

GEOMEMBRANE APPLICATIONS IN AUSTRALIA ⁽¹⁾

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ABSTRACT

This paper provides an overview of the application of geomembranes in Australia and relates the current trends in use to the environmental regulatory control now applicable. The paper presents examples of geomembrane use in Australia which effectively provides a history of usage and some indication of where future trends may lie.

INTRODUCTION

There has only been limited use of geomembranes in Australia and the current regulatory framework allows considerable flexibility in approach to disposal of wastes. Where there has been a requirement to contain waste, compacted clay has generally been the favoured choice for formation of low permeability barriers.

During the 1980's there was increased use of geomembranes in Australia for lining of waste and other containment structures. However, the extent of use of geomembranes is considerably less than in the USA even taking account of population differences. Nevertheless, the use is increasing and will continue to increase as the regulatory authorities require increased application and improved performance of waste containment systems.

This paper has been prepared to provide an outline of the regulatory environment which currently exists in Australia and the impact that this has had on the use of lining systems for waste containment. In addition the paper documents the likely future directions for lining requirements in Australia.

REGULATORY FRAMEWORK

In discussing the use of geomembranes in Australia it is important to understand the regulatory framework within the country and the factors which influence environmental control of wastes. Although Australia is considered to be an arid country, there is only limited reliance on use of groundwater for domestic purposes and this is mainly in rural areas. In many areas the groundwater is brackish to saline, thus limiting the use of the water.

The limited use of groundwater for domestic purposes, the limited manufacturing industry and the sparse population of Australia combine to produce an environmental regulatory

framework very different to those of North America and Europe. Up until very recently, the approach to disposal of industrial, mining and domestic waste has been based on the principle of "dilute and disperse". As long as the waste was placed in a confined area and was ultimately out of sight, limited control was placed on the disposal process. This attitude is now changing rapidly and we are seeing the development of a regulatory framework that will impose much greater control over the disposal of all forms of waste.

In Australia, environmental legislation and regulation is largely a state matter. Federal government can only control environmental matters through the use of financial controls on the states, although consideration is being given to formation of a national Environment Protection Authority. Each state within Australia has developed separate approaches to environmental legislation and regulation so that there has been a diversity in control measures required for waste disposal. In particular, there is seen to be a significant difference in environmental controls between so-called "manufacturing states" and the "mining states".

As environmental awareness changes within the community and attitudes to environmental responsibility and liability change within industry and government, we are seeing rapid changes in environmental regulatory control. Although there is still a diversity between the states, evidence of change in the approach to control of waste disposal and concern over contamination is seen in the following:

- Engineered containment systems have been constructed or are proposed for several landfills in at least three states.
- Most states are now requiring consideration to be given to closure of waste disposal sites in the initial planning phase. Greater attention is being given to issues such as appropriate capping measures and gas control.
- Most states are now concerned with the issue of contamination of soil and groundwater and at least three states have published guidelines for assessment of contaminated land and one is establishing a formal system of auditing of contaminated land.

GENERAL APPROACH

Australian use of geomembranes has largely been in applications for mining, industrial and public health areas and it has only been in recent times that lining has been considered in waste disposal. Some of the reasons for this are the relatively low population densities, the lack of dependence on

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groundwater for public supplies and a record with early liner types of poor ultra violet (UV) light exposure performance in a country where high UV light exposures occur.

Until the advent of heap leach mineral extraction most geomembrane applications were for water or waste water containment. Heap leaching became widespread during the 1980's and helped to develop confidence in liner performance as installations intended for short term service proved to have longer service capacity. The attention has now shifted more to environmental protection in a broader sense as well as solid or liquid waste containment and treatment including capping of existing waste deposits and covers for anaerobic processes.

Since there is limited regulatory control, the geomembrane option for lining is still chosen or not chosen on the basis of an economic life cost appraisal after comparison with other options that are considered viable. These other options may include recycling or processing, cartage to remote sites or conventional clay soil or concrete construction. As experience develops and confidence grows, the geomembrane option is being accorded a longer service life and is tending to compare more favourably, particularly, in areas where there are limited supplies of clay soil.

The following sections describe examples of geomembrane use in Australia. These examples are discussed partly in chronological order and thus provide a "potted history" of Australian geomembrane use.

