9.1 Tank Covers and Odour Control Equipment in Wastewater Treatment Plants

Odour control, that is either neutralisation or capture of odours produced within various sections of both municipal or industrial wastewater and effluent treatment plants, is becoming an ever increasing consideration in the design of new plants and the upgrading of existing ones. This is especially important in two major cases, firstly new high-volume plants capable of treating effluent equivalent to one million inhabitants or more, from which such volumes of unpleasant if not dangerous emanations would spread over large areas of the surrounding environment, affecting large numbers of local inhabitants. The second case may concern much smaller stations, but their location within built-up urban areas once again exposes a large number of inhabitants to some significant discomfort. Whilst various promotions of methods to reduce the extent of odour emission are under way, via the introduction of specific chemicals into the treatment process, and actually a group of water utilities in the UK are co-operating in a project involving a number of test methods to provide basic information on the development of odours from sewers and sewage treatment plants and how they could eventually be treated, the principle of confining odours within a limited space, and neutralising any localised emission from this zone is by far the most frequently used technology.

Typical areas within wastewater treatment plants which can release significant levels and intensities of odours to the atmosphere are clarification tanks and decanters, aeration tanks and channels, both trickling and high rate filters and sludge digesters and sludge storage tanks. Other smaller but significant zones which may require coverage are grit detritors, inlet channels and archimedian screw pumps, as well as access openings in general transfer channels in the larger plants.

Circular self-supporting composite tank covers up to 35 m in diameter have been in service for many years, and rectangular tank covers up to 100 m long or more are now commonplace. Covers are designed around two main concepts, a beam and in-fill arrangement for rectangular and small circular tanks, or a self-supporting assembly of modular sections based on a conical or domed form for larger circular tanks.

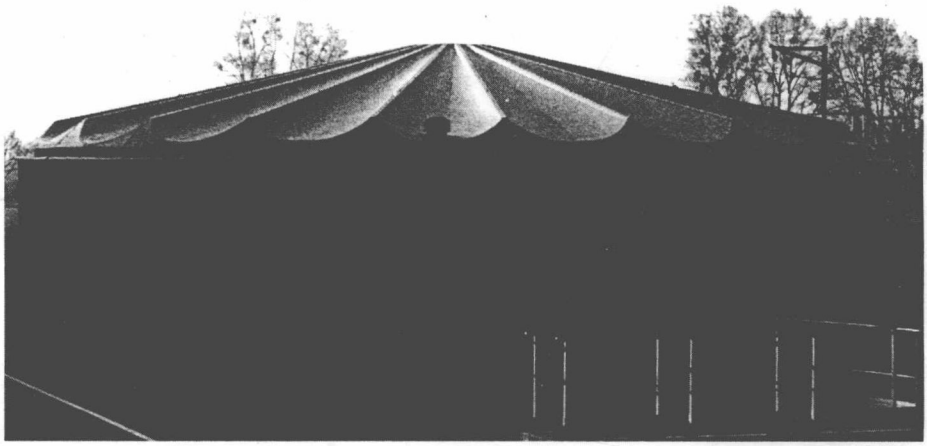

Figure 46. FRP tank cover and polypropylene odour control unit.

Whilst most storage and treatment tanks and basins are built from concrete or coated steel, composite materials have many significant advantages over both these materials and aluminum when covers are concerned.

- Weight — with a specific density of 1.8 to 1.9, combined with a judicial choice of moulded or pultruded profiles, it is often possible to assemble complete covers with little or no specialized lifting equipment or cranes. Large diameter circular covers can be assembled on the ground, close to the tank to be covered, and lifted on in one piece.
- Corrosion resistance — the level of corrosion resistance of either isophthalic or vinyl ester resins, to both internal and external environments, is assured practically indefinitely, and little or no maintenance should be expected over the normal 20 to 25 year life span of the treatment plant. The incorporation of pigments in the structural laminate as well as in the surface gelcoat eliminates even any requirement to repaint the covers, although some fading of colours will occur over an extended time period due to natural ultraviolet radiation.
- Access and removal of sections of the covers — due to the low weight of the material it is possible to remove one or more panels, usually by hand, to gain access to the tank or equipment in the tank, or in the case of a regular requirement, simple to operate access doors or panels are specifically built in to the construction.
- Architectural considerations — the facility with which a composite moulding process can be adapted to meet the requirements of even the most imaginative industrial architect is well known, and has permitted the construction of many spectacular projects at a reasonable cost, impossible to imagine in any other suitable material.

