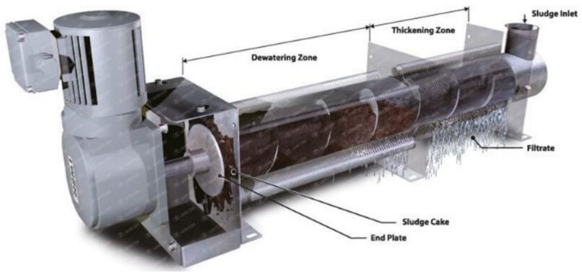
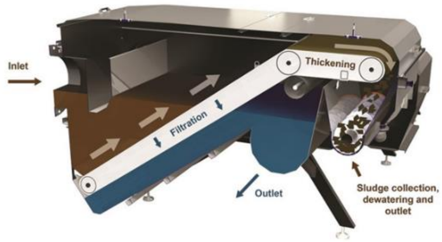
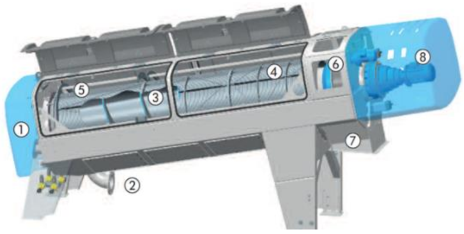
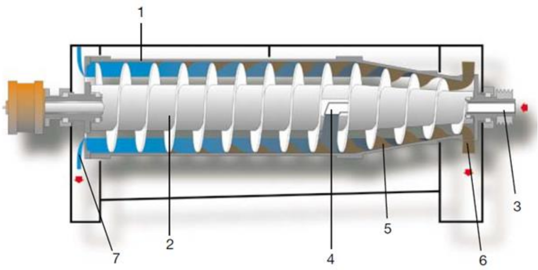








Potential technologies for dewatering of digestion reject

Authors: Antti Grönroos & Juha Heikkinen (VTT)

Confidentiality: Public

Leverage from the EU 2014–2020

European Union
European Regional Development Fund

KESKI-SUOMEN LIITTO
REGIONAL COUNCIL OF CENTRAL FINLAND

VTT

Contents

1. Sludge dewatering

Biological sludge dewatering is a crucial step in industrial wastewater treatment processes. There are always challenges as these sludges tend to form highly compressible cakes and the sludge properties are continually changing. Depending on the amount of sludge to be dewatered and total suspended solid in the sludge, single or multiple solid-liquid separation stages may be necessary (Chen 2013). The types of available dewatering technologies for biosolids are usually divided into following categories (Ron Drake, Alfa Laval Inc.):

- Batch process: filter presses
- Continuous process
    - Low speed technology:
        - belt press, rotary drum, screw press, Volute press
    - High speed technology:
        - centrifuge

Designs of filtration equipment most suitable for sludge dewatering have evolved to meet the characteristics of sludges, the most important of which are their compressibility and fine particle sizes, which lead to cakes with high solids contents close to the filter medium. Hence, the membrane plate press, the belt filter and the decanter centrifuge have become most widely accepted machines for sludge dewatering.

Filter presses tend to yield a drier solids discharge, but the level of dryness depends on the sludge properties. The same feed properties dictate the need for chemical pre-treatment to ensure the highest rates of dewatering and best clarity of filtrate, and correct choice of filter cloth is also crucial in these respects (Wakeman 2007). Figure 1 shows different filter types according to Anlauf (2019).

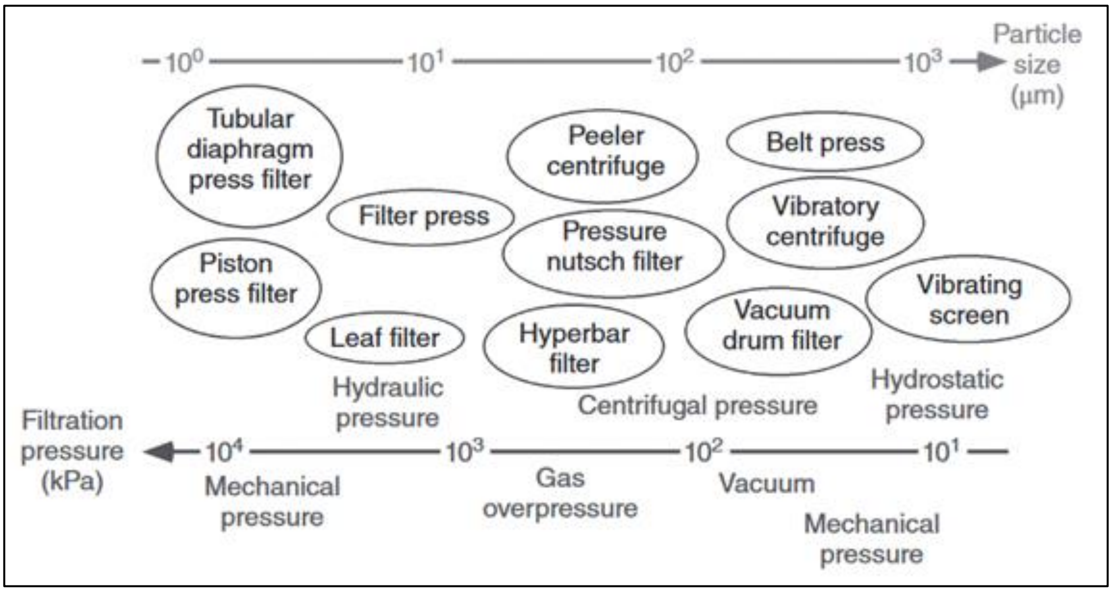


Figure 1. Cake filtration equipment depending on particle size and filtration pressure (Anlauf 2019).

Conditioning chemicals usually act on colloidal material in solution and therefore have little impact on the moisture held within sludge particles. As a result, conditioning improves the rate of dewatering but usually has little impact on the dewatered cake solids. The type of dewatering equipment used, and chemical conditioning requirements are linked. This is because some dewatering methods create more shear than others, and the conditioning chemical requirements increase as shear increases.

Centrifuges are high-shear devices, and while they can generate higher cake solids than belt presses, this comes at a price of more chemical additives. Higher dewatering pressures yield drier cakes but also greatly increase the time required to achieve water removal. This is because most sludges are highly compressible and high pressures deform the sludge particles, forming a low porosity layer next to the filtering surface (Novak 2006).

Compared to other equipment as shown in Figure 2, according to Mumbi et al. (2017), the screw press has more advantages compared to the other equipment.

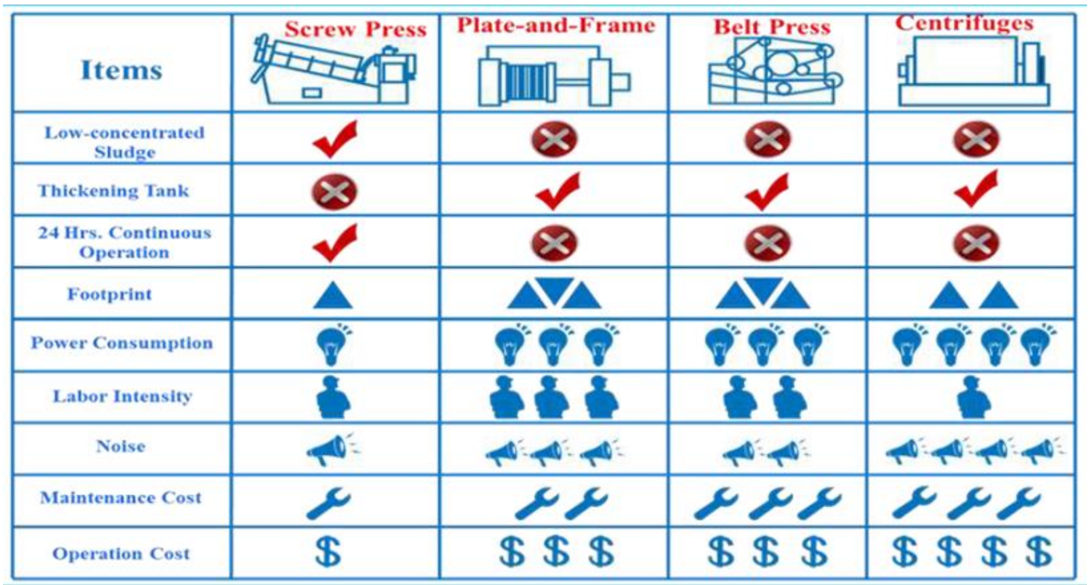


Figure 2. Technology comparison for sludge dewatering (Mumbi et al., 2017).

Wakeman presented a comparison of sidebar filter press, belt press filter and decanter centrifuge for municipal wastewater sludges (collected in Figure 3). If we take raw primary sludge as feed, cake solids contents were 25-36 %, 25-44 % and 40-50 % for decanter centrifuge, belt press and chamber filter press, respectively.

Fig. 4. Sidebar filter press (Larox Hoesch GmbH).

Recess plate filter press operating data for some municipal sludges [6]

Sludge type	Feed solids concentration (%)	Cake solids concentration (%)	Typical cycle time (h)
Raw primary + activated	3–8	45–50	2–2.5
Raw primary + activated + $FeCl_3$	5–8	40–45	3–4
Primary + activated + $FeCl_3$ digested	6–8	40	3
Tertiary + lime	8	55	1.5

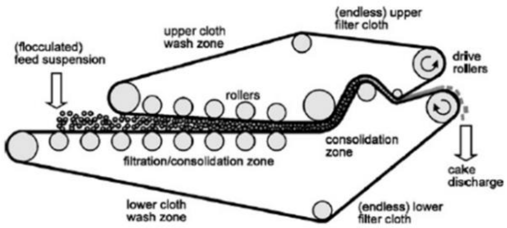


Fig. 5. Belt arrangement on a typical belt press filter.

