Mechanical properties

PPR

Parameter	UM	Requirements	Test parameters	Test method
Internal pressure resistance	h	> 1	T=20C =16MPa	EN ISO 1167
Internal pressure resistance	h	> 22	T=95C =4,3MPa	EN ISO 1167
Internal pressure resistance	h	> 165	T=95C =3,8MPa	EN ISO 1167
Internal pressure resistance	h	> 1000	T=95C =3,6MPa	EN ISO 1167

PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Internal pressure resistance	h	> 1	T=20C =15MPa	EN ISO 1167
Internal pressure resistance	h	> 22	T=95C = 4,2MPa	EN ISO 1167
Internal pressure resistance	h	> 165	T=95C = 4,0MPa	EN ISO 1167
Internal pressure resistance	h	> 1000	T=95C = 3,8MPa	EN ISO 1167

Physical properties

PPR and PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Heat shrink	%	<2	T= 135C e8 mm --> t = 1 h 8<e16 mm --> t = 2 h e>16 mm --> t = 4 h	EN743 Method B
Resistance to impact	%	no break	T= 0C	ISO/DIS 9854
MFI	%	30, max difference between pipe and MP	T= 230C m= 2,16 Kg	ISO 1133 CONDITION 12 / UNI5640/74

PPR

Parameter	UM	Requirements	Test parameters	Test method
Thermal stability through pressure tests	h	>8760	=1,9 Mpa - T=110C	EN ISO 1167

PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Thermal stability through pressure tests	h	>8760	=2,3 Mpa T=110C	EN ISO 1167

Physical properties of the raw material				
PPR and PP-RP				
	UM	**Requirements**	**Test parameters**	**Test method**
Modulus of elasticity	MPa	850-900	1 mm/min	ISO 527-2
MFI	g/10′	0,2-0,3	T= 230C - m= 2,16 Kg	ISO 1133
MFI	g/10′	0,4-0,5	T= 190C - m=5,0 Kg	ISO 1133

PPR PIPING SYSTEM

TECHNOLOGY AND APPLICATIONS

	Monolayer pipe	Fiber glass	Preinsulated	Oxygen barrier	UV barrier	Chemical barrier
Drinking water	■					
Heating systems		■				
Heating/cooling systems		■		■		
Radiant systems		■				
Industrial cooling		■	■	■		■
Industrial heating		■	■	■		■
Chilled water technology		■				
Cooling towers		■				■
Agriculture	■				■	
Swimming pools		■		■		■
Chemical fluid conveyance						■
Transport of chlorine						■
Rainwater and recycled water	■					
Irrigation	■					
Ship building	■	■			■	
District heating pipeline systems		■	■			
Compressed air systems		■				
Geothermal systems	■	■	■			

■ The system is suitable for this application

HOW TO READ THE TABLE

The table shows which technology to use, depending on the applications. Once you select the box that represents the APPLICATION, you can find the TECHNOLOGY to be used following the line corresponding to the selected box.

The choice can sometimes be multiple, as more than one product can satisfy the requirements of the same application. The solutions proposed by NUPIGECO meet the pressure values and the characteristics of the liquid to be transported, allowing the installation of major projects (airports, shopping malls, air conditioning systems) and the most common household plumbing installations.

PPR PIPING SYSTEM

Drinking water distribution networks

The system allows the transport of hot and cold drinking water.

Systems for central thermal regulation

Installations in large civil and industrial buildings for commercial or residential use that require the vertical distribution of piping for the transport of the fluid.

Air handling units and rooftop units

Systems designed to ensure the perfect installation of connections between large climatic rooms and main manifolds for the distribution of chilled fluids.

Chilled water is used to cool the air in a building and the equipment for refrigeration units, especially when many individual rooms must be separately controlled (e.g. a hotel).

Chilled water is produced by an individual unit sized according to the dimensions of the room to serve. The advantage provided by the size of the refrigeration unit is based on the principles of the economy of scale.

