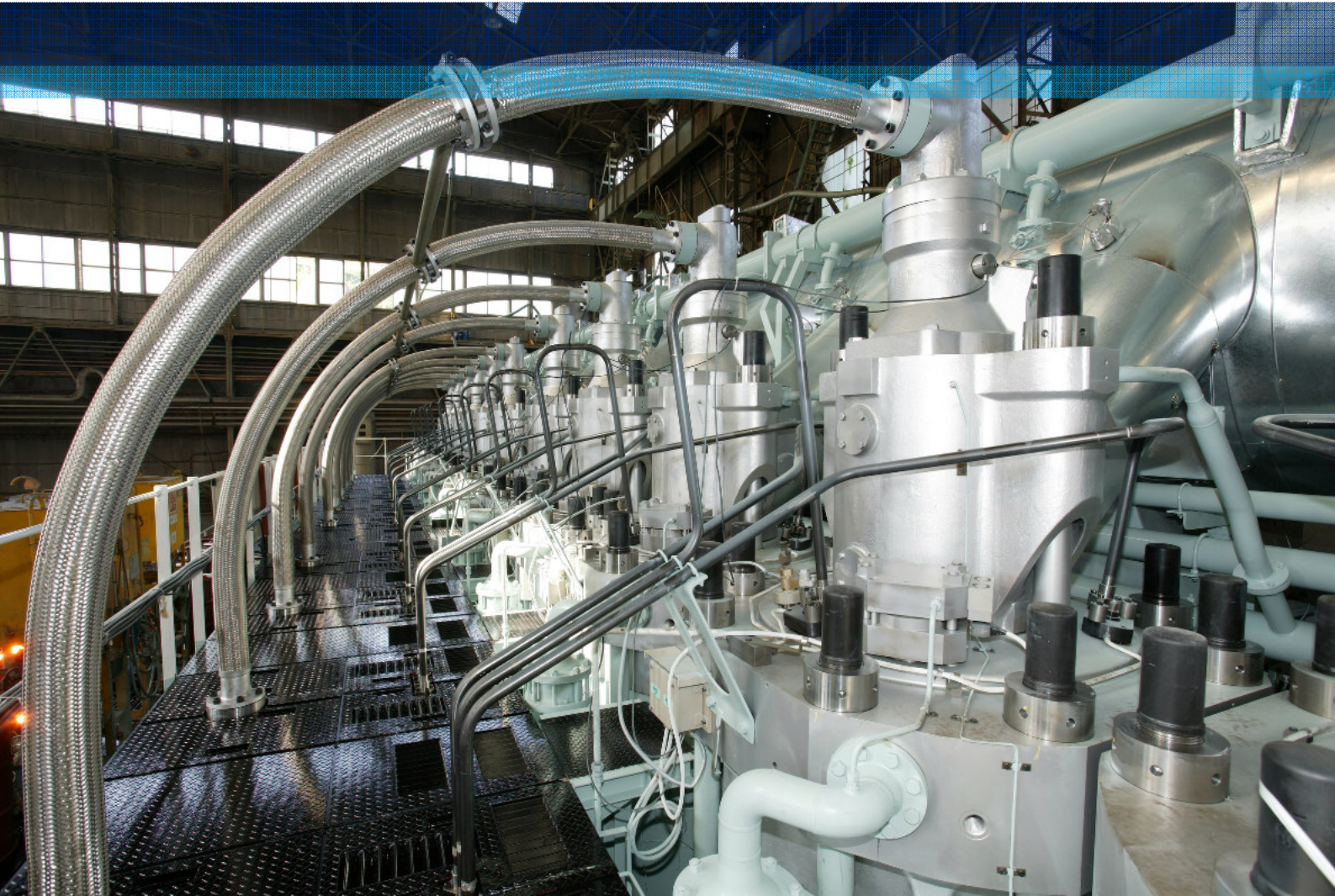




BOA® Group



**Metal Hose and
Metal Hose Assemblies Guide**

- BOA General Information
- Quality Assurance
- Applications
- Design
- Installation Instructions

Module 1

Metal Hose and Metal Hose Assemblies Guide

Modules:

- 1 Metal Hoses, General Information, Installation Instructions**
- 2 BOA Standard Program Metal Hoses (bulk) and Assemblies**
- 3 Annexe/ Standards /Corrosion**

1 Summary

	page
1 Summary	3
2 Metal Hoses General	4
2.1 Metal hose	4
2.2 Corrugated metal hoses – Structure and function	5
2.3 Strip wound metal hoses – Structure and function	6
2.4 Technical terms and notes	7
2.5 Inquiry specifications	8
3 Quality Assurance	10
3.1 Approvals / Certificates	10
3.2 Tests / Laboratory	11
4 Applications	12
4.1 Industrial applications	12
4.2 Aerospace	12
4.3 Rail traffic	12
4.4 Automotive	13
4.5 Solar and boiler industry	13
4.6 Heating – ventilation – air conditioning	14
4.7 Gas production	14
4.8 Food industry	15
4.9 Vacuum applications	15
4.10 Steel industry	15
4.11 Special applications	16
5 Design	17
5.1 Structure and function	17
5.2 Pressure design	18
5.3 Calculation of hose lengths	18
5.4 ISO Standard 10380: 2012 - Excerpt	30
5.5 EN 14585-1: 2006 - Excerpt	30
6 Installation Instructions	31
6.1 General	31
6.2 Handling and installation	31
6.3 Installation to absorb thermal expansion	32
6.4 Installation to compensate for misalignment	33
6.5 Installation to absorb vibrations	33
6.6 Installation through U-bend to absorb movements	34
6.7 Installation instructions for safety gas hoses and LPG metal hoses	35

2 Metal Hoses General

2.1 Metal Hose

Application fields

Metal hoses are an indispensable part of modern technology with its high demands on piping systems for a wide variety of media and temperatures. High flexibility and highest pressure and temperature resistance characterize our product program and allow their use in many areas, notably in heating, plumbing and air conditioning systems, in the oil and gas industry, in the chemical and food industry, in machine and equipment construction, ship building, railway and automotive engineering.

Reasons for the use of metal hoses rather than a solution with rigid tubes:

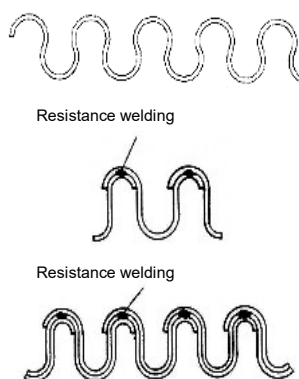
- **Stresses in the pipe system**
Due to stresses in the pipe system may occur
 - assembly inaccuracies
 - thermal expansion
 - vibrations
 - pressure variations
 To compensate for these unwanted stresses, a metal hose assembly provides the following advantages:
 - no pipe ruptures due to fatigue
 - no leaky flange connections
 - no difficulty in replacing pipes having been deformed by high temperatures.
- **Savings in assembly/ disassembly**
 - prefabrication of pipes requires less precision
 - no adjustment work needed on the hose
 - assembly inaccuracies are easy to correct
 - only part of the line must be removed
 - flexible elements are easier to remove and especially to re-install.
 This results in:
 - significant savings in assembly and disassembly of pipe systems
 - higher flexibility in designing the pipe guides and in case of any modifications.

