam of the outer housing is accessible from the outside. Concealed welds in the bottom plate are to be avoided. If the furnace systems are installed on the production building floor, bronze sheets shall be used as a sliding layer.

5.2 Components

- Ball valves with PTFE seals are to be used as shut-off devices for the technical gases.
- All devices and components must be directly accessible and easily replaceable (also applies to terminal boxes).
- Heat exchangers, recuperators and radiant tubes must undergo a leak and pressure test before delivery. Test reports must be submitted.
- Restriction orifices must be shown in the documentation. Installation of restriction orifices in screw fittings is not permitted.
- If retightening of the screw connections due to thermal expansion is necessary for design reasons after a defined period of operation, this must be carried out by the contractor.
- Analogue actuators shall be designed with continuous position feedback.

Pressure gauge shutoff fittings	
Pressure >= 500 mbar	Shutoff valve DIN
Pressure < 500 mbar and nominal diameter < DN 50	Pushbutton pressure gauge valve VE3 (clamping nut)

5.3 Control system

- Prior to execution of the control system (e.g. PLC), a functional specification must be submitted. The functional description, a process flow diagram (see Wieland delivery specification “C Part 6 Documentation”) and a piping & instrumentation (P&I) diagram in accordance with DIN EN 62424 form part of the functional specification.
- For the process control of control dampers, fans etc., the economic efficiency of operation must be taken into account.
- All process sequences must be represented visually in the HMI / control system (e.g. leak-tightness check, pre-ventilation etc.) The remaining time of the individual process steps must be displayed.
- The furnace chamber temperature control must be implemented at least as a proportional-integral (PI) algorithm. The use of combustion air as a cooling medium for temperature control is not allowed. Combustion air may only be used for specific cooling processes.
- Measurement circuit monitoring (broken wire and short-circuit) must be implemented for temperature recording.
- Cooling water inlet and outlet temperatures as well as pressure and volume flows must be monitored for each cooling water circuit, and critical states must be reported.
- Temperatures, pressures, volume flows, fan speeds, position of control dampers and valves etc. must be displayed in the process control room.
- All analogue values are to be displayed as trend functions.
- Shutdown of individual assemblies for maintenance purposes shall be provided.

5.4 Measuring devices

- Orifice plates only as standard ring chamber orifice plates in accordance with DIN EN ISO 5167.
- Measuring devices and sensors must be properly calibrated on the installation. Proof must be provided. Provide appropriate valve blocks for calibrating the pressure transducers.
- It must also be possible to perform calibration functions while the system is in operation (service switch). For thermocouples and pyrometers, a calibration function must be provided in the PLC and in the human-machine interface (HMI) (the detailed design must be discussed in the respective project).
- Transducers must not be directly attached to the sensor (e.g. integrated in the thermocouple head).
- All media must be recorded and transmitted to the higher-level control system.
- For the recording of gas consumption (fuel gas, protective gases), pressure and temperature compensation must be taken into account and the data converted into standardised consumption values.
- For media flow measurement or media pressure control, the specified calming distances must be observed.
- Digital, dry (potential-free) outputs or analogue signals are to be provided for all media quantity measurements used.
- Measured variables for “central control system” must be made available, e.g. temperatures, pressures, flow rates, etc.
- Indicator pressure gauges must always be fitted with pressure gauge shut-off valves and be fully shown in the drawings.
- Measuring devices / indicating instruments must be mounted in such a way that they can be easily read (height approx. 1.2-1.8 m).
- Order archive showing the specific corresponding energy consumptions must be provided.

5.5 Design of gas lines

- The pipes and other pipeline parts shall be joined by welding. Corrosion protection must be provided.
- Single-line construction is to be preferred owing to accessibility.
- In the case of double-line construction, care must be taken to ensure accessibility from both sides or rather to both lines.