As a consequence, the greater the size of the refrigeration unit, the lower its power consumption. According to these considerations, it is necessary to rely on a PPR pipe and fitting system that can fulfil saving requirements in terms of piping insulation, heat transmission, installation times and head loss.

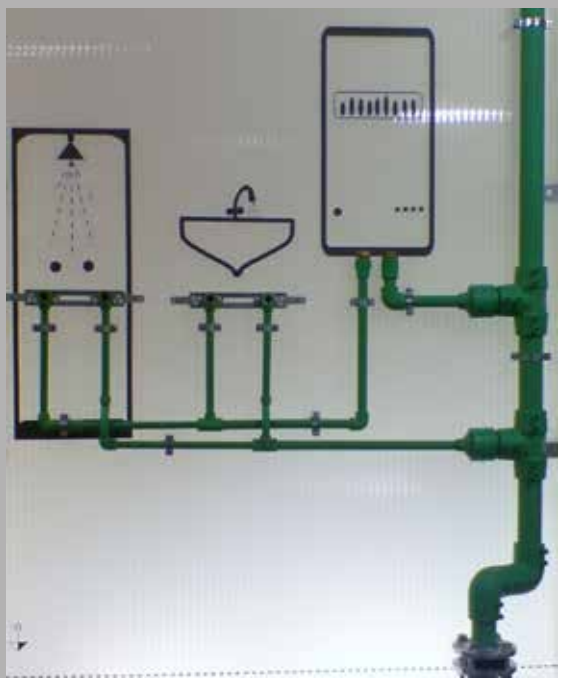
Thanks to the **PPR PIPING SYSTEM** by **NUPIGECO**, commercial buildings can lower installation costs by up to 20%.

VERSATILE HORIZONTAL AND VERTICAL INSTALLATIONS

RISERS

Hot and cold water distribution networks made with vertical risers in the following configurations:

- water distribution from public water pipelines to apartment blocks;
- branching pattern;
- horizontal ring pattern;
- cage pattern.



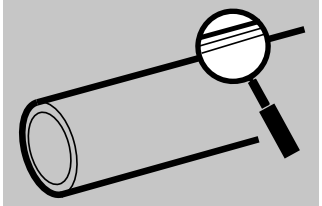
TERMINATING COLLECTION POINTS

PPR PIPING SYSTEM

COOLING TOWERS: used to dispose of unwanted heat produced by a cooler. Big office buildings, hospitals and schools typically use one or more cooling towers as part of their air conditioning systems. Industrial and commercial cooling towers are used to remove the heat of the production process. The main aim of large industrial cooling towers is to eliminate the heat absorbed by the circulating system for cooling water.

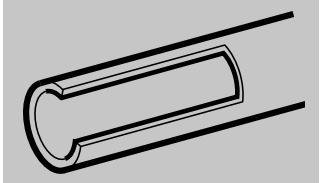
PUMP ROOMS

Class 1 pipes and fittings used for the mechanical units adopted that shall always be designed RESPECTING PPR PRESSURE CLASSES: centrifugal pumps, multistage pumps, wet rotor pumps, impellers, magnet dynamic fluid pumps, axial pumps, hydraulic water hammer pumps, linear dynamic fluid pumps.



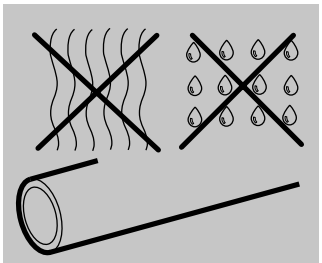
NO CORROSION

PP-R pipes are resistant to any type of water hardness and bear many of the chemical substances with pH values between 1 and 14. PPR is highly resistant to alkalis and many acids, except for some highly concentrated acids.



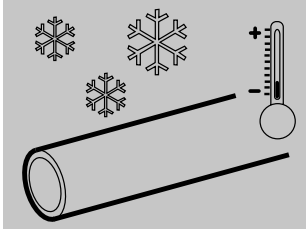
NO SCALING

The inner smoothness of pipes prevents the formation of scale.