Table 3
Belt press operating data for some municipal sludges [7]

Sludge type	Input solids concentration (%)	Cake solids concentration (%)	Polyelectrolyte dosage (kg te^{-1})
Raw primary	3–10	25–44	0.6–4.5
Raw activated	0.5–4	12–32	1.0–6.0
Raw primary + activated	3–6	20–35	0.6–5.0
Aerobically digested	1–8	12–30	0.8–5.0
Anaerobically digested	3–9	18–34	1.5–4.5
Thermally conditioned	4–8	38–50	–

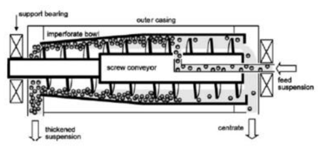


Fig. 7. Schematic representation showing the essential features of a decanter centrifuge.

Decanter centrifuge operating data for some municipal sludges [7]

Sludge type	Feed solids concentration (%)	Cake solids concentration (%)
Raw primary	5–8	25–36, 28–36
Raw activated	0.5–3	4–12
Raw primary + activated	4–5	18–25
Digested primary + activated	2–4, 4–7	15–18, 17–21
Thermally conditioned primary + activated	9–14, 13–15	35–40, 29–35

Figure 3. Comparison of dewatering equipment for municipal sludges.

Sprick 2017 made a following technology comparison summary of belt filter press, screw press and centrifuge (Figure 4), for a comparison of options for biosolids dewatering for municipal wastewater.

Parameter	Belt Filter Press	Screw Press	Centrifuge
Cake Dryness	16 to 22%	16 to 22%	18 to 26%
Power Consumption	up to 10 HP	up to 8 HP	100+ HP
Operating Speed	Relatively low	0.1 to 2 RPM	3,600 RPM
Polymer Use	8 to 16 lbs/DT	10 to 20 lbs/DT	15 to 30 lbs/DT
Capture Efficiency	95%+	Depends on MFR	95%+
Solids Loading Rate	up to 1000 lbs/hr per meter width	up to 1200 lbs/hr	Up to 4500 lbs/hr
Wash Water Use	High	Low	Lowest
Sludge Sensitivity	High	High	Low
Odor	Open	Enclosed	Enclosed
Noise	Medium	Low	High
Operator oversite	High	Lowest	Low

Figure 4. Technology summary of dewatering equipment (Sprick 2017).

In the technology comparison summary of dewatering equipment made by Sprick, screw press had the most recommended parametres.

2. Possible dewatering equipment for digestion reject

Technologies and equipment that could perform the dewatering of a slurry like digestion reject with similar capacity, cake solids content and reject water quality are listed below.

2.1 The most used dewatering equipment for digestion reject

2.1.1 Screw press

There are many different design concepts for a screw press but the key features include a scroll shaft (screw) to move sludge forward through a filtration area and then into a compression zone where progressively more water is removed through a perforated shell or screen and sludge cake is produced. There are numerous variations to the design with some unique features to mitigate fouling and plugging of the equipment.

Huber's screw press Q-PRESS® is a screw press with a conical screw shaft and cylindrical sieves consisting of three treatment zones: inlet and drive zone, three-part thickening and dewatering zone, and press zone with pneumatic counter-pressure cone (Figure 5).

In the first part of the thickening and dewatering zone the supernatant is quickly removed by the feed pump via a large free filter surface at a low primary pressure. A pressure probe in the feed area controls the primary pressure thus ensuring a constantly high filtrate quality.

In the second part of the screen the volume of material between the screw flights is reduced by the conical screw and the sludge pressed against the inner screen surface so that the sludge is dewatered, with a continuous reduction of the filter cake thickness. The screen apertures are much smaller in this screen section.

In the third part of the screen the residual water is pressed out of the sludge, at a minimum filter cake thickness, by the pneumatic counter pressure cone at the press discharge. The dewatered sludge is pushed by the conveying screw past the pressure cone into the discharge chamber. The sludge residence time in the screw press and thus the filtration time can be adjusted to individual requirements by adjusting the rotational speed of the screw shaft.

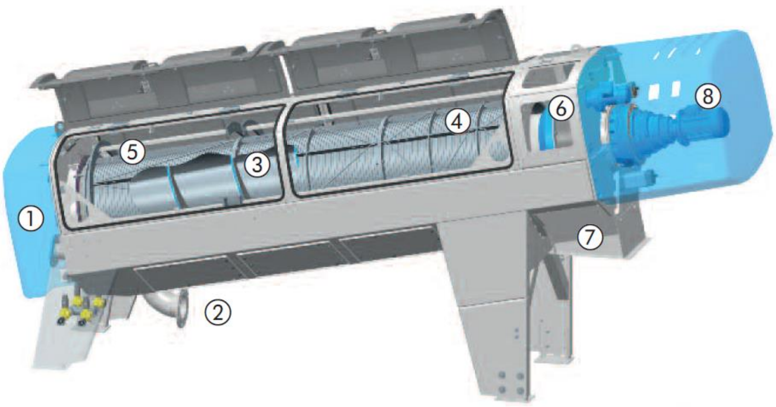


Figure 5. Partial section of a Huber Screw Press.

Huber screw press has a stainless steel wedge wire basket, spacing 0.4 mm in the beginning and 0.15 mm at the end. Table 1 shows the capacity, power demand and weight of the Q-press models.

Table 1. Huber Q-press models.

Model size	Capacity, kgTS/h	Power consumption, kW	Weight, kg
280	15 - 90	0.37	700
440.2	30 - 180	1.5	1 500
620.2	60 - 350	2.3	2 700
800.2	90 - 540	4.1	3 500

2.1.2 Decanter centrifuge

In a decanter centrifuge, separation takes place in a horizontal cylindrical bowl equipped with a screw conveyor. The feed enters the bowl through a stationary inlet tube and is accelerated smoothly by an inlet distributor. The centrifugal force that results from the rotation then causes sedimentation of the solids on the wall of the bowl. The conveyor rotates in the same direction as the bowl, but slightly slower, thus moving the solids towards the conical end of the bowl. The cake leaves the bowl through the solids discharge openings into the casing. Separation takes place throughout the entire length of the cylindrical part of the bowl, and the clarified liquid leaves the bowl by flowing over adjustable plate dams into the casing.

There are very many industrial decanter manufactures. For example, Alfa Laval's industrial decanter units can handle slurries with a solid content from as low as 0.1% w/w to more than 65% w/w. They are designed to handle a wide range of solid particles with diameters from 5 mm to a few microns. The dewatering technology produces a cake with up to 70% dry solids by mass with fine coal from flotation concentrate.

According to Alfa Laval, the high G forces in a decanter centrifuge give a very dry, stackable cake. The high separation efficiency means P3 decanter centrifuges are exceptionally good at separating out finer particles and recovering valuable process chemicals, minerals and water. In addition, the Alfa Laval P3 has the lowest power consumption of any comparable decanter centrifuge on the market. P3 decanter centrifuges are built for fully automated operation. A special upgrade to the 2Touch control system protects the decanter centrifuge against power loss, ensuring safe, uninterrupted operation, regardless of power dips or outages.

Figure 6 shows the operational aspects of a P3 centrifuge and Figure 7 technical data and dimensions of different P3 models. Separation takes place in a horizontal cylindrical bowl equipped with a scroll conveyor. The product is led into the bowl through a stationary inlet tube and is then smoothly accelerated in a full-flow feed zone design. Centrifugal forces of up to 3,500 G make the solids accumulate on the inner surface of the bowl. The conveyor rotates in the same direction as the bowl, but at a different speed. This moves the solids towards the conical end of the bowl. The solids leave the bowl through the solids discharge openings into the casing.

Working principle

Separation takes place in a rotating cylindrical bowl (1) equipped with a scroll conveyor (2) that rotates at a lower speed. The slurry is fed into the bowl through a stationary inlet tube (3) and then smoothly accelerated in the specially designed feed zone (4). Centrifugal force deposits the solids on the inner surface of the bowl (5) and leaves at openings at the end of the conical bowl (6). The clarified liquid exits at the other end of the decanter (7).

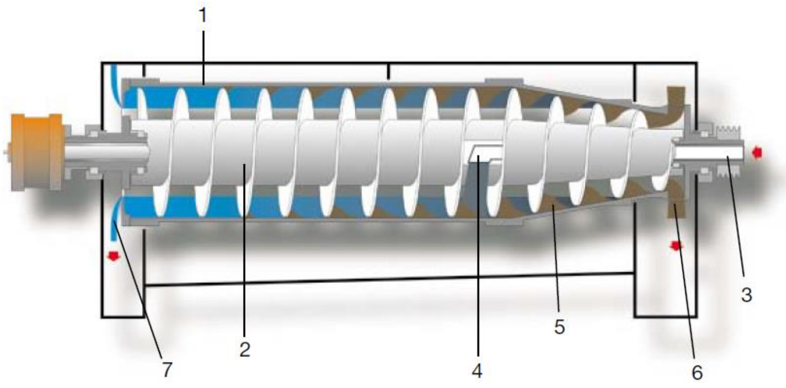
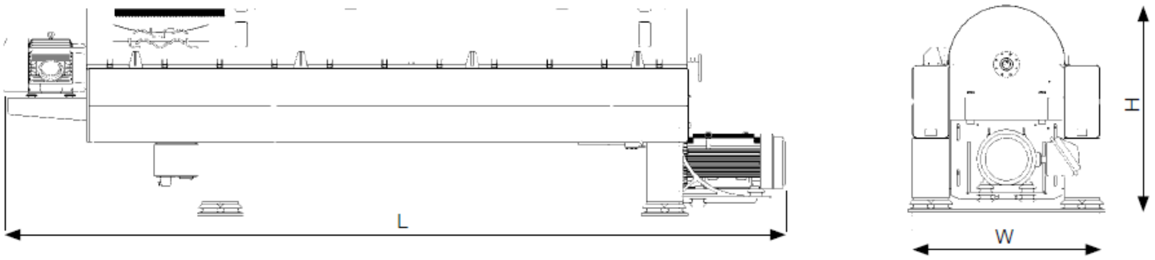


Figure 6. Working principle of Alfa Laval decanter centrifuge.