REDMUD STORAGE AREAS, WESTERN AUSTRALIA

One of the first large scale uses of geomembranes in Australia was at Alcoa of Australia's alumina works in Western Australia. Of the three refineries operated by Alcoa, the Kwinana Works, just to the south of Perth, was the first to use geomembranes on a large scale for a Cooling Pond and then a red mud storage site known as Area H.

The near surface geology of the Kwinana area comprises dunal sand overlying variable limestone (calcarenite). Shallow groundwater in the area is used for industrial and agricultural purposes. Early use of thin (less than 0.4m thick) clay liners (for Red Mud Storage Areas A, B, C and F) resulted in some leakage of caustic liquor to the groundwater. The adoption of such thin clay lining was largely dictated by the significant cost of transporting clay some 20km from the nearest substantial borrow area. Specific problems with the clay liners were attributed to the difficulty of ensuring the integrity of a thin clay layer over large areas (the surface area of each pond varies between 20 and 100 ha) and the occurrence of shrinkage cracks between construction and filling.

As a result of problems with the early storage areas it was decided that future containment systems should use a composite liner system comprising compacted clay and geomembrane. It was considered that such an approach would be more economical than construction of a thicker compacted clay liner.

The adopted liner design for the Cooling Pond (area of about 15hA) and Residue Storage Area H (area of 45hA) was as follows, in ascending sequence:

- 0.5m of compacted clay, placed at or wet of optimum moisture content
- 0.76mm thick PVC geomembrane, field welded and tested by air-lance
- 1m of sand to provide an underdrain to the red mud and as a protective layer from traffic.

A pipe network was constructed in the sand layer to facilitate liquor collection. The underdrain was required to assist with consolidation and hence densification and as a measure to reduce liquor head on the liner system.

Subsequent to the construction of the Kwinana facilities in 1980 and 1981, Alcoa constructed similar lining systems for other red mud storage areas in Western Australia and in recent years they have constructed several facilities using HDPE geomembranes. Alcoa's early use of PVC enabled a fabrication industry to be established in Western Australia and considerable use was made of PVC lining systems for water retention structures and in the resurgent Australian gold industry in the early 1980's.

PERSEVERANCE GOLD HEAP LEACH PAD, VICTORIA

Following the large scale use of geomembranes by Alcoa, the next major development with geomembranes has been use for lining systems for heap leach pads. With the introduction of HDPE membranes into Australia, the gold industry quickly changed from use of PVC to HDPE. There has now been considerable use of HDPE for heap leach pads throughout the gold mining areas of Western Australia, Northern Territory and Queensland. The following example of geomembrane use for a heap leach pad is from the State of Victoria. This site is used as an example of heap leach pad construction since it is one of the few in Australia that has close engineering control during construction.

The Perseverance Gold Mine is at Nagambie about 120km north of Melbourne in an area of traditional mixed farming and wine production. It is an open pit mine with the ore being crushed and treated by cyanide leaching in a heap leach up to 30m high with an area of some 80,000m² with ancillary pondage.

The immediate subsoil conditions comprise high plasticity clays and the 1.0mm thick HDPE geomembrane liner was installed directly over the prepared and compacted clay base. Delays in the issue of mining and environmental permits pushed the liner installation window from the dry, hot summer of 1989 into the winter which arrived with plenty of early rain.

Conditions for deployment and field welding of the 6.86m wide HDPE sheet became extremely difficult with wind damage to some of the liner and an unworkable wet clay surface. Non-woven polypropylene geotextile fabric was used extensively to improve working conditions and the liner was deployed largely by winching from fixed locations. This demanded new operator skills in weather watching to predict wind shifts and to take protective action. The majority of the welding was carried out using fusion welding plant with some extrusion welding.

The installation of the geomembrane was under the direction of mine staff with independent quality control being provided by a consulting engineer approved by the Victorian Environment Protection Authority. All work was inspected by the quality control engineer and welding was fully tested by non-destructive methods and some destructive testing.

Gold leaching operations commenced in September 1989 and proceeded satisfactorily with a second stage pad liner being installed in early 1990 under relatively good conditions in the preferred summer period.

