Technical annex
Introduction

Conforms with standards. Intensive research and testing is the reason PMA continues to set new standards and trends in cable protection.

PMA products conform to worldwide standards and regulations.

As a pioneer in the field of cable protection, we have always given high priority to our own testing facilities, and we have consciously introduced stringent in-house standards. This approach has enabled PMA to exercise a significant influence on the development of international standards. Standards committees with responsibility for cable systems regularly ask our company to provide advice or participate as an active member.

High quality product from A–Z
From basic items to high-tech products, all of our products meet the most stringent quality requirements.

Some of the outstanding are:
- Resistance to temperature, weathering, UV radiation and chemical agents
- High system pull-out resistance
- Excellent fire protection characteristics (flammability, smoke density and toxicity)
- Excellent system ingress protection up to IP68 and IP69
- Extremely long service life
- Conformance to all major international product standards

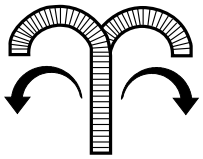
Technical annex

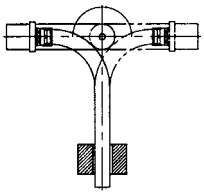
Testing methods IEC EN 61386

PMA DO is a PMA in-house test.

PMA DO 9.21-4425
IEC EN 61386

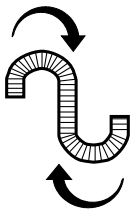
Reversed bending test with swinging movements
This standard is based on a cyclic reversed bending test (pivoting) of conduit under various conditions (temperature). The conduit are dynamically loaded and evaluated at the upper and lower application temperature limits. The test is performed based on IEC EN 61386. The minimum requirement corresponds to the specifications of IEC EN 61386. For PMA, the test is not considered completed for final evaluation until cracking or fracture. The number of cycles to fracture determines the fatigue strength of the conduit.

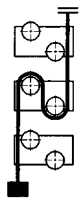




PMA DO 9.21-4420

Reversed bending test
This standard describes a cyclic reversed bending test with additional tensile loading (lifting) on flexible conduit under standard ambient conditions (23°C/50% relative humidity). The conduit is loaded until fracture. The number of cycles to fracture determines the fatigue strength of the conduit.





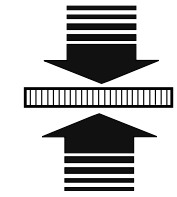
Technical annex

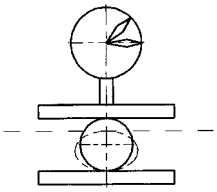
Testing methods IEC EN 61386

PMA DO is a PMA in-house test.

PMA DO 9.21-4320
IEC EN 61386

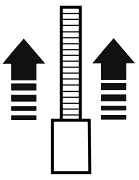
Peak load test
This standard describes the peak load test on conduit under standard ambient conditions (23°C/50% relative humidity). The conduit is deformed by a defined amount between two plates. The restoring force established over a specific time (by relaxation of the conduit) describes the crushing pressure or compressive strength.

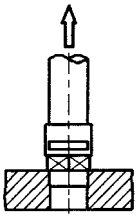




PMA DO 9.21-4610
IEC EN 61386

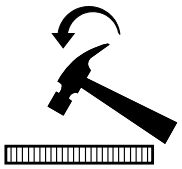
Pull out test
This standard defines the system pull-out test on conduit and connectors under standard ambient conditions (23°C/50% relative humidity). The conduit are mounted with the appropriate system connectors. The pull-out strength of the system is determined in a tensile test.

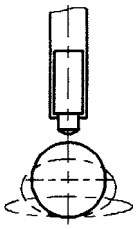




PMA DO 9.21-4330
IEC EN 61386

Impact test
This standard describes the impact strength test on conduit at various temperatures. The specimen is placed on a steel plate, centred under an impact head with a defined profile. The impact head impacts the centre of the specimen surface. In contrast to international specifications, deformation behaviour (buckling) is determining rather than fracture behaviour. The impact test is considered to be passed if no fracture or cracking can be detected after the impact, as well as no excessive permanent deformation of the conduit in accordance with PMA specifications.





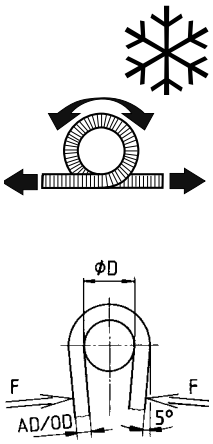
Technical annex

Testing methods IEC EN 61386

PMA DO is a PMA in-house test.

