KIO MANHOLE COVER MANUFACTURED IN KINEXT™ COMPOSITE MATERIAL

POLIECO® GROUP | KIO® the Kinext™ manhole cover

TECHNICAL MANUAL

2020

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Polieco Group is a European leading company for the production and marketing of double wall corrugated high-density polyethylene (HDPE) piping systems. The first-ever Italian manufacturer of corrugated polyethylene conduits intended for electrical and telephone systems, Polieco Group has been operating since 1992 and in 1995 it started manufacturing corrugated pipes for non-pressure sewer systems.

Today, Polieco Group is an international entity relying upon several production sites located in Italy, France, Greece, and Slovakia.

In 2010 Industrie Polieco-MPB developed a project for the production of composite manhole tops to become a valuable alternative to road manhole tops made of ductile iron (spheroidal graphite cast iron), grey cast iron (cast iron with lamellar graphite) or concrete. Over the latest years, the European market has been flooded by cast-iron products from Asian countries, sometimes of dubious quality. In the meantime, several small manufacturers of composite manhole tops entered the market as they understood composite material potential: some of them developed homemade-level production methods without guaranteeing repeatability of load bearing capacity characteristics, while others offer niche products.

In February 2012 Industrie Polieco-MPB firstly introduced KIO® to the world market – its composite manhole top is manufactured in classes and sizes similar to the cast-iron manhole tops in compliance with provisions set forth under EN124 standard. In March 2012 KIO® manhole top was certified in compliance with EN 124:1994 standard provisions and then with EN 124-5:2015 standard.

Industrie Polieco-MPB organization is based on Management Systems, which have been integrated one another and today consolidated in all corporate areas, developed and then certified in compliance with ISO 9001 (Quality Management Systems), ISO 14001 (Environmental Management Systems) and OHSAS 18001 (Occupational Health and Safety Management Systems) international standards.

This technical manual is intended for project designers and users from both public and private sectors, and provides details about product and raw materials, reference standards, tests carried out on manhole top, besides describing benefits offered by KIO® manhole top compared to cast-iron manhole tops.

Cazzago San Martino, July 2020

CHAPTER 1. OVERVIEW

The search for lightness in manhole tops – a product that has always been considered necessarily heavy – combined with high mechanical strength and service life resulted in KIO®, the ground-breaking manhole top that overturns obvious concepts and simplifies life: enhanced handling, installation and maintenance, increased transport capacity, minimized environmental impact, excellent mechanical properties and chemical resistance.

Over the last decades, composite material has stood out among other materials in aerospace and automotive applications and its use spread in several sectors thanks to the combination of higher lightness, strength, and durability it offers compared with traditional materials (cement and ferrous metals).

Since 2012 Industrie Polieco-MPB has been developing and manufacturing

the unique manhole top made of composite material.

CHAPTER 2. COMPOSITE MATERIAL

Composite materials are a combination of at least two materials with different chemical properties and are characterized by chemical-physical characteristics different from the individual components: in particular, if compared with traditional materials, composite materials are light and strong at the same time, corrosion and chemical resistant, besides offering high thermal and electrical insulation capability.

KIO® manhole top is made of Kinext™, a composite material reinforced by long fibres duly distributed inside a thermosetting resin matrix. Thermosetting resins are polymers that once produced result in insoluble and unmeltable products. Insolubility and unmeltability derive from the three-dimensional network of molecules combined with strong covalent bonds, which make the process irreversible.

The thermosetting resin used to manufacture KIO® manhole top has been formulated to maximize the finished product mechanical properties – load bearing capacity and impact resistance – and to offer maximized processability conditions.

The reinforcing agent is glass fibre: the glass fibre grade selected for KIO® offers excellent mechanical and electrical properties, high resistance to acid corrosion, enhanced high and low temperature stress tolerance and excellent stress-corrosion cracking behaviour compared with traditional glass fibres.

Glass fibre is one of the most renowned reinforcing agents and it is widely used for composite material production. Experience highlights that monolithic glass is fragile because of several crystallization shortcomings resulting in microcracks and regions with high stress concentrations. On the contrary, glass yarn having a mean fibre diameter smaller than 1.0 micron loses fragility and acquires high mechanical strength and resilience – characteristics that are preserved at extremely high temperature.

Characteristics of glass fibres used for KIO® manhole top production are detailed in *Table 1* here below.

Filament density	2.6 g/cm^3
Ultimate tensile strength	3000 ÷ 3700 MPa
Elongation at break	4.2 ÷ 4.5%
Young modulus	72 ÷ 74 GPa
Moisture content	< 0.2%
Thermal conductivity λ	1.0 W/m °K
Linear coefficient of thermal expansion (20°C through 100°C)	6 * 10^{-6} m/m/°K
Reaction to fire	non-combustible
Dielectric strength (mass glass)	60 – 100 KV/mm

Table 1 – Glass fibre properties

2. 1 – PRODUCTION METHOD

KIO® production process selection and development have been as important as material selection: Industrie Polieco-MPB decided to implement a fully-automated production process technology and a control system surveilling each production step to offer a high-reproducible production, aimed at ensuring finished product quality and performance.

KIO® production process ensures fibre homogeneous wettability by polymer matrix, prevents air bubbles, and offers maximized component interlaminar cohesion. It is well known, indeed, that composite properties, besides being linked with single component properties, shape, concentration and orientation, strictly depend on their reciprocal interaction: the synergy between reinforcing agent and matrix is an essential condition for the achievement of intended physical-mechanical properties.

CHAPTER 3. PRODUCT

3. 1 – PRODUCT

Manhole top selection depends on three essential characteristics: load class, clear area (clear opening) and shape.

The appropriate class of manhole top to be used depends upon the place of installation. The various places of installation have been divided into groups, numbered 1 through 6, as per *Table 2* below, set forth under EN 124-1:2015 standard and shown in *Figure 1*. Guidelines for recommended class for each group are provided in the third column of the same table. The selection of the appropriate class and the material is the responsibility of the designer. Where there is any doubt, the stronger class shall be selected.

Place of installation	Group	Class
Areas which can only be used by pedestrians and pedal cyclists.	Group 1	At least class A15
Footways, pedestrian areas and comparable areas, car parks or car parking decks.	Group 2	At least class B125
For gully tops, installed in the area of kerbside channels of roads which, when measured from the kerb edge, extends a maximum of 0,5 m into the carriageway and a maximum of 0,2 m into the footway.	Group 3	At least class C250
Carriageway roads (including pedestrian streets), hard shoulders and parking areas, for all types of road vehicles.	Group 4	At least class D400
Areas imposing high wheel loads, e.g. docks and aircraft pavements.	Group 5	At least class E600
Areas imposing particularly high wheel loads, e.g. aircraft pavements.	Group 6	At least class F900

