# Hynds Floatless Manhole System

Technical Guide D14.1

The Hynds Floatless Manhole System incorporates specially designed dispersion valves which prevent floatation of manhole structures during liquefaction.



## Applications

- Manholes in areas with potential for earthquakes and liquefaction
- Manholes in primary and critical access corridors (lifelines)

## Product Attributes

- Dispersion valves prevent floatation of manhole structures during liquefaction
- Retrofitted without the need to excavate around the manhole structure
- Construction noise is minimised as installation is done inside the manhole
- Construction costs minimised through an efficient well developed process

## Approvals/Standards

- Under license from Nippon Hume Corporation (Japan)
- Patent number 4603852

## Quality

- ISO 9001:2008 Quality Management Standard

***We are the supply partner of choice for New Zealand's civil construction industry, specialising in water and infrastructure based solutions.***

HYNDS PIPE SYSTEMS

# The Hynds Floatless Manhole System incorporates dispersion valves in manhole structures to relieve excess pore water pressures which may develop in soils subject to liquefaction during seismic events.

The design and 'retrofitting method' of installing this system is now available in New Zealand under license from Nippon Hume Corporation (Japan).

## Hynds Floatless Manhole System

This patented system was developed by Nippon Hume and the Tokyo Metropolitan Sewerage Service Corporation (TGS).

It has been used extensively in Japan since 2007 in retrofitting existing sewer manholes in Tokyo, and to date over 14 000 manholes have been retrofitted. The retrofitting of other cities manholes is currently in the roll out phase in Japan. During a liquefaction event, excess pore water pressures may develop in the sand/water layer, which together with the loss of skin friction between the soil and manhole structure, can lead to floatation of the manholes.

TGS has determined that floatation or projection above road surfaces of 100 mm or more, is undesirable particularly in roads considered lifelines. The design philosophy of the Floatless Manhole System uses the dispersion valves to dissipate the excess pore water pressures ensuring that skin friction is maintained, albeit at a lower value, between the manhole structure and the liquefied soil. The design has been validated by extensive laboratory testing carried out by Nippon Koei. Dispersion Valves are supplied in 4 standard specifications to suit 2, 3, 4 and 5 m hydrostatic pressures.

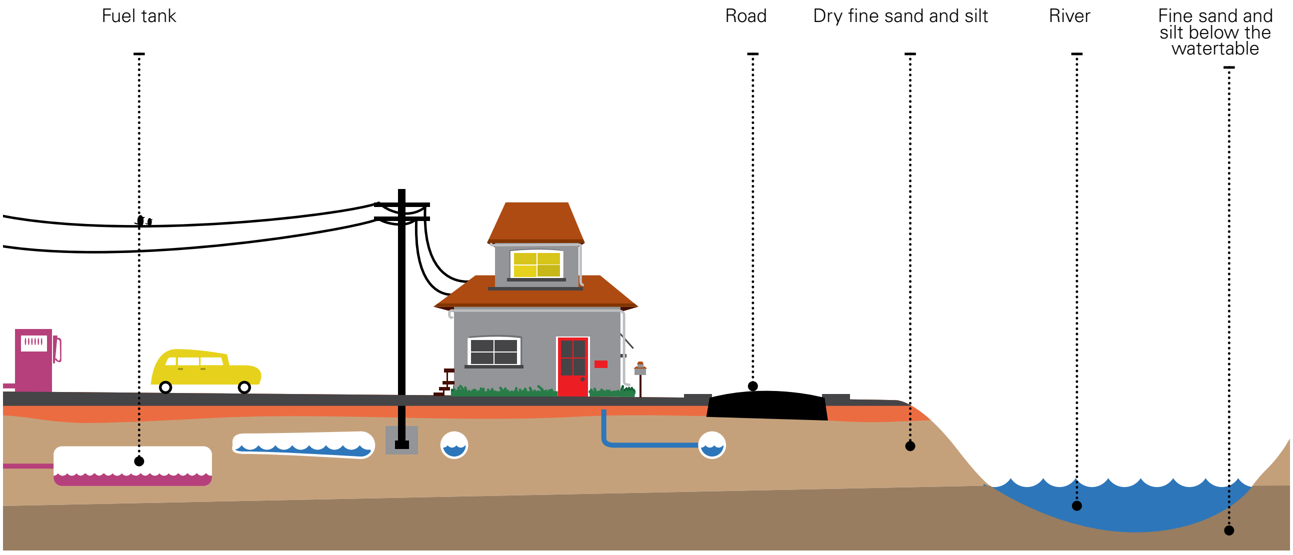
### Where does liquefaction occur?

