# INFRAPIPE DESIGN MANUAL FOR SPRINKLER & FIRE FIGHTING WATER SUPPLY TANKS 30-1000M³+ IN HDPE

This Data Sheet is for engineers, contractors and asset managers who require underground water storage for fire purposes – either for sprinklers or for supply to FENZ.

This document is supported by the Design Manuals and other Datasheets available from INFRAPIPE:, please see the Infrapipe website for more details.

- The website now also includes REVIT and AUTOCAD files on this BIM page.
- For chemical properties, please see this guide and for material properties please see this guide.

Visit the Downloads section for a complete list of all available documents.

## THIS DOCUMENT WILL

- Provide tank designs and dimensions
- Confirm the criteria for fire water supply tank selection
- Confirm the relevant standards and compliance to them
- Explain the performance criteria of INFRATANK HDPE tanks
- Explore design options for optimum use of the site
- Confirm material properties
- Detail each component of the system
- Explain trench design
- Demonstrate if buoyancy is a possibility
- Explain the installation process

*A firetank for a social club*

## WHAT IS INFRAPIPE?

INFRAPIPE is an independent NZ company established to provide for the pipe needs of sister companies Solo Plastics (waste water) and Promains (potable water). Established in 2020, it has invested in five brand new pipe machines and now makes the largest pipes in Australasia at 3.2m in diameter. It now also supplies the market as a whole with pipes, tanks, manholes, chambers, bends, junctions and any other product or structure that can be made in HDPE.

The pipes used for tanks are made on a state-of-the art German Krah machine (shown on left) which helically winds the pipe onto a rotating mandrel; first the inner waterway layer, then the reinforcing core tube which provides the strength, and then an outer layer.



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# TANK BASICS

INFRATANKS are made of INFRAPIPE HDPE profile pipes which have an effective length **of 5.8m. Sections are joined in the factory or on site as required to make a tank of any shape or size**. HDPE has a life of 100years+ and is chemically inert and biologically immune.

*This picture to the right is the start of an 8,050m³ stormwater tank in Canada!*

Tanks are made in Auckland and have a short leadtime – each pipe is approx. 6 hours on the machine. Fabrication is completely customisable so the optimum use can be made of any site.

The pipes are helically wound (extruded onto a rotating mandrel) with a radially wound core tube to provide radial compressive strength.

## INFRATANK VOLUMES AND DIMENSIONS

**THESE ARE EXAMPLE SIZES – TANKS CAN BE MADE TO ANY SIZE AND HENCE ANY VOLUME**

| | | Pipe length - volume $m^3$ | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **DN(ID)** | **$m^3$/m** | **5.8** | **11.6** | **17.4** | **25** | **40** | **50** | **100** |
| 1000 | 0.79 | 5 | 9 | 14 | 20 | 32 | 39 | 78 |
| 1100 | 0.95 | 6 | 11 | 17 | 24 | 38 | 47 | 94 |
| 1200 | 1.13 | 7 | 13 | 20 | 28 | 45 | 57 | 114 |
| 1350 | 1.43 | 8 | 17 | 25 | 36 | 58 | 72 | 144 |
| 1500 | 1.77 | 10 | 20 | 31 | 44 | 70 | 88 | 176 |
| 1600 | 2.01 | 12 | 23 | 35 | 50 | 80 | 100 | 200 |
| 1800 | 2.54 | 15 | 30 | 44 | 64 | 102 | 127 | 254 |
| 2000 | 3.14 | 18 | 36 | 55 | 79 | 126 | 157 | 304 |
| 2300 | 4.15 | 24 | 48 | 72 | 104 | 166 | 208 | 416 |
| 2500 | 4.91 | 28 | 57 | 85 | 123 | 197 | 245 | 490 |
| 3200 | 8.04 | 47 | 93 | 140 | 201 | 321 | 402 | 804 |

**THESE ARE EXAMPLE SIZES – TANKS CAN BE MADE TO ANY SIZE AND HENCE ANY VOLUME** *Add 1m to length for ends & connections.*

## SELECTION CRITERIA FOR WATER STORAGE TANKS FOR FIRE WATER SUPPLY

The following are commonly used as criteria for the selection of fire supply tanks:

- Durability and longevity
- Product costs (including transport)
- Maintenance costs
- Trench size and installation costs
- Seismic performance
- Leadtime
- Chemical and biological resilience
- Environmental stewardship - $CO^2$ and recyclability
- Cost of installing supporting systems



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# RELEVANT STANDARDS

## REQUIREMENTS FOR FIRE SUPPLY TANKS

NZS 4541:2020 *Automatic Fire Sprinkler Systems*
INFRATANK is compliant with all requirements of NZS4541:2020, namely:

- ✓ 50 year structural life & durability
- ✓ Seismic and structural loads integrity
- ✓ Watertightness
- ✓ Ability to incorporate suction arrangement
- ✓ Ability to incorporate water topping-up and filling
- ✓ Ability to incorporate level indicators, secured access, air vents & overflow discharge

This document will explain and confirm each requirement

SNZ PAS 4509:2008 *New Zealand Fire Service Firefighting Water Supplies Code of Practice*
INFRATANK can meet all stated requirements of tanked supplies:

- ✓ Capacity
- ✓ Location
- ✓ Drawings showing nozzle connections and filling methods

INFRAPIPE can supply a PS1 and a PS4 for the tanks.