Technical data

Model	Weight kg (lbs)	Bowl material	Other product and liquid wetted parts	Main drive power kW (hp)	Back drive power kW (hp)
P3-4070	3,200 (7,050)	Duplex	AISI 316 or Duplex	37-55 (50-75)	18.5 (25)
P3-7070	6,500 (14,300)	Duplex	AISI 316 or Duplex	75-160 (100-200)	37 (50)
P3-8070	8,600 (18,959)	Duplex	AISI 316 or Duplex	55-250 (75-350)	55 (75)
P3-10070	18,500 (37,700)	Duplex	AISI 316 or Duplex	132-350 (150-475)	110 (150)

Dimensions



Model	L mm (inch)	W mm (inch)	H mm (inch)
P3-4070	4,855 (191)	1,060 (42)	1,376 (54)
P3-7070	6,450 (254)	1,450 (58)	1,791 (71)
P3-8070	6,900 (272)	1,510 (60)	1,850 (73)
P3-10070	8,822 (348)	2,050 (81)	2,248 (89)

Figure 7. Technical information of P3 decanter centrifuge models.

Alfa Laval's Aldec decanter centrifuges can be adjusted to suit specific requirements by varying e.g., the bowl speed to obtain the G-force required for the most efficient separation, the conveying speed for the most efficient balance between liquid clarity and solids dryness, and the pond depth in the bowl for the most efficient balance between liquid clarity and solids dryness. Figure 8 shows the technical data of Aldec decanter centrifuges.

Technical Data

Designation	Max. weight kg (lbs)	Bowl material	Material for other parts in contact with sludge	Typical main drive size kW (HP)	Typical back drive* kW (HP)	Start method
ALDEC 10	375 kg (830 lbs)	AISI 316	AISI 316	7.5 kW (10 HP)	3 kW (4 HP)	Star-delta, VFD
ALDEC 20	1125 kg (2495 lbs)	AISI 316	AISI 316	11 kW (15 HP)	7.5 kW (10 HP)	Star-delta, VFD
ALDEC 30	1200 kg (2660 lbs)	AISI 316	AISI 316	11 kW (15 HP)	7.5 kW (10 HP)	Star-delta, VFD
ALDEC 45	2300 kg (5071 lbs)	AISI 316	AISI 316	22 kW (30 HP)	5.5 kW (7 HP)	Star-delta, VFD
ALDEC 75	3200 kg (7050 lbs)	DUPLEX	AISI 316	37 kW (50 HP)	11 kW (15 HP)	Star-delta, VFD
ALDEC 95	4500 kg (9000 lbs)	DUPLEX	AISI 316	55 kW (75 HP)	11 kW (15 HP)	VFD
ALDEC 105	5000 kg (11023 lbs)	DUPLEX	AISI 316	75 kW (100 HP)	22 kW (30 HP)	VFD

Figure 8. Technical information of Aldec decanter centrifuge models.

2.2 Other possible dewatering equipment for digestion reject

2.2.1 Belt filter press

There are many variations in belt filters, but all of them have the following characteristics (Mumbi et al., 2017, SNF Floerger, Figure 9):

- Flocculator: Sludge is conditioned before arriving in the drainage zone. Flocculated sludge is distributed evenly on the filter belt. At this level sludge is in the form of flocs with the free water in between flocs.
- Gravity drainage zone: The flocculated sludge is drained on a first belt by simple gravity, where the majority of the water freed by flocculation is eliminated.
- Progressive compression zone: The sludge is pressed between two filter belts. With the arrival of the top belt, a progressive pressurization tales place; up to 7 bars for high pressure belt filters.
- Cake scraping zone: Once pressed, the cake is scraped off from the surface of the two belts that separate at this level.
- High pressure washing station: A bank of nozzles under 7 or 8 bars continuously cleans each belt.

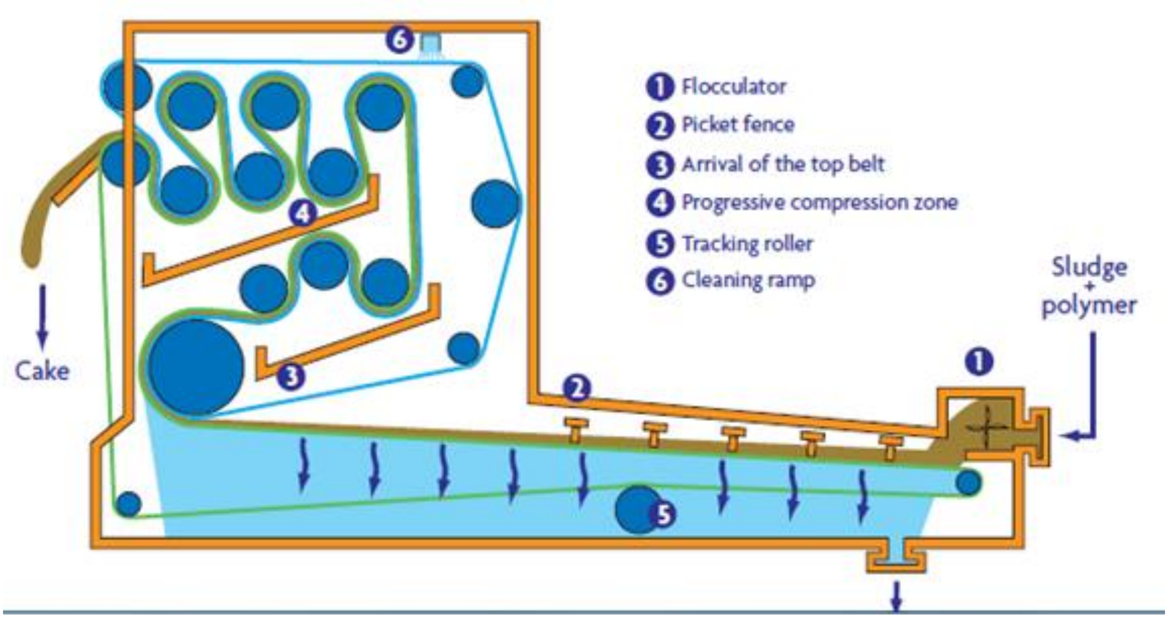


Figure 9. Description of a belt filter press operation (SNF Floerger).

Belt presses are devices for continuous sludge dehydration, which associate the effects of compression induced by the machine to the action of gravity. Belt filter presses are provided with an automatic washing system for the sheets. The required water quantity usually equals to the quantity of treated sludge. The solid-liquid separation by means of belt press leads to the obtainment of a semi solid fraction with a moisture content of 18 to 25% (Zanardo 2018).

Econet Group's DEWA FPD multi-stage series sludge dewaterer (Figure 10) is a combination of BTN (Heavy duty belt thickener) and FP (belt filter press), designed for the most demanding and large capacity applications. The FPD multi-stage dewaterer is easy to modify according to characteristics of sludge as well as throughput and cake solids requirements.

Every component is made of stainless steel or plastic material which is highly resistant to most corrosive media. All electrical, pneumatic components and bearings are located outside of the enclosure frame which makes easier to maintain without interrupting the unit operation. The enclosed construction of the FPD belt filter press enables to contain the odor within the machine, so it's rather easy to extract the fumes via ventilation connection located at top of the unit. This advanced design concept creates clean and odor free working environment.

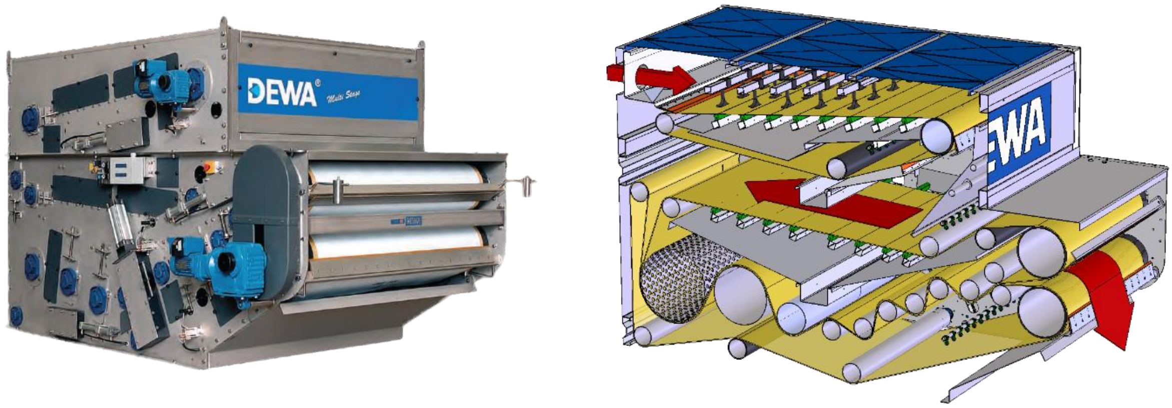


Figure 10. DEWA Belt Filter Press FPD from Econet Group.