Soil liquefaction is described as a phenomenon whereby a saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid. This phenomenon is most often observed in saturated loose (low density or uncompacted),

## LIQUIFACTION AND ITS EFFECTS

**BEFORE THE EARTHQUAKE**

Areas of flat, low lying land with groundwater only a few metres below the surface, can support buildings and roads, buried pipes, cables and tanks under normal conditions.

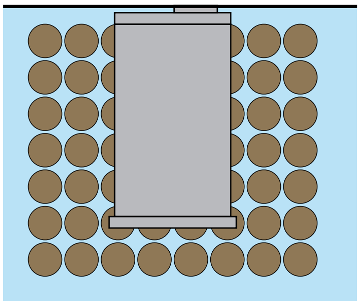


sandy soils. This is because loose sand has a tendency to compress when a load is applied.

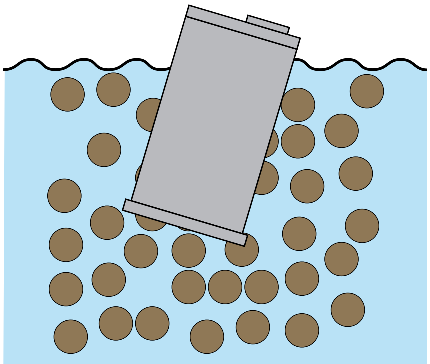
Dense sands by contrast tend to expand in volume or 'dilate'. If the soil is saturated by water, a condition that often exists when the soil is below the ground water table or sea level, then water fills the gaps between soil grains (pore spaces).

In response to the soil compressing, this water increases in pressure and attempts to flow out from the soil to zones of low pressure (usually upward towards the ground surface).

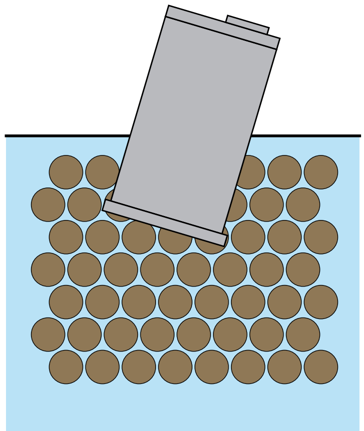
However, if the loading is rapidly applied and large enough, or is repeated many times (e.g. earthquake shaking, storm wave loading) such that it does not flow out in time before the next cycle of load is applied, the water pressures may build to an extent where they exceed the contact stresses between the grains of soil that keep them in contact with each other. The contact between grains are the means by which the weight from buildings and overlying soil layers are transferred from the ground surface to layers of soil or rock at greater depths. This loss of soil structure causes it to lose all of its strength (the ability to transfer shear stress) and it may be observed to flow like a liquid (hence 'liquefaction').



Before the earthquake



During the earthquake liquefaction occurs due to excess pore water pressure. Due to low specific gravity, the manhole bubbles to the surface.

