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| **Metallic Piping Construction**  Aboveground / Underground |
|  |

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# Scope of application

This specification applies to the fabrication, installation and modification of metallic piping systems (including mountings and supports) at construction sites and prefabrication locations and covers all piping classes specified by **COMPANY**.

# Purpose

This specification describes together with applicable regulations, standards and specifications the minimum requirements for the fabrication and erection of aboveground and underground piping systems. For scope of work refer to Exhibit B. **CONTRACTOR** shall prepare detailed work instructions for all work to be performed and present them on demand to **COMPANY**.

# Definitions

## Essential definitions for this document:

|  |  |
| --- | --- |
| CLIENT | Linde Gas |
| COMPANY | LINDE AG, Linde Engineering Division, who manages and monitors construction and erection activities and usually procures the required equipment, materials and services |
| CONTRACTOR | Construction company and its subcontractor(s) on Construction Site. The responsible party for the procurement, construction, manufacturing of non-metallic pipe and components. |
| THIRD PARTY | Inspection 'Authority  Refer to project related  Specification for Testing & Inspection of Piping |
| Construction site | This term refers to plant assembling sites (field assembling) and prefabrication locations, as well as existing plants, where welding, mending and / or rebuilding works are performed. |
| AS BUILT | Condition after finishing of assembly work |
| Spool | Prefabricated piping sections |
| Golden Weld | Weld seam that does not undergo hydrostatic or pneumatic Pressure test. Refer to &CG-W-SC 9224 (EN) |
| shall | In this document, this term has the meaning of "must" or "have to be / has to be" |

## Abbreviations

|  |  |
| --- | --- |
| SMAW | Shielded Metal-Arc Welding |
| GTAW | Gas Tungsten Arc Welding |
| WPS | Welding Procedure Specification |
| PQR | Procedure Qualification Report |
| NDE | Non-Destructive Examination |
| RT | Radiographic Test |
| UT | Ultrasonic Test |
| PWHT | Post Weld Heat Treatment |
| PT | Liquid Penetrant Testing |
| MT | Magnetic particle Test |
| BOM | Bill of Material |
| QA / QC | Quality Assurance / Quality Control |

# Applicable Documents

General norms and regulations

|  |  |
| --- | --- |
| EN 13480 | Metallic industrial piping |
| GOST 32569-2013 | Industrial steel pipe-lines. Requirements for design and operation in explosive and chemically dangerous industries |
| SP 75.13330.2011 | Process equipment and process pipelines |
| SP 129.13330.2011 | External networks and constructions of water supply and Sewerage |
| SP 74.13330.2011 | Piped Heat Distribution Systems |
| GOST R 54892-2012 | Installation of air separation plants and other cryogenic equipment. General provisions |

Linde Standard

|  |  |
| --- | --- |
| LS 133-02 | Pressure Test, Pressure Vessels and Piping on Construction Sites |
| LS 142-05 Part 2 | Cold Bending of Pipes, Manufacture and Testing |
| LS 145-10 Part 1 | Welding of piping |
| LS 164-04 | Identification Traceability of Piping Material on Construction Sites |

Linde Specifications and Documents

|  |  |
| --- | --- |
| &AZ-W-SC-2402 (EN) | Construction Specification – Alignment of Flanges to Equipment |
| &AZ-W-SC 2403 (EN) | Construction Specification – Cleanliness of Piping in Air Separation Units and Cold Box Piping General |
| &AZ-W-SC 2404 (EN) | Construction Specification – Hook-Up Specification Piping |
| &ASU-T-SA 1100 (EN) | General Legal and Quality Requirements - Piping Construction |
| &CG-W-SY 9202.002 (EN) | Mechanical Completion Certificate (per discipline) |
| &CG W-RW 9224.004 (EN) | Check Record L03 – Pressure Test |
| &AZ-W-QA 2403 (EN) | Acceptance Sheet - Orifice Flanges |
| &AZ-W-QA 2404 (EN) | Acceptance Sheet - Spring hanger and Spring support |
| &AZ-W-QA 2604 (EN) | Acceptance sheet – Wrapping of UG Metallic Piping |
| &CG-W-LX-2403 (EN) | Blind List per Test System |
| &AZ-W-LX 2404 (EN) | List of Dismantled Items per Test System |
| &AZ-W-LX 2405 (EN) | List of Pressure Test Caps and Temporary Piping Supports |
| &CG-W-SY-9202.005 (EN) | Punch list |
| &AZ-W-DW 9506 (EN) | Isometric supplement sheet |

To be considered for air separation plants

|  |  |
| --- | --- |
| LS 145-19 | Welding of Al-piping, Prefabrication and Site Welding |
| LS 419-01 | Backing Rings for Welding of Al-Pipes |
| LS 141-74 Part 13 | Cleanliness of Surfaces in Air Separation Plants and Components, -Process piping and tanks at construction sites- |
| LS 493-04 | Procurement Standard - Cold box Wall Passages for Pipes |
| LS 548-01 | Piping Supports in Cold boxes Piping Supports List of Supports and Codes |

# Fabrication instructions

## General

All requirements defined in this specification shall be calculated in the price offered by **CONTRACTOR** and will not be compensated separately by **COMPANY**.

Materials and components shall only be used as specified in the relevant isometrics, material lists and according to their pipe class specifications.

## Important Input for the Painting Contractor

**Piping CONTRACTOR** shall provide the painting contractor with all necessary information for planning and execution of painting works.

Especially:

* + - Required specifications
    - Blasting quality
    - Painting system
    - Layer thickness
    - Spool marking
    - Handling of loose items
    - Protection requirements
    - Definition of unpainted surface areas

Prior to welding as a minimum 50mm each side of the weld bevel (measured at the bevel end) shall remain uncoated. Fit-up lengths shall be considered.

For welds to be heat treated 300mm each side of the weld bevel, however a minimum distance of 150mm from the heating elements shall remain uncoated.

## Provision of fabrication documents

For the performance of work **COMPANY** solely provides the documents as defined in Exhibit G of contract. Any further documents required by **CONTRACTOR** shall be provided at his own expense without additional costs for **COMPANY**. These documents shall be provided to **COMPANY** in actual revision status.

## Marking

Marking of prime-coated materials shall be clarified with **COMPANY** in advance and requires written approval. If paint marking will be used, the composition of paint shall be compatible with the specified prime and subsequent top coat.

### Marking of spools

**CONTRACTOR** shall be fully responsible throughout the fabrication steps, that all pipe spools are marked and identifiable / traceable. Any costs caused by wrong resp. not-identifiable marking shall be at **CONTRACTOR**'s expense.

Loose piping items and prefabricated spools shall be labelled with stainless steel or aluminium tags fastened with stainless wires to the item.

Straight pipelines resting on pipe racks shall be marked with the pipeline number at least at the beginning and at the end of the pipe rack.

Piping material and prefabricated spools shall be marked as follows (information of marking)

* CONTRACTOR (if more than one)
* Construction area
* Line number / sheet number
* Spool number

### Marking of pipes (Transfer of marking)

For tracing purposes, marking according to LS 164-04 shall be ensured.

Prior to cutting of random length pipes, elbows etc., identification marking shall be transferred by CONTRACTOR'S authorised personnel, named in advance and in written to COMPANY.

Marking shall be placed approximately 150 mm away from the welding edge.

For better identification, the marking shall be framed with weather proof colour (white for C-steel and black for stainless steel / aluminium). The colour shall be free of Cl-, P-, Pb-, S- and halogens.

Low stress stamping shall be the preferable method for C-steel > 6mm and engraving shall be used for C-steel ≤ 6mm, stainless steel and Aluminium.