Table 2 – Places of installation

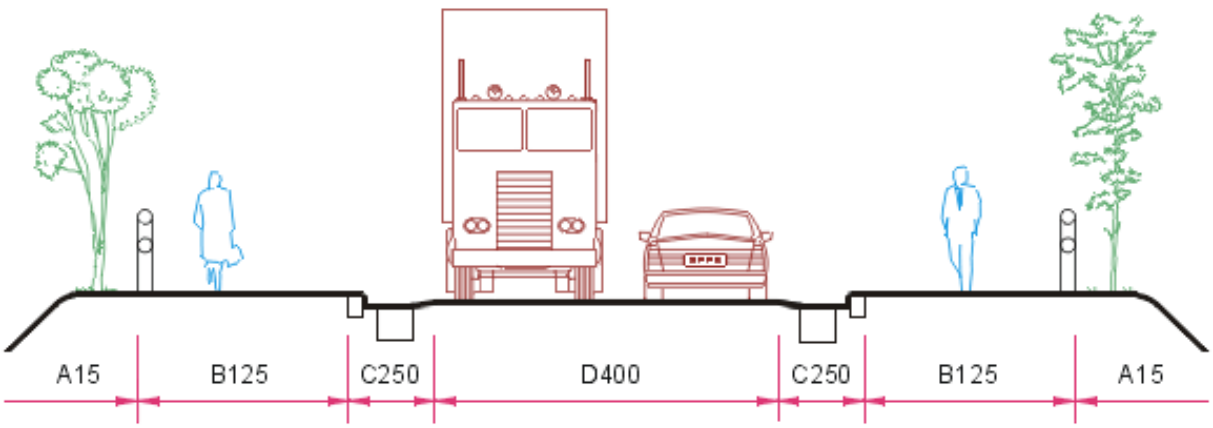


Figure 1 – Places of installation

The passageway is the diameter of the largest circle that can be inscribed in the clear area of the frame, i.e. the manhole top clear opening; this is a unique value for all manhole top manufacturers. Indeed, no specifications are provided for cover outer size and frame outer size. As a consequence, each manufacturer may offer different cover thicknesses and outer dimensions, thus basically preventing cover interchangeability.

As far as shape is concerned, square (min outer frame size: 300x300), rectangular and circular shapes are required on the Italian network and underground utilities market. Petrol stations and sewage treatment plants require manhole tops featuring outer sizes exceeding 1 m.

Current KIO® manhole top production is in class B125, C250 and D400. KIO® outer frame size and clear opening are detailed in *Table 3*.

KIO	Outer frame size (mm)	Min manhole clear opening (mm)
300	300 x 300	209 x 209
400	425 x 425	300 x 300
500	525 x 525	400 x 400
600	650 x 650	500 x 500
700	750 x 750	600 x 600
850	850 x 850	ϕ 600
950	950 x 950	760 x 760
425	ϕ 480	ϕ 314
800	ϕ 840	ϕ 600
1100	ϕ 1100	ϕ 905
1230	ϕ 1230	ϕ 980

Table 3 – Manhole top frame size and clear opening

Maximum total clearance between manhole top frame and cover may lead to horizontal displacement of the cover in its frame: in compliance with EN 124-1:2015 provisions, the sum of the maximum individual clearances between adjacent elements of the frame and cover at two parallel points shall not exceed 7 mm in case of clear opening smaller than 400 mm and shall not exceed 9 mm in all other cases.

As far as manhole tops class D400, EN 124-1:2015 standard provides several provisions concerning frames as well; in particular, the following provisions are set forth:

- Frame height shall be 100 mm at least.
- Cover depth of insertion shall be 50 mm at least, unless covers are secured within the frame by securing features against displacement due to traffic conditions.

KIO® manhole top production is further complimented with KIO® grating production. As far as gratings are concerned, reference standard provides precise parameters concerning slots. In particular, EN 124-1:2015 standard points out that slots in gratings shall be designed to ensure that waterway shall not be less than 30% of the clear opening. As far as gratings class C250 are concerned, slots parallel to the direction of traffic shall feature a width range

from 16 to 32 mm and their length shall not exceed 170 mm. Gratings designed with a dished surface exceeding 6 mm are described as concave.

3. 2 – COMPOSITE MANHOLE TOP BENEFITS

Benefits offered by manhole tops made of composite material are numberless compared with manhole tops made of cast iron or concrete: some benefits are strictly connected with raw material specifications, while others derive from implemented production system. A description of benefits offered by manhole tops made of composite material is provided here below.

3. 2. 1 – LIGHTNESS AND HANDLING EASINESS

Lightness is a major characteristic of manhole tops made of composite material. Lightness can be obtained in two ways:

- Use of materials whose specific gravity is lower than cast iron one, while ensuring strength characteristics required by reference standard.
- Study of manhole top geometric design optimised according to specific production method.

In this way, cover and frame assembly weight is considerably lower than the one of other marketed products.

A comparison between composite frame + cover assembly weight and cast iron (cast iron with lamellar graphite and spheroidal graphite cast iron) frame + cover assembly weight is provided in *Table 4*. The provided comparison is expressed in kilos. Cast iron frames and covers are made by European manufactures. On the average, weight difference exceeds 70% as against grey cast iron (cast iron with lamellar graphite) manhole tops and 65% as against ductile iron (spheroidal graphite cast iron) manhole tops.

B125	**Grey cast iron (kg)**	**Ductile iron (kg)**	**Composite material (kg)**
300 x 300	9.00	8.20	2.00
400 x 400	15.00	12.80	3.10
500 x 500	26.00	18.20	5.90
600 x 600	40.00	29.40	9.00
700 x 700	56.00	38.80	12.90
C250	**Grey cast iron (kg)**	**Ductile iron (kg)**	**Composite material (kg)**
400 x 400	23.00	25.00	5.50
500 x 500	39.00	33.00	12.00
600 x 600	57.00	45.00	19.40
700 x 700	74.00	61.00	29.80

Table 4 – Cast iron and composite manhole top weight – a comparison

Lightness significantly reduces risks for operators during manhole top handling, installation, and maintenance. Italian Law Decree no. 81/08 (Consolidated text about occupational health and safety) specifies that the maximum weight admitted for load handling at a construction site is 25 kilos: weight of composite KIO® manhole tops up to model 600x600 C250 is lower than the above stated threshold value. As far as cast iron manhole tops are concerned, even the smallest ones require the intervention of two operators and the use of mechanical means for lifting, handling, and installation.

3. 2. 2 – CORROSION AND CHEMICAL RESISTANCE

Manhole tops made of composite material are corrosion and chemical resistant: the manhole top surface is fully made of thermosetting resin, which is resistant to acid and alkaline substances, besides oil, grease, and hydrocarbons.

The above is based on literature data and on an exhaustive study carried out by Industrie-Polieco – MPB to test KIO® manhole top compatibility with various chemical substances, mainly organic solvents, such as alcohols, hydrocarbons, chlorinated solvents and ethers. Tests were carried out on KIO® manhole tops by an independent third-party laboratory under total immersion conditions during several-day time period. Only a few acids in a highly concentrated solution (hydrochloric acid, sulphuric acid, nitric acid) or some solvents (e.g. dimethylformamide) are capable of attacking external manhole top surface.

The above characteristics, combined with being non-sparking and non-condensing, make composite manhole tops particularly suitable for applications in petrol stations. Today, it is common practice worldwide to install composite manhole tops in petrol station instead of manhole tops made of cast iron.

Corrosion resistance is particularly important in industrial and civil sewer networks, especially if featuring weak slopes: gases generated inside piping systems and shafts are not capable of corroding KIO® manhole top lower side.

Finally, thermosetting resin is resistant to salt water, thus making composite manhole tops suitable for seaside resorts.

The above characteristics ensure that manhole tops made of composite material do not need any painting, required by cast iron ones.

3. 2. 3 – NOISE AND VIBRATION DAMPING

Thanks to their raw material, composite covers and frames minimize noise caused by pedestrian or vehicular traffic, typical of cast iron manhole tops and due to cover and frame loose couplings or bedding errors.

3. 2. 4 – ELECTRICAL AND THERMAL INSULATION

The outer surface made of thermosetting resin makes the manhole top a perfect insulating system, zeroing voltage dispersion and protecting pedestrians from accidental electroshocks due to exposed electrical wires.

