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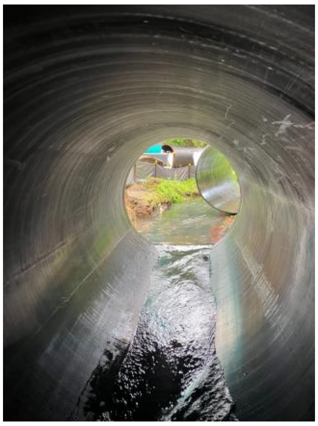
INFRAPIPE MATERIALS GUIDE FOR THERMOPLASTICS – HDPE & PP

This guide examines the properties of High Density Polyethylene (HDPE)(PE100) and Polypropylene (PP) used by INFRAPIPE. It conducts an overall assessment of material properties, looks at sustainability and then focusses on the key selection criteria:



- Hydraulic performance
- Abrasion resistance
- Material life
- Performance
- The benefits of homogeneity
- Chemical and biological resistance
- Temperatures and pressures
- Seismic resilience
- Whole Life Cost (TCO) impacts of material choice

The document then concludes with some facts to refute the common myths voiced by legacy material manufacturers.

EVOLUTION OF MATERIALS (POLYMER RESINS)

The first HDPE resin pipes were laid in 1955. Subsequent examination of those pipes 50 years later confirmed their performance – and further ones now confirm the life of a PE pipe as 100yrs +. These first resins had a lower strength, being PE63, then PE80 before the PE100 grade become the norm 30 years ago. Polypropylene was a later development in the 1970s, has a similar lifespan and is now used for some high-stiffness lower-ductility applications.

INFRAPIPE use these materials in 5 ways:

- To make profile gravity pipe DN450-DN3200 with an HDPE inner and a PP core tube for strength, sometimes with an outer layer of HDPE, using a KRAH machine.
- To make solid wall pressure pipe from HDPE alone DN20-3200, either from inline extrusion or the KRAH machine.
- To make tanks 5-1000m³, manholes, bends, connections etc. from a combination of profile pipe, solid wall pipe and HDPE sheet.
- To make twinwall profile gravity pipe in SN8 & SN6 from HDPE.
- To make twinwall profile gravity pipe in SN16 from PP.

OTHER DOCUMENTS

This document is part of the range of INFRAPIPE design manuals, datasheets and technical guides, supported by BIM files, standards information and standard drawings.

INFRAPIPE is an independent tax-paying NZ business that makes the largest pipes in Australasia. It is ISO9001 accredited with products certified to AS/NZS 5065 and AS/NZS 4130 and tested to ISO9969 and pipe solutions designed to meet AS/NZS2566.

MATERIAL PROPERTIES

MATERIALS

The table below summarises the performance of different materials with supporting detail provided overleaf:

Requirement	HDPE/PP	Concrete	FRP/GRP	PVC
Material life	Very good	Average	Can decay	Good
Abrasion resistance	Very good	Very poor	Poor	Good
Hydraulic efficiency	Very good	Average	Very good	Very good
Weight	Light	Very heavy	Heavy	Heavy
Tensile Strength	Very good	Good	Average	Average
Compressive Strength	Good	Very good	Very good	Good
Ductility	Very good	Nil	Nil	Nil
Deformation Recovery	Good	Nil	Nil	Nil
Brittleness	No	Some	Yes	Yes
Homogeneity	Yes	Yes	No	Yes
Risk of infiltration	Very good	Very poor	poor	Poor
Ease of modification	Very good	Average	Poor	Average
Ease of repair	Very good	Average	Poor	Poor
Seismic resilience	Very good	Poor	Poor	Average
Water permeability	Very good	Poor	Very poor	Very good
Biological resistance	Very good	Poor	Very poor	Very good
Chemical resistance	Very good	Very poor	Good	Good
Recycled in NZ	**Very good**	**Rare**	**Nil**	**Rare**
Sustainable manufacture	Average	Poor	Very poor	Very poor
Sustainable installation	**Very good**	Average	Poor	Average



The table below provides further information on material properties:

Requirement	Notes
Material life	HDPE/PP proven to be 100Yrs+, concrete pipes often <70. Penetrations/scratches to GRP cause rot and decay.
Abrasion resistance	See Darmstadt test below
Hydraulic efficiency	See Hydraulic section below
Weight	Concrete is 14 times heavier for pipes, PVC between 2 and 6 times heavier depending on diameter, GRP varies but typically twice as heavy for tanks.
Tensile Strength	INFRAPIPE HDPE yields at 31MPA with 8% strain.
Compressive Strength	Dependant on SN rating selected, can be as high as is needed.
Deformation Recovery	INFRAPIPE can recover from up to 50% deformation (see videos here or take a factory tour)
Brittleness	HDPE does not become brittle
Homogeneity	HDPE pipes are completely homogenous – there are no weak points or no interface issues between gelcoat and fabric (GRP) or concrete and reinforcing steel.
Risk of infiltration	Welded HDPE becomes one single structure, there are no infiltration points.
Ease of modification	Cut, prepare and weld – it is very simple for HDPE. It can be surface-dried instantly prior to welding, and can be used once cool – no extended drying or curing times.
Seismic performance	See Seismic section below
Water permeability	FRP/GRP and to a lesser extent concrete are both at risk of water penetration.
Biological resistance	FRP/GRP and to a lesser extent concrete are both susceptible to biological attack. See Biological section below
Chemical resistance	Concrete reacts with the environment and waste, GRP/FRP if exposed (the gelcoat protective layer is damaged) can also react. See Chemical section below.
Recycled in NZ	INFRAPIPE recycles all production waste and will recycle unwanted HDPE pipe.
Sustainable manufacture	See Sustainability section below
Sustainable installation	See Sustainability section below