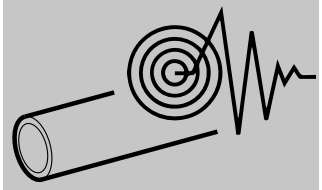
LIMITED HEAT LOSS AND CONDENSATION

Like all plastics, PP-R is a poor heat conductor and is therefore an excellent thermal insulator.



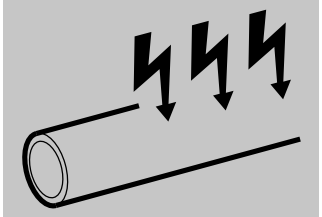
FROST RESISTANCE

The elasticity of PP-R allows the pipe to increase its section when the volume of the fluid changes as the water freezes.



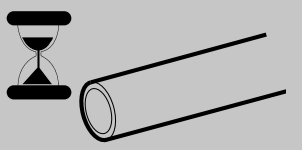
SUITABLE FOR USE IN SEISMIC HAZARD AREAS

This feature is recognized by international boards of experts, as polypropylene is resilient within the structure of a building.



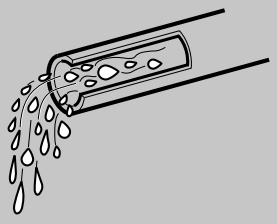
RESISTANCE TO STRAY CURRENTS

Polypropylene is a poor conductor of electricity, so no perforation in the pipe or fitting will ever occur due to stray currents.



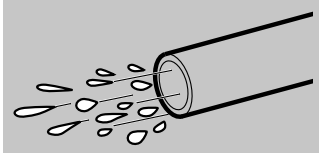
DURABILITY

More than 50 years, depending on temperatures and working pressures.



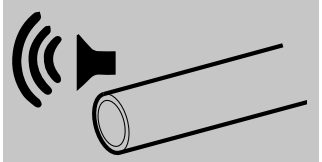
RESISTANCE TO ABRASION

The high abrasion resistance of PPR PIPING SYSTEM allows the passage of water at high velocity without erosion problems.



LIMITED HEAD LOSS

PPR PIPING SYSTEM pipes have limited head loss thanks to its inner smoothness.



LOWER NOISE OF THE SYSTEM

The elasticity and the sound absorption of the material prevent the spread of noise and vibrations due to the passage of water and the water hammer effect.

2.1 BENEFITS

- No corrosion
- No scaling
- Frost resistance
- Limited heat loss and condensation
- Low noise
- Limited head loss
- Resistance to abrasion
- Resistance to stray currents
- Durability
- Lightness

2.1.1 POLYPROPYLENE

The polypropylene used for the **PPR PIPING SYSTEM** by **NUPIGECO** is a special type of Random Copolymer with high molecular weight.

The special structure of its molecules and the appropriate additives used ensure the mechanical resistance and prolonged duration.

PPR is very light and easy to process, therefore the material is effectively used to produce a complete system that allows installation time saving from 30 to 50 %, if compared to the traditional metal systems (steel and copper).

PPR PIPING SYSTEM by **NUPIGECO** is used for the conveyance of drinking water in heating and cooling applications and is also used in the production of refrigeration systems. It is also used for the industrial, agricultural and shipbuilding fields.

The raw material is supplied by international certified suppliers and complies with the most important organoleptic requirements for the transport of drinking water and contact with food fluids.