Figure 11 shows the available FPD models from Econet, of which probably the smallest unit (FPD 11) might be sufficient for digestion reject, if the cake solids content would be at the required level.

		FPD 11	FPD 16	FPD 21	FPD 26	FPD 31
Belt width	mm	1100	1600	2100	2600	2600
Effective filtrate area	m2	12,5	18	25,5	30	36
Sludge flow	m3/h	5-20	8-30	12-40	20-60	30-80
DS Capacity	kg DS/h	100-400	250-600	300-800	400-1000	600-1200
Length	mm	3400	3400	3400	3400	3400
Width	mm	1910	2410	2950	2450	3950
Height	mm	2130	2130	2130	2130	2130
Weight	kg	2200	2900	4000	4400	5000
Power	kW	1,12	1,12	2,05	2,05	2,50

Figure 11. Econet's FPD capacity and dimension information.

2.2.2 Chamber filter press

Chamber filter presses, also referred to as plate and frame filter presses, with either steel or polypropylene plates, forming a large number of chambers covered by filter cloth as filter volume (Figure 12). The chambers are filled by pressure slurry pumping (6–16 bar) for initial filtration and compaction, while compressed air blowing through the cake, if not too impermeable, can be applied to desaturate or dry the filter cake. Filter presses are batch operated so that the chamber volume together with the cake density and the overall cycle time determines the capacity. Their high dewatering driving force allows them to filter ultrafine particles or fibres. Filter presses are particular utilized to provide dry filter cake of high ash material prior to briquetting and/or burning in power plants.

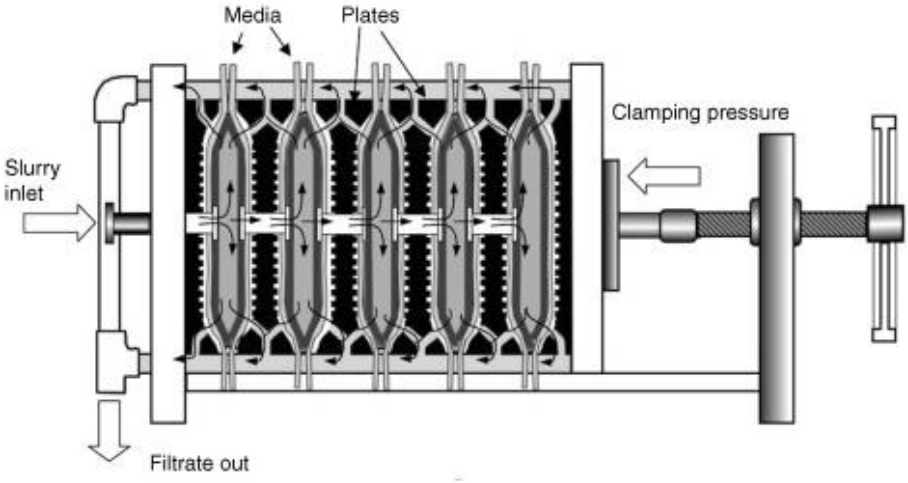


Figure 12. Scheme of chamber filter press (https://www.sciencedirect.com/topics/engineering/filter-chamber).

2.2.3 Horizontal pressure filter

Larox PF pressure filter is a recessed-plate diaphragm filter with horizontally oriented chambers and fully automatic operation, where continuous filter cloth ensures thorough cloth washing and efficient cake discharge (Figure 13). Due to continuous filter cloth, it should have higher capacity than traditional chamber filter presses with lower floor space requirements.

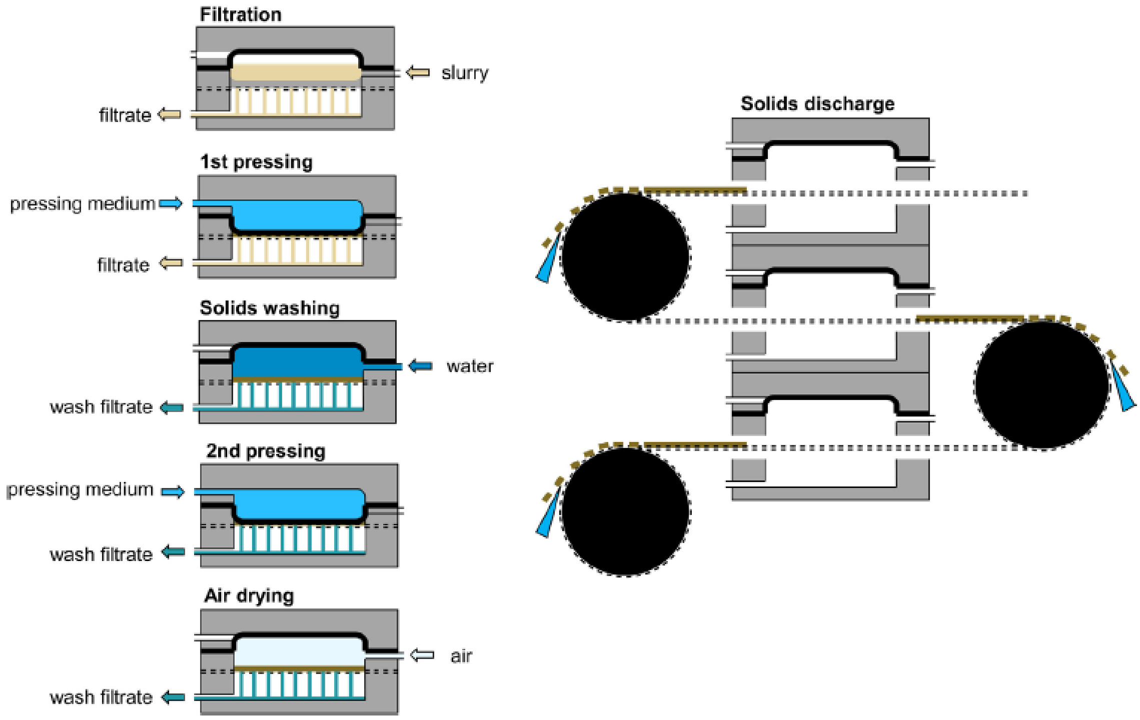


Figure 13. Larox PF operations (Teir et al. 2016).

PF pressure filter should produce similar filter cake and solids content than chamber filter press. Furthermore, as the total cycle time with continuous filter cloth is expected to be shorter, the required filtration area should be lower and probably a unit smaller than a sidebar chamber filter press would be sufficient.

Larox M1.6 Series automatic pressure filters offer filtration areas of 1.6 to 12.6 m^2 in a compact, easy-to-install unit (Figure 14 and 15). The filter is usually delivered fully assembled requiring minimal on-site assembly. This model has several corrosion protection options for demanding process conditions.

Figure 14. Larox PF 1.6 container unit.

OUTOTEC LAROX PF 1.6 SERIES

1.6 m^2 filter plate/45 and 60 mm chamber steel plates/40 mm chamber PP plates

PF 1.6 SERIES		1.6	3.2	4.7	6.3	7.9	9.5	11	12.6
Filtration area	m^2	1.6	3.2	4.7	6.3	7.9	9.5	11	12.6
Filter plates	pes	1	2	3	4	5	6	7	8
Filter plate size	mm	900 x 1750							
Cloth width	m	1.05							
Cloth length	m	17		22		28		33	
Filter length	mm	3650							
Filter width	mm	2500							
Filter height	mm	2300	2300	2400	2400	2500	2600	2700	2800
Filter weight	t	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0
Required floor area	m^2	36							
Hydraulic unit	kW (rpm)	18.5 (1500)							
Pressing water pump	kW (rpm)	4 (3000)				11 (3000)			
Pressing water tank	l	500				1500			
Hydraulic unit oil tank	l	250							

Note! PP plates available from size 6.3 and up.

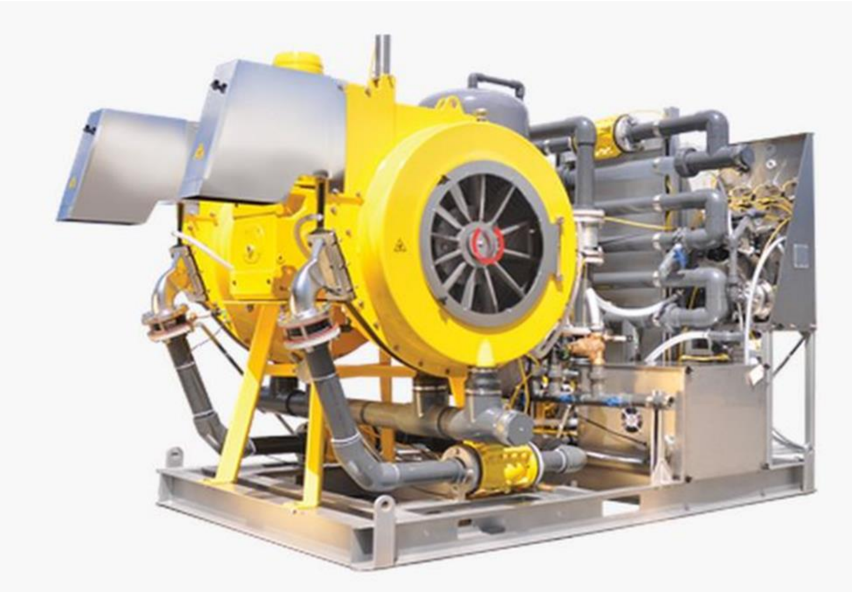
Figure 15. Outotec's small Larox PF series pressure filters.