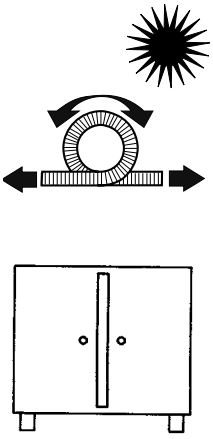
PMA DO 9.21-4380

Cold bending test
This standard describes a bending test on conduit at low temperatures. The specimens are stored in a controlled-climate cabinet at the specified test temperature. Loading is achieved by winding the specimen around a test mandrel with a defined diameter. The various products are classified based on the mandrel diameter which can be achieved.



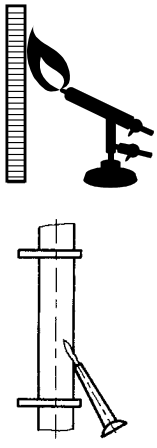
PMA DO 9.21-4360

Thermal ageing test
This standard describes a bending test on thermally aged specimens. The test conduit are stored in a controlled-climate oven at the specified test temperature. After removal from the oven, they are cooled to room temperature. Loading is achieved by winding the specimen around a test mandrel with a defined diameter. The various products are classified based on the mandrel diameter which can be achieved.



PMA DO 9.21-4430
IEC EN 61386

Self-extinguishing
This standard describes a flame test on conduit based on international specifications. The conduit is exposed to a defined flame from a standard burner. The time of ignition, flame propagation behaviour as well as time of extinguishing after removal of the flame source are significant parameters for evaluating the flame behaviour of the products.



Technical annex

Ingress protections IEC 60529

Ingress protection (IP) according to IEC 60529

Ingress protection (IP)
A standard to classify product performance regarding ingress protection.

Different number – different protection!
For example, products classified as IPx8 are not automatically protected against jet water! Immersion tests for classifications IPx7 and IPx8 differ from the tests for protection against jet water for IPx6, IPx5, or IPx4.
Therefore PMA cable protection systems are tested regarding different sealing requirements.

PMA Products

			PMAFIX Pro	PMAFIX IP68+ WPS	PMAFIX IP68/ IP68GT	PMAFIX IP66	PMA Smart Line
	IPx4	Splash water from all directions	●	●	●	●	●
	IPx5	Jet water at any angle	●	●	●	●	●
	IPx6	Powerful jet water from any angle	●	●	●	●	●
	IPx7	Submersion (1m, 30 min.)	●	●	●	–	–
	IPx8	Submersion at time and pressure >IPx7	●	●	●	–	–
> 80 bar	IPx9	High pressure (up to 100 bar, 80°C) water from any angle	●	●*	●*	●*	●*

*IEC 60529 can be fulfilled without WPS (Water impact protection ring). PMA recommends the use of the WPS ring for trouble free practical applications

PMA products offer complete protection!

Tested to 100 bar

Technical annex

Ingress protections IEC 60529

Dust

Protection against contact and penetration of foreign objects
Degree of protection
(contact/foreign bodies)

0	No protection
1	Objects greater than 50mm Ø, accidental touch by hands
2	Objects greater than 12.5mm Ø, accidental touch by fingers
3	Objects greater than 2.5mm Ø, e.g. tools/wires
4	Objects greater than 1mm Ø, e.g. tools/wires
5	Protected against dust - limited ingress (no harmful deposits)
6	Totally protected against dust (dust-tight)

Water

Protection against fluids
Degree of protection (water)

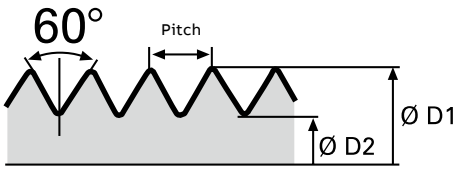
0	No protection
1	Protected against vertically falling drops of water
2	Protected against direct sprays of water 15° from vertical
3	Protected against sprays of water to 60° from vertical
4	Protected against water sprayed from all directions - limited ingress permitted
5	Protected against low pressure jets of water from all directions - limited ingress permitted
6	Protected against strong pressure jets of water, heavy seas - limited ingress permitted
7	Protection against the effects of immersion between 15cm - 1m
8	Protection against long periods of immersion under a quoted pressure, e.g. 2 bar at 24 hours
9	IP69 Automotive standard DIN40050 and signifies resistance to high pressure jets of water (up to 80 bar) from any angle