- Cost effectiveness and flexibility in design — the use of composite materials offers both the opportunity to use relatively inexpensive standard moulds thereby limiting investment costs in each new project, but also allows the designer to build in modifications, localised reinforcements and stiffening to suit the requirements of each specific project.

Ducts and the associated scrubbers or absorption towers to neutralise odours in air drawn off from tanks are in the main manufactured from polyethylene or polypropylene, both of which offer complete corrosion resistance, light weight and sufficient strength to deal with the very low pressures, negative and positive, regularly encountered in this type of installation. Absorption towers as large as 4 m in diameter and 12 m high have been built in polyethylene, as installed inside buildings they are protected from wind loadings, potentially a source of more stress than those due to the functioning of the absorber itself.

One of the most important companies involved in the odour control cover market is A-Form Projects Ltd in the UK, having more than 25 years' experience in the design, manufacture and installation of a wide range of composite covers in Europe and the Middle East. The company has introduced many novel features on covers supplied over the last few years, and is responsible for the design and manufacture of many of the largest composite covers ever constructed anywhere in the world. Two particular projects are used as case histories in Chapter 13, one involves a series of eight folding tank covers, each 6 m wide and 13 m long, associated with a stringent specification and the second example, probably the most spectacular tank cover installation ever, covering 8 off primary settling tanks, each 65 m long and 25 m wide, using a combination of rigid composite beams and flexible reinforced PVC membranes.

Design of tank covers is generally based upon or drawn up around local national standards for composite vessels, but due to the specialised nature of this equipment, it is possible to draw up a specific general specification prior to addressing the actual engineering problems.

The list below, developed from a design process used by A-Form Projects, suggests a number of points which may be considered, and which should form a specification for the design, pricing and construction of a cover:

- Define the shape of the tank, and the tolerances on the stated dimensions. This is of great significance for concrete tanks and older tanks in a refit project. A site visit and a rigourous dimension control prior to finalizing design drawings are to be recommended.
- Establish a description of any equipment which interfaces with the cover, for example, a bridge, pipework, electric cables, supports for equipment, hand railings and ladders.
- Define all requirements for access, for penetration into the tank, for inspection of tank contents, for tank cleaning or equipment within the

tank, or for servicing and adjustment of this equipment, together with a consideration of the frequency of these requirements. Other points of consideration could be hose entries for cleaning, ventilation of the space under the cover, type, size and location of walkways, non-slip requirements and hand railing.

- Relative translucency of the cover that can be specified to 80%.
- If the cover, or parts of the cover, are to be removed, how frequently and what means of handling are either required or already available.

Having completed the functional specification of the cover, the structural parameters can be examined and defined. Design loadings on this type of equipment can be split into sections:

- Wind loadings as defined by local legislation and/or current practice.
- Snow or other exceptional and similar loadings (such as sand in areas subject to significant wind-driven displacement of sand).
- Dead loadings due to the weight of any equipment supported by the tank, either permanently or occasionally, and man loads, which can be split into three types:
- Occasional access for maintenance and cleaning;
- frequent access for operational purposes; and
- areas defined as general walkways.

Occasional access for maintenance and cleaning is often calculated on the basis that the area or cover under consideration should be strong enough to support two people and their normal equipment (a toolbox for example).

Frequent access considers the same level of loading, but due to the frequency on intervention, requires that deflection of the cover is limited in order to install a high level of security, which is both real and sensed by the persons concerned. Deflection is generally limited to the smaller of 1/200 of span or 15 mm, which ever is the smallest.

Areas considered as general walkways are usually subject to the deflection of 1/200 of span, when the whole area would occasionally have people standing on it.

Unlike pipe systems or storage tanks which are generally subject to continuous loadings close to their design limit, tank covers tend to be subject to full design loadings on a very occasional basis, i.e. there is no snow or wind loading and no maintenance staff on the covers for perhaps more than 90% of the time, and practically no possibility of all loadings operating concurrently, and designs based on a minimum safety factor of three, as compared to ultimate properties, are common.

When designing a cover one must not forget the function of the tank and the consideration of the effect of this function on the cover or vice versa. Two

developments from A-Form Projects demonstrate the advantages to be gained by considering the two aspects together.