ISO 9001
CERTIFICATE OF REGISTRATION
ISO 9001 Certified ApprovalMark
ApprovalMark International hereby grants:
Infrapipe Limited
Site 1 - 3 Averton Place, East Tamaki, Auckland 2013, New Zealand
Site 2 - 12 Newark Place, East Tamaki, Auckland 2013, New Zealand
Evaluated to:
ISO 9001:2015 - Quality management systems
This covers the following scope:
"The manufacture and distribution of polyethylene, polypropylene, pipes, conduits and associated fittings for the water supply, sewerage, drainage, electrical, mining, gas, rural, transportation and communications industries and the fabrication of tanks, manholes, wetwells and other structures from pipes including custom manufacture."
Certificate No. AMI-QM 78044
Issued: 5th July 2024 Originally Certified: 5th July 2024
Expires: 5th July 2027 Current Certification: 5th July 2024
John PRASAD
Director
ApprovalMark



## MANUFACTURE

- ✓ INFRAPIPE is certified to ISO 9001:2015
- ✓ Pipes (tank sections) are certified to ISO Type 5 AS/NZS5065:2005
- ✓ Testing in INFRAPIPE test lab to ISO9969
- ✓ All welds are spark tested
- ✓ All fabrication is double weld – internal and external

## INSTALLATION

- ✓ Pipe installation design is in accordance with AS/NZS2566

*This 100m³ buffer tank is in the Manawatu*





# PERFORMANCE

## STRUCTURAL STRENGTH

- INFRATANKS are manufactured to a given ring stiffness (SN rating) measured to ISO9969.
- This is calculated for each location in accordance with AS/NZS2566 based on the cover levels, the loading, the soil types and GWL (Ground Water Level).
- This provides sufficient structural strength for the application (safety factor 1.25).

## LIFE AND DURABILITY

INFRATANK is guaranteed for 50 years (exceeding the standard).

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.

## SEISMIC RESILIENCE

Due to its ductility, HDPE is the most resilient of materials when faced with a seismic event. Analyses after the Japanese and Christchurch earthquakes of 2011 show that HDPE pipes had the lowest damage levels recorded. See here for more information

## 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 204m³ tank in Hamilton*

- × 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 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

## WATERTIGHTNESS

- ✓ HDPE does not suffer from physical deterioration over time – it does not corrode or react (like metal or concrete) and does not have penetrations which can be attacked by microbes or can act as weak appoints when under stress.
- ✓ All fabrication is double weld (interior and exterior) and all welds are spark-tested.
- ✓ HDPE retains its weathertightness in situ throughout its life.

## MAINTENANCE

- ✓ No maintenance of HDPE is required. None.



# COMPONENTS OF THE SYSTEM

## FIRE ENGINEERING REQUIREMENTS

Not all may be required for buffer tanks.

| Item | Details |
|---|---|
| Suction, strainer and vortex plates | Location and size – sumps can be manufactured in diameters up to the tank size and of nay depth |
| Automatic Top-up | Location and size of pipe/fitting |
| Manual refill | Location and size of pipe/fitting |
| Pump return | Location and size of pipe/fitting |
| Venting | Location and size of pipe/fitting |
| Overflow | Location and size (can be taken from the riser to maximise effective capacity |
| Level Sensors/Indicator | Location and size of pipe/fitting |
| Power to Pump | Location and size of pipe/fitting |
| Baffles | Can be made in any shape or size and welded into the tank in any location |
| Locked access - Cover | 600mm diameter cover |
| Risers | Any height as required to a diameter not more than 500mm greater than the tank diameter |
| Connections between tanks | Can be any standard PE size |

## TANK DESIGN & CIVIL ENGINEERING REQUIREMENTS

| Item | Details |
|---|---|
| Ladder steps | PE/PP steps every 300mm for access |
| Tank size and shape | Can be any combination of pipe sizes joined as required from 5m³ to 5000m³ |
| Trench size | As per AS/NZS2566 |
| Tank fall | As per table – 1,1.5 or 2 degrees |
| Buoyancy anchors | Either Infrapipe standard anchors or if the contractor prefers, a design so they can pour their own |
| Anchor straps | Straps as required for the anchor system |

# DESIGN OPTIONS

Tank sizes have been given above on page 4

## TANK FALL CALCULATIONS

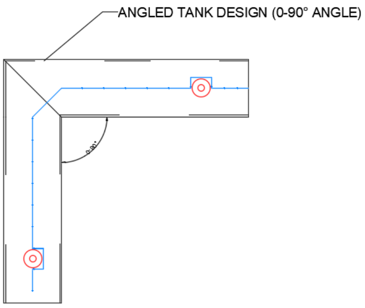
This table shows the fall across a tank for typical gradients.