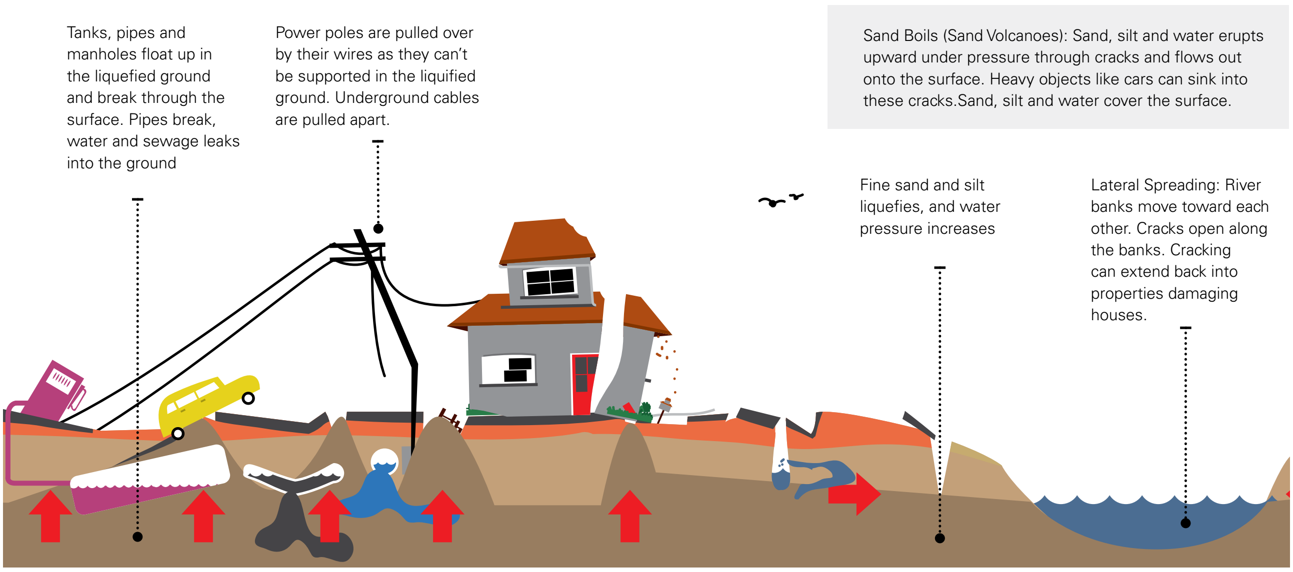


After the earthquake sand particles will reposition.

**Levitation mechanism of manholes**
The diagrams above show the floating manhole phenomenon that occurs during liquefaction.

## DURING AND AFTER THE EARTHQUAKE

During the earthquake fine sand, silt and water moves up under pressure through cracks and other weak areas to erupt onto the ground surface. Near rivers the pressure is relieved to the side as the ground moves sideways into the river channels.



# Floatless Manhole System

## Purpose of the Method

In the Tokachi Offshore Earthquake (1968) and the Niigata Chuetsu Earthquake (2004), strong tremors caused liquefaction to occur in the vicinity of the manholes (in some cases only in the area of the backfill), which in turn lead to many manholes surfacing.

The upward displacement of the manholes not only seriously impede the flow capability of the system, but the manholes protruding above the road surface cause traffic disturbance, leading to what are called secondary disasters such as those which affect the relief activities of disaster victims and recovery works. The "Floatless method of Construction" ("Floatless Method") is the technology intended to contribute to disaster mitigation measures by controlling the surfacing of manhole at times of earthquakes and maintaining the function of the system.

## Mechanism of the Method

During liquefaction, manholes not fitted with countermeasures, the loss of soil shear resistance on the manhole surfaces, allows the buoyancy forces to exceed the weight of the manhole and the resistance of the pavement. The "Floatless Method" controls the actions of the surrounding soil of the manhole during liquefaction, by fitting the manhole wall with excess pore pressure dispersion valves ("dispersion valves").

During a liquefaction event in an earthquake excess pore pressures develop which exceeds hydrostatic pressure in the surrounding soil. The dispersion valves allow the excess pore water pressure that occurs to dissipate by displacement of the pressure plate allowing a very small amount of water to enter the manhole in a controlled manner. This disperses the excess pore water pressure through the released openings of the valves allow the shear resistance of the surrounding soil against the manhole is maintained (albeit at a slightly reduced level), and the surfacing of the manhole is controlled.

## Application preconditions

The "Floatless Method" has the following two basic preconditions:

1. Manhole access cover diameter is a minimum of 535mm to provide access for the equipment to install the dispersion valves.
2. The existing manhole must be structurally sound.