2.2.4 Rotary fan press

In a rotary fan press, pressure increases as biosolids moves slowly through a tapered channel, and compress against two rotating filter screens (Figure 16).

When biosolids enter the system, pressure increases as waste moves slowly through a tapered channel. Friction intensifies as the biosolids compress against two rotating filter screens.

Filtrate takes the path of least resistance and drains through the screens. The dryness of the resulting biosolid cakes varies per application, but averages between 18–24 percent, with some applications achieving as high as 60 percent.



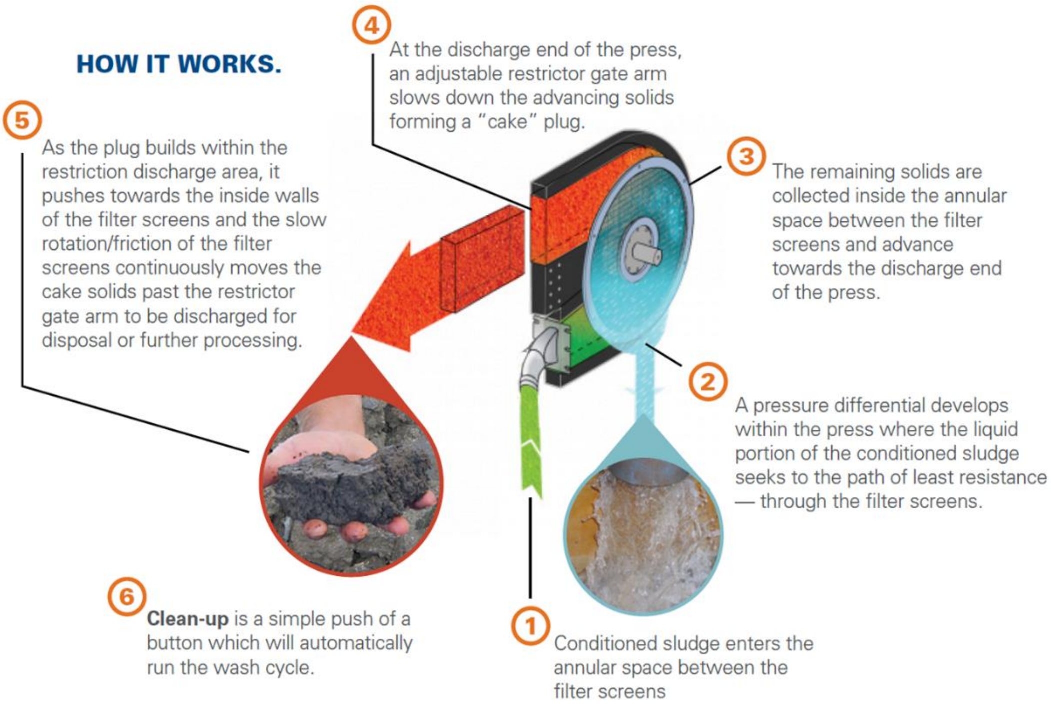


Figure 16. Prime Solution's rotary fan press picture and operation.

Prime Solutions Inc. informs that all capacities/loading depend upon the type of sludge to be dewatered, hence it is difficult to select the most suitable model for digestion reject. Figure 17 shows the available units.

The manufacturer claims that continuous dewatering within enclosed vertical dewatering channels makes it the dewatering system with the highest throughput per area of floor space required. They also offer no-cost on-site wet lab by which the effectiveness of the Prime Rotary Fan Press on different applications can be determined. To start conversation, one needs to fill out the Sample Lab Data Form at https://psirotary.com/services/lab-testing/.

FREE STANDING UNIT –
ROTARY FAN PRESS, ROTARY FAN PRESS 2.0, AND ROTARY FAN SCREW PRESS.

MODEL	CHANNELS	FILTRATION AREA (ft^2)	PRESS DRIVE HP	APPROX. LENGTH (ft.)	APPROX. WIDTH (ft.)	APPROX. HEIGHT (ft.)	APPROX. WEIGHT (lbs)
RFP24S	1	4.28	1.5	6	4.5	5.5	2,100
RFP24D	2	8.56	1.5	6	4.5	5.5	2,600
RFP36S	1	10.32	3	7.5	5.5	6.5	2,400
RFP36D	2	20.64	3	7.5	6	6.5	3,600
RFP36DE	2 (expandable)	20.64	5	8	6	8	6,600
RFP36T	3	30.96	5	8	8	8	8,300
RFP36Q	4	41.28	5	8	9.5	8	9,800
RFP48S	1	18.82	5	8.5	5.5	8	6,400
RFP48D	2	37.64	5	8.5	6.5	8	8,500
RFP48DE	2 (expandable)	37.64	7.5	9.5	6.5	8.5	9,500
RFP48T	3	56.46	7.5	9.5	8	8.5	11,800
RFP48Q	4	75.28	7.5	9.5	10	8.5	14,200

Figure 17. Rotary fan press models from Prime Solution Inc.

2.2.5 Tube press

In a tube press, filtration takes place between two concentric cylinders, outer (casing) and inner (candle) cylinder, where slurry is pumped into the annular space between the filter media and the bladder.

Hydraulic fluid, usually water, is pumped between bladder and casing pressuring slurry and causing filtration. When filtration is complete, hydraulic fluid is withdrawn until bladder is dilated against casing, candle is lowered into discharge position and pulse of air is injected between candle and filter media, this causes filter cloth to expand, and fracturing cake which is discharged under gravity (Figure 18).

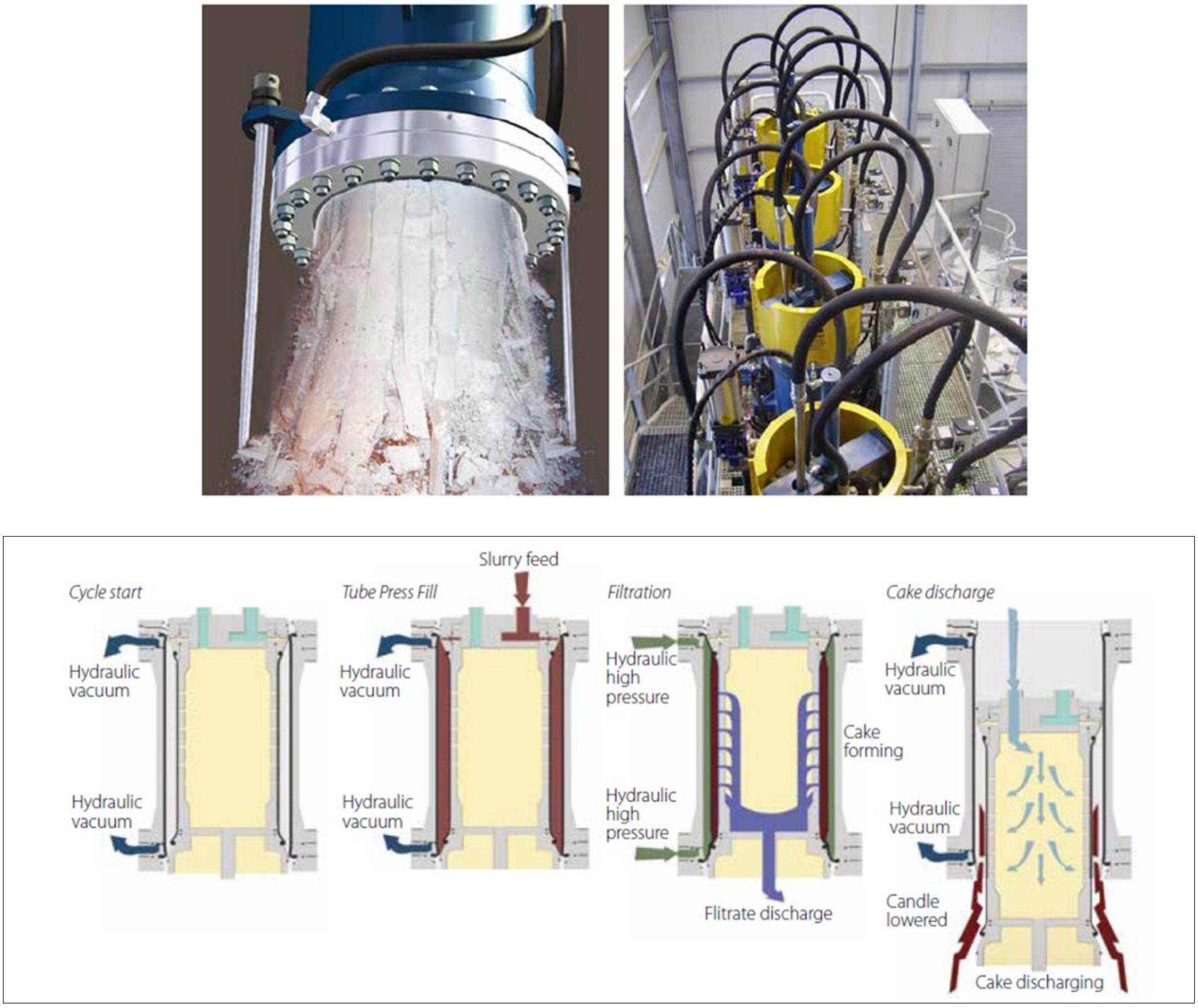


Figure 18. Metso tube press process operations.