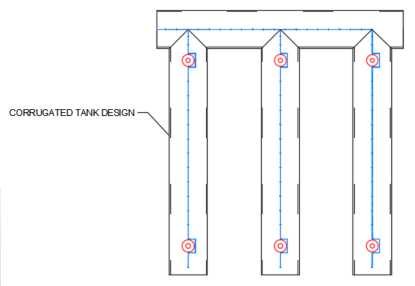
| Tank Length | 1 | 3 | 6 | 11.8 | 17.6 | 24.4 | 30.2 |
|---|---|---|---|---|---|---|---|
| Fall in degrees | Fall over the tank in mm | | | | | | |
| 0.5 | 5 | 14 | 27 | 52 | 77 | 107 | 264 |
| 1 | 18 | 53 | 105 | 206 | 308 | 426 | 528 |
| 1.5 | 40 | 118 | 236 | 464 | 692 | 959 | 791 |
| 2 | 70 | 210 | 419 | 824 | 1229 | 1704 | 1055 |

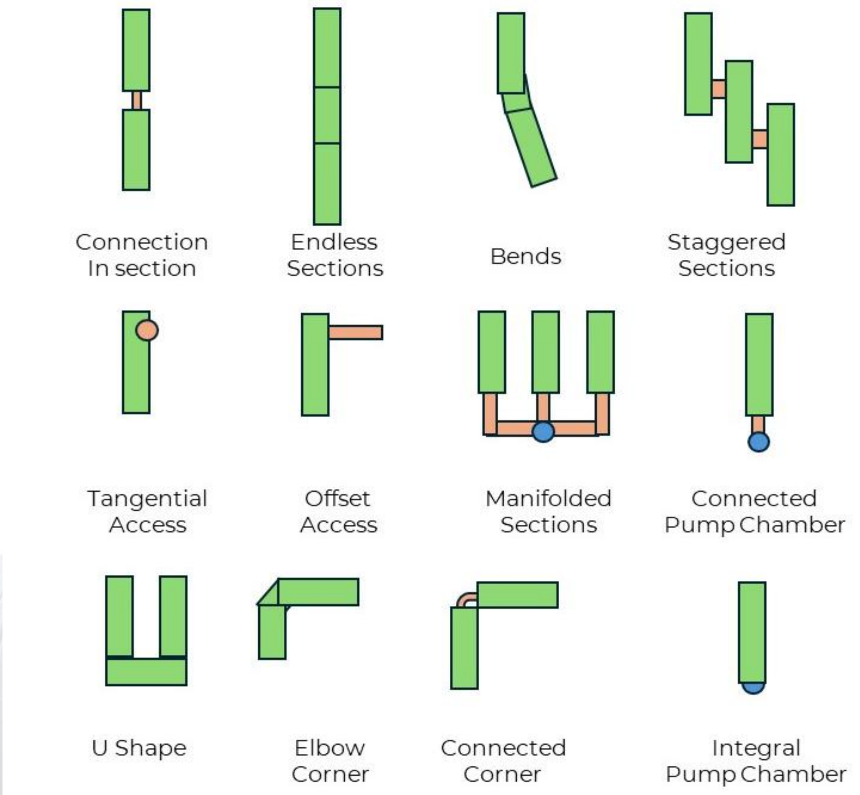
## TANK SHAPE

The base module of the Infratank, an HDPE pipe 5.8m long (or less), can be cut and welded in any way possible to form any shape. This allows the designer to optimize the solution for the site, for economic installation, for economic operation thereafter and for future modification.

Some options here show how flexible this system is, but we stress the importance of early discussions with INFRAPIPE to realise the potential of the product and the site:





# FIRE ENGINEERING REQUIREMENTS

## EFFECTIVE CAPACITY

- Effective capacity is measured between a horizontal plane 50mm below the overflow and the top of the vortex plate.
- Effective capacity can be maximised by locating the overflow and infill in the riser and locating the vortex plate and suction equipment in a sump.

## CONNECTIONS BETWEEN TANKS

UNLIKE OTHER MATERIALS, HDPE HAS NO LIMITS ON THE QUANTITY, SIZE AND PROXIMITY OF CONNECTIONS. a welded pipe connection supplies equal strength to that which has been removed with the penetration.