For the above purpose, technicians of the Department of Electronics at an important Italian University tested a KIO® manhole top: sinusoidal alternating current (30kVeff amplitude and

50Hz frequency) and direct current (10kV amplitude) were applied to a KIO® 400x400 B125 manhole top to check that insulating properties were unaltered. Cover upper side was positioned on a conductive plate and the overturned cover was partially filled with a H_20-NaCl solution to cover a brass electrode used to connect high voltage generator with the solution. The cover preserved test voltages for 1 minute, without generating any electrical discharge.

Furthermore, the cover is a poor heat conductor: specific tests carried out based on Italian UNI 7891 (*Materiali isolanti. Determinazione della conduttività termica con il metodo dei termoflussimetri*: insulating materials – determination of thermal conductivity by means of the heat flow meter method) standard highlighted that KIO® thermal conductivity is 0.21 W/m K at 10° C while it is 0.23 W/m K at 37.5° C. Literature data highlight that pure cast iron has a thermal conductivity of 57 W/m K at 0° C and 55 W/m K at 100° C.

In other words, the insulating capacity of a KIO® manhole top made of composite material is about 250 times higher than the insulating capacity of a similar cast iron manhole top of equal thickness; therefore, any KIO® manhole top placed in contact with a heat source heats up in a significantly longer time if compared with a similar cast iron manhole top. For practical purposes, such a behaviour proves to be important in case of hot steam leakages in district heating networks.

3. 2. 5 – ELECTROMAGNETIC PERMEABILITY

KIO® manhole tops show minimized interference to radio frequency and mobile phone signals associated with modern transmission systems (e.g. meters, flowmeters, aerials) installed inside underground shafts. Therefore, KIO® manhole top technological potential is huge and growing at the same pace as increasingly cutting-edge solution development: several solutions can combine KIO® manhole tops with increasingly advanced systems that will be used in smart cities in the future.

To support the above, KIO® composite manhole tops and grey cast iron (cast iron with lamellar graphite) or ductile iron (spheroidal graphite cast iron) manhole tops available on the market underwent an electromagnetic permeability test within a frequency range from 433 through 1000 MHz at a specialised laboratory. Manhole tops were positioned above a cement shaft featuring 300 x 300 mm inner size, laterally coated by an electromagnetic absorbing foil so as to simulate the effect of manhole top undergrounding. An aerial was located inside and powered by an amplifier receiving the signal to be amplified from a generator. Then, the emitted signal was measured by means of a log-periodic aerial supported by a tripod made of insulating material and connected with a receiver-spectrum analyser.

At all tested frequencies (433.92, 868 and 1000 MHZ), KIO® manhole tops showed an electromagnetic permeability higher than both ductile iron (spheroidal graphite cast iron) and grey cast iron (cast iron with lamellar graphite) manhole tops. In particular, the manhole top made of ductile iron (spheroidal graphite cast iron) attenuated the signal by a higher value ranging from 7.8 to 13.6 dB compared with KIO® manhole top of the same class (C250) while the grey cast iron (cast iron with lamellar graphite) one attenuated the signal by a higher value comprised between 10.4 and 20,5 dB.

Apart from the anomalous value detected at 1000 MHz and due to measurement chain tolerance (assessed ± 10%), the KIO® manhole top of class B125 attenuated the electrical

field less than KIO® 400 C250 by several dB. In all manhole tops, attenuation decreased upon frequency increase, consistently with expected outcomes.

The above feature is essential in modern telecommunication networks. Industrie Polieco-MPB was entrusted with the design of a composite manhole top to be implemented in historical town centres by a European leading telecommunication company. An aerial was positioned underneath the above-mentioned manhole top (1695-2690 MHz frequency range) and connected with a base station in close proximity. On-field tests highlighted that signal was of excellent quality within 100 meters around the shaft, regardless the presence of buildings.

The above characteristic offers several application fields:

- Sewer networks: a level sensor installed underneath a KIO® manhole top may monitor and control wastewater level inside shafts. Signals are transmitted by the sensor to the control centre, e.g. by means of a LoRaWAN transmission system, to signal that the defined threshold value was exceeded, or alerts about any situation worsening. Level sensor may be combined with an anti-intrusion sensor in order to detect any KIO® manhole top tampering, forcing or removal.
- Aqueduct networks.
- Transportation systems: KIO® manhole tops may be used as tops for electronic devices controlling and managing tram/LRT, train, and underground circulation.

3. 2. 6 – ENVIRONMENT PROTECTION

As far as environment protection is concerned, composite manhole top production technology implemented by Industrie Polieco-MPB offers innovative specifications compared with cast iron manhole top production as well.

As far as CO_2 emission into the atmosphere, two essential factors are in favour of composite manhole tops against cast iron manhole tops:

- The energy required to reach cast iron melting point and to mould it (higher than 1200°C) and moulding temperature needed for composite materials (60°C approx.).
- Lower unit weight which allows to load 3-4 times the manhole tops on each transport means against standard cast iron manhole tops, thus reducing pollution due to transport needs.

As evidence of the aforementioned, a specific carbon footprint study was carried out on KIO® manhole top, i.e. concerning CO_2 emissions into the atmosphere during lifetime (from raw material procurement to production and distribution) expressed in kilos of CO_2 equivalent (CO_2e). The study was carried out in 2013 within the scope of Italian *Programma Nazionale per la valutazione dell'impronta ambientale* (Italian national program for carbon footprint assessment), a project part-financed by Italian Ministry for Environment, Land and Sea Protection.

Upon completion of the study, Industrie Polieco-MPB was issued the product certification by *Lloyd's Register Quality Assurance* in compliance with ISO/TS 14067:2013 (*Greenhouses gases – Carbon footprint of products – Requirements and guidelines for quantification and communication*) standard provisions.

It is worth highlighting that scraps from the production of KIO® covers and frames may be recycled: through a special process, materials may be ground, regenerated and mixed again with a thermosetting resin to make new items, such as KIO® ϕ 800 15 kN cover.

3. 2. 7 – THEFT DETERRENCE

Recently, media reports of manhole top thefts – aimed at top sale for metal melting – are increasing. Besides the economic damage, these thefts are extremely dangerous as unmarked openings are left on roadways.

As mentioned above, composite manhole tops are recyclable but, besides requiring special processing by specialised companies, the recycled material may be used to manufacture specific pieces only. Therefore, the theft of composite manhole tops is poorly attractive as there is no illicit secondary market.

3. 2. 8 – CUSTOMIZATION

KIO® manhole tops may be customized by logo or name of city, service company or customer in dedicated areas on manhole top cover visible side, as it happens for manhole tops made of cast iron available on the market. Plugs with the following wording are available: "acquedotto", "fognatura", "fibre ottiche", "illuminazione", "irrigazione", "metano" e "telecom".

CHAPTER 4. REFERENCE STANDARD

KIO® manhole top is manufactured in compliance with provisions set forth under EN 124:2015 "*Gully tops and manhole tops for vehicular and pedestrian areas"* standard.

The above standard defines classification, materials, design and testing methods, marking and quality control of gully tops and manhole tops with a clear opening up to and including 1 000 mm for installation within areas subjected to pedestrian and/or vehicular traffic.

Standards series EN124:2015 were drawn up by CEN/TC165/WG4 technical committee "*Tops, gratings, drainage channels and other ancillary components for use outside buildings*" and were published by CEN in June 2015, then transposed into national laws by the relevant standardization bodies.

EN124:2015 standard consists of six parts:

- *Part 1: Definition, classification, general principles of design, performance requirements and test methods.*
- *Part 2: Gully tops and manhole tops made of cast iron.*
- *Part 3: Gully tops and manhole tops made of steel or aluminium alloys.*
- *Part 4: Gully tops and manhole tops made of steel reinforced concrete.*
- *Part 5: Gully tops and manhole tops made of composite materials.*
- *Part 6: Gully tops and manhole tops made of polypropylene (PP), polyethylene (PE) or unplasticized polyvinyl-chloride (PVC-U).*

Part 1 sets forth general requirements for manhole tops and gully tops made of any materials. Additionally, manhole tops and gully tops shall meet requirements detailed under Parts 2 to 6 according to specific materials. Composite materials shall comply with EN 124-5:2015 standard. Reference tests are detailed under chapter 5.