### Marking of welding seams

All welding seams are subject to the marking allowing to establish the welder who carried out these seams.

The marking should be applied in the manner specified in the drawings or technical procedures and ensuring their safety and identification for the entire period of operation of the equipment.

The hard-stamped method of branding is used on steel pipes with a wall thickness of more than 6 mm. With a wall thickness of 6 mm and less, other methods of marking are allowed, which guarantee the safety of the stamp and do not worsen the quality of the surface of the product during operation (electrographic, markers, indelible paint, etc.).

## Welding

All welding work shall be carried out according to the project specifications, codes and standards as shown in Specification for Testing & Inspection of Piping.

The COMPANY Specification LS 145-19 and LS 145-10 Part 1 shall apply.

Temporary welds and tack welds at pressure bearing components are subject to the same conditions and regulations as valid for the welds itself.

Welding works shall only be performed by qualified and approved welders according PB 03-273-99 and RD 03-495-02. Welders shall wear their identification badges well visible.

A copy of the relevant WPS/PQR shall be available at the welding spot.

Process lines, which do not allow re-welding from the root side, the root pass and the hot pass shall be welded by using GTAW-process for root passes and shall be full penetration welds. This shall apply also for mitre welds. For thin-walled material (<10mm) backing gas protection- if specified in the WPS, shall be hold up during the whole welding process.

For steels with Cr-content > 2.5%, the internal pipe area of welding shall be protected with backing gas. For CrNi-steels and Ni-based metals, the annealing colour "straw yellow" is acceptable. Unacceptable annealing colours shall be removed by appropriate methods.

Mitre-welds are only allowed after COMPANY's written approval.

Additional welds shall be approved by **COMPANY** in writing (remark and signature on isometric) prior to cutting / welding, otherwise no compensation will be granted by **COMPANY**.

Additional welds shall be marked with a suffix (e. g. "1.1", "1.2") on the isometric and isometric supplement sheet.

Work places shall be protected against flying sparks and glares using non-combustible materials. Fire protection measures (e.g. extinguishers) shall be implemented in addition.

Welding spatters, slag and other foreign materials shall be removed from the pipes and equipment by appropriate methods.

During welding, the earth connection shall be placed close to the welding point in friction locked condition. **CONTRACTOR** shall ensure that no sensitive plant equipment is located between the welding point and earth connection point.

Welding respectively heat treatment at galvanized and / or painted surfaces is prohibited. Exceptions requires **COMPANY**'s written approval of a detailed work instruction for surface preparation etc..

All weld repairs shall be reported by **CONTRACTOR** to **COMPANY**. **COMPANY** will define the extent of repair and will also take decision for eventual replacement of welds. Repairs and / or replacement of welds will not be compensated by **COMPANY**.

Root welds at orifice flanges, within flow metering devices and venturi pipes shall be grinded to inside surface level. **CONTRACTOR** shall provide an acceptance certificate according &AZ-W-QA 2403.

Welds and threaded connections within flow metering runs are prohibited.

Additional weld tests and repairs which are necessary due to faulty welds will not be compensated by **COMPANY**.

For aluminum welding, the following shall apply in addition:

* LS 145-19 "Welding of Al-piping, Prefabrication and Site Welding"
* LS 419-01 "Backing Rings for Welding of Al-Pipes"

Notches, scratches, large grinding grooves, etc. on the SS-backing ring must be removed before installation.

In case of weld repairs, high focus shall be paid to make sure that the SS-backing ring is not damaged. Damaged SS-backing rings may lead to false interpretation of the RT-film evaluation.

## Preparation of welding bevels

Material shall be pre-heated according to the relevant codes, standards and guidelines for welding if cuts or welding seam preparations are done by thermal cutting. The oxidized layer shall be removed by machining.

In order to avoid misinterpretation of radiographs (due to linear indications projected into the weld seam) **CONTRACTOR** is requested to round sharp edges on tapered ends of pipes or fittings internally and externally (e.g. adjustment of wall thickness).

The following weld preparation shall be assumed by **CONTRACTOR**:

Pipes, flanges, fittings according to GOST 16037-80 and GOST ISO 9692-1-2016:

|  |  |
| --- | --- |
| t ≤22 mm V-Weld |  |
| t > 22mm Double-V-Weld |  |

Discrepancies require **COMPANY**'s approval.

## Heat treatment

Heat treatments shall be done according to the guidelines and LINDE standards as given in **COMPANY**'s Specification for Testing & Inspection of Piping.

The stress-relieve temperature shall be kept for a minimum of 2.5 min per mm wall thickness, but at least 30 minutes.

Heat treatment shall be documented by temperature recorders. Thermocouple shall be fastened in direct contact to the surface. For DN ≥ 200, at least two thermocouples shall be fastened rotated by 180°.

The holding temperature for quenched and tempered steel shall be at least 30°C less than the tempering temperature of the base metal. In case the holding temperature drops out of heat treatment range, further proceeding shall be clarified with **COMPANY**.

If the required actual PWHT holding time for a weld exceeds the qualification range of the PQR, e.g. due to a required weld repair (repeated PWHT), **CONTRACTOR** shall in advance re-qualify the PQR on a production test piece, covering the total holding time applied. Alternatively **CONTRACTOR** may at his expenses perform RT/UT prior PWHT and repair weld defects prior to PWHT. Final NDE will be required after PWHT. Heat treatment at pressure tested, internally blasted, pickled and / or painted spools are not permitted without **COMPANY** written approval.

For welds, which will be welded under pre-stressing (e. g. if specially specified at cracked gas pipelines), all affected welds shall be heat treated and non-destructive tested prior to tensioning. Welding or heat treatment of joints under stress is not permitted.

The heat treatment shall be done locally with resistance or furnace method.

## Piping prefabrication

Prefabrication comprises manufacturing of pipe spools or spool parts dependent on e.g. size, shape, weight which need to be considered for transport, lifting and site installation. For spool sizes > DN 40 (11/2") prefabrication shall be performed to a maximum possible extend.

In order to ensure a stress free piping connection during assembly, **COMPANY** recommends a fit-up length of about 100 mm. Fit-up length and spool design is the sole responsibility of **CONTRACTOR**.

The location for prefabrication is to be nominated by **CONTRACTOR**, but shall be approved in advance by **COMPANY**.

Prefabrication of stainless steel (SS) and aluminium (AL) materials shall be performed in separate areas, segregated from carbon steel (CS) using the tools specifically defined for such fabrication.

Materials shall be utilized in the most economical way. Cutting shall be prepared in a way, that maximum 3% scrap (per Ident-No.) occurs. Cut-offs >3% shall be compensated by **CONTRACTOR**. Surplus materials shall be returned to the warehouse. Marking (e. g. Ident-No., heat number) shall remain on the returned materials.

During prefabrication planning and spool planning, special attention shall be paid that welds will be placed not resting on steel structures and not be covered by supports, clamps etc (according to GOST 32569-2013, GOST R 54892-2012, SP 129.13330.2011, SP 75.13330.2011, SP 74.13330.2011).

The prefabrication completion status is achieved, if:

* All welds including branches and instrument nozzles are welded.
* Spools are marked for identification / traceability.
* Ident - and heat numbers (if required) are checked and assigned in isometric documentation.
* Routing and dimensions are checked against isometric drawing.
* NDE is completed. All repairs and extended NDE are carried out and accepted by **COMPANY**.
* Heat treatment is completed and accepted (if any).
* Pressure tests for completed spools (if any) are completed and accepted.
* Spools are cleaned and all open connections are protected.
* SS-welds are metallic bright (outer and inner surface), straw yellow will be accepted.
* Final spool inspection is carried out by **COMPANY**, **CONTRACTOR** and by **CLIENT** and nominated **THIRD PARTY** (if specified); eventual deficiencies are rectified.
* Documentation is completed. ISO's are signed by **CONTRACTOR** and (if specified) by **CLIENT**. One copy is submitted to **COMPANY**.