The models of Metso tube press 500 series are shown in Figure 19. The height of the crane in Metso tube press is over 6 meters.

Tube press – Sizes

The Tube Press 500 serie is available mainly in two different sizes.
500 series. Casing diameter 500 mm. Nominal lengths available 1 500 mm and 3000 mm. Maximum pressure 100 bar (1 450 psi).

Model	500 Series 1.5 m	500 Series 3 m
Filtration pressure - max. (bar)	100	100
Length of candle (mm)	1 500	3 000
Candle diameter (mm)	389	389
Filter area (m^2)	1.75	3.47
Effective volume (litres)	100	200
Candle weight (kg)	580	1 100
Total weight (kg)	2 000	3 000
Crane height (m)	6.17	9.17

Model	L mm (inch) tube length	W mm (inch)	Weight (empty) ton	Filter area m^2 (ft^2)	Max op. pressure bar (psi)
SC 500-1,2	3 500 (138)	860 (34)	1.8	1.35 (14.5)	100 (1 450)
SC 500-1,5	3 800 (150)	860 (34)	2	1.73 (18.6)	100 (1 450)
SC-500-3,0	5 200 (205)	860 (34)	3	3,45 (37.1)	100 (1 450)

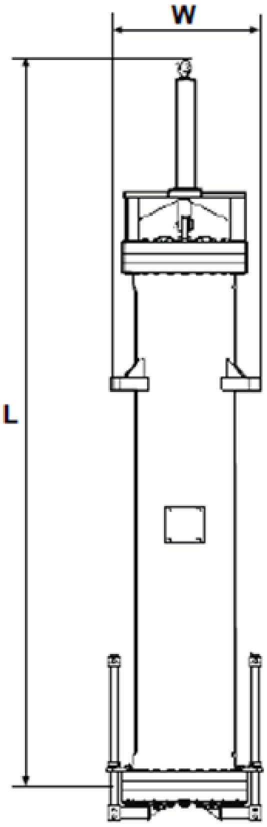


Figure 19. Metso tube press 500 series models.

2.2.6 Salsnes filter

Salsnes filter combines solids separation (rotating belt sieve), sludge thickening and dewatering (screw), shown in Figure 20. The filter mesh is made of polyethylene and is very durable. The way it's mounted and tensioned to the cogwheel is patented – it improves performance and allows the filter to handle higher flow rates and solids loadings, increasing treatment capacity in a smaller footprint.

Figure 20. Salsnes SF1000 picture and operational scheme.

The enclosed SF systems contain an optional integrated dewatering process. Sludge drops into the collection area from the thickening process (at 3 – 8 %DM with municipal wastewater) and is conveyed across the unit by an auger. It can then be fed to a sludge stabilization process (e.g. direct digester feed), or processed further through the dewatering unit to produce sludge that is 20–30% DM (without the need for any additional dewatering equipment, municipal wastewater).

The air knife filtermesh cleaning system starts automatically when the mesh begins to rotate. It uses compressed air to clean, which has many benefits compared to scrapers, brushes or water-based cleaning systems. Air is gentler on the mesh (to elongate its life) and on particles (so they do not break into smaller pieces). Air cleaning also keeps sludge drier for more effective dewatering.

A hot water or cold water high pressure flush is available to those facilities that have a high concentration of fat, oil and grease (FOG) in their wastewater. Operating only two – four times daily, this flush effectively cleans the hard-to-remove FOG from filter mesh openings.

Programmable Logic Controller (PLC) makes SF a completely automated system, ideal for remote or unstaffed facilities. A water pressure sensor tells the unit when to rotate the filter mesh (and at what speed), while the PLC simultaneously starts the air knife and sludge screw press.

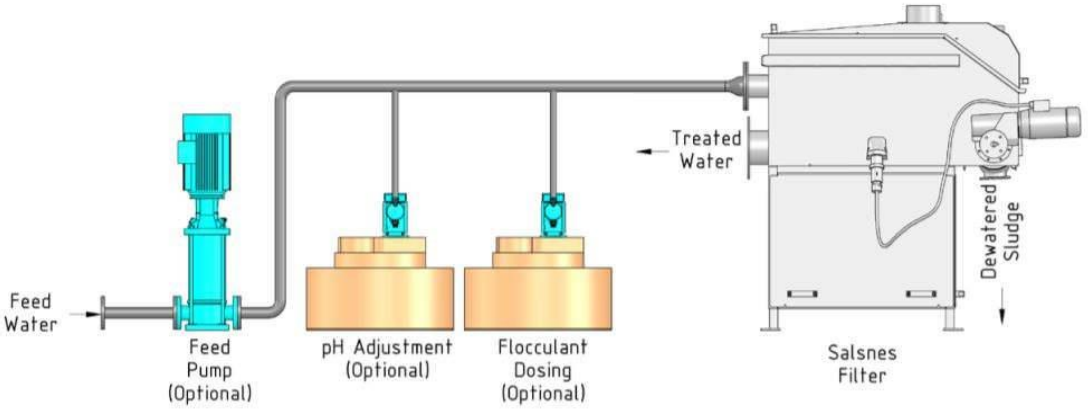


Figure 21. Main additional options of Salsnes filter system.

Salsnes model SF1000's capacity is 35 m^3/h (municipal wastewater, Figure 20). SF1000's dimensions are (length, width, height) 1.5 m x 1.3 m x 1.5 m, and weight only 480 kg. The most common belt mesh openings sizes are between 50 – 4000 µm.

Figure 22 shows the specifications of SF1000 and other SF models.

Model	SF1000	SF2000	SF4000	SF6000
Style	Enclosed, free-standing			
Material of Construction	316L Stainless Steel			
Weight (Dry)	480 kg (1,058 lbs)	530 kg (1,168 lbs)	890 kg (1,962 lbs)	1,230 kg (2,711 lbs)
Standard Electrical Voltages	480/277V 3 ph, 3 wire + gnd, 60 Hz 400/230V 3 ph, 3 wire + gnd, 50 Hz			
Typical Operating Power Consumption	1.4 - 2.8 kW	1.8 - 3.6 kW	2.1 - 4.5 kW	2.8 - 5.5 kW
Accreditations (Electrical)	CE, UL, UL approved for Class 1 Div1			
Performance				
Maximum Hydraulic Flow	54 m^3/h (0.3 MGD)	144 m^3/h (0.9 MGD)	288 m^3/h (1.8 MGD)	576 m^3/h (3.7 MGD)
Treated Flow (Municipal Wastewater)	35 m^3/h (0.2 MGD)	90 m^3/h (0.6 MGD)	160 m^3/h (1.0 MGD)	325 m^3/h (2 MGD)
Maximum Head Loss	440 mm (17")	300 mm (12")	330 mm (13")	350 mm (14")
TSS Removal Efficiency	30 – 80% (design dependent)			
BOD Removal Efficiency	15 – 40% (design dependent)			
Sludge Dry Matter After Thickening	3 – 8%			
Sludge Dry Matter After Integrated Dewatering Unit	20 – 30%			
Dimensions				
Length x Width x Height (complete unit)	1.5 x 1.3 x 1.5 m (5 x 4.4 x 4.9')	2 x 1.7 x 1.3 m (7 x 5.5 x 4.5')	2.5 x 2.0 x 1.6 m (8 x 6.5 x 5.2')	2.8 x 2.5 x 1.8 m (9 x 8.1 x 6')
Inlet Diameter (pumped/gravity)	100 mm DIN (4" ANSI)	150/200 mm DIN (6"/8" ANSI)	200/350 mm DIN (8"/14" ANSI)	250/400 mm DIN (10"/16" ANSI)
Outlet Diameter	150 mm DIN (6" ANSI)	250 mm DIN (10" ANSI)	350 mm DIN (14" ANSI)	400 mm DIN (16" ANSI)
Overflow Diameter	Combined with outlet			
Bottom Drain Diameter	N/A	100 mm DIN (4" ANSI)		
Water Connection	13 mm BSP (½" NPT)			19 mm BSP (¾" NPT) ½" NPT for UL Div1

Figure 22. System specifications of Salsnes SF models.

2.2.7 Volute filter press

VOLUTE™ is structured with a filter element that consists of two types of rings: a fixed ring and a moving ring; and a screw that thrusts the filter element and transfers and pressurizes the sludge (Figure 23).

The gaps between the rings and the screw pitch are designed to gradually get narrower towards the direction of sludge cake outlet and the inner pressure of the filter element increases due to the volume compression effect, which thickens and dewaters the sludge.

The model of sludge dewatering press based on the customer needs can be selected from a wide range of line-up, from a super-small 0.5 kg-DS/h throughput to a large 780 kg-DS/h throughput.