HENDERSON LANDFILL, WESTERN AUSTRALIA

This is the first use of a synthetic liner for a landfill in Australia. The Henderson Landfill site is located near Perth in Western Australia within the City of Cockburn (just north of Alcoa's red mud storage areas at Kwinana). The near surface geology comprises dunal sand over limestone with shallow groundwater used for industrial, agricultural and limited domestic purposes. The general area is heavily industrialised and the general waste stream includes many potential pollutants from industry as well as the normal domestic waste.

Planners were essentially left with two choices for this facility. The first was to establish a transfer station within the municipality and consolidate and cart the waste to a remote,

geologically secure (and less sensitive) site. The second was to establish a landfill within the municipality which was required to incorporate an adequate liner and leachate collection system. Costing comparisons put the cost of the first option at about A\$30 per tonne with about 40km of haulage and the second at about A\$16 per tonne including the premium for lining which was estimated at A\$4 per tonne.

The site itself is an old limestone quarry with high permeability base and the water table is normally about 3m below the quarry floor. Site preparation involved little more than trimming the site into two initial cells, as indicated on Figure 1 (Halpern Glick Maunsell, 1990a). A clay liner was installed over those parts of the site where the base was less than 3m above the water table; a requirement of the local EPA.

The liner itself is 2.0mm thick HDPE liner in 6.86m wide seamless rolls. It was welded together on site with a combination of fusion and extrusion welding techniques supplemented by a program of non-destructive and destructive testing. Total area is about 60,000m² and the complete installation took about six weeks.

The liner was covered with a protective cover of 300mm of sand and a further 300mm of crushed limestone which combine to provide a drainage layer with collection pipes and an operational surface. Leachate is collected via sumps for recirculation and eventual treatment.

GOSNELLS LANDFILL, WESTERN AUSTRALIA

This facility is in the City of Gosnells near Perth in Western Australia and it started life as an industrial liquid waste collection pit and has since been topped up with domestic waste prior to the installation of a HDPE cover.

The original pit came into service around 1979 and was constructed with a liner using a mix of local clay and bentonite in an area of generally clay soils. There has been some