Intermediate storage of prefabricated spools or components:

* Intermediate storage shall be taken into consideration, if delivered spools can't be installed directly after delivery to site. CONTRACTOR is responsible to organise the storage in a way that spools can be easily found (e.g. storage per area) and transported. Further on, intermediate storage shall be performed in a way that damages and contaminations do not occur.

## Cold bending

LS 142-05 Part 2 shall apply.

Cold bending of pipes shall only be carried out if specified and approved in writing by **COMPANY** and if specified in relevant pipe classes. Bending works shall be carried out without influence of welds seams.

Inner block pipelines with diameter less than 100 mm to make by bending method at installation with use of ready details (bends, tees, pipes, etc.) according to the instructions presented in drawings.

The bending radius of such pipes must be performed:

- for pipes up to 40 mm in diameter inclusive - not less than two pipe diameters;

- for pipes with a diameter of more than 40 mm - not less than three diameters of the pipe.

The wall thickness of the bent pipe, unless specified in the drawings, shall not exceed the following values (from the original wall thickness):

- for aluminium pipes - not more than 25% including;

- for steel pipes - not more than 20% inclusive;

- for copper pipes - not more than 10% inclusive.

The maximum ovality at the bending points of the pipes shall not exceed 15% inclusive of the nominal value of the outer diameter.

Smooth corrugations are allowed in the bending zone with the height of the scallops on bent surfaces:

- for pipes with a diameter up to 25 mm inclusive - not more than 1.5 mm inclusive;

- for pipes with a diameter of more than 25 mm - not more than 2.5 mm inclusive.

The minimum distance from the weld to the beginning of the bend to maintain equal to five times the thickness of the pipe wall, but not less than 25 mm inclusive.

Pipes bent with filler (dry river sand only) should be thoroughly cleaned from the inside and blown with dry air.

Bending with heating of austenitic steel pipes is prohibited.

Bending pipes using rosin and other lubricants is not recommended.

All piping must be thoroughly purged Before installation.

The pipes going to control and measuring devices (impulse pipes), after laying should be checked by purging on absence of possible blockages.

Cleaning of the inner surface of the pipes and / or their chemical treatment should be carried out after the completion of the manufacture of pipe assemblies before applying primer paint, as well as before their installation.

Before chemical treatment of pipe assemblies, they shall be purged with dry clean air to prevent contamination of cleaning chemical products.

The pipeline which is not subjected to chemical processing, after production is cleared by blowing dry air.

By results of cleaning of pipelines, the act of washing/purging according to the form GOST R 54892-2012 Appendix 2 is made.

## Piping field installation

The field installation comprises the installation of piping systems (including all equipment) according to the requirements of the respective isometric and bill of material respectively. All contractual requirements, including the activities shown in the "Scope of work" Exhibit B, shall be fulfilled.

Equipment supplied with N2 overpressure shall be depressurised before cutting, heat treatment and/or bolt releasing activities.

Piping, equipment, concrete structures, steel structures, buildings, etc. shall not be stressed by construction loads / forces resulting from piping installation. **CONTRACTOR** shall contact **COMPANY** to get a case to case approval.

During field installation it shall be ensured that welds do not rest on steel structures and are not covered by support clamps etc (according to GOST 32569-2013, GOST R 54892-2012, SP 129.13330.2011, SP 75.13330.2011, SP 74.13330.2011).

Pre-stressing (cold pulls) at expansion loops shall be recorded (e.g. on isometric) by **CONTRACTOR** prior to pulling and shall be approved by **COMPANY**.

## Golden Welds

Amount of golden welds shall be minimized.

In accordance with **COMPANY**, **CLIENT** and nominated **THIRD PARTY**, golden welds can be seen as an alternative, if strength testing is not applicable / practicable with water or gas.

Over the period of the project, a list of golden welds has to be compiled and kept actualized by **CONTRACTOR** l.

The following production conditions / standards have to be kept by **CONTRACTOR** and **COMPANY**:

* Written approval by COMPANY.
* Inspection of weld preparation, in-process inspection and visual testing of the completed welding seams including test report, by QC of CONTRACTOR.
* Application of GTAW welding process for root pass and "hot pass".
* Visual testing of root-pass by QC of CONTRACTOR.
* 100% non-destructive volumetric testing of the weld seam (RT or UT, depending on material and wall thickness).
* 100% surface crack inspection of seam (PT or MT).
* Detailed documentation of weld seams and tests as part of final documentation.
* The act on welding of golden joint the form 2.7 VSN 012-88 part 2.
* Verification by QA/QC of COMPANY.

## Handling of valves

Prior to installation, valves shall be stored safely (e.g. in **CONTRACTOR**'s warehouse) and shall be protected against dirt and damages.

Protection caps shall be removed just prior to installation of valves.

Prior to installation, the following shall be checked against the isometric / P&ID:

* Identification (COMPANY's identification-, tag-number)
* Nominal size, pressure rating
* Direction of flow (F) and direction of differential pressure (P)
* Cleanliness
* Operability
* Available CE-marking

Valves shall be installed completely with mounted hand wheels, respectively hand levers. Space for eventual actuators shall be considered.

Welded valves shall be installed / welded in open position.

The orientation of spindles / hand wheels shall be as indicated on isometrics. In case of interference (access, operation problems), orientation shall be clarified with **COMPANY**. No compensation will be assigned, if valves have to be removed and re-installed due to inadequate operability.

## Sensitive plant equipment

The interior of sensitive plant equipment such as control valves, butterfly valves, flow meters, strainers, plate fin heat exchangers, rotating equipment (machines), measuring and regulating devices etc. shall be protected against contamination with foreign materials (dust, water, moisture). The protection can be done with marked blind spades (thickness equal to gasket).

Orifice plates, metering runs as well as venture-pipes shall be installed strictly according to isometrics, piping plans and specifications. Attention shall be given to the direction of flow.

**COMPANY** will define sensitive plant equipment which needs to be dismantled before pressure test. The dismantled equipment shall be listed by **CONTRACTOR** in the "List of dismantled items per test system" **(&AZ-W-LX 2404)** and provided to **COMPANY** for verification (refer to "Preparation of Pressure Tests").

The temporary blind spades shall only be removed upon instruction and in the presence of **COMPANY**.

## Pipe threads

All threaded connections (if not specified as seal welded) shall be tighten by using proper sealing materials (e.g. Teflon tape, hemp, LOCTITE). Sealing material shall be suitable to withstand the specified design temperature and flow medium and requires **COMPANY**'s approval. Teflon tape shall only be used for pipelines with temperature of maximum 80°C and connections up to DN 40 / 1 ½".

Prior to execution of seal welding, all sealing materials shall be completely removed from welding area.

## Flange connections and alignment

Flange connections shall be installed by qualified personnel only.

**CONTRACTOR** is responsible for training instruction and nomination in written of erection personnel. **CONTRACTOR** shall provide **COMPANY** with a name list, showing also the related signatures and short letters.

Flange connections shall be aligned free of stress and tension. Bolts shall move free through. The full flange facings shall rest equally on the gasket. Flange tightening shall follow a sequence (in steps, uniformly crosswise) to guarantee equal force / torque over the complete surface.

The torque or tension values shall be applied with calibrated tools. Sealing shall be carried out by authorised personnel. Prior to start of manufacturing, **CONTRACTOR** shall provide a specification for flange alignment and sealing for **COMPANY**'s approval.