While drawing up this manual, CE marking is not applicable to the aforementioned products and drawing up of Declaration of Performance (DoP) (in compliance with Construction Product regulation no. 305/2011) as well, as the publication of the whole EN 124:2015 on Official Journal of the European Union (OJ) has been blocked.

Standards series EN 124:2015 came into force in the entire European Community on April 1, 2017 and are still applicable in accordance with a voluntary scheme. Within March 31, 2017, all manhole top and gully top manufacturers transposed the new EN 124:2015 standard and, implementing voluntary schemes, applied new certification schemes released by independent accredited certification bodies, according to EN 124:2015 standard pursuant to EN ISO 17065 standard provisions.

In order to minimize inconveniences and difficulties in interpreting the new standard, Italian manufacturers and UNI standardization body have drawn up a technical report that details indications about standard implementation. Italian UNI/TR 11671 technical report (*Dispositivi di coronamento e di chiusura dei pozzetti stradali – Indicazioni per l'applicazione della serie EN 124:2015*: Gully tops and manhole tops for vehicular and pedestrian areas – Indications regarding the application of standard EN 124:2015) was published by UNI at the beginning of February 2017.

4. 1 – MARKING

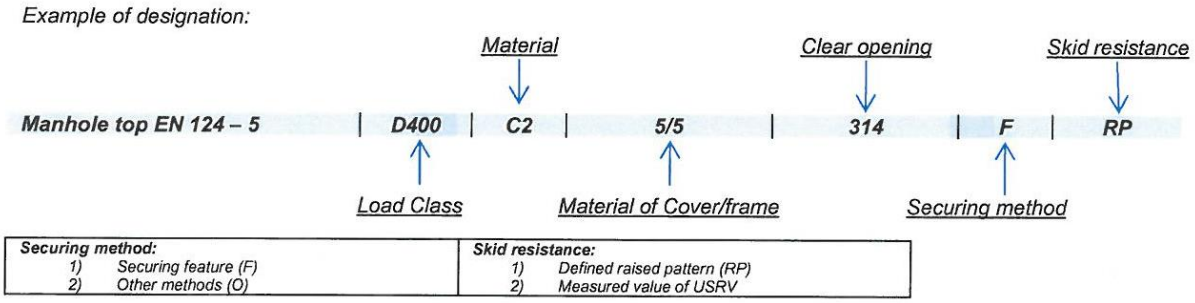
According to EN 124:2015 standard, the following information shall be clearly and durably marked on each cover, grating and frame:

- Reference standard (e.g. EN 124-5).
- Appropriate load class (e.g. B125).
- Manufacture name and/or identification mark.
- Place of manufacture, which may be expressed in code.
- Date or week and year of manufacture.

As above described, as EN 124:2015 standard is applied in accordance with a voluntary scheme, any manufacturer being issued a product certification by an independent accredited certification bodies, shall clearly and durably include the issuing body mark as well on each cover, grating and frame.

Official documentation, e.g. Certification of Conformity issued by certification bodies, shall state product designation here below, according to provisions under EN124-5:2015 standard:

- Product name.
- Reference standard (e.g., EN 124-5).
- Load class (e.g., class B125).
- Material (e.g., composite material C2).
- Number of cover and frame reference EN124 part: e.g. number 5/5 means that cover and frame are made of composite material. Under EN124:2015 standard conformity of covers and frames made of different materials is accepted provided that they meet standard requirements (e.g. covers made of composite material and frames made of cast iron).
- Clear opening size in mm (CO).
- Securing method (e.g. securing feature F).
- Skid resistance (e.g. raised pattern RP).



CHAPTER 5. TESTING

Regardless of manufacturing material, gully tops and manhole tops shall undergo tests set forth under EN 124-1:2015 standard: dimensional checks and tests to calculate permanent set (residual arrow) and load bearing capacity (maximum load), required to determine product class.

EN 124-5:2015 standard, which has specifically been drawn for manhole top made of composite material, provides that finished products shall undergo additional laboratory tests compared to tests under EN 124-1:2015 standard, aimed at ensuring specimen suitability for the relevant intended use over time. The mentioned tests, not provided for manhole tops made of different materials, are described in the following paragraphs. The laboratory at Industrie Polieco-MPB is equipped to carry out all tests under EN 124-1:2015 (*General requirements*) standard and EN 124-5:2015 (*Composite materials*) standard.

5. 1 – RESIDUAL ARROW

Test is carried out to calculate permanent set (residual arrow) by application of a load equal to 2/3 of the maximum load admitted for the product class.

A manhole top, which has never undergone any load test before, shall be positioned in the measurement equipment (preferably, an hydraulic press), with an appropriate test punch (shape and size are specified in the reference standard and depend on specimen size and shape). Before load application, the specimen initial position at its geometric centre shall be measured. Load shall be applied at a rate of 1 kN/s to 5 kN/s up to 2/3 of test load; then, load shall be released. The above procedure shall be carried out 5 times. Then, test specimen final position shall be measured at its geometric centre. Permanent set shall be determined as the difference of measured readings before the first and after the fifth loading. For the purpose of conformity, the aforementioned value shall be smaller than the expected ones according to specimen class and size (please refer to *Table 5*).

Class	Admitted permanent set (residual arrow)	
A15 and B125	$\frac{CO}{100}$ (1)	
C250 to F900	$\frac{CO}{300}$ (2) If secured by means of a securing feature or other methods, provided they are specified in design specifications	$\frac{CO}{500}$ (3) If secured by means of a sufficient mass per surface unit

(1) CO/50 if CO < 450 mm with a maximum value of 6.5 mm
(2) 1 mm max when CO < 300 mm
(3) 1 mm max when CO < 500 mm
CO = clear opening, in mm; diameter of the largest circle that can be inscribed in the clear area of the frame

Table 5 – Admitted residual arrow

5. 2 – LOAD BEARING CAPACITY

Once the specimen has been tested according to the test described in the previous

paragraph (*residual arrow*), the test load provided in *Table* 6, according to the relevant class, shall be applied to the tested specimen at a rate ranging from 1 to 5 kN/s. Test load shall be applied for 30 seconds, then released. The specimen shall not show any visible cracks during the test and upon its completion.

Class	Load test, kN
A15	15
B125	125
C250	250
D400	400
E600	600
F900	900

Table 6 – Load test

5. 3 – LOAD DEFLECTION

The test consists in determining the deflection upon application on a manhole top, which has never undergone any load test before, of a load equal to a third of the maximum load admitted for the relevant class. The value resulting from the test shall be declared by the manufacturer and expressed in mm/CO (i.e. clear opening). No requirements have been set forth.

5. 4 – CREEP RESISTANCE

A load equal to the one used to calculate permanent set (residual arrow), i.e. a load equal to 2/3 of the maximum load admitted for the product class, shall be applied to a manhole top, which has never undergone any load test before. Load shall be applied for 60 minutes; once elapsed a recovery time of 5 minutes, the specimen shall meet residual arrow requirements for the relevant class.

5. 5 – FATIGUE STRENGTH

A manhole top, which has never undergone any load test before, shall undergo a constant pulse load for a defined number of cycles. The number of cycles and the test load are detailed in the following table.