Types of metal hoses

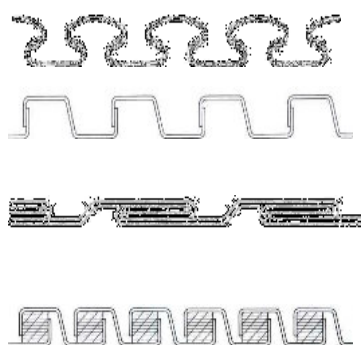
Basically there are two types of metal tubes, differing in structure and application:

- **Corrugated metal hoses** or full (all-) metal corrugated hoses
- **Strip wound metal hoses**, with or without sealing

Corrugated metal hoses



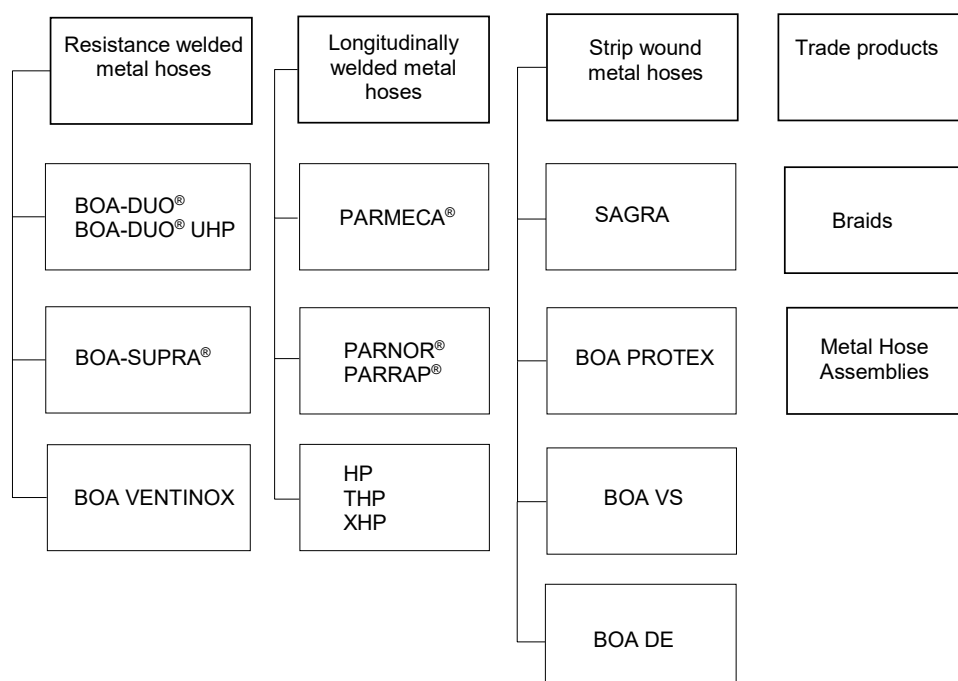
Strip wound metal hoses



Selecting the right metal hose depends on its use.

- **Corrugated metal hoses** are absolutely leak-tight and are appropriate for high pressure and vacuum
- **Strip wound metal hoses** are only of limited leak-tightness and are therefore used mainly as protection, ventilation or aspiration hoses.

BOA Metal hose products: Overview

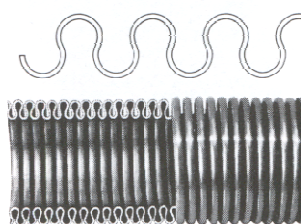


2.2 Corrugated metal hoses – Structure and function

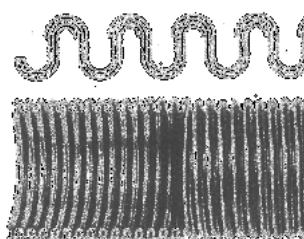
Principle of annular corrugation (parallel)/ helical corrugation (spiral)

Today, the requirements for metallic piping with regard to pressure resistance, temperature, vacuum leak-tightness and corrosion resistance are very high and still increasing. BOA offers a wide range of all-metal hoses meeting these requirements.

There are two types of corrugated metal hoses, which differ by the geometry of the corrugation: annularly corrugated metal hoses (parallel corrugation) and helically corrugated metal hoses (spiral corrugation).



*Annularly corrugated metal hose
(parallel corrugation)*



*Helically corrugated metal hose
(spiral corrugation)*

For the manufacture of corrugated metal hoses, various methods are used:

- **Longitudinally welded corrugated metal hoses**

From a thin metal strip, a tube is formed and longitudinally welded. Then the tube is mechanically or hydraulically formed into a flexible corrugated hose. With this method, parallel and spiral corrugated metal hoses can be manufactured.

- **Resistance welded metal hoses**

A narrow metal strip is formed into a double-S-shaped profile, and then wound around a mandrel in a way that one strip edge is overlapping the next one. The overlapping area is metalically connected by means of roller resistance welding. This method is a BOA invention and only allows the production of helically corrugated metal hoses.

The shape of the corrugation profile is decisive for the metal hose's flexibility. Upon bending, the outer corrugations are stretched and the inner compressed. Depending on the height and width of the profile, the flexibility is changing. Although the reduction of the wall thickness increases the flexibility, at the same time the pressure resistance is reduced.

Braiding

In order to increase their pressure resistance, the corrugated metal hoses get single or multiple braids. The material of the wire netting is usually similar to the corrugated metal hose. For corrosion relevant or economic reasons, however, completely different materials for the corrugated hose and the braid may be chosen. The braiding bears the full mechanical stress which must be absorbed by a metal hose connection. At high pressures, the inherent pressure resistance of the metal hose is almost negligible. The pressure resistance of braided metal hoses is many times higher than of metal hoses without braiding. Ultimately the braid alone is load-bearing.



Braiding machine



Braids made of stainless steel

Pressure and temperature ranges

Corrugated metal hoses can be used for pressures up to 350 bar or vacuum. The temperature resistance is dependent on the material, for stainless steel hoses it is guaranteed up to 600°C. With special materials, even higher temperatures are possible. However, when designing metal hoses, the material-dependent pressure reduction factors must be considered. Applications in the cryogenic range are possible down to approximately -270°C without pressure reduction.

BOA corrugated metal hoses are manufactured with an inner diameter of 5 to 300 mm.



High pressure metal hoses for gas bottles



Use of metal hoses in a waste incineration plant

2.3 Strip wound metal hoses – Structure and function

Principle

Strip wound metal hoses are manufactured by winding up a cold rolled, profiled metal strip onto a mandrel in a helical (spiral)-like way. Due to the profiling, the spirally rotating windings are slidably connected to each other. Thus, high flexibility and elasticity of the strip wound metal hose is achieved.

Sealing

The sealing of the metal hose is mainly made by inserting a sealing thread during the winding process into a specially profiled sealing box. More and more, however, metallic sealed strip wound hoses become important. In this case, the additional sealing thread is completely unnecessary. However, in contrast to the all-metal corrugated hose, the leak-tightness of a strip wound metal hose is always limited and therefore they are not suitable for conveying liquids and gases. They are mostly used as protection hose against outside mechanical influences or as ventilation or aspiration hoses for the transport of lightweight materials.

Material

As basic material, surface-refined steel strips, zinc or nickel plated or chromed are used, as well as stainless steel strips of various quality, or non-ferrous metals such as brass, bronze, tombac, aluminum or aluminum alloys. For sealing, cotton, rubber, fibreglass or thermo-special threads are used. In most cases, BOA products are made of stainless steel, using fibreglass as sealing.

Profile

Strip wound metal hoses are available in round or polygonal cross-sectional shapes, and the profile shapes range from a simple hook profile to the crush resistant double overlapped profile.



BOA DE



BOA PROTEX / SAGRA

2.4 Technical terms and notes

Metal hoses, metal hose

Bulk product without fittings, basic material (semi-finished product) for assembly.

Braid, braiding

Depending on the braiding type, with a wire braid, the pressure resistance can be increased in various steps. This creates a force-fit connection between the fittings mounted on both sides, which, by absorbing the pressure reaction forces, prevent an uncontrolled expansion of the hose assembly. For the braid, high-quality chrome-nickel steel 1.4301 (similar to AISI 304) is used.

End ring

Metal end ring covering the braid extremity, to enable a neat connection between the fitting and the braided metal hose.

Metal hose fitting

Connecting part to integrate the metal hose assembly into the existing pipe system (thread, screw joint, flange, coupling, etc.)

Assembly

Assembly of metal hoses with fittings by welding, soldering or pressing including all associated preparatory and finishing work.

Metal hose assembly

Completely assembled metal hose, with or without braiding, with fittings, tested.

Anti-buckling

Spiral spring or supporting hose, attached to the metal hose ends to reduce the bending stress at the joints between metal hose and fittings.

Protection spiral

Elastic spiral over the entire length of the hose assembly to protect the metal hose and its braid against mechanical damage.

Protection hose

Exterior protection (typically a strip wound metal hose) over the entire length of the hose assembly to protect the metal hose and its braid against mechanical damage.

Nominal size DN

Characteristic parameter of standard diameters. This value approximately corresponds to the inside diameter in mm.

Nominal pressure PN

The nominal pressure rounded down according to EN 1333, resulting from the maximum admissible design pressure.

Nominal length NL

Total length of a metal hose assembly including hose fittings. Permissible length tolerances see section 5.3 "Calculation of hose lengths."