Stress free connections of piping to rotating equipment, control valves, check valves, etc. shall be verified by **COMPANY** or by the Manufacturer's representative before final bolt up. No stresses / forces shall be transferred to the equipment. **CONTRACTOR** is obligated to record the flange alignment on the check record B03 – Stress Free Pipe Connections (&CG W-RW 9222.004) for inspection / approval by **COMPANY**.

Permissible tolerances for flange connections:

Misalignment of pipe centrelines: 0.8 mm max.

Misalignment of bolt holes: 0.8 mm max.

The deviation from the perpendicular sealing surface of the flange axis of the pipe or part must not exceed the values:

|  |  |
| --- | --- |
| **The diameter of the pipe (details), mm** | **Decline, mm** |
| from 25 till 60 | 0,15 |
| from 60 till 160 | 0,25 |
| from 160 till 400 | 0,35 |
| from 400 till 750 | 0,5 |
| Over 750 | 0,6 |

The misalignment of the sealing surfaces of the connection flanges shall not exceed twice the deflection indicated above; the clearance shall be the same throughout the circumference and shall correspond to the thickness of the gasket.

Not allowed alignment flanged joints tension of bolts, as well as the use of wedge gaskets.

Manufacturer's tolerances as shown in the erection manual shall be followed.

Refer to &AZ-W-SC 2402 (EN) Specification Alignment of Flanges to Equipment.

Alignment of lines / spools by application of hot or cold forming written approval of **COMPANY** is required. **CONTRACTOR** shall prepare an alignment concept considering the relevant codes and standards. Coating shall be removed prior to hot forming.

Attention shall be paid to the position of measuring taps at orifice flanges (refer to the isometric drawing).

Flange facings shall be free of damages. In case of damages, the facings shall be re-machined or the flange shall be replaced.

### Bolt connections

Hexagon screws are to be installed having the screw head at the same side of the flange. At flanges in vertical lines, the hexagon screws shall be installed with the screw head at the top.

Bolt threads and the side of the nut facing towards the flange shall be lubricated with products suitable for the relevant design temperature and flow medium. For bolt connections in Oxygen Service, lubricants shall be suitable for Oxygen Service and shall be nominated in written to **COMPANY**.

Bolts shall fully extend through their nuts with a minimum projecting length of 2 threads.

Projecting bolt ends shall be equally distributed on both sides of the flanges.

Material identification of bolts / screws and nuts shall be visible (always from the same side) and legible.

Bolt connections shall be tightened in steps, uniformly and with defined torque or tension. Values shall be as per specified torque / tension value table (if applicable). **CONTRACTOR** shall record and document the work execution for all flange connections to machinery and static equipment where the line is ≥ 4" / DN100 and ≥ PN25.

Attention shall be paid that for coated bolts the delivered bolt / nut-pairs are kept together.

### Handling of Gaskets

The following requirements for storage / installation of gaskets shall apply:

* Protection against damages and dirt during storage and installation
* Only installation of gaskets as specified in the Bill of material (BOM)
* Only new gaskets shall be used
* Flanges shall be sufficiently spread (if required with spreader), to avoid damaging the gasket during insertion.
* Ring joint gaskets shall be checked prior to installation for roundness

## Installation of blinds and spectacle blinds

The information about location of all permanent blinds to be installed in a pipe shall be taken from the P&ID together with the isometric drawing of that pipe. Also at equipment, the location of blinds is shown in the P&ID. However the orientation of spectacle blinds is not detailed in those documents further. The installation of each spectacle blind has to be defined with **COMPANY**'s construction management at site considering contractual conditions as well as **CLIENT**'s maintenance requirements and shall be documented on the related as-built isometric drawing.

The following general rules shall apply unless they are overwritten by **CLIENT**'s specifications:

* The preferable orientation for small spectacle blinds (below 25 kg) in warm insulated pipes is underneath the pipe (depending on the distance between the pipe and the grating).
* The preferable orientation for large spectacle blinds (above 25 kg) in warm insulated pipes is vertically above the pipe or horizontally.
* The preferable orientation for all spectacle blinds in cold insulated pipes is vertically above the pipe or horizontally. The blinds will be integrated in the insulation.
* The orientation of spectacle blinds must not hinder any access to valves, etc. for maintenance and must not reduce the specified alleyway size.

In case the above rules are not followed and **CONTRACTOR** has to re-arrange the blinds. This additional work will not be compensated by **COMPANY**.

## Nozzle Assemblies

Nozzle assemblies at piping and equipment shall be manufactured, tested (e.g. NDE, Pressure Test) and documented in accordance with Code and specification requirements.

## Pipe supports

The basis for fabrication and installation of pipe supports is described in the relevant standards, isometrics and detail drawings with related BOM.

Special attention shall be paid on stainless steel thin wall piping in case when support attachments are welded to pipe. Any burn through or inside annealing colours shall be avoided. Materials welded to the pipe shall be certified and of the same grade as for the pipe material. Any costs due to rectification are at **CONTRACTOR**’s expense

Pipe supports have to rest fully on their foundation or structure. If this is not possible, all-over shim plates shall be installed to fill the gap. Attention shall be paid to corrosion protection.

Supports shall be installed centred on the supporting structure. If extensive support movement is specified on the isometric, special pre-adjustment which specified on the isometric is required.

Anchor cams on pipe supports shall be fabricated by **CONTRACTOR** in the same material quality as the product line and shall be attached with full penetration welds. According to the requirements of the product line, marking with heat number and ident-number is requested. Requirements for heat treatments shall be considered.

Temporary supports (if needed) shall be located to areas not obstructing other construction activities / disciplines. **CONTRACTOR** is obliged to coordinate such activities with **COMPANY**.

## Special requirements for spring hangers and spring supports

There are special requirements applied for the storage, installation and documentation of spring support systems.

Manufacturer's requirements of storage and conservation have to be observed. Moisture and contamination have to be kept away from spring hangers and spring supports during storage.

Blockages must be set and locked during storage.

All relevant data, regarding the installation of spring hangers and spring supports can be taken from the relevant project specific spring of manufacture drawings and installation instructions. They are marked on the respective isometrics. The specified movement of the construction and the spring itself must not be interrupted due to constructive elements or external influences. After finishing construction, the cold load position has to be set up with a turnbuckle. Also preparing the connection between pipe and support with clamps is to ensure.

Blockages must be set during the whole process of installation.

First to check regarding the preparation of pressure tests is that all blockages are set on all spring hangers and spring supports installed in the relevant test circle. Each spring support has to be documented with the "Acceptance sheet for spring -hanger and -support " **&AZ-W-QA-2404 (EN)**. The signed inspection sheet is a part of the final documentation of the Test Package.

Blockages must be set during the pressure test

For mechanical completion, all blockages of the respective spring hangers or supports have to be removed. The following must be completed prior to removal of blockages:

* Installation of all weighing items like piping insulation, valves, valve actuators etc
* Removal of temporary supports being placed for construction and / or hydro test purposes
* Spring hanger / spring support is adjusted to the cold load position

Removing of the blockages and the position of the marked load has to be documented and signed on the "Acceptance sheet for spring -hanger and -support " **&AZ-W-QA 2404 (EN)**.

## Cleanliness requirements / Conservation

Piping parts shall be protected against damages, corrosion and ingress of foreign materials (e.g. dust) during the entire storage, transport, prefabrication and installation phase. Special attention shall be given to flange facings, threads, rotating and sensitive equipment.

For the outdoor storage, ends of spools, pipes and fittings shall be protected with plastic caps.

Temporary covers shall earliest be removed during installation. After finishing of construction, **CONTRACTOR** shall ensure that no foreign materials are inside of piping systems or equipment.