Class	Number of cycles	FF test load, kN	Load application rate, kN/s
B125	10,000	43	7 ± 2
C250	100,000	92	42 ± 14
D400 (a)	100,000 500,000	136 120	70 ± 20 60 ± 20
a – Test conditions for class D400 are reciprocally alternative. They both refer to the same stress level. The selection is at the manufacturer's care.			

Table 7 – Fatigue strength test conditions

Once test cycles have been completed, tested manhole top shall meet residual arrow and load bearing capacity requirements. Tested specimen shall not show any visible cracks upon test completion.

Class test conditions have been determined taking into account the load and the number of cycles an operating manhole top shall bear and applying literature data concerning ultimate tensile strength percentage (UTS, %) and number of cycles. Selection criteria concerning test conditions are based on reasonable time period according to a significant number of cycles.

For example, in case of a manhole top of class D 400, the fatigue strength curve with "number of cycles" and "test load" is shown in the following table. Conditions highlighted in bold are the ones provided under EN 124-5:2015 standard provisions.

N.	Number of cycles		% of UTS	Test load, FF
1	1 000	1.00E+03	65.0	260.0 kN
2	10 000	1.00E+04	46.5	186.0 kN
3	50 000	5.00E+04	36.8	147.2 kN
4	**100 000**	**1.00E+05**	**34.0**	**136.0 kN**
5	**500 000**	**5.00E+05**	**30.0**	**119.8 kN**
6	1 000 000	1.00E+06	28.5	114.0 kN
7	10 000 000	1.00E+07	24.0	96.0 kN
8	100 000 000	1.00E+08	20.5	82.0 kN
9	200 000 000	2.00E+08	19.6	78.3 kN
10	1 000 000 000	1.00E+09	17.0	67.9 kN

Table 8 – Fatigue strength curve for a manhole top of class D400

The above data allow for manhole service life extrapolation. If it is considered that:

- Maximum load per axle, as defined under UE (1996/53/EC) regulation, is equal to 11.5 t (11,500 kg), i.e. a 56.4 kN load per wheel.
- Road construction regulations in Germany require $230x10^6$ cycles per 10 t axial load over 30 years.

then, it may be stated that a manhole top shall withstand a 56.4 kN load for $230x10^6$ cycles to reach 30-year service time.

Finally, it is worth highlighting that the calculation of the number of cycles for 30-year service time is based on a 56.4 kN load, while axles are limited to 10.0 t (10,000 kg) for double rubber tyres and 9.5 t (9.500 kg) for single rubber tyres.

Moreover, most axles have two rubber tyres, then load is distributed on an area wider than the load test area defined under EN 124-5:2015 standard, which requires the load to be

positioned at the centre of a 250 mm diameter disk, thus generating values that feature significantly different bending moment values, adding further safety factors.

5. 6 – IMPACT RESISTANCE

A manhole top, which has never undergone any load test before, shall be conditioned at 60 °C for 30 days, left to cool down at ambient temperature for 2 hours at least and then conditioned at -20 °C for 4 hours at least. The specimen shall be hit by a hemispheroidal punch of appropriate weight (i.e. 3.75 kg for class B125; 4.50 kg for class C250 and 7.50 kg for class D400) and 50 mm diameter at the specimen geometric centre within 30 seconds, from a 2000 mm height. Then, test shall be repeated in other 7 equidistant points, of which 4 at least around the perimeter. Specimen shall not show any visible cracks or delaminations upon test completion.

5. 7 – HEAT EFFECTS

A manhole top, which has never undergone the impact resistance test described in the paragraph above, shall be kept in an oven heated up at 150°C for 60 minutes: upon conditioning completion, specimen shall not show any visible flaws, bubbles, cracks or delaminations upon test completion when viewed under light and with magnification.

5. 8 – TESTS FOR COMPOSITE MATERIAL CHARACTERISATION

Before putting any finished product on the market, EN 124-5:2015 standard provides that manhole top composite material shall undergo some characterisation tests, such as:

- Water absorption: after manhole top immersion in deionised water at 23 °C for 24 hours, mass variation shall be lower than 0.3%; the specimen, tested by residual arrow test and load test, shall meet requirements defined for the relevant class.
- Hardness: complete thermosetting resin crosslinking shall be checked; minimum value to be reached is 35 Barcol.
- Resistance to fuels: after immersion of a manhole top in diesel at 23 °C for 168 hours, mass variation shall be lower than 0.5%; the specimen, tested by residual arrow test and load test, shall meet requirements defined for the relevant class.
- Resistance to atmospheric ageing: the specimen is exposed to laboratory light sources under controlled humidity and temperature conditions, with condensation cycles and/or water sprays, to reproduce effects of accelerated weathering ageing (sun, rain, dew) under actual conditions of use; upon completion of artificial ageing, the specimen, tested by residual arrow test and load test, shall meet requirements defined for the relevant class.

5. 9 – COMPATIBILITY OF SEATINGS

To ensure stable and silent behaviour of manhole top cover and frame assembly during use, EN 124-1:2015 standard requires manhole tops of class D400 and higher to be tested by the tilt test.

To carry out the tilt test, a test block of 75mm diameter shall be applied at test points on the specimen edge, along the cover and frame perimeter (according to manhole top design geometry) in such a way that the axle centre of the test block is applied at the joint between cover and frame. A gradually increasing F_K test load, increased by 0 kN to 50 kN, shall be

applied on the test block three times at a rate of 1 kN/s to 5 kN/s. During load application, the maximum increase in the vertical distance between top frame edge and top cover edge shall be measured: this increase shall be equal to half the depth of insertion of the tested manhole cover maximum and anyway not higher than 25 mm at any point on the perimeter.

5. 10 – PULL-OUT TEST

In case of place of installation imposing traffic conditions, EN 124-1:2015 standard requires the securing of manhole top cover to frame to be tested by pull-out test.

To carry put the pull-out test, an appropriate securing feature (e.g. cable, chain, or strap) shall be anchored at cover geometrical centre; this feature shall be anchored so that the distance between the cover surface and the cable/chain/strap is 100 mm and its longitudinal axle is perpendicularly anchored to cover surface.

Maximum pull-out force F_V (N) is calculated by the equation

$$F_V = CA \times 0{,}4 \times 10^{-2}$$

where CA = clear area in mm^2.

Pull-out force shall be applied to the cover until the cover is lifted by 25 mm maximum or up to the maximum F_V force calculated by the above equation. Vertical displacement *h* shall be measured between frame top edge and the cover highest point reached during the test. If the maximum admitted vertical displacement *h* (25 mm) is reached, the relevant pull-out force shall be measured and recorded. For example, when a KIO® ϕ800 D400 manhole top is tested, a max 1.70mm displacement occurs at a pull-out force of 1130 N.

5. 11 – SKID RESISTANCE

Skid resistance of gully tops and manhole tops shall be ensured by means of a raised pattern on cover upper side. Raised pattern surface shall range between 10% and 70% of total upper surface and its height shall range between 2 and 6 mm for class B125 and class C250 and between 3 and 8 mm for class D400. KIO® manhole top features a raised pattern of 2.5 mm in height for class B125 and class C250 and 3.5 mm for class D400.

5. 12 – CHILD SAFETY

The resistance of covers or gratings to removal by children shall be met by the mass of the individual covers or gratings or locking accessory or securing feature. No further provisions thereabout apply in Italy.

5. 13 – REACTION TO FIRE

Manhole top characteristics concerning reaction to fire may be classified under national regulations (no regulations thereabout are available in Italy). Pursuant to provisions set forth under EN 124-5:2015 standard, manhole top reaction to fire may be classified according to EN 13501 – 1 standard (*Fire classification of construction products and building elements-Part 1: Classification using data from reaction to fire tests*).