## Scope of application

- Manhole shape: Round, Rectangle, Oval
- Inside dimension of a manhole:
  - Circular – circular diameters 900–1500 mm
  - Non-circular – minimum internal dimension 900 mm and maximum of 1500 mm
- Depth of manhole: Within 5 m of ground level

***Note:*** *Larger sizes may be possible. Please check with Hynds Technical Services*

***Note:*** *Manholes floating by liquefaction (Mid Niigata Prefecture Earthquake) without anti-earthquake measures*

# Dispersion Valve

The dispersion valve consists of :

- Polypropylene body or socket
- Pressure plate and pressure plate supporting ring with a nitrile rubber sealing ring
- Pressure regulating pins (colour coded)
- 316 Stainless Steel filter mesh (0.8 – 1.0 mm square)
- 316 Stainless Steel combined breaking tip and mesh retainer
- Water stop
- Grip ring
- Access cover (colour coded)
- Extension socket

The dispersion valves are designed to resist hydrostatic pressures in normal circumstances, and are available for installation in 2, 3, 4 and 5 m pressure ratings. For ease of checking during and after installation these are colour coded as follows:

- **2 m** – red
- **3 m** – blue
- **4 m** – green
- **5 m** - yellow

The pressure regulating pins fixed to the pressure plate supporting ring at three points securing the pressure receiving plate. The access cover, which prevents the pressure receiving plate from being washed away, is also colour coded to match the tensile pins fitted to make maintenance and site checks quick and accurate.

The pressure rating referred to above is the pressure resistance of the pressure regulating pins securing the pressure receiving plate. For example, in a 2 m dispersion valve, the pressure regulating pins will allow the displacement of the pressure plate when the external pressure acting on the pressure plate exceeds 2 m.

The access cover has an open and closed option. When installed the access cover is normally in the open state. After an earthquake, the cover is manually closed in order to temporarily stop the groundwater from flowing into the manhole through the dispersion valves.