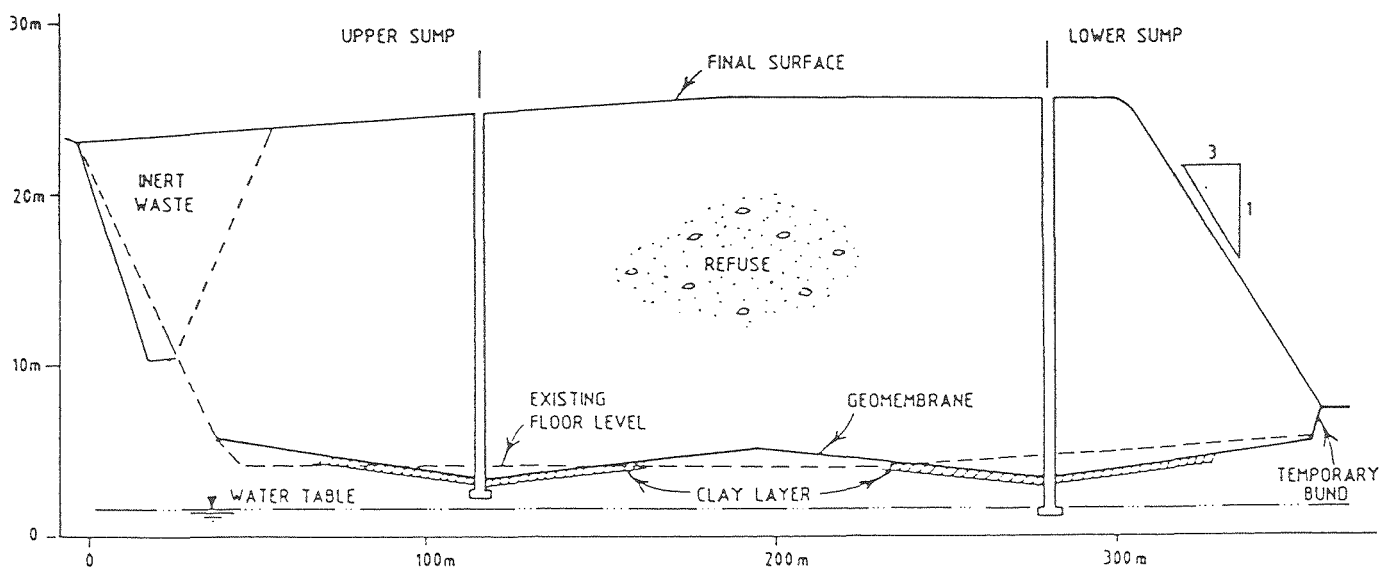


Figure 1. Cross-section - Henderson Landfill

evidence of local soil contamination and several incidents of stormwater overtopping occurred around 1987 and 1988. The liquid waste comprised a mixture of hydrocarbons and had formed a heavy sludge at the base of the pond. As a preparation to final capping the pit has been receiving solid domestic waste as landfill to a depth of about 3 metres. The surface has since become relatively firm and was able to support D7 bulldozer (with a track bearing pressure of about 10 kPa) operations without difficulty.

The cap has the following layers, as illustrated in Figure 2 (Halpern Glick Maunsell, 1990b):

- Sandy Loam - Soil Cover - 300mm
- Clean Sand - 100mm
- 1.0mm thick HDPE
- Clean Sand - 100mm
- Clay Cover - 300mm

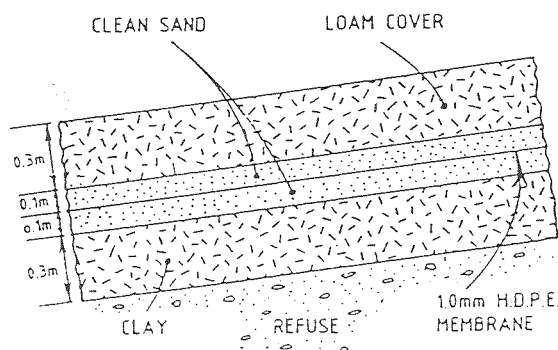


Figure 2. Capping Design - Gosnells Landfill

The plan dimensions are 132m by 58m and the cover crown is superelevated by about 3.5m relative to the perimeter which is restrained by anchor trenches. Gas vents are fitted across the crown and around the edges.

The cover is to be constructed from 1.0mm thick HDPE liner material supplied in 6.86m wide seamless rolls and welded using a combination of fusion and extrusion welding supported by non-destructive and destructive testing.

To the knowledge of the authors, the Gosnells site will be the first use of geomembranes in Australia for capping of waste. However, there are at least two other sites in the design phase which will involve capping using composite liner systems. These are a refinery tailings pond near Perth and an acid/oil sludge disposal site in Brisbane (Queensland).

BRISBANE CITY COUNCIL WASTE DISPOSAL CONTRACT, QUEENSLAND

The City of Brisbane is a municipality serving a population of about 1 million people. Tenders were called early in 1990 for a contract for waste collection and disposal of the entire Brisbane municipality for the next 30 years. Tendering for the contract attracted several bids, although at the time of writing these have been narrowed down to two remaining bids both of which involve use of geomembranes in combination with other lining materials. The following sections describe the

proposed lining systems for each of the landfills, using information obtained from publicly available information (References 3 and 4).

Proposed Rochedale Landfill The proposed Rochedale site (Pacific Waste Management, 1990) is located in a former brick clay pit located to the south of the Brisbane CBD. The floor of the pit is in clayey soil and is generally above the water table although there is evidence of spring activity in parts of the site.

The proposed liner design is illustrated in Figure 3 and comprises the following elements:

- prepared subgrade (including sub-liner groundwater drainage system)
- 0.9m of compacted local clay soil to have in situ permeability of not less than 1×10^{-9} m/s
- 1.5mm HDPE geomembrane
- leachate collection system comprising geonet (where required), geotextile and selected porous fill.

Subgrade preparation will involve levelling of the base and preparation of batters. Final capping of the site will involve a 1m thickness of compacted clay covered by topsoil.