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SUSTAINABILITY

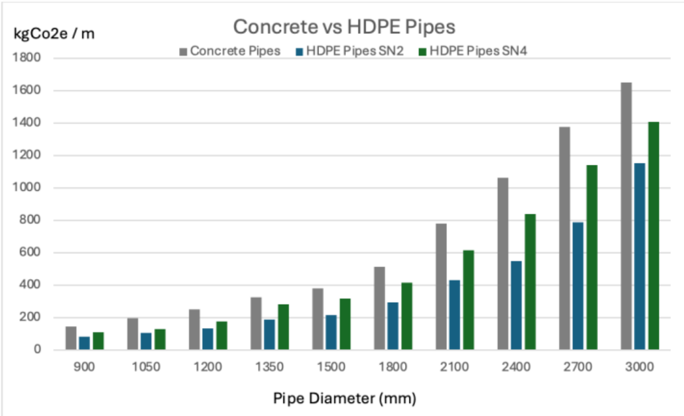
HDPE/PP is the best material for the planet.

- ✓ Polyethylene/polypropylene has been repeatedly proven to have a 100yr+ life.
- ✓ Minimal erosion equates to minimal fugitive particles.
- ✓ Alternatives which are chemically attacked by the environment pollute the soil heavily.
- ✓ Alternatives which are susceptible to biological attack will decay and pollute.
- ✓ INFRAPIPE is completely recyclable. The asset owner has no end-of life disposal liability.
- ✓ All production waste is recycled.
- ✓ Lighter products require less freight, less cranes and less diggers.
- ✓ Lighter products use less global resources in their manufacture.

HDPE/PP has one-third (or less) the environmental impact of concrete and a longer life:

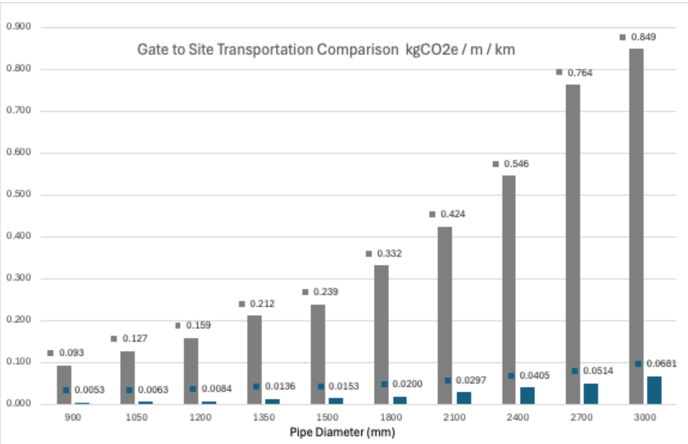
MANUFACTURE

- ✓ **CO2/Pipe:** HDPE pipes have a CO2/kg of approx. 2.2kg/m, where concrete is 0.25kg/m. However concrete pipes are 14 times heavier giving an equivalent CO2 figure of 3.5kg/m which is up to 60% higher than HDPE for cradle to gate depending on the product type.
- ✓ **CO2/Metre:** The improved hydraulic efficiency of thermoplastics allows smaller pipes for the same flow rate (typically 18%), further reducing the CO2 per metre of pipe.
- ✓ **Production waste:** All HDPE/PP production waste is reprocessed.
- ✓ **No waste:** INFRAPIPE is made to measure for large applications so there are no pipe ends or other waste. Manholes are made with connections so there is no waste from creating penetrations on site.



FREIGHT AND INSTALLATION

- ✓ **CO2/Delivery:** Pipes can be nested inside each other and being 14 times lighter, considerably less truck fuel is used.
- ✓ **CO2/Installation:** Smaller installation equipment is required for lighter pipes that are 2.5 or 5 times longer less time.
- ✓ EPDS from foreign manufacturers with identical equipment are available.
- ✓ Cradle to site the difference is even more pronounced due to the weight of concrete products.