Technical annex

Table of thread dimensions

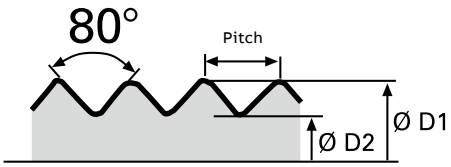
Metric fine thread - EN 60423

Metric	Pitch (mm)	Ø D1 (mm)	Ø D2 (mm)	Hole –0/+0.3 (mm)
12	1.5	12	10.16	12.0
16	1.5	16	14.16	16.0
20	1.5	20	18.16	20.0
25	1.5	25	23.16	25.0
32	1.5	32	30.16	32.0
40	1.5	40	38.16	40.0
50	1.5	50	48.16	50.0
63	1.5	63	61.16	63.0



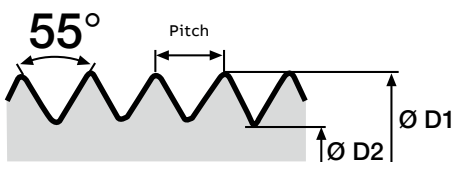
PG thread - DIN 40430

PG	Pitch (mm)	Ø D1 (mm)	Ø D2 (mm)	Hole (mm)
07	1.270	12.5	11.28	12.7
09	1.411	15.2	13.86	15.4
11	1.411	18.6	17.26	18.8
13	1.411	20.4	19.06	20.7
16	1.411	22.5	21.16	22.8
21	1.588	28.3	26.78	28.6
29	1.588	37.0	35.48	37.4
36	1.588	47.0	45.48	47.5
48	1.588	59.3	57.78	59.8



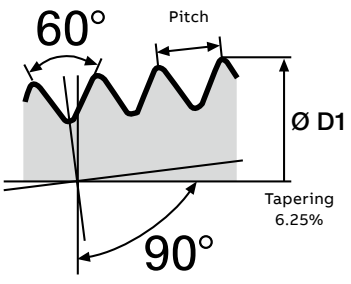
GAS pipe thread - DIN 259 Bl. 3, ISO 228/I

GAS	Pitch (mm)	Ø D1 (mm)	Ø D2 (mm)	Hole (mm)
¼″	1.337	13.157	11.445	13.4
⅜″	1.337	16.662	14.950	17.0
½″	1.814	20.955	18.631	21.3
¾″	1.814	26.441	24.117	26.8
1″	2.309	33.249	30.291	33.7
1¼″	2.309	41.910	38.952	42.4
1½″	2.309	47.803	44.845	48.3
2″	2.309	59.614	56.656	60.2



American standard taper pipe thread - ANSI/ASME B1.20

NPT	Pitch (mm)	Ø D1 (mm)	Hole D2 (mm)
¼″	1.411	13.716	13.9
⅜″	1.411	17.145	17.4
½″	1.814	21.336	21.6
¾″	1.814	26.670	26.9
1″	2.209	33.401	33.7
1¼″	2.209	42.164	42.4
1½″	2.209	48.260	48.5
2″	2.209	60.325	60.6



Technical annex

Comparison table

Conduit

Nominal width NW		
Standard	Metric	Inside Ø nom. (mm)
07	10	6.2
10	12	9.6
10	12	9.6
12	16	12.0
12	16	12.0
17	20	16.2
17	20	16.2
23	25	22.6
23	25	22.6
29	32	29.0
29	32	29.0
36	40	36.5
36	40	36.5
48	50	47.5
48	50	47.5

Connector metric

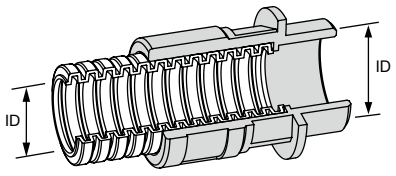
Inside diameter mm (nom.) ID		
Thread size	Metal thread	Polyamide thread
M12	–	8.0
M12	5.7	8.0
M16	9.6	11.0
M16	9.7	11.0
M20	13.5	13.0
M20	13.5	14.6
M25	18.3	19.0
M25	18.4	19.0
M32	24.2	24.0
M32	25.4	26.0
M40	31.4	32.0
M40	32.6	32.0
M50	39.5	39.0
M50	41.5	42.0
M63	51.4	53.0