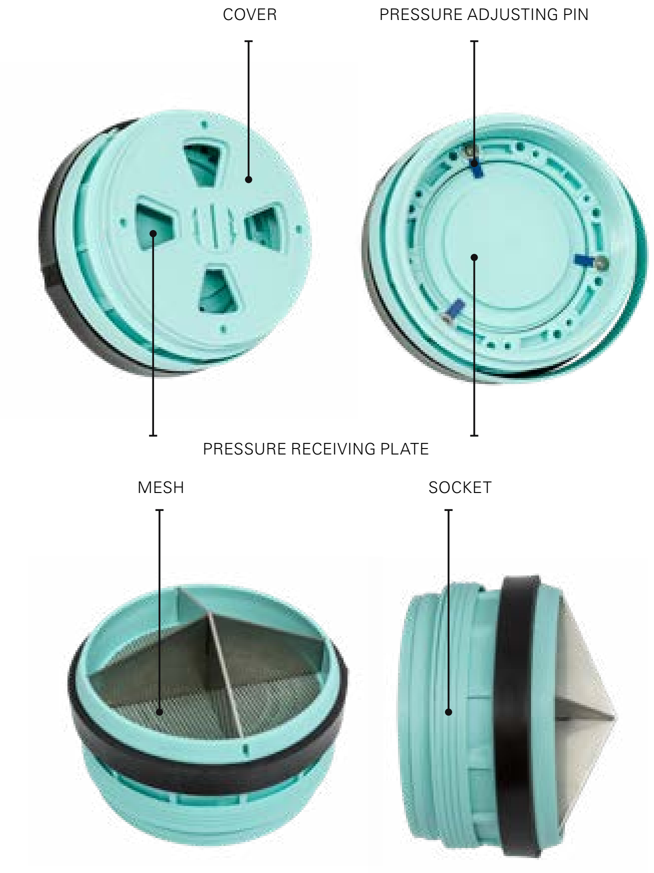



**FIG. 1** Four views of a dispersion valve

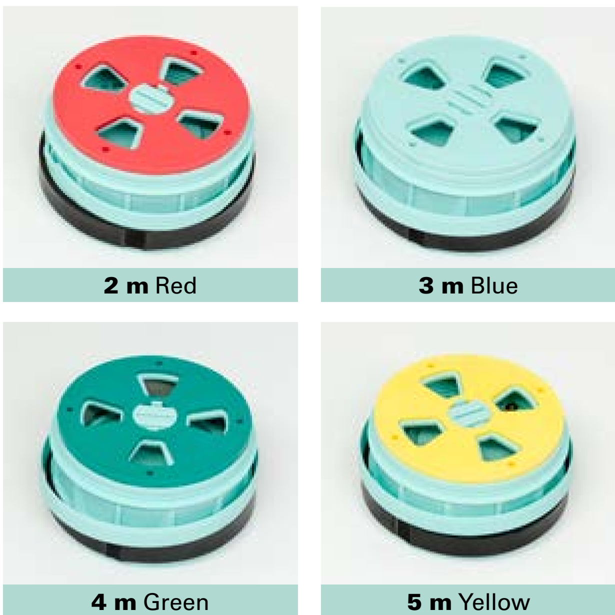



**FIG. 2** Dispersion valves colour coded

## Design philosophy

During an earthquake, any excess pore water pressure developed acts on the pressure receiving plate of the dispersion valve. If the excess pore pressure exceeds the design capacity of the pressure regulating pins on the pressure plate, the pins fail resulting in the pressure receiving plate being dislodged. This allows a small amount of water to enter the manhole relieving the high pore water pressure in the vicinity of the dispersion valve and thus allowing some skin friction to remain acting on the manhole wall.

The fine mesh on the outside face of the dispersion valve prevents the sand from entering the manhole. When the valve is inserted into the manhole wall a stainless steel point is used to break through the final 3 mm of the manhole wall which has been core drilled to the diameter of the dispersion valve.

The number of valves depend on the diameter of the manhole, depth of the manhole and installation conditions. The lowest valves are placed approximately 150 mm above the level of the benching.

For a typical installation the valves are spaced evenly at 45° intervals for 1050 Ø manholes, 36° for 1200 Ø manholes and 30° for 1500 Ø manholes as shown across. The minimum number per level will be 2 valves.

The dispersion valves are installed in vertical layers with a 500 mm spacing between layers, as required by the design calculation.

Nippon Koei Consultants in conjunction with Nippon Hume and TGS have developed design equations to calculate the potential projection of the manhole structures during a liquefaction event, and to determine the number and layout of dispersion valves required to meet the design specification.

This design philosophy has been validated by extensive laboratory testing carried out by Nippon Koei.

Floatless manhole dispersion valves are suitable for use in circular manholes Ø900–1500 mm and non circular structures with dimensions 900–1500 mm. Maximum depth of structures is 5 m.

The Japan Sewage Works Association, Manual of measures against earthquake for sewerage systems 2006 Edition, provides a Guideline for the classification of the grade of road damage. The following table is based on Table 4.3.5 of the JSWA Manual.

| Extent of damage | | |
|---|---|---|
| **Small** | **Moderate** | **Large** |
| **Step <30mm** | **Step 30–100mm** | **Step >100mm** |
| Impact can be sensed when driven over by a car | Driving over with a car is difficult | Driving over with a car is impossible |