Cleaning and conservation requirements shall comply with the requirements as specified in the piping list (isometric list, if applicable), isometric and/or P&ID.

In cases of damaged galvanized surfaces or drillings in galvanized surfaces, the cold repair shall be performed by **CONTRACTOR** immediately in accordance with related specifications.

## Non-destructive examination

For the extent and the performance of non-destructive examination reference is made to EN 13480, GOST 32569-2013, GOST R 54892-2012, SP 129.13330.2011, SP 75.13330.2011, SP 74.13330.2011.

Welds subject to non-destructive examination (NDE) shall be defined / selected by the **CONTRACTOR** and **COMPANY**. The **CONTRACTOR** is responsible for co-ordination of testing activities with the NDE – contractor.

Generally non-destructive examinations shall be performed after heat treatment.

# Tie-In and Modification activities

Piping and equipment, which will be compound in existing systems, shall be prefabricated and tested to the maximum degree.

The scope of work during the integration process shall be minimized.

The following steps shall be considered prior and during the execution:

* Written approval of **CLIENT**.
* Testing of Tie-In points for wall thickness, corrosion, condition of structure (weld ability).
* Verification of piping for flammable, combustible and poisoning materials.
* Securing and fixing of piping prior to loosening of bolting or cutting.
* Installation of temporary blinds (if applicable).

Testing of Tie-In points:

* 100% volumetric inspection of seam (UT or RT).
* 100% surface inspection of seam (PT or MT).
* Wall thickness measurement (ultrasonic test) (if applicable).
* Surface crack test for welding bevel preparation (if applicable).
* Structure test according to VGB Guideline TW 507 for pipes designed for certain life time (creep) (if applicable).
* Hardness testing (if applicable).

**COMPANY** provides a record documentation for each integration point containing tests and results.

# Pressure Testing

## General

The type of test (strength and density, additional leak test), the test method (hydraulic, pneumatic) and the test pressure value are indicated in the design for each pipeline. If there is no indication of the test method and the test pressure, the test method shall be agreed with the client and the test pressure shall be taken in accordance with GOST 32569-2013, GOST R 54892-2012, SP 129.13330.2011, SP 75.13330.2011, SP 74.13330.2011 or LS 133-02 (depending on the type of pipeline).

Only trained and qualified personnel shall be allowed to perform Pressure Tests.

CONTRACTOR is responsible for the planning and safe execution of the testing (e.g. provision of bolts and gaskets required for pressure testing).

CONTRACTOR shall execute special job safety analysis for pneumatic Pressure Test as well for hydrostatic test >10m³ volume.

Before pressure test, all temporary gaskets, bolts or screws and nuts of flange unions shall be removed and replaced by the original gaskets, bolts or screws and nuts specified on the BOM.

Measuring lines are excluded of pressure testing. Measuring lines within cold boxes are counted to piping until the first shutoff.

## Preparation of Pressure Tests

Test area shall be clearly labeled and marked with safety distance.

**COMPANY** will provide the **CONTRACTOR** with a Master test circuit P&ID.

The test pressure, test medium and the test circuit number shall be marked on the isometrics by **CONTRACTOR** prior to the pressure testing.

### Venting and draining

If not already noted on the isometric, for pipes ≥ 2" **CONTRACTOR** shall install on site venting and draining nozzles respectively in accordance with **COMPANY**'s request at high and low points.

### Sensitive equipment

Sensitive plant equipment shall be removed and listed by **CONTRACTOR** on the "List of Dismantled Items per Test System &AZ-W-LX 2404 (EN)) before pressure testing. If test system contains pressure vessels, **CONTRACTOR** shall verify that such equipment can stay in the test system, otherwise they need to be blocked out (use &AZ-W-LX 2404 (EN) too).

Measuring floaters installed inside vessels or float chambers shall be removed or the float chamber shall be shutoff and open to atmosphere.

### Temporary supports

To avoid an overloading by the test medium, locks of spring hanger, spring supports and balance weights shall be arrested. This shall be verified during preparation.

The piping shall be provided with additional support, if required.

**CONTRACTOR** shall consider temporary supports and adjusting spool pieces for pressure testing. Such items may be required if, for example, sensitive plant equipment need to be removed and / or testing of divided test circuits. **CONTRACTOR** shall generate a list showing all Pressure Test caps and temporary pipe supports &AZ-W-LX 2405 (EN)).

### Test blinds / test caps

Compounds which have to be separated from the test systems (e. g. vessels, filters) shall be disconnected at the adjacent pipe or nozzle by **CONTRACTOR** according to test system P&ID. Exceptions have to be clarified with **COMPANY**.

**CONTRACTOR** shall provide blind list showing location and line number for all temporary test blinds used &CG-W-LX 2403 (EN)).

Only temporary test blinds according to LS133-02 shall be used. The test blind location shall be shown in the test system P&ID.

Blinds installed to equipment for protection purpose (rotary equipment, vessels, aluminum plate fin heat exchangers, etc.) shall only be removed on **COMPANY'**s instruction and shall be witnessed by **COMPANY**.

At pipe ends, where no flange is available, the open end shall be closed using a welded-on test cap. The cap shall meet the requirements of the related pipe class. After pressure test, the cap shall be cut from the piping and the welding bevel shall be re-made (refer to paragraph 5.6 herein).

Regarding numbering of test blinds respective test caps on the list &CG-W-LX 2403 (EN), test blinds and test caps shall be distinct by a leading "B" in front of test blind numbers and by a leading "C" in front of test cap numbers.

### Test manometer

At least two calibrated test manometers shall be installed. On demand of COMPANY a pressure-temperature recorder shall be used.

Pressure gauges or remote measuring instruments with the same accuracy over the entire measuring range and the same measuring limits should be used to control the pressure. It is allowed to use pressure gauges (remote devices of accuracy class no more than 1.5), provided that the controlled pressure values must be within the second third of the scale of the pressure gauge (the limit pressure of the pressure gauges should be about 4/3 of the test pressure). When measuring the pressure with two pressure gauges, one must be a control.

One pressure gauge (remote device) is installed at the pressure unit after the shut-off valves, the other - on the air vent at the point of the pipeline, the most remote from the pressure unit.

### Test packages

**CONTRACTOR** shall prepare detailed test system documents / test packages for each individual Pressure Test including the following documents:

* Filled and signed "Punch list" &CG W-SY 9202.005 (EN).   
  Category A points cleared. If no punch points exist, the term "NO PUNCH POINTS" shall be written in the first line of the Punch Point Description section.
* "Check Record L03 – Pressure Test" &CG W-RW 9224.004 (EN).
* Filled and signed "Acceptance Sheet for Orifice Flanges" &AZ-W-QA 2403 (EN).
* Filled and signed "Acceptance sheet for spring -hanger and -support" &AZ-W-QA 2404 (EN).
* Colour marked P&ID (latest revision) showing the test system.
* "List of dismantled items per test system" &AZ-W-LX 2404 (EN).
* "List of Pressure Test Caps and Temporary Piping Supports" &AZ-W-LX 2405 (EN).
* "Blind List per Test System" &CG-W-LX 2403 (EN).
* Isometric drawing(s) AS BUILT.
* "Isometric supplement sheet" &AZ-W-DW 9506 (EN).
* Bill of material AS BUILT for all isometrics and isometric sketches.
* Isometric sketches AS BUILT for all pipelines for which no isometric drawing has been provided.
* Calibration certificates of measure instruments.
* Water analysis (chloride content) if applicable.
* Protocol of chemical composition of water used for hydraulic tests.
* MC documents (ITP, check records, etc.).