First of all, the requirement to cover tanks with rotating full or half bridges permitted the company to design a concept by which the tank cover is attached to the bridge and rotates with it, supported on wheels running on the periphery of the tank. The relatively low inertia of the tank requires little or zero extra energy from the motor driving the tank bridge, and adds the extra advantage of protecting the total structure within the cover. A second development, actually a further development of the preceding concept, involves the design of a clarifier which integrates a sludge scraper and an odour control cover. The combination of two well-proven technologies has produced a design that is hydraulically more efficient, as well as being cheaper and easier to install than conventional equipment. The complete cover revolves, as mentioned in the previous example, driven by a simple static motor. The scrapers, built entirely in composite materials, are attached to the roof and are arranged in a scroll configuration. This gives an extremely efficient scraping action, allows a much slower rotation, and consequently less turbulence. An initial project involving 8 off 20 m diameter covers was under construction at the time this book went to press. Should general access on covers not be required, or should the installation be of a less permanent nature, then various forms of thermoplastic covers are available, based upon a reinforced thermoplastic membrane tensioned over the surface of the tank. This concept can be taken one step further, removing the tensioning device and adding some form of flotation equipment, which allows the cover to rise and fall with the level of fluid in the tank. By maintaining the cover in close contact with the surface of the fluid, little space is created allowing the emission and concentration of odours.

A recent and typical example of this latest method, using material supplied by GSE Lining Technology was installed on a 5000 m^2 buffer pond in a wastewater treatment plant, the odours from which were upsetting local residents. This application uses high-density polyethylene floating covers that provided a seal tight cover that moves, via a number of suitably positioned floats, with the level of the effluent in the pond. All gases emanating from the effluent are extracted and cleansed by passing through a series of biofilters prior to release to the atmosphere.

9.2 Well and Borehole Equipment

Both thermoplastic and composite materials are used as casing and/or tubing for shallow depth water pumping, whereas high performance epoxy resin-based composite materials are generally retained for deep wells such as low-temperature geothermal water production, water flood enhanced oil recovery schemes in semi-depleted oilfields and general water and effluent injection or disposal.

Well casing is defined as a tubular product inserted into a borehole to retain the borehole walls and provide guidance for any required tubing or immersed pump. Casing sections at the bottom of the well are generally slotted or drilled to allow infiltration of the water from the aquifer, and are generally referred to as screens. Casings are generally designed upon the basis of their resistance to external pressure and may be grouted or cemented into the borehole.

Tubing, again a tubular product is designed to be inserted within a casing, and depending upon the pressure available within the well, may be required to support an immersed pump or a packer (device to maintain the tubing in place within the casing at the bottom of the well). For large-volume, low-pressure pumping, a casing may be used as a tubing, within an even larger casing.

9.2.1 Thermoplastic well casings

Economic considerations generally limit the depth of boreholes for the production of potable water, and most wells can be equipped with relatively inexpensive PVC casing. This type of material is generally supplied in lengths of approximately 3 and 6 metres, commensurate with the dimensional requirements of transport by container and possibilities to handle and install on site.

The main applicable standard for PVC casings are:

- **ASTM F 480-99** Standard specifications for thermoplastic well casing pipe and couplings made in standard dimension ratios (SDR), schedule 40 and schedule 80.
- **DIN 4925-1, DIN 4925-2, DIN 4925-3,** which cover respectively diameter 35 through 100 mm, using a whitworth thread, diameter 100 through 200´ mm and 250 through 400 mm, both of which use trapezoidal thread connections.

Composite casings, a relatively small market, tend to be designed, constructed and tested around ASTM standards for composite pipe.

Using a leading US producer of thermoplastic casing and associated material, Certain Teed, as an example, we can examine the range of material typically available.

Certa-Lok PVC Well Casing is designed for a large range of applications, including domestic, irrigation, municipal, industrial, geothermal, reverse osmosis supply wells and monitoring wells.

All Certa-Lok products use Certain Teed's coupling and spine locking device to form an instantaneous full strength joint, with no solvent adhesion or threading. The casing is supplied in lengths of 20 feet (6096 mm), in a variety of wall thicknesses, for installation in wells with depths of approximately 350 m.