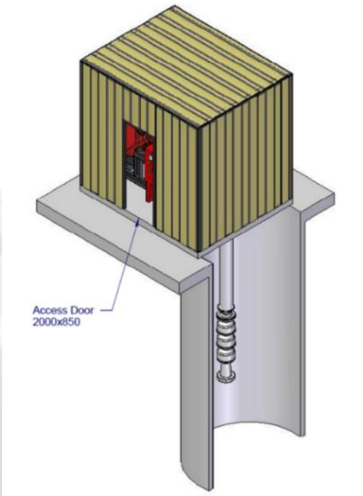
- Connections between tanks are best achieved using welded PE fittings.
- For smaller diameter use inline extruded, typical pipe Sizes by OD, in PN10 (SDR17), PN 16 (SDR 11) are 20 , 25, 32, 40, 50, 63, 75, 90, 110, 125, 140, 160, 180, 200, 225 ,250, ,280,, 315 & 355.
- For larger diameter use INFRAPIPE KRAH ID 450,525,600,700,800,900,1000+ in PN/SDR as required (or gravity).
- INFRAPIPE will supply a drawing of the fitting/connection.

## CONNECTIONS IN TANKS FOR WATER IN/OUT ETC.

- PE pipes are connected to the tanks using welded PE fittings (for this reason PE is recommended over PVC).
- Typical pipe Sizes by OD, in PN10 (SDR17), PN 16 (SDR 11) are 20 , 25, 32, 40, 50, 63, 75, 90, 110, 125, 140, 160, 180, 200, 225 ,250, ,280,, 315 & 355.
- INFRAPIPE will supply a drawing of the fitting/connection.
- Connections can be butt ended for welding or flanged.
- Connections can be placed in any location (including the risers).
- If external inspection of the external portion of the connection is needed, connections can be taken into a vertical shaft which is integral to the tank but dry and accessible – INFRAPIPE can advise.

## PUMPS

- Submersible electric pumps for underground tanks can be located in the tank sump.
- Tank risers and access should be sized to allow their replacement.
- Diesel emergency pumps are located above the tank or can be displaced horizontally (with a potential increase in pumping capacity).
- These can be located in a shipping container or similar to provide environmental protection and security – as shown on the right:

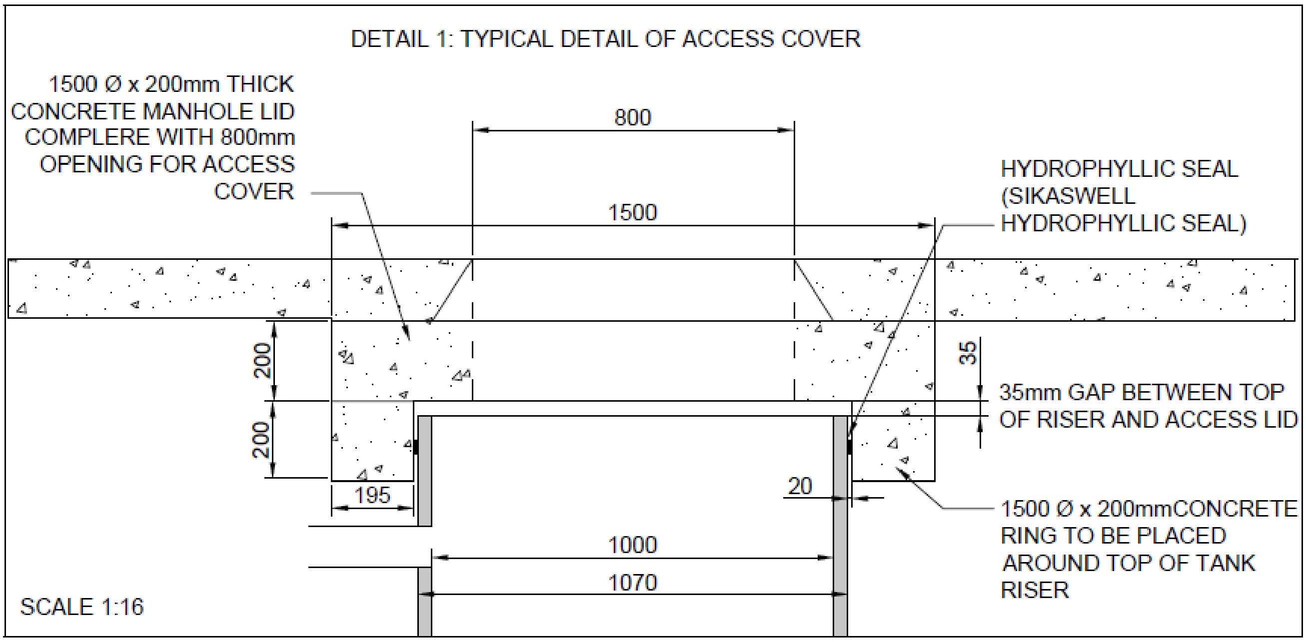




## ACCESS

- Standard access is via a DN600 locked cover into a riser which is either typically DN600 or DN1000.
- Depending on the location, this cover is located in a concrete manhole lid, or in a separate loading.
- INFRAPIPE will supply a design for this (similar to that below).
- Clients may select for pre-installed rungs at 300mm intervals.