(Graphs from "A New Comparative Analysis of the Environmental Performance Between Large Diameter HDPE and Concrete Pipes", Dr Vasileios Samaras [Swansea Univ.] et al., 2025)



MAINTENANCE AND PRODUCT LIFE

- ✓ **Chemical stability:** HDPE/PP needs no maintenance where PVC and GRP/FRP degrade and become brittle. Thermoplastics are chemically inert.
- ✓ **Wear resistance:** HDPE/PP has the best abrasion resistance of any material and therefore the longest life.
- ✓ **Product life:** HDPE/PP is guaranteed for 100 years but concrete has no certainty of longevity because it interacts with the soil and the fluid being carried. Once concrete abrades, decays or reacts to a point where the reinforcing or cracks greater than 1mm are exposed, the asset manager should condemn and replace the pipe.
- ✓ **Biological attack:** HDPE/PP is immune to biological attack where concrete and GRP are vulnerable to it.
- ✓ **Soil pollution:** HDPE/PP does not react with the soil. If it is recognized that concrete reacts with some soil types (which it is, some councils even advise installing thicker pipes in anticipation of this) then to install concrete in any such location is an act of pollution in its own right.
- ✓ **Seismic longevity:** HDPE/PP has the best seismic resilience, minimizing the environmental impact of a seismic event – pipes do not need to be replaced or repaired and the consequences of any spills remediated.
- ✓ **Damage/repair:** HDPE/PP can be repaired quickly and easily with no pollution on site. Concrete and GRP require polluting epoxy solutions.
- ✓ **Maintenance:** HDPE/PP needs no maintenance of any form. As it is smoother than concrete, less debris or sediment will accumulate.

RECYCLING OR DISPOSAL

- ✓ **Recycling:** HDPE/PP can be exhumed at end of life and sold for recycling. There is minimal recycling of concrete or PVC and none of GRP in NZ.
- ✓ **Recycled product:** Recycled HDPE/PP product is used in rural culverts. Recycled concrete loses its strength and leaches into the soil heavily so has few real-world applications.
- ✓ **Processing waste:** All HDPE/PP is recycled, concrete pour-off, ends, knockouts etc. are typically buried.
- ✓ **Disposal:** There is no disposal cost with HDPE/PP, simply clean it and freight it. Concrete and GRP must be broken down and buried.

ENVIRONMENTAL PRODUCT DECLARATIONS

The EPDs of other users of the same KRAH (profile pipe) equipment as INFRAPIPE have EPDs available to prove the figures above:

Visit EPDHUB and use the code HUB-0168 for the larger, helical wound pipes DN1200+

TEPPFA (the European Pipe Body) produced an EPD for the smaller twinwall pipes DN300-1000

TEPPFA EPD for CIVILPIPE equivalent for the smaller twinwall pipes DN300-1000

There are numerous articles available to confirm the benefits such as this:

Comparative Analysis of Green House Gases of HDPE vs Concrete. Overall, concrete has a greater Carbon Footprint associated with it, compared to equivalent sized HDPE, in both cradle-to-gate and cradle-to-site scenarios. Studies have found that on average, concrete tends to produce 21% more Green House Gas (GHG) emissions in cradle-to-gate scenarios (kgCO2e per unit length) and 95% more GHG emissions in gate-to-site scenarios (kgCO2e per unit length, per km) respectively, compared to the equivalent HDPE. The results show that HDPE is a significantly more carbon efficient product. As a result, HDPE has the potential to actively aid the construction industry in their formidable task of reducing GHG emissions in accordance with the government's targets.

Cowle, Matthew, Vasilios Samaras, and William B. Rauen. "A comparative analysis of the carbon footprint of large diameter concrete and HDPE pipes." *Plastic Pipes XVI, Barcelona* (2012).

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HYDRAULIC PERFORMANCE

MANNINGS – USED FOR GRAVITY APPLICATIONS

Different bodies apply different Mannings numbers in New Zealand, these are listed below. However, these do not take into account the impact of abrasion (see Darmstadt test below) over time. Either way, thermoplastics outperform concrete by an average of 18%, often meaning that a smaller pipe can be used for a given flow volume.

INFRAPIPE has a full set of Mannings graphs which can be found here, for 0.009, 0.011 and 0.013.

Document	PE/PVC	Concrete
NZBC E1	0.011	0.013
NZTA P46	0.011	0.013
Kiwirail	0.011	0.013

COLEBROOK-WHITE – USED FOR PRESSURE PIPES

The smoothness of pipe materials has been established as the Colebrook-White coefficient. Note this takes no account of degradation over time; a pipe with poor abrasion performance will have an even greater loss of performance. A lower figure is more efficient:

Material	Colebrook-White coefficient
HDPE/PP	0.0015
Concrete	0.15
FRP/GRP	0.06
PVC	0.03