The advantages of PVC casing over traditional metallic materials are numerous, and include:

- Light weight. The weight is approximately 20% of a comparable metallic casing, leading to easier and cheaper transport and on-site handling.
- Corrosion resistance. The PVC material is resistant to most chemicals, soft, brackish and saline water, and is immune to electrolytic and galvanic corrosion.
- Non-toxic. The PVC casings are NSF approved, will not impart any taste to the water, nor will it support bacterial growth.
- Cost efficient. The joint is instantaneous, and achieves full strength immediately upon assembly, is solvent free, and two twenty-foot sections can generally be jointed in around two minutes. The corrosion resistance and mechanical strength results in an extremely long service life, and should the casing require removal it can be quickly disassembled and removed from the borehole without having to cut out joints. The undamaged material can also be re-installed quickly and efficiently.

Certa-Lok PVC well casing is available in eight different diameters (6.9 to 17.4 inch (175 to 442 mm)) in various SDR to suit different well depths.

Certa-Lok Integral Bell Well Casing, that is casing with an integral bell rather than a separate coupling, offers all the advantages of the material described above, and is available in 4, 4.5, 5 and 6 inch diameter, in several different SDR. Due to the integral joint, assembly and installation times are further reduced.

To complete the range of casings, Certain Teed offer an extensive line of slotted casings and accessories.

It should be noted that contrary to practice with metallic casing, thermoplastic casing must never be driven but should only be installed in an oversized borehole.

Other points of interest when considering the installation of thermoplastic casings are:

- The internal diameter of the casing, taking into consideration the required flow rate, and the subsequent dimension of the pump and tubing.
- The ground structure and the overall depth of the well.
- The resultant installation, backfilling and/or grouting techniques.
- The temperature and nature of the fluid.

Certa-Lok PVC Drop Pipe. A PVC tubing or drop pipe for attachment to a submersible pipe, generally suspended within a well casing, using the same joint configurations as described above for casings. With this type of joint the submersible pump can be withdrawn for servicing and re-installed with minimum cost and down time. A Certa-Lok PVC drop pipe weighs 107 pounds per 20 ft length compared to 400 pounds for 6 inch Sch 40 steel (47 kg for 6096 mm/ 178 kg for steel).

Certa-Lok PVC drop pipe is available in sizes 1 to 8 inch, for installations up to 170 m deep, is designed and manufactured to meet or exceed ASTM specification D1785 requirements (Sch 80), and can be installed and used under the conditions given in Table 6.

The product line includes a range of fittings, including couplings, adaptor couplings—female by solvent weld socket, adapter couplings—Certa-Lok male by male thread NPT and Certa-Lok stainless steel male by male thread NPT.

An alternative approach has been made by another supplier of thermoplastic casings, this time situated in the Middle East. The National Plastic and Building Materials Industries LLC, based in Sharjah in the UAE,

Table 6. Quick selection guide for Certa-Lok PVC drop pipe for submersible pipe. *Courtesy of CertainTeed Corp.*

			Maximum discharge pressure at well head (bar)								
			0	1.7	3.4	5.2	6.9	8.6	10.3	12.1	13.8
Pipe size (inch)	Pump weight (kg)	Flow (l/min)	Maximum setting depth (m)								
1.5	38	95	137	125	112	100	87	75	63	50	38
2	90	170	129	116	103	90	77	64	52	39	26
3	135	378	170	155	142	127	113	100	85	71	57
4	180	662	150	135	120	106	91	77	63	48	34
5	270	1040	143	118	114	100	85	71	56	42	27
6	360	1514	150	136	121	106	92	77	62	48	33
8	450	2650	145	131	113	100	86	71	56	40	22

This information is taken from a quick guide published by CertainTeed, with most units transcribed into metric dimensions and volumes. CertainTeed point out these data were intended only for the purposes of an initial evaluation, based upon typical parameters of weight and flow. For a given surface discharge pressure, setting depth must be limited to the maximum values indicated. For definitive calculations, or to engineer any installations which do not fit the table data, CertainTeed require the use of the latest edition of its Design Worksheet (literature code #40-37-42).

produces a range of PVC casings and screens in accordance with the previously mentioned metric standard DIN 4925-1 / 4925-2 and 4925-3. There are two basic ranges, one for shallow and medium depth wells, and a second with a thicker heavy duty wall thickness for wells of greater depth. The casings are supplied with a male pipe thread on the spigot end, and a female thread at the socket end.