*A typical access cover assembly incorporates the opening for the locked access cover in a concrete lid, potentially with further load-bearing rings, and then a hydrophilic seal between the riser body and the concrete.*




## OFFSET OR TANGENTIAL RISERS

- There is no requirement for risers to be concentric. They can be placed offset – that is eccentric but terminating within the barrel of the tank, or tangential, that is they are partially or wholly displaced outside the line of the tank.
- This can be achieved for risers with access at any height in the tank.
- This can allow tanks to be placed entirely under a structure to maximise available space.

*An example tangential riser*

## SUCTION & VORTEX PLATES

INFRATANKS can be supplied with a sump where vortex plates can be located. These have a flat base  with an HDPE sheet welded to the base of the sump.

## REFILL

For tanks less than 500m³ refiling shall be achieved within 6 hours, for those over 500m³, 12 hours is allowed.

| Size | L per hour | L per sec |
|---|---|---|
| 100 | 16,667 | 4.6 |
| 200 | 33,333 | 9.3 |
| 300 | 50,000 | 13.9 |
| 400 | 66,667 | 18.5 |
| 500 | 83,333 | 23.1 |
| 600 | 50,000 | 13.9 |
| 800 | 66,667 | 18.5 |
| 1000 | 83,333 | 23.1 |

*A fire tank (and its pipe fitting) being fabricated before its journey to the Waikato*

# CIVIL ENGINEERING REQUIREMENTS

Buoyancy is shown at the end of this section as it includes a number of tables.

## SEISMIC DESIGN

The standard requires that "if the tank is included in the scope of the NZSEE: *Seismic design of storage tanks*, the design shall comply with that design recommendation document". Underground HDPE tanks are not included in this scope, therefore compliance is not required. The required trench design and design of an HDPE underground tank fulfil seismic resilience requirements and as shown here, this material is more resilient than any other in a seismic event.

## TEMPERATURE

According to the standard, underground tanks are sufficiently protected against freezing due to their position and require no further frost precautions, but the merits of each individual tank should be assessed.

HDPE is unaffected by freezing temperatures and its considerable ductility allows it to absorb thermal expansion from water freezing, but for applications with potentially freezing soil conditions, consideration can be given to:

- Allowing additional unused tank capacity to permit expansion within the tank
- Avoiding the use of PVC which become brittle at low temperatures
- Housing penetrations and pipes in an empty shaft to keep their temperature higher