Source: Civilweb

REYNOLDS – USED FOR DETERMINING LAMINAR/TURBULENT FLOW

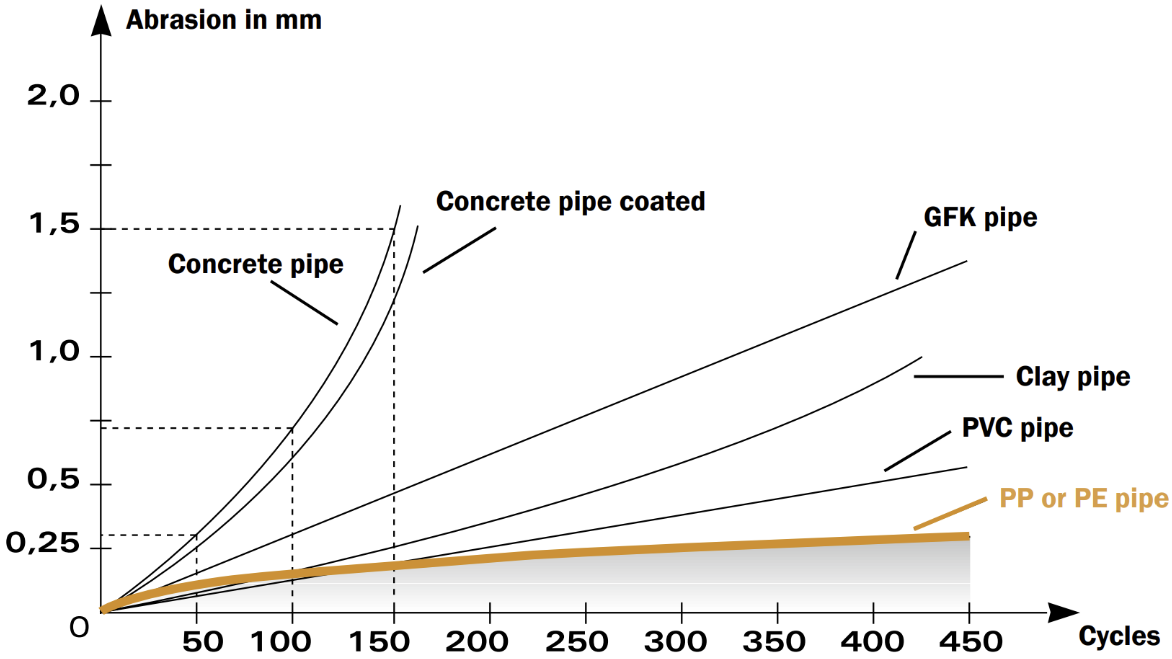
The coefficient of roughness required for Reynolds for a range of materials shows a clear advantage for Plastics.
From White, Frank, *Fluid Mechanics*, 4th Edition 2002

Material	ε (mm)
Concrete, coarse	0.25
Concrete, new smooth	0.025
Drawn tubing	0.0025
Glass,Plastic,Perspex	0.0025
Iron, cast	0.15
Sewers,old	3.0
Steel, mortar lined	0.1
Steel, rusted	0.5
Steel, structural or forged	0.025
Water mains, old	1.0

ABRASION RESISTANCE

ABRASION RESISTANCE – PRODUCT LIFE (DARMSTADT TEST)

HDPE has the optimum abrasion resistance of any pipe material as proven in numerous tests:



Abrasion curve of various pipe materials according to the Darmstadt procedure.

NB The above diagram is taken from a European paper, GFK is GRP/FRP.

The Darmstadt procedure, which has been the standard for abrasion testing since the 1960s, simulates the abrasion and resulting wear of liners and pipes that would occur in actual operating conditions by tilting a pipe section containing a mix of sand, gravel and water through 22.5 degrees above and below the horizontal for at least 100,000 cycles. The results for PP or PE pipe show a much greater resistance to abrasion and hence operating life is significantly longer.

The specimen comprises a 1metre length of DN300 pipe that is tilted to and fro in a controlled slow rocking motion at a frequency of 0.18 HZ; this corresponds to 21.6 stress cycles per minute – defined as the movement of the abrasive material in one direction.
The frequency ensures that the abrasion material travels the complete length of the test specimen. The abrasive material is a quartz sand and gravel in a water slurry containing approximately 46% by volume abrasive material in grain sizes 0-30mm. The abrasive material is changed every 100,000 stress cycles (approx. 77 hours).



LONGEVITY, DURABILITY & PERFORMANCE

MATERIAL LIFE – PRODUCT LIFE

The latest meta study by TEPPFA confirmed that the expected life of HDPE pipes is well in excess of 100 years. This is in addition to the 2006 research conducted on pipes exhumed after 50 years in the ground which confirmed their service life will exceed 100 years, or the study conducted in 2014 which investigated a wide variety of pipes to confirm their service life was 100 years plus.