Screen sections can be supplied with either a plane or ribbed surface. Ribbed surfaces increase water permeability and help prevent clogging of intake openings. Slots are arranged horizontally to improve the mechanical strength of the screens and are designed to give open areas ranging from 6 to 12%. Slot widths vary between 0.2 and 3.0 mm.

Johnson Screens, part of the USF Filtration and separations organisation has introduced two more interesting applications for a thermoplastic alternative, under the designations PVC Vee-Wire and Schumasoil.

Technologies developed for actually making slots in thermoplastic casing are generally based upon perforation or cutting. Johnson Screens have adopted a wire wrap / welding rod technology, whereby continuous PVC "wire" is wrapped around and welded to PVC rods.

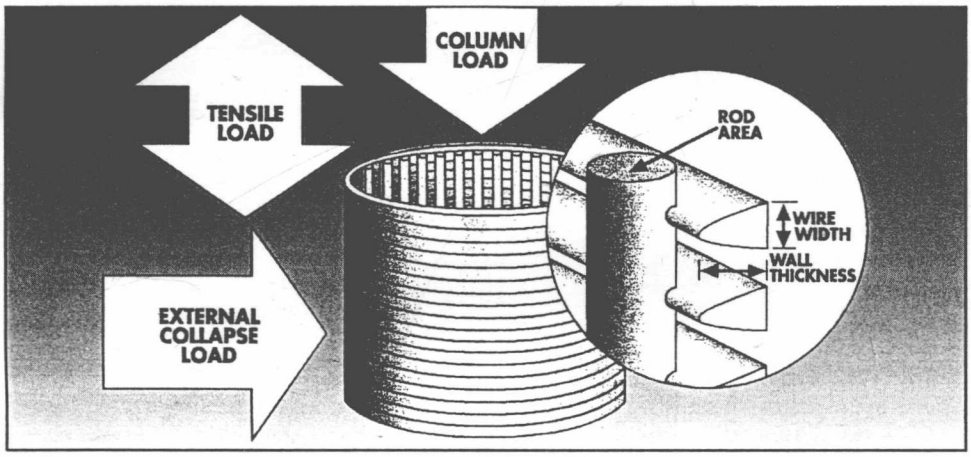

Figure 47. PVC Vee-Wire screen. Courtesy of USF Filtration and Separation.

The vee shaped wire, which narrows inwardly, tends to prevent any clogging by sand. When combined with the possibility offered by the manufacturer to vary the space between the wires, screens can be designed and manufactured to offer the maximum open area and dimensions suitable for any size and type of formation material.

Hydraulic tests comparing vee-wire screen with slotted screen, using an identical slot width, have shown that draw down with vee wire is 20% less

than with the slotted alternative. PVC offers also the advantage that it may be treated repeatedly with acid to remove encrustation. Screens to 6-inch diameter are made with a rod base (fig 47), whereas 8-inch diameter screens have a channel-rod base for enhanced strength.

The second material, Schumasoil, is a porous polyethylene well screen, originally developed by the Schumacher Company in co-operation with the University of Karlsruhe, well known for its involvement in many aspects of handling and treating water. Schumasoil screens are made by sintering high-density polyethylene beads without glues or solvents, and are designed for many difficult operations where conventional screens are not suitable.

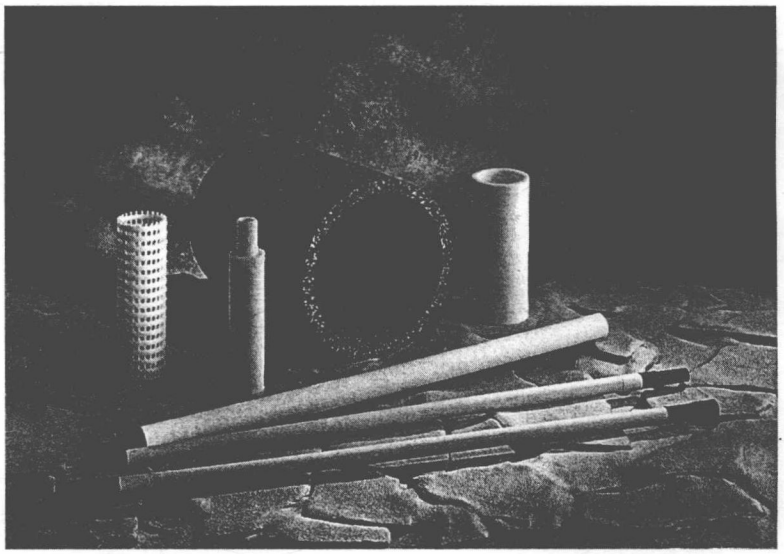

Figure 48. Schumasoil porous polyethylene well screens. Courtesy of USF Filtration and Separation.