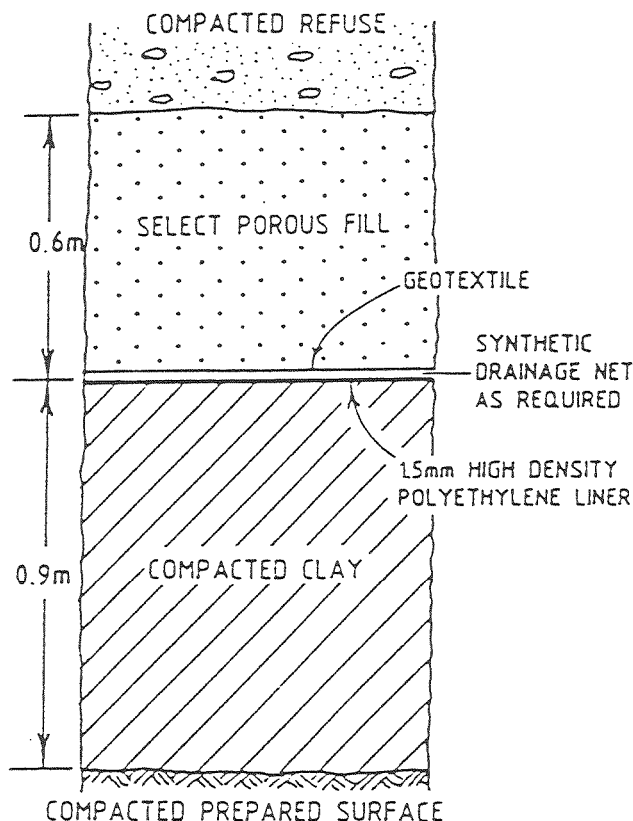


Figure 3 Proposed Base Liner Rochedale Landfill

Proposed Swanbank Landfill The proposed Swanbank Landfill (Railwaste Technology, 1990) is to be located in the Shire of Moreton located on the western boundary of the City of Brisbane. The site is a former open cut coal mine used to supply coal to the Swanbank Power Station. A cross-section of the proposed liner system is illustrated as Figure 4.

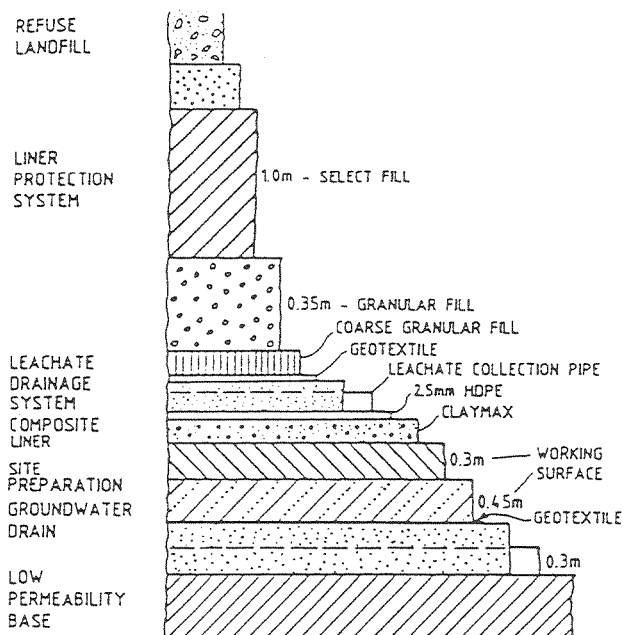


Figure 4. Proposed Base Liner Swanbank Landfill

Once the site has been shaped and prepared, a system of groundwater drains will be installed at the base of each landfill cell. These drains will consist of a trench of granular material excavated into the shaped, compacted low permeability base. Overlying the groundwater drainage system will be a geotextile and a bedding layer of non-carbonaceous material placed to provide a bedding for construction of the composite liner.

The composite liner proposed will consist of a 2.5mm thick HDPE liner underlain by a bentonite/geotextile composite liner. The bentonite liner is proposed to protect the HDPE from protrusions and to provide a back-up liner to the HDPE.

The leachate collection system above the liner will comprise ascending layers of geonet, geotextile, 0.15m fine granular layer (<25mm) and 0.35m coarse granular layer (<150mm). The leachate drainage system will be overlain by 1.0m of compacted waste to provide a working platform which in turn will be overlain by a non-combustible layer of waste as a final protection over the lining system.

Because of concern over the potential for combustion of the underlying coal strata, provision will be made for monitoring of temperature in the groundwater drainage system. If excessive temperature is monitored, water will be recycled through the groundwater drain to reduce temperature.