- The main shutoff valves are to be spatially separated from the gas condition regulators and control units (approx. 1 metre) and placed in an easily accessible and visible location.
- The main shutoff valves for flammable gases are to be marked with “fire red” colour (RAL 3000) and provided with a sign “Flammable gas – close in case of danger” *(“Brennbares Gas – bei Gefahr schließen”).*
- All connections must be accessible with standard tools.
- All installed devices and fittings must be individually removable without removing/dismantling adjacent devices.
- Protect piping and pipe fittings against vibration (provide additional fasteners or decouplers if necessary).
- Flow velocity in gas lines should be in the range of 5 to 10 m/s (approx. 5 m/s for sensitive gas trains).
- To avoid pressure surges, slowly opening and slowly closing valves should be used.
- Control lines for gas regulators, safety shutoff valves and pressure gauges must not be routed together and must also have separate sample ports (pay attention to control functions).
- Breathing lines of the regulators must not be coupled with venting lines of other assemblies.
- Venting and breathing lines carrying flammable gases must be routed individually to the open air.
- Pay attention to pressure gradation of media – highest pressure nitrogen, then hydrogen-nitrogen mixture and hydrogen.
- For high pressure gas regulators, provide for the use of safety shutoff valve (SSV) and safety blowoff valve (SBV). The safety valves must be directly monitored.
- Purge ports must be provided for lines carrying flammable gases.
- Observe “TRR” technical rules during manufacture, installation and pressure-testing of gas lines. The piping firms to be tasked with laying and welding work must have a DVGW certificate in accordance with worksheet GW301.
- Attachment of assemblies such as ignition transformer, transducer etc. to gas or air lines is not permitted.
- Use of plastic hoses as fuel gas lines, protective gas lines and air lines is only permitted subject to consultation.

5.6 Device arrangement in the fuel gas inlet line

- Manual shutoff valve
- Filter (mesh size maximum 10 µm) with differential pressure monitoring (DUNGS)
- Pressure gauge
- Pressure regulator
- Pressure gauge
- Pressure switch for gas low pressure protection and gas overpressure protection
- Gas meter, temperature and pressure compensated
- Main gas valve
- Leak-tightness monitoring
- Pressure gauge

5.7 Burner installation

- In the fuel gas supply line for each burner, the use of two automatic shutoff valves connected in series is mandatory in accordance with DIN EN 746-2.
- Manual shutoff must be provided for combustion air and fuel gas for each burner.

- Ratio regulators must be used to maintain the stoichometry of the combustion (also for OPEN/CLOSED control). A setting for the excess air factor of 1.15 should be aimed for.
- When designing the combustion air supply, care must be taken to ensure a constant supply pressure over the entire power range.
- An inlet filter with differential pressure monitoring and combustion air preheating must be provided.
- The vent line for leakage monitoring must be at least DN50.
- Gas low pressure protection, gas overpressure protection and air shortage protection must be used in general.
- Pilot burners must only be installed with approved metal hoses. The metal hoses must be long enough to allow the burner to be pulled out during operation.
- For the pilot burners, separate pressure regulators must be provided in the fuel gas and combustion air supply.
- Flame monitoring is to be implemented with an ionisation electrode (UV flame sensor permissible subject to consultation).

For maintenance functions, burner installations must be equipped on site with the following assemblies:

- Rotameter flowmeters for combustion air (for combustion air preheating a ring chamber orifice with evaluation) and for fuel gas (Vöhringen plant: natural gas / air mixture scale)
- Service switch MANUAL / AUTO / OFF, LOW POWER / HIGH POWER (or “+” and “-” buttons in the case of continuous control)

5.8 Exhaust gas paths

For the safe discharge of exhaust gases, the use of exhaust gas fans is mandatory. Exhaust gas stacks and exhaust gas lines must be designed in such a way that the exhaust gas velocity at the mouth of the emission sources complies with the local specifications of the authorities.
Due to noise generation, the maximum gas velocity must be limited. Flow losses must be limited to a necessary level.
Locally permissible sound power levels for stacks and exhaust lines must be observed.

Sample gas opening Rp 3" in accordance with DIN EN 15259 must be provided on the stacks and exhaust lines.

Pipes carrying flammable gases to the open air must be executed with PN16 pressure rating.

Pipe sections of the inner lining of stacks shall be made of V4A fully welded.

The cost-effectiveness of waste heat utilisation must always be investigated.

The height of the stack depends on the local conditions, or, for plants subject to BImSchG approval, on corresponding stack reports.

6. Safety equipment

For any thermoprocessing equipment, the supplier must carry out a hazards analysis prior to project planning and submit it as a document. The basis for conducting the hazards analysis is the applicable Wieland delivery specification “Health, safety and environmental protection”. In addition, the following rules apply to thermoprocessing equipment.

If the formation of hazardous explosive atmospheres cannot be reliably prevented, the contractor is also required to prepare an explosion protection document (see BetrSichV).

In the hazards analysis, in addition to the general hazard risks of commercial or industrial activity,

consideration must be given in particular to workplace hazards resulting from high temperatures and hazards posed by the use of technical gases. These are the following hazards: explosion hazard, suffocation hazard, burn hazard, poisoning hazard, and environmental pollution from process residues.

The first step in the hazards analysis must be to identify all substances that occur or could occur in the process and in the plant. These are input materials, end products, byproducts, impurities, auxiliary materials and operating materials. To assess the hazards, the relevant substance properties must be identified and the operating conditions, e.g. pressure and temperature, must be taken into account.