Industrie Polieco-MPB carried out tests set forth under EN 13501-1 regulation at an

accredited laboratory thus achieving the following classification:

- Reaction to fire: class D
- Smoke production: s2
- Flaming droplets/particles: d0

Main and additional classifications set forth under EN 13501-1 regulation are detailed in Table 9 below, the aim being a better interpretation of product classification.

According to EN 124-5:2015 standard provisions, if there are no national regulations, class E (*lower than class D*) shall be deemed sufficient for manhole top installation in areas imposing high wheel loads outside buildings.

Main classification		
A1	Non-combustible materials	
A2		
B	Combustible non-flammable materials – very limited contribution to fire	
C	FIGRA $_{0.4MJ}$* ≤ 250 W/s	Combustible materials – very limited and limited contribution to fire
D	FIGRA $_{0.4MJ}$* ≤ 750 W/s	
E	Combustible materials – high contribution to fire with testing criteria for classification	
F	Combustible materials – easily flammable with no testing criteria for classification. This class is assigned if a product fails to meet Class E testing criteria.	
* FIGRA $_{0.4MJ}$: fire growth rate at 0.4 MJ total heat release (THR) threshold.		

Additional classification			
s	**1**	++ (best)	Smoke production during combustion
	2	+	
	3	- (worst)	
d	**0**	++ (best)	Flaming droplets/particles
	1	+	
	2	- (worst)	

Table 9 – Main and additional classification in compliance with EN 13501-1

CHAPTER 6. CERTIFICATION

Industrie Polieco-MPB was issued its first certification in compliance with EN 124:1994 standard by *Istituto Italiano accreditato ICMQ* (the Italian Institute accredited by *Istituto di certificazione e marchio qualità per prodotti e servizi per le costruzioni* - Certification body for certification and quality marking for construction products and services) in March 2012. Certification has been integrated with compliance with tests set forth under prEN 124-5 standard draft and, today, with tests set forth under EN 124-5:2015 standard.

The certificate issued in compliance with EN124-1 and EN 124-5:2015 standards is provided here below. The certification specifies tests carried out on manhole tops as set forth under the relevant standard: KIO® manhole tops, unlike other composite products available on the market worldwide, undergo all tests provided under standard provisions.

ICMQ
Certificazione di prodotto

CERTIFICAZIONE DI PRODOTTO
PRODUCT CERTIFICATION

CERTIFICATO N° **CERTIFICATE N°**

P 195

AZIENDA ***COMPANY***

INDUSTRIE POLIECO – M.P.B. S.r.l.
Via E. Mattei, 49 – 25046 Cazzago San Martino (BS)

UNITA' PRODUTTIVA ***PRODUCTION UNIT***

Via E. Mattei, 49 – 25046 Cazzago San Martino (BS)

OGGETTO DEL CERTIFICATO ***SCOPE OF THE CERTIFICATE***

DISPOSITIVI DI CORONAMENTO E CHIUSURA PER ZONE DI CIRCOLAZIONE UTILIZZATE DA PEDONI E DA VEICOLI
Gully tops and manhole tops for vehicular and pedestrian areas

NORME DI RIFERIMENTO ***REFERENCE STANDARDS***

EN 124-1:2015, EN 124-5:2015

SISTEMA DI CERTIFICAZIONE ***CERTIFICATION SYSTEM***

Condizioni Generali di Contratto per la Certificazione di prodotto - CP DOC 229
General Agreement Conditions for the product certification – CP DOC 229

Regolamento particolare per dispositivi di coronamento e chiusura - CP DOC 243
Particular rules for gully tops and manhole tops – CP DOC 243

Indicazioni per l'applicazione della serie EN 124:2015 - UNI/TR 11671:2017
Instructions for the application of the EN 124:2015 – UNI/TR 11671:2017

PRODOTTI PRODUCTS

L'elenco dei prodotti oggetto della certificazione è allegato al presente certificato
The list of the certified products is annexed to this certificate

PRIMA EMISSIONE	EMISSIONE CORRENTE	SCADENZA
First Issue	*Current Issue*	*Expiry date*
09/03/2016	*12/05/2020*	*31/12/2020*

IL DIRETTORE GENERALE
ING. LORENZO ORSENIGO

Firmato digitalmente da
Lorenzo Orsenigo
Data e ora della firma:
12/05/2020 18:37:08

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO
PRD N° 011B
Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
Signatory of EA, IAF and ILAC Mutual Recognition Agreements

Allegato al Certificato di Prodotto P 195 del 12/05/2020

Annex to the certificate P 195 of 12/05/2020

FAMIGLIA *family*	CODICE *code*	DESIGNAZIONE *designation*	CLASSE *class*
KIO	300x300	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 210 – F – RP	B125
	300x300	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 210 – W – RP	B125
	400x400	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 304 – F – RP	B125
	400x400	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 304 – W – RP	B125
	400x400L	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 304 – F – RP	B125
	400x400L	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 304 – W – RP	B125
	500x500	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 404 – F – RP	B125
	500x500	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 404 – W – RP	B125
	500x500L	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 404 – F – RP	B125
	500x500L	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 404 – W – RP	B125
	600x600	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 500 – F – RP	B125
	600x600	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 500 – W – RP	B125
	600x600L	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 500 – F – RP	B125
	700x700	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 601 – F – RP	B125
	700x700	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 601 – W – RP	B125
	Ø 800	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 601 – F – RP	B125
	Ø 800	MANHOLE TOP EN 124-5 – B125 – C2 – 5/6 – 601 – W – RP	B125
	400x400	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 304 – F – RP	C250
	400x400	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 304 – W – RP	C250
	500x500	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 404 – F – RP	C250
	500x500	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 404 – W – RP	C250
	600x600	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 500 – F – RP	C250
	600x600	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 500 – W – RP	C250
	700x700	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 600 – F – RP	C250
	700x700	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 600 – W – RP	C250
	Ø 800	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 600 – F – RP	C250
	Ø 800	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 600 – W – RP	C250
	950x950*	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 760 – F – RP	C250
	36" – Ø 1100*	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 805 – F – RP	C250
	42" – Ø 1230	MANHOLE TOP EN 124-5 – C250 – C2 – 5/5 – 980 – F – RP	C250
	Ø 425	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 314 – F – RP	D400
	500x500	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 404 – F – RP	D400
	600x600	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 500 – F – RP	D400
	700x700	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 600 – F – RP	D400
	850x850 with hinge automatic	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 600 – F – RP	D400
	850x850 automatic	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 600 – F – RP	D400
	Ø 800 automatic	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 600 – F – RP	D400
	Ø 800 floating frame	MANHOLE TOP EN 124-5 – D400 – C2 – 5/2 – 570 – F – RP	D400
	Ø 800 with hinge automatic	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 600 – F – RP	D400
	950x950*	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 760 – F – RP	D400
	36" – Ø 1100*	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 805 – F – RP	D400
	42" – Ø 1230	MANHOLE TOP EN 124-5 – D400 – C2 – 5/5 – 980 – F – RP	D400

Allegato al Certificato di Prodotto P 195 del 12/05/2020

Annex to the certificate P 195 of 12/05/2020

FAMIGLIA *family*	CODICE *code*	DESIGNAZIONE *designation*	CLASSE *class*
KIO GRIGLIA	500x500	GULLY TOP EN 124-5 – C250 – C2 – 5/5 – 400 – F – RP	C250
	500x500	GULLY TOP EN 124-5 – C250 – C2 – 5/5 – 400 – W – RP	C250

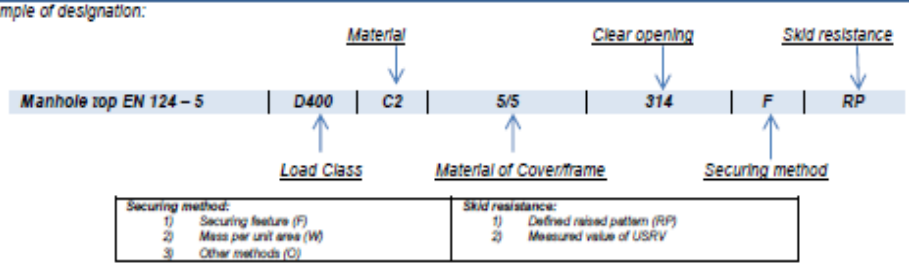
*Prodotto non ancora sottoposto a test di fatica

Tutti i dispositivi possono essere prodotti anche in versione colorata.
All products can be produced also coloured.