Bend radius

Radius of a circular arc in relation to the hose axis. The ISO 10380 standard distinguishes between the static - for single movement (bending test) - and the dynamic bend radius - for frequent movements and /or pressure pulses (fatigue test). Falling below the minimum bend radius shortens the life of the hose assembly (see section 5, "Design").

Medium

Nature and composition of the material to be conveyed, the hose assembly is determined for.

2.5 Inquiry specifications

While planning the installation of metal hoses and metal hose assemblies ask for technical support. To collect the basic information needed for hose designing, please use the checklist below.

Include, if possible, an installation sketch.

Copy the following checklist if necessary.

Checklist: Metal hoses

Company: _____

Address: _____ ZIP/ town/country: _____

Phone: _____ Fax: _____

Administrator: _____ E-mail: _____

Quantity _____ pcs DN _____ mm NL _____ mm

Hose type: ☐ PARMECA® ☐ PARNOR® ☐ PARRAP® ☐ HP / THP ☐ BOA-DUO® ☐ BOA-SUPRA®
☐ _____ ☐ _____ ☐ _____ ☐ _____ ☐ _____ ☐ _____

Hose material:
☐ 1.4541 ☐ 1.4404 ☐ 1.4571
☐ _____

Braid: ☐ without ☐ with 1 braid ☐ with 2 braids

Connection parts:	1st side	2nd side
Type:	_____	_____
Material:	_____	_____
Remarks:	_____	_____

Other: ☐ anti-buckling ☐ insulation ☐ protection hose
☐ _____

Operating conditions ☐ PED 97/23/EC
☐ Piping ☐ Container

For piping Type of fluid: _____

- ☐ group 1: dangerous gaseous / dangerous liquid
☐ group 2: innocuous gaseous / innocuous liquid

For containers, required customer's indication: Container, category _____

Fluid type: _____ - _____
 Fluid group: _____ - _____
 Inspection authority _____

Maximum working pressure PS: _____ bar ☐ constant ☐ pulsating

Minimum working pressure PS: _____ bar (if also used in vacuum)

Maximum working temperature TS: _____ °C
Minimum working temperature TS: _____ °C (if also used below 0°C)

Installation ☐ straight ☐ 180° bend ☐ 90° bend
Oscillations: ☐ amplitude _____ mm ☐ frequency _____ Hz

Tests: ☐ standard ☐ PED 97/23/EC
☐ special _____

Inspection certificates:
☐ EN 10204-2.2 ☐ EN 10204-3.1
☐ EN 10204-3.2
☐ Conformity declaration according to PED 97/23/EC
☐ Conformity certificate issued by the inspection authority

Designation:
☐ standard ☐ EN 10380
☐ customer's indication
☐ according to PED 97/23/EC

Packaging: ☐ standard ☐ special ☐ customer's indication

Issued by: _____

Date: _____

Signature: _____

Installation sketch:

3 Quality Assurance

3.1 Approvals / Certificates

BOA metal hoses are designed, calculated, manufactured and tested following latest professional and state of the art standards. Regular inspections by accredited authorities for enterprise certification confirm the efficient and professional continuity of BOA process management.

Company approvals



ISO 9001
EN 9100
ISO/TS 16949
Euro-Qualiflex
ISO 3834-2

Quality Management
Quality Management for Aerospace applications
Quality Management for Automotive applications
Quality Management System
Certification as welding company



PED Conformity
Pressure Equipment Directive PED 2014/68/EU
authorized for CE marking

Product approvals

To cover the particular market orientations, we are in possession of the necessary product type approvals, issued by accredited certification authorities.



Deutsche Vereinigung des Gas- und Wasserfaches



American Bureau of Shipping



EN 12434 - Arrêté TMD



Germanischer Lloyd



Bureau Veritas



Det Norske Veritas



Lloyd's Register

3.2 Tests / Laboratory

BOA metal hoses may be subject to various quality tests and inspections. The scope of the testing program follows the requirements and wishes of the customer or the design and production standards, as well as the inspection authority's conditions.

Product quality however is a matter of production standards and not of the subsequent tests. Those tests only confirm the rated required quality level. Therefore our production methods are generally based on a high quality level. Additional tests should be required only where the application imperatively demands it. If in a particular case design evidence is requested, the requirements must be clearly specified for a review of the permissible operating data in our factory.

Non-destructive test methods

- TP - water pressure test
- LT - leak-tightness test with air or nitrogen under water
- LT - leak-tightness test with air and foaming agents at the welds (soap bubble test)
- RT - X-ray test
- PT - dye penetration test
- LT - helium leakage test ($<1 \times 10^{-9}$ mbar l/s)
- VT - visual tests
- hardness test

Destructive test methods

- mechanical strength test
- cupping test
- metallographic investigations
- spectroscopic test
- burst pressure test
- U-bend test (endurance test under pressure)
- vibration test
- Pressure cycle test

Our VT & PT test staff is certified according to EN473 and ASME.

Our test methods

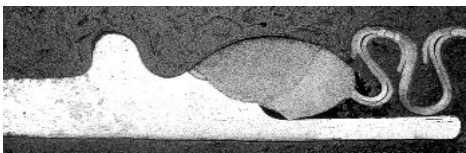
Compared with other leak test methods, the helium test permits detection of the smallest measurable leakage rate so far. Depending on the size of the specimen, it is possible to detect even a leak up to 10^{-9} mbar l/s. There are two different methods used, the vacuum test and the integral test. In the vacuum test, the metal hose is evacuated and blown from the outside with helium. The integral test works exactly the other way round. Here the hose is filled with helium. Using the "sniffer probe" or put in a test chamber, the hose is then controlled from the outside, whether helium is somewhere leaking. A leak is immediately registered by the mass spectrometer and the leak rate may be read from the measuring instrument. An acoustic signal also makes aware of a leak.



U-bend test to determinate the achievable number of cycles



Cross section of a DUO metal hose



Macro cross section of a welding zone



Air-under-water test



Helium leak test

4 Applications

4.1 Industrial applications

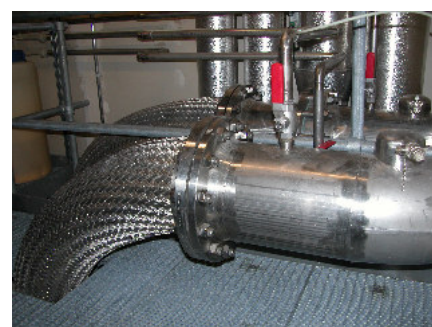
The rapid industrial development means to machinery and electrical equipment ever increasing demands in terms of quality and reliability. Performance, durability, temperature and pressure are increasing; the material is subjected to the uttermost. Increased production and automation do no longer allow operational failures. Therefore functionally reliable hose connections with a long life span are required. All-metal hoses provide best guarantee for it.



Double-walled, helically corrugated and braided metal hoses, from nominal diameter DN 5 to DN 300 have proven to take up vibrations very well. The double-walled hose gives major safety and the corrugations held low result in a small flow resistance. On installation site, they offer great benefits, and their application is simple because the restrictions made for the vibration absorbers regarding reaction forces do not exist. Reaction forces also occur in the metal hoses. But those are absorbed by metal braiding, so that anchor points and vibrating units will not be charged by this thrust.

The BOA metal hose program offers:

- DN 5 to 300
- single and double-walled
- helically or annularly corrugated
- assembled with standard or customer specific fittings
- galvanized or stainless steel design



4.2 Aerospace

In the aerospace industry safety, reliability and efficiency are of highest priority. Today's aerospace technology is subject to constant and rapid changes. Our engineers take up this challenge using their expertise and experience in order to improve continuously the performance and durability of our products.

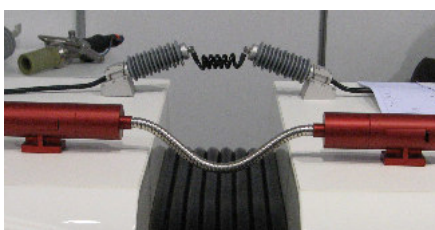


BOA stainless steel hoses are suitable as fuel lines, which are exposed to high temperatures and strong vibration. They are used as flexible hose lines for engine control in modern training aircrafts or as protection of cable controls in large commercial aircrafts of the latest generation. Both in the air and in the space they meet the high quality standards for life span and maintain their functionality even after many years of use.