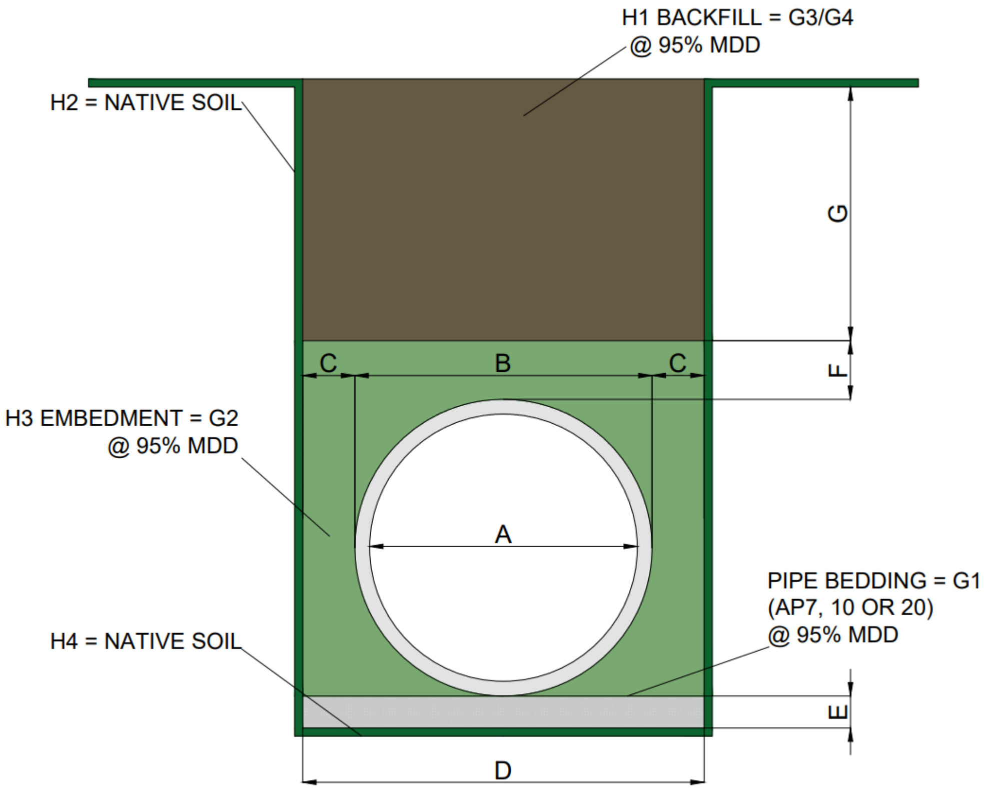
## CHEMICAL AND BIOLOGICAL

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

## TRENCH DESIGN

Trench design is in accordance with AS/NZS2566. **The tables below are a guide only** and construction will require specific calculation by an appropriate engineer. The middle row of headers is taken from the AS/NZS2566 diagram.




| SN16+ | | Bedding | Side | Overlay | **Trench Width** | Min Cover | **Trench Depth** |
|---|---|---|---|---|---|---|---|
| DN (ID) | De (OD) | Lb | Lc | Lo | **B** | Cl-Lo | **D** |
| A | B | E | C | F | **D** | G | **E+B+F+G** |
| 1000 | 1196 | 150 | 350 | 200 | **1900** | 500 | **1550** |
| 1100 | 1332 | 150 | 350 | 200 | **2050** | 500 | **1700** |
| 1200 | 1464 | 150 | 350 | 200 | **2200** | 500 | **1850** |
| 1350 | 1596 | 150 | 350 | 200 | **2300** | 500 | **1950** |
| 1500 | 1776 | 150 | 350 | 200 | **2500** | 500 | **2150** |
| 1600 | 1878 | 150 | 500 | 300 | **2900** | 400 | **2350** |
| 1800 | 2068 | 150 | 550 | 300 | **3200** | 400 | **2550** |
| 2000 | 2308 | 150 | 600 | 300 | **3550** | 400 | **2800** |
| 2300 | 2650 | 151 | 700 | 300 | **4050** | 400 | **3150** |
| 2500 | 2900 | 152 | 750 | 300 | **4400** | 400 | **3400** |
| 3200 | 3600 | 153 | 900 | 300 | **5400** | 400 | **4100** |





## INFRATANK MAXIMUM WEIGHTS

**Weight = (Pipe weight * length) + (end weight * 2) + riser & sump weights**

Add 140kg per vertical metre for 600mm risers and sumps

Add 388kg per vertical metre for 1000mm risers

End figure is for both ends and subject to soil conditions

| DN(ID) | Approx End Weight kg | SN4 | | SN16 | |
|---|---|---|---|---|---|
| | | OD | kg/m | OD | kg/m |
| 1000 | 94 | 1120 | 47 | 1196 | 65 |
| 1100 | 114 | 1242 | 54 | 1332 | 71 |
| 1200 | 136 | 1222 | 54 | 1464 | 77 |
| 1350 | 172 | 1546 | 82 | 1596 | 123 |
| 1500 | 212 | 1696 | 90 | 1776 | 148 |
| 1600 | 241 | 1796 | 96 | 1878 | 157 |
| 1800 | 305 | 2032 | 117 | 2068 | 268 |
| 2000 | 377 | 2232 | 163 | 2308 | 313 |
| 2300 | 498 | 2572 | 195 | 2634 | 466 |
| 2500 | 589 | 2778 | 242 | 2842 | 566 |
| 3200 | 965 | 3500 | 497 | Ask | |

**This is the maximum figure based on poor soil conditions**

## INSTALLATION

After trench excavation and bedding preparation, the process is as follows:

1. Laying of tank sections
2. Joining on site with either rubber gaskets or CollarFUSION welding
3. Completion of connections
4. Completing buoyancy measures if required
5. Backfilling and compaction in 150-300mm layers (with water fill to match)
6. If required, hydrostatic testing

Note the light weight of INFRATANKS permits the laying of multiple sections in one day.

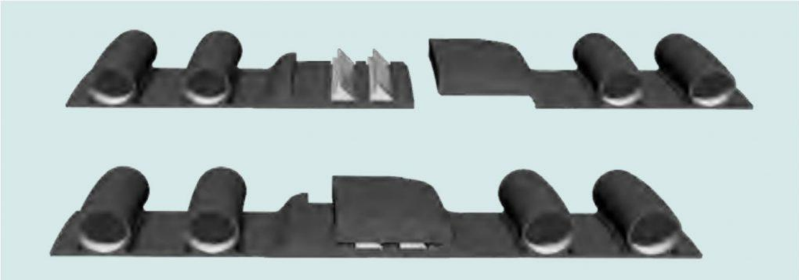
Typical tank sections for shipment are 11.6m, 15m or up to the length of the truck.

*Compacting a partially backfilled tank*



## JOINING INFRATANK SECTIONS

A join typically takes 1-2 hours. There are two types of joins used for INFRAPIPE; **Rubber Ring Joint (RRJ)** is the standard join which is conducted by contractor staff onsite.