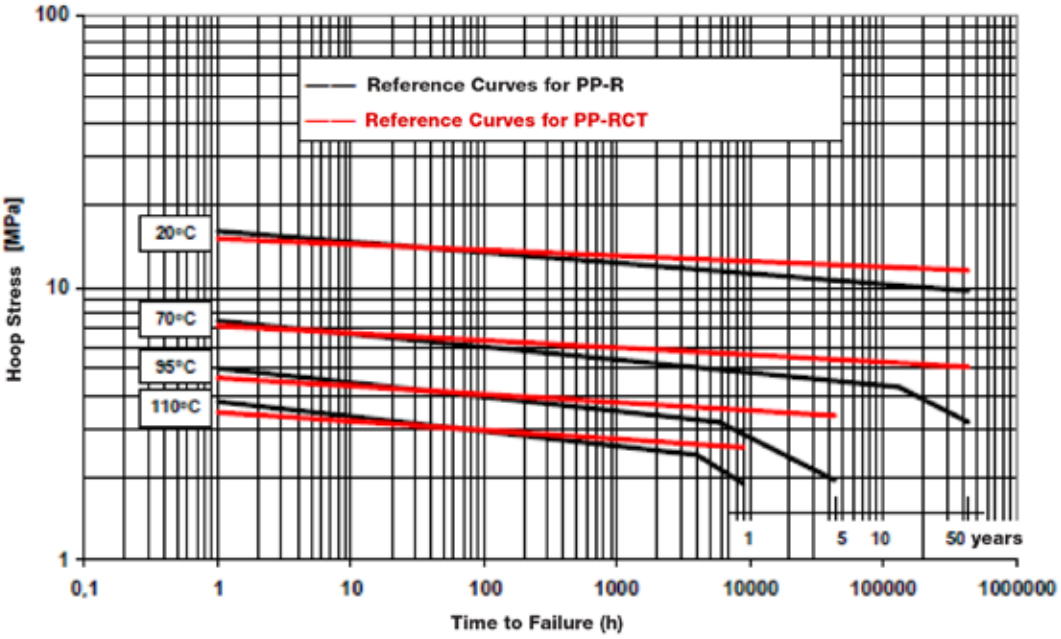
Polypropylene is available in 4 main types of polymer:

TYPE 1	TYPE 2	TYPE 3	TYPE 4
HOMOPOLYMER	BLOCK COPOLYMER	RANDOM COPOLYMER	RANDOM COPOLYMER WITH MODIFIED CRYSTALLINITY
PP-H	PP-B	PP-R	PP-RCT

NUPIGECO uses PP-R and PP-RCT (internally codified as PP-RP) for its NIRON system.

PP-RCT represents the evolution of the 2000s of PP-R. It presents better performance characteristics than its predecessor PP-R.

The regression curve flattened by ensuring lower decay of pressure/temperature performances and the "knee" of the curve disappeared for a more enhanced durability.



The required pipe series for a particular application class is calculated from the design stress and the operating pressure. The outcome of this calculation for operating pressures of 8 bar and 10 bar are presented in table V.

Table V: Comparison of the required pipe series and SDR for PP-R and PP-RCT for the individual application classes

	Operating pressure 8 bar (116 psi)		Operating pressure 10 bar (145 psi)	
	PP-R	PP-RCT	PP-R	PP-RCT
Application class 1 60°C hot water supply	S 3,2 SDR 7,4	S 4 SDR 9	S 2,5 SDR 6	S 3,2 SDR 7,4
Application class 2 70°C hot water supply	S 2,5 SDR 6	S 4 SDR 9	S 2 SDR 5	S 3,2 SDR 7,4
Application class 4 Underfloor heating and low temperature radiators	S 3,2 SDR 7,4	S 4 SDR 9	S 3,2 SDR 7,4	S 3,2 SDR 7,4
Application class 5 High temperature radiators	S 2 SDR 5	S 3,2 SDR 7,4	-	S 2,5 SDR 6

Numerous international certificates ensure high quality standard of the **PPR PIPING SYSTEM** by **NUPIGECO**:

KIWA (Italy)
DVGW (Germany)
AENOR (Spain)
OVGW (Austria)
Certif (Portugal)
CSTBat (France)
ATG (Belgium)
WRAS (UK)
RINA (Italy)
Lloyd Register (UK)
Eurofins (France)