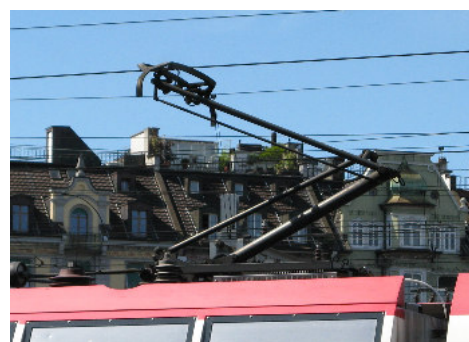
Cable protection for controlling the flaps on the A380

4.3 Rail traffic

BOA's flexible components ensure that at any speed, even under extreme pressure and temperature conditions, mechanical vibrations are safely absorbed. They compensate for thermal expansion and protect sensitive controls and electrical cables. Flexible hose and bellows elements ensure entire cooling and exhaust gas systems. In the rail vehicle technology, where safety, reliability and comfort are of utmost importance, devices, components and systems made by BOA play an important role as quality components at crucial intersections.



BOA metal hose assemblies are used for cooling and air conditioning systems of locomotives, as aeration and ventilation systems for switchgears in high speed trains or as vibration absorbers. Metal bellows make the compensation arch in exhaust systems, expansion joints are used in the turbochargers of diesel locomotives and various special vehicles for rail maintenance. Plastic hoses are used as pantographs for railcars, trams, metropolitan rail, subways, etc.



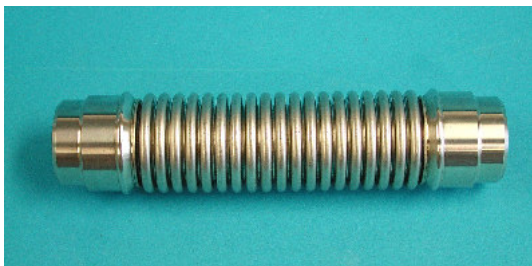
Insulating hoses for pantographs

4.4 Automotive

There is hardly another technical consumer product with as high and as special safety requirements on system partners as the vehicle technology. Often complex tasks have to be solved with the highest standards of quality and process reliability. This challenge is faced by a team of experienced engineers in our development department.

In close cooperation with the customer, the components are developed and designed. To optimize the elements, computer-aided calculation programs are used and extensive, practical tests series are performed.

For a clean environment, more and more metallic filler necks and fuel lines are used, in order to prevent the leakage of methane into the atmosphere and to contribute to the reduction of the greenhouse effect.



Automotive: filler neck



Fuel line

4.5 Solar and boiler industry

The production and use of renewable energy sources, including in particular the solar energy, is growing faster than average in the coming years. Nationwide conditions have been established taking into account this need. Many companies are working successfully in the field of renewable energies, expecting in the near future a much higher than average growth.

Annular corrugated hose assemblies (parallel corrugation) are very suitable for the connection of individual solar panels. The assembly cost is low because the bend radii of annular hose lines can be kept small and assembly may be done on site. This eliminates the inconvenient and expensive soldering and welding work, and thermal expansions caused by temperature variations are compensated.



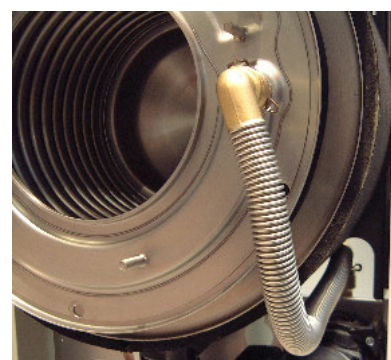
Solar panel connections



- heat exchanger units
- insulated connection lines
- quick couplings for installation on site



Heat exchanger

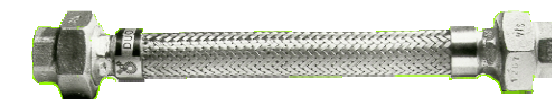
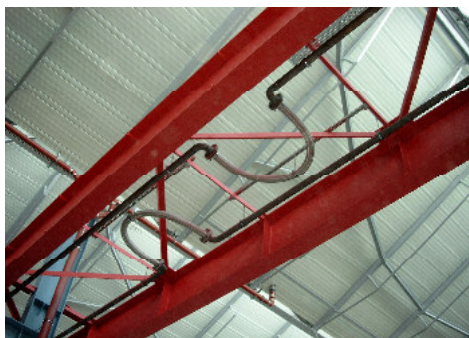


Water supply

In the creation or renovation of residential and business buildings, energy saving standards are nowadays very important. In order to achieve an optimal energy efficiency concept with as much as possible energy production and use, the installation of a properly sized energy storage device is essential. For this purpose, BOA metal hose assemblies with their large surface area are very suitable as refrigerant or heat carrier. They also have proven themselves as flexible connections to auxiliary devices such as accumulators, or as gas lines inside the device.

4.6 Heating - ventilation - air controlling

To save money and time, design and engineering offices increasingly use flexible metal hoses instead of rigid connection elements. Boilers, chillers, dishwashers and washing machines can be easily installed without soldering and welding works. In addition, they compensate for inaccuracies in installation, compensate for thermal expansion caused by temperature fluctuations and avoid vibration and noise transmission. The material being stainless steel, they easily meet the requirements for corrosion resistance, diffusion and aging resistance.



Vibration absorbers JOTA/ KAPPA with screw connections

Compensation through U-bend metal hose assemblies

4.7 Gas production

Thanks to the high quality and absolute reliability of our stainless steel corrugated hoses, they are used for conveying industrial and medical gases under high pressure up to 300 bar, as well as for the transfer of liquefied gases at temperatures down to -271.5°C .

BOA metal hoses have proven to remain leak-tight even in tough conditions and to reliably take up the frequent movements or pressure changes during the filling of gas bottles or gas containers. Also the fittings, highly stressed by frequent assembly and disassembly, withstand the high loads due to excellent quality.

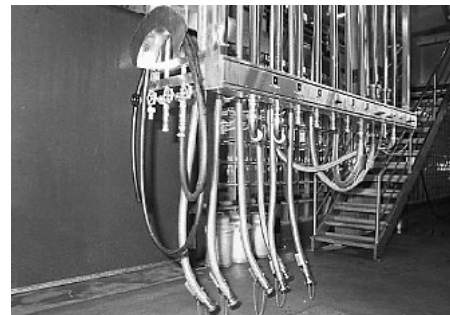
BOA high pressure metal hoses as flexible connecting elements offer:

- high safety level thanks to double-wall corrugation
- high pressure resistance
- high flexibility
- diffusion resistance
- customer specific designs



4.8 Food industry

In the past, the brewery and dairy industries exclusively used rubber or plastic hoses. Their cleaning was considered unproblematic. The big disadvantage was that this quality hoses had to be replaced almost every year due to material aging and therefore no longer guaranteed sterility. After a thorough market investigation, some years ago BOA put a new product on the market, the annular corrugated stainless steel tubing. Tests showed that after rinsing this hose appeared to be bright metal inside. The better cleaning effect after rinsing is on the one hand due to the smooth inner surface, a result of the hydraulic forming process. On the other hand, even though each parallel corrugation represents a real obstacle, a wide, deep corrugation profile avoids inhibiting double vortices. Thus, the rinsing process removes all residues from the corrugations. The asymmetric corrugation profile still guarantees very high flexibility.



In contrast to rubber and plastic hoses, BOA metal hose assemblies may be cleaned with hot steam; they are very flexible and resistant to pressure, ageing and aggressive chemicals. They can be used at high temperatures, are tasteless and have a very favorable price-performance ratio. The abbreviation CIP stands for "Cleaning in Process", i.e. the metal hose line is rinsing itself free while the product is flowing through, and it must not be disconnected for cleaning.

Use of a metal hose assembly in a brewery

4.9 Vacuum applications

Today's standard of living highly depends on the vacuum technology and its process engineering applications. Without vacuum we would not know many achievements of modern life, such as CDs, powerful computers, monitors, coated glasses and window glasses, food packaging, X-ray equipment, high performance microscopes and many other things we take for granted in our daily life.



The flexible connections for the vacuum sector, specially developed by BOA, meet the high quality requirements of high and ultra high vacuum. The connections made of single-annularly corrugated metal hoses made of high quality chrome-nickel steel are designed to make them operating with as little strains as possible on the connecting pieces. They are suitable for taking up axial, lateral and angular movements and for vibrations absorption. Provided with most varying connecting parts, these metal hoses are used e.g. in vacuum furnaces or as capillaries for semiconductor equipment.