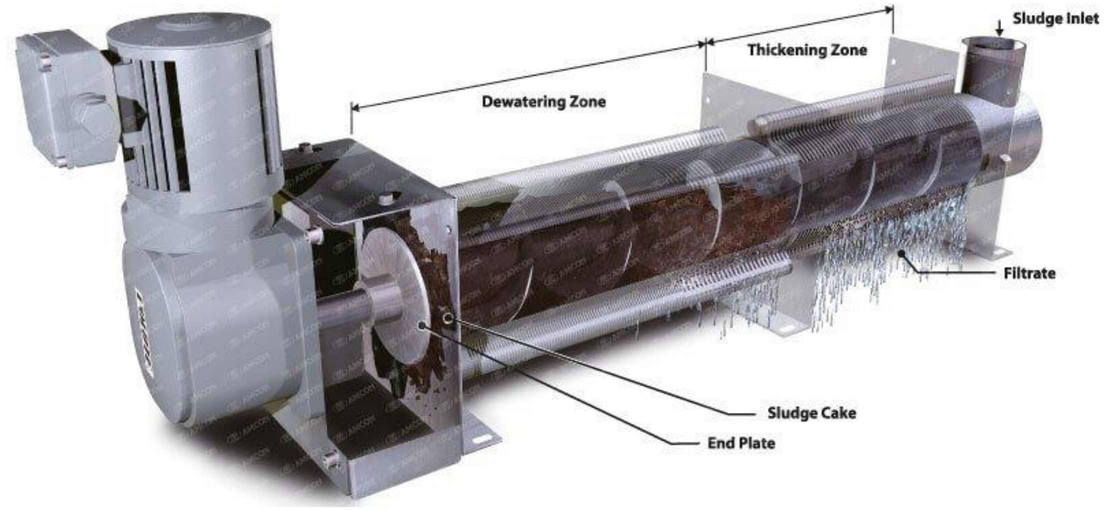
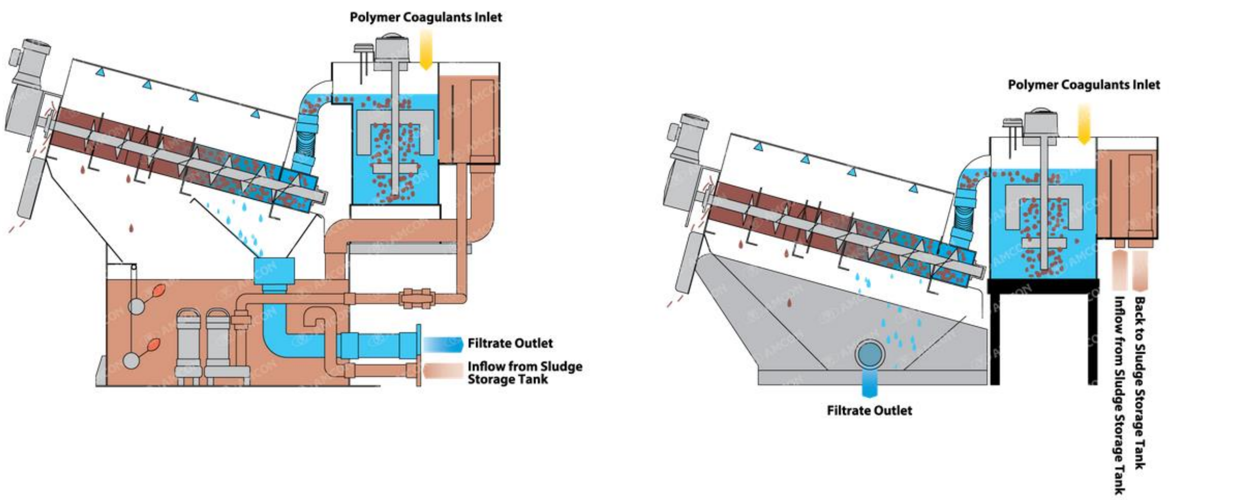


Figure 23. VOLUTE™ Dewatering Press.

There are two types of Volute dewatering press body structures: model with sludge conditioning tank, and model without sludge conditioning tank (Figure 24).



Model with sludge conditioning tank

A sludge conditioning tank temporarily stores sludge before it is dewatered. The model with a sludge conditioning tank realizes a high solid capture rate higher than 95%, and the efficiency of sludge treatment is tremendously enhanced as the inlet sludge is always conditioned beforehand. In addition, when required, the conditioning tank can be used as a reactor tank for inorganic flocculant.

Model without sludge conditioning tank

For the model without a sludge conditioning tank, an affordable price was realized by eliminating the tank. In addition, it is designed to secure the solid capture rate as high as 90% or higher. The performance is as sufficient as it needs to be.

Figure 24. Two types of main body structure of VOLUTE™ Dewatering Press.

Figure 25 shows the available models of Volute dewatering press. The gap between rings in different sections of the cylinder varies from 0.50 mm to 0.17 mm. According to T&A Mämmelä the machine is gentle on the flocs, but flocculation is required for the quality of the reject water.

Model	Dimensions (mm)			Total Power Consumption (kW)	Weight (kg)	
	L	W	H		Empty	Operation
GS-101	1899	1140	1140	0.40	330	530
GS-131	2043	1140	1140	0.40	340	540
GS-132	2043	1167	1140	0.50	410	600
GS-201	2593	1153	1440	0.48	605	825
GS-202	3228	1493	1854	1.29	1470	2100
GS-301	3824	1439	1854	1.30	1272	1922
GS-302	4044	1728	1854	1.67	1815	2810
GS-303	4224	2028	1854	2.04	2315	3595
GS-351	4500	1660	2250	2.43	2195	3165
GS-352	5185	1910	2289	5.95	4120	6750
GS-353	5429	2310	2289	7.45	5130	9280
GS-354	5579	2860	2289	8.95	6650	11120

* Throughput above is calculated as approximate and may vary depending on sludge condition.
For model selection, please contact us.
* Throughput of each model is based on sludge cake with 20± 5% solids content.
* There is no certain upper limitation on inlet sludge concentration, however, the target sludge must be flowable.
* Throughput of DAF Sludge is based on sludge contatining much fat, oil, and grease such as meat processing applications etc.

Layout Drawings

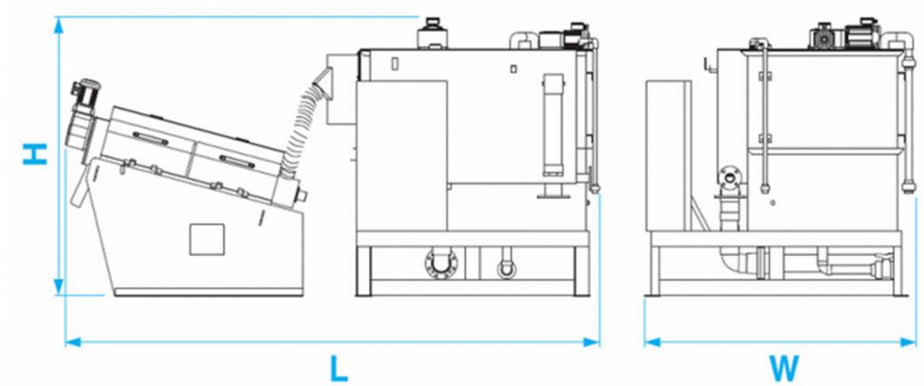


Figure 25. Volute dewatering press models.

In dimensions it should be remembered, that anchor points for sling work are required above cylinder unit for maintenance and overhaul, also making sure to secure enough height, at least 500 mm to hoist entire cylinder unit.

Volute press prevents filter mesh from clogging with its self-cleaning mechanism, removing the need for huge amounts of water for clogging prevention. When compared with dewatering equipment of the same throughput, the amount of cleaning water required for VOLUTE™ is about 1/115th of belt press and about 1/12th of conventional screw press, according to the manufacturer.

3. Coagulation/flocculation with dewatering of digestate reject

Coagulation and flocculation are used in conjunction with sedimentation, filtration and centrifugation to improve the efficiency of these other processes (Figure 26). For example, if the particles to be removed from a slurry are very small, it is possible that the filter media can become fouled (or clogged) owing to the cells filling the void space in the filter media.

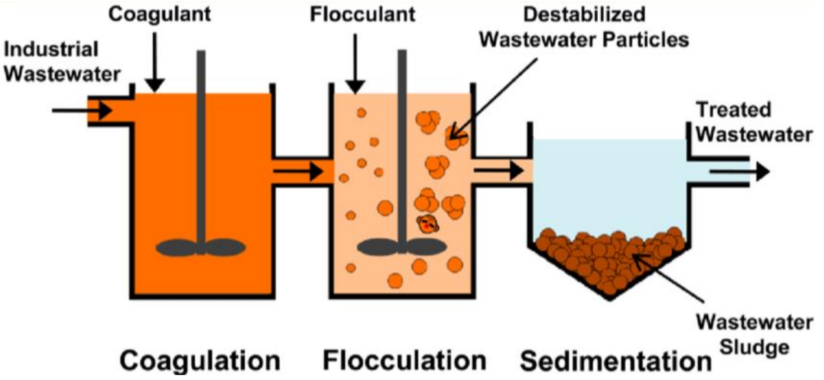


Figure 26. Coagulation−flocculation process (Teir et al. 2016).

Applying chemical coagulation and flocculation in wastewater treatment includes the chemicals addition to change the physical state of suspended and dissolved solids and in follow facilitates their removal after that by the solid/liquid separation process. Coagulation is used to remove contaminants from suspended or colloidal forms that do not settle out on standing or settle slowly, and it is considered the most useful pre-treatment procedure in wastewater treatment.

Coagulation and flocculation typically occur sequentially, governing the formation and properties of floc, and impacting the performance of downstream processes. Initial aggregation of particles/NOM occurs by destabilization during coagulation, where mechanisms include charge neutralization, interparticle bridging, and sweep flocculation. Charge neutralization occurs when sufficient cationic metal hydroxides are adsorbed to reduce zeta potential to zero, while sweep flocculation occurs when the concentration of a coagulant exceeds its solubility limit, precipitates, and enmeshes particles. Following destabilization, particle-particle interactions (i.e. collisions) result in floc formation. Dosing polymer to improve floc characteristics is a widely practiced method in water treatment to improve floc strength and size, and bulk removal of floc is achieved by solid−liquid separation processes.