2.1.2 PROPERTIES OF THE MATERIAL

Properties	Test method	Values at 23°C	Unit of measure
Volumic mass	ISO 1183	**0,898**	g/cm^3
Yield strength	ISO 527	**23**	N/mm^2
Elongation at break	ISO 527	**> 50**	%
Modulus of elasticity	ISO 527	**850**	N/mm^2
Melt flow index MFI 190/5	ISO 1133 Procedure 18	**0,5**	g/10 min
Heat conductivity (λ)	DIN 52612	**0,24**	W/mk
Linear thermal expansion coefficient	VDE 0304	**1,5 x 10^{-4}**	K^{-1}
Melting point	DIN 53736b2	**150 - 154**	°C
Impact strength (Charpy) +23°C	ISO 179/1 e A	**no break**	KJ/m^2
-30°C	ISO 179/1 e A	**50**	KJ/m^2
Volumic strength	IEC 93	**>10^{15}**	Ω cm
Dielectric strength	IEC 243/1	**75**	KV/mm
Dielectric loss factor	DIN 53483	**< 5 x 10^{-4}**	
Fire resistance	DIN 4102	**B2**	

2.1.3 CHEMICAL AND THERMAL DISINFECTION

A) CHEMICAL DISINFECTION OF DRINKING WATER

The continuous disinfection with chlorinated drinking water may occur with a concentration of free chlorine up to 0,5 ppm (mg / l).

In Italy, the maximum allowable concentration of free chlorine in water is 0,2 ppm (mg / l).

The maximum temperature of 70° C shall not be exceeded.

The level of parameters is different for each country, for this reason the system must comply with the restrictions relating to drinking water in the country where the pipe will be installed.

Chlorine dioxide as a disinfectant

The use of chlorine dioxide as a disinfectant in drinking water supply is increasing in recent years, as the chemical reactivity (and therefore the effects of the disinfection) is about three times higher in case of free chlorine.

This high oxidation generates potential damage to the **PPR PIPING SYSTEM**.

B) THERMAL DISINFECTION OF THE SYSTEM

The washing temperature is adjusted so that the level of 70° C for a minimum of 3 minutes at all points of the drinking water network is maintained.

It is essential to observe the maximum allowable limits indicated by the regulations in force, as regards temperature and working pressure, that differ according to the application and use of the building where the system is placed.

C) UV TREATMENT FOR THE DISINFECTION OF DRINKING WATER SYSTEMS

The irradiation with ultraviolet light is a valid alternative method for the disinfection of drinking water. The application of ultraviolet light is a method of disinfection which seems to be more effective in the proximity of the point of use.

GENERAL INDICATIONS FOR ALL PLUMBING APPLICATIONS

We hereby list some possible actions aimed at preventing the spread of the bacterium that causes Legionellosis in water supply zones:

- avoid pipes with closed end sections;
- move the recirculation loop (if any) as close as possible to the user;
- periodically increase the water supply temperature to 55° C (more if required by maintenance protocols);
- expose the supply of water to UV rays using special lamps.

The preventive treatments against the bacterium, in air conditioning systems, are the following:

- use of special devices (droplet separator) in cooling towers;
- design of cooling towers so that the air flow can be channeled into the outer air intakes;
- regular cleaning of prevention systems, in order to eliminate the nutrients of the bacterium;
- regular chlorination of the network, according to the standards and parameters of the law.

2.1.4 CERTIFIED QUALITY

We hereby list the reference laws, guidelines and standards for the **PPR PIPING SYSTEM** by **NUPIGECO**:

- GENERAL QUALITY AND DIMENSION REQUIREMENTS

UNI EN ISO 15874 Plastics piping systems for hot and cold water installations -- Polypropylene (PP).

ASTM F2389 Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems.

CSA B137.11 Polypropylene (PP-R) pipe and fittings for pressure applications.

NSF/ANSI Standard 14 Plastics Piping System Components and Related Materials.

DIN 8077 Polypropylene (PP) Pipes - PP-H, PP-B, Pp-R, PP-RCT – Dimensions.

DIN 8078 Polypropylene (PP) Pipes - PP-H, PP-B, Pp-R, PP-RCT – General quality requirements and testing.