As the entire screen is made of a porous material, it can be installed without the requirement of gravel packing. This makes it suitable for use in horizontal wells or in vertical wells completed in heaving sands, two conditions where gravel packing would be costly or impossible. The level of porosity is determined by the sizes of the particles used in the sintering process, and can range from 29 to 45% making the screens suitable for use in even fine grained or silt materials. The screens are currently available in six standard diameters (3 inch through 12 inch) and with five levels of average pore size (40 through 500 microns) and are suitable for continuous service a temperatures up to 80°.

Because of their original properties, Schumasoil screens have been used in many different and sometimes difficult applications, including;

- Soil vapour extraction, where the screens open area allows high efficiency laminar flow of vapours.
- Air spacing where high volumes of air distributed evenly along the entire screen increases cost-effectiveness of remediation programs.
- Bioremediation, where the non micro-porous surface resists biological fouling.
- Groundwater extraction, when downhole conditions prohibit conventional completion of ground water wells, or monitoring, remediation and infiltration wells.

9.2.2 Composite tubing and well casing/screens

Composite tubing and casing tend to fall into two categories, polyester-based systems for shallow to medium depth water wells, and epoxy-based systems for greater depths, higher temperatures, or for oilfield-related applications.

The first type of product is offered by companies such as Sarplast Initiative Industriali in Italy or the Burgess Well Company located in Nebraska, USA. The second type of product is well represented by Fiberglass Systems, based in San Antonio, Texas, USA.

Sarplast proposes a standard range of casing from 100 to 500 diameter, in three different wall thicknesses corresponding to three different maximum installation depths of 100, 200 and 300 m. They also indicate that designs to greater depths are available, as well as an extension of the range of diameters up to as high as 3000 mm.

Screens are available in two different formats, that is monoskin screens, with cut slots, suitable for medium depth applications. Open areas of 12% and above are standard, which would indicate fewer problems with clogging compared to lower values with PVC casing. A second higher performance configuration, designated pipe base screens, with 'V' shaped slots is also available. This configuration, see Figure 49, has, it is claimed by Sarplast, several advantages:

- They provide the same performances of the continuous slots screen in stainless steel.
- The composite material gives the screen higher tensile strength and collapse resistance, and as such is more suitable for deeper wells.
- The 'V' shaped slots eliminate clogging.
- The relatively low speed of inlet flow and the high transmitting capacity, as well as the limited pressure drop across the screen allow an economical water supply because of the reduction in consumption of energy by the pump.

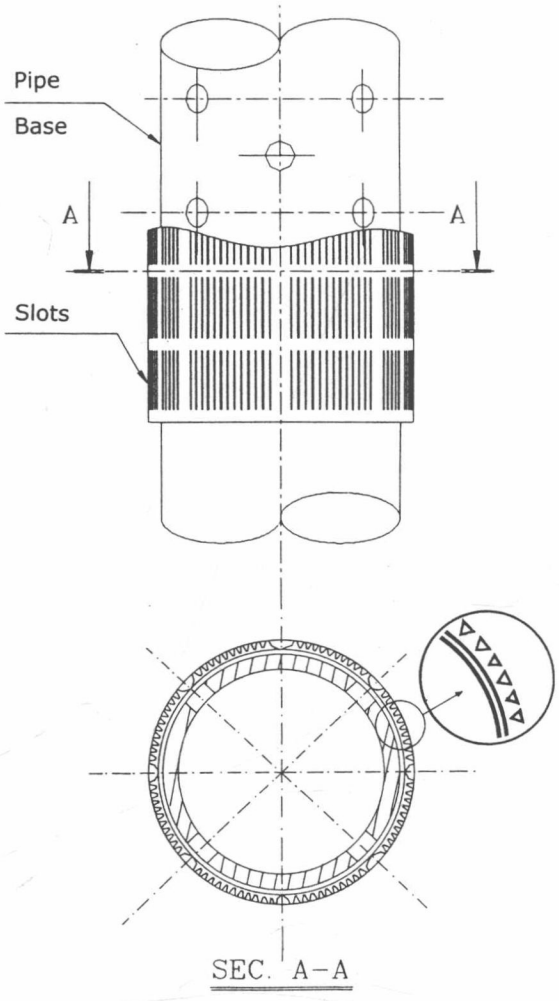

Figure 49. Screen with 'V' shaped slots. Courtesy of Iniziative Industriali SpA.