Ai fini della certificazione i prodotti sopra elencati hanno effettuato le seguenti prove in conformità alle norme EN 124-1:2015 e EN 124-5:2015:
To the purpose of the certification the above products were submitted to the following tests conforming with EN 124-1:2015 and EN 124-5:2015 standards:

Famiglia Family	PROVE/Tests											Classe class
	Prova dimensionale Dimensional test	Prova di freccia residua Permanent set	Prova di carico Load test	Prova di fatica Fatigue test	Assorbimento H_2O e carburante Water and fuel absorption	Deformazione sotto carico Deflection under load	Prova di Creep Creep test	Prova d' urto ed effetto HT Impact and high temperature test	Resistenza all' invecchiamento Weathering resistance	Test di durezza Hardness test	Resistività superficiale Surface Resistivity	
KIO	x	x	x	x	x	x	x	x	x	x	x	B125
KIO	x	x	x	x	x	x	x	x	x	x	x	C250
KIO	x	x	x	x	x	x	x	x	x	x	x	D400

Example of designation:



CHAPTER 7. INSTALLATION AND BEDDING

Proper installation is a prerequisite to ensure appropriate service life and efficiency of any construction products, manhole tops included. Manhole top incorrect installation may cause damages or hazards to pedestrians or vehicles, regardless the relevant manufacturing material. The installation of manhole tops shall therefore be undertaken by appropriately skilled and trained operatives, using the proper equipment.

EN 124-1:2015 standard provides for a specific annex *(Annex F - Recommendations for installation)* under which essential criteria for manhole top installation and embedment are defined.

Furthermore, in 2007 an Italian UNI technical commission drew up a specific manhole top installation guide: UNI/TR 11256: *Guida all'installazione di dispositivi di coronamento e di chiusura in zone di circolazione pedonale e/o veicolare (chiusini e caditoie)* [*A guide to the installation of gully tops and manhole tops for vehicular and pedestrian areas*]. The above specification, conceived for manhole tops made of cast iron may be adopted for composite manhole tops as well: in this case the light weight of the frame and cover assembly make operations described at the following points easier, quicker, less dangerous and less subject to human errors.

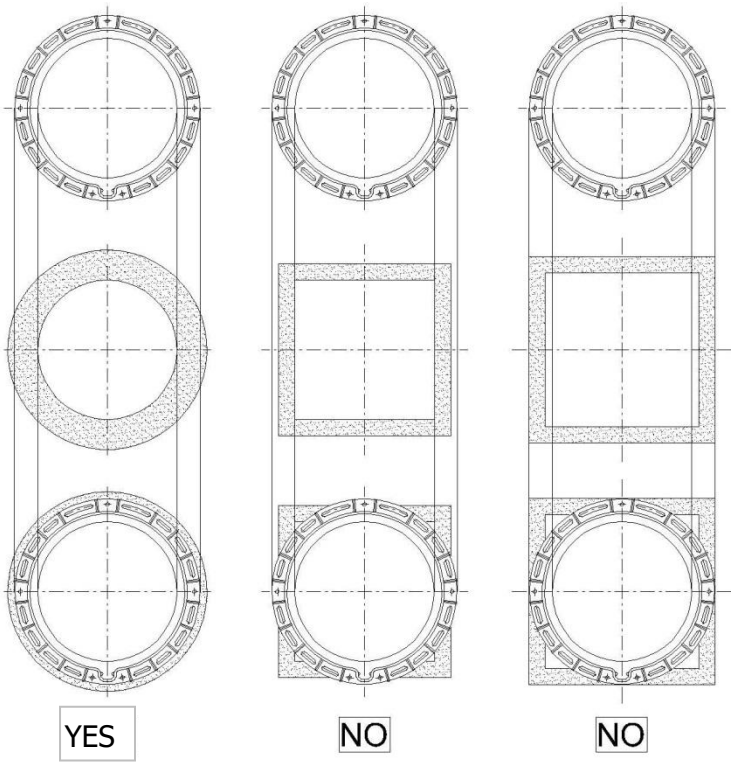
Information required for an appropriate installation and embedment of manhole tops are provided in the following paragraphs, as detailed in the aforementioned documents, with special reference to KIO® manhole tops of class D400 installation in carriageways.

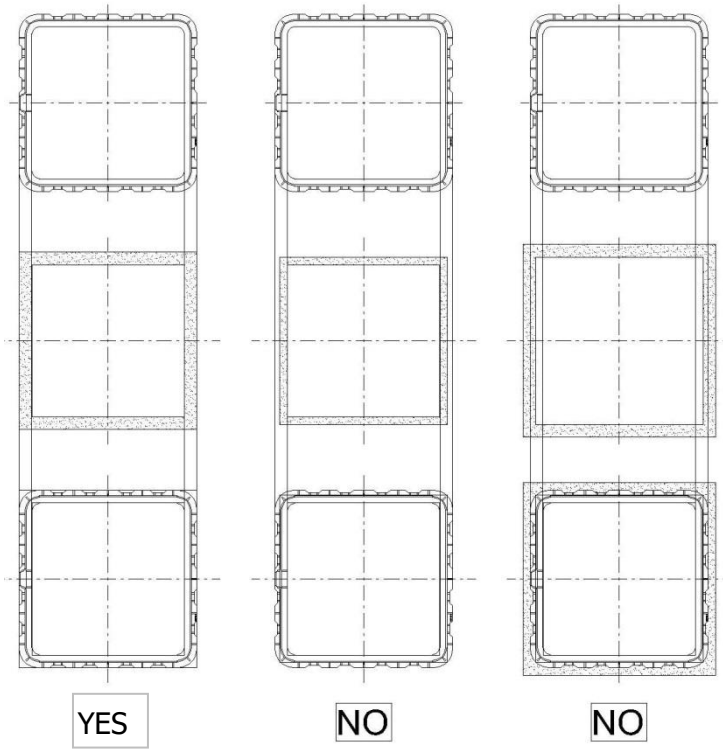
7. 1 – MANHOLE TOP SELECTION

The appropriate load class of manhole tops to be used depends upon the place of installation and, therefore, consequent stress; in case of doubt, a manhole top of stronger class shall be selected. Furthermore, the designer shall select an appropriate opening size (*clear opening*) for safe entry.

Moreover, the following shall be checked before installation:

- Manhole top is appropriately marked to show compliance with the reference standard (EN124) and the certification body that issued the relevant certification marking.
- Manhole top frame has the same shape of the shaft on which it is embedded, and clear opening size is similar to shaft size. Some examples are provided in the following images to highlight – for square as well as round frames – the correct frame/cover (or grating) matching set according to underground shaft.
- Frame height is smaller or equal to depth of seating so that frame, cover, and pavement are at the same level once the installation has been completed. It is preferable that seating depth is higher than frame height by 2 to 4 cm to allow for a concrete embedment to ensure an appropriate load distribution on the surface.
- Orientation against direction of vehicular traffic, represented by an arrow on the KIO® ϕ 800 and KIO® 850x850 D400 cover, is met.