DVGW Working sheets.

- HYGIENIC LAWS AND SPECIFICATIONS

W270 (Germany) [Increase of Microorganisms on materials. Used for potable water application-Test and Evaluation].

BS 6920 British Standard Suitability Of Non-Metallic Products For Use In Contact With Water Intended For Human Consumption With Regard To Their Effect On The Quality Of The Water.

ACS (Attestation de Conformité Sanitaire)

Hydrocheck (Belgaqua)

D.M. 174 of 16.04.04 (Italy)

NSF/ANSI Standard 61 Drinking Water System Components - Health Effects.

- INSTALLATION STANDARDS

DIN 2000 Guidelines For Drawing Up Requirements For The Design, Construction, Operation And Maintenance Of Public Drinking Water Supply System.

EN 806 Specifications For Installations Inside Buildings Conveying Water For Human Consumption.

DIN 1988 Codes of practice for drinking water installations - DVGW code of practice.

DIN 4109 Standard for the elimination of noise in the field of structural engineering.

DIN 16962 Pipe Joints And Elements For Polypropylene (Pp) - Pressure Pipelines.

DVS 2207 Welding of thermoplastic materials.

DVS 2208 Welding machines and devices for thermoplastic materials.

DIN 18381 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - Installation of gas, water and drainage pipework inside buildings.

DIN 16928 Pipes of Thermoplastic Materials; Pipe Joints, Elements for Pipes, Laying; General Directions.

CERTIFIED QUALITY

The quality of the PPR PIPING SYSTEM by NUPIGECO is guaranteed by numerous national and international independent bodies.

2.1.5 CONTROL SYSTEM

The production of pipes and fittings requires the supervision, regulation and control of all the working operations. All results are recorded and documented.

OUR STANDARD INCLUDES:

- acceptance testing of raw materials and incoming goods;
- process control;
- inspection and testing of products;
- final inspection and sample tests on the production batches.

This procedure is required by the standard that regulates the Quality Management System (UNI EN ISO 9001) and the relevant protocols for the quality control of piping systems for the transport of water inside buildings (UNI EN ISO 15874, ASTM F2389, etc.).

INTERNAL CONTROL

Skilled employees ensure that all assessments are carried out according to the appropriate regulations and fulfill all technical arrangements in accordance with the quality policy.

All internal quality controls are documented, recorded and stored in accordance with the provisions of law.

2.1.6 QUALITY ASSURANCE

ACCEPTANCE OF INCOMING GOODS

All incoming goods are subject to specific tests that guarantee that incoming products conform to the specified requirements.

INSPECTION AND TEST

The quality plan adopted by NUPIGECO requires that tests and inspections are carried out before and during the production process.

During the production phase, the quality plan establishes that products pass the following tests:

- dimensional check;
- surface check;
- marking check;
- control of process parameters.

The samples are collected and sent to the quality department that performs quality checks and performance testing on the products and submits them to various degrees and types of stress (pressure, temperature, oxidation, etc.).

FINAL INSPECTION AND TESTING

The quality plan adopted by NUPIGECO requires that the inspections and tests are carried out on the entire production cycle.

All test results are documented in the test report and the certificate 3.1 (available on request).

Final tests include:

- internal pressure test at 95° C (time and pressure are specified in the reference standard);
- cold impact test;
- oxidation induction time;
- melt flow index;
- homogeneity test with polarized light microscopy;
- dimensional checks;
- elongation test with dynamometer;
- tensile test (> 23 N/mm^2) with dynamometer.