## Performance of Pressure Tests

Application of pressure requires approval of COMPANY. The release is carried out after inspection according to chapter 8.2 "Inspection before Pressure Test".

Test systems shall be filled from bottom to top to avoid damage to the installations. Vents must be kept in open position during filling and the system must be completely de-aerated.

Testing of pipelines for strength, density and tightness shall be carried out according to GOST 32569-2013, GOST R 54892-2012, SP 129.13330.2011, SP 75.13330.2011 or SP 74.13330.2011 (depending on the type of pipeline).

Small piping systems shall be pressurized using a hand pump, larger systems with the use of a motor-driven pump. The pump needs to be observed permanently during pressurizing. During the hold-time the pump shall be disconnected from the system.

Exceeding the maximal defined test pressure is not permitted. Special attention shall be given to pressure drops due to external influences e. g. temperature fluctuations due to solar radiation.

All piping joints (welded and other e.g. screwed) shall be left uncovered and uncoated during the pressure test.

### Pressure Testing of equipment items

If plant equipment with several chambers (process streams e.g. heat exchangers), are included in a test system, it shall be ensured that chambers not being subject to the pressure test are open to the atmosphere. The ratio of internal / external pressure for heat exchanger shall be considered. In case of leaks or tube rupture, the neighboring system (chamber) shall be prevented from being pressurized above its operation pressure. This can be assured by opening of a blind flange or a valve to the atmosphere. In case of an opened valve, it shall be locked open during the entire pressure testing.

Coils, aluminum plate heat exchangers, silencer, cold boxes shall not be hydrostatic tested.

Machines (pumps, compressors) shall not be pressure tested.

### Leaks

During Pressure Test, the test system shall be checked for leaks. In case leaks are found, the test must be stopped immediately.

After draining the system, repairs shall be performed as per relevant codes and standards. The use of sealing material and caulking of leaks are not allowed. Re-tightening of leaking flange connections under pressure is strictly forbidden.

The points of repair shall be checked according to specification including NDE, annealing etc. The Pressure Test shall be repeated.

The scan for leaks includes, but is not limited to all screwed connections, welding and brazing joints, no matter if the **CONTRACTOR** was responsible for their execution or not.

## Draining after Pressure Test

**CONTRACTOR** shall ensure that all High- and Low-points (risk of vacuum formation) are open for draining. High-points shall be opened at first. Low-point drains shall be kept in open position for approx. 2 days after draining to allow complete drainage of residual water.

After complete draining, the piping respectively piping system shall be flushed with a clean medium till no coloration of the drained medium can be detected. Afterwards the piping system shall be dried in agreement with commissioning personnel (**COMPANY**).

Vents and drains shall be closed after complete draining of the tested piping systems in accordance with **COMPANY** and after checking for internal dryness.

## Pneumatic Pressure Test

Pneumatic Pressure Test systems shall be kept to a small volume, to minimize the safety risk. The test system shall be equipped with at least one safety valve close to the compressor or the feed-in point. The safety valves must be suitable to vent the whole flow-rate of test medium as the compressor respective the feed-in auxiliary is able to deliver. The safety valve inlet shall be at least one pipe size larger than the feed-in connection. **CONTRACTOR** shall provide calibrated safety valves necessary for the test.

**CONTRACTOR** shall consider a high noise level during depressurisation of the test system and shall take preventive action not to exceed the allowed values of noise.

The usage of non-specified test mediums needs written approval from **COMPANY**. The utilization of N2 requires additional safety procedures.

## Documentation

The successful Pressure Test shall be confirmed by all parties involved by signing the inspection and test record. **COMPANY** will release the test system for follow on work.

The acceptance of Pressure Tests shall be carried out by **COMPANY** and (if specified / requested) by **CLIENT** and /or **THIRD PARTY**.

# Inspections

Intermediate and final inspections shall be executed according to the "Inspection and Test plan (ITP)".

## Intermediate inspections

Intermediate inspections take place during prefabrication / installation. Intermediate inspections are carried out by the **CONTRACTOR** in accordance with **COMPANY** and (if specified / requested) by **CLIENT**, covering the following (but not limited to) activities based on the construction contract including the specified norms and standards:

* Inspection of piping items for correct marking (heat number, ID number, item number, weld seam and welder number)
* Transfer of marking prior cutting
* Positive Material Identification Test, if required
* Visual inspection of welding seams
* Verification of post weld heat treatment
* Verification of non-destructive examination and hardness testing
* Inspection of internal cleanliness of pipes
* Dimensional and routing checks
* Inspection of piping documentation (isometric supplement sheet, certificates of executed NDE)

Prior to the release of piping spools, pipe lines or piping systems to other disciplines (e.g. painting), the Intermediate Inspection including correction of subsequent defects shall be completed.

## Inspection before Pressure Test

**CONTRACTOR** shall (after his own inspection and punch out) notify **COMPANY** that a pipe spool / piping system are installed and ready for inspection. **COMPANY**, **CLIENT** (if applicable) and a **THIRD PARTY** (if required) will carry out the inspection before Pressure Test.

For the release for Pressure Test by **COMPANY**, the following pre-requisites shall be available:

* "AS BUILT" Isometrics, bill of materials (BOM), isometric supplement sheets for prefabrication and field installation, signed by all parties.
* Actual P&ID
* Quality records (welding, non-destructive examination, heat treatment, hardness tests, etc.)
* Filled and signed Punch list (all A points cleared) acc. to &CG-W-SY 9202.005 (EN).

After successful inspection and the Category A1 points (if any) are corrected, the pipe spool / piping system will be released by **COMPANY** for pressure testing.

Pressure testing shall be in compliance with the **COMPANY** Specification for Testing & Inspection of Piping. Test blinds and blind flanges, caps shall be set in accordance with the P&ID's of the test systems.

**CONTRACTOR** is responsible for scheduling pressure testing. Deadlines for notification for **COMPANY**, **CLIENT** and (if specified) a **THIRD PARTY** shall be identified during Kick-Off meeting.

## Construction Completion Inspection – Piping

**CONTRACTOR** shall notify **COMPANY** that the piping system is completed and ready for inspection. **COMPANY**, **CLIENT** and (if specified) a **THIRD PARTY** will carry out the inspection.

Pre-condition for such inspection is:

* Piping system is pressure tested.
* Test medium is drained.
* Test system is dried and cleaned.
* All items dismantled for the Pressure Test are reinstated.
* All punch points are closed.
* Valve locking devices are inspected according to the locking plan (key locking plan) and accepted.

When Construction Completion of Piping is achieved, it will be confirmed by all parties involved by signing the Mechanical Completion Certificate &CG-W-SY 9202.002 (EN).

# Modifications

Changes / modifications of pipelines and vessels require the written approval of **COMPANY** and shall be recorded and transferred into the relevant documents.

The procedure for handling changes and modifications is described in the "Conditions of Contract" (CoC).

# Piping of Air Separation Plants

The information in this chapter applies in addition to the fabrication instructions in chapter 5.

For cleanliness the Linde-Standard LS 141-74 Part 13 and GOST R 54892-2012 shall strictly be followed.

## General fabrication instructions for Cold boxes

Cutting of aluminum shall be performed by sawing and the weld edge preparation shall be done by using SS-grinder or milling. Precautions have to be taken to avoid inner contamination of pipes and or vessels. In case of using plugs, the plugs shall be numbered and shown on drawings / isometric with the information of installation and removal.

All pipeline parts and valves shall be protected from damage and contamination (oil, grease, dirt etc.). All openings must be closed with appropriate material (see LS 141-74 series).

All threaded pipe joints in the cold box which are subject to pressure (e.g. threaded nozzles for measuring lines) shall be sealed with LOCTITE (or similar thread sealant).