COMPRESSIVE STRENGTH

The strength of a flexible pipe is a combination of the inherent strength of the pipe and the support of its bedding material as the high Poissons ratio of the material is used to transfer the compressive force from the vertical to a horizontal, using the trench either side. This strength is reflected in the SN rating (ring stiffness) of the pipe.
The total load this can bear is therefore dependant upon:

- ✓ The depth of the trench and cover
- ✓ The embedment materials used
- ✓ The native soil
- ✓ The ground water level
- ✓ The pipe itself

The ring stiffness a pipe is rated to is how much force is required to make that pipe deflect by 3%.
An SN16 pipe is 16 kPA which is 1,632 kgs per m2. On a DN600 at 3% (which is 203mm wide) that is a force of 331 kgs per metre. However, the pipe can recover from much greater forces.

For more details see trench design and strength, tolerances etc.

RECOVERY FROM DEFORMATION

A flexible pipe is designed to operate with short-term deflection of 5% and long-term deflection of 7.5%.

INFRAPIPE KRAH helical profile pipes will recover from a peak deformation of 30% to their per-deformation shape.

There is an older, obsolete technology called SRP – Steel Reinforced Pipe – which can appear visually to be the same as thermoplastic flexible pipe as it is manufactured from HDPE with steel reinforcing coils inside the profile shapes but lacks the ability to recover from deformation and should not be used.



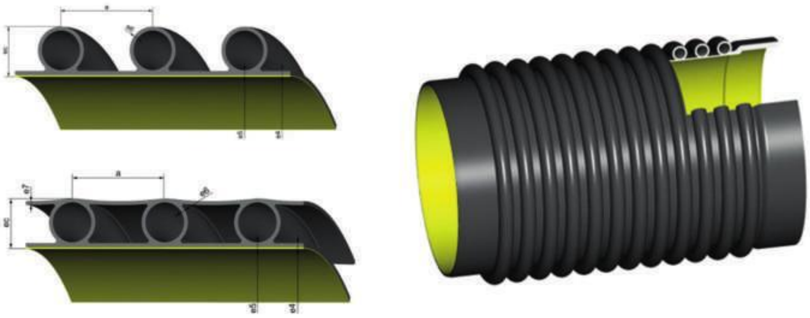
HOMOGENEITY IS A GUARANTEE OF LONGEVITY

HDPE pipes are homogenous as the active parts are one continuous structure of identical materials which are not friable. This guarantees the life of INFRAPIPE over other materials:

- × A material which is protected by an exterior layer (of its own or different material) such as a gelcoat or liner is at significant risk should this sacrificial layer be penetrated through damage or abrasion.
- × A material which is friable (that is, crumbles once it begins to deteriorate in the surface layer as the uneven exposure of more material increases the rate of decay) is at great risk of abrasion becoming pipe failure as turbulent flow in the fluids will exacerbate the issue exponentially.
- × A material which needs internal reinforcing is at risk of the exposure and failure of this reinforcing.
- × A penetration is a weak point for any material that is not homogeneous. In time, it will decay or corrode.

CRACK RESISTANCE

- × Inline extruded solid pipes force the molecules into a longitudinal orientation during extrusion. This can enable the propagation of cracks in a longitudinal direction in solid wall pipes.
- ✓ INFRAPIPE KRAH helically wound profile pipes extrude radially, therefore molecules are extruded in circumferential direction reducing the ability for crack propagation. Secondly as those polymers are not forced through thin and twisting channels they are more likely to be arranged in a random fashion, further preventing crack propagation. This is also true for solid wall pipes extruded helically.
- ✓ Even more powerfully, most KRAH profile pipes have a profile with a core tube outermost (unlike the smooth continuous surface of solid wall pipes). It is geometrically impossible for cracks to persist with this profile:



On the top left and on the right, a PR profile showing the exposed core tubes and the gap between them

CHEMICAL AND BIOLOGICAL

HDPE and PP are chemically inert and highly unattractive to biological attack.
This is a 26-page guide for the entire range of chemicals for HDPE & PP, though because of the way a profile pipe is manufactured, a KRAH pipe the PP is never in contact with anything other than its encasing HDPE.

This article unequivocally confirms the superior performance of HDPE to concrete pipe (and ductile iron) in relation to microbial adhesion and fouling.

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PRESSURE AND TEMPERATURE

PRESSURE RATINGS FOR APPLICATIONS

- ✓ Gravity applications for KRAH profile pipes typically reach 3 bar (PN3), with the limitation being the fittings – the pipe waterway can actually be made to any thickness needed.
- ✓ Twinwall CIVILPIPE applications are rated at 1 bar but with joints tested to 2 bar.
- ✓ Solid wall INFRAPIPE can be made to very high pressure ratings – e.g. up to PN20 for DN800 and PN16 for DN1200.

MAXIMUM ALLOWABLE OPERATING PRESSURE FOR A GIVEN TEMPERATURE AND PN RATING

The performance of HDPE/PP pipes under pressure is directly related to the thickness of the material – a given Wall Thickness (WT) for a given diameter using PE100 will result in a known pressure rating at 23 degrees. If the fluid to be carried is at a temperature which affects the strength of the polymer, then its bursting strength is reduced.