After the final tests, more tests are carried out on some batches:

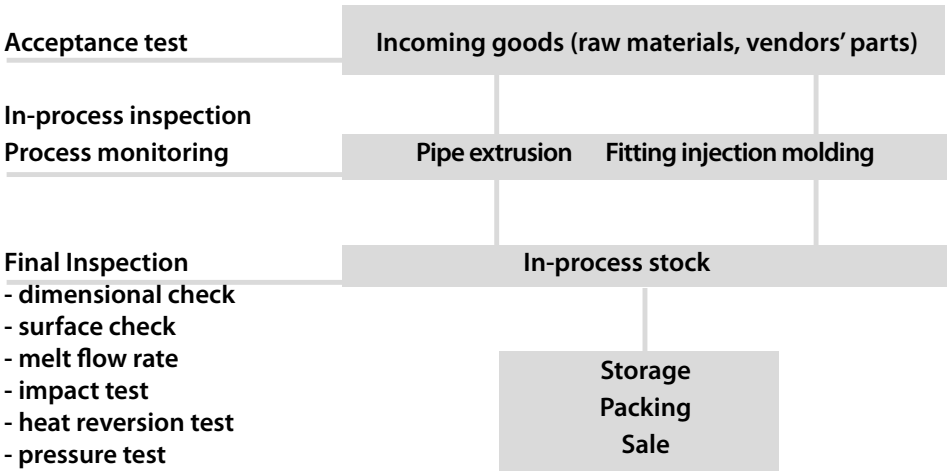
- thermal cycle: pipes and fittings are subjected to temperature cycles lasting 15 minutes at 95° C and 15 minutes at 20° C with a pressure of 10 bar for a total of 5.000 cycles;
- oxidation induction time: determining the percentage of antioxidants in the product after the extrusion process;
- thermal stability at 110° C for 8.760 hours (= 1 year).

STORAGE/PACKING/SHIPPING

Upon positive test results, the products are suitably packaged and stored in suitable warehouses.

The internal procedure regarding the method of packing, storage and shipping of products is represented by the following diagram.

INTERNAL CONTROL - SYSTEM CONTROL



EXTERNAL AUDIT

NUPIGECO submits its management and production system to external audits performed by third party certification bodies.

The external audit consists of tests carried out at given intervals.

Audit frequency depends on the procedure established by the specific standard and by each certification body.

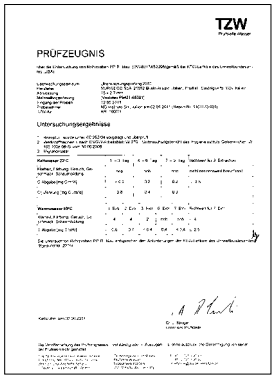
The external supervision also provides:

- verification of the quality system;
- calibration of test equipment;
- hygiene and toxicity tests.

The results are confirmed by test certificates obtained by NUPIGECO.













4.1 CHEMICAL, PHYSICAL AND MECHANICAL PROPERTIES OF PPR

Characteristics	Test method	Values	Unit of measure
Volumic mass	ISO 1183	0,898	g/cm^3
Yield strength	ISO 527	23	N/mm^2
Elongation at break	ISO 527	> 50	%
Modulus of elasticity	ISO 527	850	N/mm^2
Melt flow index MFI 190/5	ISO 1133 Procedure 18	0,3	g/10 min
Heat conductivity (λ)	DIN 52612	0,24	W/mk
Linear thermal expansion coefficient	VDE 0304	1,5 x 10-4	K^{-1}
Melting range	DIN 53736b2	150 - 154	°C
Impact strength (Charpy) +23°C	ISO 179/1 e A	no break	KJ/m^2
-30°C	ISO 179/1 e A	50	KJ/m^2
Volumic strength	IEC 93	$>10^{15}$	Ω cm
Dielectric strength	IEC 243/1	75	KV/mm
Fire resistance	DIN 4102	B2	

4.2 THE PIPE

PPR PIPING SYSTEM pipes are manufactured in accordance with standards UNI EN ISO 15874 and ISO21003 and are divided into:

- MONOLAYER PIPES
- MULTILAYER PIPES

They are sized to meet the needs of different types of installation.
The maximum constant pressure in bar at 20° C for 50 years, is obtained by the relation:

$$PN = \frac{20 \cdot \sigma}{C \cdot (SDR - 1)}$$

where:
PN = Nominal Pressure (bar)
σ = Hoop Stress of PPR (MPa)
SDR = Standard Dimension Ratio (External Diameter/Thickness)
C = Safety Coefficient

The European Standard **UNI EN ISO 15874** includes the classification of PPR piping systems intended to be used for hot and cold water installations. The **PPR PIPING SYSTEM** by **NUPIGECO** meets these requirements by ensuring a performance as per classes 1, 2 and 4 listed in the table below and classe 5 thanks to PP-RP.