CERN: flexible elements on LHC superconductor

Equipped with small flanges ISO-KF, clamping flanges ISO-K, or CF according to DIN 28404, they connect vacuum lines efficiently and in a time saving manner, ensuring high leak-tightness (leakage rate $< 1 \times 10^{-9}$ mbar · l/s).

4.10 Steel industry

The constantly increasing environmental and economic requirements of the steel industry require more and more improved materials and sophisticated welding and assembly techniques to withstand the extreme conditions of high temperatures, pressures and wear factors.

The flexible lance hose systems and expansion joints of BOA have proven themselves in numerous steel mills thanks to their robustness and longevity. BOA metal hoses are successfully used worldwide for injecting oxygen and carbon dust in blast furnaces, or as heavy duty cooling water pipelines.



Oxygen lance for steel plant, DUO® DN250/PN16, length 18 m, produced in one piece

4.11 Special applications

BOA offers a range of services focused on problem solving and performance improvement, including

- application test: performance analysis (dynamic and static) under simulated and real conditions.
- in-house laboratory: mechanical testing, material and failure analysis, consulting on material and welding methods.
- FEM calculations: engineering analysis, including Finite Element Analysis, static analysis

To ensure optimal customer service, each customer is assigned to a BOA service team consisting of engineers, quality managers and customer service staff. These cross-functional teams ensure that all aspects of customer satisfaction are met, from products integrity to delivery and modified designs. As a small and directly addressable team, these people offer a fast, consistent, and personal communication with our customers.

5 Design

5.1 Structure and function

5.1.1 Introduction

For most practical applications, the fatigue life of metal hose assemblies is not an issue. The flexible connection usually achieves easily the life span of the entire plant. Where there are exceptional stresses such as major movements, pressure fluctuations etc., those must be (mathematically) taken into account. If the problem can be captured fairly precisely, in most cases a reasonable design is possible.

Nevertheless, despite ever-improving tools, especially in the field of calculation, it is often not possible to predict exactly the service life or the behavior of a hose. In these cases, it is inevitable to perform (as practical as possible) tests.

5.1.2 Basics

The basics for the design of metal hoses are

- ISO 10380 (valid worldwide)
- various national standards, national validity
- internal standards of the manufacturer, based on years of experience

Many national standards have the ISO 10380 standard as a basis.

5.1.3 Fatigue life

The fatigue life of a hose assembly can be influenced by the following factors:

- flow rate of the medium
- pressure variations (pulsations, water hammers)
- temperature
- installation static/dynamic
- stresses during installation
- environmental influences (damages, improper handling, etc.)

Some of these factors can be influenced by a professional and correct design, others may not be influenced.

Concerning the calculation, the fatigue life depends mainly on the parameters

- working pressure (as a function of temperature)
- movement
- installation radius

These parameters are in the following interdependence:

Fatigue life constant	Parameter to be influenced	Consequence
	higher pressure	- bigger radius - smaller movement
	smaller radius	- lower pressure - smaller movement
	larger movement	- lower pressure - bigger radius
Movement constant	Parameter to be influenced	Consequence
	higher pressure	- lower fatigue life - bigger radius
	smaller radius	- lower fatigue life - lower pressure
	longer fatigue life	- bigger radius - lower pressure
Radius constant	Parameter to be influenced	Consequence
	higher pressure	- lower fatigue life - smaller movement
	longer fatigue life	- smaller movement - lower pressure
	larger movement	- lower pressure - lower fatigue life

5.1.4 Bend radius

The bend radius is an absolutely crucial parameter when it comes to make a statement concerning fatigue life in case of movements. It is regulated by the ISO 10380 standard. In this norm, metal hoses are divided into four different types:

- type 1-50: corrugated metal hoses of high flexibility with high fatigue life
- type 1-10: corrugated metal hoses of high flexibility with medium fatigue life
- type 2-10: corrugated metal hoses of average flexibility
- type 3: corrugated metal hoses where only pliability is required

Excerpt from ISO Standard 10380:

"Corresponding radii for pliability tests are given in Table 6 and corresponding radii for fatigue tests are given in Table 8".

In the technical documentation, the static (R_{static}) and dynamic radii ($R_{dynamic} = R_N$) are listed. When designing, the correct radius must be selected depending on the application.

5.2 Pressure design

Also the pressure design is generally based on the ISO 10380 standard. It defines that the burst pressure must be 4 times higher than the nominal pressure. However, in certain circumstances and together with the customer, a compromise might be found (e.g. the pressure peak must not necessarily correspond to the design pressure). In any case, **always precise knowledge of operational data is needed** to create the conditions for optimum pressure design.

The pressure design is mainly influenced by 3 parameters:

- working pressure
- working temperature $\vartheta_{working}$ (\Rightarrow thermal derating factor k_t)
- operating behaviour (\Rightarrow dynamic derating factor k_d)

Calculation of the admissible working pressure

Taking into account all operational factors, the admissible working pressure $p_{max adm}$ is calculated as follows:

$$p_{max adm} = PN \cdot k_t \cdot k_d$$

PN: theoretical maximum operating pressure according to the catalogue tables

k_t : temperature derating factor

k_d : dynamic derating factor

Temperature derating factor k_t

The temperature derating factors for materials and temperatures may be taken from ISO 10380 (Table 3 - Derating factors and limiting temperatures). Below is an excerpt of the mentioned table. If the corrugated hose and the braid are not made of the same material, the lowest value must be taken.

k_t		Working temperature [°C]													
		-200	20	50	100	150	200	250	300	350	400	450	500	550	600
Material	1.4301	1	1	0.90	0.81	0.76	0.72	0.69	0.65	0.63	0.61	0.59	0.59	0.58	o.r.
	1.4404	1	1	0.92	0.83	0.78	0.74	0.7	0.67	0.64	0.62	0.61	0.60	0.59	o.r.
	1.4541	1	1	0.88	0.74	0.67	0.62	0.58	0.54	0.52	0.50	0.48	0.47	0.47	o.r.
	1.4571	1	1	0.88	0.73	0.66	0.60	0.56	0.52	0.50	0.48	0.47	0.46	0.42	o.r.

o.r. = on request

Dynamic derating factor k_d

k_d	Movement	
Flow	Uniform, frequent movements, oscillations of small amplitude	Impact movements, oscillations of large amplitude
Static or slow and uniform flow	1.00	0.80
Pulsating and irregular flow	0.80	0.50
Pressure shocks, pulsating flow	0.50	o.r.

o.r. = on request

5.3 Calculation of hose lengths

Recognizing the stress

The most important factor in calculating hose lengths is to recognize the stress and the subsequent evaluation of the installation situation. The investigations often end with the set of movement directions and the movements' size. Most of time, a crucial factor is forgotten, that is the movements' **frequency** and their **speed**. Is it really a movement at a given frequency or is it just a slowly occurring expansion?

Example: A slow movement, taking place only 2 times a week, may well be treated as a thermal expansion. This in turn has consequences for the hose length, etc.

Installation positions should be laid out whenever possible according to installation principles.

(see sector 6 "Installation Instructions")

Principle:	In calculating the hose length, for all dynamic tasks, always the dynamic bend radius r_{dyn} must be used, thus also for thermal expansions.
-------------------	--

To simplify the subsequent equations, first the length „l“ of the connection area is calculated.

Length of connection area l

$$l = EH + A$$

In the subsequent equations the dimension „l“ will appear. This dimension defines the length of the connection area (l). It is calculated from the length of the end ring (EH) and the protruding length (A) of the fitting.

Length of end ring EH:

The end sleeve/end ring protects the weld area from overstraining. The length EH (mm) for the calculation of the length l of the connection area may be taken from the table below:

DN	5	6	8	10	12	16	20	25	32	40	50	65	80	100	125	150	175	200	250	300
EH	16	16	20	20	24	24	28	28	34	34	42	42	54	54	30	30	40	40	50	50

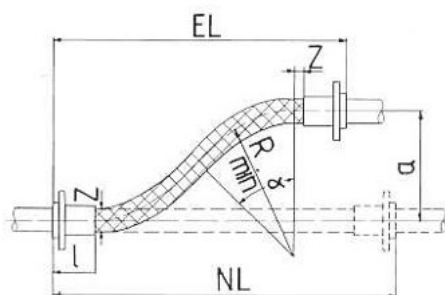
Length of fitting A:

The protruding length A (mm) of the concerned fitting can be taken either from the technical data sheet „Fittings to BOA Metal Hoses“ or from the „Metal Hose Guide“, Module 2, chapter 3).