Conduit

Nominal width NW		
Standard	Metric	Inside Ø nom. (mm)
07	10	6.2
10	12	9.6
12	16	12.0
–	–	–
17	20	16.2
23	25	22.6
29	32	29.0
36	40	36.5
–	–	–
48	50	47.5

Connector PG

Inside diameter mm (nom.) ID		
Thread size	Metal thread	Polyamide thread
PG07	–	8.0
PG09	9.5	10.0
PG11	12.5	13.0
PG13.5	14.5	14.5
PG16	16.5	17.5
PG21	22.0	22.5
PG29	30.0	30.5
PG36	40.0	37.5
PG42	–	46.0
PG48	49.5	50.0



Inside diameter threads to inside diameter conduit.

Technical annex

Torques

Recommended torques for PMA fittings - For threaded bore holes and with lock nuts

Thread	Metal* [Nm]	Polyamide** [Nm]
M12	4.0	1.5
M16	4.0	3.0
M20	6.0	4.0
M25	8.0	6.0
M32	10.0	8.0
M40	15.0	9.0
M50	15.0	10.0
M63	15.0	10.0

Thread	Metal* [Nm]	Polyamide [Nm]
PG07	3.5	1.5
PG09	4.0	1.5
PG11	6.0	2.0
PG13.5	6.0	2.5
PG16	7.0	4.0
PG21	8.0	5.0
PG29	10.0	9.0
PG36	15.0	15.0
PG48	15.0	15.0

* Thread combination: Metal + metal
** Thread combination: Metal + polyamide or polyamide + polyamide

Strain relief fittings - According to EN 50262

Thread	Metal NVNZ-Mxxxx NKNZ-Mxxxx [Nm] EN	Metal NVNZ-Mxxxx/P NKNZ-Mxxxx/P [Nm]	Polyamide S/BVNZ-Mxxxx [Nm] EN
M12	5.0	6.0	0.9
M16	5.0	8.0	3.0
M20	7.5	10.0	4.0
M25	10.0	10.0	7.5
M32	15.0	15.0	10.0
M40	20.0	20.0	10.0
M50	20.0	20.0	10.0
M63	20.0	20.0	10.0

Note: These values where gauged at standard climate (23°C/50% relative humidity)

According to DIN VDE 0619

Thread	Metal NVNZ-Pxxxx [Nm]	Metal NVNZ-Pxxxx/P [Nm]	Polyamide S/BVNZ-Pxxxx [Nm]
PG07	6.25	6.0	2.5
PG09	6.25	8.0	3.75
PG11	6.25	10.0	3.75
PG13.5	6.25	10.0	3.75
PG16	7.5	10.0	5.0
PG21	10.0	15.0	7.5
PG29	10.0	20.0	7.5
PG36	10.0	30.0	7.5
PG48	10.0	40.0	7.5

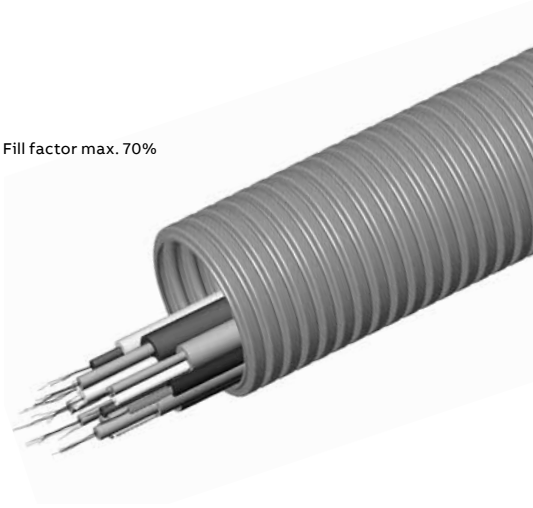
Technical annex

Applications engineering information

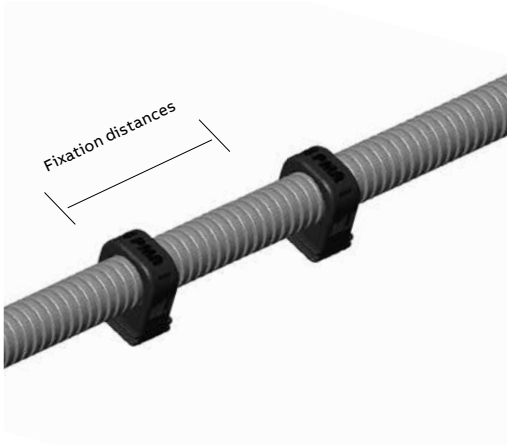
Fill factor, relevant guidelines
The question of conduit capacity or fill factor arises in the use of cable protection systems. This describes the extent to which a conduit can or should be filled with cables and/or conductors based on the available cross-sectional area.