For each process step in each plant section, it must be assessed whether the above-mentioned hazards can arise under the operating conditions. Initial startup, normal operation, startup and shutdown of the plant, periods of downtime, production interruptions, malfunctions, cleaning, maintenance and repair work must be taken into account. The result of the hazards analysis must be a list of effective protective measures.

Before commissioning the thermoprocessing equipment, it must be checked whether the protective measures have been practically implemented and are effective. A report on these checks must be prepared and submitted to Wieland. In the event that Ex zones are defined, an Ex zone plan must be prepared.

Explosion hazards must in principle be eliminated by preventing the formation of an explosive mixture (primary explosion protection).

Plants are to be designed in such a way that no Ex zones have to be defined in the production buildings (possibly use of gas warning system).

Double valve technology with leak-tightness monitoring must be provided for shutting off flammable media (also applies to air supply instead of protective gas, for plants with flammable protective gases).

The safety-relevant control processes must be implemented as hardware circuits with safety-approved devices or with devices in redundant configuration. The individual safety functions must be designed in such a way that mutual interferences or influences are not possible.

Flame arresters (crimped metal ribbons) must not be used in protective gas flowlines.
As a substitute, injectors can be used which guarantee the minimum necessary flow rate of the combustible mixture.

Safety-relevant messages must be stored in a separate database (implemented as a ring buffer, i.e. the oldest messages are overwritten). No delete functions may be programmed for this database. In addition, these messages must be copied cyclically to a Wieland network drive (redundant data storage).

In the event of a power and nitrogen failure, a system operating with flammable protective gas must go into a safe state. When the supply is restored, the system must automatically switch to safety backwashing after a defined delay time.

Any gases (e.g. H2) escaping into the surroundings of the plant must be considered in the risk assessment and appropriate measures must be implemented to avert the potential hazard.

For the calibration of the gas warning system used, the sensors must be provided with test attachments and test leads. The test lead connections must be easily accessible. Testing and adjustment must be possible during operation.

For safety-related gas analysis, only measuring instruments that have been tested and proven to be suitable may be used. The cross-sensitivity of the measurement must be taken into account. For each safety-relevant gas analysis, a separate gas measuring line must be provided.

For thermoprocessing equipment with combustible protective gases, four floating (potential-free) signals must be provided: two signals from the system to the central control system (“system under H2”, “emergency purging initiated”), and two from the central control system to the system (“N2 supply pre-alarm”, “N2 supply alarm”).
When “N2 supply pre-alarm” signal is activated, the annealing run can be terminated. In this case, no new annealing run can be started while the signal is still active.
When the signal “N2 supply alarm” is activated, the safety backwash must be initiated on the system during hydrogen operation.

The systems with flammable protective gases must be operated with forming gas (5% H2 rest N2) at regular intervals in order to detect leaks in the furnace housing at an early stage.

7. Commissioning and acceptance

Design or functional decisions made during project planning must be documented in a checklist and their implementation checked before acceptance.

Before acceptance, the gas installation must be subjected to a leak-tightness check and pressure test by the supplier in the presence of a Wieland employee. A corresponding report must be submitted.

Before acceptance of the installation, the following checks, tests and measurements must be carried out by the contractor together with the appropriate Wieland employees:

- Reference annealing or heating tests
- Control tolerance for furnace chamber temperature and pressure
- Guarantee limit values such as temperature, furnace chamber pressure, oxygen partial pressure, dew point, belt speed, furnace throughput, etc.
- Heating and cooling curve
- Empty (no-load) consumption values for the furnace at the defined furnace temperature
- Specific energy consumption (fuel gas, protective gas, electricity, water)
- Leak-tightness of the furnace
- Outer wall temperatures
- Exhaust gas analysis
- Exhaust gas exit velocity at the stack
- Air pollution (maximum allowable concentration (MAC) values)
- Noise level
- Other measurements/testing as required

The contractually fixed limit values form the basis.
For temperature measurements, only calibrated class 1 thermocouples are to be used.

A measurement report is to be prepared.

The following limit values must generally be complied with:

- NOx concentration in the exhaust gas from the burners ≤ 300 mg/m³, based on dry exhaust gas under standard reference conditions and O_2 content 5 %vol.
- Furnace outer wall temperature ≤ 35 K over room temperature, measured at the highest furnace temperature (excluding thermal bridges).
- Organic substances in exhaust gas must not exceed a mass concentration of 10 mg/m³, specified as total carbon (this applies to all emission sources and relates to dry exhaust gas under standard reference conditions and with O_2 content 5 %vol.

The plant documentation is to be prepared in accordance with Wieland delivery specification “C Part 6: Documentation”.