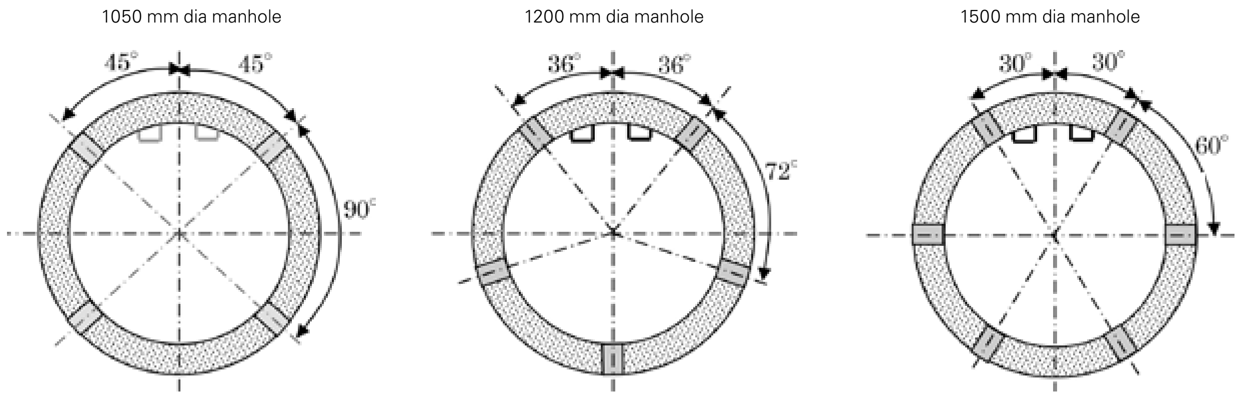



**FIG. 3** Typical Valve Spacing (per level)

## Case Study: 2011 Great East Japan Earthquake

The 2011 Great East Japan Earthquake, with a magnitude of Mw=9.0 occurred in the Pacific Ocean about 130 km off the northeast coast of Japan's main island on March 11, 2011. Liquefaction occurred in a wide area of reclaimed land along Tokyo Bay, though the epicentral distance was very large, about 380 to 400 km. Much land has been reclaimed in the Tokyo Bay area since the seventeenth century. Liquefaction has been induced during past earthquakes, such as the 1923 Kanto Earthquake and the 1987 Chibake-toho-oki Earthquake. However, the Great East Japan Earthquake is the first on record to cause liquefaction in such a wide area and to severely damage houses, lifelines and roads.

The reclaimed land from Odaiba to Shinkiba saw about 30 cm of liquefied sand, dislodging of manholes, cracked and uneven pavements and leaning fences and walls. In Shinkiba – which recorded a magnitude 5 earthquake – the total of 58 manholes installed with dispersion valves had zero manholes floating in the liquefaction event. The other areas of liquefaction were seen with a combination of tsunami damage in Miyagi Prefectures' Ishinomaki and Higashimatsujima Cities. Again, in these areas where dispersion valves were installed there were zero reports of manholes floating. In Uruyasu Ward which neighbours Shinkiba, there were large reports of manhole failures due to floating in the liquefaction event.

| Location of Installation | Earthquake Information | No of MH with dispersion valves installed at location | No of MH which floated with dispersion valves | No of MH where dispersion valves were activated | No of dispersion valves installed in MH | No of dispersion valves that were activated | Percentage of activated dispersion valves |
|---|---|---|---|---|---|---|---|
| Shinkiba Township* | **Magnitude 5** Liquefaction | 40 | 0 | 10 | 265 | 114 | 43% |
| Ishimaki City | **Magnitude 6** Liquefaction, Tsunami | 20** | 0 | 16 | 73 | 46 | 63% |
| Higashimatsujima City | **Magnitude 6** Liquefaction unknown, Tsunami | 4 | 0 | 0 | 8 | 0 | 0% |

**** An analysis of the activation of the dispersion valves Shinkiba manholes shows the following:***
*0% of 2 m valves activated*
*30% of 3 m valves activated*
*88% of 4 m valves activated*
*100% of 5 m valves activated*

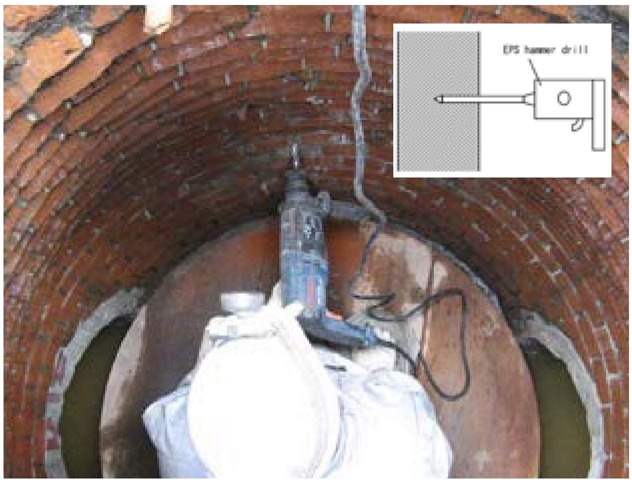
***** Out of the 20 installed manholes, 1 manhole was unable to be accessed due to road conditions preventing access due to liquefaction soils damaging roadway. The Ishimaki City numbers are therefore based on the analysis of 19 manholes.***

Tokyo Metropolitan Sewerage Service Corporation (TGS) has determined that flotation or projection above road surfaces of 100 mm or more, is undesirable particularly in roads considered Lifelines. Since 2007 to date, over 14,000 manholes have been retrofitted in Tokyo alone.