5.3.1 Straight metal hose assembly for parallel installation offset (static)

(Movements perpendicular to the hose plane are not permitted)

Installation type: straight metal hose assembly
Application: lateral installation offset
singular lateral bending
(not for repetitive movement absorption!)



Equations:

$$\cos \alpha = 1 - a / (2 \cdot R_{static})$$

cos α must not be ≤ 0.5 , otherwise the radius $R > R_{static}$ must be taken.

$$NL = 0.035 \cdot R_{static} \cdot \alpha + 2 \cdot (Z + l)$$

$$EL = 2 \cdot R_{static} \cdot \sin \alpha + 2 \cdot (Z + l)$$

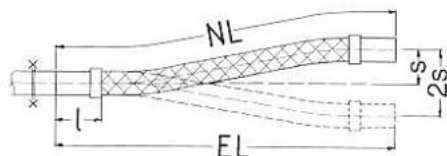
Symbols:

a:	offset from the axis	(mm)
α :	bend angle	(°)
R_{static} :	static bend radius	(mm)
Z:	outside diameter of the metal hose	(mm)
l:	length of the hose fitting	(mm)
NL:	nominal length	(mm)
EL:	installation length	(mm)

5.3.2 Straight metal hose assembly for lateral movements

(Movements perpendicular to the hose plane are not permitted)

Installation type: straight metal hose assembly
Application: lateral installation offset
 - low amplitude (max. $\pm 100\text{mm}$)
 - low movement frequency



Equations:

$$NL = 4.5 \cdot (R_{\text{dynamic}} \cdot s)^{1/2} + 2 \cdot (DN + l)$$

$$s = (NL - 2 \cdot l) \cdot 2 / (20 \cdot R_{\text{dynamic}})$$

$$EL \cong NL \cdot (1 - 0.15 \cdot s / NL)$$

$$\text{Minimum nominal length } NL_{\text{min}} = 7 \cdot s + 2 \cdot l$$

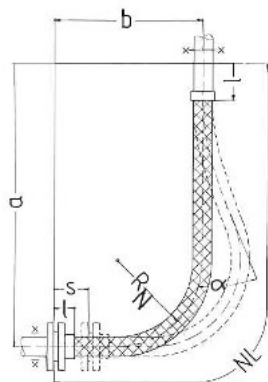
Symbols:

s:	lateral expansion absorption	(mm)
R_{dynamic} :	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l:	length of the hose fitting	(mm)
NL:	nominal length	(mm)
EL:	installation length	(mm)

5.3.3 90° Metal hose assembly for lateral expansion absorption from one direction

(Movements perpendicular to the hose plane are not permitted)

Installation type: 90° metal hose assembly
Application: lateral expansion absorption in 1 axis
 - low amplitude (max. $\pm 100\text{mm}$)
 - low movement frequency



Equations:

$$\cos \alpha = 1 - s / (2 \cdot R_{\text{dynamic}})$$

The angle α must not exceed 60°!
 $\Rightarrow \cos \alpha$ must be ≥ 0.5 , otherwise the
 radius $R > R_{\text{dynamic}}$ must be taken.

$$NL = R_{\text{dynamic}} \cdot (1.57 + 0.035 \cdot \alpha) + 2 \cdot (DN + l)$$

$$a = R_{\text{dynamic}} + (2 \cdot R_{\text{dynamic}} \cdot \sin \alpha) + DN + l$$

$$b = R_{\text{dynamic}} + R_{\text{dynamic}} \cdot (0.035 \cdot \alpha - 2 \cdot \sin \alpha) + DN + l$$

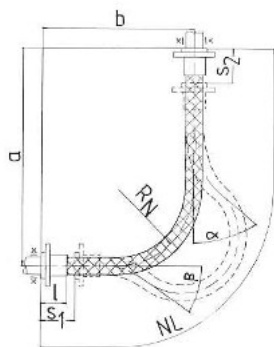
Symbols:

s:	expansion absorption lateral	(mm)
a:	installation dimension 1	(mm)
b:	installation dimension 2	(mm)
l:	length of the hose fitting	(mm)
α :	bend angle	(°)
R_{dynamic} :	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
NL:	nominal length	(mm)

5.3.4 90° Metal hose assembly for lateral expansion absorption from two directions

(Movements perpendicular to the hose plane are not permitted)

Installation type: 90° metal hose assembly
Application: lateral expansion absorption in 2 axes
 - low amplitude (max. $\pm 100\text{mm}$)
 - very low frequency



Equations:

$$\cos \alpha = 1 - s_1 / (2 \cdot R_{\text{dynamic}})$$

$$\cos \beta = 1 - s_2 / (2 \cdot R_{\text{dynamic}})$$

The angle α must not exceed 60°!
 $\Rightarrow \cos \alpha$ must be ≥ 0.5 , otherwise the
radius $R > R_{\text{dynamic}}$ must be taken.

$$NL = R_{\text{dynamic}} \cdot (1.57 + 0.035 \cdot \alpha + 0.035 \cdot \beta) + 2 \cdot (DN + l)$$

$$a = R_{\text{dynamic}} + R_{\text{dynamic}} \cdot (2 \cdot \sin \alpha + 0.035 \cdot \beta - 2 \cdot \sin \beta) + DN + l$$

$$b = R_{\text{dynamic}} + R_{\text{dynamic}} \cdot (2 \cdot \sin \beta + 0.035 \cdot \alpha - 2 \cdot \sin \alpha) + DN + l$$

Symbols:

s_1 :	expansion absorption 1 lateral	(mm)
s_2 :	expansion absorption 2 lateral	(mm)
a :	installation dimension 1	(mm)
b :	installation dimension 2	(mm)
l :	length of the hose fitting	(mm)
α, β :	bend angle	(°)
R_{dynamic} :	dynamic bend radius	(mm)
DN :	nominal diameter	(mm)
NL :	nominal length	(mm)

5.3.5 U-bend to take up expansions from one direction

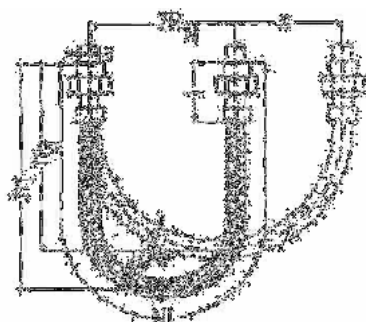
(Movements perpendicular to the hose plane are not permitted)

Installation type: vertical 180° bend

Application: absorption of expansion from 1 direction (e.g. thermal expansion)

- big amplitude

- very low movement frequency



Equations:

$$NL = R_{dynamic} \cdot \pi + 1.57 \cdot s + 2 \cdot l$$

$$h_{1 \max} = R_{dynamic} + 0.785 \cdot s + l$$

$$h_{2 \min} = R_{dynamic} + 0.5 \cdot s + l$$

Symbols:

s:	movement	(mm)
$R_{dynamic}$:	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l	length of the hose fitting	(mm)
NL:	nominal length	(mm)
h_1 :	maximum height of the 180° arc	(mm)
h_2 :	minimal height of the 180° arc	(mm)

5.3.6 U-bend to take up expansions from two directions

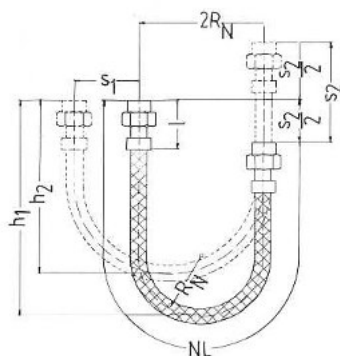
(Movements perpendicular to the hose plane are not permitted)

Installation type: vertical 180° bend

Application: absorption of expansions from 2 directions (e.g. thermal expansion)