Aluminum and stainless steel bolt threads shall be treated with oil-free Molykote powder 'Z' or Teflon spray. The lubricant shall be approved by **COMPANY** before use.

The distance between the outer pipe wall and the outer box shell shall be in accordance with the requirements shown in the drawings / ISO to guarantee the specified insulation thickness and to avoid icing during operation.

Pipe supports shall be manufactured and installed in accordance to the specified Linde standards, isometrics, BOM and detailed drawings (refer to LS 548-01). The space between the supporting pipe, the box wall and the pipe clamp must be stuffed with mineral wool before welding. The pipe and the mineral wool shall be dry.

When welding the Cold box wall penetration plate to the pipe according to LS 493-04, the heat sensitive gasket shall not rest on the aluminum plate, to avoid damage of the gasket.

Internal Cold box-valves shall be installed completely with supports, insulation separator boxes, etc.

Openings in separation boxes of cold valves shall be closed after performance of leak test.

Counter flanges on the internal wall shall be protected in a way that the internal flange is not shifting during the external dismantling of the valves / connection.

## Fabrication instructions for carbon steel piping under oxygen service

Piping under oxygen service shall be prefabricated in spool sizes suitable for internal sand-blasting.

After internal sandblasting and cleaning, the pipe spools shall be installed and welded (root GTAW), cleaned, dried and closed gas tight within short time. At the connection point to the exchanger box, line blinds (suitable for pressure testing and with a gasket on both sides) must be installed and the lines must be flushed / filled with purge gas (e. g. N2 or Argon).

After completion, the system must be pressurized and kept at an overpressure of 0.2 bar dry N2 until start up.

## Oxygen compatible lubricants

The list below shows oxygen compatible lubricants according to BAM (German Federal Institute for Materials Research and Testing) list (List of non-metallic materials, M034e „Oxygen“, 9/2011). For the use in Air separation Plants, Companies approval is required in advance.

|  |  |  |  |
| --- | --- | --- | --- |
| **Lubricant** | **Appearance** | **Maximum use pressure (bar) at 60°C** | **Manufacturer or sales office** |
| Klüberalfa YV 93-1202 | Paste | 450 | Klüber Lubrication, Munich |
| gleitmo 599 | Paste | 430 | Fuchs Lubritec Kaiserslautern |
| Turmoxygen LCO 45 plus | Paste | 450 | Lubricant Consult GmbH, Maintal |
| Turmoxygen LCO 36 | Paste | 360 | Lubricant Consult GmbH, Maintal |
| Zolliker Magnafluor | Paste | 450 | Tribolex Lubricantes, Mexico |
| Krytox NRT 8908 | Paste | 350 | Du Pont |
| Krytox TLF 8908 | Paste | 350 | Du Pont |

1. **Under Ground Steel Piping**
   1. **Installation**

Pipes shall be laid and bedded in excavated trenches true to line and level. Slopes shall be considered, according to SP 74.13330.2011, SP 129.13330.2011.

Before laying of pipes commences, **COMPANY** shall be notified, in advance, for checking of pipe bedding, PE-coating, etc.

Prior to laying, pipes and joint material shall be cleaned internally.

All pipe material shall be inspected before laying. Defective material shall be discarded.

Before lowering in, caps shall be placed on open ends, flanges, etc., which shall remain in place until piping connections, can be made.

All precautions shall be taken to prevent material damage when lowering piping into trenches. Any accidental damage shall be repaired or replaced immediately before lowering piping into trench. Repairs shall only be performed written confirmation from **COMPANY**.

No lowering in shall be undertaken in the absence of the **COMPANY**, who shall be entitled to demand that any piping, which has not fulfilled this condition be removed from the trench, irrespective of the state to which back-filling has progressed.

All lowering in and back-filling operation shall be carried out ensuring minimum damage of PE-coating materials as follows:

* For handling and transport of pipes covered with PE-coating and wrapping, wide and smooth Teflon-lined straps or belts shall be used.
* Before laying the piping, the bottom of the excavated trench shall be checked for possible hard objects, such as stones, which may cause the coating to be scratched or damaged.

Local deviations from the straight line or plane shall be agreed with **COMPANY** in writing.

Pipe sockets may not be placed closer than 0,5 m to manhole, crossing pipe, etc.

Backfilling, including compaction, shall be carried out by Civil CONTRACTOR in accordance with relevant specifications. Backfilling shall only be done after written approval from **COMPANY** is received.

* 1. **Trenches for installation of underground piping**

The width of the trench shall be dimensioned/arranged in a way to provide sufficient work space. Special work space is necessary at field welds for alignment, welding, testing and wrapping purpose.

The trench shall be leveled after excavation in such a way, that sufficient space remains beneath the pipe in order to allow a proper sand filling.

Before installation the trench shall be checked for piping installation in respect to suitability, correctness and safety requirements.

* 1. **Internal coating of UG Piping**

Where required by CATHODIC PROTECTION VENDOR underground piping shall be internally coated. Coating type and application shall be as specified by CATHODIC PROTECTION VENDOR.

* 1. **Polyethylene (PE) Wrapping of UG Piping**
     1. **General**

Wrapping shall be applied to all bare metallic surfaces of components which will be buried underground.

Straight pipe lengths under this specification shall have shop applied polyethylene coating in accordance with DIN 30670.

For handling and transport of pipes covered with PE-coating and wrapping, wide and smooth Teflon-lined straps or belts shall be used.

Pipes with Polyethylene (PE)-coating or wrapping shall be stored using suitable supporting materials and shall be handled carefully throughout storage, prefabrication, installation and trench-backfilling.

Wrapping Manufacturer’s instructions regarding weather conditions under which coating or wrapping may be performed shall be strictly adhered to.

All personnel shall be trained.

* + 1. **Material for coating and wrapping**

**CONTRACTOR** shall select a suitable material for wrapping of UG piping. Selected material shall be reviewed and approved by **COMPANY**.

All material shall be in accordance with the relevant project requirements and specifications.

Material certification and quality assurance shall be in accordance with Reference Documents.

* + 1. **Surface preparation and Application** 
       1. **Surface treatment and Preparation**

Prior to application the surface has to be carefully cleaned and prepared.

The surface shall be free of any rust, moisture, ice, oil, grease, waxes, salts, sulphates, dirt, dust, condensate and all foreign materials.

Cleaning with scrapers and power driven wire brushes is normally sufficient, although shot blasting may be required to remove rust, loose mill scale or foreign matter.

When required, solvents may be used to achieve specified surface cleanliness conditions. The compatibility of selected solvent with the wrapping material shall be confirmed with Wrapping Manufacturer.

Refer to Wrapping Manufacturer’s instructions and DIN 30670 for additional requirements on surface treatment and preparation.

* + - 1. **Primer Application**

Immediately before priming, the entire pipe surface shall be wiped clean using oil-free rags to remove any loose dust present which could interfere with primer adhesion to the pipe.

Surfaces to be primed shall be completely dry.

The primer shall be thoroughly mixed to obtain complete dispersion of the solids. Hand mixing with clean sticks or rods is normally sufficient, but mechanical mixers or shakers may be required. If thinning is necessary, Wrapping Manufacturer’s recommendations shall be followed.

Primer shall be applied according to Wrapping Manufacturer’s instructions, ensuring the pipe is completely and evenly covered.

Primer shall not be applied during periods when dust and sand are likely to settle on it. If sand becomes embedded in the primer the primer shall be removed with a suitable solvent and the area re-primed.

* + 1. **Application of Tape Coating**
       1. **General**

During application, care shall be taken that no moisture penetrates between the metal surface of piping and the applied tape

Wrapping Manufacturer’s standards and instructions shall be adhered to at all times for the application of tape coating.