AQUACULTURE

There are many innovative uses for geomembranes being considered in Australia, some of which are following overseas trends. These include geomembranes for sludge digesters, cut-offs for existing dams, and aquaculture. The use of geomembranes for lining of aquaculture ponds is described below as an example of one of these innovative uses.

In Australian coastal regions interest is growing in the use of membrane liners in the establishment of efficient environments for the farming of high protein and gourmet food sources such as fish, prawns, and crayfish. The major requirements are relatively warm, stable water temperatures, clean water and lagoons shaped to permit rapid harvest. Nutrition requirements are supplemented at controlled levels as cultivation proceeds.

Many early ventures used polyvinylchloride and modified polyethylene liners and suffered from UV light degradation or animal penetration. HDPE contains no plasticisers or additives and provides excellent UV light performance without attracting animals or insects in search of food. Wide roll widths allow for operator installation without welding (narrow pond widths are chosen so that only one width of HDPE is required to avoid need for welding).

There are now several successful farms in northern New South Wales producing fresh water crayfish for gourmet markets and there are proposals in hand to use spent sea water from power station cooling to cultivate seasonal tropical fish.

FUTURE DIRECTIONS

The mining industry in Australia has enjoyed a buoyant period which is now slowing down as commodity prices subside and new taxation measures on gold production take effect. Geomembrane use is likely to continue for pondages and heap leach pads in the mining industry but at a reduced level of activity.

It can be expected that there will be increasing environmental awareness and greater regulatory control for the disposal of waste in Australia. This is likely to lead to increased requirements for containment of waste disposal systems where natural geological containment is not an option. If current trends continue it is likely that regulatory authorities will assess each individual site on its merits with both natural and artificial lining systems being accepted where appropriate.

Where artificial lining systems are required, it can be expected that compacted clay, geomembranes or composite systems will be selected depending in the cost effectiveness of each system. Traditionally, compacted clay soil has been used as the usual medium when lining for waste containment is considered. However, geomembranes are gaining acceptance as an alternative to clay for use in composite systems. It can be expected that a conservative view will apply to the further introduction of geomembranes so it will be a matter of establishing performance records in existing applications and demonstrating that geomembranes provide an effective alternative or adjunct to clay liners.

In this environment it can be expected that geomembrane use will grow in Australia but on a basis of continual enhancement of performance and cost effectiveness. If there is to be growth in the use of geomembranes in a relatively unregulated environment it will be necessary to encourage a quality image based on material performance and selection, proper design and detailing, appropriate installation and quality assurance programs. It will be necessary to educate owners that quality lining systems will only be achieved if all of these aspects are handled appropriately by experienced engineers, suppliers and fabricators.

CONCLUSIONS

Geomembrane use in Australia is increasing at a significant rate but does not have the impetus provided by centralised regulations and technical guidance which would give rise to extensive environmental applications. There are geographical and hydrogeological reasons for the less regulated approach to environmental matters in Australia. However, geomembrane use will continue to increase on the basis of economic appraisal of control measures and provided that performance standards are maintained.

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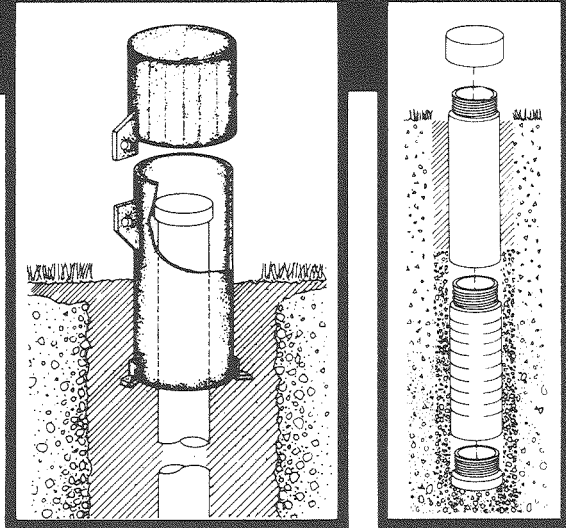
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GROUNDWATER POLLUTION MONITORING WELL EQUIPMENT



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