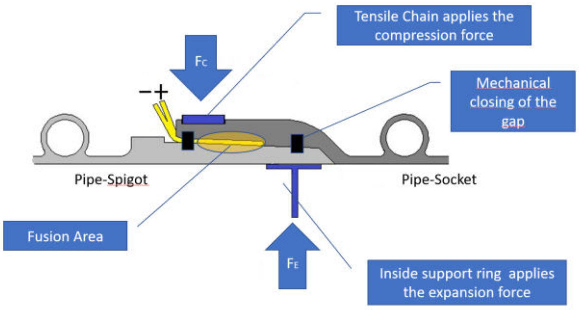


Plug-in system with double seal

**CollarFUSION Welds** are performed onsite by INFRAPIPE specialist personnel or by contractor personnel who have been trained by INFRAPIPE. Integrated wires in the socket (shown below) heat the HDPE to 160°C (with the pipe braced at the welding point) so it expands by 30%. Once it cools, it produces a completely homogenous pipe joined along 90mm of length. Welds take approximately one hour each, depending on pipe size, during which time the next pipe can be laid in the trench ready for insertion joining.

*The wire installed*

*The process*





*In progress*

# BUOYANCY

HDPE tanks can be buoyant when empty in some combinations of GWL and soil types and cover levels – typically a high GWL and low cover with light native soil.

However, as fire tanks typically have at least 700mm of cover, which is engineered fill or pavement, only the very largest tanks are likely to be buoyant (see tables below).

- ✓ INFRAPIPE will calculate the buoyancy as part of the trench design process.
- ✓ Buoyancy can be mitigated by in trench design by:
  - ✓ Increasing the cover depth
  - ✓ Using more dense material in the cover
- ✓ Buoyancy can be prevented with these mechanical measures:
  - ✓ Laying PE sheet or other flexible medium over the tank to widen the zone of influence
  - ✓ Using deadman anchors with restraining strops
  - ✓ Adding flowable fill to the void spaces and core tube in the pipe structure
  - ✓ Adding flowable fill or a concrete collar

The tables below are taken from the INFRAPIPE pipe design manual and **are a guide only**, approximate and conservative. Each tank location will be independently calculated during the design process using the *Easypipe* software.

## BUOYANCY TABLES WITH ENGINEERED FILL

These tables show 2 different ground water level scenarios; at the crown of the pipe and at the surface.

### Trenches with GWL to Crown and cover with engineered fill

GWL: Crown | Soil weight 1.68 tonne/m3

| | | | | Buoyancy | | Cover Depth | | |
|---|---|---|---|---|---|---|---|---|
| Pipe | Weight | OD | Volume | kgs | Soil area | 450 | 700 | 1000 |
| 1000 | 62 | 1166 | 1.07 | 1005 | 1.166 | 758 | 1737 | 2913 |
| 1100 | 68 | 1320 | 1.37 | 1299 | 1.32 | 696 | 1805 | 3136 |
| 1200 | 77 | 1464 | 1.68 | 1605 | 1.464 | 608 | 1838 | 3314 |
| 1350 | 123 | 1614 | 2.04 | 1922 | 1.614 | 518 | 1874 | 3501 |
| 1500 | 148 | 1776 | 2.48 | 2328 | 1.776 | 357 | 1849 | 3639 |
| 1600 | 188 | 1880 | 2.77 | 2587 | 1.88 | 256 | 1835 | 3730 |
| 1800 | 245 | 2088 | 3.42 | 3177 | 2.088 | -20 | 1734 | 3838 |
| 2000 | 313 | 2310 | 4.19 | 3876 | 2.31 | -383 | 1557 | 3886 |
| 2300 | 466 | 2634 | 5.45 | 4980 | 2.634 | -998 | 1215 | 3870 |
| 2500 | 566 | 2842 | 6.34 | 5775 | 2.842 | -1477 | 910 | 3775 |
| 3200 | 752 | 3542 | 9.85 | 9097 | 3.542 | -3741 | -766 | 2804 |