- The vertical slots reduce the friction between the gravel pack and the screen. The 'crushing' of the gravel pack, and the subsequent consequences on screen clogging, are much lower.

Sarplast use integral bell and spigot joints on all casings. The hydraulic sealing is obtained by single or double O-rings, and the axial resistance is taken by a mechanical locking device that is inserted into prepared groves in both the spigot and socket via an opening in the socket. Associated well head piping using the same material and jointing configurations can also be supplied.

The Burgess Well Company proposes a range of casings and associated column pipe (tubing), based upon a polyester resin system, with an alternative using a vinyl ester. All casings and screens are assembled with proprietary 'V' threads and Teflon tape associated with a Teflon-based pipe dope.

Casing is available in 2 to 16 inch diameter in three different wall thicknesses and ratings, whereas tubing is proposed in 4 to 12 inch diameter.

Higher performance composite tubing and casing is available from Fiberglass Systems under the trade name Star who supply anhydride-cured epoxy resin based tubing in diameters of $1\frac{1}{2}-4\frac{1}{2}$ inch, with pressure ratings up to 4000 psi, and casing in diameters $4\frac{1}{2}$, $5\frac{1}{2}$, 7 and $8\frac{5}{8}$ inch, in 1500 and 2000 psi ratings, all for service temperatures up to 93°C. Although mainly developed for oilfield applications, Star Fiberglass tubing and casing have been used successfully in low temperature geothermal wells, to depths as low as 1750 m. Smith Fiberglass proposes similar materials, including anhydride-cured epoxy casings in $4\frac{1}{2}$ to $13\frac{3}{8}$ inch and Ameron, who offers a similar range of materials via its acquisition of Centron, complete the trio of the most significant producers in this market.

Depending upon the diameter and pressure rating, each pipe joint may be supplied with an integral threaded female socket at one end, and a matched male threaded spigot, or pin, at the other, or as an alternative with a female threaded coupling bonded to one end of the pipe joint instead of the integral coupling. Assembly between the different lengths is achieved via API 8RD threaded joints which use a wide range of proprietary sealing materials.

9.3 Coatings and Linings

9.3.1 Initial protection of new equipment

9.3.1.1 Pipe systems

The family of thermoplastics and thermosetting composite materials have proven over the last 10 years their technical and commercial dominance in the field of in-situ pipe renovation. Many thermoplastic materials are also used to line steel pipe, under the designation of plastic lined pipe, essentially in the field of aggressive chemicals, although some applications are possible when handling chemicals for water treatment or in some ultra-pure water applications.

Typical liner materials are polypropylene, polyvinylidene chloride (PVDC), PVDF and PTFE.

9.3.1.2 Tanks, vessels and other constructions

Linings of storage tanks, and even road tankers with composite or thermoplastic materials is a relatively common practice within the chemical and petrochemical markets, and a great deal of formulations and application technologies exist worldwide for the water treatment and handling activities discussed in this book. The range and scope of these materials is such that an entire handbook could be dedicated to this activity. A brief introduction is, however, attempted in Section 9.3.2.2.

Most FRP jobbing shops can offer laminated liners inside storage or process vessels, and many of the manufacturers of dual laminate tanks and vessels can offer either bonded or loose thermoplastic liners within a steel envelope.

9.3.2 In-situ lining of existing equipment

9.3.2.1 Pipe systems

By far the largest actual market, and without doubt the largest market for many years to come for pipeline renovation by lining, is the potable and wastewater sector. Due to the deterioration of water and sewer lines installed

essentially in densely built up urban areas over the last 100 years or so, many companies have developed highly effective renovation and rehabilitation techniques, using various and wide ranging no-dig technologies. The essence of these technologies is the ability to resolve problems with buried pipe systems such as corrosion, deposits, leakage and damage whilst causing minimum disturbance to surrounding surface traffic, commerce and residents.

Several manufacturers of both thermoplastic and composite pipes have adapted their standard products to the requirements of this activity, whilst other companies have devoted their total business to the in-situ repair of pipe systems.