In all cases, PMA recommends that a conduit **capacity of 70%** not be exceeded. (Application-specific procedures and standards must also be considered.)

This ensures that operation is not unnecessarily impaired by increased friction between the individual conductors in dynamically moving systems. In addition, subsequent installation of additional conductors and/or cables is also possible if necessary.



Wiring installation: fixation
PMA AG recommends that cable protection systems be fastened with a spacing of **300mm to 500mm** between supports. This spacing can be varied depending on the application and location. This recommendation applies for all available dimensions. For larger diameters, the increased load due to the cables and conductors in the conduit is accounted for by adherence to the support spacing. PMA supplies suitable system supports for various strength requirements and applications.



European standard **EN 50343:2003-5.15** “Railway applications – Rolling stock – Rules for installation of cabling” specifies the following spacing between supports for fastening conductors:
Horizontal wiring: 300mm
Vertical wiring: 500mm
(Application specific guidelines and standards should also be considered.)

Technical annex

Chemical resistance

Chemical resistance comparison table

Resistance against	Chemical formula	PA6, Polyamide 6 PA6.6, Polyamide 6.6	PA12, Polyamide 12 PA11, Polyamide 11	PP, Polypropylene PE, Polyethylene	TPU	PFA PVDF
Acetic acid (10%)	C2H4O2	1	2	3	0	3
Acetone	C3H6O	3	3	3	0	3
Ammonia (30%)	NH3	3	3	3	0	3
Benzine	–	3	3	2	1	3
Brake fluid	–	3	3	3	0	3
Caustic soda	NaOH	3	3	3	1	3
Ethyl alcohol (40%)	C2H6O	3	3	3	1	3
Glycol	C2H6O2	3	3	3	0	3
Hydrochloric acid (10%)	HCL	0	1	3	0	3
Methanol	CH4O	2	3	3	1	3
Methyl ethyl ketone	C4H8O	3	3	3	0	3
Nitric acid (10%)	HNO3	0	0	2	0	3
Ozone	O3	2	2	2	1	3
Paint thinner	–	3	3	1	0	3
Perchlorethylene	C2Cl4	2	2	2	0	3
Paraffin	–	3	3	1	0	3
Phosphoric acid (10%)	H3O4P	1	2	3	0	3
Sea water	–	3	3	3	2	3
Soap solution	–	3	3	3	2	3
Sodium chloride	NaCl	3	3	3	3	3
Sulphuric acid (10%)	H2SO4	1	2	3	0	3
Toluene	C7H8	3	3	1	0	3
Trichlorethylene	C2HCl3	1	2	0	0	3
Turpentine	–	3	3	0	0	3
Urine	–	3	3	3	3	3

Resistance against oils and greases	Chemical formula	PA6, Polyamide 6 PA6.6, Polyamide 6.6	PA12, Polyamide 12 PA11, Polyamide 11	PP, Polypropylene PE, Polyethylene	TPU	PFA PVDF
Cutting oils*	–	3	3	2	1	3
Diesel oil	–	3	3	2	2	3
ASTM Oil Nr. 3	–	3	3	2	1	3
Fuel oil	–	3	3	2	1	3
Hydraulic oils*	–	3	3	2	1	3
Mineral oils	–	3	3	2	3	3
Spark-erosion liquids	–	3	3	2	1	3
Skydrol	–	1	2	2	0	3
Transformer oils*	–	3	3	2	1	3

*Synthetic additives can affect the oil resistance of plastics. Please contact PMA for further information

Key:
3 = Excellent resistance/suitable for permanent contact
2 = Resistant/suitable for occasional contact
1 = Relatively resistant/suitable for short-term contact
0 = Not recommended

Important
The chemical resistance of plastic products is also dependant on factors such as temperature, amount of time exposed to chemicals (e.g. occasional contact or immersed) as well as the concentration of the specific chemicals. The stated chemical resistances are valid for a temperature of 20°C. The chemical resistance table above serves only as a guide for the use of polyamide products in conjunction with the listed chemicals. Each specific application should be controlled for suitability by the end-user.