## Trenches with GWL to Surface and cover with engineered fill

| GWL: | Surface | Soil weight | 1.68 | tonne/m3 |
|---|---|---|---|---|

| | | | | Buoyancy | | Cover Depth | | |
|---|---|---|---|---|---|---|---|---|
| Pipe | Weight | OD | Volume | kgs | Soil area | 450 | 700 | 1000 |
| 1000 | 62 | 1166 | 1.07 | 1005 | 1.166 | 654 | 1667 | 2761 |
| 1100 | 68 | 1320 | 1.37 | 1299 | 1.32 | 552 | 1714 | 2921 |
| 1200 | 77 | 1464 | 1.68 | 1605 | 1.464 | 419 | 1726 | 3025 |
| 1350 | 123 | 1614 | 2.04 | 1922 | 1.614 | 276 | 1739 | 3124 |
| 1500 | 148 | 1776 | 2.48 | 2328 | 1.776 | 46 | 1686 | 3136 |
| 1600 | 188 | 1880 | 2.77 | 2587 | 1.88 | -104 | 1653 | 3137 |
| 1800 | 245 | 2088 | 3.42 | 3177 | 2.088 | -495 | 1511 | 3016 |
| 2000 | 313 | 2310 | 4.19 | 3876 | 2.31 | -1005 | 1285 | 2747 |
| 2300 | 466 | 2634 | 5.45 | 4980 | 2.634 | -1878 | 865 | 2132 |
| 2500 | 566 | 2842 | 6.34 | 5775 | 2.842 | -2558 | 504 | 1530 |
| 3200 | 752 | 3542 | 9.85 | 9097 | 3.542 | -5762 | -1407 | -2243 |

*Most tanks (like this one) do not require permanent anti-buoyancy measures if they are covered in engineered fill 700mm+*



## BUOYANCY TABLES WITH NATIVE SOIL

These tables show 2 different ground water level scenarios; at the spring line, at the crown of the pipe and at the surface.

### Tanks with GWL to Crown and cover with native soil

GWL: Crown | Soil weight 1 tonne/m3

| | | | | Buoyancy | | Cover Depth | | |
|---|---|---|---|---|---|---|---|---|
| Pipe | Weight | OD | Volume | kgs | Soil area | 450 | 700 | 1000 |
| 1000 | 62 | 1166 | 1.07 | 1005 | 1.166 | 44 | 627 | 1327 |
| 1100 | 68 | 1320 | 1.37 | 1299 | 1.32 | -111 | 549 | 1341 |
| 1200 | 77 | 1464 | 1.68 | 1605 | 1.464 | -288 | 444 | 1323 |
| 1350 | 123 | 1614 | 2.04 | 1922 | 1.614 | -470 | 337 | 1306 |
| 1500 | 148 | 1776 | 2.48 | 2328 | 1.776 | -729 | 159 | 1224 |
| 1600 | 188 | 1880 | 2.77 | 2587 | 1.88 | -895 | 45 | 1173 |
| 1800 | 245 | 2088 | 3.42 | 3177 | 2.088 | -1298 | -254 | 999 |
| 2000 | 313 | 2310 | 4.19 | 3876 | 2.31 | -1797 | -642 | 744 |
| 2300 | 466 | 2634 | 5.45 | 4980 | 2.634 | -2610 | -1293 | 288 |
| 2500 | 566 | 2842 | 6.34 | 5775 | 2.842 | -3217 | -1796 | -91 |
| 3200 | 752 | 3542 | 9.85 | 9097 | 3.542 | -5909 | -4138 | -2013 |

### Tanks with GWL to Surface and cover with native soil

GWL: Surface | Soil weight 1 tonne/m3

| | | | | Buoyancy | | Cover Depth | | |
|---|---|---|---|---|---|---|---|---|
| Pipe | Weight | OD | Volume | kgs | Soil area | 450 | 700 | 1000 |
| 1000 | 62 | 1166 | 1.07 | 1005 | 1.166 | -60 | 557 | 1176 |
| 1100 | 68 | 1320 | 1.37 | 1299 | 1.32 | -256 | 457 | 1126 |
| 1200 | 77 | 1464 | 1.68 | 1605 | 1.464 | -477 | 332 | 1034 |
| 1350 | 123 | 1614 | 2.04 | 1922 | 1.614 | -711 | 202 | 929 |
| 1500 | 148 | 1776 | 2.48 | 2328 | 1.776 | -1041 | -5 | 720 |
| 1600 | 188 | 1880 | 2.77 | 2587 | 1.88 | -1254 | -136 | 580 |
| 1800 | 245 | 2088 | 3.42 | 3177 | 2.088 | -1773 | -477 | 176 |
| 2000 | 313 | 2310 | 4.19 | 3876 | 2.31 | -2419 | -914 | -395 |
| 2300 | 466 | 2634 | 5.45 | 4980 | 2.634 | -3490 | -1643 | -1450 |
| 2500 | 566 | 2842 | 6.34 | 5775 | 2.842 | -4297 | -2202 | -2335 |
| 3200 | 752 | 3542 | 9.85 | 9097 | 3.542 | -7929 | -4779 | -7060 |





# 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 mm² compared to the tensile strength of HDPE 100.

## *OTHER HISTORICAL ANALYSES OF SEISMIC EVENTS*

There have been significant other analyses of seismic events (see here) and guidance (see here) 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 |
| 2011 The Great East Japan Earthquake | 9.0 | 996km | None |
| 2016 Kumamoto Earthquake | 7.3 | 147.7km | None |