4. Filter aids with dewatering of digestate reject

Filter-aid filtration is widely used to remove impurities which tend to clog the filter medium. Filter aids can serve in the filtration cycles of various types of filters, such as plate-and-frame filter presses, horizontal and vertical pressure leaf filters, candle or tubular filters, Nutsche filters and rotary vacuum drum filters. Diatomite, perlite and cellulose are the filter aids most frequently used in industry (Figure 27).

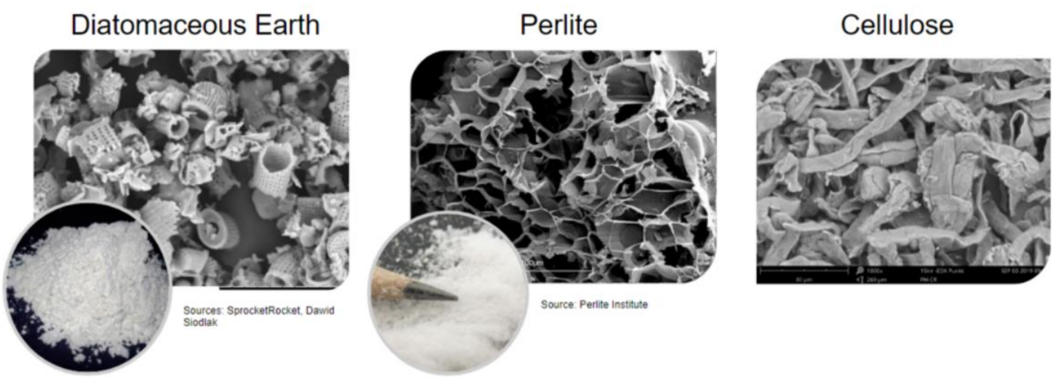


Figure 27. Three of the most commonly used filter aids in precoat filtration (Veolia, https://www.veoliawatertech.com/en/expertise/applications/precoat-filtration).

Filter aids are used via two methods: precoat or body feed (Figure 28). In precoat the filter aid generates a thin layer of solids on top of the filter medium. Once formed, this cake functions as the primary means of filtration. Therefore, the filter cloth no longer serves as the real filter when using precoat. For that reason, a filter cloth that is as open as possible while still retaining the filter aid material should be selected.

The precoat process involves mixing the filter aid into clear liquid or mother filtrate in a tank. Diatomite filter aids usually work best with a precoat slurry concentration in the 0.3–0.6 wt.% range. This slurry then goes to the filter where the filter medium captures the solids. The clean filtrate returns to the precoat tank. Typical precoat thicknesses are in the 1–3 mm range.

Body feed technique involves blending the filter aid with the slurry feed either by dosing concentrated filter aid suspension into the slurry feed and in-line mixing or by mixing the filter aid into the entire slurry batch and maintaining agitation. The filter aid solids and the native solids continuously build a filter cake until either the maximum cake height or maximum operating pressure is reached. By adding filter aid into the slurry feed, the resulting filter cake is more porous, allowing higher and longer sustained flow rates. Body feed also helps restrict solids movement, which improves filtrate clarity.

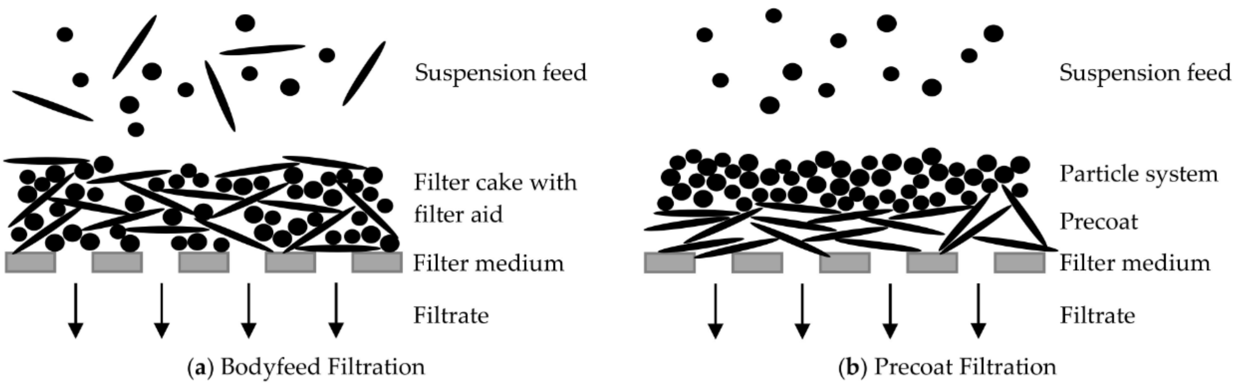


Figure 28. Continuous addition of the filter aid with the suspension (a) and addition as a primary filter cake (b) (Bäckle et al. 2021).

Pressing aids are usually long fibres for clarifying very difficult to dewater sludges. Pressing aids are long compressible fibers (>300 µm), they build up drainage channels for dewatering, hence can only be applied as bodyfeed. As an example, long cellulose fibres are suitable as pressing and draining aid for sludge dehydration.

5. Conclusions

Dewatering equipment continue to develop, both in respect of the invention of new machines and making significant improvements to existing technology platforms. Over the years three types of dewatering technology have been ever-present in the municipal market: decanter centrifuges, belt presses and filter presses. They all are excellent examples of technologies which have been subject to significant development and diversification. Changes made to the machines have widened their range of application and the new upstream processes producing the sludge have further blurred each machine's traditional range of application (Evans and Venkatesan 2001). The highest cake dryness is achieved by chamber press, but it has also the largest foot print. Centrifuge has smallest foot print, but highest power consumption. Belt and screw presses require a lot of wash water.

A laboratory-scale pressure filter provides a general direction, but the data may not reflect the full-size filter press performance well. Pretreatment is required for most biosludges and tests are required to identify the optimum pretreatment strategy. The decision on dewatering options needs to consider both cake dryness and sludge treatment rate and match that to the plant requirements.

Coagulation and/or flocculation should be tested for a slurry for a successful pretreatment prior to separation device.

6. References

Anne Wambui Mumbi, Li Fengting, Fridah Mwarania and Batzorig Uuganchimeg, AN ASSESSMENT OF MULTI-PLATE SCREW PRESS IN DEWATERING PROCESS OF SLUDGE TREATMENT, Int. J. Adv. Res. 5(12), 2017, 740-747

Chee Yang Teh, Pretty Mori Budiman, Katrina Pui Yee Shak and Ta Yeong Wu, Recent Advancement of Coagulation−Flocculation and Its Application in Wastewater Treatment, Ind. Eng. Chem. Res. 2016, 55, 4363−4389

Evans, L. and Venkatesan, Raj PhD (2001) Belt press, centrifuge, screw press or other alternative dewatering device – What is best for your plant?. In Proceedings of the WEF/AWWA/CWEA Joint Residuals and Biosolids Management Conference Biosolids 2001: “Building Public Support”

Harald Anlauf, Wet Cake Filtration: Fundamentals, Equipment, and Strategies, First Edition.
© 2019 Wiley-VCH Verlag GmbH & Co. KGaA. Published 2019 byWiley-VCH Verlag GmbH & Co. KGaA

https://cdn.ymaws.com/www.ncsafewater.org/resource/collection/DA8375FB-1514-4325-9CF6-0369B08C4385/WW_Tues_NOON_12.00_Williams_PAPER.pdf

https://www.sciencedirect.com/topics/engineering/filter-chamber

John T. Novak, Dewatering of Sewage Sludge, Drying Technology, 24: 1257–1262, 2006

Matthew Higgins, Sudhir N. Murthy, Perry Schafer, Alan Cooper, Ersin Kasirga, Kean Lee, John Machisko, Paul Fountain and K. Kelleher, Dewatering Characteristics of Cambi Thermal Hydrolysis Biosolids: Centrifuges vs. BFPs, WEFTEC 2011

Matthew J. Higgins, Bernhard Wett, Thomas Puempel, Imre Takacs, Perry Schafer, Beverly Stinson, Walter Bailey and Sudhir Murthy, Downstream Process Impacts as Criteria for Selection of Thermal Hydrolysis at Large Plants, Proceedings of the 11th IWA Large Wastewater Treatment Plant Conference, Budapest, 2011.

Richard J. Wakeman, Separation technologies for sludge dewatering, Journal of Hazardous Materials 144 (2007) 614–619

SNF Floerger, Sludge Dewatering handbook

Sprick Matt, Comparison of Options for Biosolids Dewatering, Water Environment School 2017, 3/28/2017

Teir S, Auvinen T, Said A, Kotiranta T and Peltola H (2016) Performance of Separation Processes for Precipitated Calcium Carbonate Produced with an Innovative Method from Steelmaking Slag and Carbon Dioxide. Front. Energy Res. 4:6. doi: 10.3389/fenrg.2016.00006

Veolia web page 5.6.2023, https://www.veoliawatertech.com/en/expertise/applications/precoat-filtration

Williams Elijah, Howard Don, Crotwell Christopher, Knosby Mary and Shull Will, SELECTING THE BEST DEWATERING TECHNOLOGY FOR A CHALLENGING ASH SLURRY, City of Greensboro, Water Resources Department

Volker Bächle, Patrick Morsch, Marco Gleiß and Hermann Nirschl, Influence of the Precoat Layer on the Filtration Properties and Regeneration Quality of Backwashing Filters, Eng 2021, 2, 181–196

Wu Chen, Optimization of Sludge Dewatering Through Pretreatment, Equipment Selection, and Testing, Drying Technology, 31:2 (2013), 193-201.