7. 2 – BEDDING MATERIALS

As far as bedding materials are concerned, if road closure can be provided, the use of cement mortar is admitted, provided it features a characteristic compressive strength (R_{ck}) equal to 50 N/mm^2 or higher and mortar curing time recommended by manufacturer is met.

If the road needs to be rapidly set back to traffic, manhole tops shall be positioned on quick curing bedding materials featuring the following minimum characteristics:

- *Maximum aggregate granulometry* *4 mm*
- *Fresh mortar volume mass* *2300 kg/m³ – 2600 kg/m³*
- *Volume increase in 1 d* *+ 0.5%*
- *Workability time* *~15 min*
- *Compressive strength after 30 min* *> 1.5 N/mm²*
  after 1 hour *> 8.0 N/mm²*
  after 24 hours *> 35.00 N/mm²*
  after 28 days *> 50.0 N/mm²*
- *Material characteristic compressive strength upon curing completion* *>50.0 N/mm²*
- *Service life and constancy of performance over time*
- *Freeze-thaw and de-icing salt resistance*
- *Water resistance*
- *Absence of chlorine*

GeoLite® Asfalto by Kerakoll is an example of quick curing bedding material and it is easily available at construction dealers.

Under special temperature conditions, appropriate bedding materials shall be selected according to place of installation and application. Bedding materials shall always be applied in compliance with the relevant manufacturer's recommendations. Any shimming materials may be incorporated into the embedment, provided a check is carried out to verify the assembly definitive stableness.

Whenever it is necessary to raise the level of the manhole top seating at the shaft top, a shimming material may be used, provided it features a minimum compressive strength of 50 N/mm^2, it is durable over time and compatible with the selected bedding materials.

Generally, shimming materials are made of cast iron, steel, or concrete; hollow bricks, shattered briquettes and/or tiles, wood pieces or plastics material and, anyway, any material that cannot meet the required strength and service life recommendations are NOT admitted.

7. 3 – NEW INSTALLATIONS

First of all, the contractor shall check that the shaft, prefabricated or laid on site, is in sound conditions and may safely structurally carry the KIO® manhole top to be embedded.
Moreover, it is essential that frame and seating on the shaft are cleaned, removing any mud, grease, and debris. If necessary, shaft top may be roughened to enhance bedding material setting.

Seating depth shall be calculated considering the height of features to be installed in order to minimize the use of shimming materials. Seating width shall be equal to 1.6 times the maximum outer feature frame size at least to have the chance to provide for a thick and uniform concrete curb around it.

It is recommended to mix bedding material mechanically and not manually in order to obtain a homogeneous product: the operation shall be completed very shortly and anyway before quick curing is completed.

Once the bedding material has been laid, frame shall be quickly positioned at height, and frame actual section shall be centred with the shaft one, exercising an appropriate pressure onto the embedment to ensure it is firmly set, besides making sure that no inner frame part is not aligned to the shaft. Frame positioning on shaft top directly is not admitted.

Frame shall be positioned on the embedment so that frame bearing surface is adequately supported by shaft/chamber top. In case of installation in areas imposing high wheel loads and/or frequent vehicular traffic it is suggested to anchor KIO® ϕ 800 and KIO® 850 x 850 D400 manhole tops to concrete slab or to underlying concrete shaft wall, positioning fixing dowels into the appropriate circular slots on the frame. Moreover, frame shall be positioned at road surface level by means of reference points and be aligned to the adjacent paved surface.

It is necessary to make sure that no gaps are left between the frame and the shaft top; it is hereby recommended to pay special attention when bedding material is laid nearby cover seating, preventing material debris from depositing. Furthermore, it is required to check that bedding material covers frame flanges by a minimum 1 cm thickness and outcomes from any frame holes and slots, if any, thus ensuring perfect securing.
If embedment thickness is greater than 4 cm, layers shall be laid in two times: the first one should be 2 to 4 cm thick, while the following one should be laid after a suitable gripping material is applied, paying attention to leave a residual thickness sufficient for road surface finishing; exposed embedment surfaces, inside or outside the frame, shall be smoothed and made uniform.

The cover/grating shall be inserted with caution into the frame once material has set sufficiently and has achieved enough compressive strength and only after an accurate check and cleaning of the gasket support seating and frame seating where the KIO® cover shall be inserted.

Finishing filling around the manhole top shall be made after 3 hours at least with the same bedding material, leaving a layer of 3 cm minimum to allow road pavement to be finished by asphalt. Compactor shall not pass over the manhole cover to prevent damages to the

embedment/frame/cover assembly. Installation shall not be subject to any strain until embedment material has reached proper strength level. Once the installation has been completed, manhole top frame and cover/grating shall be aligned to the adjacent road paved surface.

Before opening the area to traffic, make sure that adequate curing time has elapsed as recommended by product manufacturer: unless otherwise recommended, wait for 72 hours at least.

7. 4 – REPLACEMENT OF MANHOLE TOPS

In case of replacement of broken or damaged manhole tops or interventions for rise in road height because of road pavement resurfacing, the following recommendations shall be taken into account, besides provisions detailed in the previous paragraph:

- Frame support structure may be deteriorated and may not comply with safety requirements any longer or it has been damaged during assembly and/or surrounding pavement removal, then complete renovation is required.
- Cover and frame shall be thoroughly checked to ascertain if they are suitable for being used again and if they are under sufficiently good conditions to be installed again. If cover or frame are no longer suitable for use, the whole assembly shall be replaced and not only the deteriorated part: using a new cover in an old frame and vice versa is strictly forbidden.

Firstly, mark cut position on road pavement for manhole removal so that a seating is created at least 1.6 times larger than maximum outer frame size of the feature to be removed in order to have the chance to provide for a thick and uniform concrete curb around it. If pavement material shows any visible evidence of rupture or cracks, cuts shall be carried out 50 mm outside the rupture/crack so that it is removed.

Then, cut the whole depth of pavement layers along frame perimeter (by circular saw or similar equipment) and remove any material between cut and frame, so that the frame and the whole shaft wall width is unencumbered.

Pavement cutting

Removal of material around the frame

Cover/grating shall be checked, and frame shall be lifted to view underlying bedding material and remove any loose material. Then, it is essential to check shaft conditions thoroughly to ascertain its structural integrity: shaft shall always be able to support the manhole top or gully top and any other additional dynamic or static load, which may be discharged on it by external forces. In case of evident deterioration or lack of concrete, it is necessary to check if a repair could ensure original characteristics are restored; on the contrary, assembly shall be replaced.

Cleaning

Frame adjustment to road level

Supporting structure shall be of appropriate size and its characteristic strength shall be equal to 50 N/mm^2 or greater to stand frame base, cover, and external stress. Then, manhole top shall be installed in compliance with instructions detailed in the previous paragraph.

7. 5 – MAINTENANCE

Suitable maintenance of manhole tops and all its components shall ensure optimized system operation and longer service life.

Therefore, it is essential that the following operations are carried out every time manhole tops are opened:

- Check for cracks in the frame supporting structure.
- Clean frame seating and gasket from stones, debris, dirt with a brush or by compressed air.
- Check gasket integrity and replace it, if necessary.
- Check that any steel inserts in the frame and in the cover are suitable anchored and show no signs of failure.
- Check proper working of any hinge system and cover locking feature in open position.

The same care and attention shall be paid to check the area surrounding manhole top; in particular, it shall be checked that:

- Framework surrounding manhole top shows no signs of failure.
- Framework surrounding frame outer edge is uniform and homogeneous and shows no cracks.
- Manhole top is aligned to the adjacent road level.

According to check outcomes, the need for restoring works shall be evaluated.