- big amplitude

- very low movement frequency



Equations:

$$NL = R_{dynamic} \cdot \pi + 1.57 \cdot s_1 + 0.5 \cdot s_2 + 2 \cdot l$$

$$h_{1 \max} = R_{dynamic} + 0.785 \cdot s_1 + 0.5 \cdot s_2 + l$$

$$h_{2 \min} = R_{dynamic} + 0.5 \cdot s_1 + l$$

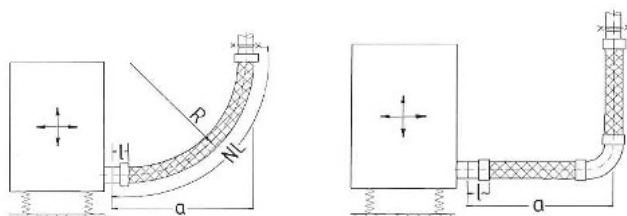
Symbols:

s ₁ :	movement (horizontal)	(mm)
s ₂ :	movement (vertical)	(mm)
R _{dynamic} :	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l	length of the hose fitting	(mm)
NL:	nominal length	(mm)
h ₁ :	maximum height of the 180° arc	(mm)
h ₂ :	minimal height of the 180° arc	(mm)

5.3.7 90° bend to take up vibrations

Installation type: 90° metal hose elbow or
90° dog-leg

Application: vibrations from all directions
- small amplitude
- high frequency



Equations:

$$NL = 2.3 \cdot R_{\text{dynamic}} + 2 \cdot l$$

$$a = 1.365 \cdot R_{\text{dynamic}} + l$$

Symbols:

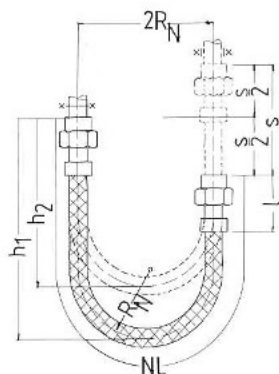
a:	leg length	(mm)
R_{dynamic} :	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l:	length of the hose fitting	(mm)
NL:	nominal length	(mm)

5.3.8 U-bend for vertical movement

(Movements perpendicular to the hose plane are not permitted)

Installation type: vertical 180° bend

Application: vertical movement
- big amplitude
- low movement frequency



Equations:

$$NL = 4 \cdot R_{dynamic} + 0.5 \cdot s + 2 \cdot l$$

$$h_{1 \max} = 1.43 \cdot R_{dynamic} + 0.5 \cdot s + l$$

$$h_{2 \min} = 1.43 \cdot R_{dynamic} + l$$

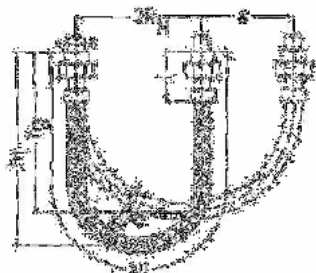
Symbols:

s:	movement	(mm)
$R_{dynamic}$:	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l	length of the hose fitting	(mm)
NL:	nominal length	(mm)
h_1 :	maximum height of the 180° arc	(mm)
h_2 :	minimal height of the 180° arc	(mm)

5.3.9 U-bend for horizontal movement

(Movements perpendicular to the hose plane are not permitted)

Installation type: vertical 180° bend
Application: horizontal movement
 - big amplitude
 - low movement frequency



Equations:

$$NL = 4 \cdot R_{dynamic} + 1.57 \cdot s + 2 \cdot l$$

$$h_{1 \max} = 1.43 \cdot R_{dynamic} + 0.785 \cdot s + l$$

$$h_{2 \min} = 1.43 \cdot R_{dynamic} + 0.5 \cdot s + l$$

Symbols:

s:	movement	(mm)
$R_{dynamic}$:	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l	length of the hose fitting	(mm)
NL:	nominal length	(mm)
h_1 :	maximum height of the 180° arc	(mm)
h_2 :	minimal height of the 180° arc	(mm)

5.3.10 U-bend for vertical and horizontal movement

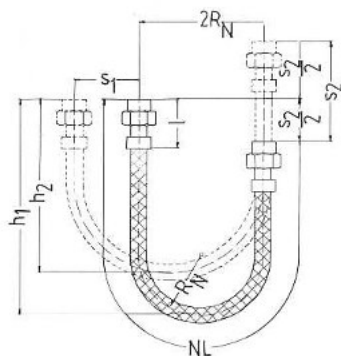
(Movements perpendicular to the hose plane are not permitted)

Installation type: vertical 180° bend

Application: vertical and horizontal movement

- big amplitude

- low movement frequency



Equations:

$$NL = 4 \cdot R_{dynamic} + 1.57 \cdot s_1 + 0.5 \cdot s_2 + 2 \cdot l$$

$$h_{1 \max} = 1.43 \cdot R_{dynamic} + 0.785 \cdot s_1 + 0.5 \cdot s_2 + l$$

$$h_{2 \min} = 1.43 \cdot R_{dynamic} + 0.5 \cdot s_1 + l$$

Symbols:

s_1 :	movement (horizontal)	(mm)
s_2 :	movement (vertical)	(mm)
$R_{dynamic}$:	dynamic bend radius	(mm)
DN:	nominal diameter	(mm)
l	length of the hose fitting	(mm)
NL:	nominal length	(mm)
h_1 :	maximum height of the 180° arc	(mm)
h_2 :	minimal height of the 180° arc	(mm)

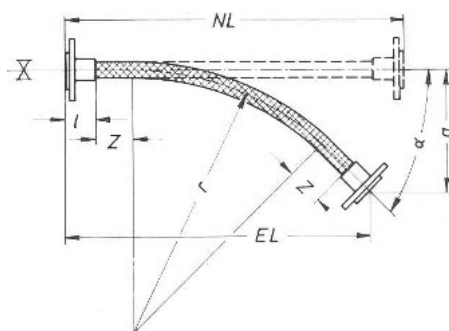
5.3.11 Straight metal hose assembly for angular movement

(Movements perpendicular to the hose plane are not permitted)

Installation type: straight metal hose assembly becomes elbow

Application: angular movement in one plane

- big amplitude
- low movement frequency



Equations:

$$NL = (R_{dynamic} \cdot \pi \cdot \alpha) / 180 + 2 \cdot (l + z)$$

$$EL = R_{dynamic} \cdot \sin \alpha + (l + z) \cdot (1 + \cos \alpha)$$

$$a = R_{dynamic} \cdot (1 - \cos \alpha) + (l + z) \cdot \sin \alpha$$

Symbols:

α :	bend angle	(°)
z :	additional length for hose ends	(mm),
	see table below	
a :	distance of the bend	(mm)
$R_{dynamic}$:	dynamic bend radius	(mm)
DN :	nominal diameter	(mm)
l :	length of the hose fitting	(mm)
NL :	nominal length	(mm)
EL :	installation length	(mm)

Nominal diameter DN	≤ 12	16 - 25	32 - 40	50 - 65	80-100	125-150	200-300
Add. length z	25	50	75	100	150	200	300

5.4 ISO Standard 10380: 2012 – Excerpt

Title: Pipework — Corrugated metal hoses and hose assemblies

Excerpt: The International Standard ISO 10380:2012 specifies the minimum requirements for the design, manufacture, testing and installation of corrugated metal hose and metal hose assemblies.

It specifies the range for the nominal sizes from DN 4 to DN 300, the pressure range from PN 0.5 to PN 450, the derating factors of pressure at elevated temperatures, three hose types with different types of flexibility/ fatigue life of hose assemblies.

5.5 EN 14585-1: 2006 – Excerpt

Title: Corrugated metal hose assemblies for pressure applications

Excerpt: EN 14585-1 characterizes the specific properties of a corrugated metal hose assembly

- by the mutual effect of their pressure bearing parts: corrugated metal hose, braid, connecting parts and non-detachable connections, and
- by the opposing requirements on pressure resistance and flexibility.