## Installation Guidelines

The standard construction procedures with the use of specialized equipment are as shown

- Installation is speedy, safe and reliable with specially developed equipment
- Installation equipment fits through standard 535 or 600 mm diameter manhole openings
- Installation of the Floatless Manhole Systems has little impact on the lives of local residents and vehicle movement as there is no requirement for excavation around the manhole.



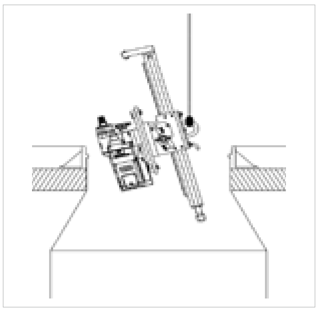
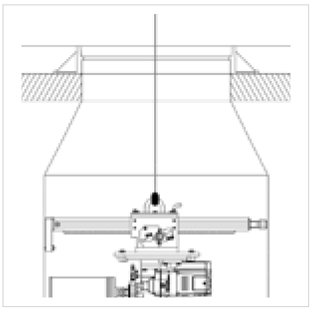

### *Advance survey work*

- Check the positions of buried utilities close to the subject manhole in concern.
- Determine manhole wall thickness.

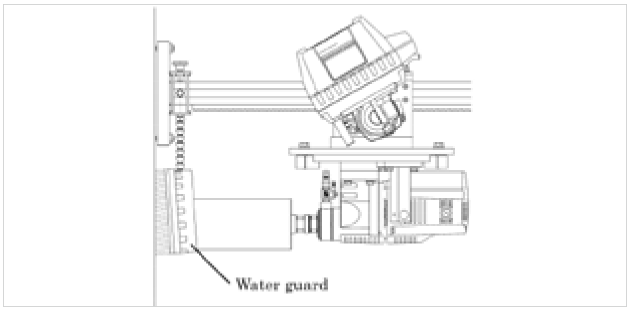
## Dispersion Valves Installation Work

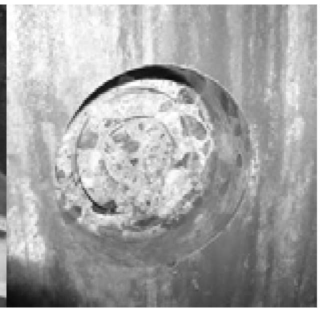
Specialised dispersion valve installation equipment is required, along with a suitably trained and experienced operator. Hynds can recommend a suitable contractor.

1. Set the installation equipment inside the manhole.

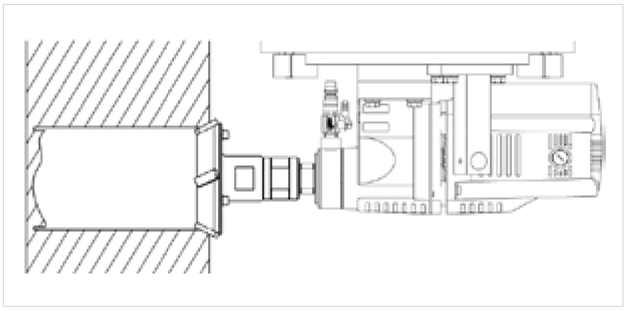
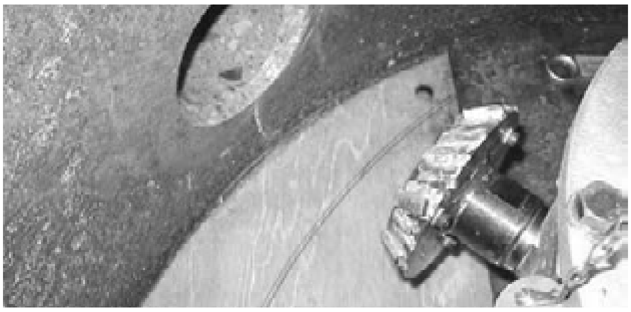




2. Perform preliminary coring to the specified depth of the wall, and remove the core. This leaves a 3 mm skin maintaning watertightness.



3. After removing the core, grind a chamfer on the edge of the hole.

4. Fit the dispersion valve into the hole, break the remaining thin part of the wall and grout chamfer to complete installation.