EUROPEAN STANDARD
UNI EN ISO 15874

Class	T_{oper} (°C)[2]	Years to T_{oper}	Pressure Bar	T_{max} (°C)[2]	Years at T_{max}	T_{mal} (°C)[2]	Hours at T_{mal}	Fields of use
1	60	49	10	80	1	95	100	Hot water (60°C)
2	70	49	8	80	1	95	100	Hot water (70°C)
4	20 Followed by 40 Followed by 60	2,5 20 25	10	70	2,5	100	100	Floor heating and heating at max temperature 70°C
5	20 Followed by 60 Followed by 80	14 25 10	10	90	1	100	100	High temperature heating systems

Note 1: if more than one operating temperature is present in only one class, times must be combined.
For example, the operating temperature expected for 50 years for class 2 is 70° C for 49 years combined with 80° C for 1 year and 95° C for 100 hours.

Note 2: for values of T_{oper} (working temperature), T_{max} (maximum working temperature) and T_{mal} (malfunctioning temperature) higher than those indicated in the table, these standards are not applicable.

4.3 THERMAL EXPANSION

Plastic pipes are subject to thermal expansion, a phenomenon that has to be taken into consideration to prevent any possible damage.

The thermal expansion or contraction of a plastic pipe can be calculated using formula B.1 below and the coefficients of thermal expansion shown in the following table.

COEFFICIENT OF LINEAR THERMAL EXPANSION FOR PLASTIC PIPING

Pipe material	α (mm/mK)
PE	0,20
PE-X	0,15
PP	0,15
PB	0,13
PE-RT	0,19

$$\Delta L = \alpha \, L \, \Delta T$$

(FORMULA B.1)

Symbol	Description	Value	Unit of measure	
ΔL =	linear thermal expansion		mm	millimeters
αf =	coefficient of linear thermal expansion of monolayer PPR pipes	0,15	mm/mK	millimeters/meter kelvin
α(FG) =	coefficient of linear thermal expansion of PPR pipes with fiber glass	0,035	mm/mK	millimeters/meter kelvin
L =	pipe length		m	meters
ΔT =	difference between the installation temperature and the temperature of the transported fluid		K	degrees Kelvin

We hereby suggest some solutions to compensate the effects of linear expansion according to the different types of installation:

- **INSIDE WALL INSTALLATION**
- **INSTALLATION ON HORIZONTAL CONTINUOUS SUPPORTS**
- **FREE INSTALLATION**

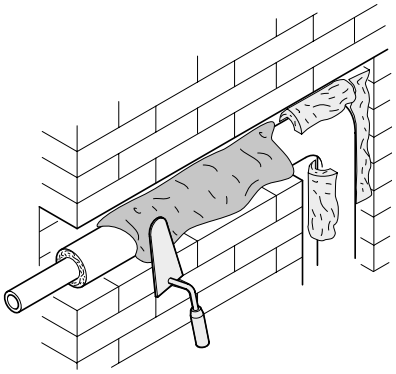
INSIDE WALL INSTALLATION

- **Non-insulated pipe:** the expansion will spread inside the pipe.
- **Insulated pipe:** the expansion will slightly compress the insulation layer to compensate the elongation.

Inside wall installation has always been the most recommended kind of installation for monolayer PP-R pipes because it avoids direct exposure to UV rays and benefits from a lower linear expansion as the outer layer is completely in contact with a large exchange area:

- the pipe can be walled directly in contact with plaster, lime and cement;

- the expansion does not carry the force required to remove the tiles and/or break the plaster.



INSIDE WALL INSTALLATION