Proper tension is mandatory for adequate bond, and depends partly on tape and ambient temperatures.

The coating system shall be applied by hand. Hand-held tape tensioning machines are the preferred application method whenever physically possible, as they provide a uniform and correctly tensioned layer.

Sudden changes of contour shall be smoothed out by application of mounding putty to achieve a smooth transition suitable for tape wrapping in accordance with Wrapping Manufacturer’s recommendations.

The correct spiral angle is essential in order to achieve the specified overlap. Adjustment shall never be made by applying uneven tension across the tape width. Uneven tension will result in wrinkles and folds which shall not be acceptable.

Occasionally isolated wrinkles and small blisters may be removed and patched as specified in Wrapping Manufacturer’s specifications. In all other cases, the tape shall be removed and the pipe surface cleaned with solvent and primer and tape reapplied.

Wrapping Manufacturer’s instructions shall be adhered to where the tape wrapping ties into existing coatings.

If taped sections are to be pushed into casing or sleeve or any other such opening, the tape shall be spirally applied in the direction of the push. The outer wrap shall be applied in the same manner than the inner layer. The use of metal banding or wire to hold the outer layer in place shall not be permitted.

Transition areas between underground and above ground piping shall be handled as specified by Wrapping Manufacturer. If a possibility exists for moisture to enter between the pipe and shop applied PE coating, where the PE coating ends, additional measures shall be taken to ensure that no moisture ingress is possible. Such additional measures shall be in accordance with Wrapping Manufacturer’s recommendations and agreed with **COMPANY** in writing.

* + - 1. **Transition from soil to air**

PE wrapping needs only to be applied to areas where the pipe is in contact with the soil. Areas where the pipe is exposed to atmospheric conditions (e.g. valve pits, transitions points between AG and UG) shall be coated with the required corrosion protection system for AG piping as defined in the relevant project specifications.

PE wrapping shall extend past the transition point by at least 150mm.

Where the PE coated/wrapped pipe runs through pipe sleeves it shall be ensured that the shop applied PE coating or site applied PE wrapping is not damaged. The gap between the coated pipe and the sleeve shall be clean and shall be sealed to avoid penetration of water and humidity.

Should the pipe run directly through concrete and/or unpaved areas, additional PE wrapping shall be applied to reinforce existing PE-Coating. The additional PE wrapping shall be applied at least 300mm in each direction of the transition points.

The above shall apply for horizontal transitions (e.g. valve pits) and vertical transitions (e.g. aboveground / underground transitions)

* + - 1. **Cathodic Protection**

Areas where cathodic protection connects to the underground pipe shall be wrapped in accordance with the requirements of the CATHODIC PROTECTION VENDOR. It shall be ensured that no air or moisture can be trapped between the pipe and the wrapping or between subsequent layers of wrapping. A filler material (e.g. mastic or bitumen), as recommended by Wrapping Manufacturer shall be used before the application of wrapping in order to ensure a smooth transition area.

Overlap of wrapping on cathodic protection cables shall be as specified by CATHODIC PROTECTION VENDOR but shall not be less than 50mm. Wrapping Manufacturer’s instructions shall be adhered to.

* + 1. **Inspection and testing** 
       1. **Visual inspection**

Continuous visual inspection shall ensure a correct execution of the corrosion protection during the wrapping process.

* + - 1. **High Voltage (HV) Testing / Holiday Testing**

In addition to the visual inspection, the corrosion protection shall be 100 % tested with a suitable HV-test instrument.

Prior to the start of testing works, the correct function of the test instrument shall be checked at an intentional defective point of the coating.

The test instrument shall be pre-set to the test voltage recommended by the Wrapping Manufacturer. The HV Instrument shall not be set to a higher voltage than recommend by the Wrapping Manufacturer.

The test probe (metal brush) must touch the surface of the jacket, since air gaps may distort the test result. The pipe jacket is considered to be free of defects, if during the HV-tests, no electric sparking is evident.

Attention shall be paid that the required earthing of the HV-test instrument is available; only instruments with trailing earth shall be used.

The speed with which the HV-test instrument moves along the tested piping shall not exceed 300 mm/sec. Stops shall be avoided while the instrument is active.

All defects shall be clearly marked for repair and the results of visual examination and testing shall be recorded.

The HV-test instrument shall only be used for the determination of defective points like air bubbles, gaps, cracks and other defects. It shall not be used for the determination of the thickness of corrosion protection layers.

* + 1. **Patching and Repair**
       1. **Patching**

Patching shall be performed per layer whenever blisters or wrinkles occur. The total number of layers, including overlaps shall be maintained.

Patching shall be performed in accordance with Wrapping Manufacturer’s instructions. If no specific instructions are provided this specification shall be used as a guideline:

Wrinkles or blisters exceeding the following limits shall be treated as defects and repaired in accordance with Wrapping Manufacturer’s instructions.

* Isolated wrinkles (not longer than one-third of the pipe circumference and not more than one (1) wrinkle in five (5) consecutive turns of tape)
* Small blisters not more than 25 mm in diameter,

Small defects falling within the limits specified above shall be repaired as follows if no specific instructions are provided by Wrapping Manufacturer.

* Blisters and wrinkles shall be cut out completely and the adjacent tape smoothed down. One (1) coat of primer shall be applied over the cut and the adjacent tape to cover at least 125 mm beyond the cut tape in all directions. Tape coating shall be applied in accordance with subsection 11.4.3.1.
* Areas where patching has been performed shall be tested in accordance with chapter 11.4.5.2 of this specification.
  + - 1. **Repair**

All coating defects as determined during inspection and testing, inspection holes and all torn, abraded, damaged, mutilated or otherwise defective areas in the pipe coating shall be repaired by **CONTRACTOR** at no extra cost.

All repairs shall be done in accordance with the Wrapping Manufacturer’s recommended repair procedure.

All repairs shall be subject to retesting until the results are satisfactory.

* + 1. **Documentation**

CONTRACTOR shall be responsible for completing form &AZ-W-QA 2604 (EN) - Acceptance sheet – Wrapping of UG Metallic Piping.

1. **Final documentation and quality records**

**CONTRACTOR** prepares the original inspection documents and the required copies during the entire prefabrication and construction phase according to Specification for Testing & Inspection of Piping.

The final documentation consists of:

* Isometrics drawings (As-built) including inspection signatures
* If specified, isometric sketches (As-built) including all required information for piping, for which no BOM has been provided by **COMPANY**
* Isometric supplement sheets (&AZ-W-DW 9506 (EN))
* Bill of material (BOM)
* Quality certificates
* NDE-reports
* Hardness testing reports
* Heat treatment diagrams
* PMI reports
* Pressure Test records
* (if specified) certification of conformity according to pressure equipment directive
* Documentations according to list of turn-over documents for construction

The isometric shall contain prefabrication boundaries and weld number, divided into prefabricated and erection welds.

Only documents of the latest issue shall be used and shall be transferred to "AS BUILT". All documents (incl. referenced documents – reports – records) shall be original, signed and stamped in red with "AS BUILT" and shall be handed over (including all required copies) to **COMPANY**.

Isometrics show the updated routing of pipes in red. The isometric supplement sheet (&AZ-W-DW 9506 (EN)) must be completely filled and signed. The location of additional welds must be recorded with dimensioning on the "AS BUILT" isometrics.

The bill of material (BOM) shall be updated (material- and quantity changes, weight, factors).

Additional to handwritten "AS BUILT" markings, "AS BUILT" information can be shown electronically (e. g. "Eye Sketch Software"). In this case, **CONTRACTOR** has to hand over the electronic files to **COMPANY** as well.