This standard describes the experimental design method (basis PED Annex I, Section 2.2.2)

6 Installation Instructions

6.1 General

The metal hose must be protected from mechanical damages such as

- damaging of braid wires
- sharp buckling
- dragging the metal hose on the floor
- dragging it across sharp edges

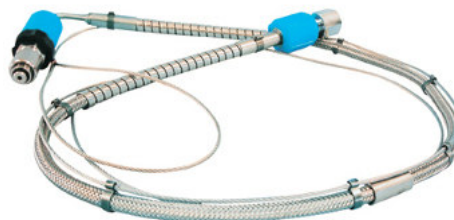
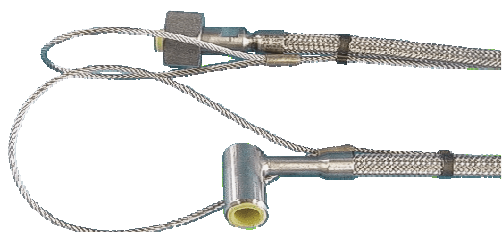
While installing, make sure that no torsional forces act on the metal hose assembly

- torsion leads to early failure

Under extreme mechanical stress conditions or at high temperatures the metal hose assembly must be equipped with one of the following outer protective tubes or accessories:

- protection hose C150 *
- protection hose Sagra *
- wire spiral
- fire protection hose (high temperature applications)
- safety cable (high pressure applications)

* for further information see sector 2.3 Strip wound metal hoses



High pressure metal hose assemblies with safety cable

The metal hose assemblies must be protected against corrosive environment (chlorides, etc.). In extreme conditions, the following measures are necessary:

- outside leak-tight metal hose made of highest quality material (e.g. Incoloy)
- fire protection hose
- design relevant measures

The figures below illustrate some examples of incorrect metal hose assembly installations, frequently found in practice, and how this can be easily corrected. In case of uncertainty, please contact our experts.

6.2 Handling and installation

Example 1

Lay the metal hose straight and uncoil it to avoid torsion and to fall below the minimum bend radius.

correct



incorrect



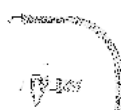
Example 2

Use a saddle or a roller to avoid buckling and, as a result, the hose from falling below the minimum bend radius.



Example 3

Install the metal hose in neutral position. Torsion leads to early failure. Therefore, as a rule, the metal hose should have one movable connection end.



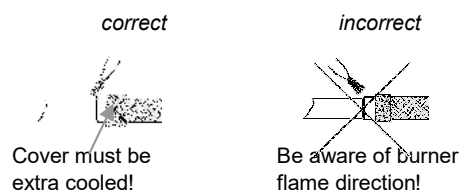
Example 4

Tighten screws evenly crosswise to obtain better sealing.



Example 5

While installing a corrugated hose system through welding or soldering, make sure that the soldering point between fitting and hose is protected and cooled by a very wet cloth. The open flame must always be directed away from the hose system. No solder paste containing chloride shall be used.



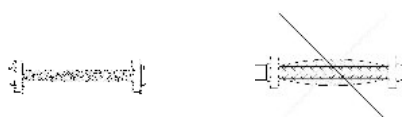
Example 6

For manual use the hose fitting must be protected from bending. If necessary use a rigid pipe elbow.

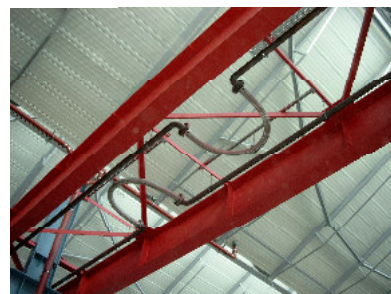


Example 7

Don't install the hose system in compressed position. The braid shall not shift from the hose.



Coiled metal hose (ill. to example 1)

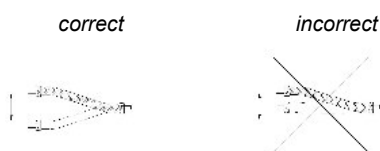


Installation as a U-bend (ill. to example 12)

6.3 Installation to absorb thermal expansion

Example 8

Install the metal hose with lateral prerestraint to make use of the permissible movement. Avoid compression.



Example 9

The metal hose must be installed perpendicular to the expansion direction. The hose must only absorb lateral, no axial movements.



Example 10

If large lateral movements occur, install in a 90° bend.



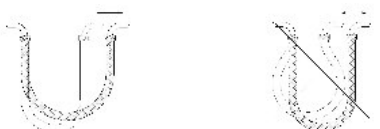
Example 11

Movements may only be absorbed in one plane, the hose direction. Strictly avoid torsion.



Example 12

If large axial movements are to be absorbed, install the hose in a U-bend to protect it from buckling. In any case, the hose must be connected via pipe elbow to the piping system.



6.4 Installation to compensate for misalignment

Example 13

Calculate the exact hose length to avoid hose buckling or overstretching.

Example 14

The hose is too long.

Example 15

The hose is too short.

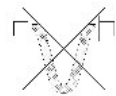
Example 16

The misalignment must not be too large.

correct



incorrect



Metal hose assembly extendable to double length (DTFlex)

6.5 Installation to absorb vibrations

Example 17

The metal hose shall be installed perpendicular to the occurring vibrations in order to avoid compression of the metal hose in service.

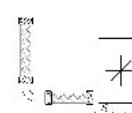
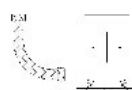
Example 18

If vibrations occur in two directions, the metal hose shall be installed in a 90° bend.

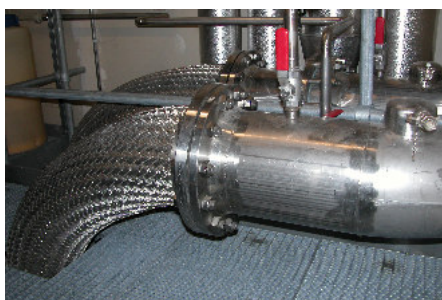
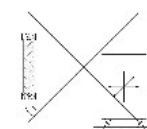
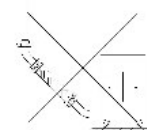
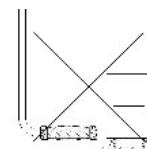
Example 19

If vibrations occur in three directions, two hose assemblies are to be installed in a 90° display by a rigid elbow.

correct



incorrect



Vibration absorbers in service

6.6 Installation through U-bend to absorb movements

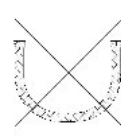
Example 20

Calculate exactly the nominal hose length in order not to fall below the dynamic bend radius, which would shorten its fatigue life (for bend radii see technical data sheet „Technical Information Metal hoses and metal hose assemblies“).

correct



incorrect



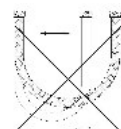
Example 21

For correct connection always use pipe elbows to protect the hose from overbending.



Example 22 +23

Movement is only allowed in the hose axis to avoid torsion which leads to early failure.



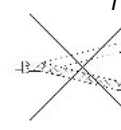
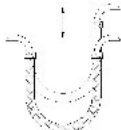
Torsion



Torsion

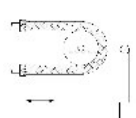
Example 24

Installation of a U-bend system for lateral movements.



Example 25

If horizontally installed, the hose weight (medium filled) has to be supported, e.g. through roller or support.



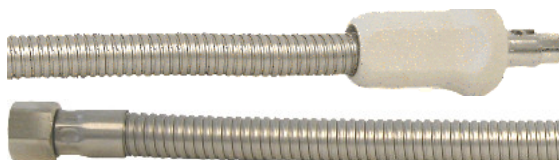
6.7 Installation instructions for safety gas hoses and LPG metal hoses

The following instructions must strictly be observed:

- Always install the gas hose behind a shut off device.
- The gas metal hose has to be controllable over its whole length and the layout must provide easy replacement.
- It has to be protected against excessive mechanical stress.
- While installing, any torsion has to be avoided.
- Keep a sufficient distance between metal hose and heating source to avoid overheating.
- Never connect a metal hose to the gas appliance without metallic sealing or special gasket.
- Never fall below the following bend radii:
Safety gas hoses: static: 45 mm; dynamic: 125 mm
LPG hose assemblies: static: 32 mm; dynamic: 100 mm
- Coupling two or several gas metal hoses together is not permitted.
- Never repair damaged gas metal hoses; they must be replaced.
- Fix connections of gas metal hoses may be subject to unintentional unscrewing movement due to excessive motion of the appliance and the resulting torsion. Avoid such movements which could also damage the metal hose.

Additional rules for **safety gas hoses**:

- Check the tightness of the gas connection with soapy water (or equivalent).
- Never disconnect fix gas connections (not equipped with safety gas plug) without correct interruption of the gas supply.
- Movable gas appliances should be connected by hoses provided with a safety gas plug which automatically cuts the gas supply in case of decoupling.



Gas metal hose assembly provided with safety gas plug



Gas plug with shutoff valve