This table is from Plastic Industry Pipe Association in Australia and shows the effect of operating temperature on PE and the consequent reduction in bursting strength. As the effect is uniform across all SDR ratings, the contents can be extrapolated to cover lower PNs or interpolated between them.

https://www.pipa.com.au/wp-content/uploads/2019/07/POP013.pdf

Table 2: Maximum Allowable Operating Pressure – PE100

Temp (°C)	Min Life (yr)	Design Factor	PN 4	PN 6.3	PN 8	PN 10	PN 12.5	PN 16	PN 20	PN25
			SDR41	SDR26	SDR21	SDR17	SDR13.6	SDR11	SDR9	SDR7.4
20	100	1.0	40	64	80	100	127	160	200	250
25	100	1.1	36	58	73	91	115	145	182	227
30	100	1.1	36	58	73	91	115	145	182	227
35	50	1.2	33	53	67	83	106	133	167	208
40	50	1.2	33	53	67	83	106	133	167	208
45	35	1.3	31	49	62	77	99	123	154	192
50	22	1.4	29	46	57	71	91	114	143	179
55	15	1.4	29	46	57	71	91	114	143	179
60	7	1.5	27	43	53	67	85	107	133	167
80	1	2.0	20	32	40	50	63	80	100	125

Note the minimum life periods may be considered to be the minimum potential service lives and represent the maximum extrapolated periods permitted by the ISO9080 extrapolation rules given the available test data.

AMBIENT TEMPERATURE

HDPE operates happily in the range of temperatures found in the global environment and hence is used in the icy wastes of the Arctic and the scorching sands of Egypt (see pics below). It is not suitable for sustained use with liquids over 40C as this can reduce the life of the material, but INFRAPIPE supplies potable water, waste water and stormwater requirements which are at ambient temperature.

SEISMIC RESILIENCE

HDPE pipes and tanks have high flexibility allowing them to absorb seismic energy without breaking or cracking unlike more rigid alternatives. The ductile nature of HDPE allows the structure to deform without breaking, allowing pipes to stretch and elongate rather than fracture (elongation can reach 600%) After the Japanese earthquake of 2011, all the HDPE KRAH pipes (the same as INFRAPIPE) in the area were surveyed and none found to be damaged:

Place	Date of Investigation	Diameter (mm)	Length (m)	Soil embankment (m)	Ratio of deflection (%)	Appearance
Hiranai town Aomori Pref.	3rd June 2011	1200	68.0	11.0	4.1 %	no damage
Rokkasho village Aomori Pref.	2nd June 2011	1800	140.0	27.5	4.4 %	no damage
Miyako city Iwate Pref.	26th May 2011	2400	5.0	1.0	0.2 %	no damage
Kamaishi city Iwate Pref.	25th May 2011	1800	80.0	9.8	3.9 %	no damage
Kamimasuzawa Iwate Pref.	25th May 2011	1000	75.0	12.0	3.0 %	no damage
Sumida town Iwate Pref.	23rd May 2011	2000	85.0	17.3	1.8 %	no damage
Sumida town Iwate Pref.	23rd May 2011	1100	105.0	10.8	3.0 %	no damage
Rikuzen Takata city Iwate Pref.	24th May 2011	1200	64.6	10.8	3.9 %	no damage
Rikuzen Takata city Iwate Pref.	24th May 2011	1500	65.0	8.0	1.7 %	no damage
Rikuzen Takata city Iwate Pref.	24th May 2011	1000	80.0	15.8	4.2 %	no damage
Rikuzen Takata city Iwate Pref.	28th May 2011	1000	84.8	16.3	3.9 %	no damage
Rikuzen Takata city Iwate Pref.	28th May 2011	1000	74.6	13.5	3.9 %	no damage
Rikuzen Takata city Iwate Pref.	28th May 2011	1000	35.3	6.2	2.5 %	no damage
Rikuzen Takata city Iwate Pref.	30th May 2011	1000	70.0	13.0	4.3 %	no damage
Rikuzen Takata city Iwate Pref.	30th May 2011	1000	66.0	11.4	3.0 %	no damage
Rikuzen Takata city Iwate Pref.	30th May 2011	1000	78.0	13.0	3.9 %	no damage
Rikuzen Takata city Iwate Pref.	31st May 2011	1000	67.8	10.3	1.0 %	no damage
Rikuzen Takata city Iwate Pref.	31st May 2011	1000	58.1	9.3	3.0 %	no damage
Tome city Miyagi Pref.	1st June2011	900	82.0	16.0	3.6 %	no damage
Osaki city Miyagi Pref.	1st June 2011	1200	60.0	10.0	3.3 %	no damage
Fukushima city Fukushima Pref.	27th May 2011	1800	159.0	27.0	0.6 %	no damage

SEISMIC OUTCOMES

The full range of scenarios from a seismic event (such as wave propagation, permanent ground deformation and liquefaction) is too weighty for this brief guide, however they can be simplified to a range of outcomes for the pipeline:

Outcome	HDPE performance
Pipeline is elongated in places	HDPE is the most ductile material available
Pipeline is elongated in places	COLLARFUSION has no welds and is continuous; for RRJ the socket/spigot allows for 3% elongation
Pipeline is compressed in places	HDPE has the flexibility to absorb this either internally (temporarily) or by bending (permanently)
Pipeline is displaced – effect on laterals	If the laterals are also HDPE then the pipes and joints will respond as above and the connection will be flexible
Pipeline is displaced – Ridge pattern	The ability to bend to a radius of 50*ID (long-term) and 25*ID (short term)
Pipeline is displaced – block pattern	Shear force calculations at the point where the load is taken
Pipeline is bent	The ability to bend to a radius of 50*ID (long-term) and 25*ID (short term)
Pipeline is bent	COLLARFUSION has no welds and is continuous; for RRJ the socket/spigot allows for 3% elongation

The shear force outcome, common with vertical permanent ground deformation and at the interface between a structure designed to be seismically resilient and its surrounding soil, can be assessed by using the weight of the pipe and soil above it for the length which the short-term bend radius of 25*ID causes to be unsupported to calculate the force which must be applied as a shear force against the face of the pipe at the shear point expressed in mm^2 compared to the tensile strength of HDPE 100.

OTHER HISTORICAL ANALYSES OF SEISMIC FAILURES

There have been significant other analyses of seismic events (see) and guidance (see) but the Japanese have been the most assiduous – or unfortunately the best placed – in their investigations which prove the resilience of HDPE.

Table1. Investigation of damage by earthquake

Name of earthquake	Magnitude	Total length of PE	Damage
2003 Miyagiken Hokubu Earthquake	6.4	10km	None
2003 Tokachi-oki Earthquake	8.0	2.6km	None
2004 Mid Niigata Prefecture Earthquake	6.8	11.4km	None
2004 Noto Hanto Earthquake	6.9	2km	None
2007 Niigataken Chuetsu-oki Earthquake	6.8	13km	None
2008 Iwate-Miyagi Nairiku Earthquake	7.2	47.4km	None
2011The Great East Japan Earthquake	9.0	996km	None
2016 Kumamoto Earthquake	7.3	147.7km	None



TCO

Calculating the Lifetime cost, the Whole of Life Cost (WoLC or WLC) or the Total Cost of Ownership (TCO) requires the asset manager to have taken into account the following components of life time cost:

Component	Clarification
Delivered cost	Manufactured cost plus freight cost and unloading cost
Installation cost	Direct installation costs plus the risk of damage to the products plus the costs of the elapsed time such as P&G, TMP
Cost of complementary or additional products required	Solutions which require more manholes or larger pipes need to be assessed in totality
Inspection cost	Acceptance and initial inspection costs
Maintenance costs	Costs of the maintenance required and ongoing inspection costs at a frequency which is appropriate to the likelihood of deterioration
Maintenance indirect costs	The cost of the loss of use of the asset during maintenance
Maintenance management costs	The cost of operating the unit required to provide the management, planning and budgeting for maintenance
Repair costs	Direct repair costs plus costs of disposal and the costs of the elapsed time such as P&G, TMP
Maintenance indirect costs	The cost of the loss of use of the asset during maintenance
Insurance costs	These can be affected not just by the replacement cost of the item but the risk level
Seismic resilience costs – direct	Direct repair costs plus costs of disposal and the costs of the elapsed time such as P&G, TMP, recognizing the seismic resilience
Seismic resilience costs - indirect	The costs arising from the failure of the asset
End of life - exhumation	The cost to recover the product
End of life disposal	The cost to dispose of the product at end of life
End of life replacement	The cost to replace the product at end of life (see top of table)
End of life - frequency	All the above End of life costs need to be multiplied by a factor which reflects the relative lifespans of the different options



MYTHBUSTERS

There are a number of legacy technologies that have seen the rest of the world change and fear being supplanted by HDPE. As a result there are some myths floating around which need to be addressed:

Fat adhesion

- There is no evidence that fat or waste adheres to HDPE, nor can any information be found on the issue globally. None of the proofs or studies of the Hazen-Williams nor Darcy-Weisbach equations have identified this as an issue. This has been investigated and the results can be read here in this study on the effects of fat accumulation in HDPE pipes in NZ.
- It appears that when HDPE pipes first became available, they were used to reinstate burst or buckled clay or other broken sewer lines and when this was not always successful, this was attributed to the material, not the mechanical impediments which may have rendered some of these operations unachievable.