Using the wide range of technologies presented by one of the world's leading specialists in trenchless pipeline rehabilitation and renovation, the UK company Subterra, it is possible to explore most of the available solutions for relining existing pipe systems, all of which avail themselves of thermoplastic or thermosetting resins.

Before considering the actual lining technologies themselves, it is important to carry out an in-situ examination of the pipe to be lined via a CCTV survey, or as with Subterra technology, an enhanced level of information using ground probing radar (GPR) or in-sewer ground probing radar (ISGPR).

GPR and ISGPR are two effective surveying methods that offer a no-dig opportunity to accurately identify areas of pipe damage, leaks and other anomalies, such as wet or dry voids around the pipeline, soil types and other solid masses in the surrounding ground.

GPR is used in the location of services and pipes, and to survey a wide area from the surface, and can accurately survey and assess the substrata, both prior to excavation and following rehabilitation. It can also be used to obtain a rapid profile, as an aid in leak detection by mapping out ground moisture in the vicinity of suspected leaks.

ISGPR, a newly developed technology based upon experience drawn from previous use of the GPR system, is a system that can 'see' both into the wall of the pipe and the surrounding soil to give a picture in real time of the actual conditions underground.

Once complete, both technologies allow the presentation of the survey as a simple coded layout with an optional full written report complete with scaled CAD drawings portraying the interpreted information.

Proceeding now with a review of actual lining and coating technologies, and based upon the designation adopted by Subterra for each technique, it is possible to identify 10 or more significant procedures for the in-situ renovation and repair of buried pipe systems.

Epoxy spray lining — ELC 257/91 is a two-part solvent free second generation epoxy resin lining material, offering advantages over the first generation system from Subterra (ELC 173/90), particularly with respect to slump resistance and durability. The application of a thin epoxy resin internal

coating by in-situ spraying can improve flow, ease pressure problems and address a variety of water quality issues. Lengths of up to 200 m and thicknesses of 1 mm can be sprayed in one pass. Computerised monitoring of both pumping and winching rates ensures a high degree of control, ensuring optimum performance, and provides a corrosion-resistant, cost-effective lining for water mains. The material can be applied using standard spraying equipment incorporating heated materials storage tanks and umbilical hoses.

The ELG 257/91 epoxy resin formulation has been approved for use in contact with potable water in the UK, USA and Canada, Belgium, France, Hong Kong, Norway and Singapore.

Epoxy resin linings can be applied to a wide range of materials, including cast and ductile iron, steel, asbestos cement, non-reinforced, reinforced and pre-stressed concrete and composite materials. Typical areas of application are potable water mains, raw water pipes, fire mains and industrial process water systems.

Epoxy resin linings in general are solvent free formulations, have excellent adhesive properties, even on moist surfaces, and offer minimal shrinkage. ELC 257/91 is touch dry in 4 hours and the coated line can be returned to service after curing. In the UK, the cure period for all in-situ epoxy resin linings for water supply applications is stipulated by the Drinking Water Inspectorate as a minimum of 16 hours from completion of the spray-up.

ELC 257/91 epoxy resin provides a hard, durable corrosion resistant barrier layer over the material to be protected, and the application does not block off customer service connections.

Sprayed epoxy resin linings are also available from a wide range of suppliers some of which are listed in Chapter 14.

Another company highly active in the non-structural epoxy lining market has also developed a fast-setting, spray-on lining system based upon a two-part urethane formulation. Pipeway Ltd, together with E Wood Ltd have developed the E Wood/Pipeway Copon Hycote 169 lining system, which has recently been approved by the DWI.

Copon Hycote 169 is a two-part urethane system, light grey in colour, with a similar but glossier appearance to epoxy coatings when cured. After mixing and application to the pipe walls, initial set is achieved in approximately 40 seconds, with the coating hard and unmarkable after approximately two minutes. With such physical properties, DWI approval allows CCTV inspection to be undertaken 30 minutes after completion of the lining. A total cure period of two hours is required from completion of the lining to commencement of return to chlorination procedures. These comprise, as with epoxy lining, a 30 minute chlorination contact time followed by one hour of flushing.

This same company is also developing a product designated Pipesaver Pipeline Renovation, a new method for the structural renovation of existing pipelines. The process involves the enhancement of cement mortar lining by the use of an overlaying polyethylene membrane to provide leakage