Microplastics

- There is no evidence that microplastics emanate from HDPE more than an FRP tank and its epoxy layers or from the PVC pipes that initially handle the waste, in fact as the Darmstadt data below shows, less abrasion must mean less free particles. Cementitious particles (which are more frequent due to the much higher abrasion levels) are equally as harmful due to their very high alkalinity.
- The amount of surface area exposed by piping in NZ pales into insignificance compared to the polyester clothjng that is worn and washed every day, or the PVC food wrapping that is cut or torn to access its contents, all of which are going down the same pipes.
- It was confirmed in 2024 that HDPE has no effect on the reproductive function (for instance) where PVC is responsible for falling sperm counts etc. because "PVC contains chemicals that cause endocrine disruption"
- Latest research has proven that there is no correlation between microplastics in a pipe and the material of the pipe (ie the pipe is not responsible).

Biological adhesion

- ✓ The evidence shows that HDPE is the most resistant to the adhesion of biofilms, which enable microbial accumulation and invasion. For more details see: https://www.mepmiddleeast.com/news/borouge-krah-misr-bahr-al-baqr
- ✓ There is no comparison to be made between thermoplastics and concrete for biofilm XX, the porosity of concrete makes it a haven for microbes. This study shows that PE outperforms PVC as well.

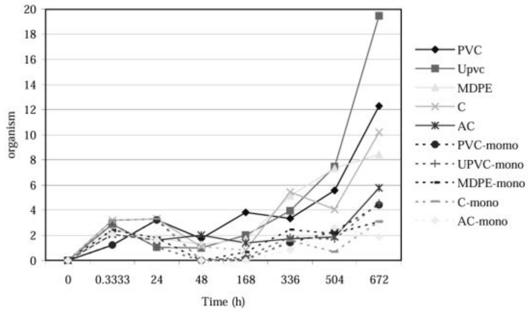

Figure 2
Mean counts of coliform bacteria (cfu·cm^{-2}) by time and pipe materials within chlorine (0 h - 672 h) and combined chlorine-monochloramine (24 h - 672 h) treated water systems

Buoyancy

In some situations (larger pipes, less cover, high ground water and low density fill above) then tanks and closed pipes (ie not culverts) can become buoyant and exert a lifting force on the soil above. This is only likely in situations with larger pipes, less dense soi, less cover and high ground water levels. For more detail, please see the buoyancy tables in this document.



Ovality/circularity

Pipes that are left in the harsh sun for a couple of seasons can deform. This is easily prevented by:

- Using proper dunnage in the correct location
- Storing pipes with their alignment marks at the 3 o'clock or 9 o'clock position.
- Only storing pipes one high

In the extreme event that the above is insufficient, INFRAPIPE has braces which can be used to ensure the circular shape of each socket and spigot prior to laying.

EF Welding

When HDPE first arrived in NZ 30 years ago, there were no AS/NZS standards and imperfect product introductions. There were some poor practices, often unwittingly, in both applying EF couplers (joining small plumbing fittings and pipes) and buttwelding pipes, the failures of some of which have required remedial action in the past. Since then a lot has been learnt and improved, in NZ and globally - so now HDPE, profile pipe and KRAH are all mature, reliable solutions.

In this period there have also been some noticeable failures in concrete too but that technology has had two millennia to be perfected.

Fire

Concrete deteriorates at these temperatures and could need structural replacement as spalling – which commences above temperatures of 200C – weakens the concrete permanently.

HDPE drainage pipes and fittings do not self-sustain in fires, the practical amount of flammable material and the volume of airflow needed to reach the consistent temperatures required is too great for the vast majority of applications. A material that will stay in place (not drain away) is typically not intense enough and the quantity needed then blocks the very airflow it requires. This has been tested overseas (to the satisfaction of the appropriate authorities), as these photos from tests by the Bahrain government Ministry of Works show:

UV

Under AS/NZS5065, INFRAPIPE standard HDPE comes with sufficient carbon black additive in the resin to ensure a 50 year resilience to NZ's worst UV levels. However, asset managers in sunnier locations seeking extra reassurance can request a further uplift in carbon black levels.



ABBREVIATIONS

The pipe world uses a number of definitions, clarified here:

Definition	Meaning
DN	Nominal Diameter – how the pipe is known. For INFRAPIPE this is also the ID
HDPE	High Density Polyethylene, the primary raw material for INFRAPIPE
ID (& OD)	Internal Diameter. INFRAPIPE refers to the ID of its pipes; some competitors market their products under their Outer Diameter (OD) which can imply a capacity 15-20% greater.
LDPE	Low density polyethylene, used for rural applications
MDPE	Medum density polyethylene, used for rotational moulding
PE63	An early form of HDPE
PE80	A less strong but more ductile form of PE used for small pipe applications such as domestic watermain
PE100	The standard grade of HDPE used.
PN	Used in pressure applications and expressed in bar, this is the pressure rating of the pipe. Corresponds to SDR for solid wall pipe, ie for PE100 PN16 = 16 bar = SDR11
SDR	Standard Dimension Ratio – the ratio between WT and OD for solid wall Pipe, ie SDR 11 has a WT of 1/11 the OD
SN	Ring Stiffness – the strength of the pipe
WT	Wall Thickness - the difference between ID and OD